

14. Environmental Impact Assessment (EIA)

14.1 Condition of Natural Environment

14.1.1 Land use



The target area for Corridor 1, 2 and Depot begins from the Danapur cantonment to Depot area through some commercial areas, residential areas, special areas and public areas. The underground section is from the western area of Patliputra St. to the northern area of Mithapur St. for Corridor 1, and from Patna St. to the northern area of Malahi Pakri Sr. for Corridor 2. The other section is elevated, and Patna St. and Khemni Chak St. are allocated as interchange station between corridor 1 and corridor 2



Source: JST based on Patna Master Plan 2031

Figure 14-1: Land Use Condition along Patna Metro

Table 14-1: Environmental Condition along Patna Metro









Corridor 1	
	
1. Danapur	2. Saguna More

Corridor 1	
 <p>3. RPS More</p>	 <p>4. Patliputra</p>
 <p>Under Digha AIIMS Elevated Rd.</p>	 <p>5. Rukanpura</p>
 <p>6. Raja Bazar</p>	 <p>7. Patna Zoo</p>
 <p>8. Vikas Bhawan</p>	 <p>9. Vidyut Bhawan</p>

Corridor 1	
	
10. Patna	11. Mithapur
	
12. Ramkrishna Nagar	13. Jaganpura

Source: JST

Corridor 2	
	
Railway Patna Station	2. Akashvani
	
3. Gandhi Maidan	4. PMCH

Corridor 2	
	
5. University	Between University St. and Stadium St.
	
6. Moin-ul-Haq-Stadium	7. Rajendra Nagar
	
Railway Rajendra Nagar Station	8. Malahi Pakri
	
9. Khemni Chak	10. Bhootnath



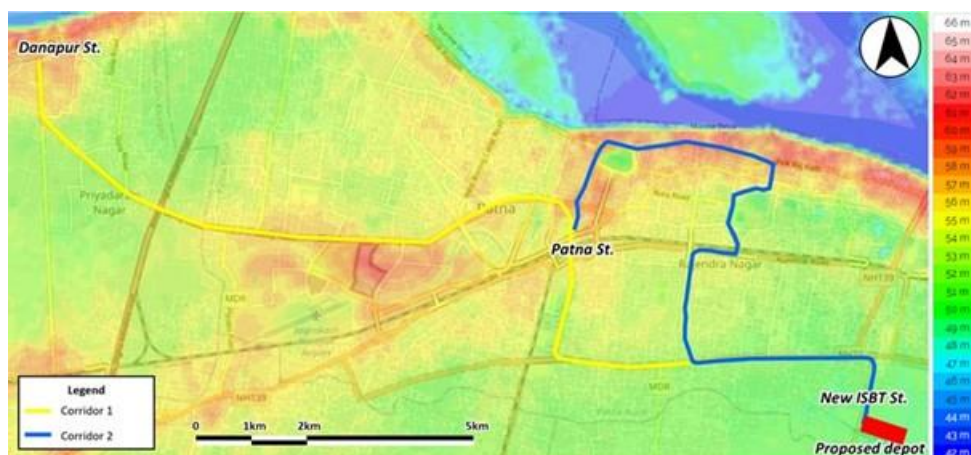
Source : JST



Source : JST

14.1.2 Geology and Topography

The target area for Corridor 1, 2 and Depot is located from latitude 25°34'13" N to 25°37'59"N and from longitude 85°02' 27" to 85°11'57" E. The corridors are planned to cross the center of Patna city. The altitude of proposed Depot area is the lowest, but it is over 50 m. The highest altitude is recorded at the middle point of Corridor 1 and Corridor 2 along the Ganges River with an altitude of 60 m.

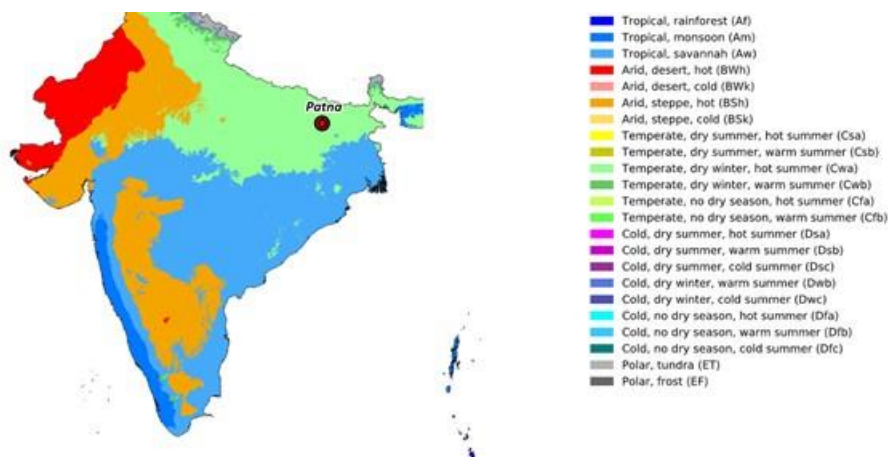


Source: JST based on topographic-map.com

Figure 14-2: Land Use Condition along Patna Metro

14.1.3 Climate

India is classified into 23 Köppen climate classifications in total because of the large nation land. The climate at Patna is divided into 3 seasons: the intense heat season from late in March to early in June, the rainy season from late in June to late in September, and the dry season from November to February. Patna, in which the construction site is located, belongs to the Monsoon-influenced humid subtropical climate and the temperature difference is large with 15°C between the intense heat season and the dry season. The maximum temperature also ranges from 23°C in January to 38.4°C in May, and the average yearly rainfall in Patna is 1,213 mm



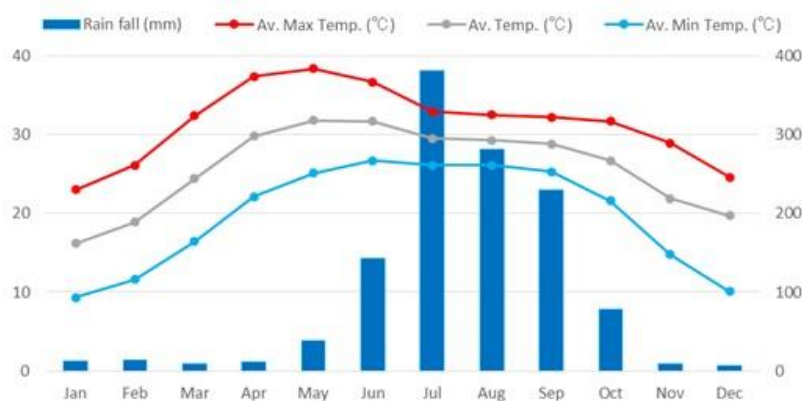
Source: Peel, M. C., Finlayson, B. L., and McMahon, T. A. (2007) (University of Melbourne)

Figure 14-3: Köppen Climate Classification for India

Table 14-2: Weather Condition in Patna

Station	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Patna	Rainfall	12.2	14.1	9.4	10.8	38.1	142.5	381.0	281.6	229.3	78.6	8.7	7.0	1213.3
	Temperature	16.2	18.9	24.4	29.8	31.8	31.7	29.5	29.3	28.8	26.7	21.9	19.7	25.7
	Max. Temp	23.0	26.1	32.4	37.4	38.4	36.7	32.9	32.5	32.2	31.7	28.9	24.6	-
	Min. Temp	9.3	11.6	16.4	22.1	25.1	26.7	26.1	26.1	25.3	21.6	14.8	10.1	-

Source: JST based on the data of India Meteorological Department



Source: JST based on the data of India Meteorological Department

Figure 14-4: Weather Condition in Patna

14.1.4 Natural Disasters

“PATNA MASTER PLAN 2031¹” shows that Patna has a high risk for natural disasters because of a vulnerable city for Earthquake and Flood due to Monsoon.

(1) Flood

Since Patna has lower average altitude than the flood level of the Ganges River except for the old town area on the northeast side of the project site, muddy currents flow into the city beyond the flood level of the river during the monsoon season, which causes damage. In 1975 and 1984, the flood levels were observed at 51.34 m and 51.6 m respectively. The left figure below shows the flood damage area in August 2016, and it can be seen that Patna has also been damaged in addition to the Saran and Vaishali districts on the north side of the River. However, according to the interview with PMRCL staff and some local people, JST has received their answer that there has been no flood damage in the project area. Google Earth also has a satellite photo (black and white) of August 2016 just after the flood, but the vehicles on the road along the alignment of Patna Metro can be checked. Additionally, according to the site inspection, waterstop boards shall be installed along the riverbanks to prevent floodwater from flowing into the city when the risk of flooding increases. From the above, it can be understood that the areas along the Patna Metro were not flooded.



Source: Mapping cropland impact from flooding in Saran & Vaishali (Bihar) using Theos1 Satellite Images (28 August 2016)

Figure 14-5: Flood Damage Area in August 2016

(2) Earthquake

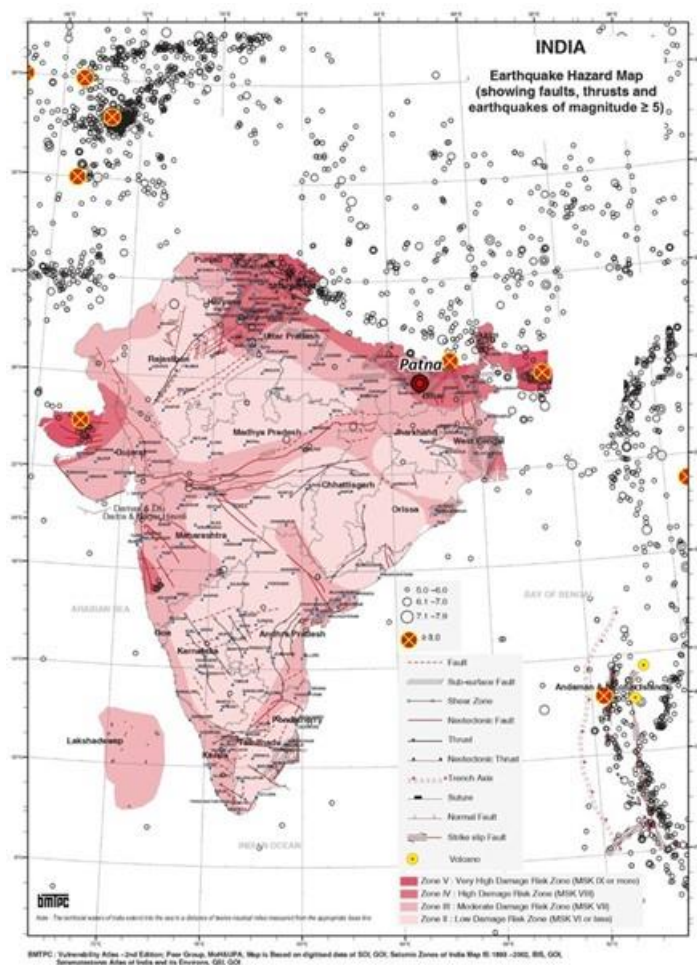
According to the seismic distribution map issued by the Bureau of Indian Standards, the project site is covered by Zone IV which corresponds with a high-risk area. The figure below explains the earthquakes with over magnitude 5 occurred in India and its surrounding areas for the 110 years from 1893 to 2002. Although there is a few number of occurred earthquakes in Patna, an earthquakes with a magnitude of more than 8 has occurred at the point of 200 km northeast of Patna. According to PMRCL, there has been no large-scale earthquake damage in the project area. The damages caused by major earthquakes that occurred in recent years around Bihar state are shown below. Regarding the cause of deaths in both earthquakes, most of them were not directly caused by building collapses, but from heart attacks, panic, and riots after the earthquakes. Therefore, it can be said that there has been no earthquake damage in Patna city at least for the last 130 years.

¹ PATNA MASTER PLAN 2031, Town and Country Planning Organization Urban Development & Housing Department Patna, Bihar, 2016

Table 14-3: Weather Condition in Patna

Year	Hypocentre	Magnitude	Number of death in Patna	Remarks
1988	South of Sagarmatha Zone, Nepal	6.8	0	There were no casualties or injuries in Patna, but several buildings collapsed and breakwaters were damaged ² .
2015	Gandaki zone, Nepal	7.8	Unknown (Very few)	The number of casualties in Bihar state is 58 people, mainly close to the boundary with Nepal. Patna city is unknown), but most of them were not directly caused by building collapses, but from heart attacks, panic, and riots after the earthquakes ³ .

Source: JST based on the data of India Meteorological Department



Source: Building Materials and Technology Promotion Council

Figure 14-6: Epicenter of Earthquakes with over M 5.0 in and around India

² <https://reliefweb.int/map/india/india-severe-floods-bihar-state-august-2016-comparison-between-pre-and-post-flood-0>

³ https://zeenews.india.com/news/india/quake-toll-in-india-now- 78_1587267.html

14.2 Legal System Regarding Environmental Considerations in India

14.2.1 Laws and Regulations Regarding Environmental Considerations in India

(1) Environmental policy, strategies and legal frameworks

The law on the environment, the "Environment (Protection) Act 1986" has been enacted in India, which was established the basic outline of environmental protection. The "National Environment policy" was established in May 2006, and the "Environment Impact Assessment Notification" 2006" on project categories for environmental compliance certificate, screening and scoping procedures, public consultations, etc. has been enacted in September 2006. These procedures are under the responsibility of the Impact Assessment Division under the Ministry of Environment, Forest and Climate Change (hereinafter referred to as "MoEFCC").

(2) Environmental Management Law

1) Environment (Protection) Act 1986

The Environment (Protection) Act is positioned as the Basic Environment Law in India, and explains the basic outline of environmental protection, and consists of 4 chapters and 26 items in total. The law stipulates the central government's responsibilities for the prevention, management and reduction of environmental pollution. The government is empowered to develop appropriate rules to achieve the goals of the Act. The Act defines "Environment" as "includes water, air and land and the inter-relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property". The Act provides the authority to prevent, regulate and reduce environmental pollution and activities which damage environment. The government is empowered to set rules in sectors where environmental protection and regulation are required.

2) Environment Impact Assessment Notification" 2006

EIA in India is positioned as the primary procedure for reviewing and approving new or modified projects under the National environment policy 2006, which was developed under the Environmental (Protection) Act. The EIA procedure is stipulated in the Environmental Impact Assessment Notification 2006, which includes Requirements of prior Environmental Clearance (hereinafter referred to as "EC"), Assessment authority, Categorization of projects and activities, Screening, Scoping and Appraisal Committees, EC application, Validity of EC, Post EC Monitoring, and Transferability of EC etc. Various formats have also been established in the Notification. There is no EIA ordinance system by regional governments in India. The environmental categories of India are divided into three groups, A, B1 and B2 as shown in the table below. The criteria between category A and B is relatively clear, but the criteria between category B1 and B2 is indefinite. Therefore, it will be judged by screening process. The EC issuance supervisory authority, the inspection authority, and other necessary documents are different for each category.

Table 14-4: Supervisory authority, Inspection authority for each category in India

Category	Supervisory authority (Regulator)	Inspection authority	EIA	EC	Monitoring
A	MoEFCC	EAC	Need	Need	Need
B1	SEIAA	SEAC	Need	Need	Need
B2 except Mining, extraction of natural resources	SEIAA	SEAC	Needless	Need from SEIAA	Need
B2 for Mining, extraction of natural resources	DEIAA	DEAC	Needless	Need from SEIAA	Need
Non-EC project	-	-	Needless	Needless	Need

* SEIAA: State/Union Territory Environment Impact Assessment Authority, SEAC: State or Union territory level Expert Appraisal Committee, DEIAA: District Environment Impact Assessment Authority, DEAC: District Expert Appraisal Committee

Source : Environment Impact Assessment Notification 2006

(3) Environmental Screening for the Project

1) Screening Based on the Environmental Impact Assessment Notification 2006

EC is not required because all railway projects in India are exempt from EC procedures.

2) Screening Based on the JICA Guidelines

The project is classified as “Category A” in the JICA guidelines published in April 2010, because it corresponds with the condition that it is likely to have significant adverse impacts on the environment and society as a railway sector which has a characteristic of large-scale involuntary resettlement.

(4) Survey policy of the project

This project is not applicable for the EC procedure in India mentioned in the EIA Notification 2006, and is classified as Category A in the JICA guidelines. Therefore, the survey shall be conducted in accordance with the JICA guidelines. In the table below, the corresponding part of each item mentioned in the Notification is listed for reference.

Table 14-5: Gap between EIA Procedure in India and JICA guidelines

Subject	JICA guidelines	EIA in India (EIA Notification 2006)	Policy of this survey
Underlying Principles	<ul style="list-style-type: none"> Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan. 	Details of Alternatives shall be examined, and EMP would consist of all mitigation measures for each item.	Follow JICA guidelines (PMRCL has prepared an EIA report when planning for this project began in 2020. This feasibility study will conduct an additional EIA survey to examine alternatives and mitigation measures in line with the JICA Guidelines. PMRCL will be requested to incorporate the results of this survey in the project plan.)
Information Disclosure	<ul style="list-style-type: none"> EIA reports (which may be referred to differently in different systems) must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted 	MOEF&CC shall display the Summary of the draft EIA report on its website, and also make the full draft EIA available for reference at a notified place during normal office hours at the Ministry in Delhi.	Follow JICA guidelines (In 2020, PMRCL has already prepared an EIA report in English and Hindi, which is widely used in India. PMRCL has explained the project to local residents through public consultations when preparing the EIA. PMRCL will be requested to make the report’s copy available to local stakeholders throughout the project.)

Subject	JICA guidelines	EIA in India (EIA Notification 2006)	Policy of this survey
Stakeholder meeting	<ul style="list-style-type: none"> • For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of project plans. • In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Records of such consultations must be prepared • Consultations with relevant stakeholders, such as local residents, should take place if necessary throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared. 	Public consultation shall be conducted after submission of draft report.	Follow JICA guidelines (Meetings were held by PMRCL when preparing EIA Report and SIA Report, and JST checked the minutes of these meetings and confirmed its compliance with the JICA Guidelines. Another meeting will be held at the time of preparing Draft Final Report in this survey.)

Subject	JICA guidelines	EIA in India (EIA Notification 2006)	Policy of this survey
Assessment Items	<ul style="list-style-type: none"> • The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. • In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle should be considered throughout the life cycle of the project. 	<p>In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent.</p>	<p>Follow JICA guidelines (Where there are impacts stated in the JICA Guidelines that were not sufficiently analysed in the EIA report prepared by PMRCL, this survey will conduct additional assessments, Environmental impact assessments for facilities related to this project, such as quarry, borrow pits, and construction yards, will be conducted to the extent possible.)</p>

Subject	JICA guidelines	EIA in India (EIA Notification 2006)	Policy of this survey
Monitoring, Grievance Redress Mechanism	<ul style="list-style-type: none"> Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems. 	Project proponents are required to submit environmental management plan & programme. It shall be mandatory for the project management to submit every half a year compliance reports in respect to the stipulated prior environmental clearance terms and conditions.	Follow JICA guidelines (Request PMRCL to disclose monitoring results to the stakeholders, and to conduct additional meetings as needed throughout the project.)
Ecosystem and Biota	Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests.	Separately discussed in each concession, law, and standard.	Follow JICA guidelines (JST will conduct an assessment of critical natural habitats and critical forests, and will examine alternatives and mitigation measures. PMRCL will be requested to reflect the results in the project plan.)
Indigenous Peoples	Any adverse impacts that a project may have on indigenous peoples are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures must be taken to minimize impacts and to compensate indigenous peoples for their losses.	Separately discussed in each concession, law, and standard.	No indigenous or ethnic minority communities were found in the area along the 2 corridors of the Project.

Source : JST

(5) Other environment-related permits required for this project

As mentioned above, the project is not applicable to the EC procedures in India, but various regional permits for Bihar state and Patna City shall be required as follows. The application period for the permits is mainly at the stage of pre-construction, construction, and operation.

Table 14-6: Environment-related Permits

Item	Acts/ Rules	Concerned Agency	Stage
Consent to Establish and Consent to Operate for Batching plant	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988 and The Air (Prevention and Control of Pollution) Act 1981, amended 1987	Bihar State Pollution Control Board	Pre-Construction
Permission for felling trees	Tree Preservation Act	Forest Department/ Municipal Authorities	Pre-construction

Item	Acts/ Rules	Concerned Agency	Stage
Construction and Demolition (C &D) Waste Management Plan	C&D Waste Management Rules, 2016	Local Authority	Pre-construction
Permission for extraction of ground water	Environment (Protection) Act, 1986	CGWA (Local Unit)	Pre-construction as well as for operation
Generation, handling, storage and transportation of hazardous waste	Hazardous and Other wastes (Management & Transboundary Movement) Rules, 2016	Bihar State Pollution Control Board	Construction and Operation
Consent to establish and operate Sewage Treatment Plant (STP) and Effluent Treatment Plant (ETP)	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988	Bihar State Pollution Control Board	Operation

Source : Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC

(6) Other environment-related Acts, regulations

Other environment-related Acts, regulations are shown as below.

Table 14-7: Other environment-related Acts, Regulations

Category	Law, Act, Guideline
Air quality	Air (Prevention and Control of Pollution) Act, 1981 Air (Prevention and Control of Pollution) Rules, 1982 Revised National Ambient Air Quality Standards, Notification, 2009
Water quality	Water (Prevention and Control of Pollution) Act, 1974 Water (Prevention and Control of Pollution) Rules, 1975 IS 10500 : 2012 Indian Standard DRINKING WATER — SPECIFICATION
Waste	Bio-Medical Waste (Management and Handling) Rules, 1998, as amended to date, 2003 The Batteries (Management and Handling) Rules, 2011
Noise	Noise Pollution (Regulation and Control) Rules, 2000 EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IV th Edition.
Ecosystem	Wildlife Protection Act, 1972 The Wild Life (Protection) Amendment Act, 2002 The wild life (Protection) Rules, 1995 Biological Diversity Act, 2002 Indian forest Act, 1927 Forest conservation act, 1980, 1988, etc. National forest policy, 1988 Forest rights act, 2006 Forest conservation amendment rules, 2003
Cultural and historical heritage	Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010

Source : JST

14.3 Comparative study of alternatives (Including No project)

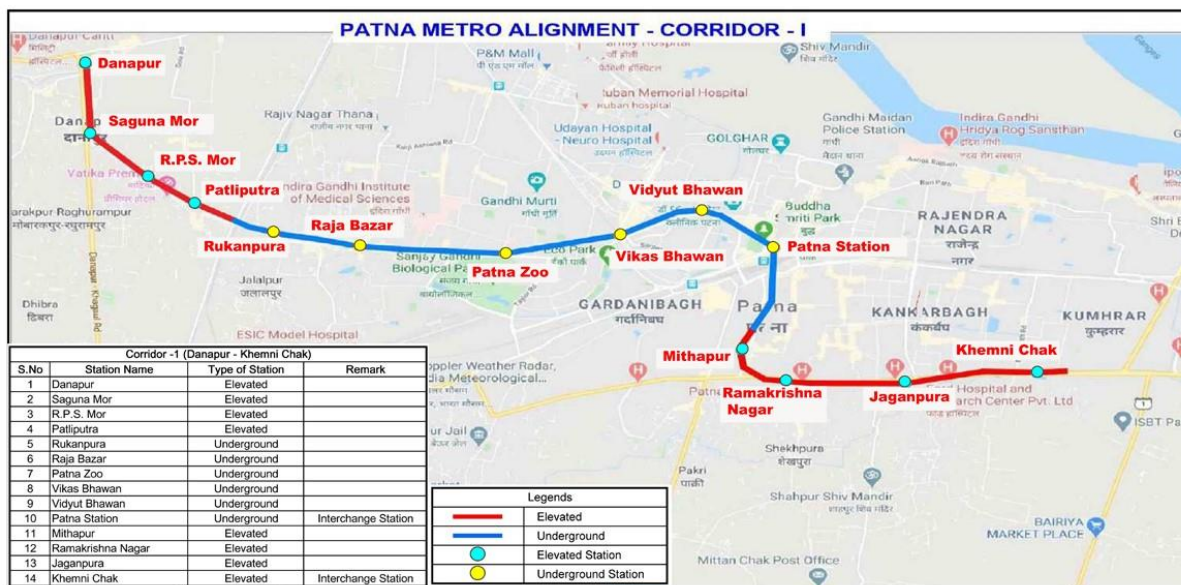
. Alternatives for Corridor 1 and Corridor 2 are studied in the Updated Detailed Project Report (DPR) and the Social Impact Assessment (SIA) report. The JST analysed the following items in the comparative study of alternative plans.

- Possibility to start projects earlier.
- Reduction of the project cost
- Impact of the project on the surrounding environment
- Contribution to the reduction of road traffic congestion compared with zero option (without project).

14.3.1 Corridor 1

(1) Overview

Corridor 1 is planned as an elevated section between Danapur and Patliputra stations, starting from Danapur at the western end. There is a transitional section from an elevated section to an underground section towards the end of the line from Patliputra station, and an underground section starts from the east of Patliputra station. The line then reverts back to an elevated section between Patna and Mithapur stations and joins Corridor 2 at Khemni Chak station.



Source: Detailed Project Report 2021, PMRCL

Figure 14-7: Route Overview of Corridor 1

(2) Alternatives

The following three alternatives are being considered including a case where the project is not implemented.

1) Alternative 1

Alternative 1 is the case where project is not implemented.

2) Alternative 2

Alternative 2 consists of 16.9 km route and 12 stations. Proposed line passes through Saguna More, Rukanpura, Raja Bazar, Zoo, Patna Station and Mithapur districts. This plan envisages the construction of a depot at Aitwarpur.



Source: Detailed Project Report 2018, PMRCL

Figure 14-8: Route Overview of Alternative 2

3) Alternative 3

Alternative 3 considers the Danapur - Khemni Chak section passing through Saguna More, Rukanpura, Zoo, Patna Station, Mithapur, Jaganpura and Khemni Chak. Unlike Alternative 2, this alternative proposed to connect Corridor 1 and Corridor 2 at Khemni Chak. The dedicated depot for Corridor 1 is not considered in this alternative and it is assumed that a depot near the New ISBT station is shared for Corridor 1 and Corridor 2 instead.



Source: Detailed Project Report 2021, PMRCL

Figure 14-9: Route Overview of Alternative 3

(3) Results of comparative study of alternatives

The table below shows the results of the alternatives evaluation with the 5 ratings set from +2 to -2 including Zero. A comparative evaluation shall be adopted, and it assigns +1 or +2 to the more desirable one and -1 or -2 to the less desirable one after comparing the three alternatives. Regarding the weighting of each evaluation item, since there are 10 items for environmental and social items, and it is more significant to focus on business sustainability, the item of Profitability and Cost, which are cost-effectiveness indicators, shall be evaluated with a double rate compared with the other environmental and social items. The total score was calculated for each alternative. As a result of the overall evaluation, the alternative 3 is assessed as the most suitable plan.

Table 14-8: Comparative Study Results of Alternatives

No.	Comparative study item	Alternative 1. (Case in which the project is not implemented)	Alternative 2	Alternative 3. (Adoption proposal)
1	Beginning point of route	-	Danapur	Danapur
2	End point of route	-	Mithapur	Khemni Chak
3	Length of route	-	16.94 km The spur track from/to the depot is long. Given that this track is used by a train out of service only, a not-for-profit section is longer.	17.933 km Although the route length is longer than Alternative 2, the section used for the revenue train is longer than it. Therefore, the revenue increase can be expected.
4	Route	-	Suguna - Danapur Main Rd Bailey Rd Fraser Rd Mithapur Bus Stand Rd Patna - Sitamarhi Rd Patna - Gaya Rd	Suguna - Danapur Main Rd Bailey Rd Fraser Rd Mithapur Bus Stand Rd Patna - Sitamarhi Rd
5	Number of stations	-	12 Stations Comparing to the Alt.3, the available space for the railway is narrow along the route.	14 Stations Comparing to the Alt.2, the additional stations for the route altered improves the conveniences of passengers along the route.
6	Length of elevated section	-	5.48 km	7.393 km
7	Number of elevated stations	-	3 Stations	8 Stations
8	Length of underground section	-	11.20 km	10.54 km
9	Number of underground stations	-	8 Stations Comparing to the Alt.3, a larger number of underground stations worsens the road congestion during the construction period and increases the project cost.	6 Stations Comparing to the Alt.2, a smaller number of underground stations can avoid the road congestion during the construction period and reduces the project cost.
10	Length of at-grade section	-	0.26 km	0km
11	Ground level station	-	1 Station	-
12	Number of depots	-	1 Location Due to long spur line between the main line and the depot, the increase of the project cost for the viaduct construction and the increase of energy consumption rate by out-of-service trains are anticipated.	Given the depot shared with Corridor 2, the depot dedicated for Corridor 1 is not needed. It has the advantages in the feasibility of the project by reducing the land acquisition and the procurement of facilities and equipment.
Environmental and social considerations				

No.	Comparative study item	Alternative 1. (Case in which the project is not implemented)	Alternative 2	Alternative 3. (Adoption proposal)												
13	Air Quality	Further deterioration by increased traffic volume is expected.	Improvement of the situation is expected due to reduced traffic volume.	Improvement of the situation is expected due to reduced traffic volume.												
	Rating	-1	+2	+2												
14	Noise and vibration	The increase of noise and vibration from the traffic and the car horns is expected.	The noise and vibration during/after the construction can be reduced by the preventive countermeasures.	The noise and vibration during/after the construction can be reduced by the preventive countermeasures.												
	Rating	-1	+1	+1												
15	Earthquake/Flooding • Submergence	-	Although there is a risk of earthquake, flooding and submergence, the damage can be prevented by a countermeasures such as seismic retrofitting and the entrance/exit level raising.	Although there is a risk of earthquake, flooding and submergence, the damage can be prevented by a countermeasures such as seismic retrofitting and the entrance/exit level raising.												
	Rating	0	0	0												
16	Number of affected trees	-	935 trees	864 trees												
	Rating	0	-2	-2												
17	Affected landmark	-	-	-												
	Rating	0	0	0												
18	Land acquisition area (However, the temporary construction area and the depot are excluded.)	-	9.98 ha *In addition, Alt.2 needs 14.40ha of another land acquisition for the depot connected to Corridor 1. A total of 24.39ha needs to be acquired.	10.83 ha *Alt.3 has no depot connected to Corridor 1.												
	Breakdown of land by owner (However, the temporary construction area and the depot are excluded.)	-	<table border="1"> <tr> <td>Central Government Land</td> <td>0.10 ha</td> </tr> <tr> <td>State Government Land</td> <td>3.30 ha</td> </tr> <tr> <td>Private Land</td> <td>6.58 ha</td> </tr> </table>	Central Government Land	0.10 ha	State Government Land	3.30 ha	Private Land	6.58 ha	<table border="1"> <tr> <td>Central Government Land</td> <td>3.79 ha</td> </tr> <tr> <td>State Government Land</td> <td>2.05 ha</td> </tr> <tr> <td>Private Land</td> <td>4.99 ha</td> </tr> </table>	Central Government Land	3.79 ha	State Government Land	2.05 ha	Private Land	4.99 ha
	Central Government Land	0.10 ha														
State Government Land	3.30 ha															
Private Land	6.58 ha															
Central Government Land	3.79 ha															
State Government Land	2.05 ha															
Private Land	4.99 ha															
Rating	0	-2	-1													
19	PAPs and PAFs (The number includes PAFs not subjected to the resettlement.)	-	1,178 persons (178 families) *This number is from Corridor 1 and the depot.	256 persons (52 families)												
	Rating	0	-2	-1												
20	Affected structures	-	88 structures	19 structures												
	Rating	0	-2	-1												
21	Traffic safety	Low	High	High												
	Rating	-2	+2	+2												
22	Climate change	Increase in CO ₂ emission is expected due to higher traffic volume.	Decrease in CO ₂ emission is expected due to lower traffic volume. However, it incurs CO ₂ emission from the electricity generation to operate the metro.	Decrease in CO ₂ emission is expected due to lower traffic volume. However, it incurs CO ₂ emission from the electricity generation to operate the metro.												
	Rating	-2	+1	+1												
Profitability																
23	Total Passenger area and Profitability	No passenger area	9.4 km ² (12 stations, assuming catchment area as a 500m radius)	11.0 km ² Three stations (Ramkrishna Nagar-Khemni Chak) increased but one station (Golf club) omitted, i.e., two stations increased. Simply												

No.	Comparative study item	Alternative 1. (Case in which the project is not implemented)	Alternative 2	Alternative 3. (Adoption proposal)
			<p>The transfer station to the Corridor 2 is one (Patna Station).</p> <p>941 thousand per day in 2031. (the difference demand projection methodology with the Alt. 3 is unclear)</p> <p>Number of transferring station: 1</p> <p>2024 585,023 pax/day 2031 941,935 pax/day 2041 1,065,218 pax/day 2051 1,316,282 pax/day</p>	<p>17% increase of profitability.</p> <p>The transfer station to the Corridor 2 is two (Patna St and Khemni Chak), which will increase the network redundancy and accessibility.</p> <p>978 thousand per day in 2031. (the difference demand projection methodology with the Alt. 2 is unclear)</p> <p>Number of transferring station: 2</p> <p>This will increase network redundancy and passengers' accessibility twice from Alt. 2.</p> <p>2024 598,998 pax/day 2031 978,052 pax/day 2041 1,144,930 pax/day 2051 1,444,632 pax/day</p>
	Rating	0	+2	+4
Cost				
25	Project cost	—	<p>6565.27 Rs. in Crore</p> <p>The route length including the spur track from/to depot is shorter than Alt. 3, which means the maintenance cost will be lower than Alt.3. Given with a larger number of underground stations proposed, however, the project cost for the railway construction is expected to be higher than Alt. 3.</p>	<p>5348.88 Rs. in Crore</p> <p>The route length including the spur track from/to depot is longer than Alt.2 which means the maintenance cost will be higher than Alt.2. Given with a smaller number of underground stations proposed, however, the project cost for the railway construction is expected to be lower than Alt. 2.</p>
	Rating	0	-4	-2
Evaluation		-6	-4	+3
		3rd	2nd	1 st

Source : Detailed Project Report 2021, PMRCL, Social Impact Assessment 2020, DMRC, JST

(4) Validation of route selection

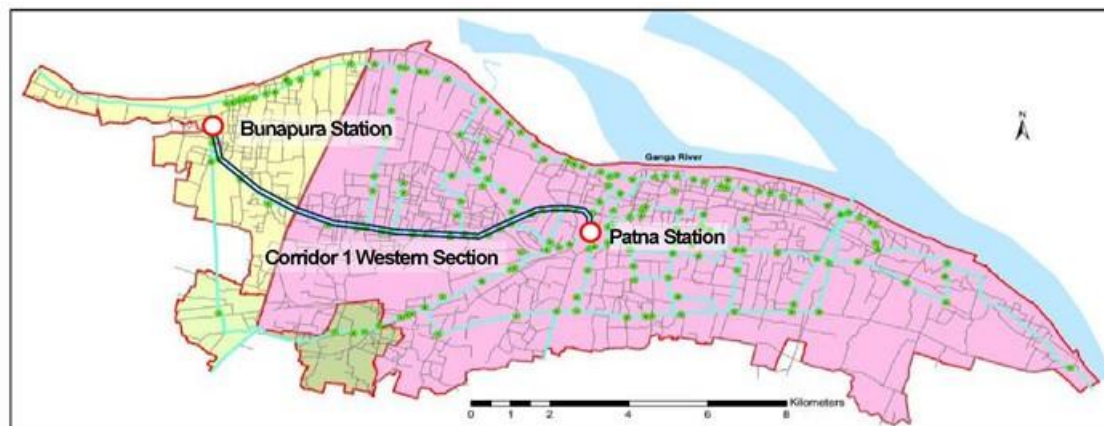
1) West side selection (Danapur – Patna St.)

The same section of the route has been selected for both Alternatives 2 and 3. There are no parallel arterial roads other than Bailly Road along the project route. For the western side of the Patna city area, the existing bus routes are also distant from the project route except for Bailly Road, and there are no competing or alternative bus routes. The area around Bailly Road, where the western section of Corridor 1 will be introduced, is undergoing redevelopment as a residential area by a private company, and it is expected that demand from the surrounding residents will increase in the future. Currently an arterial road on the west side of the Patna city area where public transport such as buses are concentrated, this

is deemed to be highly demanded for the introduction of rail-based transport. As a result of review, it is concluded that the proposed route is appropriate.

Reasons for selection of alternatives.

- To alleviate the traffic congestion compared with zero option (without project) by passengers transferred from main arterial roads and bus routes for which no alternative routes exist.
- To improve the convenience for residents living along the route.
- To reduce the project cost



Source: Detailed Project Report 2018, PMRCL

Figure 14-10: Existing Bus Route

2) South Side Selection (Patna – Mithapur, Khemni Chak)

Alternatives 2 and 3 of Corridor 1 have the same route to Mithapur station, the next station after Patna station. In the case of Alternative 2, Mithapur station would be the temporary terminus and the route would follow the Patna - Gaya Rd to the south and reach to future station envisaged at a point approximately 900 m from Mithapur station. The line continues further south to a planned depot approximately 3 km from Mithapur station. The depot in Alternative 2 is planned as a regular maintenance and overhaul facility. As Corridor 1 is not connected to Corridor 2, not only vehicles can be accommodated but also all maintenance can be completed at this depot. Under Alternative 2, if the route terminates at Mithapur station, the distance to the depot would be approximately 4 km, which is a very long distance for non-revenue services. The construction of non-revenue line is not desirable for the commercial feasibility since it increases the project cost and the electricity cost consumed by non-revenue train operation. In the case of Alternative 3, the route would follow Patna - Sitamarhi Rd to the east after Mithapur Station and it reaches to Khemni Chak Station, the junction station with Corridor 2, via Ramakrishna Nagar and Jagapura station. The distance from Mithapur Station is 3.3 km, which is slightly shorter than the distance between Mithapur Station and the depot in Alternative 2. In reality, however, it is necessary to take into account the lead track, therefore, the track length would be almost the same. Alternative 3 does not require the depot used exclusively for Corridor 1 since its function is substitutionally handled by Corridor 2 depot. This can reduce the project cost and the impact on the surrounding area by land acquisition.

Reasons for selection of alternatives

- Improved profitability through the improvement of the convenience for residents along the rail line and an increase in the number of stations attracting more passenger.

- Reduction in the number of depots and its related spur line to lower the overall project cost and further reduce the land acquisition area.



Source: Detailed Project Report 2018, 2021, PMRCL, JST

Figure 14-11: Comparative Figure for the Southern Section of Corridor 1

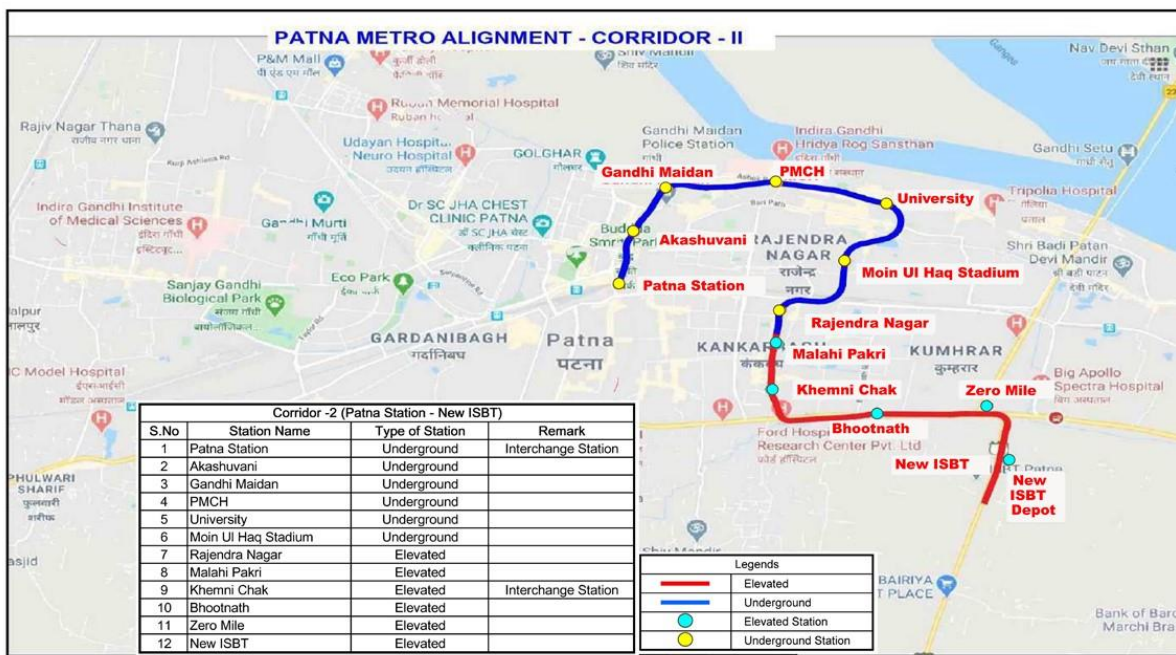
(5) Conclusion from the comparison of alternatives

As a result of the validation of Alternative 2 and Alternative 3, the introduction of rail transport on Bailly Road is a desirable route from the perspective of transferring passengers from buses and reducing road congestion compared with zero option (without project) since Bailly Road has no alternative bus route despite it is a major arterial road in the western section of the project route. Considering the long non-revenue section and the depot construction for the south section, Alternative 2 has the obvious disadvantages in terms of the increase of project cost and land acquisition. Although the Alternative 3 has almost same route length, it is more reasonable since the additional three stations can stimulate passenger demand for the railway. Given that the depot can be shared with Corridor 1 and Corridor 2, the reduction of the land acquisition and the depot construction cost can be expected even though the ordinary expenses by reducing the number of depots will be higher. Therefore, Alternative 3 has a high advantage. In terms of environmental and social considerations, the number of trees to be cut under Alternative 3 is 864, which is 71 less than Alternative 2, and the number of PAHs, PAFs, and affected structures are significantly reduced compared to Alternative 2, therefore Alternative 3 is highly advantageous overall.

14.3.2 Corridor 2

(1) Overview

Corridor 2 is planned as an underground section between Patna and Rajendra Nagar stations, starting at Patna station. After Rajendra Nagar station, the transition to the viaduct starts at about 300m behind Malahi Pakri station and then the elevated section continues to the southward. The spur line to the depot is branched at the south of the terminal station, New ISBT station. Corridor 2 has the junction with Corridor 1 at Patna and Khemni Chak stations and the depot is shared with Corridor 1.



Source: Detailed Project Report 2021, PMRCL

Figure 14-12: Overview of Corridor 2 route

(2) Alternatives

The following three alternatives are being considered as alternatives, including cases where the project is not implemented.

1) Alternative 1

Cases where projects are not implemented

2) Alternative 2

The route is planned as an elevated section from Patna Railway Station along Frazer road through Dak - Banglow Chowk, Akashvani, Gandhi Maidan and PMCH districts. The transition from the viaduct to the underground starts at PMCH station towards the east and Dinkar Chowk and Rajendra Nager stations are underground sections. A ramp is planned from Rajendra Nagar station towards the end of the line, where the line will again be elevated near Railway Coach Maintenance and will run via Gandhi Setu, Zero mile and Bodhgaya road to the terminus at ISBT.



Source: Detailed Project Report 2018, PMRCL

Figure 14-13: Outline of Route for Alternative 2

3) Alternative 3

Alternative 3 passes through Gandhi Maidan, PMCH, University and Rajendra Nagar. It has the underground section between Patna and Rajendra Nagar stations and the other section up to New ISBT station is planned as an elevated section. After Rajendra Nagar station, the underground section has the transition to the viaduct at Doctor’s colony near Malahi Pakri. Thereafter, Malahi Pakri, Khemni Chak, Bhootnath and Zero Mile stations will be elevated sections, terminating at the end of the line. A DEPOT is planned near ISBT. PMRCL has a vision to develop a commercial facility in conjunction with the depot. The DEPOT location has been changed from southwest to southeast of the NEW ISBT station as part of the neighbourhood development plan to bring the bus terminal and commercial facilities closer together.



Source: Detailed Project Report 2021, PMRCL

Figure 14-14: Outline of Route for Alternative 3

(3) Results of comparative study of alternatives

The table below shows the results of the alternatives evaluation with the 5 ratings set from +2 to -2 including Zero. A comparative evaluation shall be adopted, and it assigns +1 or +2 to the more desirable one and -1 or -2 to the less desirable one after comparing the three alternatives. The item of Profitability and Cost shall be evaluated with a double rate compared with the other items as same reason mentioned in the comparative study of Corridor 1. The total score was calculated for each alternative. As a result of the overall evaluation, Alternative 3 was assessed as the best option.

Table 14-9: Comparative study results of alternatives

No.	Comparative study item	Alternative 1. (Case in which the project is not implemented)	Alternative 2	Alternative 3. (Adoption proposal)
Project component				
1	Beginning point of route	-	Patna Station	Patna Station
2	End point of route	-	New ISBT	New ISBT
3	Length of route	-	14.45 km	14.564 km
4	Route	-	Fraser Rd Gandhi Maidan Rd Ashok Rajpath Rd Nara Rd Arya Kumar Rd Kankarbagh Main Rd Chapra Highway Bodhgaya Rd	Fraser Rd Gandhi Maidan Rd Ashok Rajpath Rd Moin Ul Hap Kankarbagh Main Rd Malahi Pakri Rd 90 Feet Rd Patna – Sitamarhi Rd Bodhgaya Rd
5	Number of stations	-	12 Stations	12 Stations
6	Length of elevated section	-	9.99 km Some transitional sections to underground are planned. A part of crossing road is divided by the transitional section.	6.638 km One transitional section to underground is planned. However, this location hardly divide the crossing road.
7	Number of elevated stations	-	9 Stations Given Patna station planned as the elevated station, the passenger is forced to go up and down to transfer from/to the underground station of Corridor 1. Therefore, the passenger's convenience is deemed inferior.	5 Stations Given Patna station planned as the underground station, the passenger's convenience in terms of transfer from/to Corridor 1 is superior to Alternative 2.
8	Length of underground section	-	4.55 km	7.926 km
9	Number of underground stations	-	3 Stations A smaller number of underground stations is deemed an advantage in terms of the project implementation.	7 Stations A larger number of underground stations is deemed a disadvantage in terms of road congestion by the construction and the project costs.
10	At Grade section	-	0km	0km
11	Ground Level Station	-	-	-
12	Number of depots	-	1 Location	1 Location
Environmental and social considerations				
13	Air Quality	Further deterioration by increased traffic is expected.	Improvement by reduced traffic volume is expected.	Improvement by reduced traffic volume is expected.
	Rating	-1	+2	+2

No.	Comparative study item	Alternative 1. (Case in which the project is not implemented)	Alternative 2	Alternative 3. (Adoption proposal)												
14	Noise and vibration	Noise and vibration from traffic and horns would be worsened.	Noise emissions can be reduced by installing countermeasures	Noise emissions can be reduced by installing countermeasures.												
	Rating	-1	+2	+2												
15	Earthquake/Flooding • Submergence	-	Although there is a risk of earthquake/flooding • submergence, the damage can be prevented by a countermeasures such as seismic retrofitting and raising the entrance/exit level.	Although there is a risk of earthquake/flooding • submergence, the damage can be prevented by a countermeasures such as seismic retrofitting and raising the entrance/exit level.												
	Rating	0	0	0												
16	Number of affected trees	-	705 trees	506 trees												
	Rating	0	-2	-1												
17	Affected historical structure	-	4 structures Archaeological verification is required and it takes time to implement the project.	-												
	Rating	0	-2	0												
18	Land acquisition area (However, the temporary construction area and the depot are excluded.)	-	8.17ha *In addition, Alternative 2 needs 12.50ha of another land acquisition for the depot connected to Corridor 2. A total of 20.66ha needs to be acquired.	6.65ha *In addition, Alternative 3 needs 19.60ha of another land acquisition for the depot connected to Corridor 2. A total of 26.25ha needs to be acquired.												
	Breakdown of land by owner (However, the temporary construction area and the depot are excluded.)	-	<table border="1"> <tr> <td>Central Government Land</td> <td>1.09 ha</td> </tr> <tr> <td>State Government Land</td> <td>5.79 ha</td> </tr> <tr> <td>Private Land</td> <td>1.29 ha</td> </tr> </table>	Central Government Land	1.09 ha	State Government Land	5.79 ha	Private Land	1.29 ha	<table border="1"> <tr> <td>Central Government Land</td> <td>2.90 ha</td> </tr> <tr> <td>State Government Land</td> <td>1.88 ha</td> </tr> <tr> <td>Private Land</td> <td>1.87 ha</td> </tr> </table>	Central Government Land	2.90 ha	State Government Land	1.88 ha	Private Land	1.87 ha
	Central Government Land	1.09 ha														
	State Government Land	5.79 ha														
Private Land	1.29 ha															
Central Government Land	2.90 ha															
State Government Land	1.88 ha															
Private Land	1.87 ha															
Rating	0	-1	-2													
19	PAPs and PAFs (The number includes PAFs not subjected to the resettlement.)	-	295 persons (56 families) *This number is from Corridor 2 and the depot.	463 persons (94 families) *This number is from Corridor 2 and the depot.												
	Rating	0	-1	-2												
20	Affected structure	-	118 structures	83 structures												
	Rating	0	-2	-1												
21	Traffic safety	Low	High	High												
	Rating	-2	+2	+2												
22	Climate change	Increase in CO ₂ emission is expected due to higher traffic volume.	Decrease in CO ₂ emission is expected due to lower traffic volume. However, it incurs CO ₂ emission from the electricity generation to operate the metro.	Decrease in CO ₂ emission is expected due to lower traffic volume. However, it incurs CO ₂ emission from the electricity generation to operate the metro.												
	Rating	-2	+1	+1												
23	Number of transition section from elevated to underground (Community severance)	-	2	1												
	Rating	0	-2	-1												
Connectivity																
24	Enhancement of transfer convenience between Corridor 1 and 2 at Patna	-	The two corridors are connected in the different level, which will force	The two corridors are connected at the same level but passengers must pass												

No.	Comparative study item	Alternative 1. (Case in which the project is not implemented)	Alternative 2	Alternative 3. (Adoption proposal)
	Station by undergrounding Patna St. of Corridor 2		passengers more than 30 meters vertical movement for transfer and will take 8 minutes for transferring.	through the concourse for transferring which will take 2-3 minutes, and its vertical movement could be less than 10 meter. The transfer can be done in the underground, which is much comfortable for passengers.
	Rating	0	-1	+1
25	Enhancement of transfer convenience by connection improvement between Patna Metro and IBST, Rajendra nagar St.	-	There are 4 inter-stations between the IBST and Rajendra Nagar St. There are 10 stations between the IBST and Patna St.	The distance between the IBST and Rajendra Nagar St. is not different, however, the distance between the IBST and Patna St. comes 7 stations, which will shorter than Alt. 2, though it requires transferring at Khemni Chak.
	Rating	0	+1	+2
Profitability				
26	Advantage and profitability improvement for passenger growth	-	The alignment runs along the Indian Railway corridor, where has low accessibility to the surrounding area and low growth potential. 2024 373,460 pax/day 2031 588,104 pax/day 2041 662,445 pax/day 2051 773,133 pax/day	The alignment runs along the National Highway and Malahi Pakri, where has high development potential to the Alt. 2 corridors. 2024 443,829 pax/day 2031 674,160 pax/day 2041 728,604 pax/day 2051 811,947 pax/day
	Rating	0	+2	+4
Cost				
27	Project cost	-	Given the viaduct section towards the beginning point of the route, the project cost is lower than Alternative 3.	Given that the underground section is longer than Alternative 2, the project cost is higher than it.
	Rating	0	-2	-4
Evaluation		-6	-3	+3
		3rd	2nd	1st

Source : Detailed Project Report 2021, PMRCL, Social Impact Assessment 2020, DMRC, JST

(4) Validation of route selection

1) Beginning point side section (Patna - Premchandra, Moin UL HAQ)

The same section has been selected for both Alternatives 2 and 3. While the Patna - PMCH section is an underground section and the road as the space for the railway is relatively wide, the PMCH - Rajendra Nagar section is narrow and there are no suitable roads along the route. Thus, the majority of the section passes under private land. The surrounding area is densely populated with low-rise residential buildings and small shops, and there are several large hospitals and universities on the route. Corridor 2 will have stations near these public facilities, therefore the high passenger demand is expected. Considering the current situation where road traffic is currently disrupted by narrow roads and it is difficult for buses to operate smoothly, the introduction of the subway is highly recommended to mitigate the situation. However, due to heavy road traffic and narrow roads, the construction of the subway will be very difficult.

Reasons for selection of alternative.

- Undergrounding is recommended to reduce the number of transitions due to concerns about the fragmentation of the crossroads caused by multiple underground transitions.

2) Intermediate section (Premchandra, Moin UL HAQ – Zero Mile)

Alternative 2 and Alternative 3 have different routes in this section.

Alternative 2 follows the Indian Railways line from Rajendra Nagar station to the east on Kankarbagh Main Rd and then it goes to southwards along Chapra Highway from Gandhi Setu station up to Zero Mile station. The section along the Indian Railways Line has no stations on the Indian Railways Line except Rajendra Nagar Station. The Indian Railways Line runs on a level section and there are few points to cross the Indian Railways Line on the section where it runs alongside Corridor 2 as there are only two pedestrian bridges. Therefore, in addition to the Rajendra Nagar station, which will be the junction station with the Indian Railways, the Nalanda Medical College station and Kumhrar station are planned, but unless crossing the Indian Railways is provided, access to the station from the surrounding areas will be divided by the Indian Railways and the station area will be limited to the southern half of the station. Passenger demand on this section is expected to be small, as the area between Gandhi Setu and Zero Mile Station is an area with a relatively low concentration of small factories along the road and a relatively low concentration of residential dwellings. There are also four affected historic buildings and sites on this section of the alternative (see 2.5.9). If Alternative 2 is adopted, archaeological verification would be required, making it difficult to realize the project as quickly as possible. Alternative 3 would run from Rajendra Nagar Station southwards on Malahi Pakri Rd, 90 Feet Rd via Malahi Pakri Station to Khemni Chak Station, which is the connecting station with Alternative 3 on Corridor 1. After Khemni Chak station, the route continues eastwards on Patna - Sitamarhi Rd with Bhootnath station on the way and rejoins the Alternative 2 route near Zero Mile station.

Reasons for selection of alternatives.

- Early commencement of the project, avoiding the archaeological inspection period due to the proximity of historic buildings.
- Advantages in terms of user growth due to the degree of concentration of housing along the line.

3) End of the Lines side section (Zero Mile – New ISBT)

Although both Alternatives 2 and 3 have the same route for the section from Zero Mile station to the terminus, the location of the rail depot near the New ISBT station at the end of the line is south-west of the New ISBT station in Alternative 2 and south-east of the New ISBT station in Alternative 3, with the rail depot located in a different position. After the Zero Mile station, the line travels south on Bodhgaya Rd to the New IBST station. While the area around this section is a suburb of Patna City with arable land and sparse housing, a bus terminal is located adjacent to the terminus New IBST station. Although the bus terminal is still partially under construction, it is very large and long-distance buses from all over the country arrive at and depart from this terminal and the surrounding roads are heavily congested with passengers and buses. Currently, the only access to the bus terminal is by road transport such as local buses or auto-rickshaws, therefore there is an urgent need to develop rail-based transport in the Patna area. In particular, bus users' accessibility to the Indian Railways station needs to be improved through the conversion from the road transportation as soon as possible in order to mitigate the congestion on the city roads compared with zero option (without project) due to the relocation of bus users from road transport into and out of the city.

Reasons for selection of alternatives,

- Reduction of road traffic into the city by improving transport connections between the bus terminal and the city.
- Improved convenience for bus terminal users by connecting them to the Indian Railways station.



Source: Detailed Project Report 2018, 2021, PMRCL, JST

Figure 14-15: Comparison of Corridor 2

(5) Conclusions from the comparison of alternatives

In the comparison between Alternatives 2 and Alternative 3, the only difference would be the intermediate section when focusing on Corridor 2. Either alternative can achieve the purpose of the project which is to construct the rail-based transport to reduce road traffic coming into the city by connecting suburban bus terminals and Indian Railways Line stations. However, when considering the linkage with Corridor 1, Alternative 3 allows for a junction station at Khemni Chak station and also it does not need the depot exclusively used for Corridor 1 since Corridor 2 depot can be shared. This would reduce the impact on the surrounding environment and lower the overall project cost.

In addition, Alternative 2 passes through a historical district in some sections for which requires a period of archaeological verification work. Therefore, it is presumed that the project cannot proceed as soon as possible though Corridor 2 should be constructed urgently, and Alternative 3 also can ensure the convenience for more citizens of Patna by avoiding competing sections with Indian Railways between Rajendra Nagar to Gulzarbagh. Given with the above information, Alternative 3 has to be selected even if the land acquisition area for Alternative 3 increases compared to Alternative 2. However, the number of cutting trees and affected structures is significantly lower than Alternative 2. Therefore, it is concluded that Alternative 3 has the high advantage in overall.

14.3.3 Depot

The table below shows the results of the comparison of the depot alternatives with the 5 ratings set from +2 to -2 including Zero. A comparative evaluation shall be adopted, and it assigns +1 or +2 to the more desirable one and -1 or -2 to the less desirable one after comparing the two alternatives. The item of Cost shall be evaluated with a double rate compared with the other items as same reason mentioned in the comparative study of Corridor 1 and 2. The total score was calculated for each alternative same as

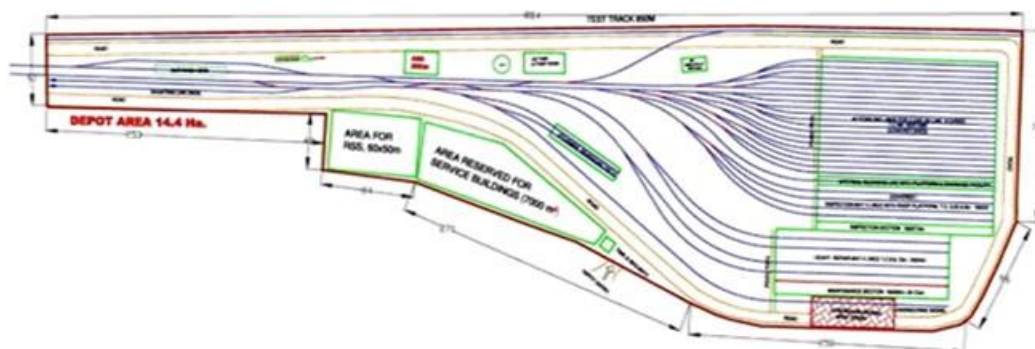
Corridor 1 and 2. As a result of the overall evaluation, Alternative 3 was assessed as the best option. Due to the selection of the Corridor 1 and Corridor 2 alternatives, Alternative 3 will be adopted for the depot, and the comparison of the depots in each alternative will be verified. As the environmental and social considerations in the depot comparison are included in the comparison for Corridors 1 and 2, this section also compares the size of the facilities and examines the possibility of locating the depot in other areas.

Table 14-10: Comparative study results of Depot alternatives

No.	Comparative study item	Alternative 2				Alternative 3. Total of Corridors 1 and 2 (Adoption proposal)			
		Corridor 1	Corridor 2	Total of Corridors 1 and 2					
1	Location	Terminus of Corridor 1 Mithapur station 3 km south point Aitwarpur	Terminus of Corridor 2 Southwest side of New ISBT station	-		Terminus of Corridor 2 Southwest side of New ISBT station			
2	Name of the depot	Aitwarpur Depot	New ISBT Depot	-		New ISBT Depot			
3	Area of depots	14.4ha	12.5ha	26.9ha		19.6ha			
4	Total length of tracks in depots	11.4km	9.1km	20.5km		9.0km			
5	Number of trains	41 trainsets (1 trainset / 3 cars)	26 trainsets (1 trainset / 3 cars)	67 trainsets (1 trainset / 3 cars)		64 trainsets (1trainset / 3 cars)			
6	Number of trains to be parked	40 trainsets Night parking at station: 1 trainset	24 trainsets Night parking at station: 1 trainset Night parking at inspection line: 1 trainset	64 trainsets Night parking at station: 2 trainsets Night parking at inspection line: 1 trainset		64 trainsets			
7	Number of stabling lines	20 lines 1 line / 2 trainsets	12lines 1 line / 2 trainsets	32 lines 1 line / 2 trainsets		16 lines 1 line / 4 trainsets			
8	Stabling line effective length	160m	160m	160m		331m			
9	Number of inspection lines	4 lines	4 lines	8 lines		4 lines			
10	Number of workshop lines	4 lines	4 lines	8 lines		4 lines			
11	Number of indoor-type car washing line	1 line	1 line	2 lines		1 line			
12	Number of wheel lathe line	1 line	1 line	2 lines		1 line			
13	Test track	850m 1 line	800m 1line	2 lines 1650m		739m 1 line			
14	Administration office	1 building	1 building	2 buildings		1 building			
15	Train operators booking office	1 building	1 building	2 buildings		1 building			
16	Capacity of power receiving facility	2500KVA	2500KVA	5000KVA		2500KVA			
Environmental and social considerations									
17	Land use status	Central Government Land	0	Central Governme nt Land	0	Central Governme nt Land	0		
		State Government Land	0	State Governme nt Land	0	State Governme nt Land	0		
		Private Land	14.4ha	Private Land	12.5ha	Private Land	26.9ha	Private Land	19.6ha
	Rating	-		-		-1			
18	Affected structures	14 structures		6 structures		20 structures		23 structures	
	Rating	-		-		-1		-1	
19	Earthquake/Flooding • Submergence	-		-		Although there is a risk of earthquake/flooding/		Although there is a risk of earthquake/flooding/	

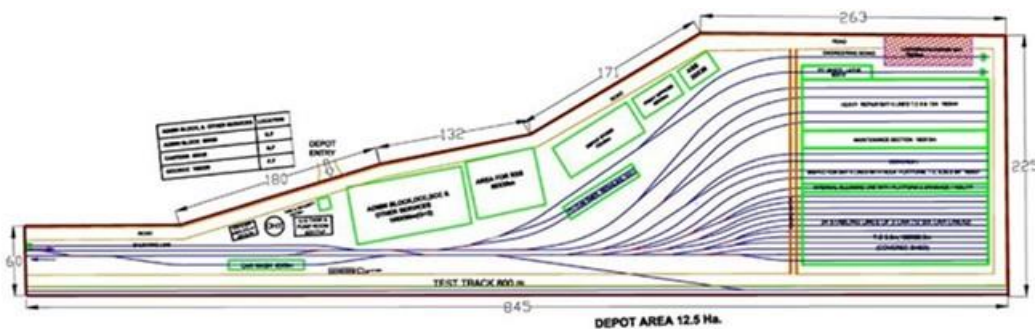
No.	Comparative study item	Alternative 2			Alternative 3. Total of Corridors 1 and 2 (Adoption proposal)
		Corridor 1	Corridor 2	Total of Corridors 1 and 2	
				submergence, the damage can be prevented by a countermeasures such as compaction on embankment and foundation.	submergence, the damage can be prevented by a countermeasures such as compaction on embankment and foundation.
	Rating	-	-	0	0
Project cost					
20	Project cost	-	-	The project cost is higher than Alternative 3 due to two depots needed.	The project cost is lower than Alternative 2 due to only one depot needed.
	Rating	-	-	-4	-2
Evaluation				-7	-4
				2nd	1st

Source : Detailed Project Report 2018, 2021, DMRC, JST



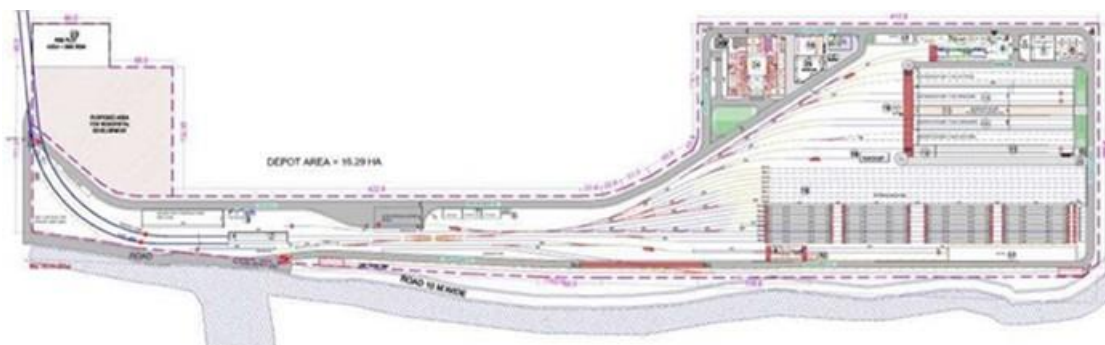
Source: Detailed Project Report 2018, PMRCL

Figure 14-16: Alternative 2 Aitwarpur Depot Plan



Source: Detailed Project Report 2018, PMRCL

Figure 14-17: Alternative 2 New ISBT Depot Plan



Source: Detailed Project Report 2021, PMRCL

Figure 14-18: Alternative 3 New ISBT Depot Plan

(1) Results of comparison of depot facility sizes

1) Depot layout policy

Given that Corridor 1 and Corridor 2 are separated in Alternative 2, the depot also needs to be separately located at Aitwarpur and New ISBT likewise. Except for the storage track which depends on the number of train set to be accommodated, both depots have the same facility since each depot has to independently handle the train parking and the maintenance work.

On the other hand, in case of Alternative 3, is the depot at New ISBT has to accommodate and carry out the maintenance for all trains of Corridor 1 and Corridor 2.

2) Number of Train-set

Under Alternative 2, 41 train-sets on Corridor 1 and 26 train-sets on Corridor 2 would be operated thus, a total of 67 train-sets would be operated. In contrast, Alternative 3 would operate 64 train-sets, which is three train-sets less than Alternative 2. The number of train-sets in operation would increase since the overall route length would be approximately 1 km longer on Corridor 1 under Alternative 3. However, the total number of train-sets including operational as well as non-operational would be less than Alternative 2 since the number of train-sets for backup could be reduced through the integration of depots.

3) Total track length in depot

In Alternative 2, the track length in depot is 20.5 km, whereas in Alternative 3 it is halved to 9.0 km. The main reasons for the halving are that the overall number of storage tracks has been reduced in Alternative 3 as four train-sets can park on one storage track. Moreover, the less number of storage tracks, results in a significant reduction in track length of the approach section from the turnout to the storage track. Although the number of turnouts is not mentioned, a reduction in the overall number of turnouts is achieved in Alternative 3 through the integration of depot.

4) Number of inspection lines and workshop lines in depot

The number of inspection lines and workshop lines is halved in Alternative 3 compared to Alternative 2. Although there is an increase in capacity under Alternative 3, the number of lines per depot does not increase from the number of lines per depot under Alternative 2 when the depots are merged because of the spare inspection capacity at each depot under Alternative 2.

5) Conclusions on the scale of facilities resulting from the integration of depots

Alternative 2 has depots for each Corridor 1 and Corridor 2, which meant that the necessary facilities have to be established at each of the two depots whereas the integration of depot proposed in Alternative 3 can centralize the depot facilities without increasing the size of the individual facilities. In conclusion, decentralizing the depot functions is to double the facilities, whereas it should be centralized into one

depot with an appropriate size as proposed in Alternative 3. Therefore, it is concluded that it is reasonable to choose the Alternative 3 that demonstrates economies of scale, such as reduction of land acquisition area and integration of duplicated facilities.

(2) Verification of the adequacy of the location of the depot

From the viewpoint of the train operation, it is preferable to locate the depot at the end of the line. It also another benefit for reducing operating costs since it can reduce the construction costs of the connecting line and reduce the power costs associated with the spur line from/to the depot.

Three locations were proposed in the study of alternatives, namely the Aitwarpur depot on Corridor 1 in Alternative 2, the New ISBT depot on Corridor 2 (south-west of the New ISBT station) and the New ISBT depot on Corridor 2 (south-east of the New ISBT station) in Alternative 3. Finally, the New ISBT depot (south-east of New ISBT station) was selected.

1) Aitwarpur depot

The Aitwarpur depot is proposed for a case that Mithapur station is planned as the terminus. This location is not recommended since the distance from the terminus station to the depot is long. In addition, the terminus has been changed from Mithapur Station to Khemni Chak Station as Alternative 3 for Corridor 1 is selected as the optimal plan. Therefore, this location is no longer connected to the terminus. Considering the complicated operation for Corridor 2 train entering to/departing from the depot, there is no positive reason to recommend the Aitwarpur depot.

2) New ISBT depot (New ISBT St. south-west)

It is located south-west of the New ISBT station but is slightly further away from the station than New ISBT station south-east which is described below. There are no technical problems with the adoption of this proposal, but it is slightly less favorable due to the longer spur line from the depot to the main line compared to New ISBT station south-east.

3) New ISBT depot (New ISBT St. south-east)

Located on the southeast side of the New ISBT station, it is close to and almost adjacent to the station, and the extension of the connecting line will be minimal.

The depot and the bus terminal on the opposite side of the station are planned to be integrated into a single commercial facility, which will be advantageous from the standpoint of increasing the number of rail and bus users.

4) Possibility of installing depots at other locations

The most desirable location for a rail depot would be near the end of the line. The following three stations are possible locations for the depot other than three aforementioned locations.

- Near Danapur station
- Near Patna station
- Near Khemni Chak station

To locate a depot near Danapur station seems not realistic since it forces a train by out-of-service for long distance. The location near Patna station is also difficult since it requires the large scale structure for the spur line due to the underground main line. It also has the difficulty in the land acquisition.

Khemni Chak Station, where Corridor 1 and Corridor 2 are connected, has a cultivated area at the southeast of the station. Whereas it is far from the station, there would be relatively few problems with land acquisition and train operations. However, there is the advantages that the connecting line would be longer. Figure 4.3.4 Schematic diagram of the location of the Khemni Chak station connecting depot shows the location of the relevant sections.

As a depot other than proposed in the alternative plan, a case of locating it on the south-east side of Khemni Chak station is envisaged. However it is difficult to change the New ISBT depot (south-east of New ISBT station) where the residents' explanation of land acquisition and construction preparations are in progress.



Source : JST based on Google earth

Figure 14-19: Schematic Diagram of the Location of the Khemni Chak Station Connecting Depot

14.3.4 Issues from a train operation perspective

Based on the results of the comparison of Alternative 2 and Alternative 3, the latter was selected for both Corridor 1 and Corridor 2. From the viewpoint of the train operation, the issue of Alternative 3 is the alignment in the premise of Khemni Chak station. The current alignment at Khemni Chak station is arranged with Corridor 1 to the north and Corridor 2 to the south. Corridor 1 operation basically terminates at Khemni Chak station and it has no revenue service to New IBST station on Corridor 2. Whereas Corridor 1 and Corridor 2 are connected at the east of Khemni Chak station, this level crossing is over the main line and only trains travelling to and from the depot are allowed to proceed from Corridor 2 to Corridor 1 through this level crossing. Therefore, it is not recommended that trains from New IBST station enter to Corridor 1 through Corridor 2 in the operation hours due to the high risk of train delays caused. This advantage will be an issue how to respond to future changes in passenger demand. In addition, although passengers travelling from New IBST to Patna Station can eventually reach the destination without the transfer, it would be much faster if they transfer to Corridor 1 at Khemni Chak Station with considering the short distance to Patna Station. However, the current alignment forces the passenger to go up and down to transfer since the platform of Corridor 1 and Corridor 2 are arranged at different level, which may let the passengers to reluctant to transfer. Although it is recommended to change the alignment to arrange both platforms at the same level for more convenient transfer, Khemni Chak station has been in progress and some piers have already been built as of June 2022. Given such a situation, it is not realistic to change the alignment with structural changes at this stage. Therefore, the issue raised in this section is described to improve the future extension plans.

14.4 Screening and Draft Scoping pertaining to Environmental and Social Considerations

This section summarizes the screening and draft scoping for the prioritized alternative concluded in the preceding section, assuming positive and negative environmental and social impacts based on the

information obtained from site reconnaissance and existing literature

14.4.1 Screening

EC is not required because all railway projects in India are exempt from EC procedures. However, the project is classified as “Category A” in the JICA guidelines published in April 2010 because it corresponds with the railway sector which has a characteristic of large-scale involuntary resettlement.

14.4.2 Scoping

The scopes of Environmental and Social considerations are the construction of the main structure including viaducts, railway tracks, elevated and underground stations, a depot, and a receiving substation. The table below shows the affected environmental and social items, the so-called scoping results. The other table also shows the scoping result for the related facilities such as borrow-pit, quarry and construction yard. However, the scoping result at the operation stage for the related facilities should be omitted because they are for use only during the construction, and the responsibility for preparing EMP and EMoP of the facilities belongs to PMRCL as the project proponent and their construction contractor. Based on the detailed design prepared by PMRCL, the contractor will formulate a construction plan including the details of the related facilities at the construction stage, and will commence using the facilities after approval by the Government of India.

Table 14-11 Scoping for the Project Facilities with Reasons Evaluated

No	Impact item	Evaluation		Reason for evaluation
		Pre-CS CS	OS	
Pollution				
1	Air pollution	✓		CS: Emission gas (NO _x , SO _x) and dust (SPM) are caused temporarily by some heavy machines and dump trucks. OS: Positive impact will be offered by the decrease of traffic along the Corridors.
2	Water pollution	✓	✓	CS: - Turbid water will be generated in surface water and ground water along the Corridors due to civil and excavation works. - Turbid water will be generated at a proposed site for depot due to soil filling works. - There is a possibility of being discharged with organic wastewater at an installed base campsite. OS: There is a possibility of discharged organic wastewater from the toilet installed at every station and the depot.
3	Waste	✓	✓	CS: - It is predicted that construction waste such as soil and felled trees is generated. - General waste and excreta will be generated from the base campsite. OS: General waste and excreta will be generated from every station and a depot, etc.
4	Soil contamination	✓	✓	CS: Excavated soil at the construction site may be contaminated. OS: Soil contamination may be generated at the proposed depot due to oil leaks of heavy machine and dump track and rolling stock coating.
5	Noise and vibration	✓	✓	CS: Noise and vibration will be generated by construction heavy machines, dump trucks, concrete placing work, and traffic congestion due to traffic control. OS: Patna Metro can contribute to reducing traffic noise and vibration through traffic volume reduction, but Patna Metro may emit additional noise and vibration from its operation.
6	Ground subsidence	✓	✓	CS/OS: Construction activities that have a negative impact on underground water such as large-scale digging and water pumping are not scheduled in this project. But there is still a possibility of ground subsidence in case the foundation under the elevated section is soft.
7	Offensive odor	✓	✓	CS: Offensive odor may be emitted depending on the volume of general waste from basecamp sites.

No	Impact item	Evaluation		Reason for evaluation
		Pre-CS CS	OS	
				OS: Offensive odor may be emitted depending on the volume of general waste from every station and depot.
8	Bottom Sediment			CS/OS: No impact on Bottom Sediment is expected because all crossing river sections are underground.
Natural Environment				
9	Protected area	✓	✓	CS/OS: Although SGB Park is designated as a protected area, it is managed by the Government of Bihar as Park-cum-Zoo, whose management type is different from that of other natural protected areas which risks disorderly destruction. However, there may be indirect impacts on fauna and flora at the construction stage and operation stage.
10	Ecosystem	✓	✓	CS: - There is a negative impact on the ecosystem through deforestation of trees due to the construction of viaducts, underground stations and a depot. - Since a partial section pass through Danapur Cantonment KBA, the impact on ecosystem is expected. - A negative impact on the ecosystem may occur due to the construction of a depot. OS: Since a partial section pass through Danapur Cantonment KBA, the impact on ecosystem is expected.
11	Hydrology	✓		CS: - Construction activities that have a negative impact on underground water such as large-scale digging and water pumping are not scheduled in this project. However, some impact on hydrology around the project site will occur in case of high groundwater level. - Since a river flows along the south of the depot candidate site, the depot construction may affect the surrounding hydrology. OS: Construction activities which have negative impact to underground water, such as large-scale digging and water pumping, are not scheduled.
12	Geology and Topography	✓	✓	CS/OS: There is no specified and valuable geology and topography in and around the alignment. However, there is a possibility of soil erosion and slope collapse due to filling soil for the Depot construction.
Social Environment				
13	Land acquisition/ Resettlement	✓	✓	Pre-CS: It is predicted that there are land acquisition and resettlement along the Corridors and in Depot area. OS: Economic displacement may be occurred due to the Metro operation.
14	Poverty	✓		Pre-CS: The impact on poverty is evaluated based on characteristics of local society around the Corridors. OS: Since land acquisition and resettlement will be completed before construction, operation activities that have a negative impact on people with poor class are not expected.
15	Indigenous and ethnic people	✓		Pre-CS: The impact on indigenous and ethnic people is evaluated based on characteristics of local society around the Corridors. OS: Since land acquisition and resettlement will be completed before construction, operation activities that have a negative impact on indigenous and ethnic people are not expected.
16	Local economy such as employment and livelihood, etc.	✓		Pre-CS/CS: - A negative impact on the livelihood of PAPs may be generated depending on land acquisition and resettlement. - With opening of Patna Metro, drivers of route buses and three wheelers, which are overlapping their operation area of transportation, may suffer negative impacts on their livelihoods. OS: - New employment may be created with opening of Patna Metro. - A positive impact for the local economy will be generated such as timesaving for traveling within Patna city and alleviation of traffic congestion.
17	Land use and utilization of local resources	✓	✓	CS: There may be a negative impact on land acquisition for agricultural land in the proposed depot area. OS: There is no land acquisition and resettlement in the operation phase. However, negative impact may be generated if disordered development and

No	Impact item	Evaluation		Reason for evaluation
		Pre-CS CS	OS	
				rough-and-tumbled utilization of local resources occur around the Corridors and stations.
18	Water use and its rights	✓		<p>CS: Land acquisition and construction work may affect drinking water sources such as wells.</p> <p>OS: There is no impact on water use because of no land acquisition, and there is no additional impact on water use and its rights because irrigation facilities and drinking water facilities such as waterworks and wells located in the project area including viaduct, station building, and the depot can be transferred as necessary.</p>
19	Existing social infrastructure and services	✓		<p>CS: - A negative impact on sensitive facilities such as schools, hospitals, and community centers may occur depending on land acquisition and traffic issues such as congestion and accidents.</p> <p>- The impact of the relocation of underground facilities is expected due to the construction work.</p> <p>- There may be a possibility of electrical power cut temporarily around the alignment when relocation and under installation of high –voltage line is conducted.</p> <p>OS: Improvement of accessibility by installing Patna Metro stations is expected, by which there is a possibility of a positive impact on the use of social infrastructure such as school, hospital, etc.</p>
20	Social institutions such as social infrastructure and local decision - making institutions			<p>CS: Since the construction is mainly conducted in the central part of the existing road and underground, there is no possibility of local community severance.</p> <p>OS: There is no community severance because Patna metro will be constructed by elevated and underground structures for all sections.</p>
21	Maldistribution of benefit and damage	✓	✓	<p>CS: Depending on the construction area, there may be a maldistribution of benefit and damage such as the prohibition of road crossing and setting of the detour route.</p> <p>OS: With opening of Patna Metro, companies of route buses and union of three wheelers, which are overlapping their operation area of transportation, may reduce their operating profit.</p>
22	Local conflict of interest	✓		<p>CS: Residents and municipalities may demand that construction contractor should supply employment opportunities equally as construction workers.</p> <p>OS: It is predicted that there is no local conflict of interest because Patna Metro services are evenly accessible for local communities.</p>
23	Cultural Heritage	✓	✓	<p>Pre-CS/CS: It is predicted that there is low possibility of impact on religious and historical buildings such as temple under the current proposed alignment. However, impacts should be carefully reviewed.</p> <p>OS: There is no impact on religious and historical buildings because of no-additional land acquisition at the operation stage. However, the impact of vibration from Patna Metro operation should be reviewed.</p>
24	Landscape		✓	<p>CS: - There is no landscape conservation area designated by law and regulation in the vicinity of the elevated section.</p> <p>- Since the construction is mainly conducted in the central part of the existing road and underground, there is no impact on landscape.</p> <p>OS: - The everyday landscape in the vicinity of the Corridors will change due to elevated structure, station buildings.</p>
25	Gender	✓	✓	<p>CS: There may be a gender gap regarding wage, salary, and treatment as construction workers.</p> <p>OS: Employment opportunities for women may be limited concerning Patna Metro operation because the opportunities may not be the same for females despite having the same qualifications and abilities as males. Additionally, female passengers may give up getting on trains for fear of congestion on the train during commuting time.</p>
26	Children's right	✓		<p>CS: Negative impact on children's rights is not estimated by the project, but the impact possibility should be evaluated based on the information collected by the field survey.</p> <p>OS: There is no impact on children's rights by Patna Metro operation.</p>

No	Impact item	Evaluation		Reason for evaluation
		Pre-CS CS	OS	
27	Health (Infectious diseases such as HIV/AIDS, etc.)	✓	✓	<p>CS: Infectious diseases such as STD, COVID-19, etc. may be spread by the inflow of construction workers. Additionally, Land use changes by soil cutting and soil filling may create new habitats for mosquitoes that can mediate dengue fever.</p> <p>OS: There is a possibility that STD and other infectious diseases spread by increasing the number of settlers and travellers after Patna Metro operation.</p>
28	Labor environment including labor safety	✓	✓	<p>CS: It is necessary to improve the labor environment for construction workers following related laws and regulations.</p> <p>OS: - There is no big change in the labor environment for residents by Patna Metro operation. - The appropriate labor environment for working staff needs to be secured following related laws and regulations.</p>
Others				
29	Accidents	✓	✓	<p>CS: Since construction-related vehicles use arterial roads on the Corridors, there is a possibility of increasing traffic accidents.</p> <p>OS: It is estimated that the risk of traffic accidents will maintain due to increased vehicle velocity by reducing traffic volume.</p>
30	Cross-border impact and climate change	✓	✓	<p>CS: Greenhouse gas emissions will increase slightly by cutting street trees along the Corridors, operation of construction heavy machinery, and construction of structures.</p> <p>OS: Since the traffic volume along the Corridors will reduce due to Patna Metro operation, the reduction of greenhouse gases can be expected. On the other hand, it is also conceivable that greenhouse gases will be generated due to the electric consumption by Patna Metro operation.</p>

Note: ✓: Items to be assessed, Pre-CS: Pre-Construction Stage, CS: Construction Stage, OS: Operation Stage
Source: JST

Table 14-12 Scoping for the Related Facilities (Quarry, Borrow-Pit, and Construction Yard) with reasons for Evaluation

No.	Impact item	Evaluation		Reason for evaluation
		Pre-CS CS	OS	
Pollution				
1	Air pollution	✓		Emission gas (NO _x , SO _x) and dust (SPM) are caused by some machines and dump trucks temporarily.
2	Water Pollution	✓		If the drainage is undeveloped, it may affect the surrounding water sources during rainfall.
3	Waste	✓		Surplus materials will be generated.
4	Soil contamination	✓		Temporary soil contamination due to oil leakage that may be caused by using fuel for heavy machines and vehicles.
5	Noise and vibration	✓		Noise and vibration are caused by construction heavy machinery and dump trucks.
6	Ground subsidence			No activity that will cause land subsidence is expected.
7	Offensive odor			No activity that will cause offensive odor is expected.
8	Bottom Sediment			No activity that will deteriorate bottom sediment is expected.
Natural Environment				
9	Protected area	✓		If there are protected areas in the vicinity of the related facilities, it may affect the conservation area.
10	Ecosystem	✓		If the need for soil and crushed stones exceeds the expectations, the excavation range may be expanded and the ecosystem may be affected. There is also a possibility of logging trees.
11	Hydrology			No activity that will cause changes to hydrology is expected.
12	Geography and topography	✓		If the valuable geography and topography exist in the vicinity of the related facilities, it may affect geography and topography.
Social Environment				
13	Land acquisition/ Resettlement			As a basic policy, the registered site by the local government should be utilized, so there will be no land acquisition, resettlement or economic displacement.

No.	Impact item	Evaluation	Reason for evaluation
		CS	
14	Poverty		Because of no land acquisition and resettlement, activities that have a negative impact on people with poor class are not expected.
15	Indigenous and ethnic people		Because of no land acquisition and resettlement, activities that have a negative impact on indigenous and ethnic people are not expected.
16	Local economy such as employment and livelihood, etc.		No activity that will impact on local economy and livelihood is expected.
17	Land use and utilization of local resources	✓	If the need for soil and crushed stones exceeds the expectations, the excavation range may be expanded and Land use and utilization of local resources may be affected.
18	Water use and its rights	✓	If the need for soil and crushed stones exceeds the expectations, the excavation range may be expanded and water use and its rights may be affected.
19	Existing social infrastructure and services	✓	Existing roads, schools, hospitals, and community centers may be temporarily affected due to frequent dump truck traffic.
20	Social institutions such as social infrastructure and local decision - making institutions		No activity that will impact social institutions is expected.
21	Maldistribution of benefit and damage		No activity that will impact distribution of benefit and damage is expected.
22	Local conflict of interest	✓	If the need for soil and crushed stones exceeds the expectations, the excavation range may be expanded and local conflict may occur between the owner and residents.
23	Cultural Heritage	✓	Some negative impacts may occur if there is a cultural heritage near the project area.
24	Landscape	✓	If the need for soil and crushed stones exceeds the expectations, the excavation range may be expanded and the landscape may be affected.
25	Gender		No activity that will impact on gender is expected.
26	Children's right		No activity that will impact on children's rights is expected.
27	Health (Infectious diseases such as HIV/AIDS, etc.)		No activity that will impact on health is expected.
28	Labor environment including labor safety	✓	It is necessary to secure an appropriate working environment following relevant laws.
Others			
29	Accidents	✓	Traffic accidents may increase because of construction vehicles.
30	Cross border impact and climate change		Cross-border impacts and impact on climate change is not expected.

Note: ✓: Items to be assessed, CS: Construction Stage

Source: JST

14.4.3 Method of Environmental baseline Survey and Analysis

The TOR of the Environmental and Social Consideration Survey (EIA survey) and the survey points and area are shown below. Since the construction of the project has already been started on the partial section, the status of land acquisition, EMP, EMoP, and project implementation shall be confirmed by checking the monthly report of the section as retroactive confirmation items.

Since a survey in the dry season by PMRC has already been conducted in 2020, an additional survey for each assessment item will be conducted in the rainy season. Additionally, an interview survey for local people was conducted to understand their socio-economic status that were not included in the same types of survey conducted in 2020 such as Child labor, Gender Equity, Ecosystem services etc. along the Corridors. The target will be 10 people per station, 240 people in total.

Table 14-13 Content and analysis method of baseline survey

No	Impacted Item	Sampling/Site Measurement Survey	Analysis and Method
Pollution			
1	Air pollution	<p><u>I. Field survey</u> (1) 8 points in total for all alignment of Corridor 1 and 2 (2) Air (prevention and control of pollution) Act, 1981 (3) Item: SO₂, CO, NO₂, O₃, PM₁₀, PM_{2.5}, 24hrs (4) Frequency: Once Note) Since the survey in dry season has already been conducted, a survey in rainy season will be conducted.</p> <p><u>II. Impact during construction</u></p>	<p>I. Comparison of survey results with existing survey results and standard values. II. Confirm the contents of construction, method, period, area, type of construction machine, its operating position and period, number of construction vehicles, its period, and running route.</p>
2	Water pollution	<p><u>I. Field survey</u> <u>Surface Water</u> (1) 6 points at canals, ponds, rivers along the alignment of Corridor 1 and 2 (2) IS 10500 : 2012, DRINKING WATER — SPECIFICATION (3) Item: Colour, Odor, Turbidity, pH at 25°C, Electrical Conductivity, Total Hardness as CaCO₃, Chloride as Cl, Total Iron as Fe, Total Dissolved Solids, Sulphates as SO₄, Nitrates as NO₃, Lead as Pb, Copper as Cu, Manganese as Mn, Mercury as Hg, Cadmium as Cd, Zinc as Zn, Chromium as Cr⁺⁶, Total Alkalinity as CaCO₃, Calcium as Ca, Magnesium as Mg, Sodium, Potassium, Dissolve Oxygen, BOD, COD (4) Frequency: Once Note) Secondary data collection, if any</p> <p><u>Ground Water</u> (1) 8 points in total for all alignment of Corridor 1 and 2 (2) IS 10500 : 2012, DRINKING WATER — SPECIFICATION (3) Item: Colour, Odor, Taste, Turbidity, pH at 25°C, Total Hardness as CaCO₃, Chloride as Cl, Total Iron as Fe, Total Dissolved Solids, Sulphates as SO₄, Nitrates as NO₃, Fluorides as F, Lead as Pb, Copper as Cu, Manganese as Mn, Phenolic Compound as C₆H₅OH, Mercury as Hg, Cadmium as Cd, Arsenic as, Cyanide as Cn, Zinc as Zn, Detergent as MBAS, Chromium as Cr⁺⁶, Total Alkalinity as CaCO₃, Aluminum as Al, Boron as B, Coliform, E-Coli (4) Frequency: Once Note) Since the survey in dry season has already been conducted, a survey in rainy season will be conducted.</p> <p><u>II. Impact during construction</u></p>	<p>I. Comparison of survey results with existing survey results and standard values. II. Confirm the contents of construction, method, period, area, type of construction machine, its operating position and period, number of construction vehicles, its period, and running route.</p>
3	Waste	<p>Construction waste disposal method Note) A construction waste disposal site currently in use has been identified.</p>	<p>- Information collection on registered construction waste disposal sites along Corridor 1 and 2 or conducted field surveys in some cases. - Quantitative prediction</p>
4	Soil contamination	<p><u>I. Field survey</u> (1) 8 points in total for all alignment of Corridor 1 and 2 (2) Item: pH, Electrical Conductivity, Cadmium as Cd, Lead as Pb, Mercury as Hg, Cyanide as Cn, Chromium as Cr⁶⁺, Arsenic as (3) Frequency: Once Note) Since the survey in dry season has already been conducted, a survey in rainy season will be conducted.</p> <p><u>II. Impact during Patna Metro operation</u></p>	<p>I. Comparison of survey results with existing survey results and standard values. II. Hearing with PMRCL</p>
5	Noise and Vibration	<p><u>I. Field survey</u> <u>1. Noise</u> (1) 8 points in total for all alignment of Corridor 1 and 2 (2) Noise pollution (regulation and control) rules, 2000 (3) Item: L_{Amax}, L_{Amin}, L_{Aeq}, 24hrs (4) Frequency: Once</p> <p><u>2. Vibration</u> (1) 8 points in total for all alignment of Corridor 1 and 2 (2) Item: Lv: Vibration as velocity (3) Frequency: Once</p>	<p>I. Comparison of survey results with existing survey results and standard values. II. Noise: Quantitative prediction (Traffic noise at the road boundaries of typical elevated sections and at sensitive points/ L_{Aeq} dB(A)) Vibration: Quantitative prediction (Traffic vibration at the road boundaries of typical</p>

No	Impacted Item	Sampling/Site Measurement Survey	Analysis and Method
		Note) Add the sampling points adjacent to the sensitive buildings such as school, hospital and heritage, if existed in and around the project site. Since the survey in dry season has already been conducted, a survey in rainy season will be conducted. <u>II. Noise/vibration level during construction and operation at the representative section</u> <u>III. Impact during construction</u>	underground sections and at sensitive points/ Lv dB) III. Confirm the contents of construction, method, period, area, type of construction machine, its operating position and period, number of construction vehicles, its period, and running route.
6	Ground subsidence	Impact during construction	Utilization of existing topographic survey results and underground survey results, and hearings with PMRCL (including construction details of the depot and countermeasures against the impact on a surrounding river)
7	Offensive odor	Impact during construction and during Patna Metro operation	Information collection of odor that are expected to generate from base camps, stations and a depot
Natural environment			
8	Protected Area	Impact during construction and during Patna Metro operation	Collecting information (including bird list, if possible) on the protected area and confirming the content of discussions with PMRCL and park authority
9	Ecosystem	<u>I. Field survey</u> (1) Site measurement: 8 points in total along Corridor 1 and 2 including Danapur Cantonment Key Biodiversity Area (KBA), and Sanjay Gandhi Biological Park (2) Target: Affected flora and fauna by the construction (3) Item <u>Terrestrial flora and fauna</u> : Species name, Scientific name and Distribution including categorization of IUCN Red list and their photos for identification. Especially for current condition of breeding, nesting of below species. Asian Openbill (<i>Anastomus oscitans</i>), Painted Stork (<i>Mycteria leucocephala</i>) (4) Frequency: One time Note) Interview for Expert, Professor, if any judging whether it is a “critical habitat” in the JICA guidelines depending on the habitat status of the species. <u>II. Confirmation of land use, Ecosystem distribution and Ecosystem services</u>	I. Information collection through existing literature survey and field survey II. Information collection through existing literature and interviews with experts, etc. as necessary
10	Hydrology	<u>I. Past flood history survey</u> <u>II. Impact during construction</u>	I. Information collation II. Utilization of existing topographic survey results and underground survey results, and hearings with PMRCL
11	Topography and geology	Impact during construction	Utilization of existing topographic survey results and underground survey results, and hearings with PMRCL
Social environment			
12	Land acquisition / resettlement	Refer to Social Impact assessment (SIA) survey (Chapter 15)	
13	Poverty		
14	Indigenous and ethnic people		
15	Local economy such as employment and livelihood, etc.		
16	Land use and utilization of local resources	Confirmation of land use and utilization of local resources	Utilization of existing data, and Interview survey results
17	Water use and its rights	Confirmation of water usage situation of local people	Utilization of existing data, and Interview survey results

No	Impacted Item	Sampling/Site Measurement Survey	Analysis and Method
18	Existing social infrastructures and services	I. <u>Field survey</u> (1) Site measurement: A range of 100 m width along the Corridors (2) Item: Distribution of hospital, school, religious place, community center, etc. (3) Frequency: One time II. <u>Distribution of underground facility</u>	I. Utilization of existing data, site inspection and interview survey results II. Existing CAD data
19	Maldistribution of benefit and damage	I. <u>Confirmation of prohibition of road crossing and setting of the detour route.</u> II. <u>Opinion collection from companies of route buses and union of three wheelers</u>	Utilization of existing data, SIA survey results and Interview survey results
20	Local conflict of interest	Impact on local conflict of interest	Utilization of existing data, and Interview survey results
21	Cultural heritage	Cultural and historical heritage in the vicinity of the Corridors	Utilization of existing data, and Interview survey results
22	Landscape	I. Site measurement: Survey of main view spot (commanding Viaduct, Railway track, Station buildings) II. Collection of similar cases	I. Photo shoot II. Utilization of existing data
23	Gender	Refer to Social Impact assessment (SIA) survey	
24	Children’s rights	Impact on children’s rights	- Confirmation of domestic related laws - Whether there is any child labor around the project site
25	Health (Infectious diseases such as HIV/AIDS, etc.)	I. Infectious disease rate in the vicinity of the Corridors II. Implementing agency of related activity	Utilization of existing data, and Interview survey results
26	Labor environment including labor safety	I. Confirmation of related domestic laws and international standards II. Confirmation of work safety measures at the construction site	I. Information collection II. Site inspection and hearing
Others			
27	Accidents	Number of traffic accidents along the Corridors and reasons for the accidents	- Utilization of existing data , and site inspection - Collection of traffic accident data from police station, if any
28	Cross border impact and climate change	I. Calculation of the amount of CO ₂ - During operation - Reduction amount from road traffic compared to when the project was not implemented II. Interview survey with Attachment 1, Secondary data collection	I. Estimation result of future traffic volume, JICA Climate FIT II. Data collection, and hearing with PMRCL

Source: JST



Source: JST based on Google Earth

Figure 14-20 EIA Survey points and Areas in rainy season

14.5 The result of the EIA survey

PMRCL has already conducted a survey on various impact items for environmental and social considerations, and summarized the survey results in the Environmental Impact Assessment (hereinafter referred to as "EIA") Report and Social Impact Assessment (hereinafter referred to as "SIA") Report in July 2020. Therefore, the results excerpts from those reports are mentioned as the survey result in dry season. The survey points for each impact item are as follows, and the results are shown in the below chapter alongside the results conducted in rainy season, that is July, 2022.



Source: JST based on Google Earth and Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC

Figure 14-21 Survey Points conducted in dry season

14.5.1 Air Pollution

(1) Survey

The air quality surveys were conducted by WHO in 2016 and 2018 in Patna, and especially the value of PM_{2.5} was ranked third (149 mg/m³) and fifth (144 mg/m³) respectively from the bottom among 3,000 cities in the world. Therefore, it can be said that the air quality in Patna has extremely poor condition⁴. The air quality survey for the project was conducted in January 2020 during the dry season, and in July 2022 during the rainy season, and the results are as follows. The values of PM₁₀ and PM_{2.5} exceeded the environmental standard of India at all points in both seasons, and some of the PM_{2.5} values are more than the WHO's values in dry season. In addition, since the value of SO_x also exceeded the standard at 5 points in dry season, an urgent countermeasure shall be needed to improve the air quality environment. Main factors of air pollution include rapid population growth in India, traditional cooking styles, thermal power plant operations, and soot/smoke due to brick production. A power plant is located on the southern area of Patna Junction, but it was closed in 1984, and there could be no large-scale pollution source facility along the Corridors. Standard values for general air quality in India are stipulated in Central Pollution Control Board (CPCB) Notification dated 18th Nov. 2009.

Table 14-14 Survey Result in dry season

Location	PM ₁₀	PM _{2.5}	CO	NO ₂	SO ₂	O ₃
1. Danapur	124	96	0.77	11.3	73.2	-
2. Raja Bazar	137	101	0.83	11.9	79.8	-
3. Patna Zoo	146	113	1.23	13.8	87.4	-
4. Patna Junction	259	156	1.39	17.2	119.3	-
5. Mithapur	217	143	1.27	15.4	105.3	-
6. PMCH	216	137	1.19	9.7	57.1	-
7. University	253	171	1.14	10.4	64.5	-

⁴ Air quality database 2016 and 2018, WHO

Location	PM ₁₀	PM _{2.5}	CO	NO ₂	SO ₂	O ₃
8. Khemni Chak	312	168	1.41	15.6	94.1	-
9. New ISBT	281	141	1.37	14.2	88.2	-
CPCB 2009	100 (24 hrs)	60 (24 hrs)	4.0 (1 hr)	80 (24 hrs)	80 (24 hrs)	180 (24 hrs)
IFC	150 (24 hrs)	75 (24 hrs)	-	200 (1 hr)	125 (24 hrs)	160 (8 hrs)

Source: Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC, Central Pollution Control Board Notification dated 18th Nov. 2009/ Environmental, Health, and Safety Guidelines, IFC

Table 14-15 Survey Result in rainy season

Location	PM ₁₀	PM _{2.5}	CO	NO ₂	SO ₂	O ₃
1. R.P.S More	169.84	81.79	0.57	16.24	6.84	23.54
2. Raja Bazar	178.23	89.23	0.63	19.52	9.87	17.69
3. Patna Zoo	157.49	96.21	0.68	17.36	6.54	22.08
4. Patna Junction	186.47	79.36	0.71	16.53	7.36	18.69
5. Gandhi Maidan	129.54	76.52	0.69	13.57	5.69	19.84
6. Rajendra Nagar	201.48	71.25	0.70	15.47	8.42	18.66
7. Khemni Chak	196.32	91.47	0.73	20.13	7.32	21.38
8. New ISBT	195.24	84.78	0.86	18.74	9.51	19.74
CPCB 2009	100 (24 hrs)	60 (24 hrs)	4.0 (1 hr)	80 (24 hrs)	80 (24 hrs)	180 (24 hrs)
IFC	150 (24 hrs)	75 (24 hrs)	-	200 (1 hr)	125 (24 hrs)	160 (8 hrs)

Source: JST, Central Pollution Control Board Notification dated 18th Nov. 2009/ Environmental, Health, and Safety Guidelines, IFC

1) Particulate Matters (PM₁₀ and PM_{2.5})

PM₁₀ and PM_{2.5} refer to particulate matter 10 micrometers or less in diameter and particulate matter 2.5 micrometers or less in diameter, respectively. PM_{2.5} is generally described as fine particles. The major components of PMs are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust, and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. Dust emission level was checked by measuring the concentration level of PM₁₀ and PM_{2.5} for 24 hours. Values of PM₁₀ at all points are found that exceeded the Standard of India of 100 µg/m³. During the dry season, many points exceeded twice the standard value, especially at Khemni Chak, where they were more than three times the standard value. Even during the rainy season, the values at Rajendra Nagar, Khemni Chak and New ISBT were particularly high, and were more than double the standard value or close to it. Also, all values of PM_{2.5} exceeded the standard values. During the dry season, many points exceeded twice the standard value.

2) Carbon Monoxide (CO)

Carbon monoxide is a poisonous gas that has no taste or smell. It is mainly generated from incomplete combustion of carbon, i.e., when there is not enough supply of oxygen to produce carbon dioxide (CO₂), only half of the oxygen is combined with carbon, and carbon monoxide is formed. It is also formed from the combustion of fossil fuels, motor vehicle exhausts, and industrial fumes. When carbon monoxide is inhaled, it enters the bloodstream of the body and inhibits the carriage of oxygen and the lack of oxygen causes the function of body cells and tissues to fail. Excess inhalation of carbon monoxide can even lead to death. In 1 hour measured values of CO level concentration, all concentrations were within the standard of India of 4.0 mg/m³.

3) Nitrogen Dioxide (NO₂)

Nitric oxide (NO) and nitrogen dioxide (NO₂) are the two principal nitrogen oxides. It can be generated from the operation and maintenance of vehicles and on-site power generation facilities. The quantity of nitrogen oxides depends on the available nitrogen and oxygen concentration, reaction time, and

temperature. It can cause bronchitis and edema in the lungs.

The concentration of ambient NO₂ levels was measured for 24 hours in the survey. The 24 hours concentration at Patna Junction where is the highest point during the dry season was 17.2 μg/m³, and it at Khemni Chak where is the highest point during the rainy season was 20.13 μg/m³. All measurements were found to be lower than 80 μg/m³, the standard value of India.

4) Sulfur Dioxide (SO₂)

Sulfur dioxide is generated from the combustion of fuel such as oil, and as a by-product of some chemical products. On-road and off-road vehicles can also be emission sources of SO₂ which may cause respiratory diseases and irritation of the throat and eyes. During the dry season, five of the nine sites exceeded the standard, and values were generally high. On the other hand, during the rainy season, the values were not only below the Indian standard of 80 μg/m³ at all points, but were also very low compared to values during the dry season.

5) Ozone (O₃)

Ground-level ozone is not emitted directly into the air. It is created from chemical reactions between oxides of nitrogen and volatile organic compounds in the presence of sunlight. Gas exhausted from industrial facilities, motor vehicles, internal combustion engines, especially automobiles, and coal fire power plants is the main sources of nitrogen oxides and VOCs. Besides, to damage vegetation and ecosystem, ground-level ozone may cause a variety of health issues such as lung damage and irritation along the respiratory tract when inhaled. The concentration of ozone was recorded for 1 hour at each point. In comparing the resultant average concentrations with the standard of India, it can be seen that all the values are under the standard value 180 μg/m³.

(2) Prediction

A quantitative prediction was expected, but a confident evaluation of the prediction result could not be made due to underdevelopment of general environmental data in India, including wind direction and speed, a flux of insolation, atmospheric radiant quantity, cloudiness, and atmospheric stability. Therefore, a qualitative prediction was implemented.

1) Construction phase

Based on the current status of air quality in Patna city, construction heavy machines and dump trucks may cause further traffic congestion and deterioration of atmospheric environment. However, this adverse impact is not severe because of the following reasons:

- Most of the earthworks is limited only to excavation at pillars in the elevated section
- Since most of the underground station will be constructed under arterial roads or under the land along narrow roads, the deterioration of traffic congestion due to the operation of heavy machinery is limited.
- Proper work schedules will be developed so that the construction equipment will not be concentrated at a certain point for a long time.

In addition to the above, mitigation measures during construction such as an adaptation of low-exhaust heavy machines and dump trucks, unnecessary idle running of the engine, the periodical water spray, and installation of high fence should be taken not to deteriorate the quality.

2) Operation phase

Since the number of registered vehicles in Patna city is anticipated to increase as the population in the city continues to grow, the traffic volume along Patna Metro will also increase. On the other hand, it is expected that the traffic volume along Patna Metro declines temporarily after 2025 because a transportation shift from private cars and buses to Patna Metro is expected. Additionally, some road

improvement projects such as the construction of high standard road construction and flyover are planned along Patna Metro to mitigate the current traffic congestion. Therefore, it can be said that the air quality in Patna city will slightly improve. Besides, since no emission gas generates from the Patna Metro, and the emission coefficient for NO_x and SO_x will be reduced by the renewal of the vehicle, it is anticipated that the air quality in Patna city will be improved accordingly.

14.5.2 Water Pollution

(1) Survey

Ground water quality survey along the alignment, was carried out in January 2020 during the dry season, and in July 2022 during rainy season. The location of ground water quality sampling and a summary of the results are shown in the below table. Since the values of Fluorides and Nitrate exceeded the environmental standard of India at all points during the dry season, and the values of Iron exceeded the standard at some points during the rainy season, the water quality environment can be said to be poor. However there is a minor impact on the local people because all the respondents have told that they use water supplied through tap water provided by Patna Municipal Corporation (PMC) for daily usage and there is no use of nearby river water or lake water for fishing, fishery, washing for laundries and dishes etc. in daily life according to the interview survey conducted in July 2022. There are no large-scale pollution source facilities in the surrounding area. Standard values for drinking water quality in India are stipulated in IS 10500: 2012, Indian Standard, Drinking Water - Specification. For surface water quality measurement, in comparing against the Indian standards values, values of all items were lower than Indian surface water requirements at all points. Standard values for surface water quality in India are stipulated in General Standards for Discharge of Environmental Pollutants in Environment (Protection) Rules, 1986.

(2) Prediction

Regarding the treatment of domestic wastewater and industrial related drainage in Patna city, it is discharged untreated into the drainage channel with rainwater and flows into rivers and lakes in the city. In the rainy season, the rainwater mixed with sewage overflows into the city resulting in deterioration of the sanitary environment. Additionally, turbid water may be generated from the excavation work for the construction of Patna Metro piers and underground stations due to the high groundwater level, so further deterioration of water quality may occur. However, this impact is not severe because of the following reasons:

- Earthwork for elevated sections is limited to excavation for pier construction
- Insertion of diaphragm wall at every underground station site to avoid phreatic fluctuation and deterioration of ground water quality

Adding to the above, mitigation measures such as installation of settle basins at every construction site and the wastewater treatment system at construction yard should be installed not to deteriorate the water quality. In the operation phase, there is a possibility of discharged organic wastewater from the toilet installed every station and a depot, but the wastewater treatment system at every station and a depot should be also installed to keep the water quality. In addition, "all sewage treatment plants (SYPs) construction work" in Patna City area is scheduled to be completed in 2022-2023⁵ as a Namami Gange Programme⁶, by which future water quality improvement of rivers and lakes is expected.

⁵ <https://www.constructionworld.in/urban-infrastructure/wastewater-and-sewage-treatment/patna---s-sewerage-projects-under-namami-gange-to-be-completed-by-2023/33939>

⁶ Integrated Conservation Mission, approved as "Flagship Programme" by the Union Government of India in June 2014 with budget outlay of Rs.20,000 crore.

Table 14-16 Result of Ground water quality in dry season (1)

Item	Unit	Danapur	Raja Bazar	Patna Zoo	Mithapur	Permissible Limits (IS 10500:2012)	WHO (drinking water)
Colour,	Hazen	Colourless	Colourless	Colourless	Colourless	5 (15) Max	15 Pt-unit
Odor		Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Agreeable	Acceptable
Taste		Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Acceptable
Turbidity,	N.T.U	3.5	2.3	3.7	2.6	1 (5) Max	Less than 5 N.T.U
pH at 25°C		7.86	7.74	7.82	7.72	6.5-8.5 Max	-
Total Hardness as CaCO ₃ ,	mg/l	246	258	217	182	200 (600) Max	
Chloride as Cl	mg/l	89	67	92	87	250 (1000) Max	-
Total Iron as Fe	mg/l	0.05	0.09	0.17	0.11	0.3 Max	0.3
Total Dissolved Solids	mg/l	1497	1388	1635	1402	500 (2000) Max	
Sulphates as SO ₄	mg/l	124	129	105	114	200 (400) Max	250
Nitrates as NO ₃	mg/l	51	57	58.1	51	45 Max	50
Fluorides as F	mg/l	3.28	2.74	3.87	3.31	1.0 (1.5) Max	1.5
Lead as Pb	mg/l	BDL	BDL	BDL	BDL	0.01 Max	0.01
Copper as Cu	mg/l	BDL	BDL	BDL	BDL	0.05 (1.5) Max	1.0
Manganese as Mn	mg/l	BDL	BDL	BDL	BDL	0.1 (0.3) Max	0.1
Phenolic Compound as C ₆ H ₅ OH	mg/l	BDL	BDL	BDL	BDL	0.001 (0.002) Max	-
Mercury as Hg	mg/l	BDL	BDL	BDL	BDL	0.001	0.001
Cadmium as Cd	mg/l	BDL	BDL	BDL	BDL	0.003	0.003
Selenium as Se	mg/l	BDL	BDL	BDL	BDL	0.01	0.01
Arsenic as As	mg/l	BDL	BDL	BDL	BDL	0.01 (0.05)	0.01
Cyanide as Cn	mg/l	BDL	BDL	BDL	BDL	0.05	0.07
Zinc as Zn	mg/l	2.07	1.84	1.04	1.65	5 (15)	-
Detergent as MBAS	mg/l	BDL	BDL	BDL	BDL	0.02 (1.0)	-
Chromium as Cr ⁺⁶	mg/l	BDL	BDL	BDL	BDL	0.05	0.05
Total Alkalinity as CaCO ₃	mg/l	127	124	146	138	200 (600)	-
Aluminum as Al	mg/l	BDL	BDL	BDL	BDL	0.03 (0.2)	-
Boron as B	mg/l	BDL	BDL	BDL	BDL	0.5 (1.0)	0.5
Coliform	MPN/100ml	Nil	Nil	Nil	Nil	-	-
E-Coli	MPN/100ml	Negative	Negative	Negative	Negative	-	0

Source: Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC, IS 10500 : 2012 Indian Standard DRINKING WATER — SPECIFICATION / Guidelines for Drinking-water Quality, (WHO)

*BDL: Below Detection Limit

Table 14-17 Result of Ground water quality in dry season (2)

Item	Unit	Patna Junction	PMCH	Patna Univ.	Khemni Chak	Permissible Limits (IS 10500:2012)	WHO (drinking water)
Colour,	Hazen	Colourless	Colourless	Colourless	Colourless	5 (15) Max	15 Pt-unit
Odor		Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Agreeable	Acceptable
Taste		Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Acceptable
Turbidity,	N.T.U	4.1	3.6	3.2	2.7	1 (5) Max	Less than 5 N.T.U
pH at 25°C		7.65	7.75	7.69	7.83	6.5-8.5 Max	-
Total Hardness as CaCO ₃ ,	mg/l	315	224	216	253	200 (600) Max	
Chloride as Cl	mg/l	142	94	73	129	250 (1000) Max	-
Total Iron as Fe	mg/l	0.28	0.16	0.12	0.27	0.3 Max	0.3
Total Dissolved Solids	mg/l	2147	1671	1237	1924	500 (2000) Max	
Sulphates as SO ₄	mg/l	168	117	91	108	200 (400) Max	250
Nitrates as NO ₃	mg/l	76	78	49	71	45 Max	50
Fluorides as F	mg/l	2.58	2.97	2.69	4.32	1.0 (1.5) Max	1.5
Lead as Pb	mg/l	BDL	BDL	BDL	BDL	0.01 Max	0.01
Copper as Cu	mg/l	BDL	BDL	BDL	BDL	0.05 (1.5) Max	1.0
Manganese as Mn	mg/l	BDL	BDL	BDL	BDL	0.1 (0.3) Max	0.1
Phenolic Compound as C ₆ H ₅ OH	mg/l	BDL	BDL	BDL	BDL	0.001 (0.002) Max	-
Mercury as Hg	mg/l	BDL	BDL	BDL	BDL	0.001	0.001
Cadmium as Cd	mg/l	BDL	BDL	BDL	BDL	0.003	0.003
Selenium as Se	mg/l	BDL	BDL	BDL	BDL	0.01	0.01
Arsenic as As	mg/l	BDL	BDL	BDL	BDL	0.01 (0.05)	0.01
Cyanide as Cn	mg/l	BDL	BDL	BDL	BDL	0.05	0.07
Zinc as Zn	mg/l	2.31	2.41	1.09	1.61	5 (15)	-
Detergent as MBAS	mg/l	BDL	BDL	BDL	BDL	0.02 (1.0)	-
Chromium as Cr ⁺⁶	mg/l	BDL	BDL	BDL	BDL	0.05	0.05
Total Alkalinity as CaCO ₃	mg/l	159	163	135	156	200 (600)	-
Aluminum as Al	mg/l	BDL	BDL	BDL	BDL	0.03 (0.2)	-
Boron as B	mg/l	BDL	BDL	BDL	BDL	0.5 (1.0)	0.5
Coliform	MPN/100ml	Nil	Nil	Nil	Nil	-	-
E-Coli	MPN/100ml	Negative	Negative	Negative	Negative	-	0

Source: Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC, IS 10500 : 2012 Indian Standard DRINKING WATER — SPECIFICATION / Guidelines for Drinking-water Quality, (WHO)

*BDL: Below Detection Limit

Table 14-18 Result of Ground water quality in rainy season

Item	Unit	R.P.S. More	Raja Bazar	Patna Zoo	Patna Junction	Gandhi Maidan	Rajendra Nagar	Khemni Chak	New ISBT	Permissible Limits (IS 10500:2012)	WHO (Drinking Water)
Colour	Hazen	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	5 (15) Max	15 Pt-unit
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Acceptable
Taste	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Acceptable
Turbidity	NTU	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1 (5) Max	Less than 5 N.T.U
pH at 25°C	-	7.45	7.40	8.02	7.1	7.4	7.69	7.5	7.55	6.5-8.5 Max	--
Total Hardness as CaCO ₃	mg/L	212.85	207.9	123.75	287.1	212.85	247.5	292.05	222.75	200 (600) Max	
Chloride as Cl	mg/L	57	28.5	16.63	28.5	49.88	30.88	49.88	57	250 (1000) Max	-
Iron as Fe	mg/L	0.16	0.21	0.35	0.24	0.26	0.31	0.41	0.21	0.3 Max	0.3
Total Dissolved Solids	mg/L	310	255	165	320	248	275	359	261	500 (2000) Max	
Sulphates as SO ₄	mg/L	19.97	16.09	9.77	16.23	19.83	15.95	21.69	24.42	200 (400) Max	250
Nitrates as NO ₃	mg/L	4.56	3.27	1.02	5.24	4.15	5.44	7.21	4.15	45 Max	50
Fluoride as F	Mg/L	0.23	0.21	0.19	0.24	0.2	0.22	0.25	0.2	1.0 (1.5) Max	1.5
Lead as Pb	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01 Max	0.01
Copper as Cu	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05 (1.5) Max	1.0
Manganese as Mn	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.1 (0.3) Max	0.1
Phenolic Compound as C ₆ H ₅ OH	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001 (0.002) Max	-
Mercury as Hg	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001	0.001
Cadmium as Cd	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.003	0.003
Total Arsenic as	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01 (0.05)	0.01
Cyanide as Cn	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05	0.07
Zinc as Zn	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	5 (15)	-
Deergent as MBAS	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.02 (1.0)	-
Hexavalent Chromium as Cr ⁶⁺	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05	0.05
Total Alkalinity as CaCO ₃	mg/L	138.8	115.04	92.5	97.1	60.1	101.8	111	134.1	200 (600)	-

Item	Unit	R.P.S. More	Raja Bazar	Patna Zoo	Patna Junction	Gandhi Maidan	Rajendra Nagar	Khemni Chak	New ISBT	Permissible Limits (IS 10500:2012)	WHO (Drinking Water)
Aluminium as Al	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.03 (0.2)	-
Boron as B	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.5 (1.0)	0.5
Coliform	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-	-
E-Coli	MPN/100ml	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	-	0

*BDL: Below Detection Limit

Source: JST, IS 10500:2012 Indian Standard DRINKING WATER-SPECIFICATION, Guidelines for Drinking-water Quality (WHO)

Table 14-19 Result of Surface water quality in rainy season

Item	Unit	R.P.S. More	Patliputra	Mithapur	Moin UI Haq Stadium	Khemni Chak	New ISBT	WHO	India (Inland surface water)
Colour	Hazen	BDL	BDL	BDL	BDL	BDL	BDL	-	All efforts as far as practicable
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-	
Turbidity	NTU	BDL	BDL	BDL	BDL	BDL	BDL	5	-
pH at 25°C	-	7.46	7.65	7.15	7.17	7.15	6.95	-	5.5 - 9
Total Hardness as CaCO ₃	mg/L	99.00	108.90	148.50	153.45	59.40	247.50	-	-
Chloride as Cl	mg/L	16.63	40.38	19.00	95.01	21.38	76.00	-	-
Iron as Fe	mg/L	0.14	0.22	0.24	0.32	0.12	0.38	-	3.0
Total Dissolved Solids	mg/L	128.00	190.00	202.00	312.00	108.00	350.00	-	-
Sulphates as SO ₄	mg/L	5.46	8.48	5.60	27.73	6.08	20.69	-	-
Nitrates as NO ₃	mg/L	1.43	1.70	2.18	3.54	1.63	5.72	-	10
Lead as Pb	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	-	0.1
Copper as Cu	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	-	3.0
Manganese as Mn	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	-	2.0
Mercury as Hg	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	-	0.01
Cadmium as Cd	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	-	2.0
Zinc as Zn	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	-	5.0
Hexavalent Chromium (as Cr ⁶⁺)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	-	0.1
Total Alkalinity as CaCO ₃	mg/L	83.3	97.1	143.4	129.50	64.8	83.3	-	-
Calcium as Ca	mg/L	31.74	33.73	45.63	45.63	13.89	91.26	-	-

Item	Unit	R.P.S. More	Patliputra	Mithapur	Moin UI Haq Stadium	Khemni Chak	New ISBT	WHO	India (Inland surface water)
Magnesium as Mg	mg/L	4.77	5.97	8.36	9.57	6.00	4.70	-	-
Sodium as Na	mg/L	1.04	11.09	17.62	32.08	9.30	36.33	-	-
Potassium as K	mg/L	0.07	0.79	0.28	1.10	0.59	1.72	-	-
Electrical Conductivity	ms/cm	0.219	0.372	0.395	0.573	0.175	0.687	-	-
Dissolved Oxygen	mg/L	5.0	5.1	5.3	5.0	5.2	5.1	-	-
Chemical Oxygen Demand (COD)	mg/L	54.2	58.1	4.14	109.8	78.2	205.0	125	250
Biological Oxygen Demand (BOD)	mg/L	9.8	10.0	BDL	15.9	11.7	21.5	30	30

*BDL: Below Detection Limit

Source: JST, WHO, General Standards for Discharge of Environmental Pollutants Part-A: Effluents of Schedule – VI, The Environment (Protection) Rules, 1986

14.5.3 Waste

(1) General waste

In Patna City, regarding general waste, Door-to-Door Garbage Collection Service is implemented from 2018. In addition, there are currently four sewage treatment plants at Saidpur, Beur, Pahari and Karmali Chak, and construction of new sewage infrastructure is underway in the city from 2019.

(2) Construction and Demolition waste

Since construction works have already been begun on a part of the elevated section of Patna Metro (between Khemni Chak St. and New ISBT St.), excavated soil has been generated due to the construction of piers. Currently, PMRCL transports the excavated soil to lowlands and swamps owned by the Government of Bihar and civilians for landfill, and carries the excavated soil to other candidate sites after the land is full. The candidate sites currently known are as shown in the satellite images below. As of October 2022, there is a large acceptable space for the excavated soil, construction and demolition waste.



Source: JST based on the information of PMRCL

Figure 14-22 Acceptable Site for Construction Generated Soil and C & D Waste

Table 14-20 Excavated Soil Transportation, and Reuse and Storage of Crushed Stones

	
<p>Excavated soil filling</p>	
	
<p>Acceptable site for generated excavated soil</p>	
	
<p>Storage of crushed stones</p>	<p>Reuse of crushed stones</p>

Source: PMRCL

(3) Prediction

It is expected that land modification will be expected, at a depot area, at the pier construction sites, TBM section, ramp section, and every underground station sites, with a total of 2,232,568 m³ of excavated soil. PMRCL plans to reuse an excavated soil generated at these sites as landfill for the embankment section of the expressway "Loknayak Ganga Path" under construction and the soil filling for a depot construction of Patna Metro, because a large amount of soil will be required for the construction of the depot. On the other hand, crushed stones that cannot be used for landfill are stored in the construction site with a cover to minimize the dust scattering, and will be reused as a base material for road pavement.

14.5.4 Soil contamination

Soil sampling was conducted in January 2020, during the dry season, and in July 2022 during the dry season. The location of soil sampling points and results for each sample are shown in the tables below. As there are no reference standard values for soil in India, the results of some parameters were compared with Environmental Quality Standards for Soil in Japan as an international standard. In the dry season, the pH values of the soil are slightly alkaline, and the values of electric conductivity tend to be slightly higher than that of general soil. No other items were detected. In the rainy season, Lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As), which were not detected in the dry season, were detected, but the values were sufficiently small compared to Japanese standards. The pH values of the soil, except for

R.P.S More and Raja Bazar, were alkaline, and the degree of alkalinity tends to be stronger than in the dry season. There could be no large-scale pollution source facilities in the surrounding area.

Table 14-21 Result of Soil Quality in dry season

Item	Unit	Danapur	Raja Bazar	Patna zoo	Patna St.	Japan
pH	-	7.72	7.79	7.59	7.63	-
Electrical Conductivity	mS/cm	1.15	1.45	1.84	1.79	-
Lead as Pb	ppm	ND	ND	ND	ND	150
Mercury as Hg	ppm	ND	ND	ND	ND	15
Cadmium as Cd	ppm	ND	ND	ND	ND	45
Arsenic as As	ppm	ND	ND	ND	ND	150
Cyanide as Cn	ppm	ND	ND	ND	ND	50
Chromium as Cr+6	ppm	ND	ND	ND	ND	250
Item	Unit	PMCH	Patna Univ.	Khemni Chak	New ISBT	Japan
pH	-	7.81	7.67	7.76	7.82	-
Electrical Conductivity	mS/cm	2.06	2.14	1.37	1.95	-
Lead as Pb	ppm	ND	ND	ND	ND	150
Mercury as Hg	ppm	ND	ND	ND	ND	15
Cadmium as Cd	ppm	ND	ND	ND	ND	45
Arsenic as As	ppm	ND	ND	ND	ND	150
Cyanide as Cn	ppm	ND	ND	ND	ND	50
Chromium as Cr+6	ppm	ND	ND	ND	ND	250

Source: Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC, Environmental Quality Standards for Soil, Japan

Table 14-22 Result of Soil Quality in rainy season

Item	Unit	R.P.S. More	Raja Bazar	Patna zoo	Patna St.	Japan
pH	-	4.81	5.57	8.09	7.85	-
Electrical Conductivity	mS/cm	0.616	0.153	0.148	0.326	-
Lead as Pb	ppm	1.19	2.08	1.98	0.86	150
Mercury as Hg	ppm	0.23	0.25	0.26	0.21	15
Cadmium as Cd	ppm	0.90	0.82	0.64	0.88	45
Arsenic as	ppm	0.55	0.62	0.91	0.44	150
Cyanide as Cn	ppm	ND	ND	ND	ND	50
Chromium as Cr+6	ppm	ND	ND	ND	ND	250
Item	Unit	Gandhi Maidan	Rajendra Nagar	Khemni Chak	New ISBT	Japan
pH	-	7.97	8.14	8.74	8.40	-
Electrical Conductivity	mS/cm	0.634	0.269	0.129	0.137	-
Lead as Pb	ppm	0.79	1.02	1.22	0.93	150
Mercury as Hg	ppm	0.22	0.27	0.31	0.42	15
Cadmium as Cd	ppm	0.68	0.72	0.79	0.95	45
Arsenic as	ppm	0.58	0.86	0.98	0.74	150
Cyanide as Cn	ppm	ND	ND	ND	ND	50
Chromium as Cr+6	ppm	ND	ND	ND	ND	250

Source: JST, Notification of the National Environmental Board: Soil Quality Standard" in the Royal Gazette on 11 March 2021, Thailand, Environmental Quality Standards for Soil, Japan

(2) Prediction

As mentioned in the sub-chapter of "Waste", it is expected that land modification will be expected, at a depot area, at the pier construction sites, TBM section, ramp section, and every underground station sites, with a total of 2,232,568 m³ of excavated soil. There are plans to reuse the excavated soil generated from the sites for the embankment section of the expressway "Loknaya Ganga Path" under construction and the soil filling for a depot construction of Patna Metro. Therefore, since it can be said that there are some impacts on soil contamination, periodical soil monitoring analysis should be conducted to find early detection of soil contamination. During the construction phase, regular maintenance and inspection for heavy machinery should be carried out to prevent oil leaks. During the operation phase, oil traps, septic tanks, and drainage ditches should be installed at the proposed depot as mitigation measures to prevent the spread of soil contamination to the surrounding area.

14.5.5 Noise and Vibration

(1) Survey

1) Noise

Noise survey was conducted in February 2020 during dry season, and in July 2022 during rainy season. Day and night time averaged noise levels are shown below and compared with Indian standards for commercial areas, because all of the point is located at main road side whose category is designated as commercial area. The environmental noise quality was recorded for 24 hours by using Digital Sound Level Meter. The values at all points, except PMCH, Khemni Chak, ISBT, and Patna Univ. during the day time in dry season, and Gandhi Maidan during the day time in rainy season, exceeded the environmental standard of India. Especially the values during rainy season were higher than the rainy season due to the severe traffic congestion by raining. Standard values for noise in India are stipulated in EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS / 02/1992, IVth Edition.

Table 14-23 Standard of India

Category of Area/Zone	Day Time	Night Time	Regulation
I. Industrial Area	75 dB	70 dB	EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IV th Edition.
II. Commercial Area	65 dB	55 dB	
III. Residential Area	55 dB	45 dB	
IV. Silence Area	50 dB	40 dB	
Industrial Area/ Commercial Area	70 dB	70 dB	Environmental, Health, and Safety Guidelines, IFC
Residential Area	55 dB	45 dB	

Source: EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IVth Edition./ Environmental, Health, and Safety Guidelines, IFC

Table 14-24 Result of Noise level in dry season

Location name & Land mark	Unit	Day time (AM 6:00 – PM 10:00)				Night time (PM 10:00- AM 6:00)			
		Lmax	Lmin	Leq	Standard	Lmax	Lmin	Leq	Standard
1 Danapur	dB(A)	86.5	59.3	70.4	65	79.6	47.4	59.8	55
2 Raja Bazar		78.2	58.7	68.7		73.7	48.9	60.2	
3 Patna Zoo		81.1	56.5	67.4		76.2	45.3	57.7	
4 Patna Junction		104.8	67.9	76.3		80.8	46.3	67.5	
5 Mithapur		86.7	61.5	73.2		77.1	51.8	62.3	
6 PMCH		79.4	51.0	60.8		77.9	42.6	51.4	
7 Patna University		83.1	56.5	66.2		78.6	45.8	50.9	
8 Khemni Chak		80.9	49.6	63.8		76.2	46.1	54.1	
9 New ISBT		76.2	51.1	58.2		68.9	43.4	50.5	

Source: Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC

Table 14-25 Results of Noise Level in rainy season

Location name	Unit	Day time (AM 6:00 – PM 10:00)				Night time (PM 10:00- AM 6:00)			
		Lmax	Lmin	Leq	Standard	Lmax	Lmin	Leq	Standard
1 R.P.S. More	dB(A)	104.5	55.2	74.3	65	85.1	50.3	60.1	55
2 Raja Bazar		108.2	56.7	77.6		93.1	72.6	74.3	
3 Patna Zoo		104.1	56.6	73.1		82.6	57.1	61.9	
4 Patna Junction		91	43.4	68.1		102.6	41.8	69.1	
5 Gandhi Maidan		90	49.9	64.2		78.3	47.8	56.8	
6 Rajendra Nagar		98.7	57.8	75.2		95.2	70.8	73.9	
7 Khemni Chak		91.8	46	68.7		90.7	57.3	71.5	
8 New ISBT		107.2	42.5	73.0		91.2	58.7	66.4	

Source: JST, Noise Regulation (Pollution & Control) Rules 2000

2) Vibration

Vibration survey was conducted in February 2020 during the dry season, and in July 2022 during the

rainy season at the same time as noise survey, and the results are as follows. Since the results are integrated day and night, it is unknown whether the results exceed the standard, but it is assumed that the impact of road traffic vibration along the Corridors will be large. Since there is no reference standard value for vibration in India, Vibration levels are compared with the vibration limits specified FTA-VA-90-1003-06 specifications for Reinforced-concrete, steel/timber (no plaster) Building, because the calculation method for FTA specifications suits the vibration calculation method used in India. As a result of the survey, vibration levels at all sites are below FTA limits in both seasons. Overall, the values in the rainy season are higher than those in the dry season, but the survey locations and the distance from the point to the roadway are different in each season, so it is meaningless to compare the values of both seasons.

Table 14-26 Results of Vibration Level in dry season

Location name		Max Value		FTA (dB)
		V rms (mm/s)	V dB	
1	Raja Bazar	0.11	72	102
2	Patna Zoo	0.19	77	
3	Patna Station	0.16	76	
4	Gandhi Maidan	0.05	66	
5	Rajendra Nagar	0.13	74	

Source: Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC, TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT: FTA-VA-90-1003-06 (USA)

Table 14-27 Results of Vibration Level in rainy season

Location name		Max Value (dB)		FTA (dB)
		V rms (mm/s)	V dB	
1	Rukanpura	0.38	83	102
2	Raja Bazar	0.64	88	
3	Patna Zoo	0.51	86	
4	Patna Junction	0.25	80	
5	PMCH	1.27	94	
6	Ramakrishna Nagar	0.64	88	
7	Gandhi Maidan	0.51	86	
8	Khemni Chak	0.64	88	

Source: JST, TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT: FTA-VA-90-1003-06 (USA)

3) Sensitive receptor

Regarding sensitive receptors there are some hospitals, schools and religious facilities which are located in the vicinity of the alignment. The details are given in the table and figure below.



Source: Detailed Project Report 2021, PMRCL

Figure 14-23: Details of sensitive receptors along Patna metro

Table 14-28 List of sensitive receptors along Patna metro

HOSPITALS		Distance from alignment (m)	SCHOOLS		Distance from alignment (m)
H1	Bimal Hospital	145	S1	Kendriya Vidyalaya Danapur	55
H2	Royal Hospital	120	S2	JD Women's College	46
H3	Paras HMRI Hospital	24	S3	Dr. Zakir Hussain Institute	50
H4	Shekhar Hospital	22	S4	Patna Women's College	135
H5	Patna Central Hospital	53	S5	National Institute of Fashion Technology	19
H6	Vatsalya Advance Children Hospital	19	S6	Aryabhata Knowledge University	13
H7	Apex Hospital	16	S7	Amity Global Business School	27
H8	Pulse Emergency Hospital	32	S8	Dental College	16
H9	PMCH	16	S9	Public Health Institute	15
H10	Patna Boneand Spine Hospital	21	S10	PMCH	16
H11	Jeevak Heart Hospital	21	S11	Patna University	24
H12	Bihar Cancer Surgical	123	S12	RPS Public School	70
H13	Jaiguru Dev Hospital	13	RELIGIOUS		
H14	Ford Hospital	36	R1	Panchmukhi Hanuman Mandir	16
H15	Rachita Trauma Hospital	32	R2	Hanuman Mandir Patna Station	23
H16	New Paramount Hospital	23			
H17	Earth Hospital	60			

Note: Receptors with bold letters are located at elevated section.

Source: Detailed Project Report 2021, PMRCL

(2) Prediction

1) Construction phase

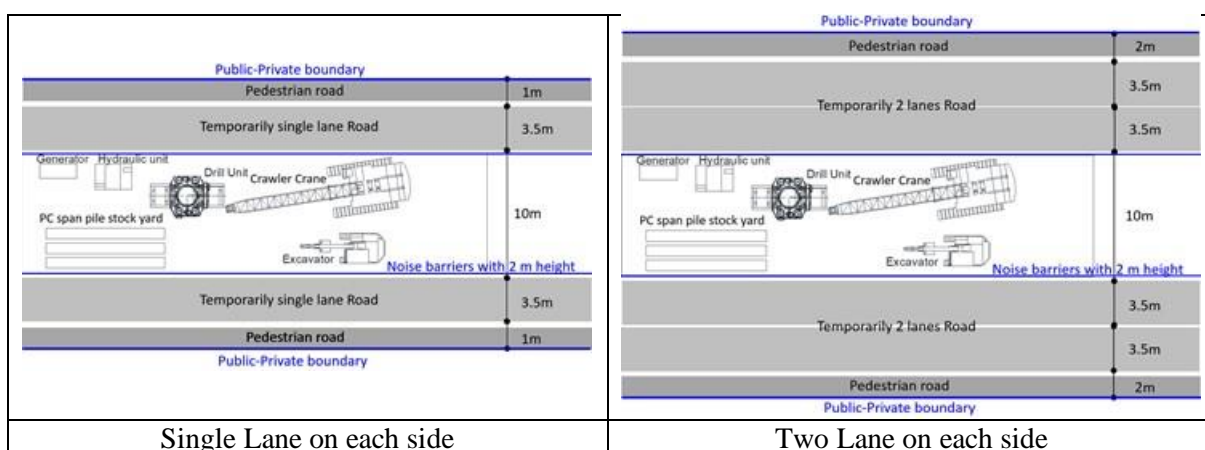
In the elevated and underground railway construction project, the work that generates the highest level of noise and vibration is pile driving activity for piers, so the noise and vibration level of the activity is the target of prediction. As one of mitigation measures, the PC span pile with a hydraulic driver for the

pile driving method is proposed as a construction method. The general main construction machines are an excavator (0.7m³), a crawler crane (70 ton), a hydraulic driver for pile driving, and a generator, which are shown in the table below with their output level of noise and vibration. It is assumed that these will be located at the central of arterial road with 9 or 10 m width in the most of the elevated section, and the noise and vibration level at the road edge will be predicted. However, there is no standard for noise and vibration during construction in India. Therefore, the standard value regulated by the Tokyo Metropolitan Government should be referred to in this case.

Table 14-29: Standards for regulation of noise generated by specific construction work

Construction activity	Tokyo, Japan
Pile driving work	80 dB

Source: Tokyo Metropolitan Environmental Security Ordinance, Tokyo Metropolitan Government



Source : JST

Figure 14-24: Typical Construction Yard Arrangement of PC spun Pile

Table 14-30: Noise and vibration generated by construction machines for pile-driving works

Construction machine		Noise power level (dB) (1m from machine side)	Vibration level (dB) (7m from machine side)
1	Excavator (0.7m ³)	105	63
2	Crawler crane (70 ton)	101	40
3	Hydraulic driver	96	55
4	Generator (200kVA)	92	9

Source:

- Report on the Study and Testing of the Prevention and Elimination of Construction Noise and Vibration, 1979, Public Works Research Institute, Ministry of Construction, Japan
- Research on Methods of Prediction and Assessing Noise and Vibration Induced by Construction Works (Report No.1), 1981, Public Works Research Institute, Ministry of Construction, Japan
- ASJ Prediction Model 2007 for Construction Noise, 2007, Acoustical Society of Japan
- Noise and Vibration Countermeasure Handbook for Construction, 2009, Japan Construction Machinery and Construction Association

a) Noise

i. Prediction procedure

The noise level assessment during construction should be considered with sound level generated by each construction machine located at a different position from the public-private boundary, and Noise attenuation formula (1) should be used in this assessment. After the calculation, the attenuated noise level

of each construction machine should be combined following the formula (2).

$$L_p = L_{p0} - 20 \log_{10} \left(\frac{r_0}{r} \right) \text{ ----- (1)}$$

Where

L_{p0} : Noise power level at a distance r_0 from the origin

L_p : Noise power level at a distance r from the origin

r_0, r : Distance from the origin at a sound level L_{p0} and L_p ($r_0 = 1m$)

$$L_{CN} = 10 \times \log_{10} \left(\sum_{i=1}^n 10^{\left(\frac{L_{pi}}{10}\right)} \right) \text{ ----- (2)}$$

Where

L_{CN} : Combined Noise level

L_{pi} : Noise power level at distance r from the origin of each construction machine

n : Number of Construction machine

ii. Result of Noise prediction

According to the result, the maximum noise power level from the construction activity is predicted as 77.5 dB for Single lane road and 73.3 dB for 2 lanes road respectively at 1.5m height on the Public-Private boundary. Then, the current noise level on the roadside at the same height obtained by the survey as a representative point is 74.3 dB and 77.6 dB each, which means that the predicted level is 79.2 dB and 79.0 dB for each. Therefore it can be said that these noise levels are below the standard value regulated by the Tokyo Metropolitan Government.

Table 14-31: Result of Noise Prediction

Road type	Noise level of Survey	Prediction noise level	Combined noise level	Tokyo, Japan
Single lane on each side	74.3 dB	77.5 dB	79.2 dB	80 dB
2 lanes on each side	77.6 dB	73.3 dB	79.0 dB	

Source: JST, Tokyo Metropolitan Environmental Security Ordinance, Tokyo Metropolitan Government

b) Vibration

i. Prediction procedure

The vibration level assessment during construction should be considered the same as the case of noise with the level generated by each construction machine located at a different position from the public-private boundary, and vibration attenuation formula (1) should be used in this assessment. After the calculation, the attenuated vibration level of each construction machine should be combined following the formula (2).

$$VL = VL_0 + 15 \log_{10} \left(\frac{r_0}{r} \right)^n + 8.68(r_0 - r)\alpha \text{ ----- (1)}$$

Where

VL : Vibration level at a distance r from the origin

VL_0 : Vibration level at a distance r_0 from the origin

r_0, r : Distance from the origin at a vibration level VL_0 and VL ($r_0 = 7m$)

n : Geometric attenuation

Surface wave: $n = 0.5$

α : Ground attenuation

Clay layer: $\alpha = 0.02$

$$L_{CV} = 10 \times \log_{10} \left(\sum_{i=1}^n 10^{\left(\frac{VLi}{10}\right)} \right) \text{ ----- (2)}$$

Where

L_{CV} : Combined Vibration level

VLi : Vibration level at distance r from the origin of each construction machine

n : Number of Construction machine

ii. Result of Vibration prediction

According to the result, the maximum vibration level from the construction activity is predicted as 61.1 dB for Single lane road and 61.2 dB for 2 lanes load respectively at ground level on the Public-Private boundary. Then, the current maximum vibration level on the roadside at ground level obtained by the survey as a representative point is 92.4 dB and 100.4 dB for each, which means that the predicted level is 92.4 dB and 100.4 dB for each. Therefore it can be said that the predicted vibration level is extremely low not to affect the value of the maximum vibration level of the survey results, and combined vibration levels are still below FTA limits.

Table 14-32: Result of Vibration Prediction

Road type	Max vibration level of Survey	Prediction vibration level	Combined vibration level	FTA limits
Single lane on each side	92.4 dB	61.1 dB	92.4 dB	102 dB
2 lanes on each side	100.4 dB	61.2 dB	100.4 dB	

Source: JST, TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT: FTA-VA-90-1003-06 (USA)

2) Operation phase

Regarding the noise and vibration from Patna Metro operation, since noise problem hardly occurs in underground section in India due to the predominance of road traffic noise, and there is no authenticated noise prediction formula for underground sections internationally, noise and vibration prediction for elevated section, and vibration prediction for underground section shall be conducted.

a) Noise prediction for elevated section

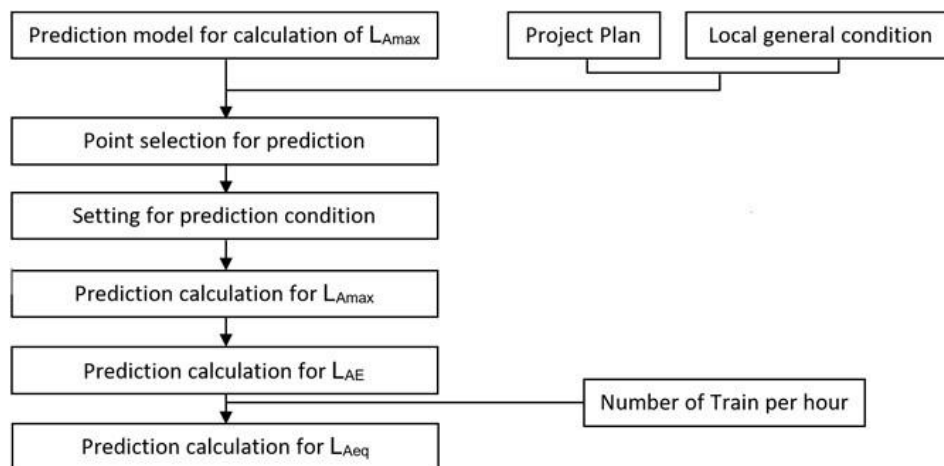
As mentioned in the subsection of air pollution, total traffic volume along Patna Metro will increase in the future, which means that the noise level in the vicinity of Patna Metro will be maintained or larger than the current condition. On the other hand, since the ratio of electric vehicles in the future will be grown by renewal from old types of gasoline automobiles, the future noise level may be reduced the same as contemporary Japan⁷. Therefore, since it is difficult to predict future noise levels generated from road traffic, the numerical data from field surveys shall be utilized for the prediction accordingly.

i. Prediction procedure

Noise level assessment on the operation stage will be following these steps;

1. To calculate the Maximum Noise level (L_{Amax}) based on the cross-section structure and Train speed.
2. To calculate Single event noise exposure level (L_{AE}) based on L_{Amax} and train passage time.
3. To calculate the equivalent noise level (L_{Aeq}) based on the number of trains per hour

⁷ https://www.jstage.jst.go.jp/article/jasj/75/4/75_188/_pdf, Acoustical Society of Japan, ASJ



Source: Railway Technical Research Institute

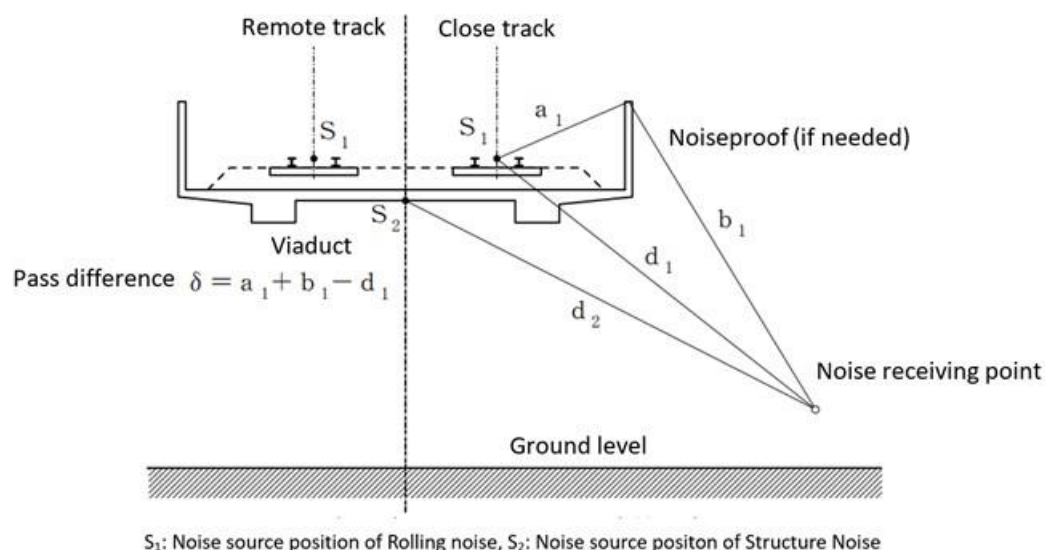
Figure 14-25: Prediction procedure for Railway Noise of elevated section

ii. Prediction Model

An appropriate prediction model for Railway noise⁸ suggested by Mr. Yoshio Moritoh (Railway Technical Research Institute, Japan) et al. can be utilized in the Patna Metro project because of applying to several railway structural requirements such as Viaduct and Flat on the straight section. Since there are these requirements in the project, the model should be adopted. Since Metro running noise is compound of various noise types; Rolling noise, Structure noise, and Rolling stock device noise, these noises should be calculated and combined to the composite noise level.

iii. Calculation of Maximum Noise level

The important information in the operation phase that will be utilized in this assessment is including; the number of train trips, length of the train, train speed, distance from the noise source, etc. The maximum Noise level (LAmax) is calculated by the three calculation formulas; (1), (2), and (3) as follows.



Source: Railway Technical Research Institute

Figure 14-26: Explanation of Noise source, Noise receiving point and Pass difference

iv. Rolling Noise

⁸ Proposal of a Prediction Model for Noise of Conventional Railway, the Institute of Noise Control Engineering of Japan, 1996.

$$L_{Amax}(R) = PWL_R - 5 - 10\log_{10}d_1 + 10\log_{10} \left\{ \frac{\left(\frac{l}{2d_1}\right)}{1 + \left(\frac{l}{2d_1}\right)^2} + \tan^{-1} \left(\frac{l}{2d_1}\right) \right\} + \alpha_1 \text{ ----- (1)}$$

- Where $L_{Amax}(R)$: Maximum Rolling Noise Level (dB)
- PWL_R : Power Level of Rolling Noise (dB)
- $PWL_R = PWL_R (100) + 30\log_{10} (V/100)$
- Slab track : $PWL_R (100) =$ between 100 and 105 dB
- d_1 : Distance from track central point to Noise receiving point (m)
- l : Length of a train (m)
- V : Train speed (km/h)
- α_1 : Shield attenuation by noise-proof (if needed) (dB)

v. Structure Noise

$$L_{Amax}(C) = PWL_c - 5 - 10\log_{10}d_2 + 10\log_{10} \left\{ \frac{\left(\frac{l}{2d_2}\right)}{1 + \left(\frac{l}{2d_2}\right)^2} + \tan^{-1} \left(\frac{l}{2d_2}\right) \right\} + \Delta L_c \text{ ----- (2)}$$

- Where $L_{Amax}(C)$: Maximum Structure Noise Level (dB)
- PWL_c : Power Level of Structure Noise (dB) $PWL_c = PWL_c (100) + 20\log_{10} (V/100)$
- Concrete Viaduct : $PWL_c (100) =$ between 83 and 87 dB
- d_2 : Distance from a central point of Viaduct’s undersurface to Noise receiving point (m)
- ΔL_c : Correction value (dB)
- If $r < 4h, \Delta L_c = 0, r > 4h, \Delta L_c = -10\log_{10} \left(\frac{r}{4h}\right)$
- R : Horizontal distance between Viaduct’s central point and Noise receiving point (m)
- h : Height of Viaduct’s undersurface (m)

vi. Rolling stock device noise

$$L_{Amax}(M) = PWL_M - 5 - 10\log_{10}d_1 + 10\log_{10} \left\{ \frac{\left(\frac{l}{2d_1}\right)}{1 + \left(\frac{l}{2d_1}\right)^2} + \tan^{-1} \left(\frac{l}{2d_1}\right) \right\} + \alpha_1 \text{ ----- (3)}$$

- Where $L_{Amax}(M)$: Maximum Rolling stock device Noise Level (dB)
- PWL_M : Power Level of Rolling stock device Noise (dB)
- $PWL_M = 60\log_{10} (6.53V/100) + \beta$
- β : Slab track = 57 dB
- α_1 : Shield attenuation by noise-proof (if needed) (dB)

vii. Maximum Noise level

The maximum Noise level under train passage is calculated by synthesizing Rolling Noise, Structure Noise, and Rolling stock device noise (Calculation formula (1), (2), and (3)).

$$L_{Amax} = 10\log_{10} \left(10^{\frac{L_{Amax}(R)}{10}} + 10^{\frac{L_{Amax}(C)}{10}} + 10^{\frac{L_{Amax}(M)}{10}} \right) \text{ ----- (4)}$$

Correlation between L_{Amax} and L_{AE}

Correlation between L_{Amax} and L_{AE} is calculated by a formula as follows.

$$L_{AE} = L_{Amax} + 10\log_{10}(l/(1000V/3600))$$

viii. Calculation of Equivalent Noise level

Equivalent Noise level is calculated based on the L_{AE} of each train passing direction and its number.

$$L_{Aeq} = 10\log_{10} \left[\left(\sum_{i=1}^n 10^{L_{AEi}/10} \right) / 3600 \right] \text{ ----- (5)}$$

Where L_{AEi} : Single event noise exposure level of each train passing direction and its number

n : Number of the train

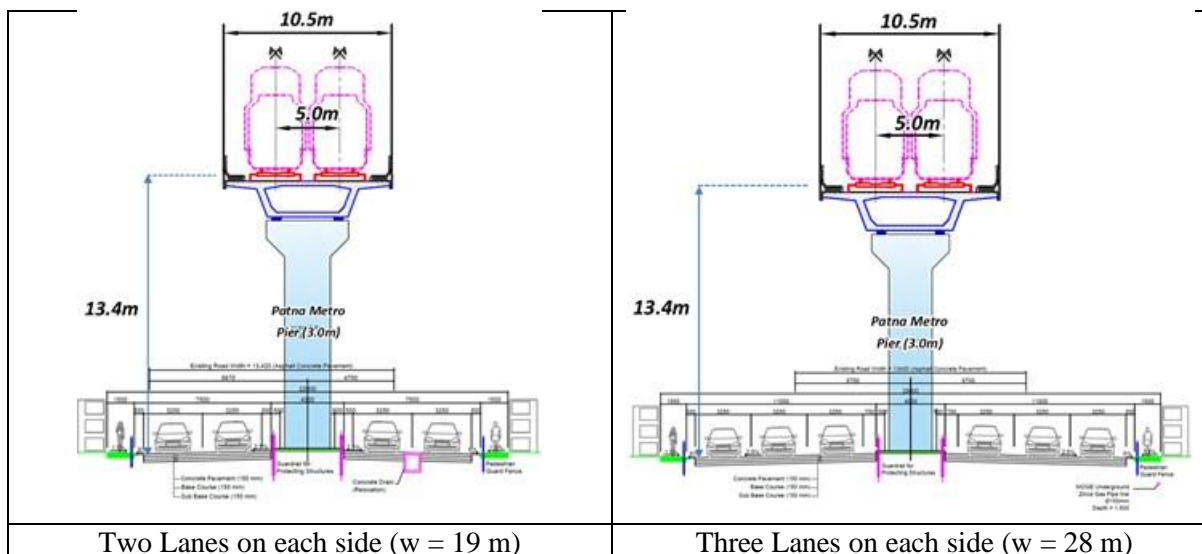
ix. Prediction Condition

Noise prediction for Patna Metro is implemented following the below condition.

Table 14-33 Prediction Condition for Patna Metro

Item	Condition	
Prediction Point	Representative elevated straight points along Patna Metro	
Train Service	Number per hour	12 trains/line
	Speed	85 km/h (Maximum)
	Length	65m or 129m (Corridor 1), 65m (Corridor 2)
Rolling Noise	PWLR	100.38 dB
Structure Noise	PWLc	83.59 dB
Rolling stock device Noise	PWLM	101.66 dB

Source: JST



Source: JST

Figure 14-27: Typical elevated cross section

x. Result of Noise prediction

From Table and Figures shown above and Calculation Formula (1), (2), (3), (4) and (5), the assessment shows the equivalent noise level, which is the national standard unit, from train passage without any noise-proof such as noise barrier, street trees, and any buildings, etc. Noise prediction results at the representative point along two lanes and three lanes show as below Figures with sectional noise contour.

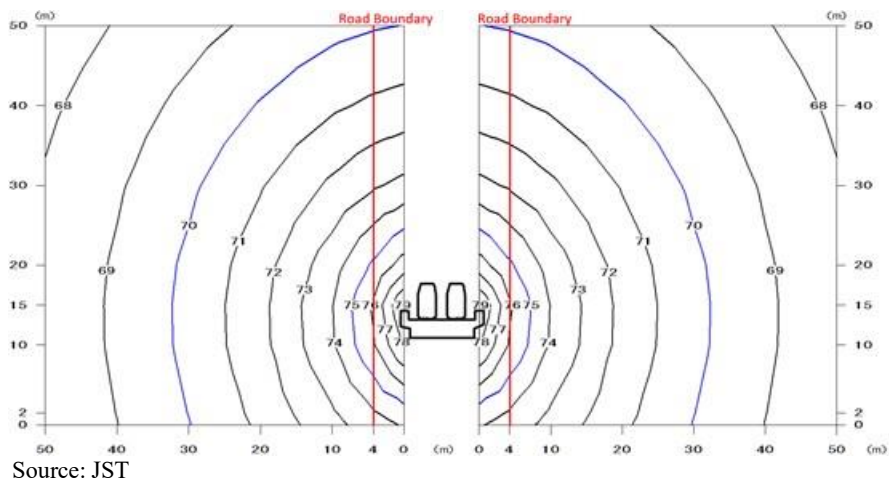


Figure 14-28: LAeq from Metro passage at the viaduct section with 2 lanes on each side

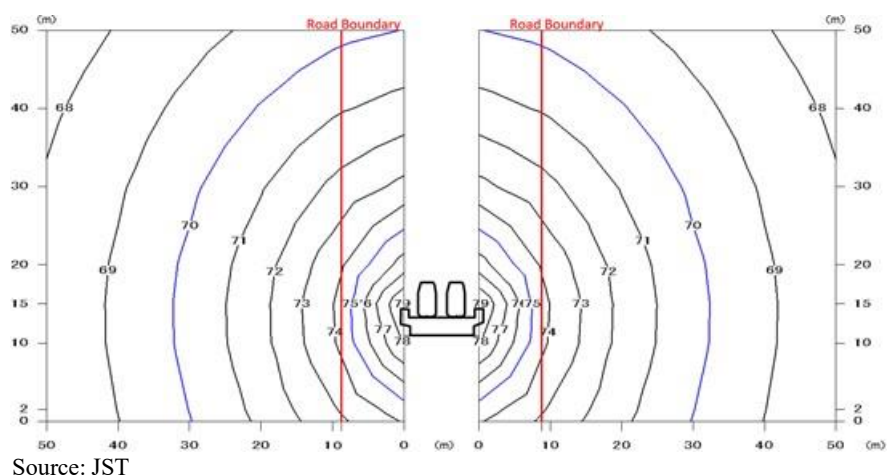


Figure 14-29: LAeq from Metro passage at the viaduct section with 3 lanes on each side

Table 14-34: Result of Noise Prediction

Road type	Noise level of Survey	Prediction Noise level	Combined Noise level	Standard
2 lanes on each side	74.3 dB	73.9 dB (without NB)	77.1 dB	65 dB
		57.1 dB (with 2m height NB)	74.4 dB	
3 lanes on each side	77.6 dB	73.1 dB (without NB)	78.9 dB	
		56.6 dB (with 2m height NB)	77.6 dB	

Note: NB: Noise Barrier
Source: JST

The prediction result shows that the Noise source level from Patna Metro passage is 73.9 dB for 2 lanes road on each side and 73.1 for 3 lanes road on each side at 1.5m on the boundary. Then, the current noise level on the boundary at 1.5m height obtained by the survey as a representative point is 74.3 dB and 77.6 dB respectively, which means that the noise level from Patna Metro contributes to the current noise

level. Therefore, installing of noise barrier with 2m height on both sides of the elevated section shall be proposed as a mitigation measure. In this case, it is predicted that the noise level will be attenuated by approx. 15 dB, and it can be said that it hardly contributes to the current noise level.

Regarding sensitive facilities such as hospitals, schools and kindergartens, noise barriers should be installed not only for noise reduction but also for privacy protection. Additionally, since multi-storied buildings are standing on both roadsides, installing of the barrier also should be considered to secure the privacy and living environment of the residents.

b) Vibration prediction for elevated section

Since a railway vibration has complicated generation and propagation paths and is affected by Rolling stock, tracks, and their structures, etc., no official prediction method has been established so far. Therefore, the prediction of railway vibration was carried out by a model formula, for slab track on the elevated section, created by analyzing the correlation between the train speed and the distance from the vibration source for the existing railway in Japan (1999, West Japan Railway Co., Ltd.). The prediction conditions are the same as noise prediction ones.

The model formula for Railway vibration⁹: $VL = 12.9 \times \log_{10} V - 13.2 \log_{10} R + 39.3$

Where V : Train speed (km/h)

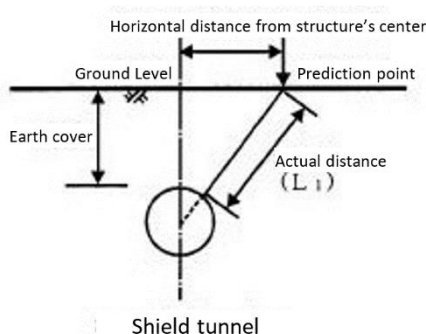
R : Distance from track central point to vibration receiving point (m)

The prediction result shows that the vibration level from Patna Metro passage is 51.3 dB for 2 lanes road on each side and 49.1 for 3 lanes road on each side at ground on the boundary. Then, the current vibration level on the boundary at ground obtained by the survey as a representative point is 86 dB respectively, which means that the vibration level from Patna Metro doesn't contribute to the current vibration level at all.

c) Vibration prediction for underground section

As a method of vibration prediction for underground section of single shield tunnel, a prediction formula shown below which was suggested by Tokyo Metro Co., Ltd. (former Teito Rapid Transit Authority) is adopted in general.

$$VL = K - A \times \log L + 25 \times \log(V/50) - 24 \times \log(W/20) + X$$



Where VL : Vertical vibration predicted level at a surface point of the earth (dB)

L : Actual distance from outside of the tunnel to a prediction point (m)

V : Velocity ($V=85\text{km/h}$)

W : Tunnel weight (16 tf/m)

⁹ "Environmental Impact Assessment for the Osaka outside loop-line Railway Construction Project" (1999, Osaka Soto-Kanjo Railway Co.,Ltd)

K	: Constant value for classified structure (K = 68dB)
A	: Weighting factor of distance (Diluvium = 14)
X	: Other weighting factor $X = X_1 + X_2$
X ₁	: Linear Correction (Straight section = 0)
X ₂	: Correction for reduction weight of rolling stock (All section = -5)

The prediction result shows that the vibration level from Patna Metro passage is approx. 54 dB at the section where the passage train has the maximum speed. Then, the current vibration level on the boundary at ground obtained by the survey as a representative point is 86 dB respectively, which means that the vibration level from Patna Metro doesn't contribute to the current vibration level at all.

3) Sensitive receptor

According to the result of filed survey and prediction, impact of noise during the construction phase and operation phase at elevated section is expected. Therefore, some necessary mitigation measures should be taken in the both phases as below.

a) Construction phase

- Noise suppressors such as mufflers will be installed whenever deemed necessary to maintain the noise generated by various heavy equipment and other construction machinery within permissible limits.
- High noise-generating construction activities will be scheduled during daytime only (6:00 – 22:00) to avoid noise disturbance to adjacent residential and commercial areas and other noise-sensitive areas. In the case of educational facilities, the activities should be considered during the night time not to interfere with the class-works.
- Around the construction site is fenced as high as 2-2.5 m.
- Use low-noise and vibration machinery for construction such as piling

b) Operation phase

- Additional noise barriers shall be discussed, as needed
- At the station platform on elevated sections, paging and train melody volume shall be adjusted to the lowest level where it will not detract from their function.
- Slow speed in curve sections

14.5.6 Ground Subsidence

The results of the standard penetration test (SPT) of the existing geological investigation are not in the range of soft ground. Moreover, there is no possibility of any subsidence due to dewatering in the area along the proposed tunnels according to DPR.

When there is tunneling or huge underground excavation making the substantial gap in strata, there are chances of subsidence of upper strata. The construction of underground section involves construction of twin tunnels of 6 m diameter each which will be done by using TBM. Considering the local geology, groundwater abundance and the working technology, the probability of subsidence is very low. However, monitoring and countermeasure shall be done for the impact because there is still possibility of ground subsidence in the construction areas and the damage will be serious if once occur.

14.5.7 Offensive odor

Possible points of offensive odor are related to waste / garbage generation, therefore, construction areas including camping yards during the construction phase and station including depot facilities during operational phase might be the major locations. This impact depends on not only collection system but also how to keep waste / garbage until collection at each location generally.

14.5.8 Protected Area

(1) Information collection

15 protected areas such as wildlife and bird sanctuaries, national parks and botanical parks have been designated in Bihar state. Among them, Sanjay Gandhi Botanical Park (hereinafter referred to as "SGB Park") is designated as a protected area along the Corridors. SGB Park was opened as a botanical garden in 1970 by Forest Department of Bihar State for the purpose of forest conservation, and then the department changed the name to Biological Park in 1972. In the same year, the land of the adjacent Revenue Office and Public Works Bureau were transferred to the Forest Department, and the Government of Bihar declared that all forests within 61.6 ha in total would be designated as protected ones. In 1973, the Government opened the all area as a park-cum-zoo, and declared "Park-cum-Zoo services" as an essential administrative services under the Bihar Essential Services Maintenance Act (1948). Then the Park-cum-Zoo was renamed to the current name, SGB Park in 1980. Although SGB Park is designated as a protected area, it is managed by the Government of Bihar as Park-cum-Zoo because it is a valuable place for local people to be relaxed and recreate. Therefore, the management type is different from that of other natural protected areas which has t risks disorderly destruction.

Table 14-35 Protected Area in Bihar

Name	Place /District	National Park / Sanctuary
Valmiki	West Champaran	National Park
Sanjay Gandhi	Patna	Botanical Park
Valmiki	West Champaran	Sanctuary
Bhimbandh	Monghyr	Sanctuary
Rajgir	Nalanda	Sanctuary
Kaimur	Rohtas	Sanctuary
Gautambudha	Gaya	Sanctuary
Udaypur	West Champaran	Sanctuary
Nagi Dam	Jamui	Bird Sanctuary
Nakti Dam	Jamui	Bird Sanctuary
Vikramshila Gangetic Dolphin	Bhagalpur	Sanctuary
Kanwar Jheel	Begusarai	Sanctuary
Gogabil Pakshi Vihar	Kaithar	Closed Area
Kusheshwarsthan	Darbhanga	Closed Area
Barela S.A.Z.S	Vaishali	Sanctuary

Source: <http://scstsenvis.nic.in/index4.aspx?ssslid=76&subsubsublinkid=428&langid=1&mid=1> (Environmental Information System (ENVIS))



Source: JST based on Google Earth

Figure 14-30 Positional Relation between Patna Metro and SGB Park (Patna Zoo)

Patna Zoo provided the list of animals including birds which are kept in enclosures/cages shown below. Some endangered species reared in the zoo are identified, but most of them are living in their enclosed spaces surrounded by trees as shown in the photo below. Therefore, noise, vibration, dust, etc. caused by construction work are expected to be largely mitigated.

Table 14-36 Entrance and Inside of SGB Park (Patna Zoo)



Source: JST

Table 14-37 List of birds and mammals in enclosures/cages in Patna Zoo

No.	Scientific Name	Common Name	IUCN Category
Birds kept in enclosures/cages			
1	<i>Agapornis</i>	Love Birds	-
2	<i>Anas platyrhynchos</i>	Duck Mallard	LC
3	<i>Anser indicus</i>	Goose-Bar Headed	LC
4	<i>Anthracoeros malabaricus</i>	Hornbill-Indian pied	-
5	<i>Aro macao</i>	Scarlet Macaw	LC
6	<i>Bubo</i>	Owl-Indian Great Horn	LC
7	<i>Bubo nipalensis</i>	Owl Eagle Forest	LC
8	<i>Butastur teesa</i>	Buzzard	LC
9	<i>Cacatua galerita elonora</i>	Medium sulpher crested Cockatoo	-
10	<i>Cacatua galerita</i>	Greater sulpher crested Cockatoo	-
11	<i>Casuaris</i>	Cassowary	LC

No.	Scientific Name	Common Name	IUCN Category
12	<i>Chakophaps indica</i>	Emerald Dove	LC
13	<i>Chrysolophus amherstiae</i>	Pheasant-Lady Amherst	LC
14	<i>Chrysolophus pictus</i>	Pheasant-Golden	LC
15	<i>Cygnus atratus</i>	Black Swan	LC
16	<i>Dendrocygna javanica</i>	Lesser Whistling Duck	LC
17	<i>Dromaius novaehollandiae</i>	Emu	LC
18	<i>Elanus caeruleus</i>	Kite-Black Winged	LC
19	<i>Gallinula chloropus</i>	Moorhen	LC
20	<i>Gallus</i>	Red Jungle fowl	LC
21	<i>Gracula religiosa</i>	Myna-Hill	LC
22	<i>Grus antigone</i>	Crane-Sarus	VU
23	<i>Grus</i>	Crane-Common	LC
24	<i>Gyps himalayensis</i>	Vulture Himalayan Grffon	NT
25	<i>Leptoptilos javanicus</i>	Stork Adjutant (lesser)	LC
26	<i>Lophura nycthemera</i>	Pheasant-Silver	LC
27	<i>Melopsittacus undulatus</i>	Budgerigar	LC
28	<i>Milvus migrans</i>	Kite-Pariah/Black Kite	LC
29	<i>Mycteria leucocephala</i>	Painted Stork	NT
30	<i>Nycticorax</i>	Heron-Night	LC
31	<i>Nymphicus hollandicus</i>	Cockatiel	LC
32	<i>Pavo cristatus</i>	Peafowl	LC
33	<i>Pavo cristatus</i>	Peafowl-white	LC
34	<i>Pelecanus onocrotalus</i>	Pelican-Rosy/white	LC
35	<i>Primolium maracana</i>	Illiger's Macaw	NT
36	<i>Pseudibis papillosa</i>	Ibis-black	LC
37	<i>Psittacula cyanocephala</i>	Parakeet-Blossom Headed	LC
38	<i>Struthio</i>	Ostrich	-
39	<i>Tadorna ferruginea</i>	Duck-Brahmini	LC
40	<i>Tockus birostris</i>	Hornbill- Common Grey	-
41	<i>Treron phoenicoptera</i>	Yellow-legged green Pigeon	LC
42	<i>Treron phoenicoptera</i>	Pigeon-Common Green	LC
43	<i>Tyto alba</i>	Owl Barn	LC
Mammals in enclosures/cages			
1	<i>Antilope cervicapra</i>	Black Buck	LC
2	<i>Axis</i>	Deer-Spotted	LC
3	<i>Axis porcinus</i>	Deer-Hog	EN
4	<i>Boselaphus tragocamelus</i>	Nilgai- Blue Bull	LC
5	<i>Canis aureus</i>	Jackal	LC
6	<i>Canis lupus</i>	Wolf Indian	LC
7	<i>Cervus eldi thamin</i>	Deer Brow-antlered (Sangai)	EN
8	<i>Cervus unicolor</i>	Deer-Sambar	VU
9	<i>Elephas maximus</i>	Elephant-Indian	EN
10	<i>Equus quagga boehmi</i>	Zebra Grant	-
11	<i>Felis chaus</i>	Cat Jungle	LC
12	<i>Giraffa camelopardalis</i>	Giraffe	VU
13	<i>Hippopotamus amphibius</i>	Hippopotamus	VU
14	<i>Hyaena</i>	Hyena-Stripped	NT
15	<i>Hystrix indica</i>	Porcupine-Indian	LC
16	<i>Macaca mulatta</i>	Macaque-Rhesus	EN
17	<i>Macaca silenus</i>	Macaque-Lion tailed	EN
18	<i>Melursus ursinus</i>	Bear- Sloth	VU
19	<i>Muntiacus muntjak</i>	Deer-Barking	LC
20	<i>Pan troglodytes</i>	Chimpanzee	EN
21	<i>Panthera leo persica</i>	Lion Indian	-
22	<i>Panthera pardus</i>	Leopard / Panther	VU
23	<i>Panthera tigris</i>	Tiger-Royal Bengal	-
24	<i>Panthera tigris</i>	Tiger-white	-
25	<i>Paradoxurus hermaphroditus</i>	Civet-Common Palm	LC
26	<i>Presbytis entellus</i>	Langur-Common	VU
27	<i>Prionailurus viverrinus</i>	Fishing Cat	VU
28	<i>Rhinoceros unicornis</i>	Rhinoceros-Indian one horned	VU

No.	Scientific Name	Common Name	IUCN Category
29	<i>Rucervus divaucelii</i>	Deer Swamp (Barasingha)	VU
30	<i>Selenarctos thibetanus</i>	Bear-Himalayan Black	VU
31	<i>Vulpes bengalensis</i>	Indian Fox	LC

* Near Endangered (EN), Vulnerable (VU), Threatened (NT), Least Concerned (LC)

Source: Patna Zoo

(2) Discussion with Patna Zoo

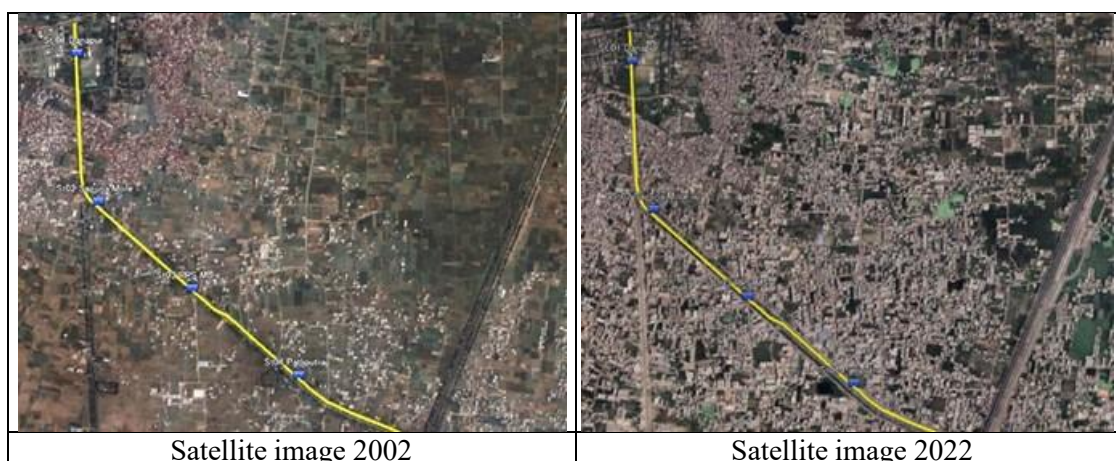
JST set a discussion opportunity with Patna Zoo staff to collect their opinion for Patna Metro construction and animal list fed in the zoo. According to the discussion with them in September 2022, since their concerns have been raised to PMRCL for noise and vibration than before, they communicated to Special Secretary of Urban Development & Housing Department (UDHD) of Bihar state in 2019 and requested as below.

- The construction work should not affect to the Zoo boundary during construction.
- To minimize impact of noise and vibration by taking necessary engineering method during construction.

During the discussion, they again requested PMRCL to take necessary measures during the construction phase to avoid any inconvenience to the animal and birds fed in the zoo. In consideration of their opinion, PMRCL promised them to take care of all concerns of Patna Zoo, and to give necessary instructions to construction contractor before construction as mentioned in the EMP.

14.5.9 Ecosystem

The target area for Corridor 1, 2 and Depot begins from the Danapur cantonment to Depot area through some commercial areas, residential areas, special areas and public areas. No major natural habitats have been confirmed except for Danapur Cantonment and SGB Park (Patna Zoo). It is also found that there is a strong pressure on natural ecosystems because the rapid urbanization from farmland to residential areas according to the Google Earth image from 2002 to 2022 shown in the below.



Source: JST based on Google Earth

Figure 14-31 Satellite image at Danapur Cantonment area from 2002 to 2022

(1) Methodology

1) Flora

The study on the floral assessment for the project activity was based on field survey of the area. Inventory Methodology was adapted to the baseline data of floral diversity within 1 km radius along the both corridors using the relevant topographic sheets of scale 1:50000. A forest inventory is “an attempt

to describe the tree species and many of the characteristics of the land area upon which the trees are grown.” The objective for this floral inventory of the study area, is to provide complete checklist of floristic structure along the corridors for formulating effective management and conservation measures.

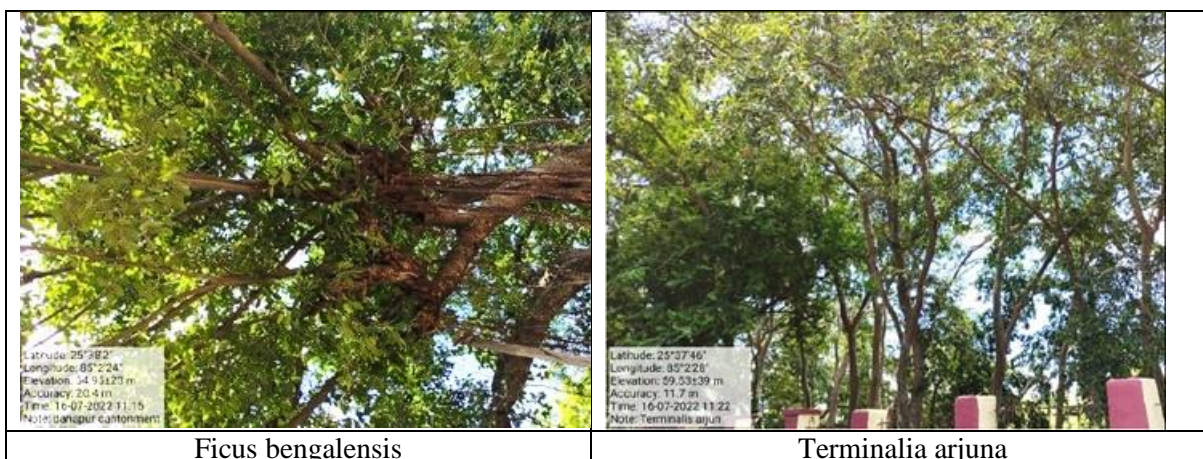
2) Fauna

A linear transect of 1.0 km each was chosen for sampling at each site. Each transect was trekked for 1.5 hours for the sampling of faunal diversity through following methods for different categories. For the sampling of butterflies, the standard ‘Pollard Walk’ method was employed and all the species recorded. Voucher specimens of the species that could not be identified in the field were collected using a butterfly net besides photographing them. For bird’s sampling, ‘Point Sampling’ along the fixed transect (Foot trails) was carried out. All the species of birds were observed through a binocular and identified with the help of field guide book and photographs. For the sampling of mammals, direct count on open width (20m) transect was used. In addition, information on recent sightings/records of mammals by the villagers/locals was also collected. For carnivores, indirect sampling was carried out and the mammals were identified by foot marks, feces and other marks/sign created by them. In case of reptiles mainly lizards were sampled by direct count on open width transects. The study of fauna takes substantial amount of time to understand the specific faunal characteristic of area. The assessment of fauna has been done by extensive field survey of the area. During survey, the presence of wildlife was also inhabitants depending on animal sightings and the frequency of their visits in the project area which was later confirmed from forest department, Wildlife Department etc.

(2) Survey

1) Flora

Ecosystem surveys including the inventory survey along the Corridors including a proposed depot area have been conducted in July of 2020 and 2022. As results of the surveys, the alignment does not pass through any forest area and there is no tree in the depot area. Trees have been found of indigenous and common species like Eucllyptus, Ficus, Jamun, Neem, Palm, Babool, Ber, Gulmohar and other trees. Among herbs species, weed are commonly reported along the alignment. Commonly reported weeds species are Congress grass (Parthenium hysterophorus), Lantana (Lantana Camara), Eipatorium trilpineve, Solanum xanthiocarpum and Datura (Dathura stromonium). The species of grasses reported along the banks are Cyanodon dactylon, Achyranthes aspera, Saccharum arundinaceum, Vetiveria zizanoides, Ludwigia parviflora, Rungia repens, etc. These are mainly reported along the road side area. A list of identified species is shown below. In total, 115 species were identified including Aegle marmelos and Pterocarpus marsupium which are classified as Near Threatened by the IUCN.





Source: JST

Figure 14-32 Photograph of Floral Species

Table 14-38 Identified species along the alignments (Natural Vegetation)

No.	Family	Scientific Name	Local Name	IUCN Category
Tree				
1	Rutaceae	<i>Aegle marmelos</i>	Bel	NT
2	Simaroubaceae	<i>Ailanthus excelsa</i>	Rukhdo	-
3	Apocynaceae	<i>Alstonia scholaris</i>	Saptparni	LC
4	Annonaceae	<i>Annona squamosa</i>	Sitafal	LC
5	Rubiaceae	<i>Anthocephalus cadamba</i>	Kadam	-
6	Mimosaceae	<i>Albizia lebbek</i>	Kala Siris	LC

No.	Family	Scientific Name	Local Name	IUCN Category
7	Moraceae	<i>Artocarpus heterophyllus</i>	Kathal	-
8	Meliaceae	<i>Azadirachta indica</i>	Neem	LC
9	Leguminosae	<i>Bauhinia variegata</i>	Kachnar, Papri	LC
10	Bombaceae	<i>Bombax ceiba</i>	Semal	LC
11	Arecaceae	<i>Borassus flabellifer</i>	Tad	-
12	Burseraceae	<i>Boswellia serrata</i>	Salai	-
13	Fabaceae	<i>Butea monosperma</i>	Palash	LC
14	Fabaceae	<i>Cassia fistula</i>	Amaltas	LC
15	Fabaceae	<i>Cassia javanica</i>	Cassia	LC
16	Caesalpinaceae	<i>Cassia siamea</i>	Kassod	LC
17	Fabaceae	<i>Dalbergia sissoo</i>	Shisham	LC
18	Fabaceae	<i>Delonix regia</i>	Gulmohar	LC
19	Ebenaceae	<i>Diospyros melanoxylon</i>	Kendu	-
20	Myrtaceae	<i>Eucalyptus globulus</i>	Eucalyptus	LC
21	Myrtaceae	<i>Eugenia jambolana</i>	Jambhul	LC
22	Moraceae	<i>Ficus benghalensis</i>	Bar, Bargad	-
23	Moraceae	<i>Ficus glomerata</i>	Gular	LC
24	Moraceae	<i>Ficus religiosa</i>	Peepal	LC
25	Bignoniaceae	<i>Jacaranda mimosifolia</i>	Neel Gulmohor	-
26	Lythraceae	<i>Lagerstroemia speciosa</i>	Jarul	-
27	Sapotaceae	<i>Madhuca indica</i>	Mahua	-
28	Anacardiaceae	<i>Mangifera indica</i>	Aam	DD
29	Meliaceae	<i>Melia azedarach</i>	Bakain	LC
30	Sapotaceae	<i>Mimusops elengi</i>	Bakul	LC
31	Moringaceae	<i>Moringa oleifera</i>	Sanjna	LC
32	Fabaceae	<i>Peltophorum ferrugineum</i>	Copper pod	-
33	Annonaceae	<i>Polyalthia longifolia</i>	Mast tree	-
34	Fabaceae	<i>Pongamia pinnata</i>	Karanj	LC
35	Fabaceae	<i>Pterocarpus marsupium</i>	Paisar	NT
36	Arecaceae	<i>Roystonea regia</i>	Royal Palm	LC
37	Dipterocarpaceae	<i>Shorea robusta</i>	Sal	LC
38	Myrtaceae	<i>Syzygium cumini</i>	Jamun	LC
39	Fabaceae	<i>Tamarindus indica</i>	Chinch	LC
40	Combretaceae	<i>Terminalia arjuna</i>	Arjun	-
41	Combretaceae	<i>Terminalia bellirica</i>	Bahera	LC
42	Combretaceae	<i>Terminalia tomentosa</i>	Asan	-
43	Fabaceae	<i>Vachellia nilotica</i>	Acacia nilotica	LC
44	Rhamnaceae	<i>Ziziphus jujuba</i>	Bordi	LC
45	Rhamnaceae	<i>Ziziphus mauritiana</i>	Ber	LC
Bamboo				
46	Poaceae	<i>Bambusa arundinacea</i>	Kanta bans	-
47	Poaceae	<i>Dendrocalamus strictus</i>	Bamboo	-
Shrubs				
48	Alangiaceae	<i>Alangium salviifolium</i>	Ankula	LC
49	Malvaceae	<i>Abutilon indicum</i>	Kanghi	-
50	Acanthaceae	<i>Adhatoda vasica</i>	Vasaka	LC
51	Nyctaginaceae	<i>Bougainvillea spectabilis</i>	Boganvel	-
52	Apocynaceae	<i>Calotropis gigantea</i>	Rui	-
53	Asclepiadaceae	<i>Calotropis procera</i>	Shet-akanda	-
54	Fabaceae	<i>Cassia sophera</i>	Kolokasunda	-
55	Fabaceae	<i>Cassia tora</i>	Panwar	-
56	Solanaceae	<i>Datura metel</i>	Datura	-
57	Malvaceae	<i>Hibiscus rosa-sinensis</i>	Jaba	-
58	Convolvulaceae	<i>Ipomoea carnea</i>	Bara Kalmi	-
59	Verbenaceae	<i>Lantana camara</i>	Chotra	-
60	Lythraceae	<i>Lawsonia inermis</i>	Mehndi	LC
61	Apocynaceae	<i>Nerium indicum</i>	Kaner	-
62	Euphorbiaceae	<i>Ricinus communis</i>	Rehri	-
63	Apocynaceae	<i>Vinca rosea</i>	Sadaphuli	-

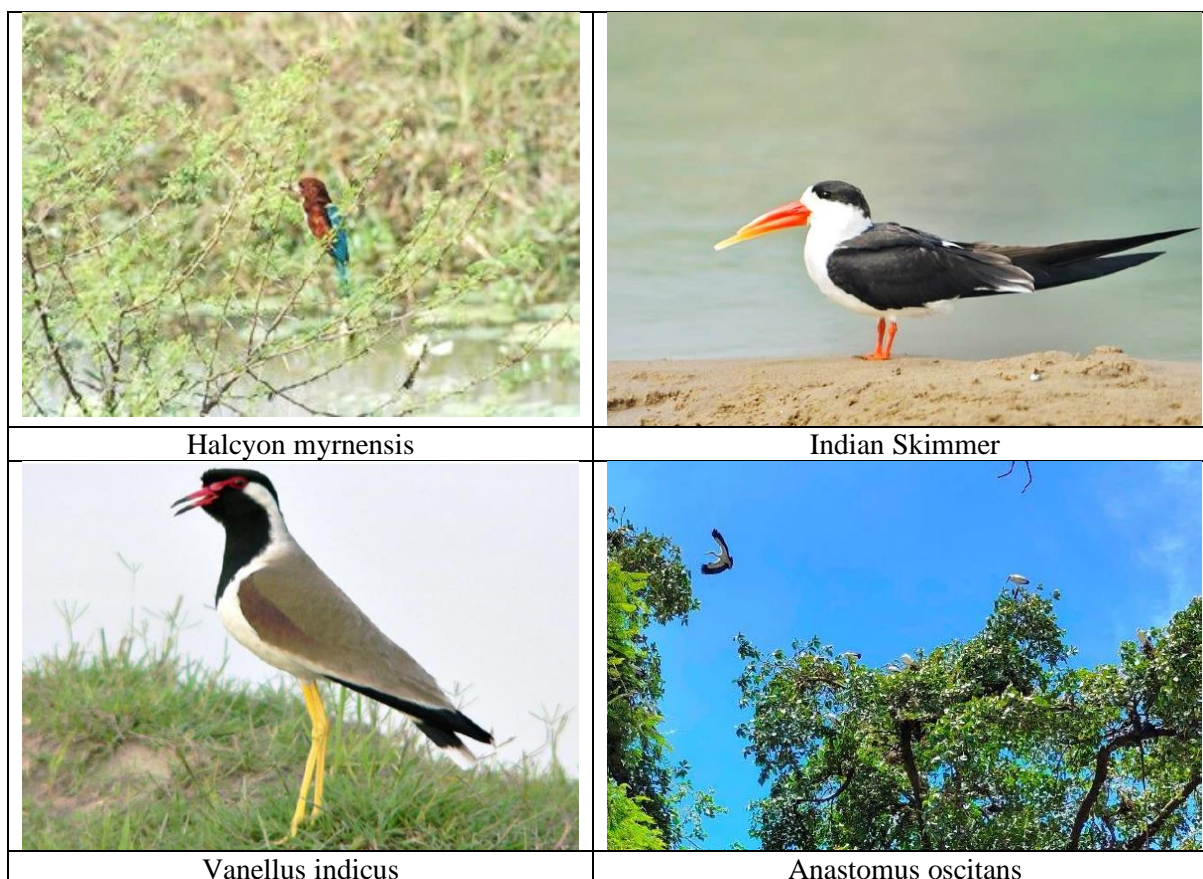
No.	Family	Scientific Name	Local Name	IUCN Category
64	Rhamnaceae	<i>Ziziphus mauritiana</i>	Beri	LC
Herbs				
65	Amaranthaceae	<i>Achyranthes aspera</i>	Apang	-
66	Asteraceae	<i>Ageratum conyzoides</i>	Dochunty	-
67	Amaranthaceae	<i>Amaranthus spinosus</i>	Katanotey	-
68	Amaranthaceae	<i>Alternanthera sessilis</i>	Garundi	LC
69	Papaveraceae	<i>Argemone mexicana</i>	Seyalkanta	-
70	Nyctaginaceae	<i>Boerhavia diffusa</i>	Punarnaba	-
71	Nyctaginaceae	<i>Boerhavia repens</i>	Ghodapuruni	-
72	Umbelliferae	<i>Centella asiatica</i>	Thankuni	LC
73	Cleomaceae	<i>Cleome viscosa</i>	Hurhure	-
74	Fabaceae	<i>Clitoria ternatea</i>	Gokarna	-
75	Commelinaceae	<i>Commelina benghalensis</i>	Kansiri	LC
76	Euphorbiaceae	<i>Croton bonplandianum</i>	Bon-tulsi	-
77	Caesalpiniaceae	<i>Cassia tora</i>	Chakundo	-
78	Cyperaceae	<i>Cyperus</i> spp.	Motha	-
79	Cyperaceae	<i>Cyperus rotundus</i>	Motha	LC
80	Papilionaceae	<i>Crotalaria retusa</i>	Atasi	-
81	Solanaceae	<i>Datura stramonium</i>	Dhatura	-
82	Euphorbiaceae	<i>Euphorbia hirta</i>	Boro-karni	-
83	Rubiaceae	<i>Ixora coccinea</i>	Rangan	-
84	Mimosaceae	<i>Mimosa pudica</i>	Lajjabati	LC
85	Musaceae	<i>Musa x paradisiaca</i>	Kanch-kala	LC
86	Mosaceae	<i>Musa balbisiana</i>	Kodoli	LC
87	Lamiaceae	<i>Ocimum sanctum</i>	Tulasi	-
88	Asteraceae	<i>Parthenium hysterophorus</i>	Gajar Ghas	-
89	Solanaceae	<i>Physalis minima</i>	Bon-tepari	-
90	Phyllanthaceae	<i>Phyllanthus urinaria</i>	Hazarmani	-
91	Acanthaceae	<i>Ruellia tuberosa</i>	Popping pod	-
92	Solanaceae	<i>Solanum nigrum</i>	Kakmachi	-
93	Asteraceae	<i>Tridax procumbens</i>	Tridaksha	-
94	Typhaceae	<i>Typha angustifolia</i>	Patera	LC
95	Typhaceae	<i>Typha angustata</i>	Pankanis	LC
Climbers				
96	Liliaceae	<i>Asparagus racemosus</i>	Satamuli	-
97	Caesalpiniaceae	<i>Bauhinia vahlii</i>	Gront	-
98	Combretaceae	<i>Combretum roxburghii</i>	Punk	-
99	Cucurbitaceae	<i>Coccinia grandis</i>	Telakucha	-
100	Dioscoriaceae	<i>Dioscorea bulbifera</i>	Gachalu	-
101	Dioscoriaceae	<i>Dioscorea oppositifolia</i>	Shora-alu	-
Grasses				
102	Poaceae	<i>Apluda mutica</i>	Chunkarki	-
103	Poaceae	<i>Aristida depressa</i>	Lambi	-
104	Poaceae	<i>Chrysopogon fulvus</i>	Dholu	-
105	Poaceae	<i>Chrysopogon gryllus</i>	Dholu	-
106	Poaceae	<i>Chrysopogon montanus</i>	Dholu	-
107	Poaceae	<i>Cynodon dactylon</i>	Dhoob	-
108	Poaceae	<i>Eragrostis tenella</i>	Bharbusi	-
109	Poaceae	<i>Eragrostis unioides</i>	Kush	LC
110	Poaceae	<i>Heteropogon contortus</i>	Lamb, Sariala	-
111	Poaceae	<i>Imperata cylindrica</i>	Oolu	-
112	Poaceae	<i>Pennisetum orientale</i>	Fountain Grass	LC
113	Poaceae	<i>Thysanolaena maxima</i>	Phulijharu ghas	-
Others				
114		<i>Andropogon contortus</i>	Surwal	-
115		<i>Andropogon martinii</i>	Rohis	-

* Near Threatened (NT), Least Concerned (LC), Data Deficient (DD), NE (Not Evaluated)

Source: Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC, JST, IUCN red list

2) Fauna

All sites of the project affected area are completely covered with grasses & plantations along the road sides and have no major faunal diversity except Danapur Cantonment and SGB Park (Patna Zoo). A complete checklist of fauna from project affected area and surrounding of project affected area has been prepared. Lists of identified species are below. No mammal species are classified as endangered species on the IUCN Red List. 41 bird species were identified including Anhinga melanogaster, Mycateria leucocephala, Ciconia episcopus which are classified as Near Threatened under by the IUCN. In addition, 8 species of butterflies and 5 species of reptiles that are very common in the region were identified.



Source: JST

Figure 14-33 Photograph of avifaunal Species

Table 14-39 Identified species along the alignments (Mammals)

No.	Scientific Name	Common Name	IUCN Category
1	<i>Funambulus pennantii</i>	Palm Squirrel	LC
2	<i>Semnopithecus entellus</i>	Common Langur	LC
3	<i>Macaca mulatta</i>	Monkey Rhesus	LC
4	<i>Suncus murinus</i>	Chachundar	LC

Source: JST, IUCN red list

Table 14-40 Identified species along the alignments (Avifauna)

No.	Family	Scientific Name	Common Name	IUCN Category
1	Podicipitidae	<i>Tachybaptus ruficollis</i>	Little Grebe	LC
2	Pelecanidae	<i>Pelecanus onocrotalus</i>	Great White Pelican	LC

No.	Family	Scientific Name	Common Name	IUCN Category	
3	Phalacrocoracidae	<i>Phalacrocorax carbo</i>	Great Cormorant	LC	
4		<i>Anhinga melanogaster</i>	Oriental Darter	NT	
5	Ardeidae	<i>Ardeola grayii</i>	Indian Pond-Heron	LC	
6		<i>Ardea cinerea</i>	Grey Heron	LC	
7		<i>Ardea purpurea</i>	Purple Heron	LC	
8		<i>Butorides striata</i>	Striated Heron	LC	
9		<i>Nycticorax</i>	Black-Crowned Night Heron	LC	
10		<i>Bubulcus ibis</i>	Cattle Egret	LC	
11		<i>Casmerodius albus</i>	Great White Egret	LC	
12		<i>Egretta garzetta</i>	Little Egret	LC	
13		Ciconiidae	<i>Mycteria leucocephala</i>	Painted Stork	NT
14			<i>Ciconia episcopus</i>	Asian Woollyneck	NT
15	<i>Anastomus oscitans</i>		Asian Openbill	LC	
16	Threskiornithidae	<i>Pseudibis papillosa</i>	Red-naped Ibis	LC	
17	Anatidae	<i>Tadorna ferruginea</i>	Ruddy Shelduck	LC	
18		<i>Sarkidiornis melanotos</i>	African Comb Duck	LC	
19		<i>Dendrocygna bicolor</i>	Fulvous Whistling-duck	LC	
20	Dicruridae	<i>Dicrurus macrocercus</i>	Black Drongo	LC	
21	Rallidae	<i>Amaurornis phoenicurus</i>	White-breasted Waterhen	LC	
22		<i>Gallinula chloropus</i>	Common Moorhen	LC	
23	Cuculidae	<i>Eudynamis scolopaceus</i>	Western Koel	LC	
24	Charadriidae	<i>Vanellus indicus</i>	Red-wattled Lapwing	LC	
25		<i>Pluvialis fulva</i>	Pacific Golden Plover	LC	
26		<i>Charadrius dubius</i>	Little Ringed Plover	LC	
27		<i>Tringa totanus</i>	Common Redshank	LC	
28	Pycnonotidae	<i>Pycnonotus cafer</i>	Red-vented Bulbul	LC	
29	Alcedinidae	<i>Ceryle rudis</i>	Pied Kingfisher	LC	
30		<i>Alcedo atthis</i>	Common Kingfisher	LC	
31		<i>Halcyon smyrnensis</i>	White-breasted Kingfisher	LC	
32	Passeridae	<i>Passer domesticus</i>	House Sparrow	LC	
33	Corvidae	<i>Corvus splendens</i>	House Crow	LC	
34	Phoenicopteridae	<i>Phoenicopterus roseus</i>	Greater Flamingo	LC	
35	Apodidae	<i>Apus</i>	Common Swift	LC	
36		<i>Apus affinis</i>	Little Swift	LC	
37	Psittaculidae	<i>Psittacula krameri</i>	Rose-ringed Parakeet	LC	
38	Columbidae	<i>Columba livia</i>	Rock Dove	LC	
39		<i>Streptopelia decaocto</i>	Eurasian Collared-dove	LC	
40	Leiothrichidae	<i>Turdoides striata</i>	Jungle Babbler	LC	
41	Sturnidae	<i>Acridotheres tristis</i>	Common Myna	LC	

Source: JST, IUCN red list

Table 14-41 Identified species along the alignments (Butterflies)

No.	Scientific Name	Common Name	IUCN Category
1	<i>Catopsilia crocale</i>	Common Emigrant	-
2	<i>Eurema hecabe</i>	Common Grass Yellow	-
3	<i>Phalantha</i>	Common Leopard	-
4	<i>Precis lemonias</i>	Lemon Pansy	-
5	<i>Hypolimnas bolina</i>	Great Eggfly	-
6	<i>Ariadne merione</i>	Common Castor	-
7	<i>Danaus chrysippus</i>	Plain tiger	LC
8	<i>Hypolimnas misippus</i>	Danaid Eggfly	LC

Source: JST, IUCN red list

Table 14-42 Identified species along the alignments (Reptilia)

No.	Scientific Name	Common Name	IUCN Category
1	<i>Bufo stomaticus</i>	Marble Toad	LC

No.	Scientific Name	Common Name	IUCN Category
2	<i>Calotes versicolor</i>	Common garden lizard	LC
3	<i>Duttaphrynus melanostictus</i>	Common Indian Toad	LC
4	<i>Hemidactylus flaviviridis</i>	Northern House gecko	LC
5	<i>Euphlyctis hexadactylus</i>	Indian pond frog	LC

Source: JST, IUCN red list

3) Habitat Area

Danapur Cantonments is located along the Corridors as an Important Bird Area (IBA) as well as a Key Biodiversity Area (KBA) and is under the jurisdiction of the Indian Army so it is protected from general human disturbance. Since KBA is defined by expanding it to species other than birds using the IBA Criteria, IBA is included in definition of KBA. Therefore it will be referred to as Danapur Cantonment KBA from this chapter onwards. According to the Important Bird and Biodiversity Areas in India, Priority sites for conservation¹⁰ published in 2016, the following table is the key species which were not identified as vulnerable species in the IUCN Red List. However, depending on the habitat conditions of the key species, it may fall under the category of “critical habitat” in the JICA guidelines. Therefore, the field survey and secondary survey was conducted to identify key species and collect the habitat status mainly along the KBA of the Corridors in order to determine whether it is a critical habitat or not. The Corridor will pass on the Bally Road, which is one of the main roads in Patna, located in Danapur Cantonment KBA shown below.

Table 14-43 Key Species for KBA designation

General name	Scientific name	IUCN category	Identified in the survey
Mammal			
Nilgai	<i>Boselaphus tragocamelus</i>	LC	
Indian Grey Mongoose	<i>Herpestes edwardsii</i>	LC	
Avifauna			
Asian Openbill	<i>Anastomus oscitans</i>	LC	✓
Painted Stork	<i>Mycteria leucocephala</i>	NT	✓
Flora			
Common Indian Mango	<i>Mangifera indica</i>	DD	✓
Ashvattha tree	<i>Ficus religiosa</i>	LC	✓
Cluster fig	<i>Ficus glomerata</i>	LC	✓
Gum Arabic Tree	<i>Acacia nilotica</i>	LC	
Black Plum	<i>Syzygium cumini</i>	LC	✓
-	<i>Tamarindus indica</i>	LC	✓
-	<i>Acanthocephalus indicus</i>	NE	
-	<i>Dalbergia sissoo</i>	LC	✓

* Near Threatened (NT), Least Concerned (LC), Data Deficient (DD), NE (Not Evaluated)

Source: Important Bird and Biodiversity Areas in India, Priority sites for conservation

¹⁰ Important Bird and Biodiversity Areas in India, Priority sites for conservation, 2016, Bombay Natural History Society



Source: JST based on Important Bird and Biodiversity Areas in India, Priority sites for conservation

Figure 14-34 Positional Relation between Patna Metro and KBA



Source: JST

Figure 14-35 Danapur Cantonment KBA on Bally Rd.

4) Tree counting

Tree counting survey was carried out in 2020 along the proposed alignment, and the additional survey was also implemented in 2022 for the station sites. Tree with Girth at Breast Height (GBH) 30 cm have been counted. The alignment does not pass through any forest area, and there is no tree in Depot area. The total number of trees found in the proposed metro corridor and the station sites are 864 trees on Corridor 1 and 506 trees on Corridor 2. Basically, PMRCL will transplant all of the trees from the original place to another one because no tree cutting is allowed in the Law of Bihar. If tree cutting is required, or if any trees died, PMRCL will plant four trees newly instead of one affected tree as a compensation planting. Regarding the species of counted trees, no endangered species of trees have been noticed during field survey. Trees have been found of indigenous origin and common species like Euclyptus, Pipal, Jamun, Neem, Palm, Babool, Ber, Gulmohar and other planted trees. These species are those that are suitable for the climatic conditions of this place¹¹.

(3) Summary

Regarding *Aegle marmelos* and *Pterocarpus marsupium* which are classified as NT under the lower category of IUCN, their habitats have been identified through the tree counting survey. Therefore, mitigation measure of transplanting shall be taken or has already been taken in prior to the construction commencement. According to the fauna survey, some species, categorized as “Near Threatened”, are identified along the Corridor 1 and 2. Therefore, some mitigation measures should be taken to conserve the species as below.

¹¹ Updated Detailed Project Report for Metro Rail System in Patna, Jan 2021, PMRCL

- A preliminary survey should be conducted before the construction commencement and during construction in order to confirmation of nesting and flying observed by the construction contractors.
- Countermeasures such as avoidance of construction during their spawning and growing season should be considered if nesting or flying off the specified species is confirmed in the project area.

JST also asked experts' opinion and advice to collect further mitigation measures, and Mr. Abhinav Sahay, Assistant Professor, Environmental Sciences, Amity University in Patna, responded to us and suggested some conservation measures to mitigate any adverse impacts due to the Patna Metro project, which are as follows. Hence the proposed measures should be added in the EMP and EMoP.

- Compensatory afforestation with native trees.
- Reduction of noise pollution during night hours and within the environmental standards.
- Reduction of light pollution during night hours by keeping lights close to the ground, directed and shielded.

Regarding the issue of "critical habitat", Danapur Cantonment KBA has the possibility of being a "critical habitat" for the following reasons.

- Painted Stork, categorized as "Near Threatened" in the IUCN Red List, is identified in the KBA area.
- Nearly 3% of the breeding population of the Asian Openbill in South Asia is found in the KBA area as of 2012¹².

On the other hand, even if the KBA is determined as a critical habitat, this project does NOT lead to "significant conversion or significant degradation of critical natural habitats and critical forests" as mentioned in the JICA guideline due to the reasons below.

- Patna Metro construction in the KBA area shall be conducted within the boundary of Bally Rd., which is already developed. Additional development of the natural habitats area will be avoided.
- No significant conversion: the integrity of the critical natural habitat will NOT be significantly reduced due to the construction and operation.
- No significant degradation: the ecosystem function to conserve and maintain the native species in the KBA area will NOT decrease significantly due to the construction and operation.
- No species categorized as Critically Endangered (CR) and Endangered (EN), was identified in the survey
- Effective long-term mitigation measures and monitoring will be implemented.

From the above, it can be seen that the project complies with the JICA guidelines in this regard.

14.5.10 Hydrology

(1) Entire area of Patna Metro

According to the report on dynamic ground water resources of Patna district, 2020, the total annual ground water recharge of Patna district is 989,712,900 m³, total annual ground water extraction from irrigation, industry and domestic sectors 553,295,900 m³. Therefore, it can be said that the current stage of ground water development is 55.9%, which means that the stage of Patna district falls under "Safe category according to the index of Stage of Ground Water Extraction as shown in the table below. Also, the pre monsoonal and post monsoonal depth to water level varies from 4.8 - 13.82 Meters Below Ground Level (mbgl) to 3.85 - 13.27 mbgl in the study area.

¹² Important Bird and Biodiversity Areas in India, Priority sites for conservation

Table 14-44: Categorization of Assessment Unit Based on Quantity

Stage of Ground Water Extraction	Category
Less than 70%	Safe
From 70% to 90%	Semi-Critical
From 90% to 100%	Critical
Over 100%	Over Exploited

Source: Dynamic Ground Water Resources of Bihar, 2020

(2) Depot area

Regarding the depot area, there is no change in the amount of rainwater treated by the river, which flows south of the depot, before and after the construction. However, since the area is currently surrounded by rice paddies, it can be assumed that the rainfall will take time to reach the river as subsoil water. On the other hand, when it is in the operation phase, the rainfall on the roof of the facilities and on the paved surface will be drained into the river through installed rainwater pipes, which means that it takes less time to reach the river. Mitigation measures shall be required to prevent the overflow of water. Additionally, since embankment is scheduled at the construction phase, perforated sheet piles shall be required to secure groundwater flow, as well as to prevent landslides into the river during construction. On the other hand, since oily water will be generated by washing coaches and using oil for maintenance, it should be filtered in oil pits or septic tanks before flowing into the river.

14.5.11 Geology and Topography

According to a literature survey, there is no specified and valuable geology and topography in the study area.

The terrain of Patna city is mostly flat. The average elevation of the project site area is ranges range from 48-63m above the mean sea level (MSL). Geomorphologically the study area is covered with active flood plain and older flood plain. The project area is completely covered by the alluvium formation formed by Ganga River and basement of the alluvium is Vaishali formation and lithologically charactered with sand, silt and clay. The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. According to the Bureau of Indian Standards, the city falls under seismic zone-IV, in a scale of II to V (in order of increasing proneness to earthquakes).

14.5.12 Land Acquisition/ Resettlement

Details of Land Acquisition and Resettlement are reported in the SIA chapter (Chapter 15).

14.5.13 Poverty

Details of Poverty are reported in the SIA chapter (Chapter 15).

14.5.14 Indigenous and ethnic people

Indigenous people will not be affected by the Project. Details are reported in the SIA chapter (Chapter 15).

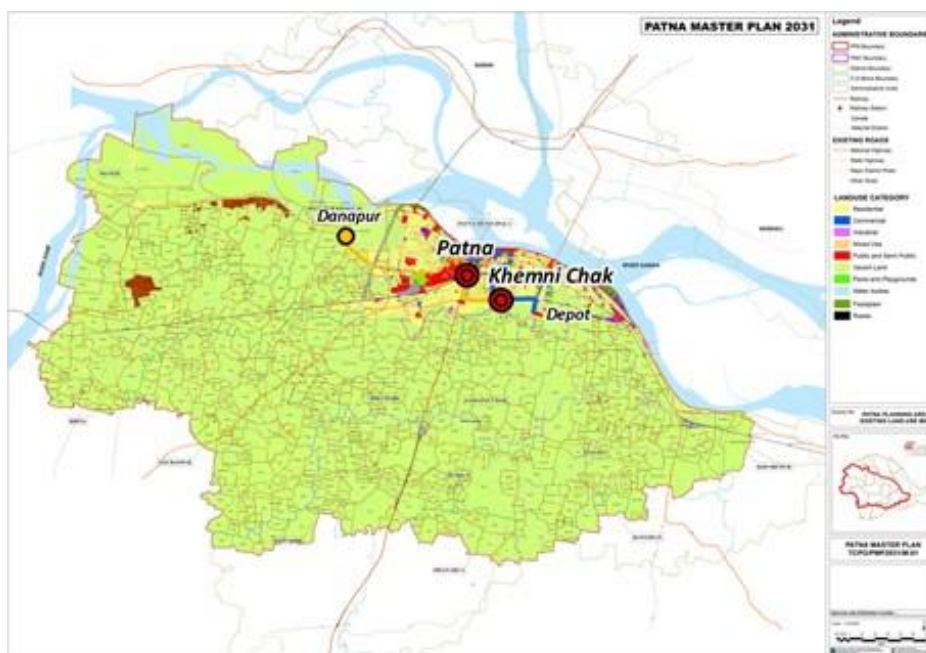
14.5.15 Local economy such as employment and livelihood, etc.

Details on the impacts on livelihoods and other modes of transportation are reported in the SIA chapter (Chapter 15).

14.5.16 Land use, utilization of local resources and ecosystem services

Patna city is undergoing very rapid changes in land cover and land use due to population growth, economic development, migration, and infrastructural innovations

Since this project will be implemented in an already urbanized area, it will not bring about major changes in land use. However, the proposed depot area currently contains agricultural land and is subject to land use change. According to the site inspection and the interview with local farmers in and around the proposed depot area, seasonal vegetables, paddy, wheat and millet are generally cultivated there, and the cultivation area (Light green colour zone in the below figure) spreads widely to the east and south from the depot area. Therefore, it can be said that a minor impact on land use and utilization of local resources expected. Additionally, JST conducted another interview survey for Land use and utilization of local resources including ecosystem services with 10 local people at each proposed station area in July 2022, which is 240 people in total. All of them opined that there would be no loss of land use or local resources by the project. On the other hand, regarding the question of ecosystem services, some of the respondents answered that they received ecosystem services by visiting Sanjay Gandhi Biological Park/ Patna Zoo as a relaxation and healing spot.



Source: Patna Master Plan 2031

Figure 14-36 Existing land use map

14.5.17 Water usage and its rights

According to the interview survey, the water usage is mainly for daily use such as bathing, drinking, washing and other purpose. Water is not used for economic purpose such as fishing activity.

As for drinking water, 110 water supply centres and about 1500 km of water supply pipeline are operated by Patna Municipal Corporation (PMC). Therefore, all the respondents have told that they use water supplied through tap water provided by PMC for daily usage and there is no use of nearby river water or lake water for fishing, fishery, washing for laundries and dishes etc.in the daily life.

14.5.18 Existing social infrastructures and services

(1) Sensitive receptors

According to the results of the field survey, there are 17 hospitals, 12 educational facilities such as schools and universities, and 2 religious facilities. As mentioned in the Noise and vibration part, some noise impact will be generated at the construction phase and operation phase along the Corridors. Therefore, some necessary mitigation measures should be taken in the both phases.

(2) Transport services

1) Bus

At present, bus service provided by Bihar State Road Transport Corporation (BSRTC) and three-wheel Auto including rickshaws are used by the citizens in Patna.

According to the information collected from BSRTC office, the BSRTC buses have started to operate in the city since 2018. Total number of city buses are about 600; 350 private busses, 130 of PPP mode busses, 90 of Nigam Buses and 25 electric buses. Although these number of bus might be one factor of the traffic congestion in Patna city, total number of daily passengers are 38,000, which means that Bus transport services shall be essential for the citizens. However, even though it is a main means of transportation, bus passengers are very eager to welcome Patna Metro as they are facing the traffic accidents and very crowded in Buses according to the interview survey. So it can be said that they have no choice but to get on a bus. On the other hand, bus drivers are also willing to welcome Patna Metro as they expect to reduce of traffic volume on road, and to decrease accidents and honking which is the major problem in Patna city. The details are mentioned in the “Consideration on impacts on existing transportation industry” of SIA chapter.

2) Three-wheel auto

JST also conducted another interview survey with 30 three-wheel auto drivers at Patna Junction, Gandhi Maidan, Saguna More and Mithapur. Most of them answered with satisfaction with Patna Metro Project and they added that they could have chances to drive short distance repeatedly by picking up passengers at the operation phase more often than now with the same as current cost. Because there are agents of three-wheel drivers who decide the rates and routes for drivers. The upcoming metro project will reduce the driving distance but will increase their number of trips per day. Overall, they are happy with the project. They also hope that the number of auto will be decentralized with each metro station, which may help them to get rid from the agents’ harassment. The details are mentioned in the “Consideration on impacts on existing transportation industry” of SIA chapter.

14.5.19 Maldistribution of benefit and damage

The results of the interviews indicate that the most important requirement of the respondents is transportation, traffic management, noise pollution control, job opportunities, education and health facility. These conditions may be hindered during the construction period partially and temporally due to access blocking by fencing and traffic control. As a result, some areas may receive negative impact on their livelihood and daily life temporally.

14.5.20 Local conflict of interest

As a result of the interview survey, respondents are expecting job opportunity in the Patna Metro project during the construction and operational phase. Also, respondents are highly unsatisfied towards the current situation of Patna City regarding traffic safety, green environment, air pollution and noise pollution. Therefore, the Patna Metro Project will strongly contribute to improve not only the transportation conditions prominently securing the traffic conditions but also the atmospheric environment as the number of vehicles on the road will reduce. Local people will prefer to travel by

Patna Metro, which will make the transport system for the people cheaper, safer and less time consuming.

14.5.21 Cultural Heritage

There is no cultural or historical heritage structure along the Corridors, but there are six heritage structures in Patna as shown in the table below. According to the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010, all construction projects shall be regulated within 100 m from the boundary of prohibited area and 200 m from the boundary of regulated area, and the permission of Archaeological Survey of India (hereinafter referred to as "ASI".) shall be required. Although the closest heritage structure to the Corridors is Golghar, Patna, the separation of 290 m from the Corridor 2 is secured. Therefore, the permission of ASI for the project is not required. According to the vibration prediction using the formula mentioned in "Noise and vibration", the result value at the closest point from Golghar, Patna is approx. 33 dB, which is negligible. Therefore it can be seen that no impact is occurred.

Table 14-45 List of Heritage Structure in Patna

No.	Name of structure	Location	Closest St.	Distance from alignment
1	Palace of Ashoka	Kumrahar, Patna	Zero Mile	Approx. 1.55km
2	Bulandibagh	Bulandipur, Patna	Moin Ul Haq Stadium	Approx. 1.94km
3	Choti Pahari	Chhotipahari	Zero Mile	Approx. 0.70 km
4	Wooden foundations and ancient mauryan walls	Sandalpur	Moin Ul Haq Stadium	Approx. 1.25 km
5	Mir Ashraf's Jama Mosque	Ashraf Masjid, Patna	Zero Mile	Approx. 3.78 km
6	Golghar, Patna	Ashok Rajpath, Patna	Gandhi Maidan	Approx. 0.29 km

Source : Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC



*No.5 was omitted due to out of range on the Map

Source : Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC

Figure 14-37 Location Map of Heritage Structure in Patna

14.5.22 Landscape

The photos, taken in May 2022, at the representative point on Corridor 1 and 2 are shown as follows. As mentioned previously, the height of the Patna Metro viaduct is approx. 13.4 m. As of September 2022, there is some multiple storied building, along with the elevated section of Corridor 1 in which has 6 traffic lanes, and Corridor 2 in which has 4 traffic lanes.



Source: JST

Figure 14-38 Proposed sectional view and current situation

It is considered that enough road width will be secured on Corridor 1 at the operation phase, and there will be less oppressive feeling from the Patna Metro viaduct. On the other hand, parallel section with Corridor 1 and 2 will not have enough open space due to the 2 alignment on the 4 traffic lanes and a side road, so it would be better to install a wall greening panel as a mitigation measure to relieve the oppressive feeling. The colour of the panel should avoid eccentric vivid colours which are different from the surrounding landscape.

14.5.23 Gender

Details are mentioned in the “Consideration on Gender” of SIA chapter (Chapter 15).

14.5.24 Children’s right

According to the past media releases¹³, child labor cases are reported and the state government has been challenging to solve the issues through a number of schemes in collaboration with different agencies, including UNICEF, and other volunteers. According to the interview survey conducted in July 2022, all of the respondents opined that no child labour has been experienced in their community.

14.5.25 Health (Infectious diseases such as HIV/AIDS, etc.)

During the study, no cases of sanitation and infectious diseases were reported among the respondents in the study area. However, the most common diseases prevalent in the city are Cough, Cold, Diarrhea, Typhoid mainly higher during rainy season and Diabetes. Besides that, risk of HIV/AIDS spread-out shall be considered among construction worker because that is a common social health risk. COVID-19 including following variations are also the social health issue especially in a crowded public space such as train coaches and stations.

14.5.26 Labor environment including labor safety

There are several laws and regulations on labor environment in India, such as Industrial Relations Code (2020), Occupational Safety, Health and Working Conditions Code (2020), Code on Social Security (2020) and Code on Wages (2019). These principal laws shall be respected during the construction phase. The construction of the project includes variety of labor environment such as work at high places, work underground, work along with roads with traffic, and etc. Therefore, different types of risks for

¹³ <https://timesofindia.indiatimes.com/city/patna/dy-cm-steps-taken-to-eradicate-child-labour/articleshow/92167716.cms>

labor safety are expected during the construction stages.

14.5.27 Accidents

Annual traffic accident information for the city of Patna is shown in the table below. In 2019, the number of traffic accidents was high, with 460 accidents occurring. Despite the increase and decrease in the number of accidents, the number of fatal accidents is on the rise.

Table 14-46: Traffic Accidents in Patna City

	2017	2018	2019	2020
Number of Traffic Accidents	400	347	460	347
Deaths recorded due to Traffic Accidents	132	139	171	172
Number of cases Injured due to Traffic Accidents	213	198	286	223

Source: District transport office, Gandhi Maidan

14.5.28 Cross-border impact and Climate change

According to the DPR 2021, the annual vehicle km saved is shown below, and Ministry of Housing and Urban Affairs (MoHUA) has issued the volume of pollutant (gram per km) including CO₂ for different modes. Therefore, the CO₂ reduction effect due to the opening of the Patna Metro can be calculated as follows. CO₂ emission might be reduced by 58,111 (t-CO₂) in 2024, and by 128,631 (t-CO₂) in 2051, which can be said that Patna Metro will make a significant contribution to the reduction of greenhouse gases.

Table 14-47: Traffic Accidents in Patna City

Mode	Volume of CO ₂ emitted (g/km-CO ₂)	Annual Vehicle km saved (million km)				Annual saved CO ₂ emission (t-CO ₂)			
		2024	2031	2041	2051	2024	2031	2041	2051
Bus	787.72	7.9	11.1	11.8	13.8	6,223	8,744	9,295	10,871
Car	139.52	95.8	168.8	175.9	207.3	13,366	23,551	24,542	28,922
2-Wheelers	28.58	737.1	1146.8	1395.2	1735.3	21,066	32,776	39,875	49,595
3-Wheelers	77.89	201	316.7	347.9	435.4	15,656	24,668	27,098	33,913
Taxi	139.52	12.9	23.5	32.6	38.2	1,800	3,279	4,548	5,330
Total		1,055	1,667	1,963	2,430	58,111	93,017	105,358	128,631

Source: JST calculated through DPR, 2021

On the other hand, the Metro operation will produce some amount of greenhouse gases (GHG) by using electricity for its operation, the amount is not significant especially comparing with the effect of reducing road traffic which produce much GHG. No other impact on cross-border and climate change was observed and expected.

14.6 Impact Assessment

This section describes the possible environmental and social impacts during the pre-construction, construction, and operation phase of the project. Predictions of the impacts were conducted based on the results of scoping, analysis of the project components, and the baseline data including field survey results.

Scoping for the project was discussed for both main project and related facilities including quarry, borrow-pit, etc. However, the impact assessment for such related facilities shall be omitted because it has not been decided at the time of feasibility study. Therefore, the prediction and evaluation of the environmental assessment for the items will be carried out in the following phases.

The result of the environmental and social impact assessment is shown in the table below along with the results of the assessment made earlier at the scoping stage to allow comparisons to be made.

Table 14-48: Results of Assessment for the Project

Category	No.	Impact Item	Evaluation				Reason for evaluation
			Scoping		Based on Survey		
			Pre-CS/CS	OS	Pre-CS/CS	OS	
Pollution	1	Air pollution	✓	✓	B-	B±	CS: Emission gas (NO _x , SO _x) and dust (PM) will have a temporary negative impact on the air quality by construction machineries and vehicles. (Baseline data showed PMS at each measuring point exceeded the standard) OS: - Positive impact will be offered by the decrease in traffic along the Patna metro lines. - Pollutant concentration may be occurred around the ventilation facilities in the underground sections and substations.
	2	Water pollution	✓	✓	B-	B-	CS: - Turbid water will be generated in surface water and ground water along the Patna metro alignment due to civil works. - Turbid water will be generated at a proposed site for depot due to soil filling works. - There is a possibility of discharged organic wastewater from the base campsite. OS: There is a possibility of discharged organic wastewater from the toilet installed at every station and the depot.
	3	Waste	✓	✓	B-	B-	CS: - General waste and excreta will be generated from the base campsite. - Construction waste such as soil and deforestation trees are generated. - Muck due to tunnel excavation is generated and some of them may be not suitable for reuse. OS: General waste and excreta will be generated from every station and a depot.
	4	Soil contamination	✓	✓	B-	B-	CS: Oil leaks from construction equipment may cause soil contamination. OS: Soil contamination may occur at the proposed depot due to oil leaks of related facilities, rolling stock coating.
	5	Noise and vibration	✓	✓	B-	B±	CS: Noise and vibration will be generated by construction machineries and vehicles. OS: Metro rail can reduce noise and vibration from road traffic by mode changes. Metro rail, however, may generate additional noise and vibration by itself at elevated sections. On the other hand, no impact on noise and vibration occurred at underground section according to the prediction result.
	6	Ground subsidence	✓	✓	B-	B-	CS: There is possibility of ground subsidence because of liquefaction under the elevated section, land filling at the deport area, and underground construction sections including stations. OS: There is no significant impact. However, monitoring in the operation phase should be necessary as a follow-up observation and maintenance.
	7	Offensive odor	✓	✓	B-	B-	CS: Offensive odor may occur depending on the volume of general waste etc. from construction sites and basecamp sites. OS: Offensive odor may occur depending on the volume of general waste etc. from every station and the depot.
Natur	8	Protected area	✓	✓	B-	D	CS: Although Sanjay Gandhi Botanical Park (SGB Park or Patna Zoo) is designated as a protected area, it is managed by the Government of Bihar as Park-cum-Zoo, whose management type is different from that of other natural

Category	No.	Impact Item	Evaluation				Reason for evaluation
			Scoping		Based on Survey		
			Pre-CS/CS	OS	Pre-CS/CS	OS	
							protected areas which risks disorderly destruction. However, the area may have ecological functions in urban environment of Patna. Therefore, general considerations to mitigate impacts from the project regarding pollution items shall be taken in both construction and operational phases.
							OS: No impact on noise and vibration occurred at underground section according to the prediction result. Because Sanjay Gandhi Botanical Park (SGB Park or Patna Zoo) is located near underground section of Patna Metro.
	9	Ecosystem	✓	✓	B-	B-	CS: - There is a negative impact on the ecosystem through deforestation of trees due to the construction of viaducts, underground stations and a depot. - Since a partial section pass through Danapur Cantonment KBA, the impact on ecosystem, especially on avifaunal diversity, such as light pollution, noise and vibration are expected.
							OS: Since a partial section pass through Danapur Cantonment KBA, the impact on ecosystem, especially on avifaunal diversity, such as light pollution is expected.
	10	Hydrology	✓		B-	D	CS: - Some impact on hydrology around the project site including TBM sections will occur. - Since a river flow along the south of the depot candidate site, the depot construction may affect the surrounding hydrology.
							OS: Operation of the Metro may not cause any impact on surrounding hydrology.
	11	Geology and Topography	✓	✓	D	D	CS/OS: There is no specified and valuable geology and topography in and around the alignment. It was not observed any risks of slope collation and soil erosion in the proposed site for the depot. Also, the depot is designed as the structure of retaining wall instead of slope structure which can cause soil erosion in some situations.
Social Environment	12	Land acquisition/ Resettlement	✓	✓	A-	D	Pre-CS / CS: Resettlement in some areas in elevated areas have been started and structures have been resettled already (84 households) and 62 households are remaining as of July 2022. Besides the physical relocation, private Land acquisition and resettlement is required. Project affected households is going to take impact on their property and livelihood. OS: Economic displacement may be occurred due to the Metro operation. But according to the SIA report 2022, - The livelihood of the title holder PAHs will suffer little negative impact because they receive 212 percent price of minimum market value for their loss of land and assets. - The non-title holder PAHs will find new locations for residences and commercial activities in adjacent areas in Patna metro area, and they will be eligible for compensations for loss of assets and various additional assistances for livelihood rehabilitation. It is assumed, therefore, that there will be little negative impact on the livelihood of the non-title holder PAHs after resettlement.
	13	Poverty	✓		A-	D	Pre-CS: Households under poverty line living in the project affected areas (7 families) are affected due to resettlement.

Category	No.	Impact Item	Evaluation				Reason for evaluation
			Scoping		Based on Survey		
			Pre-CS/CS	OS	Pre-CS/CS	OS	
							OS: Since there is no land acquisition and resettlement during the operation phase, operation activities that have a negative impact on people with poor class are not expected.
	14	Indigenous and ethnic people	✓		D	D	Pre-CS and CS: Indigenous people was not observed in the project affected areas based on a survey on private land by the provincial government as well as past statistic data. OS: No impact is expected with the reasons same as the case of Pre-CS and CS.
	15	Local economy such as employment and livelihood, etc.	✓		B±	B±	Pre-CS and CS: - New employment and job opportunity may be created with construction of Patna Metro. - A negative impact on the livelihood of PAPs may be generated depending on land acquisition and resettlement including business loss due to loss of access by fencing works around the construction areas. OS: - New employment may be created with opening of Patna Metro. - A positive impact for the local economy will be generated such as timesaving for traveling within Patna city and alleviation of traffic congestion. - With opening of Patna Metro, drivers of route buses and three wheelers, which are overlapping their operation area of transportation, may lose their opportunities. However, positive expectation were observed because they can find another function such as feeder transportation between Patna Metro stations and customers final destination.
	16	Land use and utilization of local resources	✓	✓	D	B-	CS: Construction work in the area will not bring any significant changes in the land use pattern. The development of station buildings will not have any major significant impact on the future land use. OS: There is no land acquisition and resettlement in the operation phase. However, negative impact may occur from disordered development and rough-and-tumbled utilization of local resources around the Corridors and stations.
Social Environment	17	Water use and its rights	✓		B-	D	CS: Land acquisition and construction work such as TBM method may affect drinking water sources such as wells. OS: There is no impact on water use because of no land acquisition in the operation phase.
	18	Existing social infrastructure and services	✓		B-	B+	Pre-CS and CS: - A negative impact on sensitive facilities such as schools, hospitals, and community centres may occur due to land acquisition and traffic issues such as congestion and accidents. - The impact of the relocation of underground facilities is expected due to the construction work, which cause a temporal power outage in the surrounding area. OS: Improvement of accessibility by installing Patna Metro stations is expected, by which there is a possibility of a positive impact on the use of social infrastructure such as school, hospital, etc.
	19	Maldistribution of benefit and damage	✓	✓	B-	D	CS: Depending on the construction area, there may be a maldistribution of benefit and damage such as the prohibition of road crossing and setting of the detour route. OP: Outstanding maldistribution of benefit is not expected.
	20	Local conflict of interest	✓		B-	D	CS: - Residents and municipalities may demand that construction contractor should supply employment opportunities equally as construction workers.

Category	No.	Impact Item	Evaluation				Reason for evaluation
			Scoping		Based on Survey		
			Pre-CS/CS	OS	Pre-CS/CS	OS	
							- Pollution status may cause conflict along the construction affected areas OP: Outstanding impact on local conflict of interest is not expected.
	21	Cultural Heritage	✓	✓	D	D	Pre-CS/CS: No historical/ cultural monument will be affected as a result of the proposed development of project. Hence no prior permission is envisaged. OS: No historical/ cultural monument will be affected as a result of the proposed development of project. Hence no prior permission is envisaged.
	22	Landscape		✓	D	D	CS: There is no landscape conservation area designated by law and regulation in the vicinity of the elevated section. OS: Since the construction is mainly conducted in the central part of the existing road and underground, there is no impact on landscape.
	23	Gender	✓	✓	B-	B-	CS: There may be a gender gap regarding wage, salary, and treatment as construction workers. OS: - Employment opportunities for women will be limited concerning Metro operation. - Female passengers may give up getting on a train because of being afraid of congestion on the train during commuting time.
	24	Children's right	✓		B-	D	CS: - There might be a possibility of child labour in construction sites. - Construction work may interfere with going to educational facilities. OS: There is no impact on children's rights by Patna Metro operation.
	25	Health (Infectious diseases such as HIV/AIDS, etc.)	✓	✓	B-	B-	CS: Infectious diseases such as HIV/AIDS, COVID-19, etc. may be spread by the inflow of construction workers. OS: Infection of COVID-19 may occur in the train due to three Cs (closed spaces, crowded places, and close-contact settings) if the epidemic continues until the operation phase.
	26	Labor environment including labor safety	✓	✓	B-	D	CS: Occupational injuries / disease may occur with inappropriate labor environment including safety management in the construction sites, such as working on high structures and in underground spaces. OS: There is no big change in the labor environment for residents by Patna Metro operation.
Others	27	Accidents	✓	✓	B-	D	CS: - Since construction-related vehicles use arterial roads on the Patna Metro Corridors, there is a possibility of increasing traffic accidents. - Detour and caused traffic congestions may increase the number of traffic accidents. OS: Outstanding and direct impact on traffic accident due to the Metro operation is not expected.
	28	Cross-border impact and climate change	✓	✓	B-	B±	CS: Greenhouse gas emissions will increase by reducing the absorbed amount of greenhouse gas by cutting street trees along the alignment, operation of construction heavy machinery, and construction of structures. OS:

Category	No.	Impact Item	Evaluation				Reason for evaluation
			Scoping		Based on Survey		
			Pre-CS/CS	OS	Pre-CS/CS	OS	
							- Since the traffic volume along the Corridors will reduce due to Patna Metro operation, the reduction of greenhouse gases can be expected. - It is conceivable that greenhouse gases will be generated due to the electric consumption by Patna Metro operation.

Pre-CS: Pre-Construction Stage, CS: Construction Stage, OS: Operation Stage

A+/-: Significant positive/negative impact is expected, B+/-: Positive/Negative impact is expected to some extent, C: Extent of impact is unknown, D: No impact is expected

Source: JICA study team

14.7 Environmental Management Plan

14.7.1 Retroactive verification of EMP for the section under construction

Patna Metro construction project has already been commenced partially in the section of both corridors. PMRCL prepared their own Environmental Management Plan (EMP) for the section in prior to the construction commencement and is following and implementing the EMP shown below. The EMP are set for a wide range of environmental and social items during construction, but it does not cover all designated items by the JICA guidelines, especially social consideration items: Existing social infrastructure and services, Gender, Local conflict of interest etc. Regarding these social consideration items, currently there are no particular issues due to the ongoing construction work, but complaints from local people about dust and traffic congestion etc. have been confirmed. Therefore, PMRCL shall be requested thorough compliance with EMP prepared by JST. Regarding the operation phase, the EMP is limited to noise, vibration and water quality, it is considered insufficient. Therefore, PMRCL shall follow the EMP prepared by JST.

Table 14-49: Environmental Management Plan prepared by PMRCL

Environmental Impact item	Mitigation Measures Taken or to Be Taken	Time Frame	Implementation Body	Responsibility Body
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimize the land disturbance to avoid environmentally sensitive areas.	During Design	DPR and design consultant	PMRC/DMRC
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	PMRC/DMRC
Flood	Bridges shall be well designed	During Design	DPR and design consultant	PMRC/DMRC
Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-IV.	DPR and design stage	DPR and design consultant	PMRC/DMRC
PRE -CONSTRUCTION STAGE				
Water requirement	The requirement of water for construction purpose etc. shall be planned and shall be arranged from available and authorized sources in order to avoid digging of Tube wells.	Pre-construction stage	Contractor	PMRC/EMP implementing agency
Disposal of final treated effluent from treatment plant	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact on receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage/ and pre-construction of treatment plant	Contractor	PMRC/EMP implementing agency
Batching Plant and Casting Yard	These facilities to be located away from habitation. Consent to Establish and Consent to Operate to be taken from PCB and to comply with all stipulations.	During Pre-construction Stage	Contractor	PMRC/EMP implementing agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	PMRC/EMP implementing agency
Dust	Water should be sprayed during construction phase, wherever it is required to avoid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During construction	Contractor	PMRC/EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards. No vehicle without valid PUC certificate would be allowed at Construction Sites.	Beginning with and continuing throughout construction period	Contractor	PMRC/EMP implementing agency

Environmental Impact item	Mitigation Measures Taken or to Be Taken	Time Frame	Implementation Body	Responsibility Body
Equipment Selection maintenance and operation	Construction plants and equipment will meet acceptable standards for emissions and will be maintained and operated in a manner that ensures that relevant air, noise, and discharge regulations are met.	During construction	Contractor	PMRC/EMP implementing agency
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Machinery to be provided noise barriers (Stone walls and plantation) for silence zones including schools and hospitals.	Beginning and through construction	Contractor	PMRC/EMP implementing agency
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak velocity as given in Environmental Manual	Beginning and through construction	Contractor	PMRC/EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into any rivers, drainage and irrigation system	Throughout construction period	Contractor	PMRC/EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughout construction	Contractor	PMRC/EMP implementing agency
Sewerage disposal during construction at Service Centers	A minimum distance of any sewage or toilet facility from water sources should be 200 meters.	Throughout construction period	Contractor	PMRC/EMP implementing agency
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage tank and sanitation facilities. Waste in septic tanks will be resettled periodically. Drinking water will meet Indian National Standards. Garbage will be collected in a tank and disposed of daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.	Before and during building of construction camps	Contractor	PMRC/EMP implementing agency
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only. All environmental mitigation measures shall be enforced at Quarry site also.	During construction	Contractor	PMRC/EMP implementing agency
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation resettled will be replaced according to Compensatory Afforestation Policy under the Forest Conservation Act. Four trees will be planted against every tree felled as per norms.	During and after completion of construction activities	PMC	PMC/PMRC
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	PMRC/ Traffic department
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	PMRC/ Traffic department

Environmental Impact item	Mitigation Measures Taken or to Be Taken	Time Frame	Implementation Body	Responsibility Body
Safety with vehicles, people and Livestock and signage	Safety education and fines. Allow for adequate traffic flow around construction areas. Provide adequate signage, barriers and flag persons for safety precautions. Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions	During construction	Contractor	PMRC/ Traffic department
Increase in disease Water-borne Insect-borne Communicable diseases	Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies. Provide adequate sanitation and waste disposal at construction camps. Provide adequate health care for workers and locate camps away from vulnerable groups, if any	During construction At start-up Throughout construction	Contractor	PMRC/EMP implementing agency
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	PMRC/EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	PMRC/EMP implementing agency	PMRC/EMP implementing agency
WATER				
Maintenance of Storm Drainage System	The urban drainage systems will be periodically checked and resettled so as to ensure adequate storm water flow.	Beginning and end of monsoon	PMRC/EMP implementing agency	PMRC/EMP implementing agency

Source: Detailed Project Report 2021, PMRCL

The following photos illustrate current mitigation and monitoring practices. PMRCL has taken measures to deal with dust and traffic congestion, which are the most common complaints from local residents, but since further complaints are still delivered by local residents, it is necessary to analyze the complaints and focus on spot areas to address them.

Table 14-50: Implementation status of Environment Management Plan

	
Use of nozzle-based mist system for dust suppression	Water sprinkling in dry season



Dust collector in batching plant



Wheel washing facility



Covering of conveyor belt



Covering of dry soil/sand at site



Use of bio toilet at site









Top soil conservation at Moin ul Haque stadium



Regular noise monitoring



Use of silent Diesel Generator set with appropriate stack height

	
<p>Recycle of C & D waste for making flower pot</p>	<p>Recycle of fly ash for making bricks</p>
	
<p>Use of color coded dust bin for waste segregation</p>	<p>Hazardous waste storage</p>
	
<p>Traffic Diversion works</p>	<p>Morning gathering, differentiate positions and responsibilities by the helmet color</p>

Source: Monthly Progress Report Patna Metro Rail Project, PMRCL

14.7.2 Environmental Management Plan for the section to be constructed

EMP including mitigation measures has been prepared negative or potentially negative impacts mentioned so that it should be examined for respective project stages so that the project can achieve the intended objectives while minimizing accompanied environmental and social negative impacts. The costs, for mitigation measures and their implementation, are also included as follows.

The below table shows a preliminary set of mitigation measures for the impact items evaluated “A-” or “B-” in the matrix of Results of Assessment as above mentioned.

Table 14-51: Proposed Mitigation Measures against expected Impacts (Pre-Construction or Construction Phase)

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
1-a	Air pollution	Emission gas (NO _x , SO _x) and dust (PM) will have a temporary negative impact on the air quality by construction machineries and vehicles.	Regular preventive maintenance service of construction equipment and machinery should be strictly implemented and should require conducting daily routine equipment and machinery check-ups to ensure that there are in the optimum working conditions.	Construction Contractor	PIU	Included in construction cost
1-b			The proper work schedules should be considered not to concentrate the construction equipment at a certain point for a long time.			
1-c			To reduce the dust, the periodical water spray should be taken.			
1-d			Around the construction site is fenced as high as 2-2.5 m.			
2-a	Water pollution	<ul style="list-style-type: none"> Turbid water will be generated in surface water and groundwater along the Corridors due to civil and excavation works. Turbid water will be generated at a proposed site for depot due to soil filling works. There is a possibility of discharged organic waste water at an installed base campsite. 	Washing the construction tools in limited areas where there are appropriate facilities for water treatment for discharge	Construction Contractor	PIU	Included in construction cost
2-b			Construction waste should be treated at a designated site and disposed of following the instruction of management authority and rules. If the waste must be kept at the construction site, the tarpaulin should be covered on it.			
2-c			In construction works near water bodies, turbid waste water shall be treated at designated sites and released again.			
2-d			Temporary sanitation facilities with septic tanks such as portable (mobile) toilets and garbage bins will be provided by the contractors to ensure that the domestic wastes to be generated by the construction personals are properly handled and not thrown into the drainage to prevent further pollution.			
3-a	Waste	<ul style="list-style-type: none"> General waste and excreta will be generated from the base campsite. Construction waste such as soil and deforestation trees are generated. Muck due to tunnel excavation is generated. 	Construction waste generated from the construction and camp sites should be treated at a designated site and disposed of according to the instructions of management authority and rules. If the waste must be kept at the construction site, the tarpaulin should be covered on it.	Construction Contractor	PIU	Included in construction cost
3-b			Generated waste could be utilized for other purpose such as land filling depending upon the suitability.			
4-a	Soil contamination	<ul style="list-style-type: none"> Excavated soil at the construction site may be contaminated. Oil leaks from construction equipment may cause soil contamination. 	Excavated soil shall be treated at the designated site and disposed of following the instruction of management authority and rules. If the waste must be kept at the construction site, the tarpaulin should be covered on it.	Construction Contractor	PIU	Included in construction cost

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
4-b			Daily maintenance of construction equipment and vehicles.			
4-c			Soil sampling and laboratory analysis in order to check soil contamination shall be done.			
5-a	Noise and vibration	Noise and vibration will be generated by construction machineries and vehicles.	Noise suppressors such as mufflers will be installed whenever deemed necessary to maintain the noise generated by various heavy equipment and other construction machinery within permissible limits.	Construction Contractor	PIU	Included in construction cost
5-b			High noise-generating construction activities will be scheduled during daytime only (6:00 – 22:00) to avoid noise disturbance to adjacent residential and commercial areas and other noise-sensitive areas. In the case of academic facilities, the activities should be considered during the night time not to interfere with the class-works.			
5-c			Around the construction site is fenced as high as 2-2.5 m.			
5-d			Use low-noise and vibration machinery for construction such as piling			
5-e			If cracks, fissures, etc. occur in the surrounding structures during the construction of the underground section, the repair of such cracks, fissures, etc. shall be covered by the compensation.			
6-a	Ground subsidence	There is a possibility of ground subsidence in case of the soft foundation under the elevated section, depot area and underground construction sections including stations.	Application of appropriate construction measures such as earth retaining wall, penetration of piles to the support layer, and etc.	Construction Contractor	PIU	Included in construction cost
6-b			Application of ground reinforcement measures such as sand pile method to the soft-ground areas, if any.			
7	Offensive odor	Offensive odor may be issued depending on the volume of general waste, etc. from base camp sites.	Regular cleaning and collection of the general waste from camp sites with appropriate stock places and facilities to prevent offensive odor.	Construction Contractor	PIU	Included in construction cost

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
8	Protected Area	Although Sanjay Gandhi Botanical Park (SGB Park or Patna Zoo) is designated as a protected area, it is managed by the Government of Bihar as Park-cum-Zoo, whose management type is different from that of other natural protected areas which has a development risk of disorderly destruction. However, the area may have ecological functions in urban environment of Patna. Therefore, general considerations to mitigate impacts from the project regarding pollution items shall be taken.	Same as "5. Noise and vibration".	Construction Contractor	PIU	Included in construction cost
9-a	Ecosystem	<ul style="list-style-type: none"> There is a negative impact on the ecosystem through deforestation of trees due to the construction of viaducts, underground stations and a depot. Since a partial section pass through Danapur Cantonment KBA, the impact on ecosystem, especially on avifaunal diversity, such as light pollution, noise and vibration are expected. 	Compensatory planting of street trees / shrubbery species to the limited area under the elevated structures should be considered as necessary.	Construction Contractor	PIU	Included in construction cost
9-b			A preliminary survey should be conducted before the construction commencement and during construction in order to confirmation of nesting and flying in the project site of KBA area. Countermeasures such as avoidance of construction during their spawning and growing season should be considered if nesting or flying of the specified species is confirmed in the project area.			
9-d			Reduction of noise pollution during night hours and within standards.			
9-f			Reduction of light pollution during night hours by keeping lights close to the ground, directed and shielded.			
10-a	Hydrology	Some impact on hydrology around the project site including TBM sections will occur. Since a river flow along the south of the depot candidate site, the depot construction may affect the surrounding hydrology.	Discuss development of alternative water sources with periodical groundwater level monitoring, if necessary.	Construction Contractor	PIU	Included in construction cost
10-b			Discuss diversion of surface water flow around the depot area with periodical monitoring, if necessary.			

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
11-a	Land acquisition/ Resettlement	<ul style="list-style-type: none"> Resettlement in some areas in elevated areas have been started and structures have been resettled already (84 households) and 62 households are remaining as of July 2022. Besides the physical relocation, private land acquisition is required. Such project affected households is going to take impact on their property and livelihood. Follow-up actions against pre-relocated households before the official approval of RAP equivalent documents 	Resettlement implementation with necessary procedures based on RAP (SIA Report) including: <ul style="list-style-type: none"> Compensation prior to relocation with full replacement cost Functioning of grievance redress mechanism Livelihood restoration program Monitoring schemes Special assistance to vulnerable groups, etc. 	PIU	Government of Bihar	Refer to SIA
11-b			Action plan (follow-up activities) to fulfill gaps between the conditions of pre-relocation cases and the one equivalent to the JICA Guidelines.			
12	Poverty	Households under poverty line living in the project affected areas (7 families) are affected due to resettlement.	Implementation of adequate compensation and assistance based on the entitlement matrix of RAP (SIA) and/or any other follow-up documents, if any	PIU	Government of Bihar	Refer to SIA
13-a	Local economy such as employment and livelihood, etc.	A negative impact on the livelihood of PAPs may be generated depending on land acquisition and resettlement including business loss due to loss of access by fencing works around the construction areas.	Implementation of adequate compensation and assistance based on the livelihood restoration program of RAP (SIA) and/or any other follow-up documents, if any	PIU	Government of Bihar	Refer to SIA
13-b			Compensation for any business disturbance during the construction including hindrance of access to shops due to fencing around the construction sites.			
14	Water use and its rights	Land acquisition and construction work such as TBM method may affect drinking water sources such as wells.	If the water quality deems to decline, appropriate water treatment measures such as water shielding and infiltration control should be implemented.	Construction Contractor	PIU	Included in construction cost
15-a	Existing social infrastructure and services	<ul style="list-style-type: none"> A negative impact on sensitive facilities such as schools, hospitals, and community centers may be occurred depending on land acquisition and traffic issues such as congestion and accidents. The impact of the relocation of underground facilities is expected due to the construction work, which cause a temporal power outage in the surrounding area. 	Make sure to provide electrical power by auxiliary grid or generators to keep providing it. Therefore, a detailed power distribution plan should be prepared in advance.	Construction Contractor	PIU	Included in construction cost
15-b			Make sure to provide safe access to sensitive facilities such as hospital, school, etc. during the construction period by installing traffic guides and warning signs, and if required, measures such as detour route should be set up based on the traffic congestion condition.			

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
16	Maldistribution of benefit and damage	Depending on the construction area, there may be a maldistribution of benefit and damage such as the prohibition of road crossing and setting of the detour route.	Make sure to provide safe access to sensitive facilities such as hospitals, schools, etc. during the construction period by installing traffic guides and warning signs, and if required, measures such as detour route should be set up based on the traffic congestion condition.	Construction Contractor	PIU	Included in construction cost
17-a	Local conflict of interest	<ul style="list-style-type: none"> Residents and municipalities may demand that construction contractor should supply employment opportunities equally as construction workers. Pollution status may cause conflict along the construction affected areas 	Give employment opportunities to residents and municipalities evenly.	Construction Contractor	PIU	Included in construction cost
17-b			If the residents and pedestrians complain about the construction activities, the consultant of the supervision and contractors should deal with them with a sincere response following the Grievance Redress mechanism and should designate staff in charge of public complaints and communications.			
18	Gender	There may be a gender gap regarding wage, salary, and treatment as construction workers.	Must be careful there will be no discrimination between male and female in employments and payments	Construction Contractor	PIU	Included in construction cost
19-a	Children's right	There might be a possibility of child labour in construction sites.	Construction contractor and supervision consultant as well as PIU check and monitor the list of worker and field situation in order to prevent any forms of child labor in the project.	Construction Contractor	PIU	Included in construction cost
19-b		Construction work may interfere with going to educational facilities.	Same as "15-b"			
20-a	Health (Infectious diseases such as HIV/AIDS, etc.)	Infectious diseases such as STD, COVID-19, etc. may be spread by the inflow of construction workers.	To prevent the spreading of infectious diseases, awareness training to workers shall be provided with the cooperation of the local public health center.	Construction Contractor	PIU	Included in construction cost
20-b			A periodic health check-up program will be conducted.			
20-c			To reduce ponds and puddles, where wigglers grow, by covering them with a tarpaulin.			
20-d			【Countermeasures for COVID-19】 <ul style="list-style-type: none"> Keep physical distance Washing hands and alcohol disinfection Body temperature test before morning gathering 			
21-a	Labor environment including labor safety	Occupational injuries / disease may occur with inappropriate labor environment including safety management in the	Construction personnel will be provided with the necessary safety gear such as a protective hard hat and safety belt.	Construction Contractor	PIU	Included in construction cost
21-b			First aid stations supervised by the safety health officer of the contractor will be located within the construction site office.			

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
21-c		construction sites, such as working on high structures and in underground spaces.	Arrange safety training for the worker periodically.			
21-d	Compliance with the related laws and regulations.					
22-a	Accidents	<ul style="list-style-type: none"> Since construction-related vehicles use arterial roads on the Corridors, there is a possibility of increasing traffic accidents. Detour and caused traffic congestions may increase the number of traffic accidents. 	Sound traffic management and detour plans duly approved by the concerned governmental agency will be strictly implemented to minimize traffic congestions and accidents.	Construction Contractor	PIU	Included in construction cost
22-b			Traffic enforcers will be designated along these areas to assist in directing traffic flow.			
23	Cross-border impact and climate change	Greenhouse gas emissions will increase slightly by reducing the absorbed amount of greenhouse gas by cutting street trees along the Corridors, operation of construction heavy machinery, and construction of structures.	Planting of shrubbery species to the limited area under the elevated structures should be considered as necessary to reduce the emission of greenhouse gases.	Construction Contractor	PIU	Included in construction cost

Note: PIU: Project Implementation Unit

Source: JST

Table 14-52: Proposed Mitigation Measures against expected Impacts (Operation Phase)

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
1	Air pollution	Pollutant concentration may be occurred around the ventilation facilities in the underground sections and substations.	Periodical maintenance of relevant facilities such as ventilation system, substation, and the depot.	PMRCL	Government of Bihar	TBD
2	Water pollution	There is a possibility of discharged organic waste water from the toilet installed at every station and the depot.	Periodical maintenance of relevant facilities such as toilet installed at every station and the depot.	PMRCL	Government of Bihar	TBD
3	Waste	General waste and excreta will be generated from every station and the depot.	Installation of enough garbage bin at appropriate location in stations and the depot and collection rules based on local collection systems.	PMRCL	Government of Bihar	TBD
4	Soil contamination	Soil contamination may occur at the proposed depot due to oil leaks of related facilities, rolling stock coating.	Necessary facilities and equipment for preventing leaking oil shall be prepared at the depot.	PMRCL	Government of Bihar	TBD
5-a			Additional noise barriers are discussed, as needed	PMRCL		TBD

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
5-b	Noise and vibration	Metro rail may generate additional noise and vibration by itself in both underground and elevated sections.	At the station platform, paging and train melody volume shall be adjusted to the lowest level where it will not detract from their function.		Government of Bihar	
5-c			Slow speed in curve sections			
6	Ground Subsidence	Monitoring in the operation phase should be necessary as a follow-up observation and maintenance.	No specific measures but conduct necessary monitoring for "just in case". When measures are need, they are to be discussed to determine the best solution suitable for the conditions.	PMRCL	Government of Bihar	TBD
7-a	Offensive odor	Offensive odor may be issued depending on the volume of general waste etc. from every station and the depot.	Regular cleaning and collection of the general waste from stations and depot.	PMRCL	Government of Bihar	TBD
7-b			Installation of appropriate garbage bin with cover.			
8	Ecosystem	Since a partial section pass through Danapur Cantonment KBA, the impact on ecosystem, especially on avifaunal diversity, such as light pollution is expected.	Reduction of light pollution during night hours by keeping lights directed and shielded.	PMRCL	Government of Bihar	TBD
9	Local economy such as employment and livelihood, etc.	With opening of Patna Metro, drivers of route buses and three wheelers, which are overlapping their operation area of transportation, may lose their opportunities.	Monitoring impact on drivers of bus, three wheeler, and other alternative transportation around the Metro. Livelihood assistance or job meditation including the Metro related opportunities.	Government of Bihar	Government of Bihar	TBD
10	Land use and utilization of local resources	A negative impact may be generated as disordered development and rough-and-tumbled utilization of local resources around the Corridors and stations.	Coordination with local government and private developers for healthy socio-economic development along the Metro lines.	Government of Bihar	Government of Bihar	TBD
11-a	Gender	<ul style="list-style-type: none"> • Employment opportunities for women will be limited concerning Metro operation. • Female passengers may give up getting on a train because of being afraid of congestion on the train during commuting time. 	Active employment of female staff for PMRCL with fair conditions	PMRCL	Government of Bihar	TBD
11-b			Keep provision of the designated seat for women on the train, enough number of toilet and other facilities as much as possible.		Government of Bihar	
12-a	Health (Infectious)	Infectious of COVID-19 may occur in the train due to three Cs (closed spaces,	A periodic awareness program for the PMRCL officials	PMRCL	Government of Bihar	TBD
12-b			A periodic health check-up program for the PMRCL officials			

No.	Item	Expected Impact	Mitigation Measure	Implementation Body	Responsibility Body	Cost (USD)
12-c	diseases such as HIV/AIDS, etc.)	crowded places, and close-contact settings) if the epidemic continues until the operation phase.	【Countermeasures for COVID-19】 <ul style="list-style-type: none"> • Air circulation in the train by air conditioning • Cleaning rolling stocks periodically • Opening the windows in the train • Promotion of staggered working hours • Installation of disinfectants at every toilet and ticket gate 			
13	Cross- border impact and climate change	It is conceivable that greenhouse gases will be generated due to the electric consumption by Patna Metro operation.	Periodical maintenance of relevant facilities such as ventilation system, substation, and the depot.	PMRCL	Government of Bihar	TBD

Note: PIU: Project Implementation Unit

Source: JST

14.8 Environmental Monitoring Plan

14.8.1 Retroactive verification of EMoP for the section under construction

Same as EMP, PMRCL prepared their own Environmental Monitoring Plan (EMoP) for the section under construction in prior to the construction commencement and is following and implementing the EMoP shown below. However, the EMoP are set for the limited environmental items at construction phase and operation phase, especially ecosystem and social consideration items: Existing social infrastructure and services, Gender, Local conflict of interest etc. Regarding these items, currently there are no particular issues due to the ongoing construction work, or no endangered species under the ongoing construction sections. But complaints from local people about dust and traffic congestion etc. have been confirmed. Given the above, it cannot be said that EMoP can cover all designated items by the JICA guidelines. Hence, PMRCL shall follow the EMoP prepared by JST.

According to the monitoring result of air quality and noise, the values of all of the parameter at all point were lower than the baseline ones. It can be said that the traffic impact is larger than the impact from construction. Especially, since the values of construction noise level in daytime at almost points are about 10 dB lower than the baseline noise level, it can be said that the construction noise hardly contributes to the increase of baseline noise. The details of monitoring result at the sections under construction are attached as an Attachment 13.

Table 14-53: Environmental Monitoring Plan prepared by PMRCL

Environmental Impact item	Number of sampling, contents etc.	Implementation Body	Responsible Body
Pre-construction phase			
Air quality	2 samples each at 9 locations	Contractor	PIU
Water quality	1 samples each at 9 locations	Contractor	PIU
Noise and Vibration	Noise: 1 samples each at 9 locations Vibration: 2hours each at 9 locations	Contractor	PIU
Soil quality	1 samples each at 8 locations	Contractor	PIU
Construction phase			
Air quality	The parameters recommended are Particulate Matter (PM ₁₀), (PM _{2.5}). The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of project authority.	Contractor	PIU
Water quality	Water quality should be analyzed following the procedures given in standard methods. Parameters for monitoring will be as per BIS: 10500:2012. The monitoring points could be ground and surface water. The contractor shall also monitor soil leachate monitoring.	Contractor	PIU
Noise and Vibration	The noise levels will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of project authority. At sensitive locations Vibration shall also be monitored as per the directions of the employer.	Contractor	PIU
Workers health and safety	Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any reoccurring incidents such as irritations, rashes, respiratory problems etc. shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans.	Contractor	PIU
Operation phase			
Air quality	1 samples each at 7 locations monthly for 3 years The parameters recommended are Particulate Matter (PM ₁₀), (PM _{2.5}).	PMRCL	Government of Bihar
Water quality	1 sample yearly for 3 years The parameters recommended are pH, TSS, BOD, COD, oil and grease for waste water, but water quality parameters that will be	PMRCL	Government of Bihar

Environmental Impact item	Number of sampling, contents etc.	Implementation Body	Responsible Body
	monitored will be as per BIS 10500:2012.		
Noise and vibration	1 samples each at 15 locations yearly for 3 years	PMRCL	Government of Bihar

Note: PIU: Project Implementation Unit

Source: Detailed Project Report 2021, PMRCL

Table 14-54: Example of air quality monitoring result

Date	Locations	PM ₁₀ (µg/m ³)		
		Monitored value	Baseline Value	Air quality Standards
03-Jun-22	Bhootnath	150.49	279.3	100
03-Jun-22	Zero mile	190	210.5	
04-Jun-22	Malahi Pakri	162.76	191.2	
04-Jun-22	Khemni Chak	154.04	191.3	
05-Jun-22	New ISBT	167.5	395.8	
14-Jun-22	Bhootnath	173.68	279.3	
14-Jun-22	Zero mile	197.32	210.5	
15-Jun-22	Malahi Pakri	148.52	191.2	
15-Jun-22	Khemni Chak	136	191.3	
16-Jun-22	New ISBT	178	395.8	

Source: PMRCL

Table 14-55: Example of noise monitoring result

Date	Locations	Construction site Leq dB (A)		Baseline Leq dB (A)		Permissible limit Leq dB (A)	
		Day	Night	Day	Night		
04-Jun-22	Malahi Pakdi	64.1	62.9	78.2	63.4	65	55
10-Jun-22		63.6	60.3				
15-Jun-22		63.8	62.5				
20-Jun-22		67.2	60.0				
04-Jun-22	Khemni Chak	64.1	63.1	73.7	63.2		
10-Jun-22		63.6	59.1				
15-Jun-22		63.8	61.3				
20-Jun-22		67.2	61.3				
03-Jun-22	Bhootnath	71.3	63.0	82.0	73.0		
09-Jun-22		68.4	63.4				
4-Jun-22		69.2	64.1				
19-Jun-22		70.1	63.7				
03-Jun-22	Zero Mile	62.0	60.9	75.0	63.0		
09-Jun-22		67.8	62.4				
14-Jun-22		66.3	62.8				
19-Jun-22		65.9	62.0				
05-Jun-22	New ISBT	72.4	66.2	83.4	67.1		
11-Jun-22		66.7	63.0				
16-Jun-22		70.1	66.2				
21-Jun-22		71.9	65.8				

Source: PMRCL

14.8.2 Environmental Monitoring Plan for the section to be constructed

Regarding the environmental and social consideration items for which the draft mitigation measures are set for Patna metro construction work, EMoPs to inspect the effect of the measures are shown as below.

Table 14-56: Environmental Monitoring Plan (Pre-Construction and Construction Phase) proposed by the survey

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
1-a	Air pollution	Regular preventive maintenance service of construction equipment and machinery should be strictly implemented and should require conducting daily routine equipment and machinery check-ups to ensure that there are in the optimum working conditions.	Sampling survey using the same methods as the baseline survey for SO ₂ , NO ₂ , PM ₁₀ , PM _{2.5} , CO, Ozone and any other necessary items	Construction Contractor	PIU	Measured points during the baseline surveys	Monthly during the construction period	Included in construction cost
1-b		The proper work schedules should be considered not to concentrate the construction equipment at a certain point for a long time.	Construction plan / schedule	Construction Contractor	PIU	Whole construction area		
1-c		To reduce the dust, the periodical water spray should be taken.	Record of sprinkler truck operation	Construction Contractor	PIU	Whole construction area		
1-d		Around the construction site is fenced as high as 2-2.5 m.	Visual confirmation of installation of fences	Construction Contractor	PIU	Whole construction area		
2-a	Water pollution	Washing the construction tools limited areas where there are appropriate facilities for water treatment for discharge	Visual confirmation of appropriate operation of washing activities	Construction Contractor	PIU	Washing areas	Monthly during the construction period	Included in construction cost
2-b		Construction waste should be treated at a designated site and disposed of following the instruction of management authority and rules. If the waste must be kept at the construction site, the tarpaulin should be covered on it.	Record of disposal / Visual confirmation	Construction Contractor	PIU	Designated sites		

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
2-c		In construction works near water bodies, turbid waste water shall be treated at designated sites and released again.	Sampling survey using the same methods as the baseline survey:	Construction Contractor	PIU	Measured points during the baseline surveys		
2-d		Temporary sanitation facilities with septic tanks such as portable (mobile) toilets and garbage bins will be provided by the contractors to ensure that the domestic wastes to be generated by the construction personals are properly handled and not thrown into the drainage to prevent further pollution.	[Surface water] BOD, COD, DO, Colour, Odour, Taste, pH, Turbidity, Temperature, etc. [Groundwater] Colour, Odour, Taste, pH, Turbidity, Temperature, Total Hardness as CaCO ₃ , etc.	Construction Contractor	PIU	Measured points during the baseline surveys		
3-a	Waste	Construction waste generated from the construction and camp sites should be treated at a designated site and disposed of according to the instructions of management authority and rules. If the waste must be kept at the construction site, the tarpaulin should be covered on it.	<ul style="list-style-type: none"> The volume of waste including soil, vegetation, existing railway structures, and garbage The condition of storage and transportation for the generated waste Voices and complaints from the local community 	Construction Contractor	PIU	Construction site and labor camps	Monthly and when complaints are heard in this regard	Included in construction cost
3-b		Generated waste could be utilized for other purpose such as land filling depending upon the suitability.	Soil / muck reuse plan and record of dumping	Construction Contractor	PIU	Project sites	Monthly during the construction period	
4-a	Soil contamination	Excavated soil shall be treated at the designated site and disposed of following the instruction of management authority and rules. If the waste must be kept at the construction site, the tarpaulin should be covered on it.	Same as "3-a"					

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
4-b		Daily maintenance of construction equipment and vehicles.	Sampling survey using the same methods as the baseline survey pH, Electrical Conductivity, Lead (Pb), Mercury (Hg), Cadmium (Cd), Arsenic (As), Cyanide (Cn) and Chromium (Cr ⁺⁶)	Construction Contractor	PIU	Measured points during the baseline surveys	Monthly during the construction period	Included in construction cost
4-c		Soil sampling and laboratory analysis in order to check soil contamination shall be done.						
5-a	Noise and vibration	Noise suppressors such as mufflers will be installed whenever deemed necessary to maintain the noise generated by various heavy equipment and other construction machinery within permissible limits.	<ul style="list-style-type: none"> • Visual observation of installation of necessary facilities • Record of construction work (operation time) • Record of using machinery • Same methods as the baseline survey On weekday [Noise] LAeq [Vibration] Lv 	Construction Contractor	PIU	Whole construction area Measured points during the baseline surveys	Monthly during the construction period	Included in construction cost
5-b		High noise-generating construction activities will be scheduled during daytime only (6:00 – 22:00) to avoid noise disturbance to adjust residential and commercial areas and other noise-sensitive areas. But in the case of academic facilities, the activities should be considered during the night time not to interfere with the class-works.						
5-c		Around the construction site is fenced as high as 2-2.5 m.						
5-d		Use low-noise and vibration machinery for construction such as piling						
5-e		If cracks, fissures, etc. occur in the surrounding structures during the construction of the underground section, the repair of such cracks, fissures, etc. shall be covered by the compensation.						

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
6-a	Ground subsidence	Application of appropriate construction measures such as earth retaining wall, penetration of piles to the support layer, and etc.	<ul style="list-style-type: none"> • Measurement of control points Ground subsidence level by subsidence plate • Necessary foundation works 	Construction Contractor	PIU	Construction sites	Monthly during the construction period	Included in construction cost
6-b		Application of ground reinforcement measures such as sand pile method to the soft-ground areas, if any.						
7	Offensive odor	Regular cleaning and collection of the general waste from camp sites with appropriate stock places and facilities to prevent offensive odor.	<ul style="list-style-type: none"> • Record and Site observation • Confirmation of voices and complaints Odor 	Construction Contractor	PIU	Construction sites, labor camps and the surrounding area	Monthly and when complaints are heard in this regard	Included in construction cost
8	Protected Area	Same as "5. Noise and vibration".						
9-a	Ecosystem	Compensatory planting of street trees / shrubbery species to the limited area under the elevated structures should be considered as necessary.	Status of storage and reuse of logged trees Status of planting	Construction Contractor	PIU	Construction sites and the surrounding area in Danapur Cantonment KBA	Before construction and monthly during the construction period	Included in construction cost
9-b		- A preliminary survey should be conducted before the construction commencement and during construction in order to confirmation of nesting and flying in the project site of KBA area. Countermeasures such as avoidance of construction during their spawning and growing season should be considered if nesting or flying of the specified species is confirmed in the project area.	Site inspection focusing on nesting and flying					
9-c		Reduction of noise pollution during night hours and within standards.	Same as "5. Noise and vibration".					

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
9-d		Reduction of light pollution during night hours by keeping lights close to the ground, directed and shielded.	Visual observation of implementation status					
10-a	Hydrology	Discuss development of alternative water sources with periodical groundwater level monitoring, if necessary.	Measurement of control points Ground water level	Construction Contractor	PIU	Construction sites and the surrounding area	Monthly during the construction period	Included in construction cost
10-b		Discuss diversion of surface water flow around the depot area with periodical monitoring, if necessary.	Visual observation of surface water flow	Construction Contractor	PIU	Depot sites and the surrounding area	Monthly during the construction period	
11-a	Land acquisition/ Resettlement	Resettlement implementation with necessary procedures based on RAP (SIA Report) including: - Compensation prior to relocation with replacement cost - Functioning of grievance redress mechanism - Livelihood restoration program - Monitoring schemes - Special assistance to vulnerable groups, etc.	Progress of RAP implementation: information including followings will be collected using the monitoring format attached to SIA Chapter. • Consultation meeting and/ or other means of communication with the PAPs • Confirmation of records of payment • Site observation • Confirmation of voices and complaints State of provision/ payment of compensation and social assistance and resettlement • Level of income and livelihood restoration of the PAPs • State of the project site • Voices and complaints from the PAPs	Social Management Unit, PMRCL, in coordination with Patna District Administration , Government of Bihar	PIU	Project affected area and locations PAHs are relocated	Progress of RAP implementation : monthly, up to the final payment and relocation.	Refer to SIA Chapter
11-b		Action plan (follow-up activities) to fulfill gaps between the conditions of pre-relocation cases and the one equivalent to the JICA Guidelines.	Due-Diligence of RAP implementation: external evaluation expert will implement mid-term and end-term monitoring.				Due-Diligence of RAP implementation : mid-term and end-term of rap implementation .	

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
12	Poverty	Implementation of adequate compensation and assistance based on the entitlement matrix of RAP (SIA) and/or any other follow-up documents, if any	Same as "11. Land acquisition/ Resettlement"					
13-a	Local economy such as employment and livelihood, etc.	Implementation of adequate compensation and assistance based on the livelihood restoration program of RAP (SIA) and/or any other follow-up documents, if any	Same as "11. Land acquisition/ Resettlement"					
13-b		Compensation for any business disturbance during the construction including hindrance of access to shops due to fencing around the construction sites.						
14	Water use and its rights	If the water quality deems to be declined, appropriate water treatment measures such as water shielding and infiltration control should be implemented.	Same as "2. Water pollution"					
15-a	Existing social infrastructure and services	Make sure to provide electrical power by auxiliary grid or generators to keep providing it. Therefore, a detailed power distribution plan should be prepared in advance.	<ul style="list-style-type: none"> Record and site observation Confirmation of voices and complaints Status of electricity supply Voices and complaints from the local community 	Construction Contractor with relevant bodies	PIU	Project affected area	Before construction commencement and when complaints are	Included in construction cost

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
15-b		Make sure to provide safe access to sensitive facilities such as hospital, school, etc. during the construction period by installing traffic guides and warning signs, and if required, measures such as detour route should be set up based on the traffic congestion condition.	<ul style="list-style-type: none"> Record and site inspection Interviews with concerned organizations Confirmation of voices and complaints Safety of access roads to these sensitive facilities Status of installation of signs, etc. Traffic congestion Voices and complaints from the local community 	Construction Contractor	PIU	Construction sites and the surrounding area	heard in this regard	
16	Maldistribution of benefit and damage	Make sure to provide safe access to sensitive facilities such as hospitals, schools, etc. during the construction period by installing traffic guides and warning signs, and if required, measures such as detour route should be set up based on the traffic congestion condition.	Same as "15-b"					
17-a		Give employment opportunities to residents and municipalities evenly.	<ul style="list-style-type: none"> Verification of employment status Voices and complaints from the local community 	Government of Bihar	PIU	Project affected area		
17-b	Local conflict of interest	If the residents and pedestrians complain about the construction activities, the consultant of the supervision and contractors should deal with them with a sincere response following the Grievance Redress mechanism and should designate staff in charge of public complaints and communications.	Confirmation of voices and complaints from the residents and pedestrians	Government of Bihar Construction Contractor	PIU	Construction sites	When complaints are heard in this regard	Included in construction cost
18	Gender	Must be careful there will be no discrimination between male and female in employments and payments	<ul style="list-style-type: none"> Confirmation of the construction contract Confirmation of voices and complaints 	Voices and complaints from the local community				

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
19-a	Children's right	Construction contractor and supervision consultant as well as PIU check and monitor the list or worker and field situation in order to prevent any forms of child labor in the project.	<ul style="list-style-type: none"> Voices and complaints from the local community and the construction workers Existence of child labor Confirmation of the construction contract Site observation 	Government of Bihar Construction Contractor	PIU	Project affected area	Before construction commencement and at the time of employment	Included in construction cost
19-b		Same as "15-b"						
20-a	Health (Infectious diseases such as HIV/AIDS, etc.)	To prevent the spreading of infectious diseases, awareness training to workers shall be provided with the cooperation of the local public health center.	<ul style="list-style-type: none"> Confirmation of health checklist of the workers and preferably of the local community Interviews with concerned organizations Confirmation of voices and complaints 	Construction Contractor	PIU	Construction sites and surrounding area	Monthly during the construction period	Included in construction cost
20-b		A periodic health check-up program will be conducted.	<ul style="list-style-type: none"> Confirmation of health checklist of the workers and preferably of the local community Interviews with concerned organizations Confirmation of voices and complaints Visual observation Confirmation of voices and complaint 	Government of Bihar Construction Contractor	PIU	Construction sites and surrounding area	Monthly and when complaints are heard in this regard	Included in construction cost
20-c		To reduce ponds and puddles, where wrigglers grow, by covering them with a tarpaulin.						
20-d		<u>Countermeasures for COVID-19</u> <ul style="list-style-type: none"> Keep physical distance Washing hands and alcohol disinfection Body temperature test before morning gathering	Same as "20-a" and "20-b"					
21-a	Labor environment including labor safety	Construction personnel will be provided with the necessary safety gear such as a protective hard hat and safety belt.	<ul style="list-style-type: none"> Confirmation of accidents records Confirmation of health checklist of workers Medical checkup of workers Number of cases that suffered from heat strokes and other occupational health problems Voice and complaints from the workers 	Government of Bihar Construction Contractor	PIU	Construction sites and surrounding area	Monthly and when complaints are heard in this regard	Included in construction cost
21-b		First aid stations supervised by the safety health officer of the contractor will be located within the construction site office.						

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
21-c		Arrange safety training for the worker periodically.						
21-d		Compliance with the related laws and regulations.						
22-a	Accidents	Sound traffic management and detour plans duly approved by the concerned governmental agency will be strictly implemented to minimize traffic congestions and accidents.	<ul style="list-style-type: none"> • Confirmation of accidents record • Record and site inspection • Interview with concerned organizations Number of accidents • Voices and complaints from the local community 	Government of Bihar Construction Contractor	PIU	Construction sites and surrounding area	Monthly and when complaints are heard in this regard	Included in construction cost
22-b		Traffic enforcers will be designated along these areas to assist in directing traffic flow.						
23	Cross-border impact and climate change	Planting of shrubby species to the limited area under the elevated structures should be considered as necessary to reduce the emission of greenhouse gases.	Same as "1 Air pollution"					

Source: JST

Table 14-57: Environmental Monitoring Plan (Operation Phase)

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
1	Air pollution	Periodical maintenance of relevant facilities such as ventilation system, substation, and the depot.	Sampling survey using the same methods as the baseline survey for SO ₂ , NO ₂ , PM ₁₀ , PM _{2.5} , CO, Ozone and any other necessary items	PMRCL	Government of Bihar	Measured points during the baseline surveys	Twice a year for the first three year (Once in the dry season and once in the rainy season)	Included in the operational cost of PMRCL

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
2	Water pollution	Periodical maintenance of relevant facilities such as toilet installed at every station and the depot.	<p>Sampling survey using the same methods as the baseline survey.</p> <p>[Surface water] BOD, COD, DO, Colour, Odour, Taste, pH, Turbidity, Temperature</p> <p>[Groundwater] Colour, Odour, Taste, pH, Turbidity, Temperature, Total Hardness as CaCO₃, Total Dissolved Solids, Nitrates (NO₃), Fluorides (F), Iron (Fe), Coliform, E-Coli</p>	PMRCL	Government of Bihar	Measured points during the baseline surveys	Twice a year for the first three year (Once in the dry season and once in the rainy season)	Included in the operational cost of PMRCL
3	Waste	Installation of enough garbage bin at appropriate location in stations and the depot and collection rules based on local collection systems.	<ul style="list-style-type: none"> Confirmation of waste disposal forms Confirmation of voices and complaints Waste management condition Voices and complaints from the local community and passenger 	PMRCL	Government of Bihar	Every station and Depot sites	Twice a year for the first three year	Included in the operational cost of PMRCL
4	Soil contamination	Necessary facilities and equipment for preventing leaking oil shall be prepared at the depot.	<p>Sampling survey using the same methods as the baseline survey pH, Electrical Conductivity, Lead (Pb), Mercury (Hg), Cadmium (Cd), Arsenic (As), Cyanide (Cn) and Chromium (Cr+6)</p>	PMRCL	Government of Bihar	Measured points during the baseline surveys	Twice a year for the first three year (Once in the dry season and once in the rainy season)	Included in the operational cost of PMRCL
5-a	Noise and vibration	Additional installation of noise shield at the elevated section.	<ul style="list-style-type: none"> Noise and vibration level (L_{Aeq}, L_{vmax}) Voices and complaints from the local community 	PMRCL	Government of Bihar	Points exceeding the standard and where complaints are raised	Whenever complaints are heard in this regard	Included in the operational cost of PMRCL

No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
5-b		At the station platform, paging and train melody volume shall be adjusted to the lowest level where it will not detract from their function.	Same methods as the baseline survey On weekday [Noise] LAeq [Vibration] Lvmax	PMRCL	Government of Bihar	the baseline surveys	Twice a year for the first three year	
5-c		Slow speed in curve sections	<ul style="list-style-type: none"> Railway operation plan Voices and complaints from the local community 	PMRCL	Government of Bihar	Curve points	Whenever complaints are heard in this regard	
6	Ground subsidence	No specific measures but necessary monitoring for "just in case". Measures taking for the case are to be discussed to determine the best solution suitable for the conditions.	Measurement of control points Ground subsidence level	PMRCL	Government of Bihar	The construction sites	Twice a year for the first three year	Included in the operational cost of PMRCL
7-a	Offensive odor	Regular cleaning and collection of the general waste from stations and depot.	<ul style="list-style-type: none"> Record and Site observation Confirmation of voices and complaints Odor Voices and complaints from the passenger and the local community 	PMRCL	Government of Bihar	Every station, Depot sites and the surrounding area	Twice a year for the first three year	Included in the operational cost of PMRCL
7-b		Installation of appropriate garbage bin with cover.						
8	Ecosystem	Reduction of light pollution during night hours by keeping lights directed and shielded.	Visual observation of implementation status	PMRCL	Government of Bihar	Every station, Depot sites and the surrounding area	Twice a year for the first three year	Included in the operational cost of PMRCL
9	Local economy such as employment and livelihood, etc.	Monitoring impact on drivers of bus, three wheeler, and other alternative transportation around the Metro. Livelihood assistance or job meditation including the Metro related opportunities.	<ul style="list-style-type: none"> Consultation meeting and/ or other means of communication with the bus service and the drivers Confirmation of voices and complaints State of provision of social assistance Level of income and livelihood change of drivers Voices and complaints from the drivers 	PMRCL	Government of Bihar	Along the Metro and the surrounding areas	Twice a year for the first three year	Included in the operational cost of PMRCL

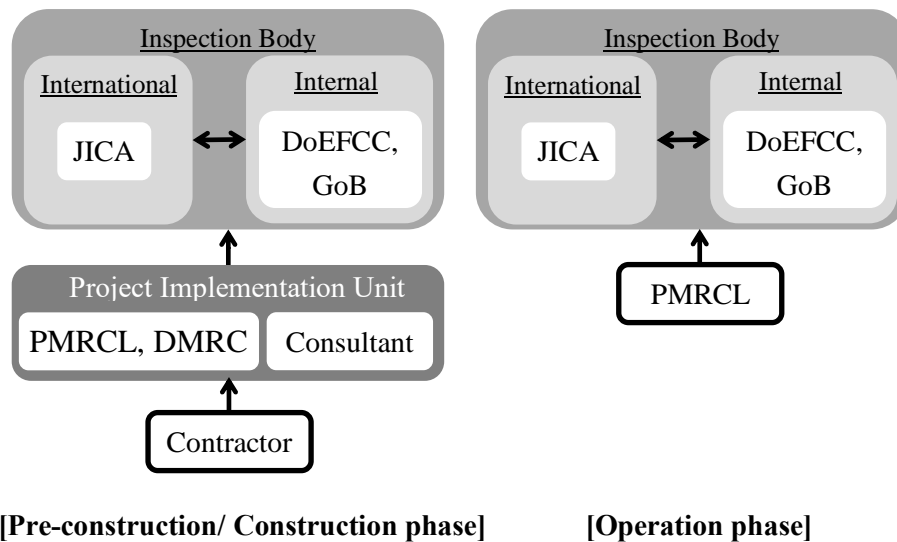
No.	Impact Item	Mitigation Measure	Method / Survey Item	Implementation Body	Responsible Body	Location	Frequency	Cost/Year
10	Land use and utilization of local resources	Coordination with local government and private developers for healthy socio-economic development along the Metro lines.	<ul style="list-style-type: none"> Confirmation plans of the projects and the development plan Status of other projects Development plan by local government 	Government of Bihar PMRCL	Government of Bihar	Along the Metro and the surrounding areas	Twice a year for the first three year	Included in the operational cost of PMRCL
11-a	Gender	Active employment of female staff for PMRCL with fair conditions	<ul style="list-style-type: none"> Confirmation of employment record Confirmation of voices and complaints from female staff of PMRCL 	PMRCL	Government of Bihar	HQ of PMRCL	Twice a year for the first three year	Included the company budget
11-b		Keep provision of the designated seat for female in the train, enough number of toilet and other facilities as much as possible.	<ul style="list-style-type: none"> Site observation Confirmation of voices and complaints from female passengers Status of introduction of the designated seat for female 	PMRCL	Government of Bihar	Every station		
12-a	Health (Infectious diseases such as HIV/AIDS, etc.)	A periodic awareness program for the PMRCL officials	<ul style="list-style-type: none"> Confirmation of health checklist of the officials Interview with concerned organizations Confirmation of voices and complaints Number of infected cases Voices and complaints from the officials and the passengers 	PMRCL	Government of Bihar	Every station, Depot sites, trains and HQ	Twice a year for the first three year and when complaints are heard in this regard	Included the company budget
12-b		A periodic health check-up program for the PMRCL officials						
12-c		<p>【Countermeasures for COVID-19】</p> <ul style="list-style-type: none"> Air circulation in the train by air conditioning Cleaning rolling stocks periodically Opening the windows in the train Promotion of staggered working hours Installation of disinfectants at every toilet and ticket gate						
13	Cross- border impact and climate change	Periodical maintenance of relevant facilities such as ventilation system, substation, and the depot.	Same as “1 Air pollution”					

Source: JST

14.9 Project Implementation System

14.9.1 Mitigation Measures and Monitoring Plan

This section describes the implementation system of the proposed mitigation measures and monitoring plan. At the Pre-construction/ Construction phase, the contractor will make periodic reports to the Project Implementation Unit (PIU), then the PIU will submit the periodic reports to JICA regarding the progress. The reporting frequency to JICA will be quarterly. If necessary, the PIU will report at any time to the Department of Environment, Forest and Climate Change (DoEFCC), Government of Bihar (GoB), the environmental supervising agency in Patna, to ask for their instructions. Also, at the operation phase, PMRCL, as the responsible agency, will make periodic reports to JICA. The reporting frequency to JICA will be biannually for 2 years after the operation commencement. Same as the Pre-construction/ Construction phase, PMRCL will report at any time to DoEFCC to ask for their instructions, if necessary. Regarding the staff organization of PMRCL, since PMRCL does not employ any special staff for EIA and SIA currently, some engineers from other sectors also have responsibility for EIA and SIA. Therefore, PMRCL shall actively hire some staff according to the scale and progress of the project. As an example of DMRC, there was a few staff for EIA and SIA when inaugurated, but currently there are dozens of staff in the sector by hiring staff little by little every year.

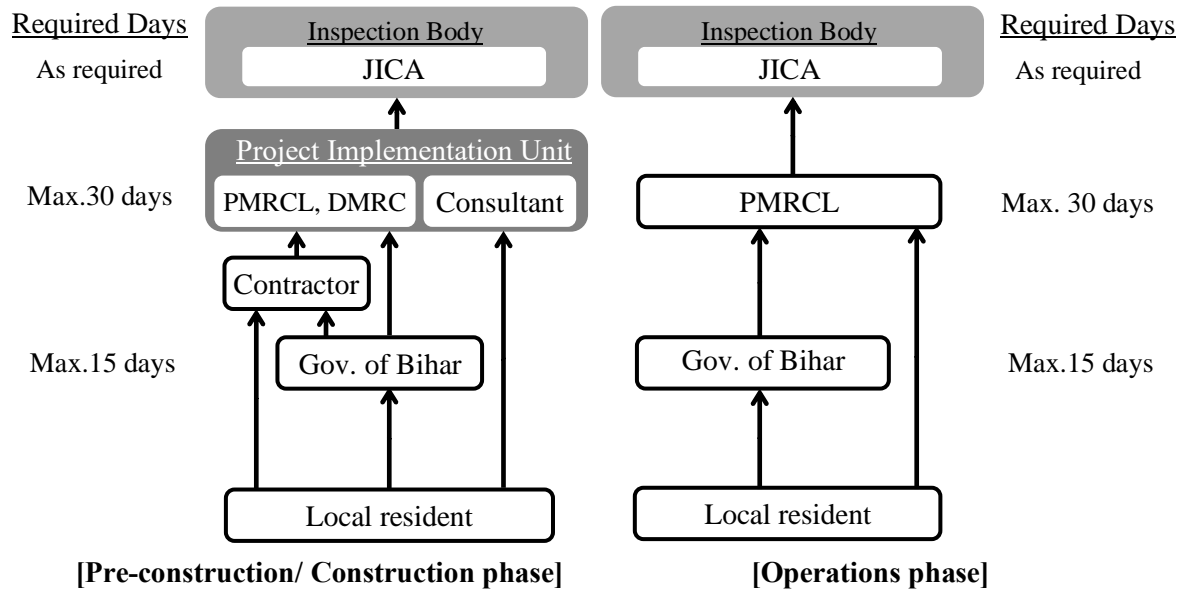


Source : JST

Figure 14-39: Draft Implementation System at Each Phase

14.9.2 Grievance Redress Mechanism

Grievances of residents and stakeholders should be responded to by the State Government of Bihar (GoB), which are the responsible municipalities, or by the PIU. Since public hearings were held organized by GoB, and GoB might have their strong connections with the residents, it is also easier for the residents to consult with GoB about their complaints. As shown in the figure below, residents should file their complaints directly with the PIU or indirectly with PIU through Contractor and GoB at the construction phase, with PMRCL at the operations phase, or with GoB as the liaison municipalities to continue discussions. A 45-day period is assumed as the maximum period of grievance redress at the construction phase and operations phase.



Source : JST

Figure 14-40: Draft Grievance Redress Mechanism at Each Phase

15. Social Impact Assessment (SIA)

15.1 Baselines of Social Environment

15.1.1 GDP and Industry

As shown in the following table, the GDP per capita of Bihar shows an annual growth of about 2% to 5%, with base year 2011-12. A high growth of about 9% was achieved in the 2018-2019 fiscal year. According to the 2020 EIA report, Patna's economic growth rate was 21st in the world and 5th highest in India as of 2015. However, compared to the GDP of states and regions in India, the ranking continues to be the lowest. The highest per capita GDP for the 2020-21 fiscal year is 307,108 INR in Goa, which is about 10 times higher than in Bihar (31,017 INR). In the 2020-21 fiscal year, Uttar Pradesh had the second lowest GDP per capita after Bihar, with an amount of 42,887 INR (1.38 times that of Bihar).

Table 15-1: PER CAPITA NET STATE DOMESTIC PRODUCT AT CONSTANT PRICES; BASE YEAR 2011-12

Item	Unit	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21
Bihar	INR	21,750	22,201	22,776	23,223	24,064	25,455	26,719	29,092	30,621	31,017
Rank among 33 States (32 in 20-21)	Rank	33	33	33	33	33	33	33	33	33	32
Growth from previous year	%	-	2.08	2.59	1.96	3.62	5.78	4.97	8.88	5.26	1.29

Source: PER CAPITA NET STATE DOMESTIC PRODUCT AT CONSTANT PRICES; BASE YEAR 2011-12, https://www.mospi.gov.in/c/document_library

According to the Bihar Economic Survey 2019-20, the Finance Department of Bihar, the economic situation in the state is as follows:

Bihar has consistently achieved socio-economic development over the last decade, despite the limited financial resources available. Gross domestic product (GSDP) growth in 2018-19 was 10.53% (adjusted price) and 15.01% (current price), which is higher than that of India. The percentages of primary, secondary and tertiary industries in Gross Value Added (GSVA) are 21.3%, 19.7% and 59.0%, respectively. Within the secondary industry, construction and manufacturing are GSVA's major contributors, with shares of 9.5% and 8.2% in 2018-19, respectively, with these shares remaining nearly flat for the past five years. The contribution of the secondary industry as a whole has remained between 19 and 20% between 2013-14 and 2018-19. In the tertiary industry, trade / repair services (18.2%) and real estate / home ownership / professional services (9.1%) contribute significantly to GSVA. The share of the total tertiary industry in GSVA increased between 2012-13 and 2018-19. As evidenced by various indicators, there are considerable disparities between districts in the state in terms of socio-economic development. Based on gasoline consumption per thousand people, the three relatively affluent districts are Patna, Muzafarpur and Goparganji. The three richest districts in terms of small per capita savings are Patna, Saran and Buksar.

Agriculture supports more than three-quarters of the population's livelihood, while the agricultural sector's contribution to the state's GSVA in 2017-18 was about 20%, and in 2018-19, 10.64%. Limited land resources, fragmented land tenure, and irregular rainfall are risk factors. In addition to food grains,

vegetables and fruits, livestock (especially dairy cows), fishing, and aquaculture are prosperous. Total fish production has increased from 479,000 tons in 2013-14 to 602,000 tons in 2018-19.

Bihar's industry has developed its agricultural processing industry based on its comparative advantage in the agricultural sector, with strong dairy and sugar production. In addition, the textile industry, sericulture and silk reeling are also active. In addition, the Bihar Industrial Area Development Corporation (BIADA) is working to promote the industrialization of Bihar through the development of industrial complexes. Meanwhile, official data on informal enterprises show that a significant portion of the working-age population engages in small-scale production activities, making a contribution to state capital formation and job creation. Furthermore, in the mining industry, copper and zinc resources are distributed in addition to the extraction of sand and stone and the brick production.

In the service industry, the number of domestic tourists is increasing year by year due to the large distribution of religious tourism resources such as Buddhism, Jainism, and Sikhism in the state. The number of tourists entering the state in 2018-19 was 336,200,000. Of these, the number of tourists from overseas was 1.09 million. The ranking of Bihar within the 36 states and union territories was 15th in the number of domestic tourists, and 9th in the number of overseas tourists.

15.1.2 Population, Language, Castes, Indigenous Peoples and Ethnic Minorities

The latest Population Census of India was conducted in 2011. The Municipality Corporation of Patna, where the Project is located, had a population of approximately 1.68 million (males: 893,399 and females: 790,823), which is 28.8% of the total population of Patna District. The population density is 6,737 persons/km², which is three to six times higher than that of Patna District and State of Bihar, respectively.

By calculation, average household size of Patna Municipality Corporation is 5.72 person per household, and 5.98 person per household in Patna District. On the other hand, CMP Patna 2018¹ Study found the average household size in the study area as 6.7 persons per household.

Table 15-2: Population, Population Density and Households

Administrative Unit	Population	Area (km ²)	Population Density (Person/km ²)	Household
Patna Municipality Corporation	1,684,222	250	6,737	294,612
Patna District	5,838,465	3,202	1,823	975,578
State of Bihar	104,099,452	94,163	1,106	18,913,565
India	1,210,854,977	-	-	249,501,663

Source: 2011 Census of India (population), Government of Bihar (area)

Patna is divided into six administrative Circles, each of which is divided into 8 to 16 Wards. According to the Patna City Population Census 2011-2022, the Patna Metropolitan Area consists of Patna City (Patna) and the surrounding areas of Badalpura, Dinapur Cantonment, Dinapur Nizamat, Khagaul, Nohsa, Pataliputra Housing Colony, Phulwari Sharif, and Saidpura.

¹ Comprehensive Mobility Plan Patna (2018) studied a total of 3,664 household interview samples in 2018. It adds on to the socio-economic data obtained in the RITES Primary surveys in 2013, in which a total of 6,626 households were interviewed in the study area representing the 89 traffic analysis zones covering Patna City area, which is the same area as covered in the DPR 2021. (p.3-1, DPR 2021)

In May 2022, JST interviewed an SIA expert hired by the District Administration to implement the SIA survey under the Land Acquisition Law (2013) on behalf of the State. According to the SIA expert, there are no publicly available administrative boundary maps. Therefore, the expert is conducting the State SIA survey while preparing an approximate boundary map based on information obtained from interviews.

Table 15-3: Circles and Wards in Patna Municipality Corporation

Name of Circle	Number of Wards
New Capital Circle	16
Patliputra Circle	16
Kankarbagh Circle	11
Bankipur Circle	12
Azimabad Circle	12
Patna City Circle	8

Source: Patna Municipality Corporation
<https://pmc.bihar.gov.in/about.aspx>

The official language of Bihar is Hindi, with Maithili and Urdu as the other recognized languages. The table below shows the mother tongues of Bihar's population. There are about 50% population who speaks mother language other than the three official or recognized languages.

Table 15-4: Language in State of Bihar

Language	State of Bihar	India
Hindi	25.62%	43.63% (1 st place)
Maithili	12.58%	1.12% (13 th place)
Urdu	8.45%	4.19% (7 th place)
Bhojpuri	24.93%	
Magahi	10.90%	
Surjapuri	1.79%	
Other Hindi dialects	14.31%	
Other language	1.42%	

Source: 2011 Census of India, Government of India National Sample Survey Office

According to the results of the 2011 Census, about 16% of Bihar's population belongs to Scheduled Castes (Dalits and Mahadalits). Of the 23 sub-castes nationwide included in Mahadarit, 21 sub-castes exist in the State. The 21 sub-castes are: Bantar, Bauri, Bhogta, Bhuiya, Chaupal, Dabgar, Dom (Dhangad), Ghasi, Halalkhor, Hari (Mehtar, Bhangi), Kanjar, Kurariar, Labegi, Musahar, Nat, Pan (Swasi), Rajwar, Turi, Dhobi, Chamar, Dusadh.

In Bihar, there are about 130 castes classified as Extremely Backward Castes (EBCs).

For indigenous peoples and ethnic minorities, about 1.3% of the state's population belongs to the Scheduled Tribes, including people from communities such as Gondi, Santhal, and Tharu. As explained in Section 15.13, no indigenous or ethnic minority communities were found in the area along the 2 corridors of the Project.

Table 15-5: Religion and Caste in State of Bihar

Group	Ratio	Included Castes and groups
Hindus	82.7%	
Scheduled Castes (SC) (Dalit + Mahadalit)	16%	Dusadh 5%, Chamar 5%, Musahar 2.8%
Other backward castes (OBC), Extremely backward castes (EBC)	48-50%	
Forward Caste	18%	Brahmin 6%, Bhumihar 7.2%, Rajput 7.2%, Kayasthas 1%
Muslims	16.9%	Sayyid, Sheikh, Mugal, Pathan
Scheduled Tribes	1.3%	
Other	0.4%	Christians, Sikhs, Jains, Buddhists

Source: 2011 Census of India, Government of India National Sample Survey Office

15.1.3 Literacy and Education

The literacy rate in Bihar, where this project is located, is 60%, 72% in urban and 59% in rural. Large differences of literacy rate is found by gender and region, with literacy rate of 67% of men (urban: 78%, rural: 66%) and 52% of women (urban: 66%, rural: 50%). In addition, according to the results of a 2014 sample survey on final education level in India, the proportion of the population below Primary is high in Bihar, and the proportion of people who have been educated above Upper primary is low, compared to the figures for the whole of India.

Table 15-6: Final Education Level in Bihar and India

Area	Illiterate	Literate with no education	Less than Primary	Primary	Upper primary	Secondary	Higher secondary	Diploma/Certificate	Graduate	Post graduate & above
Bihar	32.5	1.1	20.9	14.0	11.9	9.9	5.3	0.7	3.3	0.3
India	24.3	0.9	17.2	14.8	15.0	11.4	7.6	1.5	5.7	1.6

Source: Education in India (January - June, 2014) government of India National Sample Survey Office

The distribution of population by educational levels in the 'RITES Primary surveys²' in 2013 is presented in following table. The members of household with age below four years have been considered as children. About 41.8% have education below 10th, 22.5% have education level between 10th-12th level. Only 6.5% of the surveyed samples are illiterate.

Table 15-7: Distribution of Household Members by Education Level

SN	Education	No. of Sampled Household Members	Percentage (%)
1	Illiterate	2,030	6.5
2	Below 10 th	13,015	41.8
3	10 th to 12 th	6,987	22.5
4	Graduate	5,319	17.1
5	Post Graduate	1,217	3.9
6	Professional	435	1.4

² During RITES Primary surveys in 2013, a total of 6,626 households were interviewed in the study area representing the 89 traffic analysis zones covering Patna City area, which is the same area as covered in the DPR 2021. (p.3-24, DPR 2021)

7	Child	2,101	6.8
Total		31104	100.0

Source: RITES Primary Survey

15.1.4 Number of Earning Members per Household

The distribution of earning members per household in the study area is presented in the following table.

It is seen that 61% of the households have only 1 earning member, 29% have 2 earning members, 8% have 3 earning members while about 22 % have more than 3 earning members.

Table 15-8: Distribution of Households by Number of Earning Members

SN	No. Workers	No. of Sample Household	Percentage
1	1	4,023	60.7
2	2	1,963	29.6
3	3	512	7.7
4	4	83	1.3
5	5	29	0.4
6	6+	16	0.2
Total		6,626	100

Source: RITES Primary Survey

15.1.5 Activity Status/ Occupation

The occupational structure of the surveyed household members is presented in following table.

About 68.8% samples are non-workers comprising of students, housewives, retired and unemployed people.

31.2% samples are engaged in occupation; of which equal percentage i.e. 15% are engaged in business and service sector. Among the service class, majorly about 10% are engaged in private sector, where about 6% are engaged in government services.

Table 15-9: Distribution of Household Members by Occupation

SN	Occupation	No. of Sampled Household Members	Percentage
1	Govt. Service	2,024	6.5
2	Pvt. Service	2,994	9.6
3	Business	4,688	15.1
4	Student	10,178	32.7
5	House Wife	7,493	24.1
6	Retired	593	1.9
7	Unemployed	812	2.6
8	Others	2,322	7.5
Total		31,104	100

Source: RITES Primary Survey

15.1.6 Female Labour Force Participation

According to the Periodic Labour Force Survey (July 2017-June 2018)(National Statistics Office India), Bihar registered the lowest female labour force participation rate (LFPR) among all State and Union Territories of India at merely 4% in rural areas and 6.5% in urban areas. According to SEWA Bharat (All India Federation of Self-Employed Women's Association), an NGO working in the field, one of the reasons for such a low level of Female Work Participation Rate in Bihar has been the traditional social norm of limiting female role within household, and not encouraging female population to go out of house to take part in the labour force.

The distribution of workers by status of employment suggests that 40% of female workers in Bihar were self-employed, either as own account workers (32.3%) or as helpers in household enterprises (7.7%). The primary sector continues to provide bulk of the employment opportunities. The agriculture, forestry and fishing sector absorbed 66.8% of female workers. SEWA Bihar primarily assists home-based artisans, handloom weavers, domestic workers, farmers and agricultural producers, construction workers, vendors, and domestic workers.

On the other hand, since 2013, 35 %of the 47,000 vacant posts of Bihar Police in the rank of constables and sub-inspectors will be reserved for women. As a result, female personnel in the Bihar police reached more than 25% in 2021. Bihar also reserves 50 % of teaching jobs and the panchayats jobs for women.

From 2016, the Bihar State also has 35 % reservation for women in government jobs and engineering, medical, and technical education colleges. A similar quote will be reserved for women in an upcoming sports university in the state.

This reservation also extends to promotions. Resultantly, the government department heads have been asked to make sure that 35 per cent of boards at every level should benefit women officials. This policy would ensure an increased number of female staff in higher positions in block development officers (BDO), circle officers (CO), station house officers (SHO), and sub divisional magistrates (SDM).³

15.1.7 Income Distribution

The average monthly household income in the study area is INR. 23,640.

The distribution of sample household by monthly income indicates that 33% of the population earning Rs 5000 to Rs. 10000 followed by 25%, earning between Rs. 10001 to Rs. 15000 and 15% between Rs. 15001 to Rs. 25000.

A considerable percentage of 19% population is earning even less than or equal to Rs. 5000 per month.

Only, about 8% of the population is having their monthly income more than 25000.

Table 15-10: Distribution of Households by Monthly Household Income

SN	Income Group	No. of Sample Household	Percentage (%)
1	< INR. 5,000	6,047	19.4
2	INR 5,001 – INR10,000	10,289	33.1
3	INR 10,001 – INR15,000	7,661	24.6
4	INR 15,001 – INR25,000	4,774	15.3
5	INR 25,001 – INR50,000	2,274	7.3

³ <https://thelogicalindian.com/good-governance/bihar-government-reserves-35-for-women-officers-29045>

6	INR50,000<	59	0.2
	Total	31,104	100.0

Source: RITES Primary Survey

15.1.8 Poverty Line and Multidimensional Poverty Index (MPI)

(1) Poverty Line

In 2014, the Rangarajan Commission calculated that the poverty line in India as 972 INR / person / month in rural areas and 1,407 INR / person / month in urban areas (adjusted price based on 2011-12). The poverty lines of India as a whole and Bihar calculated in 2011 are as shown in the following table. The poverty lines of Bihar are about 10% lower (poorer) than those of India. In addition, 33.74% of Bihar's population falls under the poverty line, compared to national average of 21.92%.

Table 15-11: Poverty Line of India and Bihar per Person per Month

	Rural (2011-12) (INR/person/month)	Urban (2011-12) (INR/person/month)	Population Ratio below Poverty Line (%)
India	816	1,000	21.92
Bihar	778	923	33.74

Source: "Handbook of Statistics on Indian Economy. Table 154: Number and Percentage of Population below Poverty Line. (2011-12)" (<https://www.rbi.org.in/scripts/PublicationsView.aspx?id=19887>) Reserve Bank of India. Retrieved 2021-09-13

Using the Urban poverty line of INR. 923 /person/month in Bihar with various average household size shown in the table below, monthly income for a household poverty line can be calculated between INR. 4,500 and INR. 6,200 per household per month, or annual income between INR. 54,000 and INR. 74,400 per household per year.

Table 15-12: Calculated Poverty Line per Household per Month

Household Size Source	Household Size (person/household)	Urban Poverty Line in Bihar (INR/person/month)	Calculated Poverty Line: Monthly Household Income (INR/household)	
			Monthly income	Yearly income
DPR SIA 2020 p.41	4.9	923	4,523	54,276
Population Census of India 2011, Patna Municipality Corporation	5.72	923	5,280	63,360
CMP Patna 2018 Study	6.7	923	6,184	74,208

Poverty line of monthly household income was calculated by equations:

$$\text{Monthly} = \text{Household size} \times \text{Urban poverty line (monthly)}$$

$$\text{Yearly} = \text{Household size} \times \text{Urban poverty line (monthly)} \times 12$$

Source: JST

(2) Multidimensional Poverty Index

The Multidimensional Poverty Index (MPI) was introduced by the United Nations Development Program in the 2010 Human Development Report to clarify the extent and frequency of poverty in terms of health, education and living standards. The MPI is composed of indicators that focus on clarifying the degree and frequency of poverty in developing countries, but it is a leading effort to grasp poverty from multiple

perspectives. For each household, it is judged whether or not each item constitutes multidimensional poverty, and if applicable, points weighted according to the item are added. When the total score is above the standard value, it is defined as a "poor household". Ultimately, the MPI index of each country will be calculated by using the number of households defined as being in poverty and the score for each household, and it will be a single index that can be compared between nations.

Table 15-13: Contribution of Indicators to MPI Score

Field		Index	Weight
Education	1. Years of Schooling	No household members have more than 6 years of school experience	$1/3 \times 1/2 = 0.167$
	2. School Attendance	Children of schooling age are not in school	$1/3 \times 1/2 = 0.167$
Health	3. Child-Adolescent Mortality	Households whose children have died in the last five years up to the date of the survey	$1/3 \times 1/2 = 0.167$
	4. Nutrition	There are undernourished adults or children (BMI <18.5 is undernourished for children over 15 years old; children under 15 years old are undernourished with weight <WHO standard z value (median-standard deviation x 2) insufficient.)	$1/3 \times 1/2 = 0.167$
Standard of Living	5. Electricity	Not receiving electricity	$1/3 \times 1/6 = 0.056$
	6. Sanitation	No improved sewage system or shared improved sewage system with other households	$1/3 \times 1/6 = 0.056$
	7. Drinking Water	No safe water available, or it takes more than 30 minutes round trip to get safe water	$1/3 \times 1/6 = 0.056$
	8. Housing	The floor of the house is mud, sand or dung	$1/3 \times 1/6 = 0.056$
	9. Cooking Fuel	Cook with dung, wood or charcoal	$1/3 \times 1/6 = 0.056$
	10. Assets	Not having a radio, TV, phone, bicycle, motorcycle, refrigerator, car, truck	$1/3 \times 1/6 = 0.056$

1. The classifications and indicators that make up the MPI are based on the Human Development Index (HDI)
2. Determine the criteria for each item based on the internationally agreed Millennium Development Goals (MDG) criteria.
3. Give the same weight to each of the three fields of health, education, and standard of living so that the perfect score is 1. All items in each field are also weighted evenly.
4. For each item, 1 point will be given if applicable, and 0 point will be given if not applicable. Weights are applied, and households with a total score of 1/3 or more of all items are identified as poor households. At this time, the total score of households with a total score of less than 1/3 (non-poor households) shall be 0 points.
5. Using the number of households defined as poor households and the score by household in the above procedure, determine the poverty rate and poverty intensity, and calculate the MPI index of each country by the product.
 - a. Poverty rate (H) = sum of the number of household members defined as poverty ÷ sum of the number of household members of all surveyed households
 - b. Poverty intensity (A) = Σ (total score of each household x number of members of each household) ÷ sum of the number of members of the household defined as poverty
 - c. The classifications and indicators that make up MPI = H x A.

Source: Japan National Cabinet Office "FY 2016 Survey and Research Report for the Development of New Indicators for Child Poverty"
https://www8.cao.go.jp/kodomonohinkon/chousa/h28_kaihatu/2_02_2_2.html

The status of the Multidimensional Poverty Index (MPI) in Bihar and Patna in the 2015-16 fiscal year in the "India National Multidimensional Poverty Index Baseline Report" published in 2021 is as follows. As shown in Table 15-14, the poverty rate of Patna City as a whole is 29.20% and the MPI is 0.138. On the other hand, the poverty rate of whole India is 25.01% and the MPI is 0.118, both indexes slightly in better

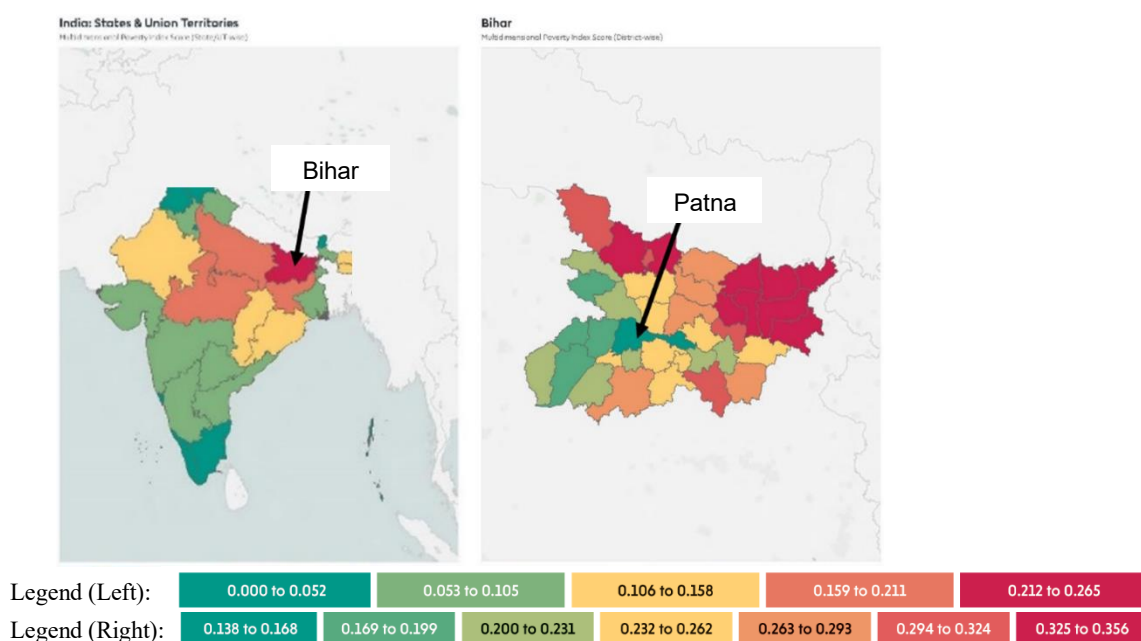
condition compared to those of Patna City.. The poverty rate in the urban Patna where the Patna Metro line is located is 13.8%, and the MPI is 0.064, which is close to the MPI of 0.04 in urban areas in India.

Table 15-14: Poverty Rate, Intensity, and MPI in Patna and India

	Poverty Rate	Poverty Intensity	MPI		Poverty Rate	Poverty Intensity	MPI
Patna	29.20%	47.26%	0.138	India	25.01%	47.13%	0.118
Urban	13.80%	46.20%	0.064	Urban	8.81%	45.25%	0.04
Rural	45.46%	47.66%	0.217	Rural	32.75%	47.38%	0.115

Source: India National Multidimensional Poverty Index Baseline Report, NITI Aayog, 2021, Based on the National Family Health Survey-4 (2015-16)

https://www.niti.gov.in/sites/default/files/2021-11/National_MPI_India-11242021.pdf



Source: India National Multidimensional Poverty Index Baseline Report, NITI Aayog, 2021, Based on the National Family Health Survey-4 (2015-16)

https://www.niti.gov.in/sites/default/files/2021-11/National_MPI_India-11242021.pdf

Figure 15-1: MPI in Bihar and Patna

The poverty rates for each index in Patna Municipality Corporation and Bihar are shown in the table below. Bihar has the highest poverty rate out of the 28 Indian States in most items, except for the “safe drinking water” indicator⁴. On the other hand, Patna Municipality Corporation has a lower poverty rate than the whole State of Bihar and is close to the national average. There is, however, still a large gap from the national average in terms of health and nutrition of pregnant women.

Table 15-15: Poverty Rate of Patna, Bihar and India by Indicator

Indicator		Patna (2015-16)	Bihar (2015-16, otherwise noted)	Ranking among 28 States (In descending order of poverty rate)	India
Education	1. Years of Schooling	14.62%	26.27%	1	13.88%
	2. School Attendance	7.04%	12.52% (2015-16)	1	6.40%

⁴ India is consisted of 28 States and 8 union territories. The comparison here is made among the 28 states.

Indicator		Patna (2015-16)	Bihar (2015-16, otherwise noted)	Ranking among 28 States (In descending order of poverty rate)	India
			9.80% (2019-20)		
Health	3. Child-Adolescent Mortality	3.28%	4.58%	2	2.69%
	4. Nutrition	42.86%	51.8%	1	37.60%
	5. Maternal Health	37.56%	45.62%	1	22.59%
Standard of Living	6. Electricity	13.05%	39.86% (2015-16) 3.70% (2019-20)	1	12.16%
	7. Sanitation	48.61%	73.61% (2015-16) 50.60% (2019-20)	2	51.97%
	8. Drinking Water	1.97%	2.34% (2015-16) 1.70% (2019-20)	27	14.60%
	9. Housing	38.07%	73.73% (2015-16) 65.30% (2019-20)	5	45.65%
	10. Cooking Fuel	50.40%	82.92% (2015-16) 63.20% (2019-20)	1	58.48%
	11. Assets	16.51%	24.32%	3	13.97%
	12. Bank Account	10.83%	26.00% (2015-16) 4.00% (2019-20)	2	9.66%
MPI		0.138	0.265		0.118

Note: Poverty Rate is that of Uncensored Headcount.

Source: India National Multidimensional Poverty Index Baseline Report, NITI Aayog, 2021, Based on the National Family Health Survey-4 (2015-16)
https://www.niti.gov.in/sites/default/files/2021-11/National_MPI_India-11242021.pdf

15.1.9 Sanitation and Health

Infant mortality rates in Bihar and India, shown in the following table, are almost the same as the world average.

Table 15-16: Infant mortality rates in Bihar and India

Area	Infant Mortality Rates (deaths per 1,000 live births)
State of Bihar (2019)	29
India Average (2019)	30
World Average (2018)	29

Source: Status of IMR and MMR in India, The State of the World's Children 2018, UNICEF

On the other hand, the 0-5 year old population ratio in Bihar (10.7%) is higher than the national average (8.6%), and the 61 year old and over population ratio (3.4%) is lower than the national average (6.6%). Looking at life expectancy, there is no difference between Bihar (68.9 years) and the whole country (69 years) in the whole population. But looked at by gender, in Bihar, the average life expectancy of men (69.2 years) is the national average. It is longer than (67.8 years) and the average life expectancy of women (68.6 years) is shorter than the national average (70.4 years). Inpatients and chronic illnesses have both been lower than the national average (3.7% and 3.1%, respectively) in Bihar (2.8% and 0.5%, respectively) over

the past year.

Looking at the average life expectancy, in the whole population, there is no difference found between Bihar (68.9 years old) and India (69 years old). By gender, the average life expectancy of men in Bihar (69.2 years) is longer than the national average (67.8 years). The average life expectancy of women in Bihar (68.6 years) is shorter than the national average (70.4 years).

The inpatient rate for the past 1 year is 2.8% in Bihar, which is lower than the national average of 3.7%. The proportion of chronically ill patients over the past 1 year is 0.5% in Bihar, which is lower than the national average of 3.1%.

Table 15-17: Life Expectancy and Patient Rates in Bihar

Area	0-5 Year Old Population Ratio (%)	61 Year Old and Over Population Ratio (%)	Life Expectancy (Years)	Male Life Expectancy (Years)	Female Life Expectancy (Years)	Inpatient Rate for the past 365 days (%)	Chronically Ill Patients (%)
Bihar	10.7	3.4	68.9	69.2	68.6	2.8	0.5
India	8.6	6.6	69	67.8	70.4	3.7	3.1

Source: Health in India (July 2017 - June 2018), Government of India National Statistical Office Average Life Expectancy (SRS Based Life Table 2013-17), Office of the Registrar General & Census Commissioner, Government of India

15.1.10 Vehicles Owned per Household

Distribution of households owning vehicles is presented in following table.

Majorly households have an ownership of two wheelers and cycles i.e. 44% and 47% respectively.

Only, 7% of the households have an ownership of car in the study area.

Table 15-18: Distribution of Households by Vehicle Ownership

	OWNERSHIP				Total
	Car	Two-Wheelers	Cycle	Others	
No. of Households	507	2,893	3,098	128	6,626
Percentage%	7.7	43.7	46.8	1.9	100

Source: RITES Primary Survey

15.1.11 Household Monthly Expenditure on Transport

The distribution of the individuals of sampled household according to monthly expenditure on Transport is shown in next Table.

About 86.7% of Households spend less than or equal to INR. 500 per month on Transport, while only 10.3% & 2.9 have monthly expenditure on transport ranging between INR. 501 – 1,000 and INR.1,001 – 3,000 respectively.

Table 15-19: Distribution of Individuals by Average Monthly Expenditure on Transport

S. No.	Expenditure on Transport	No. of Sample Household	Percentage (%)
1	Nil	15,339	49.3
2	<= INR.100	1,899	6.1
3	INR. 101- INR.200	3,606	11.6
4	INR.201- INR.300	3,164	10.2
5	INR. 301- INR.500	2,952	9.5
6	INR.501- INR.750	1,612	5.2
7	INR.751- INR.1000	1,579	5.1
8	INR.1001- INR.1500	534	1.7
9	INR. 1501- INR.3000	365	1.2
10	> INR.3000	54	0.2
Total		31,104	100

Source:RITES Primary Survey

15.1.12 Trip Purpose

Distribution of daily vehicular and walk trips is presented in next table.

It is observed that about 51.1% and 23.7% of daily vehicular and walk trips have been performed for work purpose respectively. For education purpose, 63.8% of trips have been performed by walk trips.

Table 15-20:Distribution of Vehicular and Walk Trips by Purpose

	Vehicular Trips		Walk Trips		Total
	No. of Trips	Share (%)	No. of Trips	Share (%)	
Work	15,582	51.1	3,320	23.7	18,902
Education	10,597	34.8	8,914	63.8	19,511
Others	4,312	14.1	1,747	12.5	6,059
Total	30,491	100	13,981	100	44,472

Source:RITES Primary Survey

15.1.13 Traffic and Transportation in Patna

(1) Vehicular Growth and Composition

Total vehicles in Patna city have largely increased between the years 2011 and 2018. The share of two-wheelers registration comprises about 75%, while cars comprise about 13 %.

Table 15-21: Vehicles Registration in Patna

	Year						
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Trucks	2,882	3,251	3,167	2,868	383	3,872	2,866
Bus	302	352	244	308	601	595	435
Car	12,493	13,805	12,537	11,033	13,643	18,113	14,863
Taxi	1,181	1,574	1,488	1,242	776	1,358	1,197

Jeep	2,515	1,706	1,740	1,800	1,538	1,967	3,096
Three-Wheeler	3,801	4,432	6,205	6,087	4,171	6,429	3,543
Two-Wheeler	50,917	57,836	58,134	66,889	74,335	84,008	84,202
Tractor	1,383	1,410	1,649	2,033	2,028	3,355	1,302
Trailer	839	846	693	516	806	2,134	784
Other	30	21	5	2	18	14	3
Total	76,343	85,233	85,862	92,778	98,299	121,845	112,291

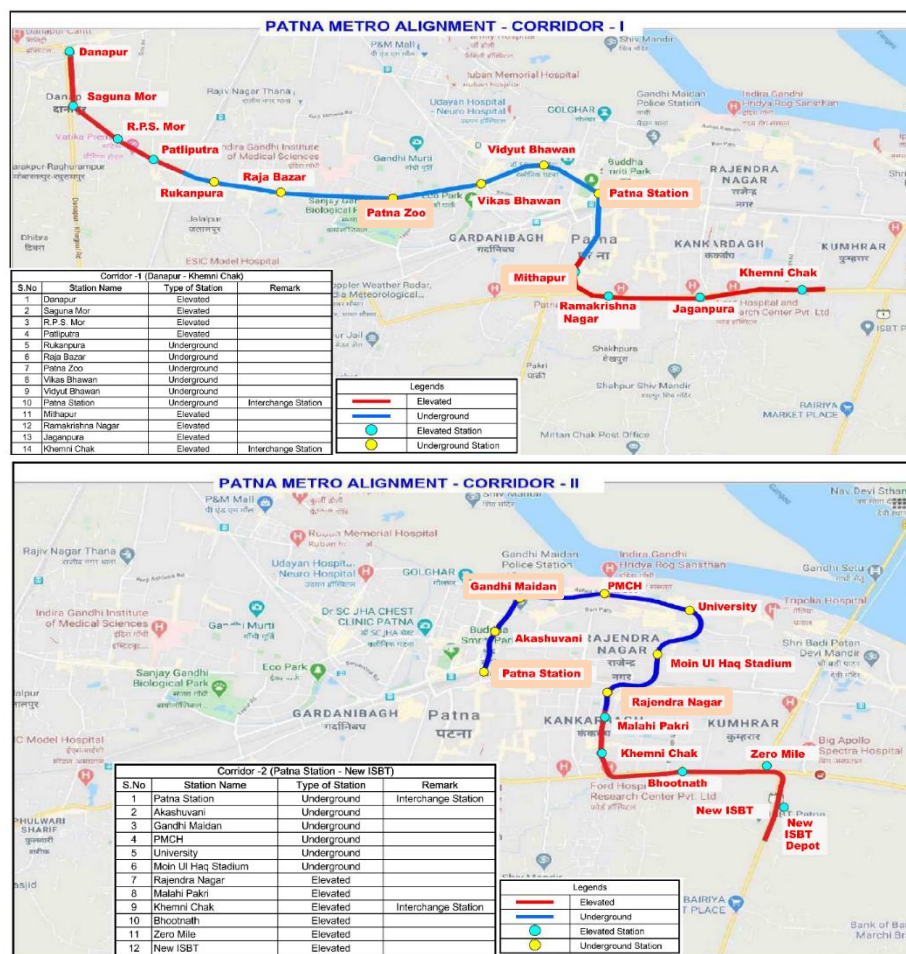
Source: CMP Patna (2018)

(2) Major Transport Nodes

Terminals are the major transport nodes which attract and produce high number of trips every day. At present, there are two bus terminals in the city. One of them is at Mithapur (Pvt. Bus Terminal), which is the major terminal for intercity buses and the second is at Gandhi Maidan which also caters to the intercity buses. As per CMP Patna 2018, Mithapur Bus Terminal caters to the 73,239 passengers daily and 6,227 passengers during peak hour.

The Howrah-Delhi railway line traverses through the entire city length in the east-west direction. Major railway stations along main line are Patna Junction (Patna Station), Patna City and Rajendra Nagar Terminal.

The city is also facilitated with an airport named Lok Nayak Jayaprakash Airport which located near Sanjay Gandhi Biological Park (Patna Zoo) which is accessible through Bailey Road, Rukunpura -Khagol road and NH 139.



Source: Prepared by JST based on Google Earth

Figure 15-2: Metro Stations at Major Transport Nodes

(3) Speed and Delays Characteristics

The journey speed characteristics during peak and off-peak periods are presented in following tables. Journey speeds are slow in Patna. Road network having journey speed less than 30 kmph during peak hour consisted 83% of the road length, and off-peak periods 63 %.

Table 15-22: Distribution of Road Length by Peak Hour Journey Speed

S. No.	Journey Speed (Km/hr)	Road Length (Km)	Percentage (%)
1	<=20	147.1	55.0
2	21-30	75.1	28.1
3	31-40	44.2	16.5
4	41-50	1.0	0.4
5	>50	0.0	0.0
	Total	267.5	100

Source: RITES Primary Surveys

Table 15-23: Distribution of Road Length by Off-Peak Hour Journey Speed

S. No.	Journey Speed (Km/hr)	Road Length (Km)	Percentage (%)
1	<=20	142.0	53.1
2	21-30	28.4	10.6
3	31-40	79.7	29.8
4	41-50	16.9	6.3
5	>50	0.4	0.2
	Total	267.5	100

Source: RITES Primary Surveys

(4) Traffic Safety

Accident statistics at Crash hotspots in 2016/17 are presented in following table. More than 300 accidents occurred including 100 fatal and 155 major accidents.

Table 15-24: Road Accidents in Patna

Road Location	Fatal	Major	Minor	Total
Bypass Road	18	23	11	52
NH 31	16	29	9	54
Gandhi Setu	15	14	18	47
Bhootnath Road	13	17	6	36
Old Bypass	10	27	18	55
Chapra Patna Highway	9	8	7	24
Jaganpura Road	8	8	5	21
Gaya Gumati Line	6	11	9	26
Gopalpur Road	5	18	7	30
Total	100	155	90	345

Source: CMP Patna, 2018

15.2 Necessity of Land Acquisition and Resettlement

The Project require lands permanently for entry/exit of stations, ventilation facilities, ramp, pier, receiving substation (RSS), and for other temporal use such as casting yards. Major part of land acquisition occurs at the planned stations. Other permanent land acquisition occurs where lamps are required within the alignment.

Residential structures, shops and vendor stalls along major roads at those station locations are to be affected and need to be relocated. The station facilities are designed on public land as much as possible to minimize the affected structures at various places.

15.3 Legal Framework for Land Acquisition and Resettlement

The Acts and Policy relevant to the study are:

- The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (No. 30 of 2013).

- Bihar Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2014
- JICA Guidelines for Environmental and Social Considerations (April 2010)

The following sections deal with these policies with a comparison and subsequently with the entitlements and eligibility for compensation and other resettlement entitlements.

15.3.1 Land Acquisition Act (2013)

The Land Acquisition Act (2013) (the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013) was enforced on January 1, 2014 by amending the Land Acquisition Law (1984). The table below outlines the contents of compensation and support stipulated by the Land Acquisition Act (2013). The land price determination method stipulated by the Land Acquisition Act (2013) stipulates that the market price of land with equivalent conditions in the neighbourhood should be confirmed by three methods, and the highest price of the three methods should be adopted. In addition, the price of attached assets to the land such as buildings is calculated by using the unit price of goods, which is updated every year, in the calculation method used when procuring buildings, etc. in public works projects, and is considered to be equivalent to the market price.

The Land Acquisition Act (2013) also stipulates that a consolation fee (solatium) should be added : 2 to 2.5 times of the land price; 2 times of the price of the building and other assets (as detailed in Table 15-26 Topic g). From this calculation, it can be confirmed that the compensation as stipulated in the Land Acquisition Act (2013) suffices the full replacement cost of the land, buildings and other assets.

Table 15-25: Due Process by the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (Land Acquisition Act 2013)

Article	Process
3	1) LAND PLAN DRAWINGS prepared by Project Owner
4	2) Land Plan submitted to District Administration
4	3) District Administration issues Art. 4 Notice 4) State SIA survey is procured 5) State SIA survey is to be finished within 6 months from issuance of the Notice
5	6) The appropriate Government shall ensure that A PUBLIC HEARING is held at the affected area (notice to the public to be published 10 to 30 days before the hearing)
6	7) State Social Impact Assessment study report and the State Social Impact Management Plan are shared with, and reviewed by the local governments and respective institution
7	8) The State Social Impact Assessment report is evaluated by an independent multi-disciplinary Expert Group organized by District Administration
8	9) The District Administration shall examine the report of the Collector on the State SIA, recommend such area for acquisition which would ensure minimum adverse impact (2)
11	10) District Administration considers that land is required for any public purpose, a preliminary notification shall be published. ● From the date of publication of such notification, No person shall ➤ make any transaction or cause any transaction of land specified in the preliminary notification or ➤ create any encumbrances on such land

Article	Process
12	11) To determine the extent of land to be acquired, any officer shall enter and survey any land stated in the notification.
14	12) Where a preliminary notification is not issued within twelve months from the date of appraisal of the State Social Impact Assessment report, such report shall be lapsed
15	13) Any person interested in any land may, within sixty days, object to the area and suitability of land proposed to be acquired; (60 days)
16	14) The Administrator for Rehabilitation and Resettlement shall conduct a survey and undertake a State census of the affected households (1) 15) The Administrator shall prepare a draft State Rehabilitation and Resettlement Scheme (2)(3) 16) The draft State Rehabilitation and Resettlement scheme shall be made public.. 17) A public hearing shall be conducted at the affected area. (4)(5) 18) The Administrator shall, on completion of public hearing submit the draft State Scheme for Rehabilitation and Resettlement to the Collector. (6)
17	19) The Collector shall review the draft State Scheme and forward the draft State Rehabilitation and Resettlement Scheme with his suggestions to the Commissioner Rehabilitation and Resettlement for approval
18	20) The Commissioner shall publish the approved State Rehabilitation and Resettlement Scheme
19	21) A declaration shall be made of an area identified as the "resettlement area" for rehabilitation and resettlement and the affected households. (Article 19 Notice) 22) The Collector shall publish a summary of the State Rehabilitation and Resettlement Scheme along with declaration. (1)(2) 23) PMRCL deposits an amount, in full or part, as prescribed as the cost of acquisition of the land: (2) 24) Where no declaration is made within twelve months from the date of preliminary notification, the preliminary notification shall be deemed to have been rescinded:(7)
20	25) The land to be acquired shall be marked out and measured
21	26) Public notice is issued stating that claims to compensations and rehabilitation and resettlement may be made to the Collector. 27) All persons interested in the land are required to appear before the Collector for payment of compensation not in less than thirty days and not more than six months
23	28) The Collector shall ➤ enquire into the objections, and into the value of the land. and ➤ enquire into the persons claiming the compensation
25	29) The Collector shall make an award within a period of twelve months from the date of publication of the declaration under section 19

Source: Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (LARR) Act, 2013

Table 15-26: System, Target, and Process of Compensation and Assurances Defined by Land Acquisition Act (2013)

Topic	Provision of the Act
a. Establishment of a specialized body	<ul style="list-style-type: none"> Establishment of the national and state monitoring committees to monitor the process of land acquisition (Section 48) Authority(s) for speedy redressal of disputes relating to land acquisition (LA) and rehabilitation and resettlement (R&R) (Section 51)
b. Eligibility	<ul style="list-style-type: none"> Title holders (landowner and registered tenants) are eligible for compensation. Those who lose their basis of livelihood by LA are eligible for rehabilitation and resettlement.
c. Properties for compensation	<ul style="list-style-type: none"> Land, buildings attached to the land, and other things attached to the land or building
d. Consultation process	<ul style="list-style-type: none"> Except under urgent acquisition (Section 9) and exempt cases (Section 105), the government will follow a series of steps, including social impact assessment study and

Topic	Provision of the Act
	public hearing to ascertain the views of affected households to be recorded and included in the report (Sections 4 and 5).
e. Determination of market value of land by the District Collector	<ul style="list-style-type: none"> The District Collector, when assessing and determining the market value of the land, will adopt the higher value of the following (Section 26): <ol style="list-style-type: none"> The market value specified in the Indian Stamp Act 1899 in the area where the land is situated; and The average sale price for similar type of land situated in the nearest village or nearest vicinity area.
f. Determination of market value of assets attached to land or building	<ul style="list-style-type: none"> The market value will be calculated using the same method that is used for procurement of construction of buildings and other facilities, with unit price that is updated every year by the state government.
g. Compensation for landowners	<ul style="list-style-type: none"> (Market value of land \times 1 (urban) or \times 1.25 (within 30 km from urban)) + (Solatium for land (Equivalent to 100% of above)) + (Market value of buildings and other things attached to the land) + (Solatium for buildings (Equivalent to 100% of above)) <p>In total, 【Market value of land \times 2 or \times 2.5】 + 【Market value of attached assets \times 2】 will be paid to the landowners.</p>
h. Rehabilitation and resettlement	<ul style="list-style-type: none"> Eleven types of elements are listed in the Second Schedule. Awards include provision of housing units, land for land, choice of annuity or employment, subsistence grant for displaced households for one year, transportation cost for displaced households, one-time grant to small traders, one-time resettlement allowance, stamp duty, and registration fee.

Source: Land Acquisition Act 1894, Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (LARR) Act, 2013

15.3.2 Bihar Rules (2014)

In addition, under Section 109 of the Land Acquisition Act (2013), the Bihar State Rules came into force on October 27, 2014, with the Department of Revenue and Land Reforms in Bihar as the competent authority. The contents of the rules are shown in following table, which outline the process of SIA and provide for preparation of Rehabilitation and Resettlement scheme notifying and conducting public hearing. It also provides for assessing land rates and provision of compensation entitlement matrix for the affected households which is in line with the act. There is no discrepancy with the Land Acquisition Act (2013) and the Bihar Rules.

Table 15-27: Structure of the Bihar Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2014

CHAPTER I	GENERAL
CHAPTER II	REQUISITION FOR LAND ACQUISITION
CHAPTER III	SOCIAL IMPACT ASSESSMENT
CHAPTER IV	CONSENT
CHAPTER V	NOTIFICATION AND ACQUISITION
CHAPTER VI	REHABILITATION AND RESETTLEMENT SCHEME
CHAPTER VII	AWARD AND COMPENSATION
CHAPTER VIII	REHABILITATION AND RESETTLEMENT COMMITTEE AND STATE MONITORING COMMITTEE
CHAPTER IX	LAND ACQUISITION, REHABILITATION AND RESETTLEMENT AUTHORITY
CHAPTER X	MISCELLANEOUS

Source: Bihar Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2014

15.3.3 Metro Railways (Operation and Maintenance) Act, 2002

The Article 48 of the Metro Railways Act 2002 states that any damage to any property arising out of the working of the metro railway shall be claimed and the Claims Commissioner shall have powers to make compensation for the loss.

Any other laws, however, were not found that defines the right of underground space, and the relationship between the right of surface landownership and the right of underground space. Therefore, a metro project is not required to compensate for the use of underground space. On the other hand, the persons who own land landowner above a metro facility is not subject to any limitation in using the underground space.

For Patna Metro project, underground corridors are located under major roads. Where station facilities are located in the roadside spaces, PMRCL is acquiring the land. Therefore, PMRCL is avoiding the risk of landowners digging and constructing their own underground structures that damages metro structures and systems.

15.3.4 JICA Guidelines

The Project is classified as “Category A” in the JICA Guidelines for of Environmental and Social Considerations (April 2010), because the Project corresponds with the railway sector which has a characteristic of large-scale involuntary resettlement.

The key principle of JICA policies on involuntary resettlement is summarized below.

1. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.
2. When population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.
3. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.
4. Compensation must be based on the full replacement cost as much as possible.
5. Compensation and other kinds of assistance must be provided prior to displacement.
6. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. The resettlement action plan should include elements laid out in the World Bank Safeguard Policy.
7. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.
8. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.
9. Appropriate and accessible grievance mechanisms must be established for the affected people and

their communities.

15.3.5 World Bank OP 4.12

In addition to the above core principles on the JICA policy, it also emphasized a detailed resettlement policy inclusive of all the above points; project-specific resettlement plan; the institutional framework for implementation; monitoring and evaluation mechanism; the schedule for implementation; and, detailed financial plan etc.

Additional key principle based on World Bank OP 4.12 is as follows.

1. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.
2. Eligibility of Benefits includes the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.
3. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.
4. Provide support for the transition period between displacement and livelihood restoration.
5. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.
6. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

15.3.6 Gap with JICA Guidelines Regarding Land Acquisition and Relocation of Residents and Countermeasures

Since the Project requires land acquisition, relocation of residents, and loss of livelihood, the details of the discrepancy between JICA Guidelines on social consideration and Indian Acts and Rules, and the project policy for bridging the discrepancies are summarized in the following table.

Table 15-28: Comparison of JICA Guidelines with Indian Acts and Rules

	JICA Guidelines, WB OPs	LARRA 2013	Gap	Policies in the 2020 SIA Entitlement Matrix and JST Proposals
1	Involuntary resettlement and loss of means of livelihood are to be avoided, when feasible, by exploring all viable alternatives.	4. 8. (1) (c) The government will ensure that only the minimum area of land required for the project is proposed to be acquired. 8. (2) The government will examine the report of the Collector and the report of the Expert Group on the	No gap	During the study, site observation was made and alternative locations of station facilities were confirmed. PMRCL has made design changes to avoid and minimize land acquisition and

	JICA Guidelines, WB OPs	LARRA 2013	Gap	Policies in the 2020 SIA Entitlement Matrix and JST Proposals
		SIA study, and will recommend such area for acquisition which would ensure minimum displacement of people, minimum disturbance to the infrastructure, ecology, and minimum adverse impact on the individuals affected.		resettlement to the extent possible.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	Ch. 2 Whenever the government intends to acquire land for public purposes, it will carry out an SIA study that contains information on minimization of the impact, extent of remaining impact, and measures to compensate for losses. 3 (c) Compensation and assistances are provided for the title holders and those whose primary livelihood depends on the land to be acquired.	No gap	The compensation for loss of assets will be done based on the LARRA 2013.
3	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported so that they can improve or at least restore their standard of living, income opportunities, and production levels to pre-project levels.	3. (p), 27. 29. The definition of 'Land', the target of compensation, includes benefits to arise out of land and things attached to the earth or permanently fastened to anything attached to the earth. 26. Land value will be the higher value of the following: a) the market value specified in the Indian Stamp Act 1899 in the area where the land is situated, or b) the average sale price for similar type of land situated in the nearest village or nearest vicinity area. 28. In determining the amount of compensation to be awarded for land, the Collector will take into consideration the expenses to change the residence or place of business. Second Schedule. Eleven types of entitlement for R&R are listed to be given in addition to the award provided by the First Schedule.	No gap	Those who were counted on the cut-off date and are to be relocated by the Project, no matter whether he/she is a title or non-title holder, will be eligible to subsistence allowance, resettlement allowance, and shifting allowance. Vulnerable households will be eligible for vulnerable assistance and skills training. JST proposed PMRCL, and both parties agreed that any PAHs who opted for the skills training will be provided the same.
4	Compensation must be based on the full replacement cost as much as possible.	26. Land value will be the higher value of the following: a) the market value specified in the Indian Stamp Act 1899 in the area where the land is situated, or b) the average sale price for similar type of land situated in the nearest village or nearest vicinity area. 29. In determining the market value of the standing crops or trees, the Collector used the services of a	The compensation is to be based on market value, not exactly the replacement cost. However, the total compensation value must be doubled by adding 100% solatium. (LARRA 2013)	The replacement value of houses, buildings, and other immovable properties will be determined on the basis of latest national Standard Schedule of Rates (SSR) as on the date without depreciation and 100% solatium will be added to the structure compensation. Compensation of the land will be calculated by an equation directed by the LARRA 2013, which provides 100% solatium added to the land value. PMRCL adds one year interest

	JICA Guidelines, WB OPs	LARRA 2013	Gap	Policies in the 2020 SIA Entitlement Matrix and JST Proposals
		<p>competent engineer or any other specialist in the relevant field.</p> <p>30. The Collector having determined the total compensation to be paid (land and other added), will impose a 'Solatium' amount equivalent to 100% of the compensation amount.</p>		<p>rate of 12 % from the beginning. Therefore, the land and asset owner will receive 212 % of the evaluated price.</p> <p>It can be concluded, therefore, that the size of compensation will surpass the full replacement cost.</p>
5	<p>Compensation and other kinds of assistance must be provided prior to displacement.</p>	<p>46 (4) No land use change will be permitted if rehabilitation and resettlement is not compiled fully.</p>	No gap	<p>JST found 2 issues in PMRCL's policies that needs to be amended.</p> <p>1) 50 structures (50 PAHs) have already left from public land they originally occupied on February 2020 without receiving compensation or assistances. JST and PMRCL agreed that PMRCL shall identify the 50 PAHs using ID information obtained during the SIA survey and pay compensation and provide R&R assistances.</p> <p>2) DPR SIA states that '80% compensation is paid prior to displacement and 100% compensation before commencement of civil works.'</p> <p>In the letter dated Sep. 21, 2022 (Point 2 and 5), PMRCL agreed that 100 % compensation and other assistances to be provided to PAHs prior to displacement.</p>
6	<p>For projects that entail large- scale involuntary resettlement, RAPs must be prepared and made available to the public.</p>	<p>6 (1), 2014 Bihar Rule to LARRA 2013. 11. The draft Rehabilitation and Resettlement Scheme will be widely published in the affected areas through the Official Gazette, newspapers, in the local government offices, the website of the government, and on a public notice in the affected areas.</p> <p>2014 Bihar Rule to LARRA 2013. 12. The final SIA Report and SIMP shall be prepared in the local language and shall be made available to Municipal Corporation, and the offices of the District Collector, the Sub-Divisional Officer, and shall be uploaded on the website of the appropriate Government.</p>	No gap	<p>District of Patna, on behalf of State of Bihar, is under process of land acquisition, including preparation of the SIA Report, and resettlement and rehabilitation plan for the Project.</p> <p>JST reviewed those SIA reports and Resettlement Policy Framework prepared by PMRCL to confirm that the whole project scope is included, the entitlement matrix fulfils the requirements of the JICA Guidelines, and the reports and plans are made available to the public.</p>
7	<p>In preparing RAPs, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.</p>	<p>4. (2) The notification (to carry out an SIA) will be made available in the local language and will be published in the affected areas and uploaded on the website of the government.</p> <p>5. Whenever an SIA is required, the government will ensure that a public hearing is held at the affected area after giving adequate publicity about the date,</p>	No gap	<p>PMRCL engineer disseminated the project information to the affected communities in the public consultations in DPR preparation phase in 2020.</p> <p>District Administration of Patna, on behalf of State of Bihar, is under process of preparing the SIA Report and resettlement and rehabilitation plan for the Project.</p>

	JICA Guidelines, WB OPs	LARRA 2013	Gap	Policies in the 2020 SIA Entitlement Matrix and JST Proposals
		time, and venue for the public hearing.		JST reviewed the information disseminated in preparation phase in 2020 and confirmed that sufficient information was disseminated in the early phase of the consultation. During the study, JST confirmed that, according to the requirement of the Land Acquisition Act 2013, District Administration is implementing consultations with the affected landowners and other stakeholders to prepare the SIA reports and the resettlement plans.
8	When consultations are held, explanations must be given in a form, manner, and language that is understandable to the affected people.	<p>5. Whenever an SIA is required, the government will ensure that a public hearing is held at the affected area to ascertain the views of the affected households to be recorded and included in the SIA report.</p> <p>6. The SIA report is prepared and made available in the local language and will be published in the affected areas and uploaded on the website of the government.</p>	No gap	The consultations were held using Hindi, and the State SIA reports were prepared in Hindi, which is the language used in basic education in Patna.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of RAPs.	<p>5. Whenever an SIA is required, the government will ensure that a public hearing is held at the affected area to ascertain the views of the affected households to be recorded and included in the SIA report.</p> <p>50. The state government will constitute a State Monitoring Committee for review and monitoring the implementation of R&R schemes.</p> <p>2014 Bihar Rule to LARRA 2013. Ch. 8. (1) The State Government shall constitute a Rehabilitation and Resettlement Committee at project level to monitor and review the progress and implementation of the Rehabilitation and Resettlement Scheme and to carry out post-implementation social audits in consultation with Municipal Council in the urban area.</p>	No clear indication of PAs participation in the implementation and monitoring phase.	JST proposed to PMRCL and two parties agreed on following regarding the participation of the PAs in the implementation and monitoring phase: - In the implementation phase, the implementing Committee will meet with each PAH, and custom-made micro RAP with all the needs and requests reflected will be developed and implemented. - In the monitoring phase, an External Monitoring Specialist will facilitate the participatory research, target group monitoring and sample survey.
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	<p>7. The government will ensure that the SIA report is evaluated by an independent Expert Group, including two representatives of <i>Panchayat</i>.</p> <p>15. Any person may object to the area, justification for public purpose, and the findings of the SIA report to the Collector.</p> <p>16. (4) (5) (6) The draft Rehabilitation and Resettlement scheme will be made known locally by wide publicity in the affected area. A public hearing will be conducted.</p>	No gap	JST discussed with PMRCL about the grievance redress mechanism of the Project, which was not yet established in September 2022. JST confirmed that all the necessary position to establish the mechanism are already filled. . Until the official establishment of the GRC, the Director (Project) will assist the General Manager (Works), PMRCL in communication and coordination with the Chief

	JICA Guidelines, WB OPs	LARRA 2013	Gap	Policies in the 2020 SIA Entitlement Matrix and JST Proposals
		<p>The claims and objections raised in the public hearing will be reported to the Collector.</p> <p>44. The Commissioner for Rehabilitation and Resettlement will be responsible for the post-implementation social audit.</p> <p>45. Where land proposed to be acquired is equal to or more than 100 acres, the Rehabilitation and Resettlement Committee will be constituted. The committee will include a representative of women residing in the affected area and a voluntary organization working in the area.</p>		<p>Project Manager (Construction) DMRCL, in solving raised grievances. The office of the Director (Project) will be responsible for taking records of grievances and follow-up until the redressals.</p>
11	<p>Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socio-economic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefits. (WB OP 4.12, Para. 6)</p>	<p>4. (1) Whenever appropriate government intends to acquire land for public purpose, it shall consult the concerned <i>Panchayat</i>, municipality, or municipal corporation, as the case may be, at the village level or ward level, in the affected area and carry out a Social Impact Assessment Study in consultation with them, in such manner and from such date as may be specified by such government by notification.</p> <p>11 (4) No person shall make any transaction or cause any transaction of land specified in the preliminary notification or create any encumbrances on such land from the date of publication of such notification.</p>	<p>Non-title holder PAPs need to be located at least three years before the cut-off date to be eligible, and whose primary source of livelihood stand affected by the acquisition of land.</p>	<p>PMRCL has made a preliminary baseline survey and produced preliminary list of the PAPs. The Survey was done in February 2020.</p> <p>JST proposed PMRCL that, for this Project, those who were counted on the cut-off date but their residence or use of land is less than 3 years are awarded with relocation assistances and income rehabilitation by utilizing existing laws and guidelines.</p> <p>PMRCL informed JICA that those who has less than 3 years of tenancy will be made eligible after approval of PMRCL Board.</p> <p>State of Bihar sets the cut-off date for title holders and non-title holders on private land by issuing the preliminary notice (Article 11 Notice) to restrict transaction of the land proposed for acquisition. The cut-off date of non-title holders will be the date of the preliminary baseline survey by PMRCL (February 2022).</p>
12	<p>Eligibility of benefits includes the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets, and the PAPs who have no recognizable legal right to the land they are</p>	<p>3. c. 'Affected Family' includes (i) a family whose land or other immovable property has been acquired; (ii) a family which does not own any land, but a member or members of such family may be working in the affected area for three years prior to the acquisition of land, whose primary source of livelihood is affected by the acquisition of land.</p> <p>Ch. 2. The appropriate Government shall implement SIA, publish the draft plan for compensation, rehabilitation and relocation. The plan for compensation,</p>	<p>Non-title holder PAPs need to be located at least three years before the cut-off date to be eligible, and whose primary source of livelihood stand affected by the acquisition of land.</p>	<p>JST proposed PMRCL, and PMRCL is under internal processing that, for this Project, informal settlers (residential and commercial) who were counted on the cut-off date but their residence or use of land is less than 3 years are awarded with compensation, relocation assistances and income rehabilitation.</p>

	JICA Guidelines, WB OPs	LARRA 2013	Gap	Policies in the 2020 SIA Entitlement Matrix and JST Proposals
	occupying. (WB OP 4.12 Para. 15)	rehabilitation and relocation shall be finalized after public hearings. 4. (4) The SIA study will include (b) estimation of affected households and the number of households likely to be displaced.		
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP 4.12 Para. 11)	The Second Schedule. Land for land-type compensation is made available for landowners for affected households owning agricultural land in the affected area and whose land has been acquired or lost.	An agricultural tenant who does not have official contract with the landowner is not eligible for assistance in finding another tenant opportunity.	The DPR compensation plan proposes cash compensation for the loss of land for landowners, and three months (90 days) advance notification for the harvesting of standing crops, or lump sum equal to the market value of the yield of the standing crop lost determined by Agricultural Department. JST reviewed the State SIA reports, and confirmed that there are no agriculture tenants affected by the project.
14	Provide support for the transition period (between displacement and livelihood restoration). (WB OP 4.12 Para. 6)	The Second Schedule. As the support for the transition period, all the affected households will be eligible for the following: choice of annuity or employment (employment in the project, one-time payment, and annuity policies per month for 20 years), subsistence grant for displaced households for a period of one year (monthly subsistence), and one-time resettlement allowance.	No gap	Those who were counted on the cut-off date and who need to be relocated due to the Project, regardless of whether he/she is a title holder or non-title holder, will be eligible to subsistence allowance, resettlement allowance, and shifting allowance. Vulnerable households will be eligible for vulnerable assistance and skills training.
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women, children, ethnic minorities, etc. (WB OP 4.12 Para. 8)	41. As far as possible, no acquisition of land will be made in the scheduled areas. In case of acquisition, special provisions will be provided for Scheduled Castes and Scheduled Tribes.	The definition of vulnerable group is limited in the LARRA 2013.	In DPR/SIA Entitlement Matrix, Vulnerable PAPs are defined as those living below poverty line, SC/ST households and women-headed households, differently abled persons are among the affected households. JST proposed PMRCL and two party agreed to include elderly households above the age of 60 years without support from other family members in the list for additional assistances.

Source: JST

15.4 Summary of Land Acquisition, Resettlement and Relocation

Total permanent land requirement for the Project is 47.625 ha (public 11.930 ha, private 35.695 ha). Total 15.764 ha, 11.930 ha of Central or State government land and 3.834 ha of private land will be used for stations and related facilities such as ventilation and entrances. To minimize the impact on private land, the station facilities are planned on government land and under the existing artery roads as much as possible. Public land is to be transferred to PMRCL from original owner institutions such as National Highway Authority of India, Road Construction Department and Revenue and Land Reforms Department of State

of Bihar. 31.861 ha of private land is to be acquired for the Depot. Temporal land use, expected to be 29.167 ha, is planned on government land only.

Land requirement at various locations is summarized in table below.

Table 15-29: Summary of Land Acquisition, Resettlement and Relocation

Corridor 1

Elevated/ Under	Corridor & Station No.	Station Name	JICA Funding ¹⁾	Title Holder	NOC for Gov. Land ²⁾	LARRA process ³⁾	Construction Works	No. Fully Affected Structures July 2022	No. Fully Affected PAHs July 2022	Government Land (Permanent) (ha) ⁴⁾	Government Land (Temporal) (ha) ⁴⁾	Private Land (Permanent) (ha) ⁴⁾
Elevated	1-1	Danapur	-	Public only	Ongoing		PC04			0.111		
Elevated	1-2	Saguna More	-	Public only	Granted		Started 2022			2.534		
Elevated	1-3	RPS More	-	Public only	Granted		Jan/10			(Include area For Rama Krishna Nagar)		
Elevated	1-4	Patliputra	-	Public only	Granted							
Under	1-5	Rukanpura	Y (PC6)	Private/Public	Granted	SIA		2	3			0.410
Under	1-6	Rajabazar	Y (PC6)	Private/Public	Granted	SIA		3	4	0.173		0.517
Under	1-7	Patna Zoo	Y (PC5, 6)	Public only	Granted			8	23	0.090	0.029	
Under	1-8	Vikas Bhawan	Y (PC5)	Public only	Ongoing					0.257	0.079	
Under	1-9	Vidyut Bhawan	Y (PC5)	Public only	Ongoing					0.136	0.117	
Under	1-10 (2-1)	Patna Junction	Y (PC5)	Private/Public	Ongoing	SIA				0.254	0.156	0.025
Under/Elevated	1-11	Mithapur	-	Private/Public	Ongoing	SIA	PC04			1.541	0.237	0.584
Up	1-12	Ramakrishna Nagar	-	Private/Public	Granted	SIA	Started 2022			(shown above)		0.070
Up	1-13	Jaganpura	-	Private/Public	Granted	SIA	Jan/10					0.058
Up	1-14 (2-9)	Khemni Chak	-	Private/Public	Granted	SIA	PC01 Started 2020 Sep.28.			(corridor 2)		(corridor 2)
		PC-04 Casting Yard	-	Public only	Granted						5.000	
		PC-05 Casting Yard	Y (PC5)	Public only	-						5.000	
		PC-06 Casting Yard	Y (PC6)	Public only	-						5.000	
		Waste Plant & Dumping Yard	-	Public only	Granted						4.368	
Corridor 1 Total (ha)								13	30	5.095	19.986	1.664

1) Shows locations of Civil Work packages to be funded by JICA. Other JICA funding is planned for items such as track works, electrical works, procurement of rolling stock, and signal and telecom works.

2) Source: Monthly progress report, August 2022, DMRCL

3) Process of private land purchase matures in the order starting from SIA phase to Art. 11 Notice phase to Art. 19 Notice phase. In Art. 19 Notice phase, District Administration is ready to start negotiation of the compensation package and payment to PAH.

4) Source: JST based on PMRCL(Land details as per July 2022)

Corridor 2

Up/Under	Station No.	Station Name	JICA Funding ¹⁾	Title Holder	NOC for Gov. Land ²⁾	LARRA process ³⁾	Construction Works	No. Fully Affected Structures July 2022	No. Fully Affected PAHs July 2022	Government Land (Permanent) (ha) ⁴⁾	Government Land (Temporal) (ha) ⁴⁾	Private Land (Permanent) (ha) ⁴⁾
Under	2-1(1-10)	Patna Junction (reshown)	-	Private/Public (reshown)	Ongoing	SIA				(corridor 1)	(corridor 1)	(corridor 1)
Under	2-2	Akashwani	-	Private/Public	Granted	SIA	PC02	5	8	0.149	0.031	0.068
Under	2-3	Gandhi Maidan	-	Public only	Granted		Started 2022	6	9	0.201	0.289	
Under	2-4	PMCH	-	Private/Public	Granted	SIA	Jan/10	3	3	0.462	0.334	0.111
Under	2-5	University	-	Private/Public	Ongoing	SIA				0.215	0.660	0.041
Under	2-6	Moin-ul-Haq	-	Public only	Granted					0.203	0.724	
Under	2-7	Rajendra Nagar	-	Public only	Ongoing					0.278	0.015	
Elevated	2-8	Malahi Pakri	-	Public only	Granted		PC01	41	41	1.335	0.128	
Elevated	2-9(1-14)	Khemni Chak (reshown)	-	Private/Public (reshown)	Granted	SIA	Started 2020	4	4	3.580		0.238

Up/Under	Station No.	Station Name	JICA Funding ¹⁾	Title Holder	NOC for Gov. Land ²⁾	LARRA process ³⁾	Construction Works	No. Fully Affected Structures July 2022	No. Fully Affected PAHs July 2022	Government Land (Permanent) (ha) ⁴⁾	Government Land (Temporal) (ha) ⁴⁾	Private Land (Permanent) (ha) ⁴⁾
Elevated	2-10	Bhootnath	-	Public only	Granted		Sep.28.	2	2	0.100		
Elevated	2-11	Zero Mile	-	Public only	Ongoing			2	2	0.177		
Elevated	2-12	New ISBT	-	Private/Public	Ongoing	Art.19 Notice				0.136		1.713
Level(raised)		Depot	-	Private only		Art.19 Notice		2	2			31.861
	PC-03 Casting Yard		-	Public only	Granted						7.000	
Corridor 2 Total								65	71	6.835	9.180	34.031

1) Shows locations of Civil Work packages to be funded by JICA. Other JICA funding is planned for items such as track works, electrical works, procurement of rolling stock, and signal and telecom works.

2) Source: Monthly progress report, August 2022, DMRCL

3) Process of private land purchase matures in the order starting from SIA phase to Art. 11 Notice phase to Art. 19 Notice phase. In Art. 19 Notice phase, District Administration is ready to start negotiation of the compensation package and payment to PAH.

4) Source: JST based on PMRCL(Land details as per July 2022)

15.5 Scale and Extent of Land Acquisition

PMRCL, the Project Owner, implemented SIA study in 2020 as a part of the Detailed Project Report for approval of the Project by the State of Bihar. After the approval of the Project by the State of Bihar, the State of Bihar takes responsibility of acquiring the land for the Project following the 2013 Land Acquisition Act. The process of land acquisition includes an independent SIA survey procured by the Patna District Administration on behalf of the State of Bihar.

Since the State SIA survey contains updated information about the land owners, information in the State SIA reports were used in Sections 15.5 and 16.2.2 to review and analyze updated condition of the Project.

15.5.1 Update of Scale and Extent of Land Acquisition

(1) Land Requirement

The latest land requirement is shown in the table below. In total, permanent land requirement is 47.63 ha, and temporal land requirement is 29.17 ha. Private land is required only for permanent purpose.

Table 15-30: Updated Land Requirement for Corridor 1 and Corridor 2 at July 2022 (in ha)

Sr. No	Item	Unit	Corridor 1	Corridor 2	Total
1	Government Land				
1.1	Permanent	ha	5.095	6.835	11.930
1.2	Temporary	ha	19.986	9.180	29.166
1.3	Total Government Land	ha	25.081	16.015	41.096
2	Private Land				
2.1	Permanent	ha	1.664	34.031	35.695
2.2	Temporary	ha	0	0	0
2.3	Total Private Land	ha	1.664	34.031	35.695
3	Total Land Requirement	ha	26.745	50.046	76.791
4	Total Permanent Land	ha	6.759	40.866	47.625
5	Total Temporary Land	ha	19.986	9.180	29.166

Source: Data received from PMRCL on August 29, 2022. 'Land details as per July, 2022'

(2) Progress of Land Acquisition Process

As of September 2022, 11 locations, including the Depot area, private land acquisition are under process of Land Acquisition Act 2013. District Administration, on behalf of State of Bihar, is implementing the State SIA survey for all 11 locations.

Article 11 Notice and Article 19 Notice have been issued for the Depot area and for New ISBT Station. Other land plots are still awaiting the approval of the State SIA study. As of September 2, 2022, PMRCL informed JST that 18 landowners for those 2 areas have already visited the District Administration Office to start the payment process of compensation.

Table 15-31: Progress of Land Acquisition

Locations	Art. 11 Notice	Art. 19 Notice	Estimated expenditure amount
Depot Area	2021.Oct.23	2022.May.11	INR. 790.80 Cr. (INR. 7,908 million)

New ISBT Sta.	2022.Feb.10	2022.May. 13	INR. 36.08 Cr. (INR. 360.8 million)
Jaganpura Sta. Ramakrishna Nagar Sta. Mithapur Viaduct Akashwani Sta. University Sta. PMCH Sta. Rajabazar Sta. Rukanpura Sta. Patna Junction Sta.	Under preparation at the District Administration	Will be published after all process completed after Art. 11 Notice publication	To be estimated after Art. 19 Notices are published
Danapur Sta. Saguna More Sta. RPS More Sta. Patliputra Sta. Zoo Metro Sta. Vikas Bhawan Sta. Gandhi Maidan Sta. Moin-ul-Haq Sta. Rajendra Nagar Sta. Malahi Pakri Sta. Khemni Chak Sta. Bhootnath Sta. Zero Mile Sta.	<ul style="list-style-type: none"> ● Only public land parcels are affected and Art. 11 and 19 Notices are not required. ● PMRCL is under process of being transferred the necessary land from original owner institutions, with assistance of the District Administration. 		

Source: PMRCL 2022.Jul. 11 'Land Status as of June 2022'

(3) Number of Affected Landowners

As per September 16, 2022, 6 State SIA reports for 11 locations of private land acquisition have been shared by the District Administration for PMRCL and JST.

According to those reports, 35.695 ha of target land is divided into 138 plots, with about 711 registered landowners. Out of those owners, 237 landowner households have cooperated for socio-economic survey of the landowners.

Following points are the limitation of the date obtained from the State SIA reports.

- The SIA experts tried to contact all the landowners registered at the District Administration Office. It was found, however, that some of those landowners were living abroad or in other parts of India and were not available for interview survey.
- The land registration at the District Administration Office is not updated, and many self-declared landowners were found during the State SIA survey. Some of those exhibited the proof of their ownership, but some did not have any proof of their ownership. Further clarification of the true title holders must be implemented by the District Administration Office before decision of the eligible person for compensation of a land plot.
- Some registered and self-declared landowners refused to cooperate in the SIA survey, refused to be photographed, and refused to sign the attendants list. The Article 77 of the 2013 Land Acquisition Act provides instruction in case part of the landowners refused negotiation or did not agree with the amount of compensation. In such case, the District Administration Collector shall deposit the amount

of the compensation in the Land Acquisition and Rehabilitation and Resettlement Authority. With the completion of the deposit, land title can be transferred to PMRCL, and PMRCL will proceed with the Project.

- The data provided in the SIA reports varies by each report. Not all data was obtained from maximum 237 PAHs surveyed.
- Census date for the residential and commercial tenants, as well as for commercial workers, will be updated after the preliminary notice (Article 11 Notice) is issued. As of September 2022, survey data from SIA 2020 is the latest, and is described in Section 15.6.1 (2) and 15.6.2 of this report.

Table 15-32: Number of Affected Landowners Recognized in State SIA

	Location	Town	Land Area for Purchase (ha)	No. of Plot (Khesra) to be Affected	No. of Registered Landowner	No. of Self-Declared Landowner	No. of Surveyed Landowner Households
1	Depot Area	Pahadi, Ranipur	31.861	85	615	N/A	111
2	New ISBT Sta.	Pahari	1.713	6	40	N/A	16
3	Akashwani Sta. University Sta.	Moharrampur, Sandalpur	0.109	5	N/A	N/A	15
4	Jaganpura Sta. Ramakrishna Nagar Sta. Mithapur Viaduct	Jaganpura, Changad, Bigrahpur	0.712	9	40	60	57
5	Rajabazar Sta. Rukanpura Sta. Patna Junction Sta.	Salempur Khajpura, Sadikpur Patna Municipality	0.952	23	55	75	38
6	PMCH Sta.	Muharrampur	0.111	10	1 (Institutional)	0	(18 commercial tenants)
	Final Total		35.695	138	711	135	237 (excluding 18 commercial tenants)

N/A: Information not available in State SIA report

Land Area: Source : PMRCL 2022.Jul. 11 'Land Status as of June 2022'

Source: SIA reports, Patna District Administration.

15.5.2 Profile of Project affected Landowners

According to those reports, 32.9 ha of target land is divided into 128 plots, with About 710 registered landowners own the targeted 32.9 ha of land. Out of those owners, 237 landowners cooperated for socio-economic survey. The results of the survey are summarized in following tables. Since the District Administration procured multiple experts to implement the SIA surveys, availability of data varies depending on the reports.

In following tables, the number 1 to 6 represents the locations of the surveyed stations;

Report Number	Location (Covered in State SIA report)	Town
1	Depot Area	Pahadi, Ranipur
2	New ISBT Sta.	Pahari,
3	Akashwani Sta.	Moharrampur,

	University Sta.	Sandalpur
4	Jaganpura Sta.	Jaganpura,
	Ramakrishna Nagar Sta.	Changad,
	Mithapur Viaduct	Bigrahpur
5	Rajabazar Sta.	Salempur
	Rukanpura Sta.	Khajpura, Sadikpur
	Patna Junction Sta.	Patna Municipality
6	PMCH	Muharrampur

Source: JST

(1) Social Class

Out of the 199 landowner households from whom data was obtained, 194 households were Hindus. More than half of the households belong to general groups. Households belonging to the Scheduled Castes were found at Depot area (Report 1) and area for Jaganpura Sta., Ramakrishna Nagar Sta., and Mithapur Viaduct (Report 4). Relatively large number of households belonging to the Extremely backward classes, and the Other backward classes were also found in the same areas.

Table 15-33: Social Class of Affected Landowners in State SIA

Social Class	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Total	%
Hindu	110	15	12	57	N/A	0	194	97.5%
Schedule caste	1	0	0	4	N/A	0	5	2.5%
Extremely backward class	4	2	0	5	N/A	0	11	5.5%
Other backward class	21	6	3	36	N/A	0	66	33.2%
General	84	7	9	12	N/A	0	112	56.3%
Others	1	1	3	0	N/A	(1)*	5	2.5%
Total surveyed PAH	111	16	15	57	(38)**	(1)*	199	100.0%

*: Institutional landowner (Bihar State Sunni Waqf Board). Excluded from the total and further analysis of landowner PAHs.

** : 38 PAHs were surveyed in the SIA but information of the social class was not described in the SIA report.

Source: JST

(2) Type of Family

Out of the 237 landowner households from whom data was obtained, about 64 %, or 151 households, were found as nuclear family household. About 34 %, or 80 households, were found as joint family.

Table 15-34: Type of Family of Affected Landowners in State SIA

Type of family	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Total	%
Single	1	0	0	0	0	0	1	0.4%
Nuclear	74	12	12	41	12	0	151	63.7%
Joint	35	3	0	16	26	0	80	33.8%
Other	1	1	3	0	0	0	5	2.1%
Total surveyed PAH	111	16	15	57	38	0*	237	100.0%

*: 1 institutional landowner was surveyed (Bihar State Sunni Waqf Board)

Source: JST

(3) Source of Drinking Water

Asked about the source of drinking water, majority of the PAHs at Jaganpura Sta., Ramakrishna Nagar Sta., and Mithapur Viaduct (Report 4) answered as tap water, and it can be understood that the area is most urbanized area among the stations. In other areas, submersible boring well is used by majority of the households.

Table 15-35: Source of Drinking Water of Affected Landowners in State SIA

Source of water	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Total	%
Submersible (Boring)	87	13	15	0	N/A	N/A	115	57.8%
Tap water	6	1	0	54	N/A	N/A	61	30.7%
Only hand pump	17	2	0	3	N/A	N/A	22	11.1%
Other	1	0	0	0	N/A	N/A	1	0.5%
Total	111	16	15	57	N/A	N/A	199	100.0%

Source: JST

(4) Available Sanitary Services

Asked about sanitary facilities and services, almost all households have toilet. About 90 % of households have drainages. On the other hand, access to waste disposal service is still not available for about 20 % of the landowners at the Depot area. Since only 2 households are residing on the Depot area, majority of the landowners at the Depot area are non-resident landowners. The locations of those non-resident landowners are not included in the SIA report.

Table 15-36: Provision of Toilet Facility and Source of Sanitation in the Residential Premises of Affected Landowners in State SIA

Source of sanitation	Provision of toilet		Disposal of waste		Provision of drainage	
	Yes	No	Yes	No	Yes	No
Report 1	111	0	82	29	98	13
Report 2	16	0	15	1	15	1
Report 3	15	0	15	0	15	0
Report 4	56	1	N/A	N/A	N/A	N/A
Report 5	N/A	N/A	N/A	N/A	N/A	N/A
Report 6	1	0	N/A	N/A	N/A	N/A
Total	199	1	112	30	128	14
%	99.5%	0.5%	78.9%	21.1%	90.1%	9.9%

Source: JST

(5) Annual Household Income

Annual household income differed largely depending on the surveyed locations. Most of the surveyed households earn over INR. 1,000,000 per year at Akashwani Sta. and University Sta. (Report 3). Most of the households who claimed annual income up to INR. 300,000 were found at Depot area (Report 1) and area for Jaganpura Sta., Ramakrishna Nagar Sta., and Mithapur Viaduct (Report 4), where relatively large number of households belonging to the Scheduled Castes, the Extremely backward classes, and the Other backward classes were found.

Table 15-37: Annual Income of Affected Landowners in State SIA

Annual income	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Total	%
Up to INR. 300,000 (-25,000/month))	19	4	0	16	N/A	-**	39	19.7%
Up to INR. 500,000 (-41,667/month)	31	11	0	12	N/A	-**	54	27.3%
Up to INR. 1,000,000 (-83,333/month)	36	0	1	29	N/A	-**	66	33.3%
Above INR. 1,000,000 (83,333/month-)	24	1	14	0	N/A	-**	39	19.7%
Total	110*	16	15	57	N/A	-**	198	100.0%

*: 1 Household did not provide the data.

** : 1 institutional landowner was surveyed. Income data is not applicable.

Source: JST

(6) Occupation

For 199 households, total 370 person were found as working member. On average, 1.89 person, are working in each household.

Sixty persons in landowner households were found working for farming at the Depot area, and 5 persons at New ISBT Sta.. The purpose of farming plays supporting role in household income, with prime income coming from another member of household working in service or business sector or other livelihood. No farming tenants were found in those areas.

Table 15-38: Occupation of Affected Landowners in State SIA

Occupation	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Total	%
Farming	60	5	0	0	N/A	0	65	17.6%
Service	88	7	7	17	N/A	0	119	32.2%
Business	30	19	19	38	N/A	0	106	28.6%
Other livelihood (i.e. Rent, Annuity)	24	24	9	2	N/A	1*	59	15.9%
Total number of working members	202	39	35	94	N/A	0	370	100.0%
Total	111	16	15	57	N/A	1	199	1.86

*: 1 institutional landowner, Bihar State Sunni Waqf Board, is a corporate body established in 1948, under provision of Central and the State acts, for the better administration of Islam persons who are minority group in India. The board provides protection,

supervision of the people, and administrate and utilize properties for social, economical and educational upliftment of Muslim community.

Source: JST

(7) Preferred Measure of Compensation

Asked about the preferred measure of compensation, 84% of the affected households preferred cash payment. Preference of cash payment was observed at the locations where existing farming activities were found, i.e. the Depot area (Report 1) and New ISBT Sta. area (Report 2).

Table 15-39: Preferred Measure of Compensation of Affected Landowners in State SIA

Preferred measure of compensation	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Total	%
Money	87	12	14	N/A	38	N/A	151	83.9%
Land/structure	12	2	1	N/A	2	N/A	17	9.4%
Employment	12	2	0	N/A	16	N/A	30	16.7%
Skill Development	0	0	0	N/A	0	N/A	0	0.0%
Total	111	16	15	N/A	38	N/A	180	100.0%

Source: JST

(8) Possible Use of the Received Compensation

Asked about the possible use of the received compensation, majority of the PAHs at the Depot area (Report 1) answered interest on land purchase for agriculture. But the idea of purchasing or investment on residential plot was also popular among the PAHs at the Depot area (Report 1) and New ISBT Sta. area (Report 2). In other areas (Akashwani Sta. and University Sta. (Report 3), Rajabazar Sta., Rukanpura Sta., Patna Junction Sta. (Report 5)), business investment was the most popular idea among the PAHs.

Table 15-40: Possible Use of the Received Compensation

Possible use of the amount received	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Total	%
Land purchase for agriculture	77	1	0	N/A	0	N/A	78	43.8%
Investment in agriculture	0	0	0	N/A	0	N/A	0	0.0%
Building a house	5	2	0	N/A	2	N/A	9	5.1%
Household expenditure	0	0	0	N/A	0	N/A	0	0.0%
Marriage	2	2	0	N/A	0	N/A	4	2.2%
Debt payment	0	0	1	N/A	3	N/A	4	2.2%
Deposit in bank	4	0	0	N/A	0	N/A	4	2.2%
Business investment	0	0	11	N/A	35	N/A	46	25.8%
Other (i.e. purchase/ investment on residential plot)	21	11	1	N/A	0	N/A	33	18.5%
Total	109	16	13	0	40	0	178	100.0%

Source: JST

(9) Main Concern of Affected Landowners

92 % of the landowners are concerned that they receive less compensation than they expect.

Table 15-41: Main Concern of Affected Landowners in State SIA

Main concern regarding the land to be acquired	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Total	%
Delay in receiving compensation	4	4	3	N/A	N/A	1	12	8.4%
Receiving less compensation than expected	107	12	12	N/A	N/A	1	132	92.3%
Total	111	16	15	N/A	N/A	1	143	100.0%

Source: JST

(10) Comparison of Land Prices

Three reports have information on the land prices claimed by the landowner as market price of their land. The total amount for the land to be acquired calculated using the governmental Minimum Value Rate (MVR) and the land prices claimed by the landowner are shown in the table below.

The compensation for the land will be calculated following the instruction of the Land Acquisition Act 2013, which mandates that the Government must pay 100 % solatium, and 12 % annual inflation rate. Therefore, all the landowners will receive 2.12 times value of MVR. When compared to this solatium added MVR value and the value claimed by the landowners, it was found that the value claimed by the landowners are much higher from 198% to 4141 % of the solatium added MVR value, except the value claimed at the PMCH Station (Report 6).

Table 15-42: Comparison of Land Prices: MVR, With Solatium, Claimed Value by Owners

	Location	Town	(a) Present Cost of land based on MVR In INR.	(b) Interim Compensation Cost of land with Solatium (MVR x 2.12) (INR)	(c) Market Value of Land Claimed by PAHs in INR	(d) Comparison (c/b)
1	Depot Area	Pahadi	2,788,225,000	5,911,037,000	15,329,000,000	2.59
		Ranipur	856,350,000	1,815,462,000	3,593,076,923	1.98
2	New ISBT Sta.	Pahari,	39,894,520	84,576,382	489,798,400	5.79
3	Akashwani Sta. University Sta.	Moharrampur, Sandalpur	4,913,278	10,416,148	431,344,000	41.41
4	Jaganpura Sta. Ramakrishna Nagar Sta. Mithapur Viaduct	Jaganpura, Changad, Bighrapur	N/A	N/A	N/A	N/A
5	Rajabazar Sta. Rukanpura Sta. Patna Junction Sta.	Salempur, Sadikpur, Moharrampur	N/A	N/A	N/A	N/A
6	PMCH Sta.	Muharrampur	37,875,600	80,296,272	56,813,400	0.71

MVR: Minimum Value Rate, Land price

Source: JST based on State SIA reports

The Minimum Value Rate (MVR) (also called the circle rate, or the ready reckoner rate) of a property is the minimum value at which the property may be transacted at. This value acts as a price floor for transactions of the property. If the transaction value for the property is found to be below the circle rate of the area, the stamp duty and registration fees for that transaction are calculated based on the circle rate, and not the transaction amount.

The MVR is calculated based on the infrastructural development or the property's worth, as well as the market rates for plots in the same neighbourhood/area and use other factors, including the below, to find out the land value.

- Condition of the land
- Infrastructure development in the area (size of roads, connectivity, transportation availability)
- Presence of amenities like schools and hospitals in the area
- Designated land use of the plots (urban/development, agriculture)

Based on the Land Acquisition Act 2013, the compensation for the land and structure will be multiplied by 2.12 to add on the solatium for the original owner. The values of land claimed by the landowner PAHs, which are shown in the table above, are more than the double of the compensation price with the solatium. It is understandable that all the SIA experts involved in the survey states that the demands of the landowners are exaggerated.

When the District Administration considers the amount of compensation for the land, structure, and any attached assets, the highest price among the following 3 different values will be considered as the market value following the instruction by the Article 26 of the Land Acquisition Act 2013.

- (a) the market value, if any specified in the Indian Stamp Act, 1899 for the registration of sale deeds or agreements to sell. As the case may be. In the area, where the land is situated (MVR) ; or
- (b) the average sale price for similar type of land situated in the nearest village or nearest vicinity area; or
- (c) in case of acquisition of lands for private companies or for public private partnership projects, consented amount of compensation as agreed upon.

(11) Anticipation about Impact of the Project

Out of the 6 State SIA reports, 3 reports used same questionnaire to understand the perception of the 141 landowners about project impacts.

1) Economic Impact

Asked about economic impacts, negative impacts on farming activities are anticipated by the PAHs during and after construction. On the other hand, positive impacts are anticipated by majority of the PAHs on increase of land price as well as on non-agriculture commercial activities and businesses after construction.

Table 15-43: Perception about Impact of the Project: Economic Impact

Economic impact		Pre construction			During construction			After construction		
		Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative
1	Impact on farming activities	138	4	0	94	0	48	78	0	66
2	Impact on Non-Agriculture Commercial Activities	125	16	1	113	22	7	12	130	0
3	Impact on daily wage income	138	4	0	117	8	17	100	24	18
4	Employment impact	139	3	0	92	13	63	79	24	39

Economic impact		Pre construction			During construction			After construction		
		Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative
5	Effects of change in work area	140	2	0	127	1	14	106	40	6
6	Impact on Agricultural Produce Marketing	141	1	0	133	8	1	58	83	1
7	Impact on non-agribusiness/industry	141	0	0	133	8	1	25	114	3
8	Impact on Marketing of Dairy/Poultry Products	141	0	0	136	5	1	54	87	1
9	Impact on land price	93	48	1	24	117	1	29	112	1
10	Effect of economic package / amount / compensation for rehabilitation	142	0	0	138	4	0	123	19	0

Source: JST based on State SIA reports (Report 1, 2, 3)

2) Impact on Transportation

Asked about impacts on transportation, almost all PAHs are anticipating positive impacts after the construction.

Table 15-44: Perception about Impact of the Project: Impact on Transportation

Impact on transportation		Pre construction			During construction			After construction		
		Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative
1	Reduction in distance	141	0	1	140	0	3	3	138	1
2	Better and productive time saving	141	0	1	134	0	7	1	139	1
3	Impact on the movement of the elderly	141	0	1	134	0	7	1	140	1
4	Impact on women's movement	141	0	1	135	0	7	4	137	1
5	Impact on the movement of the handicapped	141	0	1	132	0	10	8	133	1

Source: JST based on State SIA reports (Report 1, 2, 3)

3) Social Impact

Asked about social impacts of the Project, majority of PAHs are anticipating positive impacts on access to educational institutions, on reducing violence against women, and on crime control.

Table 15-45: Perception about Impact of the Project: Social Impact

Social Impact		Pre construction			During construction			After construction		
		Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative
1	Impact on access to educational institutions	142	0	0	134	1	7	9	132	1
2	Impact on social harmony	142	0	0	137	2	3	109	28	3
3	Impact on social structure	142	0	0	137	2	3	116	19	3
4	Socio-Culture Effects on Behaviors	142	0	0	137	2	3	117	14	3
5	Impact on gender equality	142	0	0	142	0	0	113	28	1
6	Impact on social crime	142	0	0	138	2	2	93	42	7
7	Impact on violence against women	142	0	0	140	1	1	53	86	4
8	Impact on crime control	142	0	0	135	4	3	43	93	7
9	Impact on migration	142	0	0	140	1	1	116	17	4
10	Effect of displacement	142	0	0	142	0	0	130	8	4
11	Impact on Social/ Voluntary/ Political Organization	142	0	0	142	0	0	140	2	0

Source: JST based on State SIA reports (Report 1, 2, 3)

4) Impact on Health

Asked about impacts on health of the Project, majority of PAHs are anticipating positive impacts on access to health related facilities.

Table 15-46: Perception about Impact of the Project: Impact on Health

		Pre construction			During construction			After construction		
		Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative
1	Impact on accessibility of health related facility	142	0	0	116	13	13	12	128	2
2	Impact on community health	142	0	0	125	3	14	101	30	11

Source: JST based on State SIA reports (Report 1, 2, 3)

5) Impact on Environment

Asked about impacts on environment of the Project, PAHs are anticipating negative impacts on loss of natural resources and pasture.

Table 15-47: Perception about Impact of the Project: Impact on Environment

	Impact on environment	Pre construction			During construction			After construction		
		Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative
1	Impact on exploitation of natural resources	142	0	0	65	4	77	75	17	55
2	Pasture	142	0	0	100	2	40	100	0	42
3	Cemetery/crematorium	142	0	0	142	0	0	142	0	0
4	Pond	142	0	0	142	0	0	142	0	0
5	Playing field	142	0	0	142	0	0	142	0	0

Source: JST based on State SIA reports (Report 1, 2, 3)

15.6 Scale and Extent of Resettlement

15.6.1 Update of Scale and Extent of Resettlement

(1) Affected Structures

The 2 Corridors are located either above or under the existing main roads. Land is required where station facilities are to be located. In DPR SIA 2020, 146 households in the 102 structures were identified to be affected. Out of the 146 PAHs, 111 PAHs cooperated for socio-economic survey. This Study use the same socio-economic survey data in DPR SIA 2020 to understand the characteristics of the PAHs.

Table 15-48: Number and Location of Affected Structures and PAHs in DPR SIA 2020

S.No.	Location	Structures	Total PAHs	PAHs Surveyed
Corridor -1				
1	Rukanpura	3	4	2
2	Raja Bazar	6	18	17
3	Mithapur/ Bigrapur	10	30	24
Total Corridor 1		19	52	43
Corridor-2				
1	Akashwani	5	8	3
2	Gandhi Maidan	6	9	9
3	PMCH	17	17	1
4	Rajendra Nagar	2	7	5
5	Malahi Pakri	41	41	41
6	Khemni Chak Crossing	2	2	1
7	Khemni Chak	4	4	4
8	Bhootmath to Zero Mile	2	2	2
9	Zero Mile	2	2	2
10	Depot Area	2	2	0
Total Corridor 2		82	94	68
Grand Total		102	146	111

Source: DPR SIA 2020 p.30

As shown in the next table, 33 structures among the 102 identified in 2020 were identified as Project Affected Structures in the site survey implemented in July 2022. Comparative photo album of 2020 and 2022 are shown in Attachment 9.

To minimize the impact, design changes were made and 17 structures were saved from the project impact. On the other hand, 52 structures were already cleared from the area to be affected.

Among the 52 cleared structure, 2 structures belong to the private landowners. Title holder structures on private land that were cleared before the Preliminary Notification (Art. 11 Notification) based on the Land Acquisition Act 2013 will not be compensated. The owner shall be compensated for land.

Remaining 50 structures belong to 49 non-title holders and 1 leased shop on public land. Since the Cut-Off Date for those 50 structures are February 2020, i.e. the day of the Census for DPR SIA 2020, the owners and the lessee of those structures remain as the target for the compensation, rehabilitation, and resettlement. Non-title holders already moved out from public land or private land shall be tracked down to new locations by PMRCL, and the compensation for the loss of assets shall be provided by the District Administration with funding from PMRCL. In the letter issued on September 21, 2022, PMRCL agreed that 1) those who have already moved out from the locations listed in DPR SIA 2020 will be contacted by District Administration by October 25, 2022, and 2) the payment will be started before November 2, 2022.

Table 15-49: Update of the Number and Location of Affected Structures

S.No.	Location	Structures DPR SIA 2020	Structures Remaining to be affected as of July 2022	Reason of Change	Structures Target for RAP July 2022
Corridor -I					
1	Rukanpura	3	3		3
2	Raja Bazar	6	5	1 on private land moved out (partial/owner+ tenant)	5*
3	Mithapur/ Bigrahpur	10	9	1 title holder on private land moved out (full/ 5 owners)	9*
Total Corridor 1		19	17		17
Corridor-2					
1	Akashwani	5	5		5
2	Gandhi Maidan	6	1	5 commercial on public land moved out	6**
3	PMCH	17	3	14 commercial saved by design change (full/tenant)	3
4	Rajendra Nagar	2	0	2 commercial & R+C saved by design change (full/ owner+tenant)	0
5	Malahi Pakri	41	0	1 commercial & 40 residential on public land moved out	41**
6	Khemni Chak Crossing	2	1	1 commercial saved by design change (partial/owner)	1
7	Khemni Chak	4	4		4
8	Bhootnath to Zero Mile	2	0	2 commercial on public land moved out	2**
9	Zero Mile	2	0	2 commercial on public land moved out	2**
10	Depot Area	2	2		2

S.No.	Location	Structures DPR SIA 2020	Structures Remaining to be affected as of July 2022	Reason of Change	Structures Target for RAP July 2022
	Total Corridor 2	82	16		66
	Grand Total	102	33		83

*: Structure that was cleared before the Preliminary Notification (Art. 11 Notification) based on the Land Acquisition Act 2013 will not be compensated. The owner shall be compensated for land.

** : Non-title holders already moved out from public land shall be tracked down to new locations by PMRCL, and the compensation for the loss, assistance for the relocation, and rehabilitation for the livelihood shall be provided by the District Administration with funding from PMRCL.

Source: JST based on DPR SIA 2020 p.30

As a result, the updated number of the target structures of the Project for compensation is 83 structures. (83 = 102 – 17 (saved structure) – 2 (cleared title holder structure))

Table 15-50: Affected Structures

Type	Number DPR SIA 2020	Update July 2022	Reason of Change
		Target for Compensation	
Residential:	47	45	2 on private land already cleared
CIBEs (commercial, industrial and business enterprises)	50	34	16 saved by design change
Residential cum CIBE:	4	3	1 saved by design change
Institutional	1	1	
Total	102	83	
Other social infrastructure to be affected			
Temples	5	5	
Public toilets	3	3	

Saved structure: 17 (16 commercial, 1 residential cum CIBE),

Removed structure before cut-off date (Article 11 Notification): 2 (both residential)

Source: Detailed Project Report 2021, RITES, Social Impact Assessment Report 2020, DMRCL, JST

Looking at the use of the affected structures, 45 residential structures and 34 commercial structures are to be affected. Looking at the magnitude of impacts, 78 structures out of total 83 will be fully affected, hence residents, shops, tenants in those structures need to be relocated. Looking at the location of the impacts, the largest number of 41 structures are affected at Malahi Pakri Station of Corridor 2, followed by 9 structures at Mithapur Station and 6 structures at Gandhi Maidan Station.

Table 15-51: Magnitude of Impacts on Structures

		Fully affected		Partly affected		Total
		Corridor 1	Corridor 2	Corridor 1	Corridor 2	
1	Residential	2	42	1		45

		Fully affected		Partly affected		Total
		Corridor 1	Corridor 2	Corridor 1	Corridor 2	
2	Residential + Commercial	2			1	3
3	Commercial	9	23	2		34
4	Institutional			1		1
5	Sub-total	13	65	4	1	83
6	Grand-total	78		5		83

Source: JST

Table 15-52: Location-wise, Purpose-wise Number of Affected Structures

			Residential	Commercial	R+C	Institutional	Total
Cor.1	5	Rukanpura	2	1			3
Cor.1	6	Raja Bazar	1	3		1	5
Cor.1	11	Mithapur	0	7	2		9
Cor.2	2	Akashwani		5			5
Cor.2	3	Gandhi Maidan		6			6
Cor.2	4	PMCH		3			3
Cor.2	7	Rajendra Nagar		0	0		0
Cor.2	8	Malahi Pakri	40	1			41
Cor.2	9	Khemni Chak Crossing		0	1		1
Cor.2	9	Khemni Chak Sta		4			4
Cor.2	11	Bhootnath to Zero Mile		2			2
Cor.2	11	Zero Mile		2			2
Cor.2	13	Depot Area	2				2
Total			45	34	3	1	83

Source: JST

(2) Affected Households

The DPR SIA implemented census survey of the PAHs in the affected structures in February 2020. The survey identified 146 PAHs/PAPs (including residents, shops, institutional owners) in 102 structures as shown in Table 15-53.

Among the 146 PAHs identified in 2020, 120 HH were planned to be fully affected and expected to be resettled and relocated. The fully affected PAHs included 53 residential PAHs, 18 shop owners, 42 commercial tenants, and 7 shop lessees.

Table 15-53: PAHs for Resettlement in DPR SIA 2020

		DPR SIA	
	Group	Number	By Tenancy
1	Total Project Affected Households (PAHs) (Including commercial use and institution)	146 HH / 720 persons	Title Holders: 75 HH / 370 persons
			Non-Title holders: 69 HH / 340 persons
Fully Affected			
2	Fully Project Affected Households (PAHs) (Including commercial use and institution)	120 HH / 591 persons	Title Holders: 69 HH / 340 persons
			Non-Title holders: 51 HH / 251 persons
3	PAHs which need to be resettled (as resident)	53 HH / 261 persons	Title Holders: 13 HH / 64 persons
			Non-Title Holders: 40 HH / 197 persons
4	Business owners who need relocation	18 HH / 89 persons	Title Holders: 7 HH / 35 persons
			Non-Title Holders: 8 HH / 39 persons
			Kiosk: 3 HH / 15 persons (can operate on other locations)
5	Commercial Tenants who need relocation		42 commercial tenants
6	Leases on Government Land who need relocation		7 lessees (can operate on other locations)
Partly Affected			
7	Partly Project Affected Households (PAHs) (Including commercial use and institution)	26 HH / 128 persons	Title Holders: 26 HH / 128 persons
			Non-Title holders: 0 HH / 0 persons
8	PAHs who do not need to be resettled (as resident)	5 HH / 25 persons	Title Holders: 5 HH / 25 persons
			Non-Title Holders: 0 HH / 0 persons
9	Business owners who do not need relocation	9 HH / 44 persons	Title Holders: 9 HH / 44 persons
			Non-Title Holders: 0 HH / 0 persons
			Kiosk: 0 HH / 0 persons
10	Commercial Tenants who do not need relocation		12 commercial tenants
11	Leases on Government Land who do not need relocation		0 lessees

* : Average HH size is calculated from the 111 HH survey results as 4.93 person per HH. ($4.92792 = 547 / 111$)

** : Number of PAPs is calculated using the above average HH size.

Title Holders: people with formal ownership of land, residential and/or commercial tenants who have contract with the title holders, and commercial lessees who will be awarded alternate location to do business in case of relocation.

Non-Title Holders: people without formal ownership of land, including commercial encroachers, and residential squatters.

Source: Social Impact Assessment Report 2020, DMRCL, and JST

Source: JST based on DPR SIA 2020

Update site survey in July 2022 identified 117 PAHs/shops in 83 structures as PAHs (Table 15-54). Among the 146 affected PAHs identified in DPR SIA 2020, 22 PAHs, all commercial owners and tenants, are now not affected by the design change of location of station facilities. In addition, 2 residential structures with 7 PAHs (6 owners and 1 tenant) were not found on site in July 2022, and considered to have been moved out. In total, the survey in July 2022 found 29 fewer PAHs than found in DPR SIA 2020. ($146-29=117$)

Among the 117 PAHs identified in 2022, 101 HH are planned to be fully affected and expected to be resettled and relocated. The fully affected PAHs include 48 residential PAHs, 18 shop owners, 28 commercial tenants, and 7 shop lessees.

In the letter issued on September 21, 2022, PMRCL agreed that 1) the PAHs related to the structures that

have already moved out from the locations listed in DPR SIA 2020 will be contacted by District Administration by October 25, 2022, and 2) the payment of the compensations, relocations and rehabilitations for the PAHs will be started before November 2, 2022.

Table 15-54: Updated PAHs for Resettlement as of July 2022

	Group	Update July 2022 Target for Compensation	
		Number	By Tenancy
1	Total Project Affected Households (PAHs) (Including commercial use and institution)	117 HH / 576 persons	Title Holders: 66 HH / 325 persons Non-Title holders: 51 HH / 251 persons
	Fully Affected		
2	Fully Project Affected Households (PAHs) (Including commercial use and institution)	101 HH / 498 persons	Title Holders: 50 HH / 247 persons Non-Title holders: 51 HH / 251 persons
3	Resident owners who need to be resettled	46 HH / 227 persons	Title Holders: 6 HH / 30 persons Non-Title Holders: 40 HH / 197 persons
4	Residential tenants who need to be resettled	2 HH / 10 persons	Tenants: 2 HH / 10 persons
5	Business owners who need relocation	18 HH / 89 persons	Title Holders: 7 HH / 35 persons Non-Title Holders: 8 HH / 39 persons Kiosk: 3 HH / 15 persons (can operate on other locations)
6	Commercial Tenants who need relocation		28 commercial tenants
7	Leases on Government Land who need relocation		7 lessees (can operate on other locations)
	Partly Affected		
8	Partly Project Affected Households (PAHs) (Including commercial use and institution)	16 HH / 79 persons	Title Holders: 16 HH / 79 persons Non-Title holders: 0 HH / 0 persons
9	Resident owners who do not need to be resettled	2 HH / 10 persons	Title Holders: 2 HH / 10 persons Non-Title Holders: 0 HH / 0 persons
10	Business owners who do not need relocation	7 HH / 35 persons	Title Holders: 7 HH / 35 persons Non-Title Holders: 0 HH / 0 persons Kiosk: 0 HH / 0 persons
11	Commercial Tenants who do not need relocation		7 commercial tenants
12	Leases on Government Land who do not need relocation		0 lessees

* : Average HH size is calculated from the 111 HH survey results as 4.93 person per HH. ($4.92792 = 547 / 111$)

** : Number of PAPs is calculated using the above average HH size.

Title Holders: people with formal ownership of land and structure.

Non-Title Holders: people without formal ownership of land, including commercial encroachers, and residential squatters.

Source: JST

No change was found in the number of affected crops and trees between the 2020 condition and the 2022 condition.

Table 15-55: Affected Crops and Trees

Types	Area/Number	Note
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Rice field	0 ha	
Vegetable and other agriculture field	19.2 ha	Depot
Public trees (street trees, trees in parks)	911	Corridor 1 (551) Corridor 2 (360)
Privately owned trees, trees on private land	0	
Fruit bearing trees	0	
Timber trees, non-fruit trees	0	
Other cash trees/plants	0	

Source: DPR SIA 2020, DMRCL

In 2020, out of the 146 PAHs, a total of 28 households were found to belong socially vulnerable groups. In 2022, only 4 PAHs out of 28 were remaining on site. PMRCL, however, shall track the vulnerable PAHs to new locations, and shall share the information with the District Administration for payment of additional award of rehabilitation assistances.

Table 15-56: Vulnerable Families

Sr No.	Type of Vulnerable Family	Number, Location	Total in DPR, Eligible for Compensation	Update July 2022 on Site
1	Disability – Blind	1 Malahi Pakri	1	0
2	Scheduled Castes with Below Poverty Line	4 Malahi Pakri	4	0
3	Scheduled Castes with Women Headed Family	3 Malahi Pakri	3	0
4	Scheduled Castes	1 Khemni Chak, 14 Malahi Pakri	15	1
5	Below Poverty Line Families	1 Bhootnath to Zero Mile, 1 Zero Mile	2	2
6	Women Headed Families	1 Raza Bazar, 2 Malahi Pakri	3	1
	Total		28	4 (24 to be tracked)

Source: JST, DPR SIA 2020, DMRCL, p. 48, Annexure 3

15.6.2 Profile of Project affected Households

The alignment drawing and information provided by PMRCL was the basis for identification of the affected households and project affected people due to the proposed project phase. The study represents assessment of the affected households, which includes titleholders and non-titleholders. The group of non-titleholders included tenants, squatters, kiosk owners, etc.

The interviewers interacted with the social groups involved for the purpose to disclose the information required for the questionnaires format for data collection. The survey had been conducted within the proposed Right of Way of viaduct, station areas and the land to be acquired for the project. For viaduct the ROW has been considered to be 11 m.

The survey has been carried out for 111 households. Demographic details of affected people have been taken from residential premises. Additionally, small shops/ Kiosks/ squatters are located in the proposed Right of Way marked on the alignment drawing.

The SIA was investigated in February 2020. The survey identified 146 households in the building located on the land to be acquired, and conducted a questionnaire survey on 111 of these households to understand the average number of household members, household income, and other socio-economic conditions. Of the 35 households not surveyed, 17 were not at home due to the COVID pandemic. In addition, 18 households did not cooperate with the survey.⁵

The socio-economic analysis of surveyed household has been presented in the following sections.

(1) Demographic Profile of PAHs

The social survey has been carried out on 111 households. These households have 547 members. Average household size was calculated as 4.93 ($547/111=4.92792$) person per household. This average household size was used to estimate the number of Project Affected Persons (PAPs).

The demographic profile of PAPs covers their distribution according to religion, social castes, age, education and marital status.

Data reveals that majority of PAHs are Hindus (89.19%) followed by Muslims (9.90%) and Sikh (0.91%). In Corridor 1, 83.72% PAHs are Hindus and rest 16.28% are Muslims. But in Corridor 2 Hindus are 92.65% and Muslims are 5.88 % with 1.47% Sikhs.

Table 15-57: Religion-wise Distribution of PAHs

S.No.	Religion	Numbers / Percentage (%)	Corridor-1	Corridor-2	Total
1	Hindu	Number	36	63	99
		Percentage	83.72	92.65	89.19
2	Muslim	Number	7	4	11
		Percentage	16.28	5.88	9.91
3	Sikh	Number	0	1	1
		Percentage	0	1.47	0.90
	Total	Number	43	68	111

Source: DPR SIA 2020, DMRCL

The caste-wise distribution of PAHs has also been studied. The distribution of PAHs as per castes has been given in the table below.

Distribution of PAHs by caste show that about 49.55% belong to Other Backward Castes and about 30.63 % belong to upper castes called General castes, and another about 19.82 % belong to Scheduled Castes.

There was no Scheduled Tribe among the PAHs.

Corridor-wise distribution shows that there are 46.51% General caste and 53.49% OBCs on Corridor-1,

⁵ At PMCH Station, commercial tenants refused to share social data citing the apprehension that the survey was made for collecting data as part of NRC (National Register of Citizens) and no amount of explanation could convince them. There were 17 such shops of seventeen households and only one family (one PAH) agreed to provide details and remaining 16 households refused. Additionally, residents of two houses at proposed depot area denied sharing of data.

whereas in Corridor 2, PAHs belonging to general caste are 20.59%, OBCs are 47.06% and SCs are 32.35%.

Table 15-58: Distribution of PAHs by Castes

S.No.	Caste	Numbers / Percentage (%)	Corridor- 1	Corridor-2	Total
1	General	Number	20	14	34
		Percentage	46.51	20.59	30.63
2	OBC	Number	23	32	55
		Percentage	53.49	47.06	49.55
3	SC	Number	0	22	22
		Percentage	0	32.35	19.82
Total		Number	43	68	111
		Percentage	100.00	100.00	100.00

Source: DPR SIA 2020, DMRCL

Types of Household

Assessment of type of household indicates that about 18.91 % households are Joint households whereas about 77.47 % households are Nuclear households. There are 3.60% single person households among PAHs.

Number of Household Members

Similarly, about 41.44% are small households having up to 4 members, 38.74% are medium size households having 5 to 7 members and 16.22 % are large households having more than 7 members. Family pattern is similar in both the corridors. There are 34 nuclear households in Corridor 1 and 52 in Corridor 2. Joint households are 9 in Corridor 1 and 12 in Corridor 2.

Sex Ratio

There were 547 PAPs in 111 PAHs along the corridor alignment. These comprises of 299 males and 248 females thereby having sex ratio of 829 females per thousand males. Corridor wise sex wise distribution shows that sex ratio is 777 and 870 females per thousand males in Corridor 1 and Corridor 2 respectively. There are 54.66 % males and 45.34% females among PAPs.

Age-wise Distribution

It is also found that about 64.35 % PAPs are more than 18 years and only 35.64 % are less than 18 years. The Age-wise distribution of PAPs has been given in the table below.

Age-wise distribution indicates that there are 58.87 % PAPs in working age group of 18 to 60 years. About 5.48 % are senior citizens above 60 years, and 23.40 % PAPs are in student age group between 6 to 18 years. About 12.25% PAPs are children below 6 years of age.

Table 15-59: Distribution of PAPs According to Age

S.No.	Age	No./ %	Corridor-1	Corridor-2	Total
1	<6	Number	14	53	67
		Percentage	6.06	16.77	12.25
2	6 to 18	Number	56	72	128
		Percentage	24.24	22.78	23.40
3	18-45	Number	110	145	255
		Percentage	47.62	45.89	46.62
4	45-60	Number	36	31	67
		Percentage	15.58	9.81	12.25

S.No.	Age	No./ %	Corridor-1	Corridor-2	Total
5	> 60	Number	15	15	30
		Percentage	6.49	4.75	5.48
	Total	Number	231	316	547
		Percentage	100	100.00	100.00

Source: DPR SIA 2020, DMRCCL

Education Level

The population distribution as per education level has been assessed. It is to be mentioned that the children below 6 years have been excluded from the calculations as they are subject to assessment of education level yet.

The distribution of PAPs according to education level is given in the table below.

The data revealed that about 22.08 % PAPs are illiterate, 17.71 % primary and 28.54% are educated up to 10th class. About 10.36% have studied up to class 11th – 12th and 21.46% are graduates and above.

In Corridor 1, 24.42 % have studied till less than primary level and 32.26% have studied for up to 10th class. Graduates are more than 33.18 % in Corridor 1. On the other hand, in Corridor 2 graduates are only 11.79% and illiterates are 34.22%. About 18.25 % have studied between 5th to 12th class.

Table 15-60: Distribution of PAPs According to Education Level

S.No.	Education	No./ %	Corridor 1	Corridor-2	Total
1	Illiterates	Number	16	90	106
		Percentage	7.37	34.22	22.08
2	Primary up to 5 th class	Number	37	48	85
		Percentage	17.05	18.25	17.71
3	Between 5 th to 10 th class	Number	70	67	137
		Percentage	32.26	25.48	28.54
4	11 th & 12 th	Number	22	27	49
		Percentage	10.14	10.27	10.36
5	Graduate and above	Number	72	31	96
		Percentage	33.18	11.79	21.46
6	Total	Number	217	263	480
		Percentage	100.00	100.00	100.0

Source: DPR SIA 2020, DMRCCL

The marital status of PAPs is given in the table below. 49.75 % PAPs are married and 3.47 % are widowed persons whereas the rest 46.80 % are unmarried. This includes unmarried persons below 18 years of age which is the minimum age of marriage as per law.

Table 15-61: Marital Status of PAPs

S.No.	Marital Status	No. / %	Corridor- 1	Corridor-2	Total
1	Married	Number	125	147	272
		Percentage	77.64	76.96	77.27
2	Widowed	Number	7	12	19
		Percentage	4.35	6.28	5.40
3	Unmarried	Number	29	32	61
		Percentage	18.01	16.75	17.33

S.No.	Marital Status	No. / %	Corridor- 1	Corridor-2	Total
	Total	Number	161	191	352
		Percentage	100.00	100.00	100.00
4	< 18 years		70	125	195
	Total	Number	231	316	547

Source: DPR SIA 2020, DMRCL

(2) Economic Status and Occupational Pattern

Number of Working Persons

The economic status has been assessed and it is found that there are 178 workers among PAPs. Thus, 32.54% are economically active persons among PAPs and 67.46 % are non-working PAPs.

On an average there are two dependents per earner among PAPs. One household has average 1.6 working persons ($178/111=1.60$)

In Corridor 1, there are 74 workers and 157 non workers, while in Corridor 2, there are 104 workers and 212 non workers. Thus, the distribution of worker and dependents is almost similar in both the corridors.

Occupation

The occupation and profession of the economically active persons has been considered during the social survey. The study recorded and assessed the capability, base for livelihood and skills of the family head, so that resettlement impacts can be assessed. Based on the impacts assessment, the income generation plan and rehabilitation plans shall be prepared accordingly. The occupation pattern of PAPs is given in the table below.

The survey data show that 64.61% persons are engaged in business activities, 28.09% are working in hired jobs and another 7.30 % are engaged in other activities. There are two doctors and three people have only rental income.

Table 15-62: Occupation-wise Distribution of PAPs

S.No.	Occupation	No. / %	Corridor- 1	Corridor-2	Total
1	Job	Number	10	40	50
		Percentage	13.51	38.46	28.09
2	Business	Number	59	56	115
		Percentage	79.73	53.85	64.61
3	Others	Number	5	8	13
		Percentage	6.76	7.69	7.30
Total		Number	74	104	178
		Percentage	100.00	100.00	100.00

Source: DPR SIA 2020, DMRCL

(3) Monthly Income of PAPs

Distribution of income among the working PAPs is given in the table below.

The survey result clearly shows that there are 40.45 % PAPs who earn less than INR. 10,000/- per month. Another 24.72% earn between INR.10,000/- to INR. 20,000/- per month. Thus, the monthly income of

about two third earning PAPs is less than INR. 20,000/per month.

About 20 % PAPs are earning between INR. 20,000/- to 50000/- per month and 14.61 % are earning between INR.50,000/- to INR. 100,000/- per month and another 5.06% are earning more than INR. 100,000. per month.

Out of the total surveyed households (111), 7 households are found earning below poverty line – one in Corridor 1 and 6 in Corridor 2. It means about 94% households are in APL category and 6% are in BPL category among the surveyed households.

Household Poverty Line in Bihar is estimated between INR. 4,500 and INR. 6,200 per household per month in **Table 15-11**.

Table 15-63: Distribution of Monthly Personal Income of Working PAPs

S.No.	Monthly Household Income	No/ %	Corridor 1	Corridor- 2	Total
1	Less than INR.10,000/-	Number	8	64	72
		Percentage	10.81	61.54	40.45
2	INR.. 10,000/- - INR.. 20,000/-	Number	21	23	44
		Percentage	28.38	22.12	24.72
3	INR..20,000/- to INR.. 50,000/-	Number	26	10	36
		Percentage	35.14	9.62	20.22
4	INR..50,000/- to INR.100,000/-	Number	10	7	17
		Percentage	13.51	6.73	9.55
5	More than INR.. 100,000/-	Number	9	0	9
		Percentage	12.16	0	5.06
Total		Number	74	104	178
		Percentage	100.00	100.00	100.00

Source: DPR SIA 2020, DMRCCL

(4) Assets of Families

Data collected from the survey revealed that most of the PAHs belong to middle class. Being in Patna city most of them have access to cooking gas, sanitation and hygiene facilities. It is found that 53 households have separate kitchen in their house and 61 households have toilets in their houses.

So far as fuel used in kitchen, 81% PAHs use LPG, and balance 19 % use wood for cooking their food on Chulha (cooking stove).

Source of water supply is piped supply for 89.19% PAHs, out of which about 37% PAHs have supplemented this with domestic tube well. Only about 11 % PAHs are dependent on water supply using hand pump.

Most of the PAHs have Fans (98%), Radio (21.62%) and TV (57.66%). About 32.43% PAHs also own Washing machines and 39.64 % own Refrigerators.

In terms of vehicles, 45% of PAHs own two wheelers and 19.8% PAHs also own four wheelers.

(5) Vulnerable Families

Of the 111 PAHs surveyed, a total of 28 households that are considered to be socially vulnerable and susceptible to negative effects were found as shown in the following table. Of these, 22 households in total belong to the Scheduled Caste. There were 6 households with incomes below the poverty line, 6 households headed by women, and 1 household including persons with disabilities. Notably, all PAHs, except 1 at

Raza Bazar, are squatters or commercial encroachers located on public land.

Table 15-64: Vulnerable Families

Sr No.	Type of Vulnerable Family	Number, Location	Total in DPR, Eligible for Compensation	Update July 2022 on Site
1	Disability – Blind	1 Malahi Pakri (squatter)	1	0
2	Scheduled Castes with Below Poverty Line	4 Malahi Pakri (squatters)	4	0
3	Scheduled Castes with Women Headed Family	3 Malahi Pakri(squatters)	3	0
4	Scheduled Castes	1 Khemni Chak, 14 Malahi Pakri (squatters)	15	1
5	Below Poverty Line Families	1 Bhootnath to Zero Mile, 1 Zero Mile (all commercial encroachers)	2	2
6	Women Headed Families	1 Raza Bazar, 2 Malahi Pakri (squatters)	3	1
	Total		28	4 (24 to be tracked)

Source: DPR SIA 2020, DMRCL, p. 48, Annexure 3

(6) Awareness about HIV / AIDS

Sex trade and spread of sexually transmitted diseases (STDs) also comes up as critical socio-cultural and health issue, which needs to be addressed to ensure that the construction of Metro rail project is a socially responsible development project.

Most of the respondents have shown awareness about HIV/ AIDS. The main source of information is television, newspaper and advertisement boards displayed by the government in the city.

Taking into consideration the safety issues of risks of HIV/ AIDS during the project construction period, proper training shall be imparted to labours by the contractor team engaged for the construction work. It is presumed that labour working in the project may not be aware of the hazards of the disease.

(7) Awareness and Opinion About the Project

During the socio-economic survey, some questions were asked from the PAPs regarding the awareness, source of information and opinion about the proposed Metro project.

It is reported by 83% in Corridor 1 and 76% in Corridor 2 and overall, 79% interviewee answered that they were aware of the Project before the visit of this team. The source of information ranged from Newspaper, Radio/ TV and the word of mouth as several teams have visited the area to perform preparatory works for the Project.

Moreover, 74% of Corridor 1 and 96% of Corridor 2 and overall, 87% of them categorized the Project as good in general terms.

(8) Resettlement & Rehabilitation Options

The options on resettlement and rehabilitation measures have also been collected from Project Affected Households. Different people have opted for different type of compensation acceptable to them.

Some have asked to provide jobs to the family members in the organization. Another set of PAHs asked to provide them compensation as per new Land Acquisition Act on market rate which is higher than the Circle rates. Many people have asked to provide them training for skill development.

(9) Common Property Resources/Public Utilities

The common property resources are getting affected due to construction of the proposed Project. Five Temples and three public toilets are getting affected. The common property resources and structures related to public utilities should be suitably shifted, rehabilitated, and or compensated in accordance with the consent of local communities.

15.7 Eligibility and Entitlements for Compensation, Rehabilitation, and Resettlement

15.7.1 Eligible PAHs/PAPs

PAHs/PAPs entitled for compensation and rehabilitation are those listed below.

Based on the JICA Guidelines, all who were recognized as PAHs/PAPs during the date of the Census Survey for DPR SIA, which is February 2020, are eligible, no matter the length their tenancy more than or less than 3 years. As of September 2022, PMRCL is awaiting its Board decision to make those who have tenancy of less than 3 years as eligible PAHs/PAPs.

- (i) PAHs/PAPs with legal title or traditional land rights losing land and assets attached to the land will be compensated for the loss, and will receive assistance for rehabilitation and relocation.
- (ii) Non-title holder PAHs/PAPs losing residences and commercial assets to on public land as well as on private land will be compensated for the loss, and will receive assistance for rehabilitation and relocation.
- (iii) Commercial tenant and lessees PAHs/PAPs losing immovable assets and their investment will be compensated for the loss, and will receive assistance for rehabilitation and relocation.
- (iv) PAPs losing business, income, and salaries will be compensated for the loss.
- (v) PAHs/PAPs who belongs to the Vulnerable Groups will receive additional assistance.

15.7.2 Cut-Off Dates

The final cut-off date for those who have legal title is the date of Article 11 Notification based on the Land Acquisition Act 2013.

The preliminary cut-off date for those who have legal title, and the final cut-off date for non-title holder PAHs/PAPs is the date of the Census Survey for DPR SIA, which is February 2020.

In the letter issued on September 21, 2022, PMRCL agreed that 1) the PAHs related to the structures that

have already moved out from the locations listed in DPR SIA 2020 will be contacted by District Administration by October 25, 2022, and 2) the payment of the compensations, relocations and rehabilitations for the PAHs will be started before November 2, 2022.

15.7.3 Entitlement Matrix

The following table presents the entitlement matrix for the Project.

The Entitlement was updated on the point of the range of PAHs who will receive the relocation and rehabilitation assistances. The DPR SIA was giving those relocation and rehabilitation assistances to PAHs fully and partially affected PAHs (including commercial owners and tenants). JST studied the land acquisition plan drawings, and concluded that the impacts on partially affected PAHs are limited to losing part of their front parking spaces. Their main structures will not be affected, they will not need to resettle or relocate, and their means of livelihood are not to be affected. Therefore, the partially affected PAHs are eligible for compensation for the loss of their land and asset (i.e. boundary walls and parking roof), but not eligible for the relocation and rehabilitation assistances. Therefore, the 16 PAHs who will be partially affected were excluded from the entitled PAH from the item 9 to 14 in the table below.

Table 15-65: Entitlement Matrix

	Type of impact	Entitled PAH	Unit	Quantity	Compensation entitlement	Responsible Organization
COMPENSATION FOR LOSS						
1.	Loss of land	Landowner fully or partially affected; <ul style="list-style-type: none"> ➤ Residential Titleholder, ➤ Commercial: title holder running shop in their structures, and ➤ The Owner renting out the commercial structure. 	Ha	Private land 38.853 ha Number of landowner: under study by District Administration	Compensation at replacement cost <ul style="list-style-type: none"> ➤ as per assessed value or ➤ mutually agreed terms Stamp duty shall be paid by the PMRCL.	Budget: PMRCL Provision: District Land Officer
2.	Loss of residential structure	Structure owner fully or partially affected; (Title holder) Including 3 R+C (Residential – cum - Commercial) structure	Structure	Total: 8 Fully 6 (incl. R+C 2) Partially 2 (incl. R+C 1)	Compensation at replacement cost (both land and structure) <ul style="list-style-type: none"> ➤ as per assessed value or ➤ mutually agreed terms ➤ Stamp duty shall be paid by the PMRCL. 	Budget: PMRCL Provision: District Land Officer
3.	Loss of residential structure	Squatters on public land	Structure	40	Compensation for loss of structure as per valuation of structure.	Budget: PMRCL Provision: District Land Officer

	Type of impact	Entitled PAH	Unit	Quantity	Compensation entitlement	Responsible Organization
4.	Loss of commercial structure	Structure owner fully or partially affected; (Title holder)	Structure	Total: 23 Fully 21 Partially 2	Compensation at replacement cost (both land and structure) ➤ as per assessed value or ➤ mutually agreed terms Stamp duty shall be paid by the PMRCL.	Budget: PMRCL Provision: District Land Officer
5.	Loss of commercial structure	Commercial encroacher on public land	Structure	Total: 8 Commercial encroacher 8	Compensation for loss of structure as per valuation of structure.	Budget: PMRCL Provision: District Land Officer
6.	Loss of immovable assets (crops, trees, etc.)	Owner of the assets fully or partially affected;	Number/ area	Owners of crops grown at Depot area Number of owner: under study by District Administration	At least 60 days notice for harvest, Compensation for remaining crops and trees at scheduled district rates.	Budget: PMRCL Provision: District Land Officer
7.	Loss of rented commercial unit	Commercial tenant fully or partially affected;	Commercial Tenant	Total: 35 Fully 28 Partially 7 (if shop area is affected)	Compensation for investment in shop infrastructure based on valuation	Budget: PMRCL Provision: District Land Officer
8.	Loss of kiosk (movable) Loss of leased commercial unit (Milk Parlor)	Kiosk owner Milk Parlor Lessee	Structure	Total: 10 Kiosk 3 Milk Parlor 7 (all are to be fully affected)	Cash compensation for shifting inconvenience INR. .25,000/-	Budget: PMRCL Provision: District Land Officer
ASSISTANCE FOR RESETTLEMENT AND REHABILITATION						
9.	Loss of residence (Relocation)	Resident PAH on fully affected structures (incl. R+C)	PAH	Total: 48 Title holder 6 Non-title holder 40 Residential tenant 2	<ul style="list-style-type: none"> ● Shifting allowance @ INR. 50,000/- and ● One-time resettlement allowance @ INR. 50,000/- 	Budget: PMRCL Provision: District Land Officer
10.	Loss of shops (Relocation)	Commercial PAH on fully affected structures	PAH	Total: 53 Commercial owners 7 Commercial encroachers (incl. 3 Kiosks) 11 Commercial tenants 28 Commercial Lessee (Milk parlour) 7	<ul style="list-style-type: none"> ● Shifting allowance @ INR. 50,000/- and 	Budget: PMRCL Provision: District Land Officer
11.	Loss of income, livelihood (Rehabilitation)	Resident PAH on fully affected structures (structure owner)	PAH	Total: 46 Title holder 6 Non-title holder 40	Subsistence Allowance INR.. 3,000/- per month for 12 months= Rs. 36,000/-	Budget: PMRCL Provision: District Land Officer

	Type of impact	Entitled PAH	Unit	Quantity	Compensation entitlement	Responsible Organization
12.	Loss of income (Rehabilitation)	<ul style="list-style-type: none"> Fully affected Commercial title holder (owners running shop in their structures) Fully affected Commercial tenant running shops on the above commercial structure Employees at above commercial businesses 	PAH	<p>Total: 35</p> <p>Fully affected: Commercial title holder 7</p> <p>Commercial tenant 28</p> <p>Employees: Not counted in 2020 census. Will be confirmed by District census survey</p>	<ul style="list-style-type: none"> Annuity or Employment @ One-time payment of INR. 500,000. rupees per PAH; or Annuity policies that shall pay not less than INR. 2,000 per month per PAH for 20 years, with appropriate indexation to the Consumer Price index for Agricultural Labourers 	<p>Census of number of employees: District Land Officer</p> <p>Budget: PMRCL</p> <p>Provision: District Land Officer</p>
13.	Loss of income, livelihood (Rehabilitation)	PAH belong to Vulnerable Groups (Rehabilitation)	PAH	28	Training @ INR. 15,000/-per PAH if opted for by the PAH	<p>Budget: PMRCL</p> <p>Provision: District Land Officer</p>
14.	Loss of income, livelihood (Rehabilitation)	Additional assistances to be given to the squatters and commercial encroachers on public land	PAH	<p>Total: 48</p> <p>Residential squatter 40</p> <p>Commercial encroacher 8</p>	<p>Eligible PAHs will be adjusted in the following public welfare schemes, whichever applicable, without limit of numbers of schemes applicable.</p> <ol style="list-style-type: none"> Free ration for 1-year at Fair price shop, Medical facility on priority basis in government hospital, Free medical service, Free medicine. Money for clothes Government Guarantee up to 10 Lakhs to the State Government under Industrial Policy (by PMRCL) Payment of 50% interest amount in Bank Loan by PMRCL Priority to recruitment as daily laborers in MNREGA* Priority in HFA/ NULM (provision of shelters and basic services) Priority in the recruitment in the state job (5 percent Horizontal Reservation) Free battery-operated wheelchair to the disabled Free Admission in Government Schools Free higher education in government institutions Hand pump for drinking water. 	<p>Budget: PMRCL</p> <p>Provision: District Land Officer</p>

*: MAHATMA GANDHI NATIONAL RURAL EMPLOYMENT GUARANTEE ACT 2005

Source: JST based on DPR SIA 2020 and the draft Resettlement Policy Framework, PMRCL, September 2, 2022

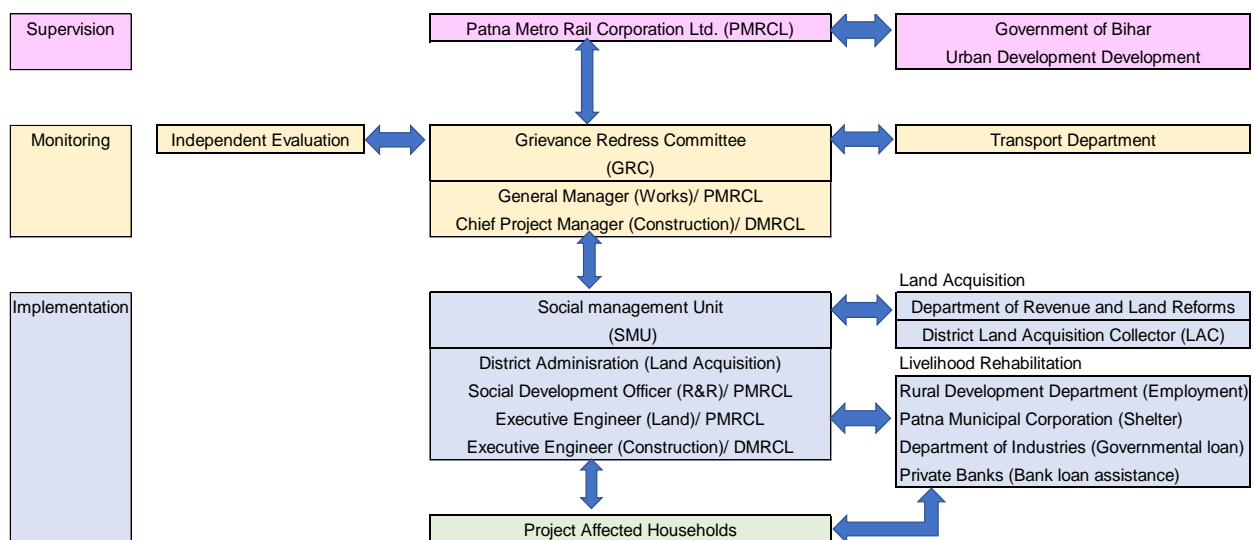
As shown in Table 15-64, most of the PAHs who belong to the Vulnerable Groups are also informal settlers who are eligible for additional assistances listed in Line 14 of Table 15-65, Entitlement Matrix. Such additional assistances include access to business loans and priority in job recruitment. Therefore, training programs of personal bank account management and business loan management will be given by the bank to the PAHs who opt for those assistances. For those who opt for priority jobs, on-the-job training opportunity will be available according to each person's capabilities and aptitude at their workplaces.

15.8 Institutional Arrangement

The implementation of Resettlement Action Plan (RAP) requires involvement of various institutions at different stages of project cycle. This section deals with roles and responsibilities of various institutions for a successful implementation of the RAP. The institutions to be involved in the process are as follows:

1. Patna Metro Rail Corporation Ltd. (PMRCL)
2. Delhi Metro Rail Corporation Ltd. (DMRCL)
3. Office of the District Collector in Patna.

The institutional framework for RAP implementation is shown below. PMRCL will take responsibilities at every level of implementation, which are supervision, monitoring, and implementation. DMRCL, as the design-build project consultant and contractor, will assist in monitoring and implementation by taking member seats in the Grievance Redress Committee and the Social Management Unit. Social Management Unit takes the role of RAP implementation, working together with the District Administration. Most of the works that need direct communication with the PAHs will be handled by the office of District Administration. As of September 2022, PMRCL hired internal specialist for Resettlement and Rehabilitation, but an outside consultant for evaluation has not yet been contracted.



Source: JST based on DPR SIA 2020

Figure 15-3: Institutional Arrangement of Implementation of Land Acquisition and Livelihood Rehabilitation

15.8.1 PMRCL/ DMRCL

Patna Metro Rail Corporation Ltd. will be the Project executing and implementing agency for the proposed metro rail project in Patna. PMRCL will be overall in charge of rehabilitation and resettlement issues such as implementation, monitoring and execution of land acquisition and resettlement issues. The designated engineering department headed by Chief Project Manager in PMRCL will assess the requirement of land acquisition and resettlement based on the engineering design.

PMRCL will be responsible for coordinating with other concerned government departments for land acquisition, planning and implementation of RAP which will include the disbursement of compensation, assistance, shifting and relocation of affected people. PMRCL will also arrange/ provide vocational training and other welfare assistance to the affected people.

To ensure proper coordination and execution of the land acquisition and resettlement issues and to ensure coordination with the implementing agency, an independent evaluation consultant (Resettlement & Rehabilitation) may be hired by PMRCL for mid and end term evaluation of implementation of resettlement and rehabilitation activities.

The independent evaluation consultant may review RAP implementation in light of the objectives, targets, budget and duration that is laid down in the plan.

PMRCL will report to JICA 4 times a year (quarterly) regarding the progress made on land acquisition and implementation of resettlement plan.

Above PMRCL tasks will be assisted by DMRCL, which is the design-build project consultant and contractor procured in September 2019.

15.8.2 Department of Revenue and Land Reforms

Department of Revenue and Land Reforms, Government of Bihar is responsible for large-scale acquisition of land for planned development. Land Acquisition Branch of the Department is responsible for overall coordination between various agencies involved in land acquisition.

For acquisition of private land for the proposed project, PMRCL will place requisition of land to Transport Department, who in turn will forward the requisition to the Department. On receipt of the proposal for acquisition of land from Transport Department, the Land Acquisition Branch of the Department will forward the same to the District Land Acquisition Collector (LAC) to initiate the process for acquisition of land. Land will be acquired by LAC/ the Department under “The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (No. 30 OF 2013)” and Bihar Government Rules (2014).

15.8.3 Office of the District Land Acquisition Collector

The proposed project covers Patna city of Bihar. The Patna District has a Land Acquisition Collector (LAC). The office of the LAC will be responsible for the land acquisition. District Land Acquisition Collector will coordinate between the PMRCL and the affected landowners. PMRCL will provide technical details and the land acquisition plans, as well as the funding for land acquisition, rehabilitation and resettlement, to the LAC.

The LAC will be responsible for initiating and issuing notice under the Land Acquisition Act 2013 and the LAC will be responsible for conducting the valuation of affected land and assets, will decide and disburse the compensation and assistances.

15.8.4 Social Management Unit (SMU)

PMRCL will have a division which shall be looking after the social safeguards activities. This is headed by Deputy Chief Engineer (Land) who coordinates with other divisions/ sections of PMRCL on social, rehabilitation and resettlement issues. Other members of this unit will include the concerned Deputy Chief Engineer of the line/ corridor referred to as Deputy Chief Engineer (construction), Executive Engineer (land) and Executive engineer of the concerned line/ corridor. PMRCL will do the overall coordination, preparation, planning, implementation, and financing of RAP.

The Social Management Unit (SMU) of PMRCL will work closely with other staff of the PMRCL and will be specifically looking after the social safeguards issues. The SMU shall ensure that all land acquisition issues are handled according to the LA policy/ guidelines as it is laid down in this report. It will also monitor that all the procedural and legal issues involved in land acquisition are fulfilled. The SMU will work for getting all the necessary clearances and implementation of the resettlement activities prior to start of any civil work. A Social Development Officer (R&R) with background of social science may be added in this SMU as full time to supervise and monitor overall activities of RAP and he/ she will report day to day progress to Deputy Chief Engineer (Land).

Some of the specific functions of the SMU in regards to resettlement management will include the following:

- Take overall responsibility of planning, implementation and monitoring of land acquisition and resettlement and rehabilitation activities in the Project;
- Ensure availability of budget for R&R activities;
- Coordinate stakeholder agencies (District Administration (Land Acquisition Collector (LAC)), Patna Metro Corporation,), the Land Acquisition Branch of the Transport Department, and the assistance provider agencies for trainings), support for land acquisition, and implementation of land acquisition, resettlement, and rehabilitation.
- Coordinate with line Departments, such as National Highway Authority, Indian Rail, and other landowner departments.
- Monitor progress and due-diligence of land acquisition and R&R activities
- Procure the external monitoring of land acquisition and R&R activities

As of September 2022, PMRCL has staffed 4 out of 5 necessary personnel for SMU as shown in the table

below. Until the official establishment of the SMU, the Director (Project), is taking lead in communication and coordination between the Patna District Administration and the Social Development Officer in PMRCL. Based on the communication, the Director (Project) gives necessary instructions to the Engineers responsible for land (PMRCL) and construction (DMRCL).

In the letter dated September 21, 2022, PMRCL expressed that the Resettlement and Rehabilitation Policy for the Project is likely to be approved by the State Government by October 10 2022. Establishment of the SMU may follow soon after the approval of the Policy.

Table 15-66: Institutions for Resettlement Activities

Institution	Planned Member (DPR SIA 2020)	Staffing
Social Management Unit (SMU)	Deputy Chief Engineer (Land)	Patna District Administration
	Deputy Chief Engineer (Construction)	To be named
	Social Development Officer (Rehabilitation and Resettlement)	Staffed in PMRCL
	Executive Engineer (Land)	Staffed in PMRCL
	Executive Engineer (Construction)	Staffed in DMRCL
Grievance Redress Committee (GRC)	Chief Engineer (General)	General Manager (Works), PMRCL
	Chief Project Manager (Construction)	Staffed in DMRCL

Source: JST, based on DPR SIA 2020 and PMRCL

15.8.5 Grievance Redressal Committee

The Grievance Redressal Committee (GRC) will address only rehabilitation assistance issues. Grievances related to ownership rights and land compensation shall be dealt in court as per the Land Acquisition Act 2013.

Efficient grievance redressal mechanism will be developed to assist the PAHs/PAPs resolve their queries and complaints. Grievances of PAHs/PAPs will be first brought to the attention of SMU, PMRCL. Grievances not redressed by SMU will be brought to the GRC. The composition of the proposed GRC will have Chief Engineer level officers nominated by top management, as shown in the table above.

The main responsibilities of the GRC are to:

- provide support to PAHs/PAPs on problems arising from land/property acquisition;
- record PAHs/PAPs grievances, categorize, and prioritize grievances and resolve them;
- immediately inform the SMU of serious cases; and
- report to PAHs/PAPs on developments regarding their grievances and decisions of the GRC.

When any grievance is brought to the field level staff, it should be resolved within three months from the date of complaint. The GRC will meet every month (if grievances are brought to the Committee), determine the merit of each grievance, and resolve grievances within three months of receiving the complaint failing which the grievance can be referred to appropriate court of Law for redressal by the PAHs/PAP.

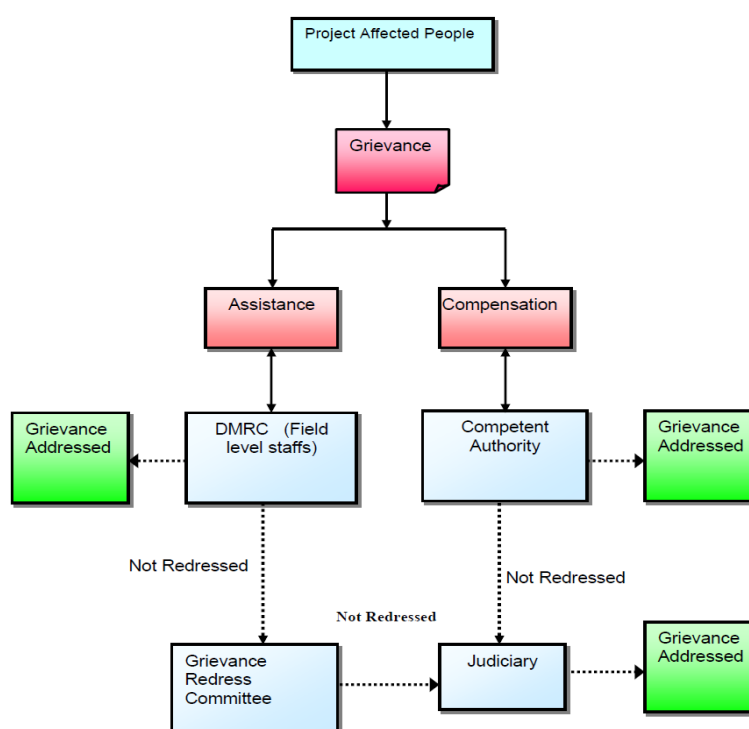
Records will be kept of all grievances received including: contact details of complainant, date the complaint was received, nature of grievance, agreed corrective actions and the date these were effected, and final outcome.

Until the official establishment of the GRC, the Director (Project) will assist the General Manager (Works), PMRCL in communication and coordination with the Chief Project Manager (Construction) DMRCL, in solving raised grievances. The office of the Director (Project) will be responsible for taking records of

grievances and follow-up until the redressals.

In the letter dated September 21, 2022, PMRCL expressed that the Resettlement and Rehabilitation Policy for the Project is likely to be approved by the State Government by October 10 2022. Establishment of the GRC may follow soon after the approval of the Policy.

A flow chart of grievances redressal is indicated in the figure below.



Source: DPR SIA 2020 p.67

Figure 15-4: Stages of Grievance Redressal

15.9 Implementation Schedule

15.9.1 Project Preparatory Stage (Pre- Implementation Stage)

Setting up relevant institutions for the resettlement activities will be the major task during the preparatory stage which is pre implementation phase. The major activities to be performed in this period include establishment of Social Management Unit (SMU) and additionally, the Grievance Redressal Committee (GRC) needs to be appointed at this stage.

As of September 2022, required members of those institutions are already assigned inside or outside of PMRCL. Setting up of SMU and GRC is not started yet.

Table 15-67: Institutions for Resettlement Activities

Institution	Planned Member (DPR SIA 2020)	Staffing
Social Management Unit (SMU)	Deputy Chief Engineer (Land)	Patna District Administration
	Deputy Chief Engineer (Construction)	To be named
	Social Development Officer (Rehabilitation and Resettlement)	Staffed in PMRCL

	Executive Engineer (Land)	Staffed in PMRCL
	Executive Engineer (Construction)	Staffed in DMRCL
Grievance Redress Committee (GRC)	Chief Engineer (General)	General Manager (Works), PMRCL
	Chief Project Manager (Construction)	Staffed in DMRCL

Source: JST, based on DPR SIA 2020 and PMRCL

15.9.2 Land Acquisition Implementation Stage

According to the 2013 Land Acquisition Act, State Scheme for Rehabilitation and Resettlement will be prepared by the District Administration using the PMRCL policies and the entitlement defined in the Act as the basis, and will be disclosed to the PAPs. Upon the approval of the State Scheme, all the arrangements for fixing the compensation and the disbursement needs to be done which includes payment of all eligible assistance; relocation of PAPs; initiation of economic rehabilitation measures.

The resettlement and rehabilitation fund will be monitored as part of the scheme implementation at this stage. Internal monitoring will be the responsibility of PMRCL which will start in early stage of the project when implementation starts and will continue till the completion of the implementation of land acquisition, resettlement and rehabilitation. PMRCL will be responsible for carrying out the monitoring on quarterly basis, and the quarterly report will be submitted to JICA for review.

15.9.3 Monitoring and evaluation phase

Public consultation, internal monitoring and grievance redressal will be undertaken intermittently throughout the project duration. Livelihood rehabilitation monitoring for those who received rehabilitation assistances is required for 3 years after the completion of payment of compensation, resettlement, and rehabilitation. The monitoring schedule is subject to modification depending on the progress of the project activities.

Activities in the monitoring and evaluation phase are described in detail in Section 15.10.

15.9.4 RAP Implementation Schedule

Public land acquisition process is on-going on the basis of individual negotiation with the owner institutions. Where the target land is transferred to PMRCL, civil works has begun. The PAHs who were residing or operating commercial business on those public land moved out without receiving compensation or assistance. PMRCL, in a letter dated September 21, 2022, promised that those PAHs will be contacted by District Administration by October 25, 2022, and the payment will be started by the District Administration before November 2.

For the private land title holders, District Administration, on behalf of State of Bihar, is implementing the land acquisition process following the instruction of the Land Acquisition Act 2013. The 11 locations (10 stations and Depot) that need private land are grouped into 6 units, and the process is handled by the units.

Regarding current progress, it is assumed that payment of compensation and taking of land will take time into the middle of 2023.

PMRCL need to set up the Social Management Unit, the Grievance Redress Committee, and to start quarterly reporting to JICA by the end of December 2022. PMRCL also need to procure external evaluation

expert for mid-term and end-term monitoring of RAP implementation.

Table 15-68: RAP Implementation Progress and Schedule

		2020				2021				2022				2023				2024				2025				2026				
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4					
1.	Commencement of Operation																													
2.	Preliminary Identification of Required Land (DPR)																													
3.	Preliminary Identification of PAHs (DPR SIA) (Cut-off date for informal settlers)																													
4.	Community/ Public Consultation (DPR)																													
5.	DPR approval by State of Bihar																													
6.	Negotiation and transfer of public land																													
7.	State SIA survey to assess the impact																													
8.	Public hearing (on State SIA)																													
9.	Identification of Required Land (Art. 11 Notification)(Cut-off date for title holders)									a	b																			
10.	State Census of PAHs, including identification of all title holders																													
11.	Boundary, topo, and boring survey on site																													
12.	Valuation of land, structures, and other assets																													
13.	Declaration of land to be acquired (Art. 19 Notification)													c																
14.	Payment for compensation, relocation and rehabilitation by District Administration																													
15.	Taking of land by PMRCL																													
16.	State Approval of Patna Metro Resettlement Policy Framework																													
17.	PMRCL Set up of Social Management Unit and Grievance Redress Committee																													
18.	PMRCL Internal monitoring (including post-resettlement monitoring for 3 years)																													
19.	PMRCL Quarterly report submission to																													

		2020				2021				2022				2023				2024				2025				2026
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
	JICA																									
20	PMRCL Procurement of External Evaluation Specialist																									
21	External evaluation (mid term and end term)																									

a.Depot, b.New ISBT Sta. c.Depot and.New ISBT Sta.

Source: JST

15.10 Cost and Budget

15.10.1 Cost Estimate and Budget

The cost of land and structure, including 100 % solatium and 12 % interest rate, is calculated as INR. 2,880.36 Crore (INR. 28,803.6 million) as per July, 2022. It was confirmed that the estimated cost for land and structure is within the budget secured based on the DPR 2021, which is INR. 2,881.83 Crore (INR. 28,818.3 million).

Table 15-69: Details of Cost of Land and Structure

S. No.	Description	Entitlement	Unit	QTY (DPR)	QTY (2022)
1	Cost of permanent Land Acquisition including 100 % Solatium and interest thereon @ 12%	Replacement Cost	ha	97.355	47.625*
2	Acquisition of structures				
2.1	Residential Houses (title holder)	Compensation for residential structure	Per Unit	7	5
2.2	Commercial structure (title holder)	Compensation for Commercial structure	Per unit	42	23
2.3	Commercial tenant (Full: 28, Partial 7)	Compensation for investment	Per unit	-	35
2.3	Residential + Commercial	Compensation for structure	Per Unit	4	3
2.4	Institutional Structure	Compensation for structure	Per Unit	1	1
2.5	Squatters (40), commercial encroachers (8)	Compensation for structure	Per unit	45	48
	Budget (Land + Structure)		INR. Crore	2,881.83	
	Cost Estimate as of July 2022		INR. Crore		2,880.36

*: See Table 15-29.

Final valuation of land and/ or structure to be done by Govt. Approved Valuer/ PWD

INR. 1 Crore = INR. 10 million.

Source: Land, Cost Estimate: Data received from PMRCL on August 29, 2022. 'Land details as per July, 2022'

Quantity of eligible structures (2022) : JST

Budget: DPR 2021

The estimated cost for resettlement and rehabilitation (R&R) in DPR SIA 2020 was INR. 5.8219 Crore (INR. 58.219 million.). The updated Project cost estimation provided by PMRCL on 9 September 2022 expect INR. 11.65 Crore (INR. 116.5 million) as the budget for R&R.

The detail of R&R budget based on the updated number of target PAHs is given in the table below. By eliminating partially affected PAHs from payment of shifting, resettlement, and subsistence allowances, as well as from annuity payment, the total cost for resettlement and rehabilitation is estimated as INR.

3.228 Crore (INR. 32.28 million.), which is within the prepared budget of INR. 11.65 Crore (INR. 116.5 million).

Table 15-70: Details of Cost of Resettlement and Rehabilitation

S. No.	Description	Entitlement	Unit	QTY (DPR)	QTY (2022)	Rate INR. Lakh	Amount INR. Lakh
1.	Shifting of Kiosk (3) and Milk parlor (7)	One-time artisan grant (inconvenience fee)	No.	3	10	0.25	2.50
2.	Shifting Allowance (Residential and Commercial)	A lump sum shifting allowance of INR.50,000/-	No.	134	101	0.50	50.50
3.	Resettlement Allowance (Residential)	A lump sum Resettlement allowance of INR.50,000/-	No.	134	48	0.50	24.00
4.	Subsistence Allowance (Residential)	For a period of one year @INR.3000/ month (36,000/year)	No.	134	46	0.36	16.60
5.	Choice of Annuity or Employment (Commercial)	A lump sum compensation @ INR. 500,000.	No.	69	35	5.0	175.00
6.	Vulnerable Families	Training etc.	No.	28	28	0.15	4.20
7.	Community structures (temples, public toilets etc.)	Compensation for structure	Lump sum	-	-	-	30.00
8.	Independent Evaluation		Lump sum				10.00
9.	Miscellaneous		Lump sum				10.00
10.	Cost Estimate as of Sep. 2022*						322.8 (3.228 Crore)*
11.	<i>Budget (DPR 2021)**</i>						1165 (11.65 Crore)
12.	<i>Total (SIA 2020)***</i>						582.19 (5.8219 Crore)

Source: *.JST, **: DPR2021p.17-07, 17-10, ***: DPR SIA 2020.p.85

INR. 1 Crore = INR. 10 million = 100 Lakh

INR. 1 Lakh = INR. 100,000. = INR. 0.01 Crore

15.11 Monitoring and Evaluation

RAP implementation will be monitored both internally and externally. PMRCL will be responsible for internal monitoring through their field level offices and will prepare quarterly reports on the progress of RAP implementation. An Independent Evaluation Consultant may be hired by PMRCL for mid and end term evaluation of RAP implementation.

15.11.1 Internal Monitoring

The internal monitoring for RAP implementation will be carried out by PMRCL. The main objectives of internal monitoring are to:

- measure and report progress against the RAP schedule;
- verify that agreed entitlements are delivered in full to affected people;
- identify any problems, issues or cases of hardship resulting from the resettlement process, and to develop appropriate corrective actions, or where problems are systematic refer them to the management team;
- monitor the effectiveness of the grievance system
- periodically measure the satisfaction of project affected people.

Internal monitoring will focus on measuring progress against the schedule of actions defined in the RAP. Activities to be undertaken by the PMRCL will include:

Liaison with the Social Management Unit, construction contractor and project affected communities to review and report progress against the RAP;

- Verification of land acquisition and compensation entitlements are being delivered in accordance with the RAP;
- Verification of agreed measures to restore or enhance living standards are being implemented;
- Verification of agreed measures to restore or enhance livelihood are being implemented;
- Identification of any problems, issues, or cases of hardship resulting from resettlement process;
- Through household interviews, assess project affected peoples' satisfaction with resettlement outcomes;
- Collection of records of grievances, follow up that appropriate corrective actions have been undertaken and that outcomes are satisfactory;

Monitoring is a continuous process and will be carried out by Resettlement Specialist on regular basis to keep track of the R&R progress. For this purpose, the indicators suggested have been given in table below.

Field Offices will be responsible for monitoring the day-to-day resettlement activities of the project. Baseline socio-economic census and the land acquisition data provide the necessary benchmark for field level monitoring. A format for monitoring of RAP implementation is presented in Attachment 10.

Table 15-71: Indicators for Monitoring of RAP Progress

Indicators	Parameters Indicators
Physical	Extent of land acquired
	Number of structures dismantled
	Number of land users and private structure owners paid compensation
	Number of families affected
	Number of PAPs receiving assistance/compensation
	Number of PAPs provided transport facilities/shifting allowance
	Extent of government land identified for house sites
Financial	Amount of compensation paid for land/structure
	Cash grant for shifting PAPs
	Amount paid for training and capacity building of staffs
	Amount for restoration of CPR (Common Property Resource)
Social	Area and type of house and facility at resettlement site
	Number of time GRC met
	Number of appeals placed before grievance redressed cell
	Number of grievances referred and addressed by GRC
	Number of cases referred and addressed by arbitration
	Number of PAPs approached court
	Women concern
Economic	Entitlement of PAPs-land/cash
	Number of business re-established
	Utilization of compensation
	House sites/business sites purchased
	Successful implementation of Income Restoration Schemes
Grievance	Consultation for grievance redressed
	PAPs knowledge about their entitlements
	Cases referred to court, pending and settled
	Number of grievance cell meetings
	Number of cases disposed by SMU to the satisfaction of PAPs.

Source: DPR SIA 2020

15.11.2 Independent Evaluation

As mentioned earlier, an Independent Evaluation Agency (IEA) will be hired by PMRCL for mid and end term evaluation. As of September 2022, PMRCL has hired 1 internal Social Development Officer for rehabilitation and resettlement. External IEA, however, has not yet been assigned.

The list of impact performance indicators suggested to monitor project objectives is delineated in the table below.

Table 15-72: Indicators for Project Outcome Evaluation

Objectives	<ul style="list-style-type: none"> ➤ The negative impact on persons affected by the project will be minimized. ➤ Persons losing assets to the project shall be compensated at replacement cost. ➤ The project-affected persons will be assisted in improving or regaining their standard of living. ➤ Vulnerable groups will be identified and assisted in improving their standard of living.
Risk Factor	<ul style="list-style-type: none"> ➤ Resettlement plan implementation may take longer time than anticipated ➤ Institutional arrangement may not function as efficiently as expected ➤ NGO may not perform the task as efficiently as expected ➤ Unexpected number of grievances ➤ Finding a suitable rehabilitation site for displaced population ➤ PAHs falling below their existing standard of living
Outcomes and Impacts	<ul style="list-style-type: none"> ➤ Satisfaction of landowner with the compensation and assistance paid ➤ Type of use of compensation and assistance by landowners ➤ Satisfaction of structure owner with compensation and assistance ➤ Type of use of compensation and assistance by structure owner ➤ % of PAHs adopted the skill acquired through training as only economic activity ➤ % of PAHs adopted the skill acquired through training as secondary economic activity ➤ % of PAHs reported increase in income due to training ➤ % PAHs got trained in the skill of their choice ➤ Role of NGO in helping PAHs in selecting trade for skill improvement ➤ Use of productive asset provided to PAHs under on time economic rehabilitation grant ➤ Type of use of additional assistance money by vulnerable group ➤ Types of grievances received ➤ No. of grievances forwarded to GRC and time taken to solve the grievances ➤ % of PAHs aware about the GRC mechanism ➤ % of PAHs aware about the entitlement frame work mechanism ➤ PAHs opinion about NGO approach and accessibility

Source: DPR SIA 2020

15.11.3 Reporting Requirements

PMRCL will be responsible for supervision and implementation of the RAP.

PMRCL will prepare quarterly progress reports on resettlement activities and submit the reports to JICA.

The Independent Evaluation Consultant will submit mid and end term evaluation report to PMRCL and determine whether resettlement goals have been achieved, more importantly whether livelihoods and living standards have been restored/ enhanced and suggest suitable recommendations for improvement.

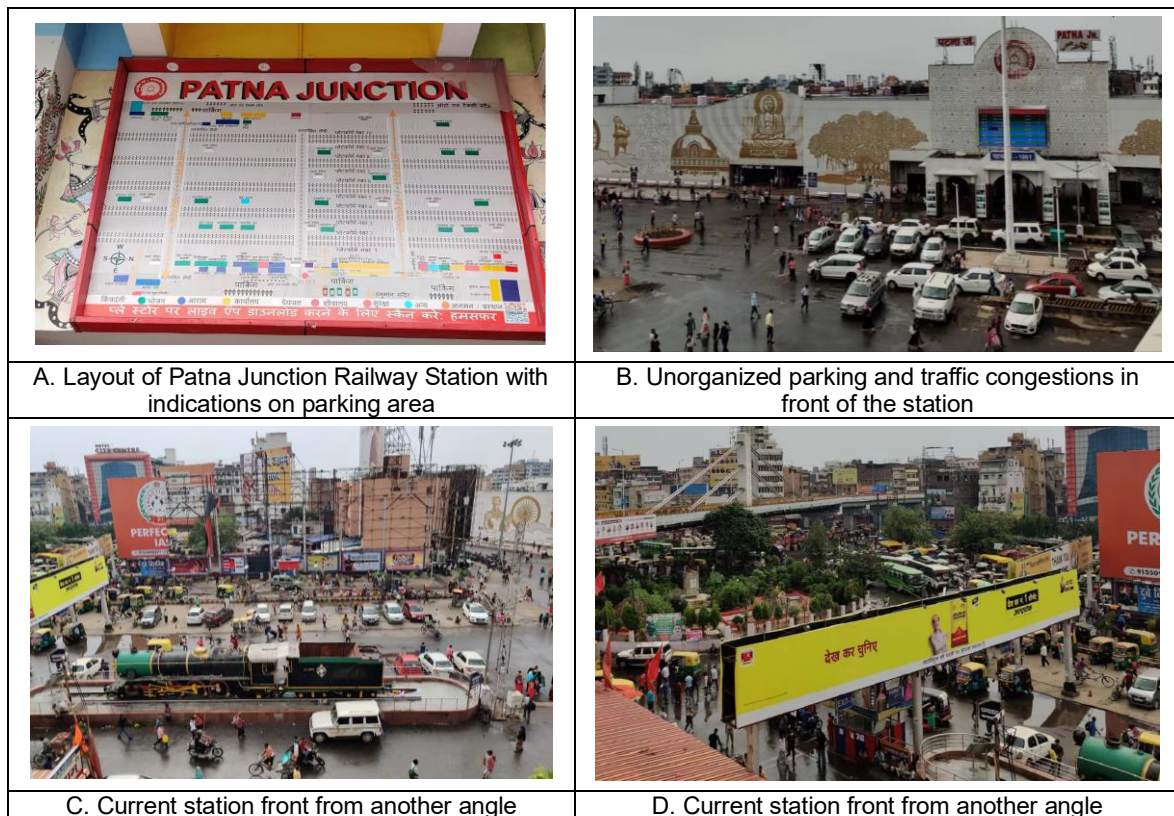
15.12 Consideration on Impacts on Existing Transportation Industry

By opening of Patna Metro, clients of existing public transportation may change their selection of transportation to the new Metro. Therefore, perceptions of the Project by the stakeholders of the existing public transportation was studied.

15.12.1 Observation of Existing Urban Transportation in Patna

At present, City Bus Service is operational on more than 10 routes in Patna. There is no uniform and a standard schedule of operation. The daily average number of trips per bus is 14. There are 350 mini-buses. The seating capacity of mini-bus is in the range of 15-20 and fare structure ranges from INR. 5 to INR. 15. In addition to these, public transport majorly includes shared autorickshaws.

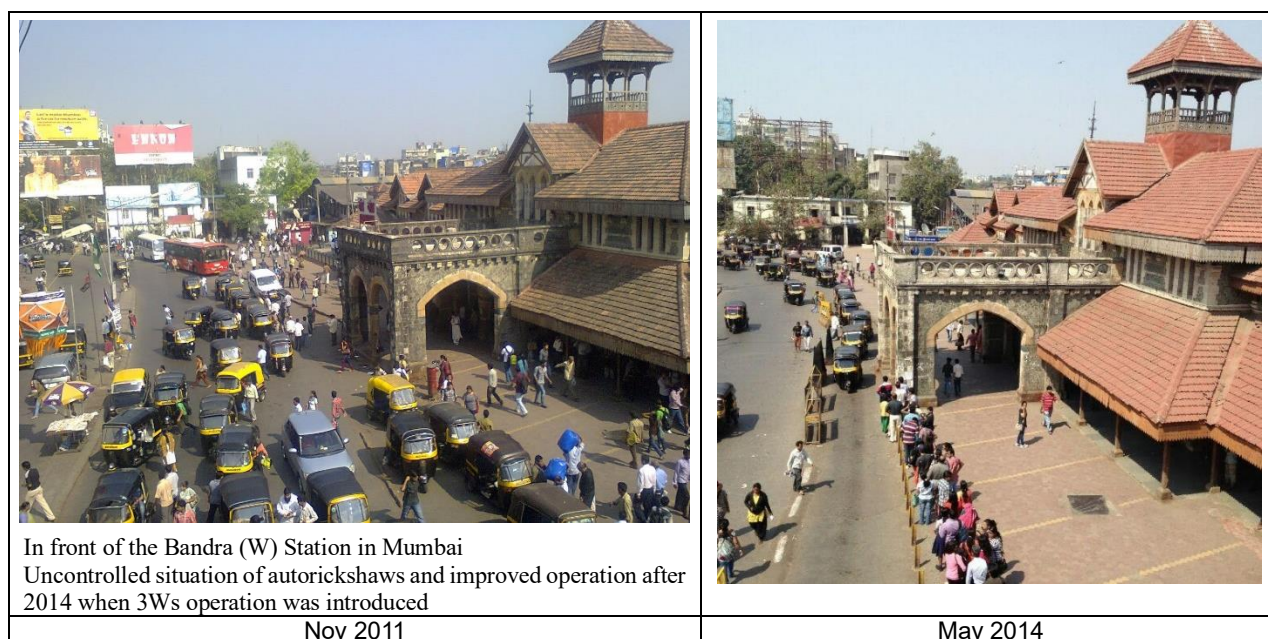
The following photos illustrate the situation in front of Patna Junction Railway Station that observed by JST during the field survey in June 2022. The station plaza (shown as B and C) in front of the station is used for private car parking, where could be used for public transport connections. The roundabout beneath a flyover is used as un-organized bus stops and autorickshaw riding zones, which should be improved.



Source: JST

Figure 15-5: Patna Junction Railway Station Front

In comparison, the Bandra (W) Station in Mumbai is a good example on how regulation of Three-Wheelers and shift of feeder services can change the station front over the years.



In front of the Bandra (W) Station in Mumbai
Uncontrolled situation of autorickshaws and improved operation after 2014 when 3Ws operation was introduced

Nov 2011

May 2014

Source: JST

Figure 15-6: Mumbai Bandra (W) Station Front

15.12.2 Case Study

JICA has been supporting numerous urban transportation projects. This section explains the strategy taken by the Delhi Metro to organize various mode of transportation by connecting them with the operation of the Metro.

As shown in the table below, Delhi Metro provides Metro users various choices of last-mile transportation. Buses, e-rickshaws, and cabs are available at many Metro stations through the Metro operating hours. For the service providers and drivers of buses, rickshaws and cabs, constant flow of customer can be expected at secured spaces for them.

In addition to above modes, Delhi Metro is operating rental e-scooters and bicycles at their stations. For example, battery operated cycles are available at 41 stations.

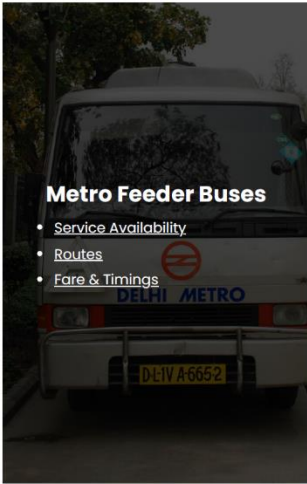
Table 15-73: Last Mile Connectivity Strategy by Delhi Metro

1.	Metro Feeder Buses	Total 47 AC buses being operated Operating on 05 routes Available at 09 metro station Operating from 06:00AM to 11:00 PM Fares: Up to 04 Kms Rs. 10.00/- From 04 Kms to 08 Kms Rs. 15.00/- From 08 Kms to 12 Kms Rs. 20.00/- Above 12 Kms Rs. 25.00/-
2.	E-Rickshaw -- Service	Available from 30 stations 295 e-rickshaws are being run as of now From starting of metro services until closure of metro services Fares: For first 2 Kms Rs. 10/- Thereafter for subsequent km. Rs. 5/-
3.	Cab Aggregator -- Service	Available at 50 stations From starting of metro services until closure of metro services

4.	E-Scooter -- Service	Available at 05 stations 30 e-scooters are available as of now Operates Round the clock Fares: Rs. 01/- per minute Rs. 50/- for one hour Rs. 120/- for one day
5.	Cycle Sharing -- Service	Pedal Cycles Available at 11 stations Battery operated cycles available at 41 stations 994 Cycles (battery & pedals) are available as of now Fares: For Pedal cycles Rs. 05/- for 30 mins (only at Rohini East, GTB Nagar & Vishwavidyalay metro stations) Rs. 10/- for first two hrs & Rs. 10/- for every subsequent hour (for remaining all stations) For battery operated cycles Rs. 10/- for 10 mins.

Source: Delhi Metro

— Last Mile Connectivity



Metro Feeder Buses

- Service Availability
- Routes
- Fare & Timings

E-Rickshaw Services

- 1 Service Availability
- 2 Fare & Timings

E-Scooter Services

- 1 Service Availability
- 2 Fare & Timings

Cycle Sharing Services

- 1 Service Availability
- 2 Fare & Timings

Cab Aggregator Services

- 1 Service Availability
- 2 Fare & Timings

Auto-Rickshaw E-Booth

- 1 Service Availability
- 2 Fare & Timings

Source: Delhi Metro

Figure 15-7: Last Mile Connectivity Strategy Web Page by Delhi Metro



Source: JST

Figure 15-8: Delhi Metro Station with Feeder Buses

15.12.3 Interview Survey

(1) Interview of Auto Rickshaw Drivers

In July 15 2022, at four (4) major Auto Rickshaws Stands listed below, 30 autorickshaw drivers were asked to cooperate an interview about their opinions about the Project.

1. Patna Junction Railway Station (Corr. 1-10, Corr. 2-1)
2. Gandhi Maidan (Corr. 2-3)
3. Saguna More (Corr. 1-2)
4. Mithapur (Corr. 1-11)

The drivers were first given general information about the Patna Metro project, including its routes, expected commencement timing, expected positive impacts on reducing the traffic jam on the road, and potential competition for customers in the operation phase. Then the drivers were asked about their opinion what kind of impact the Project will bring their work and living.

The survey results are summarized in the table below.

Table 15-74: Interview of Autorickshaw Drivers

Question asked		<ul style="list-style-type: none"> ● When the Patna Mero starts operation in near future, do you think your business environment will be better, or do you think your sales will reduce because of the competition for customers?
Answers	Number	Opinion About the Project
Positive opinion	29	<ul style="list-style-type: none"> ● After the implementation and proper running of Metro Rail, drivers will travel for shorter distance per customer, hence they could do more trips with similar cost. ● When the auto stands are prepared at Metro Stations, the number of the auto stands increase in the city, that is benefit of the drivers. ● Metro Rail will help reducing road jamming and Road accidents. Traffic congestion and honking is major problem which make fatigues to Patna citizen and reduce the work efficiency.
Neutral opinion	1	<ul style="list-style-type: none"> ● Can not decide now whether positive impacts or negative impacts will affect more on my operation
Negative opinion	0	-

Source: JST



Source: JST

Figure 15-9: Interview of Autorickshaw Drivers

(2) Interview of Institutions Related Bus Operation

Opinions from a bus operator (BSRTC (Bihar State Road Transport Corporation)) and the governing office (District Transport Office) were collected by interviews. The results are shown in the table below.

Bus transportation in Patna started in the year 2018. Before that, auto rickshaws were the main mode of transportation for the residents, besides walking, cycling, and motorcycles.

Both offices consider that the reduction of traffic jam by opening the Patna Metro will be a positive impact for their operation. No negative response regarding decline of sales were expressed. At the same time, it seems that the BSRTC has not developed operation plan including Patna Metro under operation, and the BSRTC is simply considering increase of number of operating buses in near future.

Table 15-75: Interview of Institutions Related Bus Operation

Interviewed Institution	Opinion
District Transport Office	<ul style="list-style-type: none"> ➤ The Proposed Metro Project will reduce the pressure of vehicles on the road <p>Other obtained information:</p> <ul style="list-style-type: none"> ➤ There are no Bus and Auto Operators Associations or Unions operating in the city. ➤ Transport authority are proposing to Plan Zones in the city for Auto operators.
BSRTC (Bihar State Road Transport Corporation)	<ul style="list-style-type: none"> ➤ Bus Passengers are very eager to welcome Patna Metro Project as they are facing the trouble of traffic jam and crowded buses. ➤ Bus drivers are also willing to welcome Metro as they are expecting reduction of traffic on road . ➤ No response was obtained any strategy to be taken after the operation of Metro Project. <p>Other obtained information:</p> <p>Operation started In the Year 2018.</p> <p>Total Number of Buses operating in the city PPP Mode: 130 Buses Nigam (co-op type operation): 90 buses Electric Buses: 25 (In addition to above, about 350 private buses are operated in Patna)</p> <p>Number of Passengers Electric Bus Passengers: 6000/ Day</p>

Interviewed Institution	Opinion
	City Bus Passengers: 32,000/ Day Number of Trips/Day 4 up and 4 Down Number of Routes/Day Buses Travel to Rajendra Nagar, Kankarbagh, Shri Krishna Puri, Patliputra, Gandhi Maidan, Danapur, All India Institute of Medical Sciences, Patna University, Patna Sahib, Saguna Mor, Hajipur, Manersharif, Bihta and Digha. Future Plans of BSRTC Addition of 75 buses are proposed (50 Electric Buses and 25 CNG Buses)

Source: JST

15.12.4 Proposals for Development of Urban Transportation Network

Based on above studies, following strategies are proposed for establishment of better urban transportation network in Patna. By implementing the following measures in cooperation with related organizations, a more efficient urban transportation network will be realized while maintaining the operation of existing transportation facilities.

Since the future network can not be realized by PMRCL alone, it is expected that the Department of Urban Development and the Department of Transport are expected to take the initiative in developing and implementing these strategies.

1. Route Buses on artery roads will be shifted to feeder routes that connect residential areas/villages more than 500 m from Metro stations.
2. Auto rickshaws and rickshaws will maintain operations by emphasizing the function of the last one mile linking between stations and residences or workplaces within 2 km, while avoiding congestion and congestion on arterial roads.
3. Drop/pick-up zones, parking lots, transfer information boards, etc. will be developed in line with metro development, and contribute to the creation of orderly road spaces and to ensure the integrity of public transportation services.
4. Department of Urban Development and Department of Transport will take leading role of coordination meetings and planning for planning and implementation of above three strategies together with PMRCL, bus and taxi operators, and representatives of auto-rickshaws operators.
5. By introducing standardized payment systems, discounted fare for combined trips, MaaS (Mobility as a Service) concept, public transportation service will be integrated and be easier to use and more efficient for customers.

15.13 Survey on Necessity of Indigenous Peoples Plan

As per the Census in 2011 by the Government of India, Patna City has 72 wards through which both Metro corridors are passing. There are 5,139 persons who belong to indigenous people residing in all 72 wards of Patna City.

In the surveys for DPR SIA in 2020 implemented by DMRCL, and for the State SIAs implemented in 2022, no indigenous persons were recognized among PAHs/PAPs. During the site visit by the local consultant in July 2022, no sign of indigenous person's residences were recognized along the 2 Corridors.

With the above information and observation, it can be concluded that the Project does not require an Indigenous Peoples Plan.

15.14 Consideration on Gender

15.14.1 Analysis

(1) Policies and systems

Central government of India has been working on to secure equal legal rights for men and women as shown in the following table.

The most recent moves are the Women's Reservation Bill in 2016 by the Central Government, and the State of Bihar policy issued in the same year. The Central Government Bill states 30 % quota for women in governmental and private employment. State of Bihar announced additional 5 %, a reserve of 35 % of all government jobs, and engineering, medical, and technical education colleges jobs for women. Further, State of Bihar declared that a 50 per cent reservation for women in teaching jobs, police, and the panchayats. As of September 2022, PMRCL, which was established in 2019, has not yet developed a gender action plan.

Table 15-76: Gender Related Acts and Policies

Laws prohibiting gender-based violence and harassment	<ul style="list-style-type: none"> ● Dowry Prohibition Act, 1961: Penalty for giving or taking dowry.-Penalty for demanding dowry.-Dowry to be for the benefit of the wife or heirs. ● The Sexual Harassment of Women at Work Place (Prevention, Protection and) Act, 2013: internal complaints committee, local complaints committee, duties of employer, duties and powers of district officer
Legal systems related to resettlement and compensation	<ul style="list-style-type: none"> ● The Hindu Women's Right to Property Act, 1937: the property rights of Hindu widows. ● The Hindu Succession (Amendment) Act, 2005: Hindu women's the right to be coparceners or joint legal heirs in the same way a male heir. Property rights are very complex under Muslim law.
Labor law	<ul style="list-style-type: none"> ● The Equal Remuneration Act, 1976: application of equal pay for women and men
Female quota	<ul style="list-style-type: none"> ● Constitution 1993: The constitutional amendment stated that a random one third of village council leader, or Sarpanch, positions in the gram panchayat should be reserved for women. ● Women's Reservation Bill 2016: The bill seeks to reserve 33% seats in Lok Sabha and all state legislative assemblies for women, and reservation of 30 % females in the employment of any government and private organization. The quota is mandated at each level of the staff, therefore, the employer is required to provide equal trainings as well as promotions to female and male staff. Reservation of seats for women shall cease to exist 15 years after the commencement of this Amendment Act. ● Policy of State of Bihar 2016: will reserve 35 % of all government jobs, and engineering, medical, and technical education colleges for women. A 50 per cent reservation for women in teaching jobs, police, and the panchayats.
Encouragement of female entrepreneurs	<ul style="list-style-type: none"> ● Stand Up India Scheme 2016: <ul style="list-style-type: none"> ➤ Objectives: to support entrepreneurship among women and Scheduled Caste & Scheduled Tribe communities who for the first time start business enterprise (Greenfield enterprise). ➤ Support: in setting up enterprises, obtaining loans and other support needed from time to time for succeeding in business.

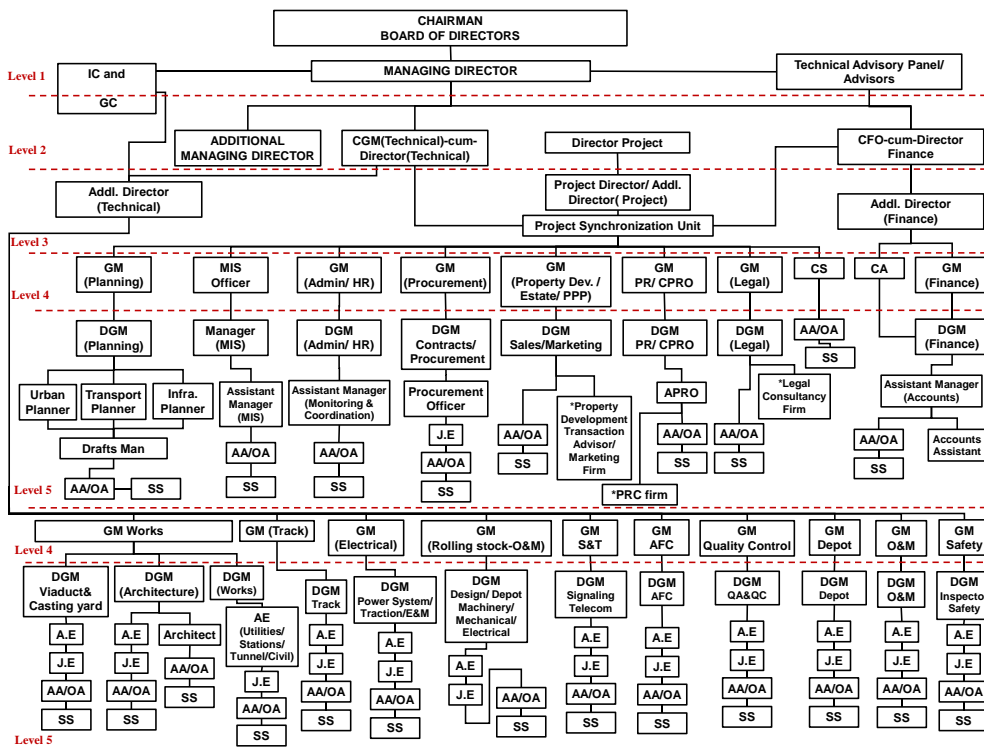
	<ul style="list-style-type: none"> ➤ Bank loans (including term loan and working capital): between INR. 10 lakh (US\$ 14,000/ about JPY. 2 million) and INR. 1 crore (US\$ 140,000/ about JPY. 20 million) ➤ Target sectors: manufacturing, services, agri-allied activities or trading. ● Supporting Bank in Bihar: Punjab National Bank, Patna
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Source: JST

(2) Female employment in organizational structure of PMRCL

PMRCL was established on February 19, 2019 for the implementation of the Patna project. The organizational chart of the Patna Metro Company is shown in the figure below.

PMRCL has 188 posts already approved by the Bihar Urban Development and Housing Authority, and 41 posts are already filled as of September 2022. Out of the total 41, 5 positions are filled by female staff. Their positions are Accountant, Data Entry Operator, and supporting staff (SS) at GM (Administration & HR) office. There are no Engineer level officers or above positions filled by female employee yet.



Source: PMRCL/DMRCL

Figure 15-10: Organization Structure of PMRCL

(3) Observation and Requests of Female Passengers on Public Transportation in Patna

In Patna, priority seats are available for women customer on the buses at the front part of the coach behind the driver. Indian Rail also provides women-only cars on every train.

During the field observation, female customers on buses and auto-rickshaws were seen regularly, although the number was less than male passengers. In addition, both male and female students of 50 universities and colleges located in Patna were seen walking in groups on main streets in Patna. Those students,

including 3 women’s college students and female students in co-education universities and colleges, can be a potential commuting customers of Patna Metro.

Passengers at busy traffic points were interviewed for desirable services for female customers at Patna Metro in operation phase. Those requests are listed below. During the interview, 75 % interviewee requested separate Female coach on the Metro train, and remaining 25% wanted special seat secured for women on general coaches.

1. Separate Female-only Car and separate place on the platform
2. Reserved seats for senior female passengers on the Female-only Car
3. Breast feeding room
4. Waiting room for women passengers at the station where they rest, and can feed their child
5. Female traveller concession in tickets and monthly pass
6. Female-only Que at the ticket counters

(4) Gender Integration Efforts by Other Metro Projects in India

JST collected information of 15 metro projects in India regarding design and activities on gender integration. Multiple metro corporation have ambitious plan to hire female staff for various positions.

Table 15-77: Gender Integration Efforts by Other Metro/Rail Projects in India

Timing and Issues	● Gender-related Strategies
Station Design	● Women help desk is located in stations.
Employment in Construction Phase	(no information was available)
Employment in Operation Phase	● 25 % of train operators are female staff. ● Corporation is aiming that 80 % of the staff to be female.
Operation of Rolling Stock	● Every train, throughout the day, one car (32 seats) out of 6 or 8 car-train is dedicated for female passengers. ● Every car has seats secured for women passengers. ● Every car has seats secured for elderlies, women, and differently abled persons. ● Half of one car is secured as Ladies Zone in one train. ● In rush hour in the morning and the evening, one train reserved for female passengers are operated.

Source: JST





Female queue sign, Namma Metro | A tape dividing a car in Ladies only zone, Hyderabad

Source: <https://www.financialexpress.com/infrastructure/railways/unique-initiative-for-women-safety-indian-railways-nfr-zone-earmark-coaches-with-pink-for-easy-identification/1661659/>
<https://gulfnews.com/world/asia/india/indian-women-drive-change-on-kochi-metro-1.63054776>
<https://timesofindia.indiatimes.com/city/bengaluru/women-cheer-throng-reserved-metro-doors/articleshow/62991644.cms>
<https://www.thehindu.com/life-and-style/the-ladies-compartment-on-the-metro-is-yet-to-become-an-exclusive-space-that-keeps-men-out/article24013728.ece>

Figure 15-11: Gender Integration Efforts by Other Metro/Rail Projects in India

15.14.2 Proposals for Gender-Responsive Activities

(1) Gender considerations in station design

It was confirmed from the tender drawings and questions and answers that the station facilities have the gender and infant considerations listed in the table below.

Additionally, JST proposed that 1) all stations should have a women's helpline desk staffed by women from the police or PMRCL security departments; 2) crime prevention measures must be installed such as monitoring of underground passes and areas near to the station entrances with CCTV, and good lighting to eliminate dark areas; 3) emergency hot lines must be installed on the train as well as at multiple locations of the station, and be connected to the security stations or local police stations.

Table 15-78: Patna Metro Station Facility Gender and Infant Design Consideration Plan

Facility	Gender and Infant considerations
Toilet separated male and female	The toilets are to be install for passengers and station staff in all station paid concourse area. Moreover, gender-segregated toilets for station staff in some station back-office areas.
Transgender toilet	The transgender toilet is to be installed alongside passenger toilet areas in the concourse are at some stations. Transgender people can use the toilets without having to worry about the stares of others which they felt when using the Male or Female toilets.
Diaper-changing tables	The diaper-changing table is to be install in multi-purpose toilets of a part of some stations. By installing the table in multipurpose toilets that can be used by both men and women
Separate security gates	Two lines of security gates to be installed at all stations that are planned as separate rows for men and women. In addition, a women's body search area is planned with a curtain to prevent women from being seen by others.
Platform	The platform is designed to have a good view and to eliminate blind spots, thereby preventing and controlling crime and allowing female passengers to use the platform safely.

Source: JST

(2) Employment in Construction Phase

As stated in Section 15.1, according to Periodic Labour Force Survey (MoSPI) NSO 2018, Bihar registered the lowest female labour force participation rate (LFPR) at merely 4% in rural areas and 6.5% in urban areas. One of the reasons for such a low level of female LFPR in Bihar has been the traditional social norm of limiting female role within household, and not encouraging female population to go out of house to take part in the labour force.

During the Site assignment of JST in Patna and State of Bihar, many road maintenance work sites were observed, but female construction workers were rarely seen. Compared to other locations in India, female workforce participation especially as unskilled construction laborer may be resented in State of Bihar.

On the other hand, PMRCL, as a part of State of Bihar institution, confirmed in a meeting with JST that PMRCL has responsibility of implementing equal recruitment for any level of workers and staff. PMRCL also confirmed that it is aiming to achieve the 35 % of female quota in the long run.

(3) Employment in Operation Phase

PMRCL is planning to start operation in 2024. Recruitment activities for operation staff has not yet started. In the beginning phase of operation, it can be expected that many DMRCL trained staff will be rented to PMRCL for smooth operation and for training of newly hired staff of PMRCL.

PMRCL, as a part of State of Bihar institution, has responsibility of implementing equal recruitment for any level of workers and staff, and responsibility to achieve the 35 % of female quota.

(4) Operation of Rolling Stock

PMRCL is planning to operate 3-car train in the beginning of their operation. After good number of customers are secured, PMRCL will operate 6-car train.

Understanding the strategy above, JST has proposed PMRCL to secure female seats in the following manner. Female-only seats must be secured throughout the operation hours. The number of secured seats will vary depending on the number of cars on a train. PMRCL responded on September 13, 2022, that the proposal will be taken into consideration.

Number of cars in a train	Availability of seats secured for female passengers	Seat number secured
On 3-car train	On every train throughout the operation hour	Half of 1 car
On 6-car train	On every train throughout the operation hour	1 car

Source: JST

15.14.3 Gender Indicators for Monitoring of Gender Integration

Following 27 indicators were proposed for PMRCL in monitoring the level of achievement of gender integration.

Table 15-79: List of Gender Indicators for Monitoring of Gender Integration

	Policies and systems
PMRCL	1. Gender Action Plans formulated
Customer Survey	2. Number of available gender disaggregated data (number of passengers)

	<p>3. Opinions of female users/passengers (received in opinion boxes) (number and contents)</p> <p>4. Solutions adopted based on these opinions (number and contents)</p>
	Organizational structure
PMRCL	<p>[Gender training for executives and staff]</p> <p>5. Number of gender training sessions for executives and staff</p> <p>6. Number of training participants (by gender and age)</p> <p>7. Change in gender awareness after training</p> <p>[Female executives]</p> <p>8. Increase in the number and percentage of female executives</p> <p>9. Percentage of quota to increase female executives (planned and actual)</p> <p>[Female staff and technicians]</p> <p>10. Increase in the number and percentage of female staff and technicians</p> <p>11. Percentage of quota for active employment of women (planned and actual)</p> <p>12. Personnel policy for active recruiting of women (content)</p> <p>[Work environment]</p> <p>13. Details of improved work environment</p> <p>14. Satisfaction level of female employees with the work environment</p> <p>[Strengthening the capacity of female technicians]</p> <p>15. Participation status in various training programs (by gender)</p> <p>16. Identified training needs of female technicians and staff</p> <p>17. Enhanced competencies and skills of female technicians</p> <p>[Harassment and SGBV in the workplace]</p> <p>18. Number of reports of harassment and SGBV (Sexual and gender based violence) in the workplace (by type)</p> <p>19. Number of incidents of harassment and SGBV in the workplace (by type)</p> <p>20. Training on harassment and SGBV (number of times conducted, number of participants (by gender))</p> <p>21. Changes in staff understanding and awareness of harassment and SGBV</p> <p>[Participation in decision-making]</p> <p>22. Increase participation of female members in the Committee for Gender Action Plan</p> <p>23. The Gender Action Plan Committee is held in the timing and hours easy to participate for female members</p> <p>24. Gender-specific needs incorporated in Gender Action Plans</p>
	Project Impact on Gender Empowerment
RAP Implementation (Rehabilitation after resettlement)	<p>[Women's participation in technical training]</p> <p>25. Increase in the number and percentage of female residents who participated in technical training</p> <p>26. Techniques and skills acquired by women</p>
PMRCL/DMRCL	<p>[Employment of women]</p> <p>27. Number and percentage of women employed for the project (civil, construction, canteen, other skilled/ unskilled labour)</p>

Source: JST

15.15 Differently Abled Persons

15.15.1 Policies, Laws, and Programs Related to Differently Abled Persons

Barrier free measures in station facilities is designed in accordance with "Harmonised Guidelines and Space Standards for Barrier Free Built Environment for persons with Disability and Elderly Persons in the year 2016" the barrier free guidelines issued by the Ministry of Urban Development of India, and the Barrier Free Standards for Station Facilities of the National Building Code of India (NBC2016).

The station facilities plan to be designed with consideration for persons with disabilities (physical, visual, hearing, internal diseases, etc.) in accordance with the guidelines and basic code that is confirmed in the Station Building design report.

15.15.2 Already Incorporated Measures

The lists shown in the table below are the design criteria for barrier free design that is mentioned the Station Building design report.

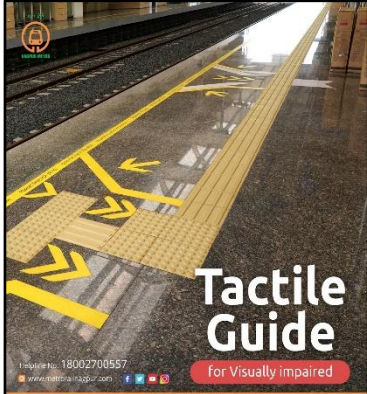

In addition, with the lead of Department of Urban Development and Housing of State of Bihar, which is the managing office of PMRCL, and the District Transport Office, the road space around the stations will be re-coordinated with safety measures such as traffic signals and crossing zones.

Table 15-80: Patna Metro Station Facility Barrier-Free Design Criteria

Facility	Criteria
Station Entrances and Exits	<ul style="list-style-type: none"> ● The station entrance/exit should not have a difference in level. If a level difference is unavoidable, install a ramp or a ramp plus staircase. ● It is desirable that space be marked out near the station entrance/exit for vehicles carrying wheelchair users.
Reservation or Information Counters	<ul style="list-style-type: none"> ● Reservation or information counters should have unobstructed approaches for wheelchair users. ● One counter height should be 750 mm.
Concourse	<ul style="list-style-type: none"> ● The concourse should not have a difference in level. If a level difference is unavoidable, install a ramp or a ramp plus staircase. ● The floor surface of a concourse should be made of non-slip material. At places, where the difference in level such as stairs, it is desirable that the appearance of the surface material be changed using color contrast. ● Install guiding blocks on the concourse for persons with impaired vision. ● Wherever columns exist, an electrical/ fiber-optic/ equivalent provisions shall be made keeping in mind the future of having revenue generating facilities as ATMS and also facilities for ease of passengers (coffee/ tea vending machines).
Staircase	<ul style="list-style-type: none"> ● For details, see the guidelines for staircases as per Part 4 'Fire & Life Safety' & Annexure J of NBC 2016 (including amendment 1 issued in March 2021).
Lifts (Elevators)	<ul style="list-style-type: none"> ● Install a lift (elevator) to enable passengers with disabilities to move between floors. ● For the lift (elevator), install one warning block for persons with impaired vision 300 mm away from the call button.
Toilets	<ul style="list-style-type: none"> ● Install a toilet and washstand suitable for use by wheelchair users and other passengers.
Ticket Gates	<ul style="list-style-type: none"> ● One of the ticket gates should have a continuous line of guiding tactile blocks for persons with impaired vision.
Platforms	<ul style="list-style-type: none"> ● The platform should have one row of dotted guiding blocks for persons with impaired vision, 800 mm or more from the edge. ● The paved surface of the platform must be made with a non-slip material ● Stairs, kiosks and dustbins on the platform must not hinder the clear passage of persons with impaired vision and wheelchair users. ● A bench should be installed on the platform, having guiding block around it.
Rolling Stock (Car) doors	<ul style="list-style-type: none"> ● Car doors should be wide enough for wheelchair users (minimum 900 mm) ● The gap between car doors and the platform should be reduced to an absolute minimum.
Information	<ul style="list-style-type: none"> ● The information board should be made easily readable by using sufficiently large text size, distinct contrast and illumination. ● It is desirable that in addition to a printed version of train schedule, table of fares and other travel information also be in Braille.

Source: PCDD 01: Design Basis Report April 2022

 <p>Accessibility for Divyang on Metro Station</p>	 <p>Ramps Accessibility for Divyang on Metro Station</p>
<p>Wheelchairs are available at the Customer Care Counter at every station</p>	<p>Ramps are installed in metro stations wherever surface level changes</p>
 <p>Wheelchair Parking Space</p>	 <p>Designated Seats</p>
<p>Wheelchair Parking space available at all the Metro Stations</p>	<p>Seats are reserved for differently abled/senior citizens.</p>
 <p>Proper Signage for All the Facilities for Persons with Disabilities</p>	 <p>Wide Baffle-gates</p>
<p>Well lit signage at appropriate places to inform about various facilities like elevator, entry, exit and accessible toilets etc.</p>	<p>Flap gates can be opened extra-wide to allow wheelchairs through.</p>
 <p>Audio systems for visually impaired</p>	 <p>Appropriately Trained staff</p>
<p>Audio system at elevators (lifts) announces the door closing/opening, next reaching floor number, and arrived floor number. Train doors have audio and visual systems that tells next station, arriving station, door opening side.</p>	<p>Station staff constantly monitors passenger movement and provides personal help to any differently-abled person who needs assistance.</p>

	
<p>On all the metro station floors tactile pathways have been made to help guide the persons with visual impairment. These paths do lead people right to the places like ticket counters, toilets, platforms etc.</p>	<p>All the Metro Station is equipped with elevators (lifts) which reach at all the levels with wheelchair.</p>

Source: Nagpur Metro

Figure 15-12 Sample Photos of Barrier-Free Design for Station Facility

15.15.3 Newly Proposed Measures

When a person with a Unique Disability ID or disability Certificate travels with Indian Rail, the ticket will be sold at 25 % of the regular price for him/her and 1 attendant. In future, it is recommended that similar price adjustment be installed at Patna Metro to encourage social and economic participation and integration of all.

16. Public Consultation¹

16.1 1st Public Consultation

16.1.1 Overview of PCs implemented by PMRCL

PMRCL conducted Public Consultations (PCs) from May 27th to 30th, 2020. Prior to the holding of the PCs, PMRCL notified local residents including affected households on May 8th, but the PCs were forced to be held in a small number of people taking basic measures; wearing masks, keeping social distance, and disinfecting, because the mass gathering was restricted due to the COVID-19. At the PCs, PMRC explained about land acquisition, affected structures, high-risk environmental and social considerations items, existence of important common resources, considerations for vulnerable groups, mitigation measures for affected assessment items, affected asset value, and other assistance/allowance to have the discussions with the local residents.

16.1.1 Implementation method and approach of PC held by PMRCL, and summary of results

The PCs were held by PMRCL for affected people in various sectors such as traders, women groups, and other residents related to the affected areas. On the PCs, discussions were held on land acquisition, compensation for them, livelihood restoration, job creation, information flow, grievance redress mechanism, safety, and the role of government. In the resettlement action plan, PMRCL will propose to deal with all the problems raised in the PCs and to strengthen the countermeasures for those problems in the future. PMRCL adopted the following method when implementing the PCs.

- On May 8, 2020, notifications were given that PCs would be conducted in several locations in the vicinity of the affected areas.
- PCs were held in the vicinity of the affected area along the Corridors. (from May 27 to 30, 2020)
- Sharing priorities and opinions of affected people

In addition, PMRCL explained to participants the summary of the EIA report and the project outline, including environmental baseline data, anticipated environmental impact items, mitigation measures, and the participants were asked for their opinions and suggestions. The PCs were held at Rukanpura, Raja Bazar, Zero Mile, Gandhi Maidan and Bigrahpur (Mithapur). In the PCs, since the land acquisition by the project implementation and itself have severe impacts on the affected people who will lose their land, they raised their opinion that it should be compensated at the market price. There was also an opinion that the lessees should be fully compensated because they have severe impacts on their lives, too. On the other hand, they had a great interest in the project, and raised their opinions that they wanted youths to be hired with full-time. The outline and discussion's content of the PCs in each venue are as follows, and the detailed discussion's content are attached as Attachment 11.

Table 16-1: Summary of PC Results Conducted by PMRCL (1)

Item	Content
Date	27 th (Wed) May, 2020
Venue	Rukanpura
Participants	3 persons (3 males)
Main opinions from participants	Q1. Private land should be avoided. Q2. What kind of measures will be taken to prevent dust generation during construction?

¹ Environmental Impact Assessment and Social Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC

Item	Content
	Q3. There is concern about noise generated by heavy machinery operation. Q4. Income loss during construction should be also compensated.
Replies from PMRCL	A1. Please understand that it is necessary to acquire private land due to restrictions on land acquisition as project land. A2. Regular water sprinkling, especially in the dry season should be proposed in order to control the dust diffusion. A3. Perform regular maintenance according to the passed time from the machinery manufacturing. In addition, operation arrangements should be conducted so that the heavy machinery operation does not overlap in order to reduce the cumulative impact. A4. Scrutinize the issue referring the Land Acquisition Law (2013).

Source : Environmental Impact Assessment and Social Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station- New ISBT, Jul, 2020, DMRC

Table 16-2: Summary of PC Results Conducted by PMRCL (2)

Item	Content
Date	27 th (Wed) and 30 th (Sat) May, 2020
Venue	Raja Bazar
Participants	7 persons (6 males, 1 females) (PCs held in 3 times)
Main opinions from participants	Q1. There is concern about dust and smoke generated during construction. Q2. Shops and tenants must be relocated due to the project. Q3. The project will induce traffic congestion during construction. Q4. Income loss during construction should be also compensated for PAHs that lose their partial land. Q5. Compensation for individual shop owners and tenant owners.
Replies from PMRCL	A1. Regular water sprinkling, especially in the dry season should be proposed in order to control the dust diffusion. Other mitigation measures related to air pollution are mentioned in the EMP. A2. The issue should be considered when paying compensation and allowances, but the payees include both owners and lessees. A3. The construction activities will be implemented underground and within barricades. Traffic management will be planned in consultation with the traffic police. A4. Scrutinize the issue referring the Land Acquisition Law (2013). A5. The issue should be discussed at the payment time, but they may also be included as eligible persons.

Source : Environmental Impact Assessment and Social Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station- New ISBT, Jul, 2020, DMRC

Table 16-3: Summary of PC Results Conducted by PMRCL (3)

Item	Content
Date	29 th (Fri) May, 2020
Venue	Gandhi Maidan
Participants	8 persons (8 males)
Main opinions from participants	Q1. Relocation site and rehabilitation as social consideration items. Q2. There is concern about dust and smoke generated during construction. Q3. There is a concern about leaving the excavated soil which will be traffic obstacles. Q4. Due to livelihood of three wheeler's driver in the same place for a long time, they are worried about losing their income during construction and operation. Q5. Relocation site and livelihood restoration.
Replies from PMRCL	A1. Relocation and rehabilitation will be implemented according to the entitlement matrix. A2. Adaptation of mitigation measures for air pollution. A3. To prohibit construction contractors from leaving construction waste and to instruct them to transport it to disposal sites on a regular basis. A4. Compensation and livelihood restoration support will be implemented according to the entitlement matrix. A5. Scrutinize available alternatives in the vicinity based on relocation and livelihood restoration support policies.

Source : Environmental Impact Assessment and Social Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station- New ISBT, Jul, 2020, DMRC

Table 16-4: Summary of PC Results Conducted by PMRCL (4)

Item	Content
Date	29 th (Fri) May, 2020
Venue	Bigrahpur-Mithapur
Participants	16 persons (16 males)
Main opinions from participants	Q1. Since there is a concern about noise generated during construction and operation, it should be controlled. Q2. To propose the alignment review. Q3. Since debris is generated even in small-scale construction, a large amount of construction waste will be generated in such a large-scale project. Q4. There is a concern about the compensation amount. Q5. Income loss during construction should also be compensated.
Replies from PMRCL	A1. PMRCL will implement mitigation measures against Station noise generation during construction and operation. A2. Alternatives have already been considered and then the alignment was finalized. A3. To prohibit construction contractors from leaving construction waste and to instruct them to transport it to disposal sites on a regular basis. A4. Compensation for landowners, tenant users, etc. will be implemented within the policy of relocation and restoration support. A5. Scrutinize the issue referring the Land Acquisition Law (2013).

Source : Environmental Impact Assessment and Social Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station- New ISBT, Jul, 2020, DMRC

Table 16-5: Summary of PC Results Conducted by PMRCL (5)

Item	Content
Date	Not mentioned
Venue	Zero Mile
Participants	6 persons (6 males)
Main opinions from participants	Q1. There is no major concern from kiosk officials located at the government land that has to be relocated. But was the avoidance of relocation examined? Q2. There is concern about dust and smoke generated during construction.
Replies from PMRCL	A1. Compensation will be implemented within the Policy and Regulated Framework. A2. Regular water sprinkling, especially in the dry season should be proposed in order to control the dust diffusion. Other mitigation measures related to air pollution are mentioned in the EMP.

Source : Environmental Impact Assessment and Social Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station- New ISBT, Jul, 2020, DMRC

Table 16-6: PC Photos Conducted by PMRCL



Source : Environmental Impact Assessment of Danapur - Mithapur- Khemni Chak and Patna station-New ISBT, Jul, 2020, DMRC

16.2 2nd Public Consultation

16.2.1 EIA

To be described

Public consultation for EIA in the presence of the residents has been held at Khemni Chak, New ISBT, R.P.S. More, Raja Bazaar, Rajendra Nagar and Patna Station where it is easier for the residents to gather along the Patna Metro Corridors. In the consultations, the project outline, the expected environmental and social impact items from the project, the survey results on the environmental and social impact, the environmental management plan, and the environmental monitoring plan have been explained. The participants asked questions about construction period and underground depth, requested that the construction be carried out in environmental consideration, and expected new employment for construction work, business opportunities, and discounts on train tickets etc. On the other hand, during consultations at the sections under construction, there were complaints about the dust generation, worsening traffic congestion caused by construction vehicles, and delays in construction etc. PMRCL carefully responded

to each question and complaint, and the consultations ended without any major issues. The summary of the result of 2nd Public meeting is shown below, and the minutes of meeting at 6 location and the participant list are attached as an Attachment 12.

Table 16-7 Summary of the Result – 2nd Public consultation

Item	Contents
Date & Venue	Khemni Chak : Jharokha Banquet, 5 th Sep 2022 10:00 – 12:00 New ISBT : Umrao Hotel, 5 th Sep 2022 14:00 – 16:00 RPS More : Heritage Garden, 6 th Sep 2022 10:00 – 12:00 Raja Bazaar : Matri Hotel, 6 th Sep 2022 14:00 – 16:00 Rajendra Nagar : Panasia Hotel, 7 th Sep 2022 10:00 – 12:00 Patna Station : Samrat International, 7 th Sep 2022 14:00 – 16:00
Language	Hindi
Announcement method for the meeting	Announced by PMRCL to the residents through the media 10 days ago
Consideration for the holding	To notify that not only the householders but also all residents such as women and vulnerable groups can participate.
Participant	<u>PMRCL</u> : Mr. S. S. Prashad <u>DMRC</u> : Mr. S. N. Pandey <u>JICA Study Team</u> : Mr. Ashish Kumar <u>Sub-Consultant</u> : Mr. Ankur Agarwal, Dr. Shiv Prakash Singh, Mr. Miland Joshi 228 local peoples (Male: 213, Female: 15)
Main opinion from local people	Q1. The negative impacts, their precaution measures and public benefits of the project Q2. Contact for complaints Q3. Length of construction period Q4. The environment development work should be continued. Q5. Plantation should be done as like Delhi. Q6. Where are the final details where we can confirm that which place is going to be affected or not? Q7. What will happen to the houses and wells on the route of the underground section? Q8. Depth of underground construction Q9. Provision for people who lose their jobs because of this project Q10. Access to store blocked by construction barricades Q11. Information disclosure and updates to local citizens Q12. How to apply to open a small store in a station Q13-1. After the Metro is in service, what facilities are proposed for the monthly ticket? Q13-2. Fare discount for local person of the Patna. Q14. Provision of underground parking Q15. Emergency actions in the event of an earthquake while the metro is in operation Q16. To hope it will be completed soon (Opinion) Expectations for employment through this project The Metro is a safe means of transportation for women and helpful for the tourist. The Metro will enhance the business opportunity and connectivity. <Sections where construction has already started> Q17-1. Dust pollution caused by material transport trucks is severe. Q17-2. The entry and exit of Hydraulic and overtaking by construction vehicles cause traffic jam. Q17-3. Part of the road is occupied by PMRC and there is no parking space. Q17-4. There is no proper traffic management by PMRC, and no proper maintenance. Q18. This construction work is too slow.

Item	Contents
<p>Reply from PMRCL</p>	<p>A1. Mostly the path will be above road and underground, and it will provide many benefits like employment, connectivity etc. However, if any adverse impact done by metro, appropriate action will be taken on it.</p> <p>A2. PMRC Office in Indra Bhawan where you can place your complain</p> <p>A3. The tentative time line is for 2025.</p> <p>A4. The Environment development program will be continued as going on.</p> <p>A5. There will also same kind of plantation will be developed.</p> <p>A6. Once finalized, the government will be notified and the owner will be informed.</p> <p>A7. If any obstruction will faced then it will be shifted properly.</p> <p>A8. 20-30 meter. It may be very depending on the design.</p> <p>A9. Provision in Metro project that on the basis of their capability and skills people get the employment.</p> <p>A10. Appropriate measures will be taken to ensure that the store is not inconvenienced.</p> <p>A11. Whatever done by the Patna Metro is advertised through the newspaper and different mediums on time to time.</p> <p>A12. The application will be published in the newspaper as an open tender for everyone.</p> <p>A13. Till now nothing has been decided but definitely your suggestion will be considered.</p> <p>A14. Installation of parking lot depends on location.</p> <p>A15. The Metro is using the earthquake resistance technique. If such situation happen, metro will stop at its location.</p> <p>A16. The work is completed within the defined framework as soon as possible.</p> <p><Sections where construction has already started></p> <p>A17 Appropriate action will be taken on it by conveying the same to the relevant authority and department</p> <p>A18. The work will be done in fast forward mode.</p>

Source : JST

Table 16-8 Photos of 2nd PC





Source : JST

16.2.2 SIA

(1) Background

On behalf of State of Bihar, Patna District Administration, Office of the Collector (Land) is responsible for implementing the land acquisition process, including the SIA study and the Public Hearing. The State public hearing for the Project has started in 2021.

PMRCL explained that the District Administration is implementing public hearings following the legal requirements of India, which reflects the findings of SIA surveys undertaken by the Bihar State. JST followed up the public hearings by the District Administration, so that they do not deviate from the JICA Guidelines' requirements for stakeholder meetings. Therefore, the public hearings by the District Administration qualifies as the second stakeholder meeting required by the JICA Guidelines

(2) Date, Locations, Number of Attendants

District Administration hired SIA experts and the experts implemented SIA surveys including identification of registered landowners as well as of self-claimed landowners. In Public Hearings, all identified landowners were invited, but anybody who are interested in the Project and land acquisition could attend freely. The meetings were started with reading the summary of the draft SIA report including the findings of the surveys of the project objectives, land registration, and socio-economic status of the landowner PAHs.

The location of the public hearings were proposed by the SIA experts and decided by the District Administration. Locations such as meeting rooms of official institution, halls at ceremonial facilities, and shop fronts of the affected structures were selected for the convenience of the attending PAHs.

As a result, almost all attendants were male attendants. The reasons of the distorted gender balance can be understood as a mixture of the followings.

- The District Administration invites representatives of PAHs to the Hearing, and the PAHs naturally send a male representative reflecting male-dominant mindset that is common in Bihar.




- The 2013 Land Acquisition Act does not mandate measures for gender-balanced participation.
- In the interview surveys for EIA and SIA in this report, many female interviewee hesitated expressing their opinions or giving their names to the interviewer, who were also female Indian surveyors. The surveyors felt that majority of female population in Patna are comfortable with following male instructions, and are not used to following their individual interests or instincts when they chose their action, including attending the Public Hearing.

Table 16-9: Locations, Date, Number of Attendants of the Public Hearing

	Corr	Location	Town	Venue	Date	Number of Attendants	Attendees
1	2	Depot Area	Pahadi, Ranipur	Patliputra Bus Complex, Pahari, Patna	2021.June 4	About 250 (Female 0)	Directly and indirectly affected people, Representative of minority groups (i.e. Muslims (Waqf Board)) Public representatives (representative of ward members), Representatives of PMRCL, SIA experts
2	2	New ISBT Sta.	Pahari	District Administration Office	2021.Aug.14	15 (Female 0)	
3	2	Akashvani Sta. University Sta.	Moharrampur, Sandalpur	Hotel Rajasthan Bihar State Sunni Waqf Board	2022.Feb.17, 2022.Feb.23	12 (Female 0)	
4	1	Jaganpura Sta. Ramakrishna Nagar Sta. Mithapur Viaduct	Jaganpura, Changad, Bigrahpur	Maa Kamla Utsav Hall	2022.May.28	35 (Female 2)	
5	1	Rajabazar Sta. Rukanpura Sta. Patna Junction Sta.	Salempur, Sadikpur, Moharrampur	Patna Municipal Corporation Office	2022.Aug.20	40 (Female 1)	
6	2	PMCH Sta.	Muhharrampur	At the affected shops	2022.Sep.5 2022.Sep.9	22 (Female 0)	

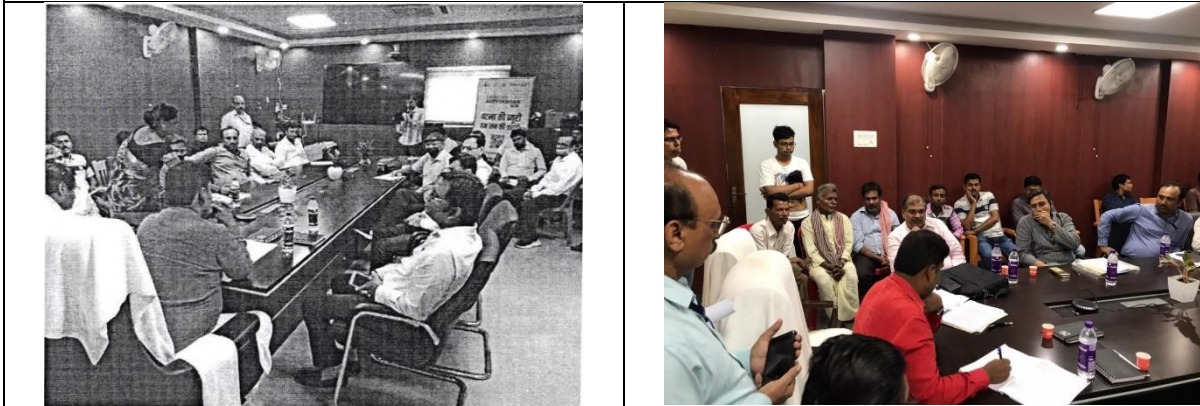
Source : JST based on the State SIA Reports

Table 16-10: Photo Records of Public Hearing by District Administration

	
Depot Area Public Hearing (2021.June 4)	
	
New ISBT Sta. Public Hearing (2021.Aug.14) (Attendants refused to sign and to be photographed)	



Jaganpura Sta., Ramakrishna Nagar Sta., Mithapur Viaduct Public Hearing (2022.May.28)



Raja bazar Sta., Rukanpura Sta., Patna Junction Sta. Public Hearing (2022.Aug.20)



PMCH Sta. Meeting with PAHs (2022.Sep.09)

Source : JST based on the State SIA Reports

In the State SIA survey, the SIA experts visited registered landowners and self-claimed land owners to disseminate the information about the Project, and to collect information of their socio-economic conditions and perception about the Project. The results of Interview Survey was summarized in 15.5.2 Profile of Project Affected Landowners.

Focus Group Discussions were held in the affected area to repeat the information dissemination, to understand collective opinions of the PAHs, including the landowners, tenants, and other PAHs, and to invite them to the Public Hearings.

Table 16-11: Photo Records of Interview Survey and Focus Group Discussion



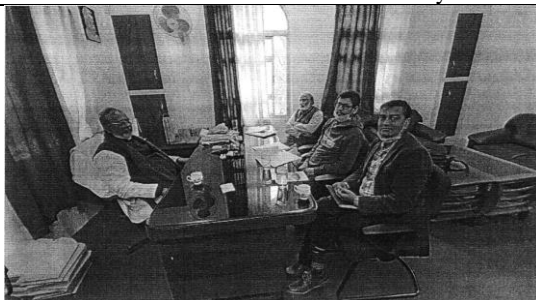
SIA Interview Survey at the Depot area (2021 Feb.)



Focus Group Discussions at the Depot area (2021.Mar.03, 2021.Mar.05)



SIA Interview Survey at Akashvani and University Stations (2021 Feb.)



Focus Group Discussions at at Akashvani and University Stations (2021.Feb.)



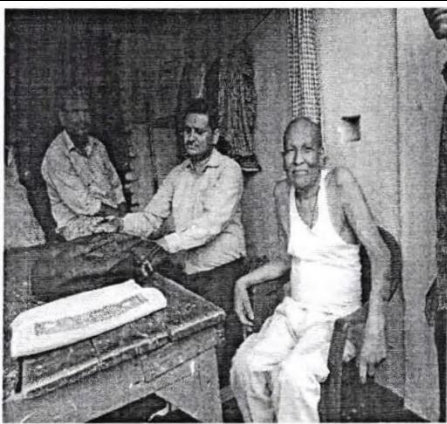
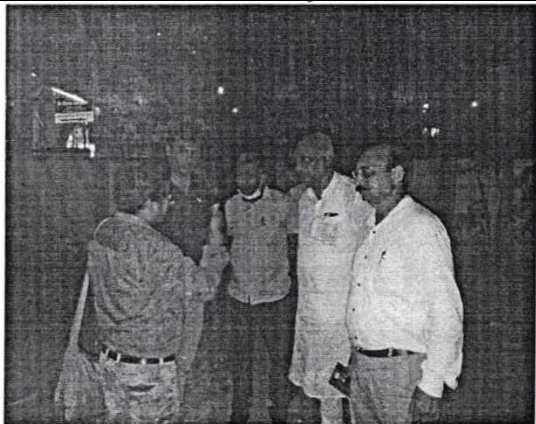


Focus Group Discussions at Ramakrishna Nagar St. (2022 Apr.12)



Focus Group Discussions at Mithapur Viaduct



Focus Group Discussions at Mithapur Viaduct

<p style="text-align: center;">(2022 Apr. 14)</p> 	<p style="text-align: center;">(2022 Apr. 15)</p> 
<p style="text-align: center;">SIA Interview Survey at Raja bazar Sta., Rukanpura Sta., Patna Junction Sta. area (2022 June)</p>	<p style="text-align: center;">Informal Discussions at Patna Junction Sta. area with PMRCL staff (2022 June)</p>
	
<p style="text-align: center;">SIA Interview Survey at PMCH Sta. area (2022 Sep.)</p>	<p style="text-align: center;">SIA Interview Survey at PMCH Sta. area (Bihar State Sunni Waqf Board Chairman) (2022 Sep.)</p>

Source : JST based on the State SIA Reports

(3) Records of Communications

Records of opinions and responses taken from the State SIA reports are explained in the following tables.

At most of the locations, the attendants made proposals of moving the Project sites to some other places a few kilometers away. Since the Patna Metro is a linear infrastructure, and it is not feasible to move parts by parts on locations distant from the designed corridors, such proposals were listened to, but were rejected.

Many attendants required that the impact on their land must be minimized. On this point, PMRCL promised that the significance of the impact will be explained in detail, and will be minimized.

Concerns were expressed by business owners about their losing entrance/exit to their land during construction or after the construction. On this point, PMRCL assured to secure adequate entrance and exit in both construction and operation phase.

It was found that the PAHs are demanding the communication with the District and PMRCL. The District and PMRCL need to meet the PAHs in separate, individual manner to explain the significance of the Project impact, as well as to listen to unique conditions each PAH has.

The Land Acquisition Act 2013 requires multiple timing of meetings between the stakeholders, as listed below. PMRCL, cooperating with the District Administration, must continue communication with the

stakeholders to reach mutual and feasible agreement between the parties.

- 1) during the site measurement activities after the publication of the Preliminary Notice (Art. 11 Notice);
- 2) during object filing phase about taking of the land, in 60 days after the publication of the Preliminary Notice;
- 3) during the public hearing on the draft State Rehabilitation and Resettlement scheme, based on the PMRCL policy; and
- 4) during object filing phase about the value of the compensation after the publication of the Article 19 Notice.
- 5) throughout the Project life through the Grievance Redress process.

Table 16-12: Opinions Presented in the State Public Hearing: Depot Area (Report 1)

	Opinions	Responses
1.	Acquisition of areas other than the area of the proposed area must be considered. Acquisition can be done 500-600 meters south from the present alignment, in which no house is built, owned by the land of Sahara India, which has to sell its land. Also, there is a common land along the north road of the bypass police station. If these options are considered, then the compensation revenue for this project is likely to cost the government comparatively less.	Proposed location has been selected as most suitable by engineering design perspective.
2.	If the acquisition process is done 2 km away from this site, then less number of people will be affected and the government will also get the benefit of revenue.	
3.	The land of Pahari Circle has been acquired four times before this under National Highway Scheme, Transport Nagar Yojana, Ganga Pollution Scheme and Patliputra Bus Complex Scheme. There should be no more land acquisition in this area.	Locating suburb of Patna Metro area, many infrastructure projects are implemented in this area.
4.	Many house construction committees are working on the land falling under the present proposed acquisition. Due to which about 1300 members who have bought small pieces of land for house construction are to be affected. Some people have already done house building work.	All project affected persons will be compensated for their loss.
5.	All the land to be acquired under one project should be at one rate for Circle Pahari and Circle Ranipur. Compensation should be paid at market rate.	Compensation will be paid at market rate, based on the survey results done by licensed surveyor, commissioned by the District Administration.
6.	Give a job in Patna Metro Corporation for affected family.	Rehabilitation measures will include provision of priority in governmental recruitment.
7.	After the construction of malls and multiplexes by bus complex and metro, the local people will have to face serious problems related to traffic and pollution.	The planned malls and bus complex will have adequate parking spaces separated from the road. Road traffic will move smoothly by construction of the Metro.

Source: JST based on SOCIAL IMPACT ASSESSMENT STUDY LAND ACQUISITION FOR PATNA METRO RAIL MULTI PURPOSE DEPOT CONSTRUCTION REGION-PATNA CITY, DISTRICT-PATNA

Table 16-13: Opinions Presented in the State Public Hearing: New ISBT Sta. Area (Report 2)

	Opinions	Responses
1.	Leaving the due proposed acquisition, land should be acquired at 500 meter away (Badsahinala) to reduce the crowd of Metro station and ISBT. If this is not possible then other options may also be considered. Compensation for all the land to be acquired under project should be at market rate. Get a job in Patna Metro Corporation.	Due to site constraint, it is not feasible The request will be considered as per Entitlement matrix and qualification.
2.	It was told by the local people that many house construction committees are working on the land falling under the present proposed acquisition.	Due to site constraint, moving the Project site is not feasible.

	Opinions	Responses
	Due to which about 60 members who have bought small pieces of land for house construction are getting affected. Some people have done house building work. If the acquisition process is done 1 km away from this site, then less number of people will be affected and the government will also get the benefit of revenue.	All project affected persons will be compensated for their loss.
3.	The local people also told that in future after the construction of malls and multiplexes by bus complex and metro, the local people will have to face serious problems related to traffic and pollution. For this reason also people do not agree with this acquisition. Hence, the proposed acquisition process should be done only after considering the options given by them.	The planned malls and bus complex will have adequate parking spaces separated from the road. Road traffic will move smoothly by construction of the Metro.

Source: JST based on Social Impact Assessment Study due to Proposed Land Acquisition for Multipurpose Metro Parking and Station Project, District-Patna, Draft Report

Table 16-14: Opinions Presented in the State Public Hearing: University Sta. and Akashvani Sta. Area (Report 3)

	Opinions	Responses
1.	The area of proposed acquisition is near both Patna Junction and AIR station, which can also be covered on foot, except other routes should be acquired. Patna Metro is not that suitable for Dak Bungalow area. If this is not possible, then other options should also be taken into consideration. If it is necessary to take the Metro path, then it should be taken through SP Verma Road or Exhibition Road, if required.	The locations of Patna Metro facilities are designed to maximize the convenience of customers who travel between different modes of transportation.
2.	Due to the blockage of the traffic route during the progress of the work, there will be a huge reduction in the activities of the general public. Due to which the entire business process of Fraser Road will come to an end. Due to which the maintenance of the families of the working workers of those related commercial establishments will be affected. Whose number is in the thousands? Along with this, due to the stagnation of business, the revenue income of the government will also decrease.	All measures will be taken to minimize impact on existing businesses and commercial activities during the construction stage. Loss of business income during the construction stage shall be assessed and negotiated against the Land Acquisition Act, 2013.
3.	There should be no effect on the entry and exit of the commercial establishment during the construction work.	
4.	The land which is the property of the Waqf is the land donated. If possible, take this project from the other side. If there is no option, pay attention to the points below. <ul style="list-style-type: none"> ➤ The construction related works should be done while maintaining the existing green area. ➤ If possible, allotment of land should be done in lieu of land. ➤ After the completion of the work, the damaged boundary wall (hostel) and the premises should be constructed as soon as possible according to the before-construction condition. ➤ The compensation for the land acquired under the project should be paid at the market rate and not through the MVR. 	Due to site constraint, selecting other land plot instead is not feasible. Compensation will be made by cash as per Entitlement matrix. At the completion of the work, boundary walls will be re-installed before handing over the site to the original owners.

Source: JST based on Social Impact Assessment Study due to proposed land acquisition for University and Akashvani metro station project, District-Patna draft report

Table 16-15: Opinions Presented in the State Public Hearing: Jaganpura Sta., Ramakrishnanagar Sta., and Mithapur Viaduct Area (Report 4)

	Opinions	Responses
1.	The owner of the Kamla Utsav Hall informed us to consider an alternative alignment as the government land is available on the opposite side of the proposed alignment. The person (Mr. Sunil Kumar) who is running the Kamla Utsav Hall has invested Rs. 3 crore since 2016 to develop that Hall, however due to Covid lockdown situation he has	Due to site constraint, it is not feasible to move the Project site. All project affected businesses, households and families will be

	Opinions	Responses
	not recovered his investment yet and there will be huge loss to him as well as people dependent on the Hall for their livelihood. As there is no clarity on which portion from plot number 30 is to be acquired and since more than 50 families are residing in that plot and their livelihood depends on that plot in terms of business establishment, the landowner begged to consider alternative alignment.	compensated for their loss against the Land Acquisition Act, 2013.
2.	Most of the landowners have a small business and they put a lot of effort to develop their business which also provides a livelihood for other indirect stakeholders, (a list of indirect people may be impacted is provided in the appendix) hence they were against the current acquisition and begged to consider an alternative alignment at Mithapur Bypass under Bigrahapur Circle.	
3.	One landowner Madhuri Devi having small children depend on a shop near Mithapur Bypass was very much worried and pleaded to consider an alternative alignment from Bigrahapur Circle.	Impacts on individual household will be communicated soon separately, and every possible effort will be made to minimize your loss.
4.	A few owners of the plot were not living permanently and tenants are staying in the house on rent. One family belonging to Dineswar A. Pandey staying on the current land for more than 50 years and a few of his family members are engaged in some private jobs, they had a plan to build some commercial/residential structures on the existing vacate land falls under current acquisition. However, they didn't oppose the acquisition and informed that they will get benefit from this metro project in terms of easy transportation and new business opportunities will also be generated. During the discussion with landowners also revealed that they pay a good amount of tax to the municipality therefore they are expecting to get a good compensation package in terms of the valuation of their land	Compensation for the land as well as the investment made by the tenants will be made against the Land Acquisition Act, 2013.

Source: JST based on Social Impact Assessment (SIA) of land acquisition in Patna district for the construction of Jaganpura metro station, Mithapur metro station, and Ramkrishnanagar metro station.

Table 16-16: Opinions Presented in the State Public Hearing: Rukanpura Sta., Raja bazar Sta. and Patna Sta. Areas (Report 5)

	Opinions	Responses
1.	Ankit Sanaf, Puran Chandra Sarraf claimed that just they abolished their building to make a multistory mall for medicine. They are under debt of INR. 85,000,000 and running interest over it. They want appropriate compensation of four times of MVR. They also requested to shift the project on its adjacent plot.	Due to site constraint, shifting the Project facility is not feasible. Impacts on individual land plot will be communicated soon separately, and every possible effort will be made to minimize your loss.
2.	Dr. A Hai, at PARAS-HMRI Hospital, made a request to shift the proposed metro project site westward of Paras HMRI Hospital to the adjacent available government land. Being reputed hospital in Bihar, around 450,000 of Out Patient Department Patient are consulted and operated around 100,000 patients yearly. According to the physical verification and demarcation sign. Total front land of the PARAS HMARI is going to be acquired. Need serious attention in this regard.	The government has been informed about the concern about the hospital access; the PMCH station is located underground, and the station facilities are located so that the existing hospital access will not be affected.
3.	Rajesh Kumar, associated with Tirupati Auto (related with Plot 754, 752) claimed that once acquisition in present form will be completed, complete entrance of the workshop will be blocked. The acquisition may be structured in a way to assure their entrance (in/out) for commercial purposes. According to Digambar Kumar Verma, Amin related with Metro, reported that Plot 752 also be acquired but it was not mentioned in the list of affected land provided by the District Land Administration Office, Patna.	Impacts on individual land plot will be communicated soon separately, and every possible effort will be made to minimize your loss. All measures will be taken to minimize impact on existing businesses and commercial activities during the construction and operation stage.
4.	Binod Kumar Bhaturia, related with Khasra 87, 89 and 90, reported that the said land is under litigation with Government itself and amalgamated and matter is pending in Hon'ble Patna High Court, so they said that first Government should handover the land then, acquisition may be taken place accordingly.	The government has been informed about the litigation; the matter is to be solved in the acquisition process as suggested.
5.	Suryanarayan Yadav, related to Plot 763 and 765, said that land may not be acquired more than one (1) meter from Bailey Road, because there is already	Impacts on individual land plot will be communicated soon separately, and

	Opinions	Responses
	Septic Tank and sewerage system. So the present form of acquisition may be avoided.	every possible effort will be made to minimize your loss.
6.	Saurabh Narayan Singh said that due to proposed land acquisition there will be land lock situation and depreciate the values for remaining land. He may suffer huge economic and financial loss. He demanded revised MVR according to market situation at present value.	All these things will be deeply considered.

Source: JST based on Social Impact Assessment of Land Acquisition for Patna Metro, Patna.

Table 16-17: Opinions Presented in the State Public Hearing: PMCH Station Area (Report 6)

	Opinions	Responses
1.	Compensation for all the land acquired under the project should be at the market rate.	Compensation for the land as well as the investment made by the tenants will be made against the Land Acquisition Act, 2013.
2.	The PAP may be preferred for employment in Patna Metro.	The request will be considered as per Entitlement matrix and qualification.
3.	Land should be acquired at 50 meters away (west, Anjuman Islamia) or 1-15 meters east. If this is not possible, then other options may also be considered.	Due to site constraint, shifting the Project facility is not feasible. Impacts on individual land plot will be communicated soon separately, and every possible effort will be made to minimize your loss.
4.	To help people in business whose small shops are likely to be affected completely, to help them with the necessary land and capital for setting up the business.	Compensation will be made against the Land Acquisition Act, 2013 and the Entitlement Matrix.
5.	The classification of land should be met with a proper compensation in the context of present use.	Compensation for land will be made against the Land Acquisition Act, 2013.

Source: JST based on Social Impact Study, Draft Report of SIA Study of Proposed Patna Medical College Hospital Metro Station, Revenue Village-Muhhampur, District – Patna

17. Detailed Project Cost Estimates (N/A)

18. Transit Oriented Development (TOD) Plan

18.1 Overview of Existing Studies

National Transit Oriented Development (TOD) Policy issued by the Government of India provides guidelines for Land Value Capture (LVC) associated with transit projects. The area within walking distance (500m to 800m) from railways and stations will receive benefits such as value increases due to the development of public transportation, and is the target area for LVC. Then, within the area, by increasing the density and multi-purpose land use through additional floor area ratio (FAR), external development charges (EDC), land use changes, etc., The tax revenue generated by the project and the profit from the sale of land with high added value will be appropriated for project financial resources and operation and maintenance costs.

In PMRCL, by applying the above methods, revenue is estimated in DPR by treating LVC as an item of TOD income (Table 18-1). It is proposed that 35% of yearly projected revenue collection from LVC will accrue to Patna Metro.

What Japanese private railway companies refer to as TOD revenue is a property development revenue in PMRCL.

Table 18-1: Estimated Revenue from TOD (In Rs.Crore)

Items	Total Revenue			
	202-25	2031-32	2041-42	2051-52
Premium on Additional FAR	60.2	84.8	138.1	224.9
External Development Charges	90.4	127.2	207.1	337.4
Change in Land use	42.2	59.3	96.7	157.4
Total	192.8	271.3	441.8	719.7

Source: DPR Table 0.26

National TOD Policy issued by the Government of India provides examples of Land Value Capture (LVC) methods. Each state and major city has established its own TOD policies based on this and is promoting public transportation projects.

JICA Study Team conducted the detailed project Report (DPR) analysis, field surveys, and interviews with PMRCL for the property development around the corridors (Tables 18-2, 18- 3, Figures 18-1, 18-2).

Table 18-2: Development Status around Metro Stations (Corridor 1)

No.	Station Name	DevelopmentStatus
1	Danapur	<ul style="list-style-type: none"> Many military facilities and lodgings are located.
2	Saguna Mor	<ul style="list-style-type: none"> This area is one of the candidate for property development.
3	R.P.S. Mor	<ul style="list-style-type: none"> Many real estate development are on-going. The condo, apartment around this area is targeted for people categorized upper-middle class. Average wage of upper-middle class is over 150,000 Rs./month. Local markets and auto rickshaws are gathering around the site of planned Saguna More Sta., where is the transport hub.
4	Patliputra	
5	Rukanpura	<ul style="list-style-type: none"> Residential area PMRCL has a plan to acquire land adjacent to the station (approx. 1,400 spm) and develop for the business.
6	Raja Bazar	<ul style="list-style-type: none"> Large hospital is located in the front of the planned station site. Residential area for people categorized middle class. Average wage of middle class is around 50,000 - 60,000 Rs/month.

No.	Station Name	DevelopmentStatus
		<ul style="list-style-type: none"> Enter the underground section from this area.
7	Patna Zoo	<ul style="list-style-type: none"> Planned station site is located in the front of Patna Zoo. There are government officials' residences, and facilities. Orderly area
8	Vikas Bhawan	<ul style="list-style-type: none"> Many government offices are located around the stations.
9	Vidyut Bhawan	
10	Patna Junction	<ul style="list-style-type: none"> Re-development of the station square in front of Patna Junction Sta. is planned. PMRCL has a plan to a land adjust to the station. But the budget and business plans are not confirmed yet.
11	Mithapur	<ul style="list-style-type: none"> Ex-Bus terminal is located in the front of the station. Patna City plans to invite a school there.
12	Ramkrishna Nagar	<ul style="list-style-type: none"> Newly developed residential area.
13	Jaganpura	<ul style="list-style-type: none"> Unauthorized local fish market is located
14	Khemni Chak	<ul style="list-style-type: none"> Common station for Corridor 1 and 2

Source: JST



(2) Rickshaws are gathering

(3) Property development near metro lines

(6) Parking spaces under viaduct

(11) Ex-Bus terminal

Source: JST

Figure 18-1: Survey of TOD around Stations (Corridor 1)

Table 18-3: Development Status along Metro Stations (Corridor 2)

No.	Station	Development Plan/Status
1	Patna Junction	<ul style="list-style-type: none"> • Common station for Corridor 1 and 2 • Connecting station to Patna Junction Station of Indian Railways
2	Akashuvani	<ul style="list-style-type: none"> • Commercial area of Patna city. Shopping malls are located around the station
3	Gandhi Maidan	<ul style="list-style-type: none"> • Planned station site is located in the front of park • Vendors and Rickshaw are gathering for people coming to the park
4	PMCH	<ul style="list-style-type: none"> • Residences and commercial area
5	University	<ul style="list-style-type: none"> • Several universities and schools are located • This area is center of old city
6	Moin Ul Haq	<ul style="list-style-type: none"> • Planned station site is in the front of the public stadium. • Renovation of stadium is planned, and the tender has been done.
7	Rajendra Nagar	<ul style="list-style-type: none"> • Connecting to the station of Indian Railways
8	Malahi Pakri	<ul style="list-style-type: none"> • Parking lots are planned at public site (1,250 sqm) • Residential area. It is seemed that local residents are against the project. • Construction is on-ongoing in the middle of a narrow road, where surrounded by local residents. The atmosphere is bad. Construction in the middle of a narrow road
9	Khemni Chak	<ul style="list-style-type: none"> • The construction is on-going along the large road.
10	Bhootnath	
11	Zero Mile	<ul style="list-style-type: none"> • Residential area along the large road
12	New ISBT	<ul style="list-style-type: none"> • New bus terminal is under construction. • Parking lots are planned at private site (8,229.37 sqm) • PMRCL plans to acquire a land (11.3 Ha) adjacent to the depot and develop real estate, and is discussing funding and business plans with private developers.

Source: DPR and JST



Source: JST

Figure 18-2: Survey of TOD around Stations (Corridor 2)

18.2 Reviews of Existing Studies and Proposals for Improvement

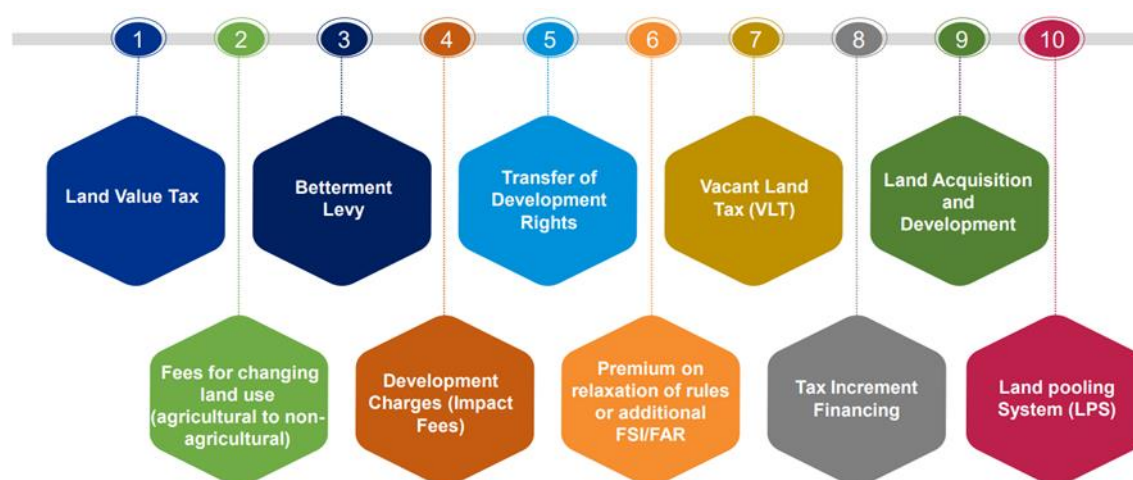
PMRCL plans that 35% of yearly projected revenue collection from LVC. PMRCL should plan a concrete introduction scheme.

In Japan, the word of TOD is used in a broad sense, such as retails in station area, property development

of railway companies for non-fare box revenue, transit oriented development for public transport friendly city, and development of station square as a transit hub. However, PMRCL classifies the revenue from the land value capture (LVC), which is the scheme to apply the profits such as land price increases along the metro corridors due to the project to the construction or O&M expenditure, as TOD revenue on account, and revenue from the property development is classified as property development revenue on account.

The national TOD policy issued in 2015 by the Government of India has introduced the various methods of Land Value Capture (LVC) in Inada and overseas (Figure 18-3). The introduction LVC is a method that has been attracting attention in recent years as one of the means of generating financing for the development of large public projects (Table18-4)

There are divided into two major LVC methods: (1) those based on taxes and fees (land/property taxes, beneficiary fees, etc.) and (2) those based on development (sales/leasing of government-owned properties, etc.). Each method is not new, but it is characterized that it is summarized under one concept as a method of financing for public works projects.



Source; Ministry of Housing and Urban Affairs, the Government of India

Figure 18-3: Methods of Land Value Capture (LVC) applied to metro projects

Table 18-4: Examples of Land Value Capture (LVC)

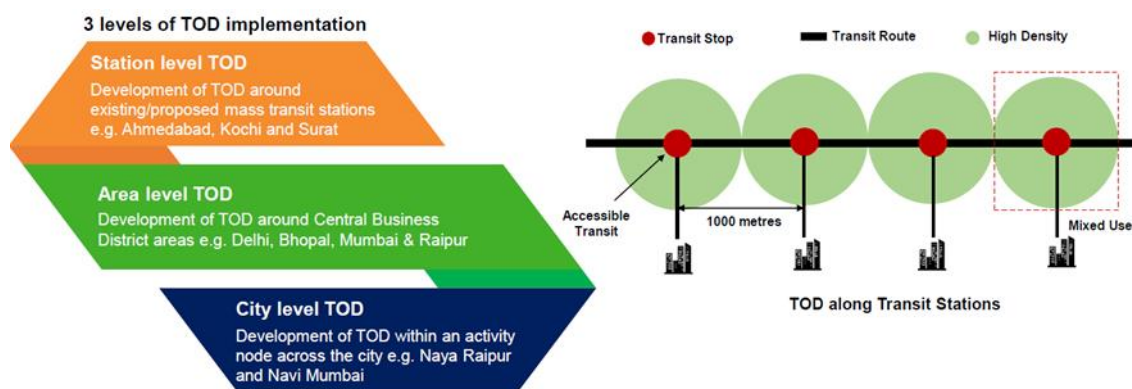
No.	City (Country)	Scheme
1	Delhi, India	<ul style="list-style-type: none"> -LVC is applied to the development along railway lines by the initiative of the Government of India. -Delhi Metro received the land transfers from several government agencies, and sells or leases development rights for supplementing the revenue.
2	Hyderabad, India	<ul style="list-style-type: none"> -Public Private Partnership (PPP) scheme is applied for Hyderabad metro -The successful bidder is given the rights to operate the metro and to develop properties along the lines. - The city has set a 300 m width along the lines as a TOD area. Property development project such as offices, residences, and the stations integrated with commercial facilities are progressing.
3	Kochi Metro	<ul style="list-style-type: none"> • Kochi Metro has agreed to receive the transfer of the city-owned land before the extension of Phase 2, and is in the process of transferring. On the transferred land, Kochi Metro plans to build a high-quality residential complex (Metro City Project) targeting the middle class families, and to apply the revenue from the project to O&M expenses. Kochi Metro plans to raise Rs. 10 Lak funding.
4	Pune Metro	<ul style="list-style-type: none"> • Maha Metro, the operator of Pune Metro plans to build a commercial building at Swargate Sta., which will be leased by the city for the non-fare box revenue. Maha metro plans to build a shopping complex there. The city increased the floor area ration (FAR) for the

No.	City (Country)	Scheme
		project. The city has decided to take 50 % of the profits from the business and use it to cover the cost of the metro project.
5	Hong Kong, China	<ul style="list-style-type: none"> • Hong Kong government owns all land in the territory. • The government exclusively grants Hong Kong MTR the rights to develop the land above and around the new stations at a low price, assuming that the stations does not exist. • Hong Kong MTR develops, sells, leases the land based on the market value assuming that the new line exists. • Income from this business will be used to supplement project costs, O&M expenditure.
6	Nanchang, China	<ul style="list-style-type: none"> • Regional municipalities have a responsibility for city-level land use planning and regional infrastructure services in China. • Nanchang city established a railway company, Nanchang Railway Transit Group (NRTG). • The city acquired the land development rights and lease rights after the release of the city master plan and land use plan. • The city raised the FAR (upper limit of floor area ratio) of the acquired land properties. • NRTG invest the properties directly, sells development rights to the private sectors etc. • The city and NRTG sell the owned properties through auction or lease them after metro starting operation, and compensate the income to the project and O&M expenditures
7	Sao Paulo, Brazil	<ul style="list-style-type: none"> • The city owns little properties available for development. • The city sets the basic floor area ration (FAR) at 100 – 299 %. The city securitize the air rights using FAR transfer scheme. And the air rights are traded on the Sao Paulo Stock Exchange. • If the developer build in excess of FAR of the property, the developer should buy a securitized certification for the additional FAR. • The securities are traded on the Sao Paulo Stock Exchange. The income become the urban development fund (Fundo de Desenvolvimento Urbano) of the city, and is used as financial resources for the project of metro and monorails etc.
8	Portland, USA	<ul style="list-style-type: none"> • As a project financial resource for the urban railway of Metropolitan Area Express (MAX) extension work, the city applied the tax increment financing method which is raised directly or as collateral to issue bonds to procure infrastructure investment funds.
9	Washington D.C, USA	<ul style="list-style-type: none"> • Washington Metropolitan Area Transportation Authority (WMATA) applied joint development program which is a scheme to develop properties together with private sectors and landowners. • The private sectors and landowners are provided the development rights for construct residential or commercial buildings above or in the public owned land, instead of offering air rights, land leasing, connection fee to stations, and operation cost.
10	London, UK	<ul style="list-style-type: none"> • The City of London will invest more than £55,000 in non-residential facilities in the City of London area to finance the Cross Rail project (£14.8bn), a 118km rail link between Heathrow Airport and the West End of the city center. Taxed at 2 pence per pound. • For this project, 40% of the funds will be procured from LVC

Source; JTTRI, Case study of LVC of the world biggest cities, JST

At the time of the JICA Team's survey, PMRCL has a plan to acquire and develop privately owned property adjacent to ICTB depot. In addition, PMRCL has similar plans for property development at Rukanpura Sta. and Patna Junction Sta. However, the financing and development plans have not been decided yet.

On the other hand, there are many possibilities for transit-oriented development for the city planning rather than commercial purposes. The National TOD policy clarifies TOD into (1) development at the station level, (2) development at the area level centring on the station, and (3) urban development at the city level (Figure 18-4).



Source; Source; Ministry of Housing and Urban Affairs, the Government of India

Figure 18-4: Categorization of TOD in National TOD Policy

Regarding the development of (1) station level and (2) station area, the redevelopment of the station square of Patna Junction Station, which is a transportation hub between the Indian Railways and the Patna Metro, and the redevelopment of the city center by relocating universities and schools to the suburbs, and supply of high-quality housing for middle- and low-income people in cooperation with the private sector or housing supply public corporations, etc. for the city level development (3) can be considered.

18.3 TOD in Japan

In Japan, a word of TOD is used in a broad sense, such as retail business in stations, urban development along rail lines, transit oriented development, and development of a station square as a transportation hub.

Since PMRCL is a public authority, there are limits to the business development of retails in stations and property development as a profitable business. On the other hand, in terms of urban development along the corridors and redevelopment of station square, collaboration with Patna city and other relevant authorities, there are great potential for the development. Patna city can be developed as a public transport friendly city with the metro as a core of public transportation. As a result, the increase of metro passengers can be expected, and which will lead to an increase of non-fare box revenue as well.

From the field survey of JICA Team, PMRCL can refer the Japanese experiences in promoting both railway construction and housing development during population growth period and the Tsukuba Express (TX) in recent years. For the TX project, the special law was enacted for the railway construction and housing development efficiently at the same time.

During Japan's high-economic growth period from the 1960s, the problem of housing shortages arose due to the concentration of the population in urban areas. For this reason, the government developed large-scale housing complexes in the suburbs to supply a large amount of housing, and also enacted legislation to integrate railway development and development along railway lines.

The Act on Special Measures Concerning the Integrated Promotion of Housing Land Development and Railway Development in Large Urban Areas (Act on Special Measures concerning Comprehensive Advancement of Housing Development) aims to promote railway projects by integrally carrying out urban development along railway corridors and integrated railway development. It is a law aimed at the development of residential land along the railway line and the supply of a large amount of housing, and the development of the Tsukuba Express (TX) was the first project to be applied. As a method of development, the housing supply area including the planned construction site of the station will be designated as a priority area, and public facilities such as roads and parks, residential areas, commercial areas, etc. will be designated in the city planning. Then, the land acquired in advance by the railway company or public authorities will be replaced with the land in the priority area. It will be possible to

supply a large amount of residential land and housing, and at the same time, it will be possible to contribute to an increase in the number of railway passengers.



Source; Ibaraki pref.

Figure 18-5: Kenkyu-gakuen Sta. of TX, before (2002) and after (2014)

In recent years, the method of land value capture (LVC) has been considered as one of the financial resources for rail projects in Japan, and is going to be applied to public and private projects (Table 18-5).

LVC is applied to the railway construction, but there is no case of it being applied to the O&M expenditure of railways.

Table 18-5: Examples of Land Value Capture (LVC) in Japan

No.	Method	Scheme	Example
1	Air rights	Buying and selling development rights that exceed the floor area ratio (FAR) to finance public works projects	<ul style="list-style-type: none"> Reconstruction of Tokyo Sta. building
2	Land readjustment	Landlords donate part of their own land, jointly develop the area, and allocate part of the generated funds and land to public works.	<ul style="list-style-type: none"> Tokyu Den-en-toshi Line Tsukuba Express line development project
3	Building an urban redevelopment scheme	Landowners and developers form joint ventures to aggregate fragmented land and create roads and public spaces. Municipalities amend redevelopment land use regulations, such as raising the maximum floor area ratio (FAR) or funding to the project	<ul style="list-style-type: none"> Redevelopment of Shiodome area Redevelopment of Tranomon area

Source; JTTRI, Case study of LVC of the world biggest cities

18.4 Recommendation from JST

JICA Study Team summarizes the current issues and possibilities of PMRCL's TOD as follows.

- Patna city has a plan to redevelop the station square in front of the Patna Junction Station of the Indian Railways which connects to the metro station. By developing this square together with the metro project, the opening effect of the Patna Metro can be greatly enhanced, and leading to the promotion of public transportation users.

- PMRCL plans to acquire lands for property development business at Rukanpura Sta., Patna Junction Sta. and ISBT depot Sta. These property development should consider not only for the revenue but also the increase of the passengers. Furthermore, since PMRCL is a public authority, it is important to match the development plan with the city development plan.

Based on the above considerations, JICA Study Team propose the services applied technical assistance and consulting scheme of JICA as follows. (Table18-6).

Table 18-6: Proposal of services to be implemented in this project (TOD)

No.	Program and contents
1	<p>Capacity development for TOD (transit oriented development for city planning along metro corridors)</p> <p>(1) Reasons for proposal Land planning work along metro corridors is outside the business of PMRCL. However, as a public utility company, it is important to work with the city of Patna to promote a transit-oriented city. By cooperating with the city planning of Patna City, PMRCL will be able to formulate more accurate future operation plan and non-fare box business. The proposal is targeted at staff of PMRCL and Patna City, and the government officials.</p> <p>(2) Contents</p> <ul style="list-style-type: none"> • Development of staff for TOD (not real estate development business of PMRCL) • Training in Japan (housing land development projects with public authorities, public-private cooperation business for housing supplying and land development, consensus building among stakeholders, Act on Special Measures concerning Comprehensive Advancement of Housing Development, case study of land value capture (LVC) , site visits, etc.) <p>(3) Effects</p> <ul style="list-style-type: none"> • Capacity development of staff of PMRCL and TOD-related organizations such as Patna City • PMRCL will be able to proceed with TOD projects together with public authorities, Transit-oriented urban development can be realized in Patna City.
2	<p>Redevelopment of the station square of Patna Junction Station, which is connecting to Indian Railways</p> <p>(1) Reasons for proposal Redevelopment of station area for some Patna Metro stations are already included in the project. However, the square in front of Patna Junction station is bigger than other stations. The station square of Patna Junction Station has been planned for redevelopment. However, at the time of the JICA study team's survey, financing resources and a specific redevelopment plan had not been planned. In conjunction with the Patna Metro project, the redevelopment of the station square of Patna Junction station is expected to increase the opening effect of Patna Metro.</p> <p>(2) Contents</p> <ul style="list-style-type: none"> • Support for financing planning, formulating a redevelopment plan (separation of pedestrians, cars and rickshaws ,securing passengers space, securing parking spaces for buses/rickshaws, securing boarding and alighting spaces, arrangement of traffic rules and access roads around the station, installation of EV charging facilities, installation of security cameras and eco-friendly toilets, etc.) • Support for consensus building among stakeholders (Patna City, Indian Railways, residents, etc.) • Support for bidding, construction management, etc. <p>(3) Effects</p> <ul style="list-style-type: none"> • The redevelopment of the square in front of Patna Junction Station will be realized. • The square in front of Patna Junction Station will be redeveloped as the face of Patna City. • PMRCL can learn how to coordinate and proceed the project and build consensus among stakeholders.

Source; JST

19. Digital Transformation (DX)

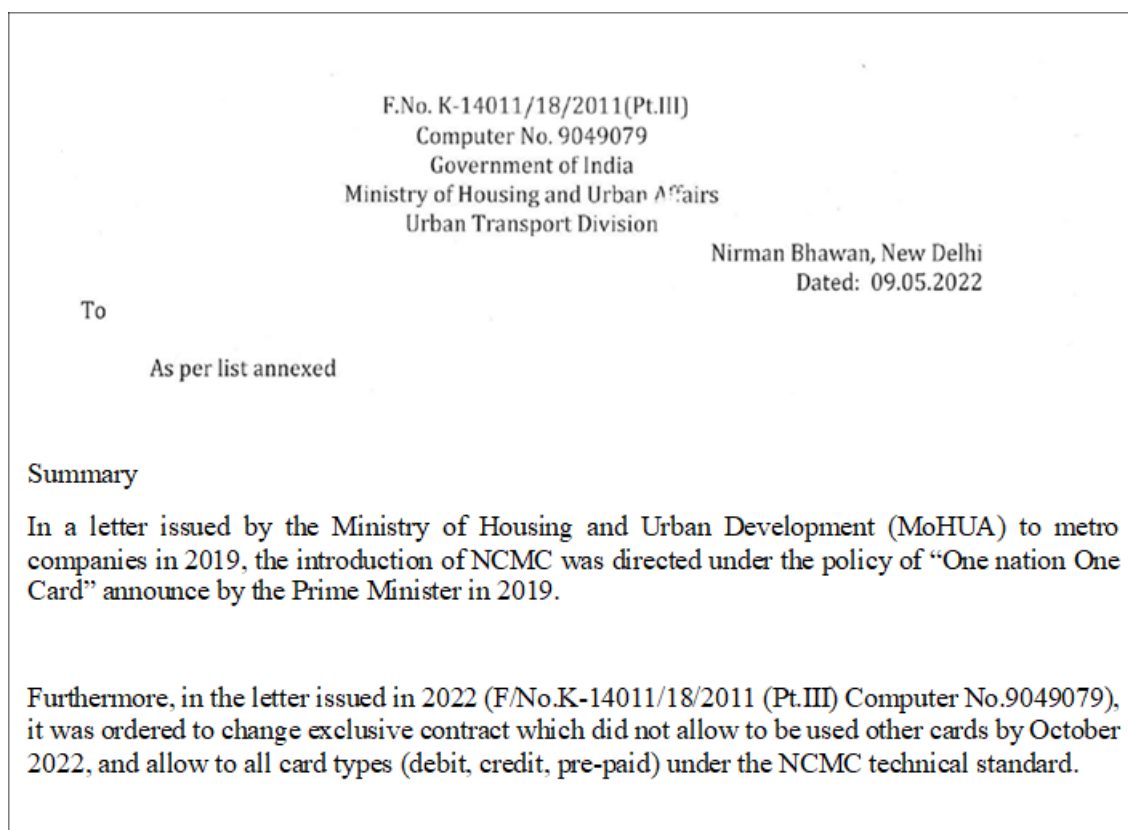
19.1 Overview of Existing Studies

19.1.1 AFC System

According to the survey by the JICA Study Team, PMRCL plans to apply the Public Private Partnership (PPP) scheme to the procurement of the AFC (Automated Fare Collection) system, and introduce the National Common Mobility Card (NCMC) and QR (Quick Response), which have been developed and recommended for introduction by the Government of India. (Figure 19-1). PMRCL is considering integrating this ticketing system with the other public transportation systems such as Patna city buses and Indian Railways. In addition, the bank that issues the NCMC will handle the settlement of charges between transport companies. PMRCL has no plan to set up its own clearinghouse.

Under the policy of One Nation One Card, the Government of India is promoting the development and introduction of the National Common Mobility Card (NCMC) as a smart card which can be used commonly in public transportation throughout the country. The project is in charge of national Payments Corporation (NPCI), a non-profit organization which was established by Reserve Bank of India and Indian Bankers Association in 2008, under the initiative of the Ministry of Housing and Urban Affairs (MoHUA). NPCI has established the National Automated Clearing House (NACH) as an institution for clearing charges between operators.

This NCMC is a technology developed in India under the national policy of Make in India. It is a contact or contactless smart card which can be used not only for public transportation, but also for highway toll payments, retail stores and ATMs due to its e-commerce functionality. NCMCs are issued by banks and can also be integrated with debit and credit card functions.

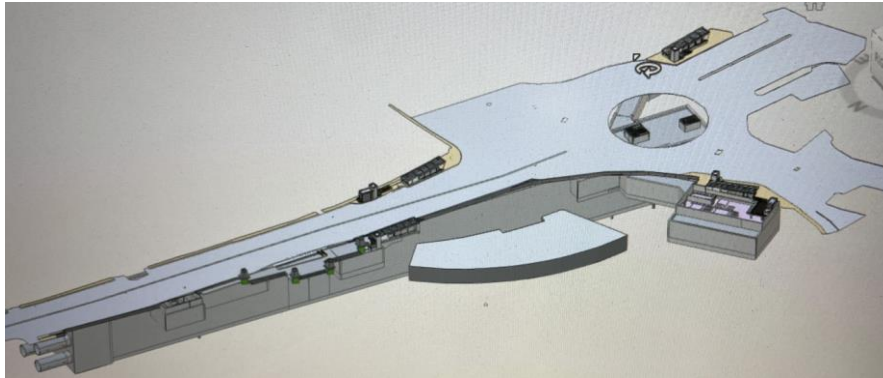


Source; PMRCL

Figure 19-1: Letter issued by the Ministry of Housing and Urban Affairs (MoHUA)

19.1.2 Building Information Modelling (BIM)

PMRCL have developed 3D models for all stations structure by using Revit 2021 and 2D drawings can be extracted from the 3D model. BIM will be utilized for further detailed design, construction and project monitoring by contractors. System for tracking and monitoring project will be introduced, in which 3D models are linked with detailed work programme prepared by the contractor in Primavera P6.



Source: PMRCL/DMRC

Figure 19-2: BIM Model for PMRCL's Basic Design

Technical specifications and DMRC guideline contain detailed requirements for utilizing BIM during design and construction phase.

PMRCL prepared technical specification of BIM and civil contractors will utilize and update the prepared BIM models. The technical specification shall include the following scopes:

For instance civil contractors' design works including all station structure as well as tunnel/viaduct and proof checking are assumed to be done using BIM modeling and contractors will be requested to produce, update and present to the engineer on a fortnightly basis an integrated 3D BIM model incorporating track, topography, architecture, structure, plumbing and all other building services. The model will be utilized in design visualization and clash detection of elements as well as finalization of design works.

During execution of works, PMRCL will introduce a software package, implementing & maintaining an Integrated Project Monitoring Software (IPMS) which is going to be a cloud-based solution. All the project design drawings in 2D CAD & 3D BIM models will be prepared by contractors and stored in Autodesk's BIM 360 Design. Contractors are supposed to submit their construction & erection programmes in Primavera P6 and IPMS shall integrate 3D BIM models stored in BIM 360 Design and Primavera P6 programmes with project progress data being picked up from field using iPad/ Smart phone. Progress monitoring & control shall happen thru outputs depicted 4D BIM and in structured dashboards made available on cloud at different levels of DMRC hierarchy for construction management decision support.

The technical specification shall also include training for PMRCL and contractors shall provide appropriate training for PMRCL staff to enable them to make proper use of software.

19.2 Reviews of Existing Studies and Proposals for Improvement

19.2.1 Smart card in India

The government of India has developed and is promoting the introduction of the National Common Mobility Card (NCMC) as a smart card that can be used commonly in public transportations through the country. The ministry of housing and urban affairs (MoHUA) has an initiative for this project. PMRCL also has a plan to introduce this smart card.

NCMC is a contact or contactless smart card which can be available not only on public transport but also for highway toll payments, retail stores and ATMs with e-commerce functions. NCMCs can be issued by banks and be also integrated with debit and credit card functions.

As a clearing house, the banks which issued NCMCs will process the procedure for settlement of fares between operators.

In recent years, metro companies in India have been preparing the introduction under the initiative of the Government of India for promoting this card (Table 19-1).

Table 19-1: NCMC introduction status in metro companies

No.	City	Operator	Available Line	Status of introduction
1	Ahmedabad	Ahmedabad Metro	All lines	March 2019
2	Chennai	Chennai Metro	All lines	February 2022
3	Delhi	Delhi Metro	Airport line	December 2020
4	Hyderabad	Hyderabad Metro	N/A	Planned
5	Jaipur	Jaipur Metro	N/A	Planned (Tender was conducted)
6	Bengaluru	Namma Metro	All lines	October 2021
7	Kanpur	Kanpur Metro	N/A	Planned (Tender was conducted)
8	Kochi	Kochi Metro	N/A	Planned
9	Kolkata	Kolkata Metro	N/A	Planned (Tender was conducted)
10	Lucknow	Lucknow Metro	N/A	Planned (Tender was conducted)
11	Mumbai	Mumbai Metro	N/A	March 2023
12	Nagpur	Nagpur Metro	All lines	Introduced
13	Noida	Noida Metro	Aqua line	Planning
14	Pune	Pune Metro	N/A	May 2022

Source; JST

PMRCL is planning to procure the AFC systems through Public Private Partnership (PPP) scheme. If the PPP scheme is applied for the procurement, the success bidder will be granted for the following rights in exchange for bearing the costs of system installation and O&M for a certain period time widely.

- Exclusive card issuance rights
- Exclusive rights to accept other cards
- Royalty payment from a bank
- Commissions from fare box revenue
- Provision of installation space for ATM/Kiosks, advertisement etc. from the metro company
- Provision of additional services from a bank or operator according to the terms of the contract.

Table 19-2 summarizes the condition when the PPP scheme is applied to the procurement of AFC in metro companies in India. Successful bidders will receive a commission of 4 % of the fare box revenue, as well as rights such as advertising and ATM installation. Royalty income is what is paid at the time of contract, and so-called compensation. It can be said that the smallest the amount, the higher the business feasibility.

Table 19-2: Terms of tenders for AFC applied PPP scheme for metros in India


No.	Operator	royalty income	Exclusive issuance rights	Commission from fare box revenue	Maintenance/support period	Others
1	Kanpur Metro	Rs. 12 Cr	Full contract period	4%	N/A	<ul style="list-style-type: none"> Advertisement rights on ticket vending machines, ticketing gates and QR tickets Naming rights for 2 stations ATM installation space at 10 stations.
2	Kochi Metro	Rs.208.8 Cr	Full contract period	4%	<ul style="list-style-type: none"> Hardware: 6 years, Softwares:10 years 	N/A
3	Noida Metro	Rs. 42 Cr	10 years	4%	<ul style="list-style-type: none"> Hardware/Software: 10 years Employee-leasing for support stations/OCC(AFC): 7 years 	<ul style="list-style-type: none"> 100 sqm. space for advertisement at each station
4	Nagpur Metro	Rs. 30 Cr	Full contract period	4%	<ul style="list-style-type: none"> Hardware: Defect warranty 2 years+4 years Software: Full contract period 	N/A
5	Pune Metro	Rs. 45 Cr	3 years	4%	<ul style="list-style-type: none"> Hardware: Defect warranty 10 years + spare parts 	<ul style="list-style-type: none"> 3,000 sqm. space for advertisement at stations


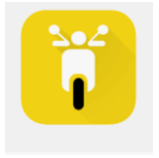


Source; PMRCL

19.2.2 DX, MaaS in India

Many startups provide various services for last-one-mile mobility such as public transportation reservations using mobile apps in India. Many people in Patna city use these services for a reservation and buying a ticket of Indian Railways and booking a rickshaw as well (Table 19-3).

Table 19-3: Transportation apps widely used in Patna

No.	App	Contents
1	 OLA	<p>This app is provided by the company whose headquarter in Bangalore, and offers rideshare reservation for cars and bikes. Softbank, a Japanese firm has a stake in this company. This company has business not in India, but also in Australia, New Zealand and UK. In recent years, it has also developed mobile payment services and microfinance business.</p>

No.	App	Contents
2	 UBER	<p>This app comes from USA, and offers rideshare reservation services. This app connect the drivers who are registered with Uber and costumer. In addition to on-demand mobility reservation, it has developed various delivery services in more than 100 countries. In India, Uber started a business in 2013. In Patna, it started a business in 2019.Its services can be available in more than 100 cities in India. Softbank, a Japanese firm has a stake in this company.</p>
3	 Rapido	<p>This app offers a service for booking on-demand mobility. This app connects customers and bike riders registered on this app. The company was established in Bangalore in 2015. In recent years, it has expanded a delivery service with collaboration with e-commerce. Its services can be available in more than 100 cities, including Patna, in India.</p>
4	 IRCTC	<p>This app is developed by Indian Railways. The service has launched in 2022. The long-distance train of Indian Railways can be reserved by this app. The ticket will be delivered on the app. If a printed out ticket is required, the customer can issue a paper ticket at an automatic ticket vending machine or at a ticket window at stations.</p>
5	 UTS	<p>This app is provided by Indian Railways, and launched a service in 2014. Single tickets, commuter passed of suburban trains within 200 km which do not require a seat can be reserved on app. The ticket will be delivered to the mobile as a QR code ticket. If a printed out ticket is required, the customer can issue a paper ticket at an automatic ticket vending machines or at a ticket window at stations.</p>

Source; JST

In India, many MaaS (Mobility as a Service) -related startups are developing motilities which can be called “the last one mile” from train stations. Also, due to the EV shift policy of the Government of India, E-buses, E-bikes, E-rickshaws, etc. are becoming popular.

The National Capital Region (NCR) Delhi plans to increase the number of e-buses by 50% by 2023 and accelerate the installation of EV charging stations. In addition to installing EV charging stations every 3km, there are also plans to install them at Delhi Metro stations (Figure 19-3). A similar project is also planned for Bengaluru Metro.



Source: ZEE NEWS

Figure 19-3: Installation of EV charging station at Delhi Metro station

The state of Bihar is also promoting the introduction of E-rickshaws, installing EV charging stations along highways, commercial facilities, and residential areas every 50km, and preparing subsidies for the purchase of EV mobility and infrastructure construction.

19.2.3 Japanese start-up in India

Terra Motors Co., Ltd., (Terra Motors) established in 2010, manufactures and sells EV mobility in India and Southeast Asia. In India, it has a business to sell EV rickshaws to low-income earners using micro financing scheme, helping to improve their lives. Terra Motors is considering not only the manufacture and sale of EV mobility, but also the development of infrastructure for EV charging facilities to spread EV mobility, and the development of new businesses that combine DX with EV mobility. Terra Motors already has a business in Patna (Figure 19-4).



Source: JST

Figure 19-4: Installing EV charging facilities at Delhi Metro stations E-Rickshaw and Japanese startup in Patna

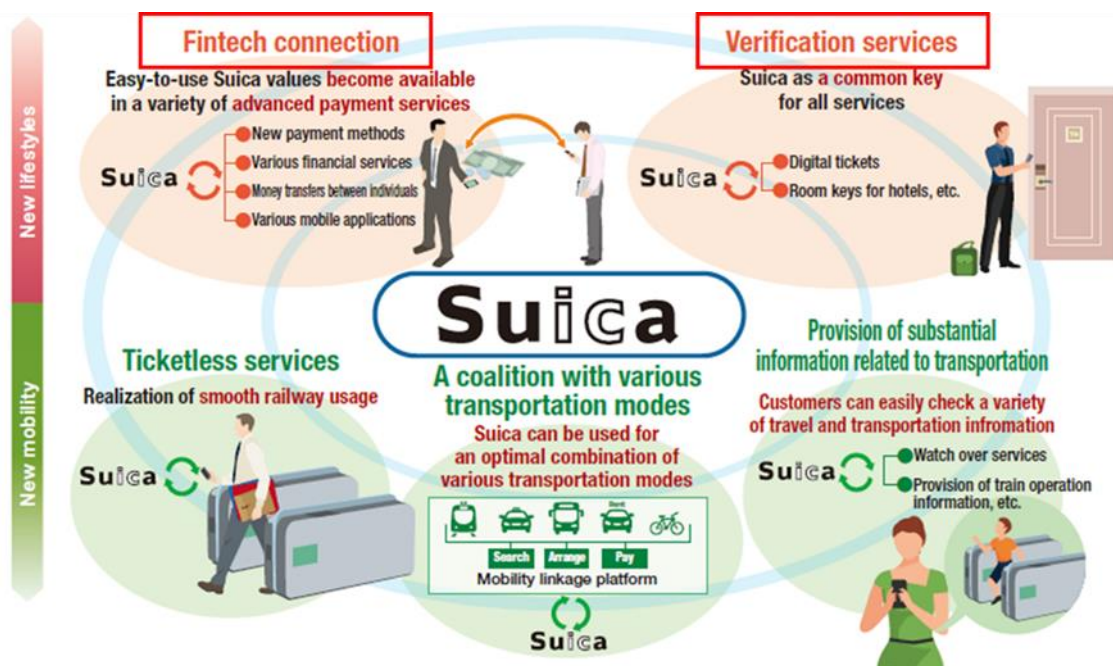
19.2.4 Cases in Japan

India has many DX (Digital Transformation) and MaaS (Mobility as a Service) startups. And even in Patna, services such as public transport ticket purchases and ride-sharing services using smartphones are widespread. In the future, Patna Metro will become the axis of public transportation, and in order to promote the use of public transportation, it is necessary for PMRCL to contribute to the promotion of DX and MaaS in public transportation, and to work on improving the business environment together with this metro project. In addition, PMRCL will also need to work to improve passenger services and promote efficient O&M by utilizing DX.

Japanese railway companies are providing new services and improving O&M that utilize DX and MaaS. These examples of DX and MaaS utilization will be of great reference for PMRCL.

(1) Expansion of services using smart cards

East Japan Railway Company (JR East) is deploying new services that utilize the functions of the smart card, SUICA (Super Urban Intelligent Card). SUICA has developed new services such as installing SUICA functions on smartphones, digital tickets and room keys for hotels using the authentication function, etc. (Figure 19-5).

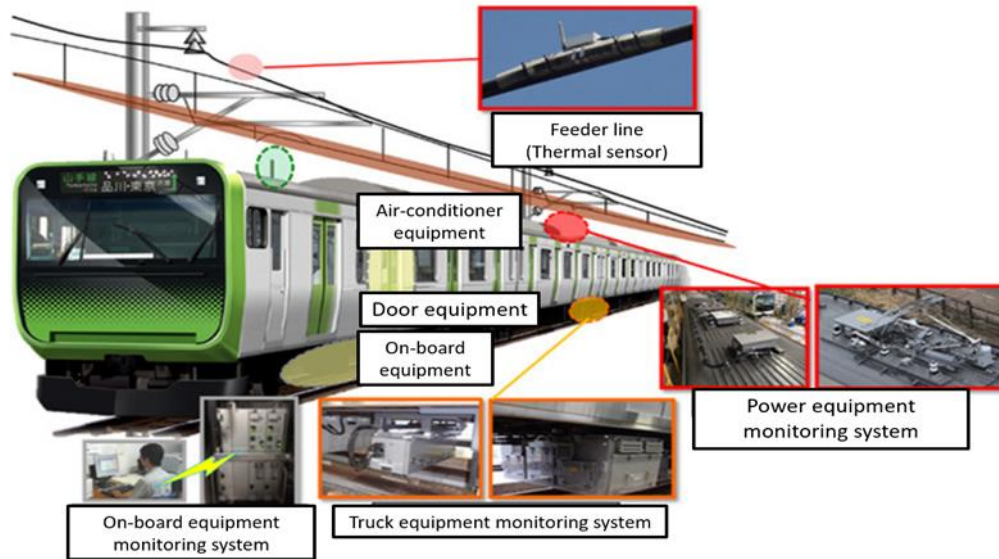


Source: JR East web.

Figure 19-5: Functions of SUICA

(2) DX for maintenance

The idea of maintenance so far has been based on time-based maintenance, which maintenance is conducted periodically regardless of the conditions. However, with the development of DX technology, by constantly monitoring the equipment conditions of the rolling stock and facilities while driving, the big data obtained from the rolling stock can be used and analysed to automatically check functions, ascertain the deterioration and service life of equipment, and identify failures. The idea of using big data is called condition-based maintenance (CBM). The maintenance based on CBM is being developed an introduced for improving safety, conducting efficient equipment maintenance, and a reduction in maintenance costs (Figure 19-6).



Source: JR East HP

Figure 19-6: Ground and vehicle facilities monitoring by commercial trains

(3) Digital Twin

Advances in IoT sensor and 5G technologies have made it possible to collect various data in real time. A technology called Digital Twin that reflects real-time information has been developed. Digital Twin is being developed for constructing infrastructure models in cyberspace like a twin and reflects real-time data.

By constructing a digital twin, it will be possible to perform various simulations in cyberspace and use it for efficient infrastructure maintenance management and urban planning. Railway companies are also making efforts to unify information and improve works by building a 3D infrastructure model in cyberspace and creating a database together with maintenance information (Figure 19-7).



Source: Ministry of Land, Infrastructure and Transport (MLIT), Transportation Data Platform

Figure 19-7: Example of Digital Twin

(4) On-demand bus

Osaka Metro provides an on-demand bus service to provide access to stations for the elderly and other people with limited mobility (Figure 19-8). An on-demand bus does not have a timetable or a fixed route. Users can reserve boarding, alighting locations, and the date and time by smartphone or phone call. Based on that reservation, AI (Artificial Intelligence) automatically creates the optimal route, enabling services to be provided on an efficient route. Users also have the advantage of being able to easily make a reservation, as well as being able to always sit down.

The introduction of on-demand bus is spreading as a means of the last-one mile mobility in suburban areas where route buss services are not feasible for the business.



Source; Osaka Metro

Figure 19-8: On-demand bus

(5) Real-time congestion rate information on smartphone

In order to provide more comfortable station and train services, JR East provides real-time information on train service cancellations and delays, as well as the congestion status in trains and the congestion status of some stations by mobile app. Passengers can avoid crowded cars when boarding, leading to alleviation of congestion and shortening of boarding and alighting times (Figure19-9).



Source; JR East

Figure 19-9: Real time congestion information (JR East App)

(6) Digital Signage

The introduction of digital signage using electronic screens is widespread in Japan. By introducing digital signage, it is possible to display multiple advertisements instead of simply renting the place as an advertising space, which is expected to increase sales.



Source, JR East

Figure 19-10: Digital Signage

19.3 Recommendation from JST

JICA Survey Team summarizes the current issues and possibilities of DX for PMRCLDX as follows.

- It is important to introduce DX technologies to realize efficient O&M and non-fare box business.
- PMRCL has a plan to introduce NCMC (National Common Mobility Card) and QR code type tickets which are developed and recommended by the Government of India, and is considering applying the PPP scheme for the procurement of AFC system. Therefore, it might be difficult for PMRCL to develop its own services using smart cards.
- Patna Metro will become the axis of public transportation, and in order to promote the use of public transportation, it is necessary to contribute to the promotion of DX and MaaS in public transportation
- In India, the government is leading the shift to EVs for mobility. In addition, along with the metro projects, many MaaS-related startups that provide last-mile mobility are developing services.

Based on the above considerations, JICA Survey Team would like to propose the business trials using JICA scheme as follows. (Table19-4).

Table 19-4: Proposal of services to be implemented in this project (DX)

No.	Program and contents
1	<p>Installation of EV charging facilities at metro stations and business trial for commercialization of selling solar power electricity</p> <p>(1) Reasons for proposal Currently, the Government of India is promoting the shift to EV motilities, and Delhi Metro and Bengaluru Metro are planning to install EV charging facilities at stations. Efforts to shift to EV are also underway in the state of Bihar. PMRCL plans to install solar panels on the roof of the station. However, for efficient use of solar generated electricity, it is important to install a storage battery as well. By installing storage batteries and EV charging equipment in addition to solar panels, along with subway construction, it will be possible to supply to EV motilities. And it is a possibility for PMRCL to establish selling electricity business as a non-fare box business.</p> <p>(2) Contents</p> <ul style="list-style-type: none"> • Installation of solar panels, large-capacity storage batteries, and high-speed EV charging facilities at metro stations • Business trial of selling electricity to EV motilities <p>(3) Effects</p> <ul style="list-style-type: none"> • The policy of EV shift of the Government of India will be supported and promoted. • The number of EV charging stations in Patna City can be increased. • Selling solar power electricity to EV motilities may become one of non-fare box business of PMRCL. <div style="text-align: center;"> </div> <p>Source : JST Picture: Business model of EV charging stations</p>
2	<p>Business trial for on-demand mobility business</p> <p>(1) Reasons for proposal</p>

No.	Program and contents
	<p>In India, startups of last mile mobility related to MaaS etc. are popular. In Patna City, as well, train and taxi reservations using smartphone apps are widely practiced. On-demand mobility bus services that can be summoned and boarded regardless of route or time have been developed and introduced as last-mile mobility from railway stations and bus stops in some countries. In the future, as residential development is carried out along the Patna metro lines, it will become an issue to consider means of access to the station in the suburban area. On-demand buses have the potential to be commercialized as one of the last-mile mobility options for PMRCL.</p> <p>(2) Contents</p> <ul style="list-style-type: none"> • Development of smartphone application for on-demand bus • Promotion of public transportation and on-demand buses • Demonstration experiment of on-demand bus <p>(3) Effects</p> <ul style="list-style-type: none"> • PMRCL can provide last-mile mobility in suburban areas. • On-demand bus may become one of PMRCL's non-fare box business. <div> </div> <p>Source : Willer Express Picture; Business trial for on-demand bus by a Japanese firm in Hanoi, Vietnam</p>

20. Non Fare Box Revenue

20.1 Overview of Existing Studies

The fields of non-fare business that PMRCL is planning include advertising, parking, filming of movies, installation of communication cables, sale of station naming rights, and rental of station space such as kiosks. These revenue estimates are calculated by converting the differences in economic growth rate and income in Bihar state, using examples of other metros in India such as Chennai Metro and Jaipur Metro as benchmarks (Table 20-1). These businesses are common among other metro companies in India.

The revenue provision in DPR for each field of every five years from FY2024 to FY2051 are as follows (Table 20-2).

Table 20-1: Rate for Non Fare Box Revenues

Type of revenue	Unit rate	Rate of increasing	Remarks
Advertising panels inside station and train coach	2,000 per sqm per month in 2018	5%/year	Estimated 50 % of the case of Chennai Metro, considering the differences in earnings.
Advertisement on external train wrap	Rs. 1.25 lakh/car/month	5%/year	Estimated 50 % of the case of Chennai Metro, considering the differences in earnings.
Parking charges at stations	Average 4 hour Rate for 3-6 hours: Rs.20 Rate for 6-12: Rs 30 Plus 20 % for time slots and vehicle variations	15 % every 3 years	Reference of the business condition in Patna
Film shooting charges	Rs. 2 Lakh per hour for inside Train/station assumed for 8 hours and once in 8 months, 12 hours in a year	5%/year	Estimated of case of Chennai Metro, considering for introducing initial promotion
Telecom cable license fee	2000 per month for entire track lengths, 50,000 per month for elevated stations	10 % every 2 year	Estimated of case of Chennai Metro, considering for introducing initial promotion
Telecom Tower license fee	15,000 per month for elevated stations	10 % every 2 year	Estimated of case of Chennai Metro, considering for introducing initial promotion
Semi naming rights of station building	75 Lakh per year per station	25 % every 5 year	Reference of other metros
Kiosk rentals	700 per sqm per month	5%/year	Reference of Jaipur Metro

Source: DPR Table 19-12, Modified by JST

Table 20-2: Non-Fare Box Revenue

Revenue Stream	Total revenue (Rs. In Crore)			
	2024-25	2031-32	2041-42	2051-52
Advertisement	94	148	250	406
Rentals from Kiosks	4	6	10	16
Parking	3	4	7	11
Film Shooting	0	1	1	1

Revenue Stream	Total revenue (Rs. In Crore)			
	2024-25	2031-32	2041-42	2051-52
Telecom Cable and Tower (licence fees)	2	2	3	6
Semi naming rights of stations	13	18	30	49
Total	116	179	301	489

Source: DPR Table 19-14

The fields of non-fare box businesses mentioned above are basically the space rental business. It is effective utilization of floors and walls of stations, and dead space of owned properties. Therefore, there is limited space available for rent, and revenues from continued business expansion cannot be expected. The increase in revenue is due to the inflation rate.

Non-fare box revenue of PMRCL consists of the above businesses, land value capture (LVC) of TOD, and income from property development business. However, regarding TOD, no specific LVC scheme has been decided in Patna, and it is calculated with reference to National Transit Oriented Development (TOD) policy issued by the Government of India. It is proposed that 35% of yearly projected revenue collection from LVC will accrue to Patna Metro.

The forecast for non-fare box revenue of PMRCL will be temporarily negative due to real estate development investment, but it will turn positive after 8 years (Table 20-3). PMRCL has plans to acquire privately owned land adjacent to ISBT depot (Figure 20-1). This plan is to establish a special purpose vehicle (SPV) with a private developer, acquire 11.3 Ha of privately owned land adjacent to ISBT depot, and construct a commercial building for rent and residential apartments for sale. At the time of study of JICA Team, PMRCL was discussing the financing and business plan with a private developer. But the plan had not been confirmed yet. There is another option that PMRCL owns and develops by itself. This land is close to the bus terminal and also the terminal station of the metro. In addition, considering a large amount of land, attracting shopping malls, which can be expected to increase the number of metro passengers, will be also a good utilization plan.

Table 20-3: Estimation of Non Fare Box Revenue for Patna Metro (Rs. In Crores)

Year	TOD	Property Development	Non Fare Box Business (Other sources)	Total
2024-25	193	281	116	590
2027-28	223	-119	135	239
2030-31	258	-92	156	322
2033-34	299	-64	198	433
2036-37	346	18	227	591
2039-40	401	21	262	684
2042-43	464	25	315	804
2045-46	537	28	365	930
2048-49	622	33	422	1077
2051-52	720	38	489	1247

Source: DPR Table 19-25 modified by JST

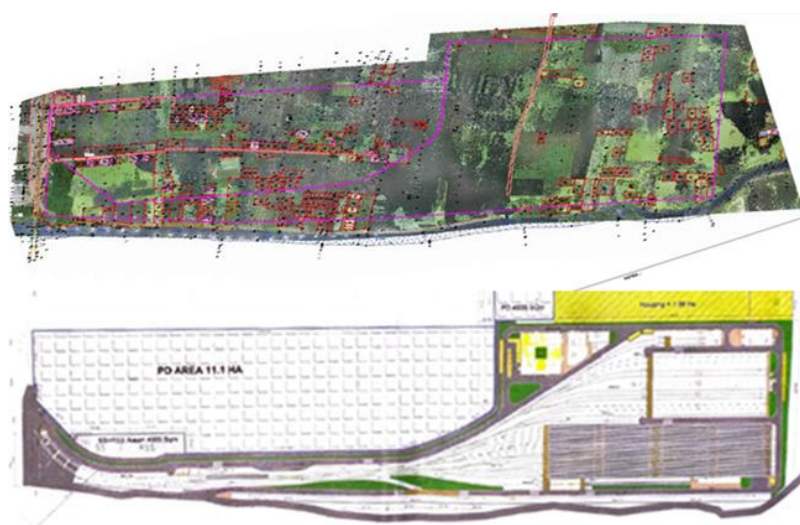


Figure 20-1: Planned acquisition land adjacent to ISBT Depot

The ratio of non-fare box revenue of PMRCL's total revenue is 35% in 2024, but it is estimated to decrease to 19% in 2051 due to the increase in fare box revenue according to the contribution of property development and the increase in passenger numbers (Table 20- 4).

Table 20-4: Ratio of Non Fare Box Revenue(Rs. In Crore)

Source of Revenue	2024	2031	2041	2051
Fare Box Revenue	934	1886	3003	5293
Non-Fare Box Revenue	590	368	765	1247
Total Revenue	1524	2254	3768	6540
Percentage of Non-Fare Box Revenue (%)	35	16	20	19

Source: DPR Table 19.16 modified by JST

20.2 Reviews of Existing Studies and Proposals for Improvement

The ratio of non-fare box revenue in PMRCL's total revenue is close to that of Chennai Metro, which is used as a benchmark data for revenue estimation. However, it can be said that it is low compared to Delhi Metro and overseas operators in Hong Kong and Singapore (Table20-5). It can be said that these cities are not only relying on fare revenue, but are actively working to increase non-fare revenue.

Table 20-5: Revenue Breakdown for Metro Operators (FY2020)

Metro Company	Revenue (%)			Others (%)	Total (%)
	Total Business Revenue	Fare Box Revenue	Non-Fare Box Revenue		
Delhi	85	48	37	15	100
Mumbai	103	89	14	-3	100
Bangalore	88	79	9	12	
Chennai	58	42	16	42	100
Transport for London	63	52	11	37	100
MTR Hong Kong (FY2019)	88	32	56	12	100
SMRT Singapore (FY 2016)	99.7	71	28	0.3	100

Source; Performance of Indian Metro Systems, UITP

Non-fare box businesses that PMRCL is planning are basically space rental business such as kiosk, advertisement, parking lots and installation space for communication cables which utilize dead spaces of metro facilities, same with the business of other metro companies in India. However the revenue from these type of space rental business is limited. Because they are proportional to the amount of space which can be rented out.

In the business model of Japanese railways, there are cases that the contract of kiosk in stations is not only renting the space. In the contract, a railway company can get a certain share in accordance with sales of kiosk. This type of contract can make win-win relation between lesser and lessee. The railway company make efforts to maximize the sales together with the lessor. The railway company conduct marketing research and arrange the spaces in consideration of the passenger flow etc.

The business strategies and contract models of Japanese railways will help to increase non-fare box business of PMRCL.

There are no regulations or guidelines for non-fare business of PMRCL at the time of JICA Team's study. However, since PMRCL is a public authority, it might be difficult to refer to the successful non-fare box business model of Japanese railways, most of which are private companies. Also, in an actual project, it is difficult to keep the number of passengers as planned (Table20-6). First of all, in order to increase the number of passengers, it will be necessary to change the negative image of public transportation in Patna.

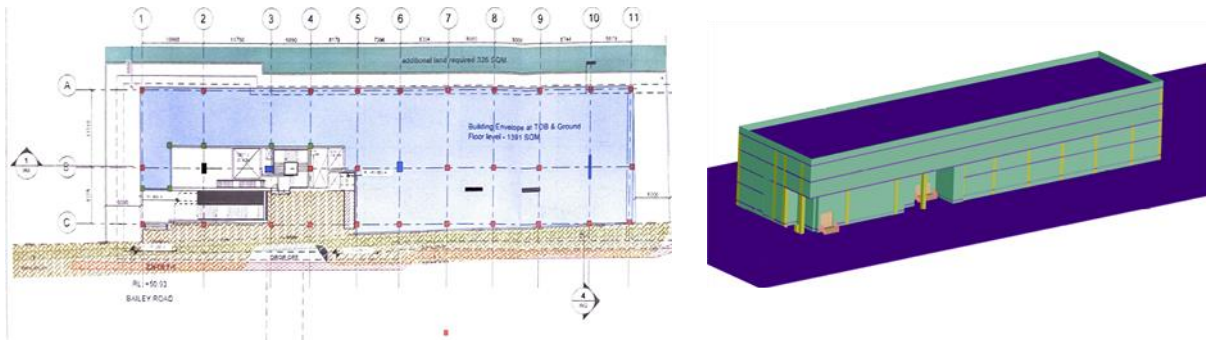
Table 20-6: Comparing Planned and Actual Passenger Rates for Metro Projects in India

Metro Company	(Fiscal year)								
	Projected daily ridership (million)			Average daily ridership (million)			Ridership achieved (%)		
	2018	2019	2020	2018	2019	2020	2018	2019	2020
Delhi Metro	6.8	7.0	7.2	2.5	4.0	5.7	38	58	79
Mumbai Metro	0.6	0.6	0.6	0.4	0.3	0.5	68	57	74
Bangalore	1.3	1.4	1.5	0.3	0.3	0.4	24	24	27
Chennai Metro	0.8	0.9	0.9	0.02	0.1	0.1	3	9	13

Source; UITP, Performance of Indian Metro system: lessons for upcoming urban rail project

PMRCL has plans to acquire land adjacent to Rukanpura Sta., Patna Junction Sta. for property development in addition to developing a property adjacent to ISBT Depot. Property development should be carried out with the aim of increase in metro passengers. At Rukanpura Sta., the land about 1,400 sqm is planned to be acquired and developed for the revenue (Figure20-2). Considering the size of this property, it is assumed that the competitiveness in Patna City, it can be proposed that a hospital or medical complex, vocational

school, vocational school, offices. Especially patients and students are more likely to use public transportation, which will contribute to an increase in metro passengers.




Source; PMRCL, JST

Figure 20-2: Planned property development site and plan at Rukanpura Sta.

Table 20-7 shows trends in non-fare businesses of metro and railway operators in India.

Table 20-7: Trends in non-fare box business of Indian metro/railway companies

No.	Metro Company	Contents
1	Delhi Metro	<ul style="list-style-type: none"> The policy for renting station space to kiosks and retails is published. The policy stipulates contract procedures, contract terms and permitted business fields. The company sells the station naming rights through an online auction conducted by the external outsourced advertisement company. The contract period is for 10 years and the winning bidder will be able to name the station to promote their brand. In addition to naming the station, Sikanderpur Sta. also repainted the exterior of the station in orange, the brand colour of the winning bidder.
2	Bengaluru Metro	<ul style="list-style-type: none"> The state of Karnataka and Bengaluru city have a policy to create a world-class business environment for startups. Under this policy, Bengaluru Metro sees the stations where people gather as an advantage and has set up incubation centers for startups at the stations. Bengaluru Metro has not plan of the introduction of vehicle wrapping advertisements considering the harmony with the urban landscape. On the other hand, digital signage using LED screens at stations are introduced widely.
3	Chennai Metro	<ul style="list-style-type: none"> In addition to the existing depot, Chennai Metro is constructing a new depot on a 4,800 sqm site adjacent to Wimco Naga Sta. In the future, there is a plan to build a 20-story building that integrates residential and commercial facilities above the depot for non-fare box revenue. <p>Source; The Times of India</p>
4	Noida Metro	<ul style="list-style-type: none"> Noida Metro decided to rent unused parking lots to food trucks. Nine out of 15 stations are be available. The minimum rental space at each station is 25 sqm. Leasing of the space will be

No.	Metro Company	Contents
		<p>carried out by tender. The opening hour of food truck is from 9:00 am to 10:30 pm. Noida Metro expects it to be a new effective way to utilize unused properties.</p>
5	Nagpur Metro	<ul style="list-style-type: none"> Nagpur Metro plans to build a station building with 18 floors above ground and 2 floors below ground at Zero Mile Freedom Park Sta. The station building is planned to have commercial facilities and parking lot. The project will be implemented through a public-private partnership (PPP), with the successful bidders receiving the right to operate the parking lot and commercial facilities for 60 years (including three years for construction). The successful bidder can decide on the design and facilities of the station building, such as hotels, restaurants, commercial facilities, and offices.  <p>Source; Nagpur Today</p>
6	Mumbai Metro	<ul style="list-style-type: none"> Mumbai Metro has signed a contract with a consulting firm to increase non-fare revenue. In addition to current business of advertisement, retail and real estate development along corridors, Mumbai Metro will consider effective utilization of assets such as air rights of unused facilities.
7	Indian Railways	<ul style="list-style-type: none"> Indian Railways is openly soliciting innovative ideas to increase non-fare box revenue by utilizing assets without compromising passenger convenience and comfort. Applicants are required to make proposals including technical feasibility, market size, profit forecasts, etc.

Source; JST

Figure 20-3 shows examples of kiosks and advertisement at Delhi Metro and Indian Railways stations surveyed by the JICA Team.





Source: JST

Figure 20-3: Examples of various non-fare box business of metro and railway companies in India

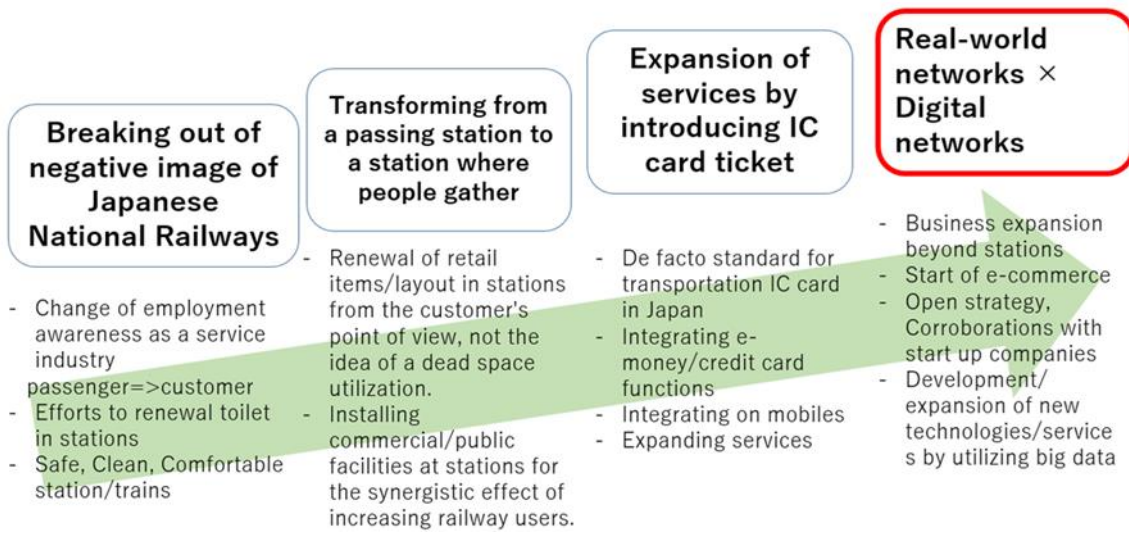
20.3 Cases in Japan

Over the past few years, metro and rail companies in India and around the world have faced a difficult business environment with reduced the number of passengers due to COVID-19. In addition, even if COVID-19 is over, it is expected that the previous lifestyle will not come back again. The companies are re-assessing its business strategies to adopt to “new normal”.

Figure 20-4 shows the transition of non-fare box business strategies of East Japan Railway Company (JR East), which has succeed in the so called in-station business and created various non-fare box business. JR East is one of the passenger railway companies which were born in 1987 by the privatization of Japanese National Railways. As a private company, JR East is required to operate independently without relying on subsidies from the government.

At first, JR East had focused on changing the bad image of the state railway (dangerous, dirty, poor service) before developing non-fare box business. The service before privatizing was at the level of just allowing passengers to use the railways. Therefore, JR East, as service provider, made efforts to reform the mindset of its employees. JR East instructed employees to call passengers customers. In addition, JR East had carried out a campaign to clean-up toilets in the stations in order to symbolize the change and reborn of the railway.

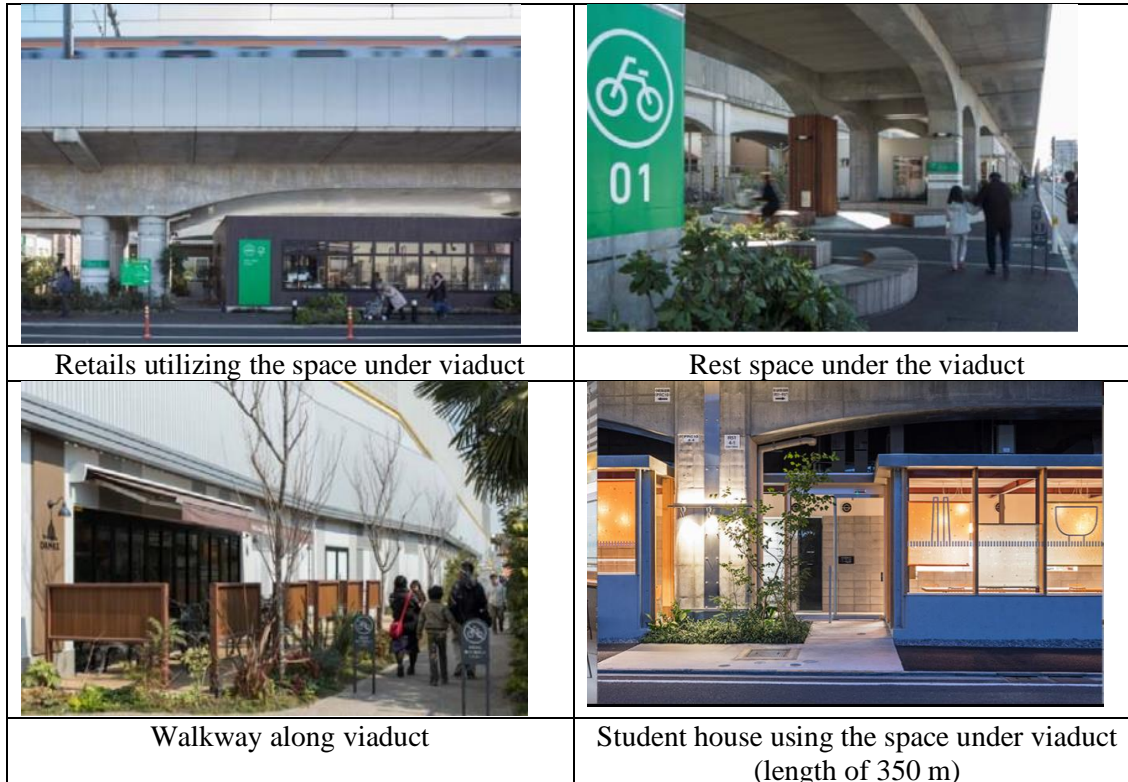
After that, JR East focused on the expansion of retails in station areas by reviewing the layout of the commercial facilities from the customer’s point of view as a station where customer gather rather than pass through. And then, along with the use of e-money integrated with a smart card, and expanded its services such as lockers and hotel entrance keys using authentication functions of the card. In addition, by reviewing underutilized assets such as spaces under the viaduct, JR East has developed and expanded the possibility of non-fare box business. JR East was cooperating with local municipalities to effectively utilize the space under the viaduct, which was created by the elevation project of the Chuo line, five stations between Mitaka and Tachikawa, about 9 km. JR East is developing non-rail business as well as enhancing the appeal of areas along the railway line through integrated development of the city planning. This experience can be useful for PMRCL to enhance the security level and scenery along the corridors, as well as the possibility of non-fare box business (Figure 20-5). Kintetsu Railway Co., Ltd (Kintetsu) started the rental business of house and garage integrated residence utilizing the space of under the about 42 km length of the viaduct as well (Figure 20-6).



Source; JST

Figure 20-4: Transitions in JR East's Non-Railway Business Strategies

As a post-pandemic strategy, JR East is pursuing new business possibilities by fusing stations as a real place where people gather with IoT data which is collected by collected by smart card or e-commerce business. Through an open innovation strategy, JR East is developing new services such as the use of big data through collaboration with startups and other industries. Big data has the potential to be used for city planning and corporate marketing, and create new services.



Source; JST

Figure 20-5: Utilization of the space under viaduct (JR East)



Source: Kintetsu Group HP

Figure 20-6: Rental business of house and garage integrated residence using the space of viaduct (Kintetsu)

20.4 Recommendation from JST

JICA Study Team summarizes the current issues and possibilities of PMRCL's non-fare box business and revenue as follows.

- For the success of non-railway business, it is important to change the passenger's image of public transportation by providing clean, safe and comfortable public transportation service.
- The business that PMRCL is planned is basically a place rental business, so the growth of the revenue is limited.
- In addition to measures for increasing the number of passengers, it is important to increase the ratio of non-fare box revenue for independent management. Therefore, it is important to develop human resources for non-fare businesses and to develop business plans before opening.
- PMRCL is considering acquiring a private land around the depot, and is proceeding with a development plan in collaboration with a private developer. There is also a plan to acquire and develop lands adjacent to Rukanpura Sta. and Patna Junction Sta. However, financing and business plans have not progressed. It is important to prepare for no-fare business and property development business from an early stage.

Based on the above considerations, JICA Study Team would like to propose the services applied technical assistance and consulting scheme of JICA as follows. (Table20-8).

Table 20-8: Proposal of services to be implemented in this project (Non-Fare Box Business)

No.	Program and contents
1	<p>Capacity development for non-fare box business (retails/advertisement in station area etc.)</p> <p>(1) Reasons for proposal For other metro projects, consideration of non-fare box business will start after the operation stabilizes after opening. However, the non-fare box business is important not only to supplement the revenue of the metro business, but also to realize self-sustaining financing. JICA Study Team proposes to start considering non-fare projects in parallel with preparations for subway projects.</p> <p>(2) Contents</p> <ul style="list-style-type: none"> • Capacity development of staff for non-fare box businesses (station retails, advertising, etc.) • Training in Japan (Non-fare box business strategies after Covid-19, marketing, organizational structure, cooperation between lessors/lessees, site visit of non-fare box business, etc.) • Support for planning of strategies, business plans, marketing, etc. • Support for business operations, revenue management of non-fare box business, etc. <p>(3) Effects</p> <ul style="list-style-type: none"> • Capacity development of staff of non-fare box business

No.	Program and contents
	<ul style="list-style-type: none"> • PMRCL can learn the know-how of non-fare box business of Japanese companies • PMRCL can learn business strategies and trends of non-railway businesses after Covid-19. • PMRCL will be able to plan and operate efficient non-fare box business.
2	<p>Capacity development for non-fare box business (property development business)</p> <p>(1) Reasons for proposal Property development business is one of the major non-fare box revenue for railway companies. PMRCL has a plan to acquire private land around the planned depot site for real estate development business. For the success of the real estate business, it is important for PMRCL to take the initiative in raising funds, developing plans, building consensus among stakeholders, etc.</p> <p>(2) Contents</p> <ul style="list-style-type: none"> • Capacity development of staff in non-fare box business (property development business) • Training in Japan (business model and strategy of real estate development business, organizational structure, business operation and profit management, case study of land value capture (LVC) in Japan, site visit, etc.) • Support for business plans, funding plans, and consensus building among stakeholders • Support for business management and revenue management <p>(3) Effects</p> <ul style="list-style-type: none"> • Capacity development of staff in the property development business. • PMRCL can learn the know-how of Japanese railways companies. • PMRCL will be able to plan and promote real estate business on its own. • PMRCL will be able to operate and manage the property development business by itself.
3	<p>Trail for measures to improve the level of safety, security, and cleanliness in and around stations</p> <p>(1) Reasons for proposal Many residents of Patna City have an image that public transportation is dirty and dangerous. They would like to avoid using it if possible. Improving the image of public transport is essential for the business operation and development of metro projects. In Japan, railway companies are working together with local governments and local residents to improve security and beautify areas around stations, as well as to introduce effective security equipment. The knowledge of these Japanese companies will be useful for PMRCL.</p> <p>(2) Contents</p> <ul style="list-style-type: none"> • Support for improving security and cleanness level around stations in collaboration with local authorities and local residents • Support for measures to promote the use of public transportation • Installation of lighting around stations, security equipment (security cameras, mosquito sound generators which can avoid especially young people gathering and improve security level around stations, etc.) • Business trials such as installation of environmentally friendly toilets through public-private partnership schemes etc. <p>(3) Effects</p> <ul style="list-style-type: none"> • PMRCL can realize safe and clean public transportation by learning the knowledge of Japanese railway experiences and technologies. • As a result, the increase of fare box and non-fare box revenue can be expected as the number of passenger's increases.

21. Financial Analysis

21.1 Overview of Existing Studies (N/A)

21.2 Applied Preconditions and Methodology for this Study (N/A)

21.3 Financial Structure of Borrowers

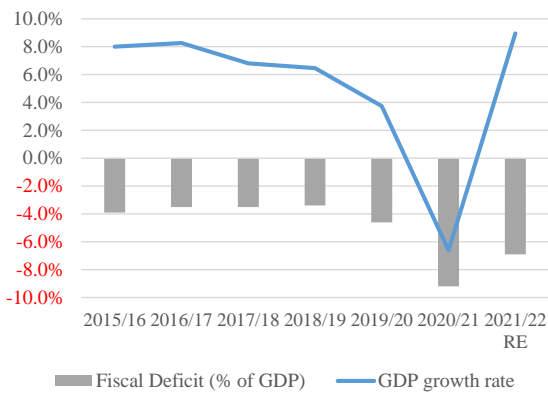
21.3.1 Financial Capacity Analysis of the Central and State Governments

(1) Central Government

1) Fiscal balance and budget expenditure

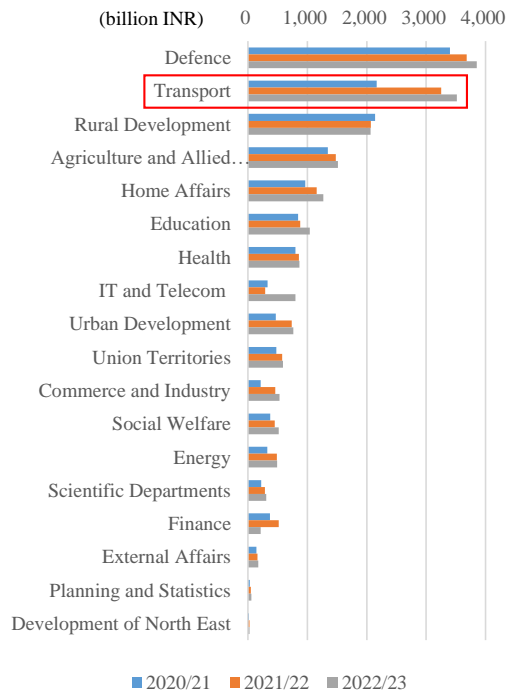
During the year 2020-21, the shortfall in revenue collection due to the interruption in economic activity and the additional expenditure created immense pressure on the available fiscal resources. As a result, the fiscal deficit for 2020-21 was 9.5% of GDP. The Medium-Term Fiscal Policy (MTFP) Statement presented with Budget 2021-22 envisaged a fiscal deficit target of 6.8% of GDP for 2021-22. The GDP growth rate also deteriorated by -6.6% in 2020-21 but will be expected to recover by 8.95% in 2021-22 (Figure 21-1).

The Union Budget 2021-22 had enhanced the budget for the more productive capital expenditure. The Government budgeted for a 34.5 % growth in capital expenditure over 2020-21 – with emphasis on railways, roads, urban transport, power, telecom, textiles and affordable housing amid continued focus on the National Infrastructure Pipeline. The National Infrastructure Pipeline covering 6,835 projects was expanded to 7,400 projects in Budget 2021-22 (Union Budget 2021-2022). The transport sector was the second most budgeted sector after defense, totaling Rs. 351,851 Crore in 2022-23 (Figure 21-2). The capital investment in transport sector will continue to be a key drive of high economic growth of the country.



(Source) MoF

Figure 21-1: Fiscal Deficits and Real GDP Growth Rate



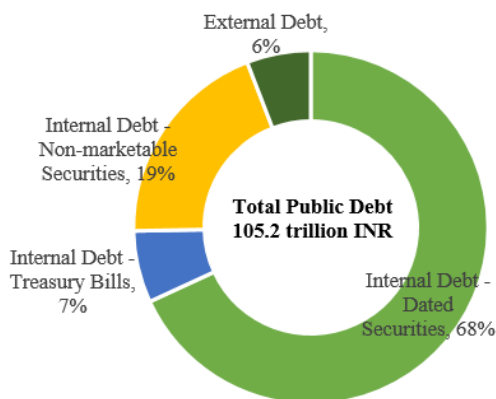
(Source) MoF

Figure 21-2: Major Expenditure Items

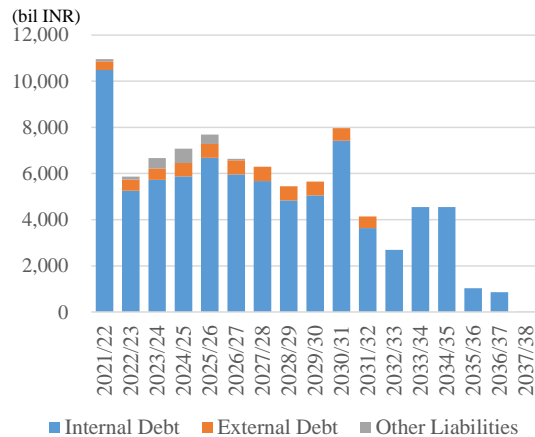
2) Public Debt

The public debt indicators of India shows that the currency risk associated with debt portfolio continues to be low since it is predominantly of domestic origin and denominated in domestic currency. The low share of external debt, almost entirely from official sources and on concessional terms, provides a safety net from volatility in the international financial markets (Figure 21-3).

External debt (at current exchange rate) as percentage of total public debt was 6% in 2020-21. This is indicative of low currency risk of debt portfolio of the Central Government (Figure 21-4). The redemption profile of public debt also shows the majority of internal debt, concentrated in less than 10 years maturity period (Figure 21-4).



(Source) MoF



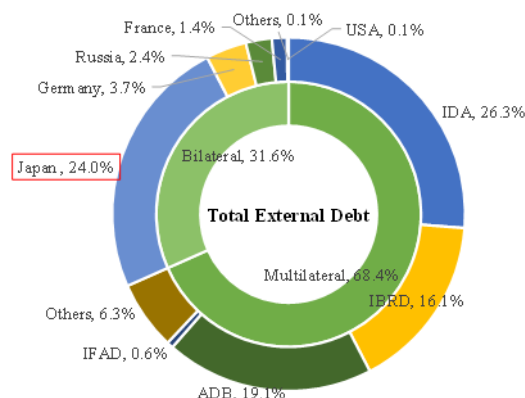
(Source) MoF

Figure 21-3: Public Debt Composition (2020/21)

Figure 21-4: Redemption Profile of Public Debt

3) External Debit

Loans from multilateral institutions are long-term and largely on concessional terms. The International Development Association (IDA) continued accounting for bulk of the multilateral debt at US\$ 22.2 billion as at end-March 2021. The debt from ADB grew to US\$ 16.1 billion as at end-March 2021 from US\$ 13.8 billion a year ago. Within bilateral debt, Japan continues to be the largest creditor to India, accounting for 24.0% at end-March 2021, followed by Germany, Russia, and France (Figure 21-5).



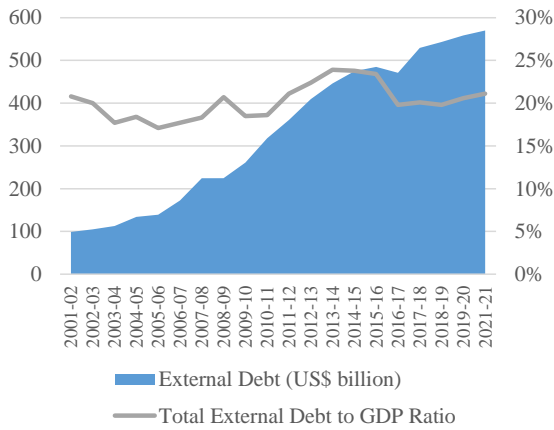
(Source) MoF

Figure 21-5: Outstanding External Debt by Creditor (2021)

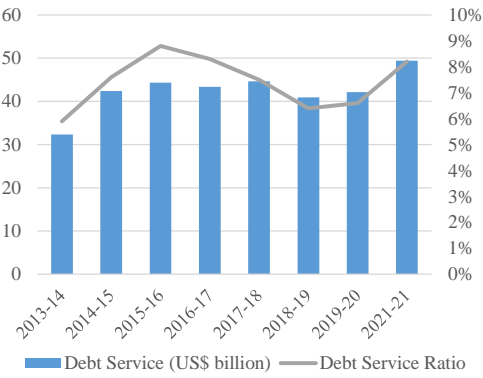
4) Outstanding External Debt Indicators

Taking external debt to GDP and the debt service ratio as important outstanding external debt indicators. External debt as a ratio to GDP rose marginally to 21.1% as at end-March 2021 from 20.6% a year ago (Figure 21-6). The debt service ratio rose to 8.2% during 2020-21 from 6.6% during the previous year mainly on account of, apart from lower current receipts, debt restructuring/debt reorganisation undertaken by leading Indian non-financial corporations. The debt service payment obligations arising out of the stock of external debt as at end March 2021 are projected to be moderate and peak in 2024-25 (Figure 21-7).

While the thresholds of both indicators of the GoI have not been confirmed, they are within the stable conditions if the standard threshold set by IMF; external debt to GDP ratio for 55% and debt service ratio for 15%, are followed.



(Source) MoF
Figure 21-6: Total External Debt to GDP Ratio

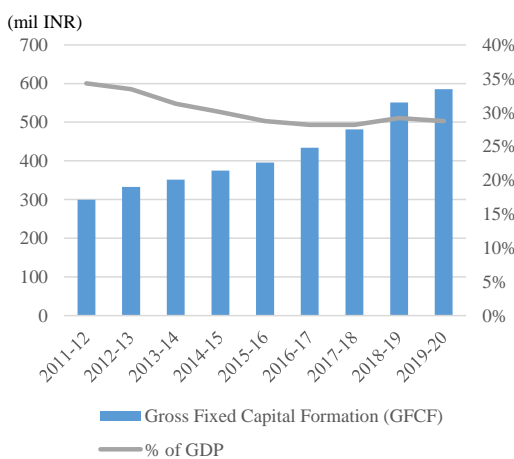


(Source) MoF
Figure 21-7: Debt Service Ratio

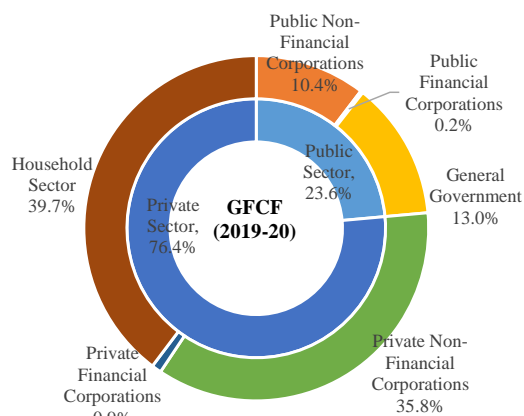
5) Gross Fixed Capital Formation

Gross fixed capital formation (GFCF), also called "investment", is defined as the acquisition of produced assets, including land improvements, plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. The indicator is important in determining the level of capital investment in the country.

Figure 21-8 and Figure 21-9 shows that India keeps the average 30% of GFCF in total GDP, which is higher than the average East and Southeast Asian countries. While the public sector contribution in GFCF is higher than the private sector in East and Southeast Asian countries, public sector components were about 24% and the private sector was about 76% in 2019-20 in India.



(Source) MoSPI
Figure 21-8: GFCF Trends in Current Prices

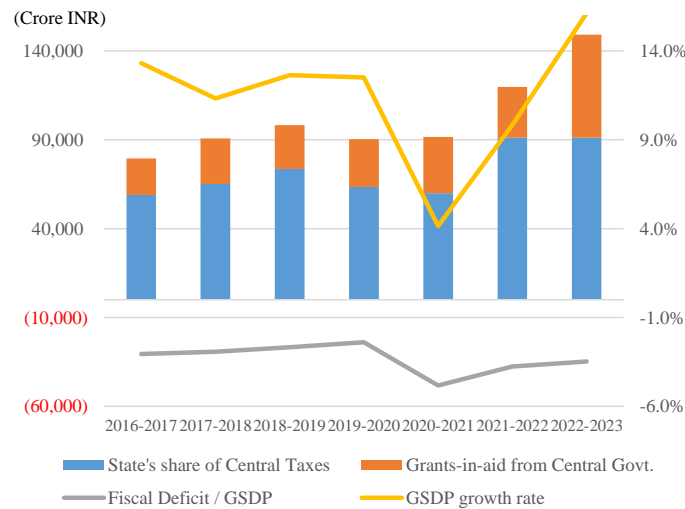


(Source) MoSPI
Figure 21-9: GFCF Breakdown (2019-20)

(2) State Government

In Bihar State, the Fiscal Deficit to Gross State Domestic Product (GSDP) has been maintained within the statutory limit of 3.5% as per Fiscal Responsibility and Budget Management (FRBM) Act. Bihar is one of those states which have taken its fiscal responsibility and implemented the FRBM Act. In the year 2022-23 it is likely to generate a revenue surplus and the fiscal deficit is likely to be contained at 3.47% of State GDP (within the FRBM limits of 3.5%). (Figure 21-10)

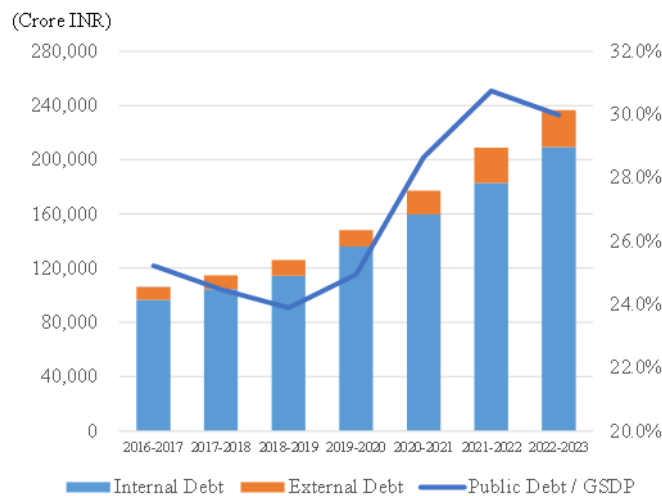
The contribution from the central government by taxes and grants will be expected to increase in 2021-22 and 2022-23. The GSDP growth rate did not show a negative figure even during the pandemic, and is expected to achieve 16% in 2022-23.



(Source) Finance Department, GoB

Figure 21-10: Debt Sustainability of Government of Bihar

The Outstanding Public Debt is estimated at Rs. 2,38,126.69 crore in 2022-23 which is 31.95% of GSDP of Rs. 7,45,310.00 crore. Out of the total outstanding public debt, 88% are internal debt and 12% are external debt from the World Bank and ADB.



(Source) Finance Department, GoB

Figure 21-11: Public Debt of Government of Bihar

(3) Budget Allocation for PMRCL

The budget of MoHUA and the Government of Bihar (GoB) has been released to PMRCL shown in the following tables.

1) MoHUA

Ministry of Housing and Urban Affairs (MoHUA) is the nodal Ministry for planning and coordination of Urban Transport matters at the central level. At the same time, technical planning of rail transport continues to be with Ministry of Railways. Similarly, road transport is the responsibility of the Ministry of Road Transport and Highways, and major responsibility for urban transport infrastructure and service delivery rests with State Governments and local bodies.

The Metro Rail Policy, introduced in August 2017, acts as a guide to States and Union Territories for preparing comprehensive proposals for systematic planning and implementation of metro rail systems in the cities. At present, more than 700 km of metro rail lines are operational in 18 cities and about 1010 km of metro lines, including 82 km Delhi-Meerut RRTS corridor, are under construction in 27 cities which include Delhi and NCR, Mumbai, Kolkata, Bangalore, Chennai, Hyderabad, Nagpur, Ahmedabad, Gandhi Nagar, Pune, Navi Mumbai, Patna, Surat, Agra, Kanpur, Meerut, Bhopal and Indore (MoHUA Annual Report 2020-21).

Around 30-40 % of the total budget under MoHUA are budget for metro (Table 21-1).

Table 21-1 Budget Allocation for the MoHUA

(in Rs. Crore)

Year	Budget Estimated (BE)	Revised Budget (RE)	Provisional Expenditure	Budgeted for Metro	Budgeted for Metro (%)	Actual Expenditure for Metro	Utilized (%)
2016-2017	24,523	32,550	22,871*	10,000	31%	15,727	157%
2017-2018	40,618	40,754	30,610*	18,000	44%	13,978	78%
2018-2019	41,765	42,965	40,731	15,000	35%	14,470	96%
2019-2020	48,032	42,267	31,732*	19,152	45%	18,908	99%
2020-2021	50,040	46,791	28,110*	20,000	43%	9,000	45%
2021-2022	54,581	73,850	-	23,500		-	-

*: The amount is a provisional expenditure as of 31 December.

Source: Annual Report of MoHUA (2016 Independent Auditors Report To the Members of Patna Metro Rail Corporation Limited (2020 and 2021))

As of April 2022, the cumulative amount of Rs. 462.50 Crore has been released from MoHUA to PMRCL as part of the Government of India's share towards equity capital (Table 21-2). The equity share of the Government of India shown in the 2021-22 financial statement of PMRCL matches with the amount of Rs. 262.50 Crore. The additional Rs. 200.00 Crore will be reflected in the financial statement of 2022-23.

Table 21-2 Fund Arranged by MoHUA

(in Rs. Crore)

Sl.	Funded portion by	Purpose	Date	Amount	Cumulative release
1	MoHUA	Share Equity	19-Nov-2019	50.00	50.00
2	MoHUA	Share Equity	25-Jun-2020	100.00	150.00
3	MoHUA	Share Equity	12-Oct-2020	63.00	213.00
4	MoHUA	Share Equity	1-Oct-2021	49.50	262.50
5	MoHUA	Share Equity	27-Apr-2022	200.00	462.50

Source: MoHUA

2) Government of Bihar (GoB)

Until PMRCL was incorporated on 18th February 2019, there was no budget for Metro by GoB. The budget portion of metro has been insignificant in the total budget of the Government of Bihar (Table 21-3).

Table 21-3 Budget Allocation for the GoB

(in Rs. Crore)

Year	Total Budget of GoB	Total Expenditure against Budget	Budgeted for Metro	Budgeted for Metro (%)	Actual Expenditure for Metro	Utilized (%)
2016-2017	154,327	126,302	-*	-*	-*	-
2017-2018	172,884	136,427	-*	-*	-*	-
2018-2019	190,919	154,655	-*	-*	-*	-
2019-2020	217,760	143,614	160.00	0.1%	33.24	21%
2020-2021	225,458	165,697	53.00	0.0%	82.83	156%
2021-2022	255,474	Not yet	1550.00	0.6%	1057.585	60%

* PMRCL was established in February 2019, so the information after 2019 is available.

Source: GoB

Based on the interview with PMRCL, the budget of GoB is released in stages. After the issuance of budget order by the Finance Department of GoB, Urban Development and Housing Department of GoB releases fund to PMRCL, however, there are some cases that the total budgeted amount is not released. For example, in 2021-22, out of the sanctioned budget of Rs. 1550 Crore, Rs. 1057.585 Crore was released with the following breakdown and table:

- Equity – Rs. 49.50 Crore + Rs. 200 Crore = Rs. 249.50 Crore
- Land – Rs. 308.085 Crore + Rs. 500 Crore = Rs. 808.085 Crore
- Total - Rs. 249.50 Crore + Rs. 808.085 Crore = Rs. 1057.585 Crore

Table 21-4 Fund Arranged by GoB

(in Rs. Crore)

Sl.	Funded portion by	Purpose	Date	Amount	Cumulative release
1	GoB	Share Equity	3-Sep-2019	3.00	3.00
2	GoB	Share Equity	24-Jul-2019	10.00	13.00
3	GoB	Share Equity	9-Feb-2019	50.00	63.00
4	GoB	Share Equity	14-Jan-2020	100.00	163.00
5	GoB	Share Equity	27-Aug-2020	50.00	213.00

Sl.	Funded portion by	Purpose	Date	Amount	Cumulative release
6	GoB	Share Equity	21-May-2021	49.50	262.50
7	GoB	Land Acquisition	28-Dec-2021	308.09	570.59
8	GoB	Share Equity	20-Jan-2022	200.00	770.59
9	GoB	Land Acquisition	20-Jan-2022	500.00	1,270.59

Source: GoB

21.3.2 Financial Structure of PMRCL

Since PMRCL was established on 18th February 2019, the financial statements (The Profit Loss Statement (P/L), Balance Sheet (B/S), and Cash flow Statement (C/S)) were prepared for the three fiscal years: 2019-20, 2020-21 and 2021-22. As PMRCL did not start its operations as of 31st March 2022, the financial statements did not show the regular working activities, however, they can be summarized as follows.

(1) Profit and Loss Statement

As PMRCL has not yet commenced its operations, PMRCL has no assets of plant and machinery. Office furniture, computer equipment, IT system, software licenses are allocated to “depreciation” in P/L and “non-current assets” in B/S. Similarly, only “other income” composed of the interest income was allocated to the income, and there was no “revenue from operation”.

The entire staff at PMRCL was on deputation from the Central Government, State Government and outsourced. While the gross salary and allowances were paid directly to the deputed staff at PMRCL which was allocated to “employees benefit expenses”, employee benefit policy such as pension were not allocated to the “operating expenses”. The liabilities towards employee benefit lies with their parent organizations, thus PMRCL paid their contributions regularly to the parent organizations and they were allocated to the “other administrative expenses”.

Table 21-5: Profit and Loss Statement of PMRCL (2019/20, 2020/21 and 2021/22)

Particulars	2019-20 Amount (Rs.)	2020-21 Amount (Rs.)	2021-22 Amount (Rs.)
A. Income			
1. Revenue from Operation	0	0	0
2. Other Income	10,663,802	82,483,480	38,922,000
Total Income (A)	10,663,802	82,483,480	38,922,000
B. Expenditure			
1. Operating Expenses			
2. Employees Benefits Expenses		158,669	17,132,000
3. Other Administrative Expenses	8,760,772	14,963,146	18,862,000
4. Depreciation and Amortization Expenses	410,567	680,061	725,000
5. Finance Cost			
Total Expenditure (B)	9,171,339	15,801,876	36,719,000
C. Profit/ (Loss) before exceptional and extra	1,492,463	66,681,604	2,203,000
Less: Preliminary Expenses write off	5,112,566	20,450,265	9,178,000
Profit/ (Loss) after exceptional and extraordina	-3,620,104	46,231,340	-6,975,000
D. Provision for tax			
(a) Current tax		13,042,961	
(b) Tax adjustment in relation to prior years			6,688,000
(c) Deferred tax liability / (assets)	-57,415	7,936	-75,000
E. Profit / (Loss) from continuing operation	-3,562,689	33,180,443	-13,588,000
F. Profit / (Loss) from Discontinuing operation			
G. Profit / (loss) for the year	-3,562,689		-13,588,000
Total	-3,562,689		-13,588,000
Earning per equity share			
(1) Basic	-713	282,000	-32,000
(2) Diluted	-713	282,000	-32,000

Source: Independent Auditors Report to the Members of Patna Metro Rail Corporation Limited

(2) Balance Sheet

1) Equity Share Capital

PMRCL was incorporated with the authorized capital of Rs. 20 Crore with the equity share of Rs. 100 per share. PMRCL has been established as a 50:50 joint venture of the GoI and the GoB. As of 31st March 2022, the equity share capital has been increased to Rs. 525 Crore with the same shared capital structure. The transition of the equity share capital by GoI and GoB is shown in Table 21-6

Table 21-6: Equity Share Capital by GoI and GoB

Period	GoI	GoB	Total
2020/3/31	0.00	0.05	0.05
2021/3/31	213.00	213.00	426.00
2022/3/31	262.50	262.50	525.00

Source: Financial Statement of PMRCL

Based on the interview with PMRCL, the release of equity share capital by GoI and GoB has been processed as follows:

- After receipt of equity amount from GoB, the equal amount of equity is asked for from MoHUA. Since the formalities such as approval and transfer take time, the receipt of equity amount from GoI tends to be delayed.
- The equity received is first kept as “share application money” and shown in B/S under head “other equity”.
- After receipt of equal equity from both side, it is necessary to obtain the approval from the Board of Directors for utilization of “share application money” as well as to issue necessary share certificates in favour of GoI and GoB.
- If the approval of Board is received within the financial year, the amount of equity is shown in B/S of the same financial year under the head “equity share capital”

For example; in 2021-22, equity of Rs. 49.50 Crore is received from GoI and GoB, and also approved by Board, therefore, in B/S of 2021-22 Equity share capital is shown as Rs. 262.50 Crore from both GoI and GoB. Besides, GoB has also released Rs. 200 Crore as equity in 2021-22 but equal share from GoI is received in FY 2022-23 (23.05.2022), therefore, Board’s approval could not be obtained in 2021-22 and accordingly, Rs. 200 Crore of GoB is shown as “share application money” under the head “other equity” in B/S of 2021-22.

2) Subordinate Debt

The interest free subordinate debts were received from GoB, for the purpose of land including R&R cost, the total of Rs. 808.085 Crore. The debts will be repayable only after all the outside debts (ODA) are repaid. Based on the interview with PMRCL, all of the debts have been disbursed as of August 2022 with the following breakdown:

- To District Land Officer/GoB - Approx. Rs. 741 Crore for acquisition of land and RR.
- Approx. Rs. 46 Crore to Indian Railways (East Central Railway) for crossing of Patna Metro under Patna and Patliputra Railway Stations.
- Approx. Rs. 22 Crore to National Highway Authority of India for making road over drainage etc.

Table 21-7: Balance Sheet of PMRCL (2019/20, 2020/21 and 2021/22)

M/S, Patna Metro Rail Corporation Limited, Patna

	Balance sheet as at 31st March' 2022	Note no.	As on 31st Mar'20	As on 31st Mar'21	As on 31st Mar'22
A	Asset				
	1 Non-current assets		808,339,077	2,255,182,121	11,677,251,000
a)	Property, Plant & Equipment	2	1,766,775	1,634,720	1,216,000
B)	Capital work in progress	3	784,224,000	2,251,652,056	11,671,646,000
c)	Intangible Assets	4	18,982	11,318	4,000
d)	Financial Assets				0
i)	Loan & Advances	5	0	0	2,439,000
ii)	Other Financial Assets	6	1,821,640	1,821,640	1,822,000
e)	Other Non-Current Assets	7	20,450,265	12,908	0
f)	Deffered Tax Assets (Net)	8	57,415	49,479	124,000
	2 Current Assets		583,258,998	2,827,620,091	5,396,487,000
a)	Financial Assets				
i)	Trade Recievable	9			
ii)	Cash & cash equivalents	10	492,468,354	1,993,604,640	3,479,606,000
iii)	Other Bank Balances	11			0
iv)	Loans & Advances	5	90,790,644	828,534,762	1,843,840,000
v)	Other Financial Assets	6			70,590,000
b)	Other Current Assets	7			4,000
c)	Current Tax Assets (Net)	12		5,480,689	2,447,000
		TOTAL	1,391,598,075	5,082,802,212	17,073,738,000
B	EQUITY AND LIABILITIES EQUITY				
	1 EQUITY		1,096,937,311	4,289,617,754	7,266,029,000
a)	Equity Share Capital	13	500,000	4,260,000,000	5,250,000,000
b)	Other Equity	14	1,096,437,311	29,617,754	2,016,029,000
	LIABILITIES		294,660,763	793,184,458	9,807,710,000
	2 Non-Current Liabilities		35,832,331	6,332,331	8,080,900,000
a)	Financial liabilities				
i)	Borrowings	15	35,832,331	6,332,331	8,080,850,000
ii)	Other Financial liabilities	16			50,000
b)	Provisions	17			
c)	Deferred Tax Liabilities (Net)	8			
	3 Current Liabilities		258,828,432	786,852,127	1,726,810,000
a)	Financial liabilities				
i)	Trade Payable	18			
ii)	Other Financial liabilities	16			421,162,000
b)	Other Current Liabilities	19		13,042,961	0
c)	Provisions	17	258,828,432	773,809,166	1,305,648,000
		TOTAL	1,391,598,075	5,082,802,212	17,073,739,000

Source: Independent Auditors Report To the Members of Patna Metro Rail Corporation Limited

(3) Cash Flow Statement

The cash flow statement of 2021-22 shows that the net cash from operating activities and investment activities were negative due to expenditure such as “capital work in progress”, however, with the positive value of net cash from financing activities, cash & cash equivalent at the end of the year showed the positive values. This trend will likely to be continued until the operating revenue is generated.

Table 21-8: Cash Flow Statement of PMRCL (2019/20, 2020/21 and 2021/22)

	2020	2021	2022
Cash Flows from Operating Activities			
Net Income	-3,562,689	33,180,443	-13,589,000
Add: Expenses Not Requiring Cash			
Depreciation	410,567	680,061	725,000
Income Tax		13,042,961	
Differed Tax	-57,415	7,936	-75,000
Preliminary Expenses write off	-	20,450,265	13,000
Other	353,152	34,181,223	663,000
Add: Decrease in Current Assets			
Inventories	-	-	-
Trade receivables	-	-	-
Short-term loans and advances	-	-	-
Other Current Assets	-	-	-
Current Tax Assets	-	-	3,034,000
	-	-	3,034,000.00
Less: Increase in Current Assets			
Current Tax Assets		5,480,689	
Short-term loans and advances	361,158,644	737,744,118	-1,015,305,000
Trade receivable			
Security deposit	1,821,640		
Other Financial Assets			-70,590,000
Other current assets	20,450,265	12,908	4,000
	383,430,549	743,237,715	-1,085,891,000
Add: Increase in Current Liability			
Short term Borrowings			
Trade Payables			
Other Financial liabilities			421,162,000
Short-term provisions	258,828,432	514,980,734	531,839,000
	258,828,432	514,980,734	953,001,000
Less: Decrease in Current Liabilities			
Short Term Borrowings			
Trade payables			
Short Term Provision			
Short Term provisions			
Other current liabilities			-13,043,000
	0	0	-13,043,000
Net Cash from Operating Activities	-127,811,653	-160,895,316	-155,825,000
Cash flows from Investing Activities			
Add: Sale of Fixed Assets			
Less: Purchase of new Equipment	2,196,324	540,342	-299,000
Less: Capital work in progress	513,856,000	1,467,428,056	-9,419,994,000
Less: Investments Increased	0	0	-2,439,000
Other			
Net Cash used for Investing Activities	516,052,324	1,467,968,398	-9,422,732,000
Add: Share capital	500,000	4,259,500,000	990,000,000
Add: Share application Money	1,100,000,000	-1,100,000,000	2,000,000,000
Less: Borrowing Repaid		-29,500,000	-6,332,000
Add: Security deposit			50,000
Add: Long-term borrowings	35,832,331		8,080,850,000
Net Cash from Financing Activities	1,136,332,331	3,130,000,000	11,064,568,000
NET INCREASE/DECREASE IN CASH	492,468,354	1,501,136,286	1,486,002,000
CASH & CASH EQUIPMENT AT THE BEGINNING OF YEAR		492,468,354	1,993,604,640
CASH & CASH EQUIPMENT AT THE END OF THE YEAR	492,468,354	1,993,604,640	3,479,606,640

Source: Independent Auditors Report To the Members of Patna Metro Rail Corporation Limited

(4) Funding of the Project (N/A)

21.4 Project Evaluation Indicators

21.4.1 Quantitative Evaluation Indicators (N/A)

21.4.2 Qualitative Evaluation Indicators

Development of new high capacity, high-frequency public metro system from Danapur to Khemni Chak and Patna Station to New ISBT corridors have a potential to cater for existing and future passenger demand and will relieve congestion on the road and the existing public transport network. Besides, the Project will significantly benefit the environment and economy directly and indirectly. The project will, therefore, be beneficial to the population in the Project area.

The expected qualitative evaluation indicators are as follows:

Table 21-9: Qualitative Evaluation Indicators

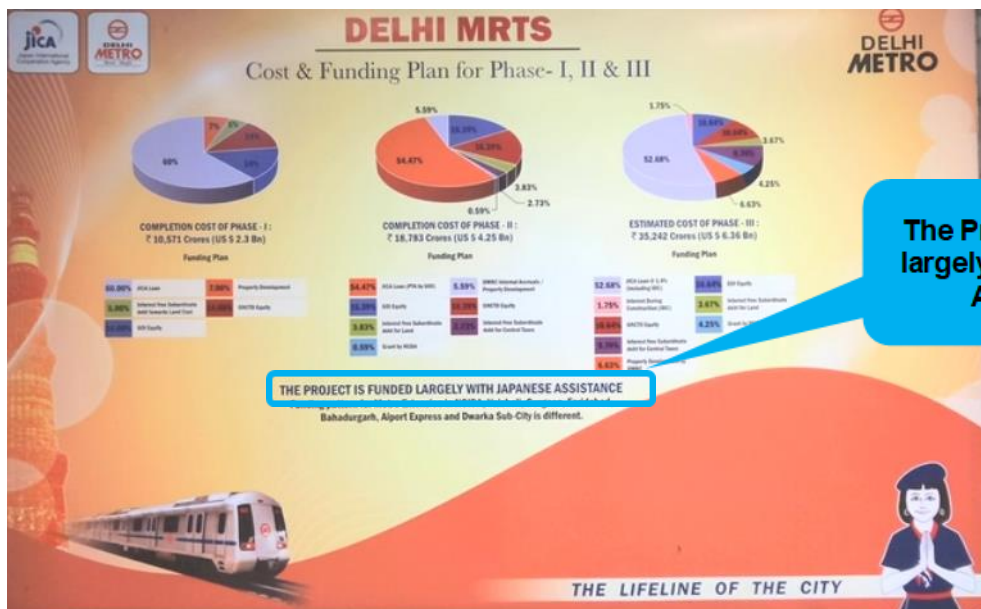
Indicators	Details
Improvement of traffic conditions in Patna	During the SIA Survey, many respondents living along the corridor complained about the traffic conditions in Patna. Some school teachers responded that the metro rail will reduce road traffic and traffic accidents, and students can reach either to school or their home safely. Some respondents experienced fatigue due to traffic jam and noise pollution created due to uncontrolled honking. The Project will significantly improve the city's public transport network and contribute to mitigate environment, health hazards, climate change impact and safety problems.
Mitigation of environmental problems	
Mitigation of health hazards	
Mitigation of climate change impact	
Mitigation of safety problems	
Enhancement of local economy	During the SIA Survey, the respondents expressed their willingness for job opportunities during construction and operation of the Project. The direct employment to be hired by PMRCL during construction and operation, and indirect employment in the commercial and residential area at TOD sites will be expected. Moreover, the implementation of the Project will offer more equitable access to transport choices for passengers wishing to access employment, education or commercial facilities, and this will contribute to the enhancement of the local economy.
Direct and indirect employment creation during construction and operation	
Social and economic impact including gender equality and poverty reduction	Several measurements for gender equality are already implemented at Delhi Metro, and the same is expected to be applied in Patna Metro: <ul style="list-style-type: none"> - Introduction of women-only cars (Figure 21-12) Delhi Metro was the first in India to introduce all-day women-only cars, and they will give comfort for women to travel without safety concerns. - Consideration to encourage use by female passengers Delhi Metro introduced an anti-disruptive behaviour surveillance cameras in each train car and deployed security personnel in the station. Escalators have a sari guard feature that deflects loose clothing from getting trapped. - Active Employment of Female Staff (Figure 21-13) Delhi Metro is taking the initiative in hiring female employees for promoting women employment in society.
Symbol of Japan – India cooperation	It is widely known that the Delhi Metro was constructed with the Japanese assistance, and the people of Delhi recognize that “Delhi Metro is the result of Japanese hardware and software assistance” (Figure 21-14). The same effect will be expected in Patna.

Source: JST



Figure 21-12: Women Only Car at Delhi Metro

Figure 21-13: Woman Employee at DMRC



The Project is funded largely with Japanese Assistance

Source: Presentation on “Delhi Metro Urban Rail Construction Project (Phase 1/2/3)”, prepared by Dr Reiko Abe, Oriental Consultants Global

Figure 21-14: Station Area Signage at Delhi Metro

21.4.3 Internal Rate of Return (IRR)

The Economic Internal Rate of Return (EIRR) and Financial Internal Rate of Return (FIRR) will be calculated based on the following benefit items. Key aspects of reviewing the DPR are:

- Economic benefit items in the economic analysis: the unit costs of savings in road infrastructure maintenance as well as the savings in capital cost of reduced buses and other vehicles are not clearly shown in the DPR, thus JST will verify them to be included in the analysis.
- Non-fare box revenue of the financial analysis: the DPR suggested the three components; namely 1) Value Capture Finance (VCF) tools, 2) Other sources like advertisement etc. and 3) Property development, however, 1) and 3) are not included in the JICA’s financial analysis model in general due to the difficulties in identifying the level of correlations in the project implementation. JST will verify the calculation methods of the two items and decide the items to be included in the non-fare box revenue.

Table 21-10: Benefit Items in Economic / Financial Analysis

Benefit items	
Economic analysis	<ul style="list-style-type: none">• Savings in Travel Time Cost (TTC)• Savings in Vehicle Operating Cost (VOC)• Savings from accident reduction• Savings from pollution reduction• Savings in road infrastructure maintenance• Savings in capital cost of reduced buses and other vehicles
Financial analysis	<ul style="list-style-type: none">• Fare box revenue• Non-fare box revenue

Source: JST

22. Economic Analysis

22.1 Overview of Existing Studies (N/A)

22.2 Reviews of Existing Studies and Proposals for Improvement (N/A)

22.3 Quality of Life (QOL) Indicators

Besides the above conventional evaluation methods, JST has been considering to conduct the QOL analysis in this Survey. The approach is to estimate people's values by focusing on “potential values” in transportation and the region. It will be possible to estimate changes in QOL associated with the construction of a metro system by income level and verify the effects through improving the accessibility of QOL indicators. JST has confirmed to seek advice from the Professor Yoshitsugu Hayashi of Chubu University and others, who have compiled a report entitled “Development of QOL-based Project Evaluation Methodology and Evaluation of Contribution to the SDGs”.

JST has included the following questionnaires in the interview survey of the LAPRAP Survey to access the QOL indicators.

- Household income and expenditure
- Access to social services (office, school, hospital, shopping centre, etc.)
- Current satisfaction level of QOL (access to bus stop, office, school, hospital, shopping centre, housing conditions, traffic safety, green environment, air pollution, noise, etc.)
- Importance of QOL items (transport, job opportunities, education, health/medical care, shopping, amusement / travel, housing conditions, traffic safety, green environment, air pollution, noise, etc.)

The interview survey was successfully conducted with a total of 240 residents, 10 at each station and the gender equality of five males and five females was maintained. The results are currently under analysis, and the initial observations are found as follows:

- While the respondents answered they were satisfied with the access to bus stop, office, school, hospital/clinic, shopping centre and movie theatre, they were not satisfied with the parameters such as traffic safety, green environment, air pollution and noise.
- It was observed that about 80-90% of respondents had positive response towards the Patna Metro Rail Project.
- According to their opinion, the city is facing the problem of heavy traffic congestion, noise pollution due to continuous vehicular movement and honking, vehicular pollution, road accidents due to heavy traffic.
- Respondents are positive about the metro fare as the auto drivers' fare are not fixed and they demand high fare rates. With the Metro project, the rates for travelling will be fixed and affordable.
- Respondents are expecting job opportunities in the Metro project during the construction and operational phase

The Proposed Metro Project will help to improve the QOL indicators of respondents through the improvement of transportation conditions in the City.

22.4 Clean Development Mechanism (CDM)

22.4.1 What is CDM?

The Clean Development Mechanism (CDM) is a system that supports efforts to reduce CO₂ emissions implemented by developing countries with funds and technology from developed countries and shares the benefits caused by achieved emission reduction between both countries. It is one of the "Kyoto Mechanisms" included in the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) and is stipulated in Article 12 of the Kyoto Protocol.

In 2016, the Paris Agreement, a new framework replacing the Kyoto Protocol for GHG emission reductions from 2020, was adopted at COP21 in Paris. The new framework has set a long-term common global goal for holding the increase in the global average temperature to well below 2 degrees above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 degrees above pre-industrial levels¹.

22.4.2 Activities in Delhi Metro

In 2007, DMRC was the world's first railway and metro operator to be approved for inclusion in the CDM list by the United Nations. DMRC has sold 4.41 million carbon credits since 2007 through the activities listed below.

Table 22-1 CDM conducted by DMRC

Project No.	Contents	Amount of Reduced CO ₂	Calculation Period	Issuance Institute
Project No. 1351	Installation of low GHG emitting rolling stock in Metro System	541,613	2007-2017	UNFCCC
Project No. 4463	Modal shift	3,835,703	2011-2018	UNFCCC
ID.GS1246, ID.GS4636 ID.GS5204	Energy Efficiency measures	15,999	2012 - current	Gold Standard
Project No. 9863	MRTS PoA (Programme of Acitieis) Project	-	-	UNFCCC
	DMRC Solar PV Project	18,437	- 2018	UNFCCC

UNFCCC: United Nations Framework Convention on Climate Change

Source: Interview with DMRC staff and DMRC website²

Based on the interview with DMRC, the first project, "Installation of low GHG emitting rolling stock in the metro system," was traded with JCF (Japan Carbon Finance). The other projects are traded with the international carbon market; the carbon prices fluctuate over the years. Due to high demands for carbon products, carbon prices are not expected to decrease over the years unless a big financial crisis happens.

Regarding the latest information, the traded value in 2020 was 20 million carbon credits with 3.5 million INR (0.175 INR/ carbon credit), which is reported in the annual report of DMRC as shown below.

DMRC has sold the credit by themselves to interested international parties. Also, if the project is registered for PoA, the credit is traded directly to international interested parties.

¹ https://www.mofa.go.jp/ic/ch/page1we_000102.html

² <https://www.delhimetrorail.com/pages/en/corporate/clean-development-mechanism>

Table 22-2 Carbon Emission Reduced Units in 2020-2021

(₹ in Lakhs)

Position as at Particulars	Carbon Emmision Reduction (CER) Units			
	2020-21		2019-20	
	Quantity (Units)	Amount	Quantity (Units)	Amount
Opening Balance	3337930	450.27	2156644	257.42
Purchase / (Transfer)	223172	41.48	1181286	192.85
Sale / Lease	15000	6.55	-	-
Closing Balance	3546102	485.21	3337930	450.27

Source: Annual Report 2020-2021, Delhi Metro

According to DMRC staff, the transaction of DMRC had been conducted based on the Kyoto Protocol, expired in 2020, and is in a transition period for the Paris Agreement signed in 2015 at COP21. As a result, it is possible to apply for CDM, but new projects will be registered as “provisional registration”. It is unclear about the Paris Agreement methodology, but not many changes are assumed as the methodologies are well established.

22.4.3 Applicability in Patna Metro

Through the interview with DMRC staff, possible CDM approaches to Patna Metro are assessed as follows. As explained, Project No. 1351 has already been applied for a new metro project since the activity is already in the PoA (Programme of Activities) Project. Also, energy efficiency projects require “before” and “after” indicators. Therefore, it is not possible to apply through a green-field project. Other projects have already been or will be considered by PMRCL with support from DMRC.

Table 22-3 Applicability of CDM Projects for Patna Metro

Project No.	Contents	Applicability for Patna Metro
Project No. 1351	Installation of low GHG emitting rolling stock in Metro System	<ul style="list-style-type: none"> The technology is applied to the rolling stock of Patna Metro. While it is registered as a “new technology” for DMRC, it has been applied in other metro projects, so the emission reduction is already included in the PoA project.
Project No. 4463	Modal shift	<ul style="list-style-type: none"> In DMRC, the modal shift project has been the most profitable; while it expired in 2018, the new baseline data was obtained after the COVID and will start again.
ID.GS1246, ID.GS4636 ID.GS5204	Energy Efficiency measures	<ul style="list-style-type: none"> There are two possible projects; LED Lighting at Station and Variable Voltage Variable Frequency Drive. The two projects are related to energy efficiency, requiring “before” and “after” indicators. As the Patna Metro is a green-field project, it is not possible to measure the comparison of “before” and “after” indicators.
Project No. 9863	MRTS PoA Project	<ul style="list-style-type: none"> DMRC can provide consultancy services to Patna Metro for CDM registration on a fee basis, including applying PoA (Programme of Activities). After issuing the LOA to DMRC by Patna Metro, approximately 6-8 months will be required to complete the assignment.
	DMRC Solar PV Project	<ul style="list-style-type: none"> It is possible to apply this to the Patna Metro Project. As per Patna Metro DPR, the expected peak solar power generation of 50 kwp for each elevated station and 2000 kwp for the maintenance depot is considered. Therefore, a total of 2.6 mwp from solar is planned as there are 12 elevated stations and one depot in Patna metro. Considering 100-120 w/sqm of solar generation, the required area of a solar panel is approximately 2166-2600 sqm.

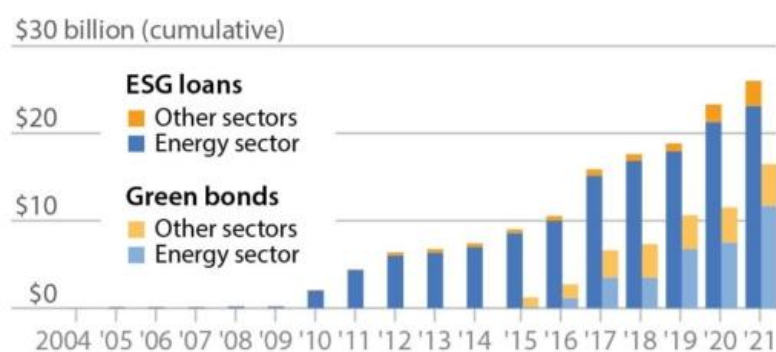
Source: Interview with DMRC and PMRCL

22.5 Environmental Social Governance (ESG) Investment

22.5.1 Trends and Applicability in India

(1) Trends in India

According to the research firm Bloomberg NEF, global ESG investments exceeded 1.6 trillion USD in 2021, more than double the amount in 2020. In India, ESG loans, mainly in renewable energy projects, are approximately 25 billion USD, and green bonds outstanding are approximately 15 billion USD.



Source: BloombergNEF

Figure 22-1: Outstanding ESG Investments in India

More than 70% of green bonds target renewable energy projects. With the issuance of a 500 million USD green bond by Indian Railway Finance Corporation Limited (IRFC), a subsidiary of the Ministry of Railways, in December 2017, further ESG investments are expected in the transportation sector. IRFC has developed a Green Bond Framework compliant with the Climate Bond Standards (CBS) set forth by the Climate Bond Initiative (CBI), and the table below outlines the green bonds issued by IRFC.

Table 22-4 Outline of IRFC Green Bond

Items	Contents
Issued Amount	500 million USD
Period	10 Years
Interest	3.835%
Usage	<ol style="list-style-type: none"> Freight dedicated railway line*1 <ul style="list-style-type: none"> All infrastructure, infrastructure upgrades, and freight rolling stock (locomotives, coaches, wagons, trucks, flats, EMUs, containers, cranes, trolleys, and other rolling stock components) for electrified freight lines All infrastructure, infrastructure upgrades, and freight rolling stock for non-electrified projects that meet freight transport thresholds (25 gCO₂ per ton-km) Public passenger railway transport <ul style="list-style-type: none"> All infrastructure, infrastructure upgrades, and rolling stock of electrified railways All infrastructure, infrastructure upgrades, and rolling stock of non-electrified projects that meet the passenger transport threshold (50 gCO₂ per passenger-km)

*1: Infrastructure and rolling stock on freight-only rail lines built for the primary purpose of transporting fossil fuels are excluded.

(2) Applicability for Metro Projects in India

The Government of India proposes to issue sovereign green bonds for the first time this year. The bonds will mobilize resources for green infrastructure deployed in public sector projects to reduce the economy's carbon intensity.

In the future, it can be proposed that a financial corporation specializing in urban transportation be established under the MoHUA, and a part of the funds raised through green bonds issued by this corporation be used for maintenance and upgrading for the next phases of Patna Metro. Through the interview with DMRC, though they are interested in the green bond, it will be the decision of MoHUA since DMRC follows guidelines MoHUA. DMRC is aware that the financial institution under the Ministry of Railway raised the green bonds, which attracted a lot of institutional investors.

22.5.2 Information Disclosure on ESG Investments

Security and Exchange Board of India (SEBI) announced that the top 1000 listed companies (based on market capitalization) are required to submit the Business Responsibility and Sustainability Report (BRSR) relevant to project accountability and sustainability. The sample items disclosed on ESG investments are shown below.

Table 22-5 Sample Items of Information Disclosure on ESG Investment

Categories	Items
General	<ul style="list-style-type: none"> ESG risks and opportunities, risk reduction, financial impact assessment
Environment	<ul style="list-style-type: none"> Resource consumption amount GHG emission amount Waste management Low energy certificate (PAT scheme)
Social	<ul style="list-style-type: none"> Workers' and laborers' condition Community consideration Consumer measures
Governance	<ul style="list-style-type: none"> Roles of the board of directors Action principals

Source: SEBI

As there is a growing international demand for non-listed companies to disclose information on decarbonization to promote corporate decarbonization activities, it is possible to suggest that the DMRC and PMRCL proactively address the above information disclosure since the activities related to the information disclosure by DMRC are not found as of now.

To the suggestion by JST, DMRC and PMRCL replied that they follow the guidelines as they do in CDM, so JST will have to discuss and receive comments from MoHUA if there is a requirement to change the current information disclosure system.

23. Implementation Plan

23.1 Tender Packages (N/A)

23.2 Procurement Plan for Materials, Machines, and Equipment (N/A)

23.3 Project Implementation Schedule (N/A)

23.4 Responsibility of Project Executing Agency

23.4.1 Construction Safety Management

For construction safety management, non-JICA packages refer to DMRC's safety manual, while PMRCL agreed to use JICA Standard Safety Specification (JSSS) for the project. Following JSSS requests PMRCL to allocate more resources to safety management than other projects as described in Attachment 16 Construction Safety Management under JSSS.

While establishing its organization, PMRCL has not employed the general manager (safety) and other staff in charge of construction safety management. PMRCL will hire an independent consultant consisting of 18 to 20 local experts to monitor DMRC's performance as the implementing agency. The scope of the independent consultant includes construction safety management, which helps PMRCL meet an acute project management demand while many construction activities are happening.



Source:JST

Figure 23-1: Construction Depot Status for PC-04

23.4.2 Land Acquisition

Chapter 15 Social Impact Assessment mentions the legal framework for the land acquisition process. Whereas the physical arrangement relating to construction works is described in this section.

(1) Construction Depot

PMRCL prepared the land acquisition drawing, including for construction depots. The construction depot for the underground civil contractor in Corridor-2 is sufficient using space in the college and stadium. The one for Corridor-1 seems less than required. The contractors for PC-05 and 06 will need to initiate a temporary land use agreement with landowners immediately after the Letter of Acceptance issue.

(2) Casting Yard

Information about existing casting yards rendered to PC-01 and PC-04 contractors refers to Sub-chapter 5.4.2 (2) Construction. PMRCL will arrange the yard for PC-05 and 06 though they have not finalized the location yet.

(3) Muck Disposal Site

The PC-01 Contractor identified a muck disposal site near New ISBT. The site belongs to a farmer, and the contractor disposes of much for free. The land along the road is 3-4 meters below the road. Hence, the landowner does not claim any fee considering the preparation of the future land development. PMRCL will arrange muck disposal sites for PC-05 and 06 Contractor though they have not finalized the location yet.



Source: JST

Figure 23-2: Muck Disposal Site for PC-01

23.4.3 Transferring PAP

Please refer to Chapter 15 Social Impact Assessment.

23.4.4 Relocating Obstacles

(1) Utility Diversion

PMRCL hired the contractors apart from the main civil contractors to divert power lines over the road for both corridors. Concerning underground utilities, the civil contractors should divert or suspend during the contract after permission from utility owners. However, it does not seem to take material time to get it (one week or so), according to an interview with PC-01 & 03 Contractor and DMRC. PMRCL prepared

underground utility identification drawings for both corridors.

(2) Tree Cut / Replantation

PMRCL already got permission to cut trees affected by construction works from Forest Department/ Municipal Authorities. However, contractors may need to cut more trees in line with their construction methodology as the area for the construction depot seems limited, as mentioned in Sub-chapter 5.4.2 (2) Construction.

23.4.5 Obtaining Permissions

Permissions PMRCL and the contractors should take from local relevant authorities for construction activities are summarized as followings.

Table 23-1: Permission Required for Construction

Permission Type	Authority	Responsibility
Working on Roads	Road Construction Department	Contractor
Traffic Diversion	Traffic Police	Contractor
Utility Diversion	Utility Owners	Contractor
Railway Crossing	East Central Railway	PMRCL

Source: JST

(1) Traffic Diversion

The contractors should get no objection from local traffic police for road diversion and temporary road occupation. No objection needs even for preparatory works like geotechnical investigation, and the contractors should focus on the application first. PMRCL will not physically support the contractors as other metro projects in India.

(2) Railway Crossing

PMRCL got permission from East Central Railway to underpass at-grade and elevated live railway lines with conditions where clearance from metro tunnels is fixed, and the contractors should monitor the rail level during the construction. The contractors should get approvals for detailed working plans before the construction. The general permission from Indian Railway is good momentum for the project execution, while the approval from Indian Railway usually takes material time.

23.4.6 Empowerment for Women and the Needy

Regarding gender consideration, PMRCL should take care of it for (i) station design, (ii) employment during the O&M phase, and (iii) provision of lady's car, which are described in Sub-chapter 15.13.2 Consideration on Gender.

The JST acknowledged that Indian Rail offers a discounted tariff for Scheduled Castes, Scheduled Tribes, and Differently Aabled Persons. PMRCL may want to refer to the scheme.

23.5 Measure against COVID-19

The government of India and the Bihar State government do not impose any restrictions relating to

COVID-19 now. Even when the situation is the worst in May 2021, the mortality rate due to COVID-19 (3 persons per million per day) was much lower than in G7 countries except for Japan.

During the pandemic, the central government developed an app called Aarogya Setu and instructed to check travelers' possible infection status at gates where people get together like shopping malls, offices, and stations. In addition, the central government established the online vaccination portal called Co-Win where people easily make an appointment to get vaccinations and maintain the record of vaccines taken in. People, including foreigners, register their individual number (Aadhaar number) in the Co-Win, so the individual data is linked to the specific person, which makes monitoring vaccine status easier.

The Contractors in this project get all workers vaccinated (at least two doses). The cost of one vaccine shot is around 2-300 Rs. (about 400JPY), though the price fluctuates. The cost of vaccination will not be a significant additional burden for the contractors.

23.6 Organization during Construction

As Patna city develops, PMRCL creates its organization and expands its functionality. PMRCL agreed with DMRC that DMRC takes total care of the metro implementation, including potential O&M engagement. Accordingly, DMRC, on behalf of PMRCL, is managing the preceding contract packages in Corridor-1 and 2. Unlike a pure government entity, PMRCL is a special purpose vehicle (SPV) that does not always continue its role and responsibility for the future. PMRCL should consider its future operational vision to expand its organization while labor-related issues are challenging all over India. That is, whereas the construction has started and will end in four years, PMRCL should judge if (1) they can quickly establish a capable team catering to the metro project and (2) it is reasonable to dissolve the incubated team in four (plus some) years.

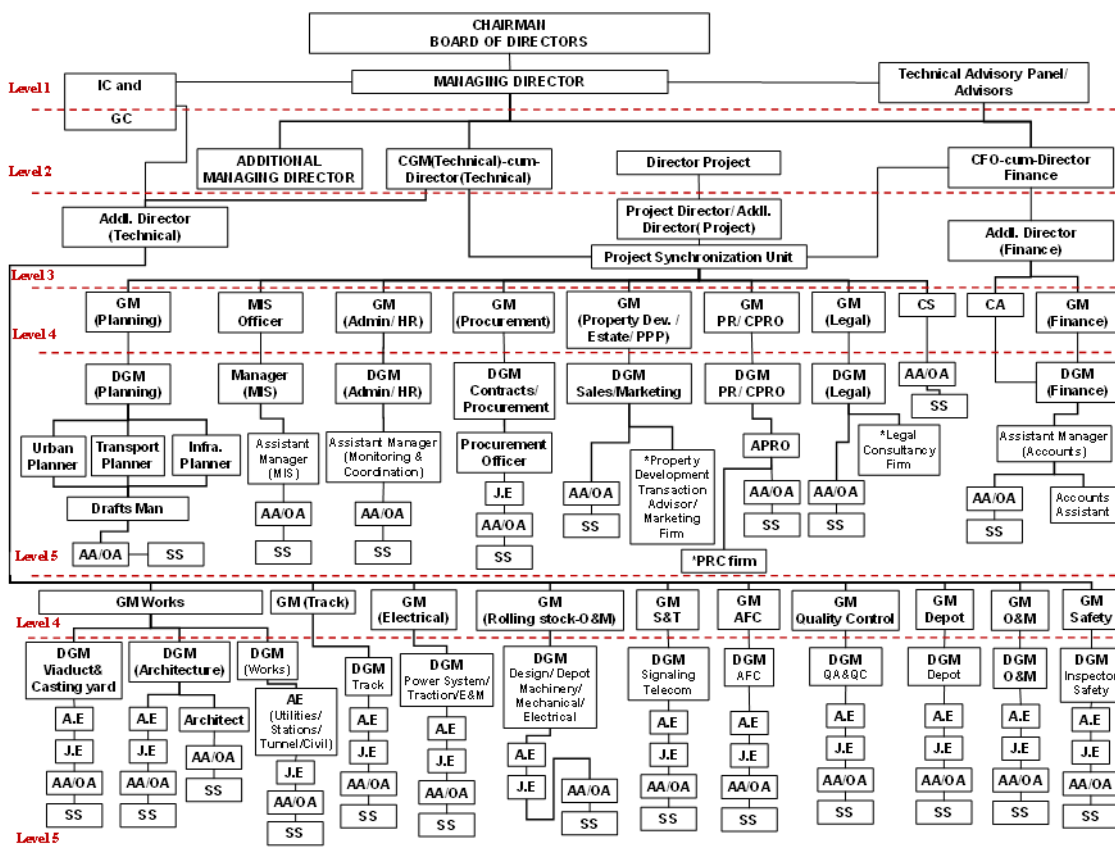
There may be an option where PMRCL concentrates on legal, financial, and administrative tasks they have to deal with as an SPV while subletting technical activities to DMRC and others that PMRCL may employ from the market. PMRCL may not have to duplicate the process DMRC underwent a couple of decades ago. Through this concentration, PMRCL can save effort and cost significantly.

23.6.1 PMRCL organization structure

PMRCL was established on February 19, 2019, to implement the Patna metro project. It appears that 188 posts in the Patna Metro Company, as shown in the following table and figure, have been approved by the Bihar Urban Development and Housing Authority.

Of these, 30 posts of urgent need will be filled immediately and the remaining posts will be filled from time to time as per the requirement.

Since PMRCL does not employ any special staff for EIA and SIA currently, some engineers from other sectors also have responsibility for EIA and SIA. Therefore, JST will propose to PMRCL to actively hire some staff according to the scale and progress of the project. As an example of DMRC, there was a few staff for EIA and SIA when inaugurated, but currently there are dozens of staff in the sector by hiring staff little by little every year.



Source:PMRCL/DMRC

Figure 23-3: Organization Structure of PMRCL

Table 23-2: PMRCL Organizational Structure Chart

No.	Name of Post	Number of Post
1	MANAGING DIRECTOR (MD)	1
2	Additional Managing Director(AMD)	1
3	Chief General manager(Technical) cum-Director Technical	1
4	Director Project	1
5	Chief finance officer –cum-Director -finance	1
6	Additional director (Technical)	1
7	Project director –cum-Additional Director (project)	1
8	Project Synchronization Unit (1.Deputy in charge, 2.Project coordinator and Liaisoning Officer, 3.Planner/scheduler-system)	3
9	Addl. Director(Finance)	1
10	GM (Planning)	1
11	MIS Officer	1
12	GM (Administration &HR)	1
13	GM(Legal)	1
14	GM (Property development/Estate/PPP)	1
15	GM PR/CPRO	1
16	GM(Legal)	1
17	CS(Company secretary)	1
18	CA(Chartered Accountant)/CA Firm	1
19	General manage (finance)	1
20	GM Works	2
21	GM Track	1
22	GM Electrical	1
23	GM Rolling Stock-O&M	1
24	GM S&T	1

No.	Name of Post	Number of Post
25	GM Automatic Fare Collection (AFC)	1
26	GM Quality Assurance and Quality Control	1
27	GM Depot	1
28	GM Operation & Maintenance	1
29	GM Safety	1
30	Deputy general manager Planning	1
31	Manager MIS	1
32	Asst. Manager-MIS	1
33	Deputy General Manager(Admin/HR/Project)	1
34	Deputy General manager(Contracts/Procurement/)	1
35	Deputy General manager(Sales & Marketing)	1
36	Deputy General manager PR	1
37	Deputy General manager(Legal)	1
38	Deputy General manager(Finance-Foreign-Indian currency)	1
39	Deputy General manager Viaduct and Casting Yard	1
40	Deputy General manager(Architecture)	1
41	Deputy General manager Works	3
42	Deputy General manager Track	1
43	Deputy General manager (Power station, Traction, E&M)	3
44	Deputy General manager-Rolling stock (1.Design, 2.Depot Machinery, 3.Mechanical, 4. Electrical)	4
45	Deputy General Manager Signaling And Telecommunication	1
46	Deputy General manager AFC	1
47	Deputy General Manager Quality Assurance and Quality Control	1
48	Deputy General Manager Depot	1
49	Deputy General Manager Operation and Maintenance	1
50	Deputy general manager Safety	1
51	Urban Planner	2
52	Transport planner	2
53	Infrastructure Planner	1
54	Asst. Manager-admin(Monitoring& Coordination)	2
55	Procurement Officer	1
56	APRO	1
57	Asst. Manager Finance	1
58	Architect	1
59	Asst. Engineer (Utilities, Stations, Tunnel, Viaduct)	4
60	Assistant engineer	19
61	Section Engineer/J.E	20
62	Drafts Man	1
63	PPS	1
64	PS/PA	5
65	Stenographer(English/Hindi)	8
66	Accounts Assistant	1
67	Administrative Assistant –Office Assistant (AA-15.OA-14)	29
68	Supporting Staff	29
	Total	188

Source: PMRCL/DMRC

For the construction and O&M of the Patna Metro, a Memorandum of Understanding (MOU) has been signed between DMRC and PMRCL, which states that the bidding and contracting for procurement of civil works and system services required for the project and the implementation of the works will be carried out by DMRC on behalf of PMRC.

It is noted that if PMRCL so desires, DMRC may operate and maintain the project until PMRCL has made adequate O&M arrangements.

The following table shows the composition of PMRCL's board of directors, which consists of the Ministry of Housing and Urban Affairs (MoHUA) of the Government of India and relevant departments of the Bihar State Government involved in the decision-making process of PMRCL.

Table 23-3: List of Board Members/Directors of PMRCL (24.05.2022)

S.N	Name	Designation	Nomination
1	Shri. Surendrakumar Bagde, Additional Secretary, Ministry of Housing & Urban Affairs, Government of India	Chairman	Nominee Director, GoI
2	Shri. Anand Kishor, Principal Secretary, Urban Development & Housing Department, Government of Bihar	Managing Director	Nominee Director, GoB
3	Shri. Jaideep Joint Secretary, Ministry of Housing & Urban Affairs, Government of India	Director	Nominee Director, GoI
4	Shri. Mahesh Kumar Director (Project), Maharashtra Metro Rail Corporation Ltd	Director	Nominee Director, GoI
5	Shri Ajit Kumar Jha, ED/CE (G), Railway Board, Ministry of Railways, Government of India	Director	Nominee Director, GoI
6	Shri. Mahendra Kumar Director (Electrical), National Capital Region Transport Corporation Limited	Director	Nominee Director, GoI
7	Smt. Shailaza Sharma Addl. Secretary Road Construction Department, Government of Bihar	Director	Nominee Director, GoB
8	Shri. Satish Kumar Singh Special Secretary, Urban Development & Housing Department, Government of Bihar	Director	Nominee Director, GoB
9	Shri. Mithilesh Mishra, Additional Secretary, Finance Department, Government of Bihar	Director	Nominee Director, GoB
10	**Vacant Joint Secretary, Transport Department, Government of Bihar	Director	Nominee Director, GoB

Source: PMRCL/DMRC

23.6.2 Technical support

PMRCL gets overall technical support from DMRC based on the contract. PMRCL, with JICA's assistance, should define demarcation between DMRC and JICA's general consultant at the execution stage. PMRCL needs to judge if they foster its team to perform as the Employer by themselves or delegate its responsibility to DMRC while DMRC does not fulfill as GC for the JICA portion.

23.6.3 The necessity of technical support during construction

PMRCL should draw its vision after Corridor-1 and 2 construction. While the organic growth can generate valuable intangible assets, PMRCL might waste those assets unless the growth path matches the vision. As the JST acknowledges that PMRCL does not have a plan to expand its operational network and the time left to form a capable team is short, the JST suggests PMRCL should capitalize on DMRC engagement to streamline team building.

23.7 Proposed Terms of Reference for Consultant (N/A)

24. Operation and Maintenance (O&M)

24.1 Overview of Existing Studies

24.1.1 Organization Structure

As shown in Section 23.6, at PMRCL, only urgent posts are currently being filled and the remaining posts will be filled from time to time as per the requirement. Regarding O&M, it is noted that if PMRCL so desires, DMRC may operate and maintain the project until PMRCL has made adequate O&M arrangements. However, JST shall make suggestions on the preferred structure for PMRCL to perform its own O&M in **Section 24.2.2**

In the operation and maintenance of PMRCL, it is considering outsourcing housekeeping and some part of maintenance (ticketing, parking, security and allied services, maintenance of lift and escalators, and maintenance of E&M assets), but most work will be performed directly by PMRCL without outsourcing. Therefore, in considering the O&M structure and number of personnel, calculations will be made based on this assumption.

24.1.2 Contents of O&M Service

(1) Number of personnel required

In DPR, the number of personnel required for O&M is estimated at 35 persons per line kilometer, including 8 HODs, 72 Dy HODs, 48 AM/Managers, 470 supervisors, and 588 Non supervisors, for a total of 1,138 persons, but these are indicative of the scale and the exact number has not been determined at this time.

(2) O&M expenses (N/A)

24.2 Reviews of Existing Studies and Proposals for Improvement

24.2.1 Training

(1) General

The DPR does not specifically mention the training of Patna Metro personnel or its agencies.

In the Memorandum of Understanding (MOU) between DMRC and PMRCL, it is mutually agreed that several engineers will be sent to DMRC for on-the-job training and that DMRC will be responsible for training PMRCL staff from the design to the implementation and commissioning of the project.

DMRC has a state-of-the-art training facility called Delhi Metro Rail Academy (DMRA) at SHASTRI PARK depot to provide customized training on all matters required by MRTS (O&M, projects, planning and implementation), where DMRC's It is already being utilized to train not only the staff but also other Metro staff and has sufficient capacity to accommodate PMRCL trainees.

(2) Contents of Training

The following training has been conducted in DMRC. We believe that similar training should be conducted in PMRCL as well. In addition to the contents of the table below, it is preferable to specifically take out and provide training in one area in addition to the contents of the table below, since ensuring safety is extremely important in all areas in railway companies.

1) Executives

DMRC provides customized training for the executives of the metro systems as shown in the following table, which indicates that it can organize customized training programs on various subjects related to metro technology.

Table 24-1: Fields of training for executives

No	Field
1	Signalling system
2	Telecommunications system
3	Automatic fare collection (AFC) system
4	Electrical systems
5	Traction system
6	Tunnel ventilation system
7	Tracks
8	Rolling stock
9	Train operations
10	Metro planning
11	Finance management
12	Construction technology

Source: PMRCL/DMRC

2) General workers

. DMRA primarily provides training for the operations listed in Table 24-3

Table 24-2: Category and occupation

Department	Category of staff	Occupation
Train operation	Station controller	Responsible for station management, revenue collection, crowd management, operating the train control system from the station control room
	Train operator	Responsible for driving the train in accordance with the train control system, troubleshooting in the train when required, manually operating (limited mode) the train in case of any failure
	Customer relations assistant	Representative of the customer care centre at every station Responsible for revenue related activities (ticketing), customer care, crowd management at the stations as the frontline staff directly dealing with passengers
Rolling stock	Supervisor (Junior engineer)	Responsible for supervising the technical servicing of rolling stock as a technical supervisory level staff
	Maintainer/fitter	Responsible for maintenance of rolling stock under close supervision of the concerned JE

Department	Category of staff	Occupation
Signalling	Supervisor (Junior engineer)	Responsible for supervising the technical services of signalling as a technical supervisory level staff
	Maintainer/fitter	Responsible for maintenance of signalling under close supervision of the concerned JE
Telecommunications & AFC	Supervisor (Junior engineer)	Responsible for supervising the technical services of telecommunications & AFC as a technical supervisory level staff
	Maintainer/fitter	Responsible for maintenance of telecommunications & AFC under close supervision of the concerned JE
Electrical & mechanical service	Supervisor (Junior engineer)	Responsible for supervising the technical services of electrical & mechanical service as a technical supervisory level staff
	Maintainer/fitter	Responsible for maintenance of electrical & mechanical service under close supervision of the concerned JE
Civil engineering	Supervisor (Junior engineer)	Responsible for supervising the technical services of civil engineering as a technical supervisory level staff
	Maintainer/fitter	Responsible for maintenance of civil engineering under close supervision of the concerned JE

Note: Unlike a general Japanese railway, DMRC considers station controllers and train operators as the same job category and exchanges their staff periodically.

Source: JST based on DMRC data.

(3) Training duration

The standard training periods are shown Table 24-4

Table 24-3: Occupation Wise Training Duration

	Occupational category		Training period (week)			Notes
			Total	School	Practice	
A	Station controller	Train operator	30	26	4	3 signal types, 3 rolling stock types for newcomers
B	Train operator (Limited license)		19	15	4	1 signal type, 1 rolling stock type for newcomers
C	Station controller (Limited license)		14	-	-	
C	Signal maintenance	Supervisor	20	20	-	for newcomers
		Maintainer	17	17	-	
D	E&M maintenance	Supervisor	24	24	-	
		Maintainer	16	16	-	
E	Track maintenance	Supervisor	19	19	-	
		Maintainer	17	17	-	
F	Rolling stock maintenance	Supervisor	19	19	-	
		Maintainer	17	17	-	
G	OCC	Train dispatcher	3	3	-	for experienced station controllers & train operators

Source: PMRCL/DMRC

Of these, drivers, in particular, require a relatively long training period, so appropriate employment timing and training plans need to be planned well in advance. Table 24-5 shows the number of drivers required in the horizon year for the train operation plan described in Section 8.2 (See 24.2.2(2)2) for calculation of the required number of drivers.)

Table 24-4: Number of drivers required in horizon year

	2024	2031	2041	2051
Corridor-1	46	56	55	61
Corridor-2	36	45	48	54
TOTAL	82	101	103	115

Source: JST

As shown in the table above, PMRCL needs to train at least 82 new drivers by the time it opens for business. As shown in Table 24-3, driver training takes as long as 30 weeks, so it is necessary to make a recruitment plan well in advance. PMRCL plans to begin recruiting 18 months prior to the opening of the new train, which should not present any problems.

(4) Equipment required for training

DMRA was established in December 2002, five months before DMRC's first metro section opened, and currently has 25 classrooms with a capacity of 904 students. It has 32 simulator rooms and 11 demonstration rooms for operation and maintenance training, and 62 faculty members. It has already provided training to more than 45,000 DMRC employees and more than 3,000 employees of other metros, including overseas metros, and in addition to training for general employees, it also provides management capacity building and advanced job skills acquisition training for mid-level executives. In addition, mid-to high-level executives are trained to improve their management skills at the Management Development Institute (DMI), which has a partnership relationship with DMRC.



Source: <https://dmra.delhimetrorail.com/about.html>

Figure 24-1: Exterior View of DMRA

This training institute is equipped with the following facilities to provide practical training.

Table 24-5: Facilities of DMRA

- | |
|--|
| <ol style="list-style-type: none"> 1. Classrooms 2. Driving Simulators |
|--|

3. Trouble-Shooting & Maintenance Simulators
4. Automatic Train Supervision [ATS] Simulator
5. CBT (Computer Based Training)
6. Traction Demonstration & OHE Yard
7. Escalator Model Room
8. Elevator
9. 33 KV Circuit Breaker Model Room
10. Civil Engineering Demonstration Room
11. True Scale Tunnel Model
12. Rigid Overhead Conductor System (OHE in Tunnel)
13. ECS/TVS Model Room
14. Operation Demonstration Room
15. S & T Demonstration Room
16. Library
17. Auditorium
18. Computer Labs
19. Tele-Presence Room
20. Training Management System (TMS)
21. Hostel and Guest House
22. Canteen
23. Holistic Development (Morning Assembly, Yoga & Meditation, Gymnasium)
24. Academy Magazine

Source: DMRC

It has been decided that the PMRCL staff training required for the opening will be conducted through DMRA, but after the opening of the PMRCL, it is expected that on-the-job training will be mainly conducted through daily operations. However, it will be necessary to accept a certain number of new employees each year in order to increase the number of employees due to the increase in transportation capacity in response to the increase in the number of users, and to fill vacancies caused by retirements. The number of personnel required by PMRCL is estimated to be 1138, and even if they are replaced every 25 years or so, the number of new trainees is expected to average about 45 per year for the entire company in total, and at this personnel size, it would be inefficient to secure a training organization and many instructors, etc. on its own.

As for drivers, a large number of new trainers will need to be trained at once just before 2031, 2041, and 2051, when the transportation capacity is scheduled to be increased, respectively, but the number is very small compared to the number at the time of opening.

On the other hand, since PMRCL is similar in many areas to other metros in India in terms of the technology and mechanisms used, and therefore the content to be trained is expected to be generally the same, it is realistic to expect that the existing training facilities in India will continue to be used for much of the curriculum.

In the case of setting up their own training facilities, it would be necessary to devise ways to make effective use of the facilities, such as actively accepting outside trainees, as in the case of DMRA, by regarding training as a form of non-railway business income business.

24.2.2 O&M Structure

(1) Organization Structure

The DPR contains only the current organizational structure of PMRCL and a rough estimate of the size of future manpower requirements.

Therefore, we will examine and propose an appropriate organizational structure for O&M of PMRCL by organizing examples from India and other Southeast Asian countries.

1) General organization structure

Generally, the operating organization of a railway company is structured based on the scale of railway operations and other factors, taking into consideration the system of responsibility (job description), chain of command, and efficient operation. The general organizational structure of a railway company is divided into two parts: non-current divisions that operate and manage the corporate organization, such as general affairs, human resources, and accounting, and current divisions that perform actual operations and maintenance. The general organizational structure is shown in Figure 24-2

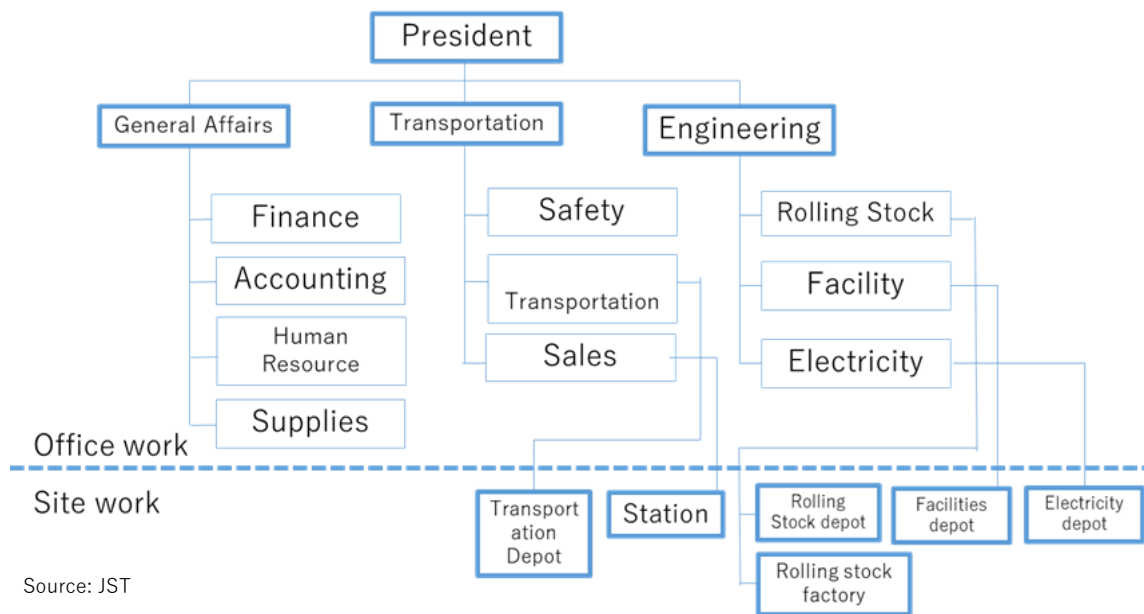


Figure 24-2: General Organizational Structure of Railway Companies

The posts that PMRCL has prepared at the present time, as summarized in Section 23.6, cover each of the organizations shown in Figure 23-3, and the members assigned to these posts can be considered as the core of the O&M system after the opening of the business. Conversely, for those positions that are not fully staffed at this time, personnel should be secured as soon as possible so that they can be trained to become core members of each organization in time for the start of operations.

2) Points to focus on when considering organizational structure

The main points of focus in examining the organizational structure include the following;

- ✓ Whether the operations and maintenance departments should be part of the same organization
- ✓ Whether to place administrative departments such as finance and human resources under the

operations department or to make them independent.

- ✓ Whether to place the operations organization under the head office departments or to make it independent from them.
- ✓ Whether to place non-rail divisions under the O&M department or to make them independent.

The following is a summary of the possible options and their advantages and disadvantages in each of these focus points.

Table 24-6: O&M Departments

	Option 1 (O&M are consolidated.)	Option 2 (O&M are separated.)
Organization Chart	<pre> graph TD A[O&M Directorate] --- B[O&M Division] </pre>	<pre> graph TD A[O&M Directorate] --- B[Operation Division] A --- C[Maintenance Division] </pre>
Strengths	<ul style="list-style-type: none"> • Easier coordination across the operation departments and maintenance departments • Smaller number of personnel in total 	<ul style="list-style-type: none"> • More focus on their own roles
Weaknesses	<ul style="list-style-type: none"> • Less focus on their own roles 	<ul style="list-style-type: none"> • More difficult coordination across the operation departments and maintenance departments • Larger number of personnel in total

Source: JST

Table 24-7: Administrative Units

	Option 1 (Independent Admin. Dept.)	Option 2 (O&M units has their own Admin. units)
Organization Chart	<pre> graph TD A[Main Directorate] --- B[Construction Directorate] A --- C[O&M Directorate] A --- D[Finance & Admin. Directorate] </pre>	<pre> graph TD A[Main Directorate] --- B[Construction Directorate] A --- C[O&M Directorate] A --- D[Finance & Admin. Directorate] C --- E[O&M Admin. Department] </pre>
Strengths	<ul style="list-style-type: none"> • More efficient management of personnel and trainings, for the entire organization • More efficient budgeting and business planning for the entire organization • Smaller number of personnel in total 	<ul style="list-style-type: none"> • More efficient management of personnel and trainings for the O&M units • More efficient budgeting and business planning for the O&M units
Weaknesses	<ul style="list-style-type: none"> • Less efficient management of personnel and trainings for the O&M units 	<ul style="list-style-type: none"> • Less efficient management of personnel and trainings for the entire organization

	Option 1 (Independent Admin. Dept.)	Option 2 (O&M units has their own Admin. units)
	<ul style="list-style-type: none"> Less efficient budgeting and business planning for the O&M units 	<ul style="list-style-type: none"> Less efficient budgeting and business planning for the entire organization Larger number of personnel in total

Source: JST

Table 24-8: Worksites Reporting Structure

	Option 1 (Worksite offices are directly under the O&M Directorate)	Option 2 (Each worksite office is under the corresponding department in HQ)
Organization Chart	<pre> graph TD OMD[O&M Directorate] --- OD[Operation Division] OMD --- MD[Maintenance Division] OD --- Dep1[Departments] MD --- Dep2[Departments] Dep1 --- WS1[Worksites] Dep2 --- WS2[Worksites] </pre>	<pre> graph TD OMD[O&M Directorate] --- OD[Operation Division] OMD --- MD[Maintenance Division] OD --- Dep1[Departments] MD --- Dep2[Departments] Dep1 --- WS1[Worksites] Dep2 --- WS2[Worksites] </pre>
Strengths	<ul style="list-style-type: none"> Worksite offices can preserve its power and independency. Opinions from frontline (i.e. worksite offices) will reach directly to the final decision maker (i.e. O&M director). 	<ul style="list-style-type: none"> Total manpower may be reduced as head posts of department in HQ and worksite office can be combined. Hierarchical structures and chain of commands will become clearer.
Weaknesses	<ul style="list-style-type: none"> Total manpower may be larger. Hierarchical structures and chain of commands will become more complex. 	<ul style="list-style-type: none"> Worksite offices will be more dependent on departments in HQ. Opinions from frontline (i.e. worksite offices) will be buffered at departments in HQ before reaching to the final decision maker (i.e. O&M director).

Source: JST

Table 24-9: Location of Non-rail Business Unit

	Option 1 (Under O&M Directorate.)	Option 2 (Under Business Development Division)
Organization Chart	<pre> graph TD MD[Main Directorate] --- BDD[Business Development Division] MD --- OMD[O&M Directorate] OMD --- NRBU[Non-rail Business Unit] </pre>	<pre> graph TD MD[Main Directorate] --- BDD[Business Development Division] MD --- OMD[O&M Directorate] BDD --- NRBU[Non-rail Business Unit] </pre>
Strengths	<ul style="list-style-type: none"> Support from the O&M directorate 	<ul style="list-style-type: none"> Support from the business development division

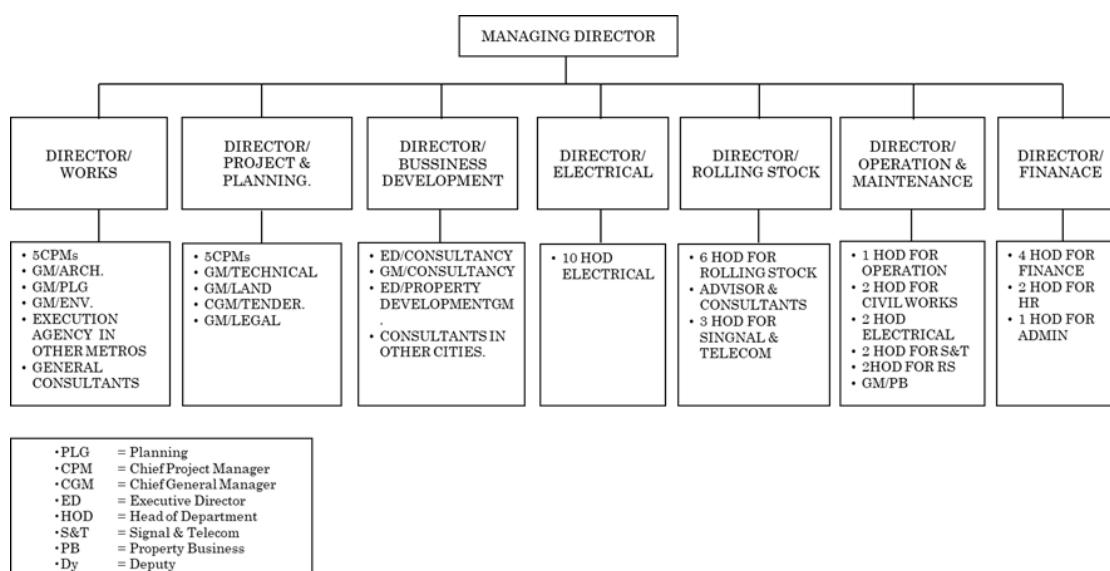
	Option 1 (Under O&M Directorate.)	Option 2 (Under Business Development Division)
	<ul style="list-style-type: none"> • Closer to the operation worksites in order to reflect the worksites opinions easily 	<ul style="list-style-type: none"> • To establish consistency in non-rail business among planning & strategy and the main directorate decision
Weaknesses	<ul style="list-style-type: none"> • Difficulty to establish close relationship with planning & development and daily operation in non-rail business 	<ul style="list-style-type: none"> • Heavy burden for the main directorate • Weaker connectivity with O&M directorate and daily operation worksites

Source: JST

Since each region has different circumstances, it is advisable to determine the organizational structure after carefully analyzing what is the best structure for that region with regard to the above issues.

3) Case study in India

Figure 24-3 shows the organizational chart of DMRC, which operates Delhi Metro, and the functions of each department.



Source: JST from materials received by DMRC.

Figure 24-3: Organization of DMRC

DMRC is comprised of seven divisions with a staff of approximately 13,500, of which approximately 12,800 are involved in O&M. Table 24-10 shows the divisions included in O&M department and the number of personnel involved.

Table 24-10: Number of personnel in DMRC's O&M department

Department	Number of Staff	managerial post				
		Executive	Sup	Non-sup	FH	
Operation	4,698	50	3,103	1,545		
Rolling Stock	2,618	82	750	1,786		
Equipment	E&M	1,402	30	356	1,016	
Electric	Traction	3,116	1,041	28	237	776

Department	Number of Staff	managerial post			
		Executive	Sup	Non-sup	FH
Signaling	1,102	29	325	748	
Telecommunication	973	29	286	658	
Civil	563	38	227	298	
General	Financial	69	23	46	
	Human Resource	33	10	23	
	Environment	13	7	6	
	Stores Development	96	15	36	15
	Security	23	6	15	2
Estate etc.	169	169			
TOTAL	12,800	347	5,410	6,844	30

Source: JST from materials received by DMRC.

At DMRC, operations and maintenance are grouped together as a single department, which includes administrative departments such as finance and human resources, as well as non-railway departments such as real estate and store development. The hierarchical structure and chain of command for each department is clear.

Figure 24-4 shows an organizational chart of the O&M department of BMRCL, which operates the Bengaluru Metro. Table 24-12 also shows the breakdown of personnel in the O&M department.

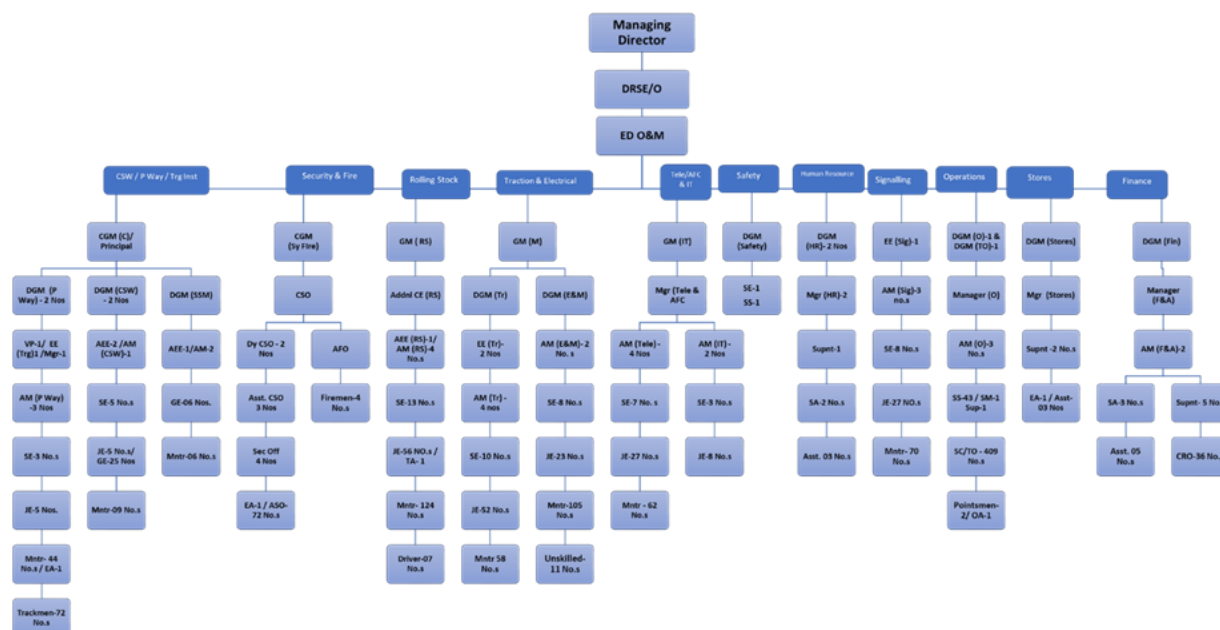


Figure 24-4: Organization of O&M Department of BMRCL

Table 24-11: Number of personnel in BMRCL's O&M department

Headquarters		On-site organization	
Financial	12	Operation	507
Human Resource	11	Civil	33
IT	14	Track work	98
Venue	7	Signal & telecommunication	209
Security	84	Electric Power	124
Store Development	34	Rolling stock	191

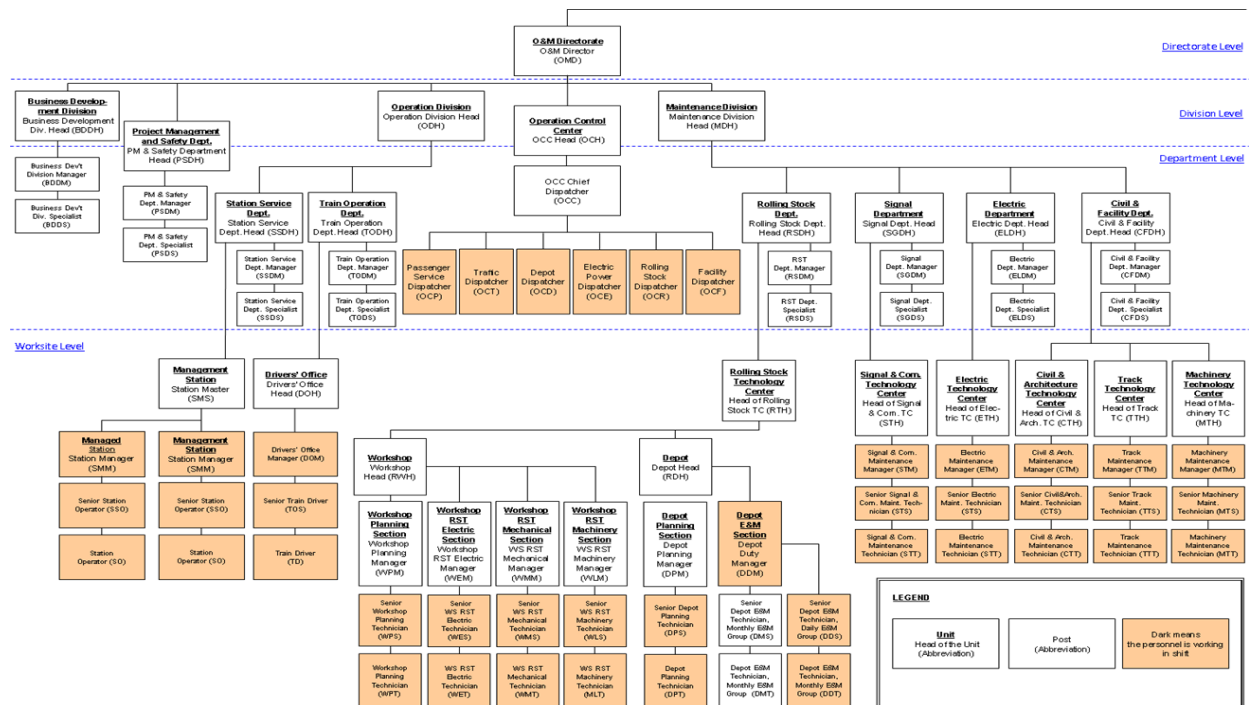
Headquarters		On-site organization	
Safety & others	8	E&M	132
TOTAL	170	TOTAL	1,294
Grand TOTAL		1,464	

Source: JST

In BMRCL, 1,464 employees (August 2020) belong to the O&M department, but as in DMRC, operations and maintenance are integrated, with administrative departments such as finance and human resources, and non-railway departments such as store development within this department. Also in BMRCL, the structure is such that the current business organization is placed under the head office functions.

4) Case Study in Indonesia

Figure 24-5 shows an organizational chart of MRTJ, which operates MRT in Indonesia.



Source : JST

Figure 24-5: Organization of O&M Department of MRTJ

In MRTJ, as in DMRC and BMRCL, operations and maintenance are integrated, and non-railway departments such as store development exist within these departments. In addition, in each department, the structure is such that the current business organization is placed under the head office function.

However, administrative departments such as human resources and finance are not under O&M department, but exist as independent organizations outside O&M department. This is because MRTJ is the first metro in Indonesia and is still a young organization, so the first priority was placed on efficient financial and human resource management.

5) Organizational structure recommended in PMRCL

Since India already has a track record of stable subway operations in many cities, we believe that it is desirable for PMRCL to adopt the same organizational structure as DMRC and BMRCL. Figure 24-6 shows a framework image of the proposed organizational structure. In addition, Table 24-13 shows the proposed major division of duties for each organization.

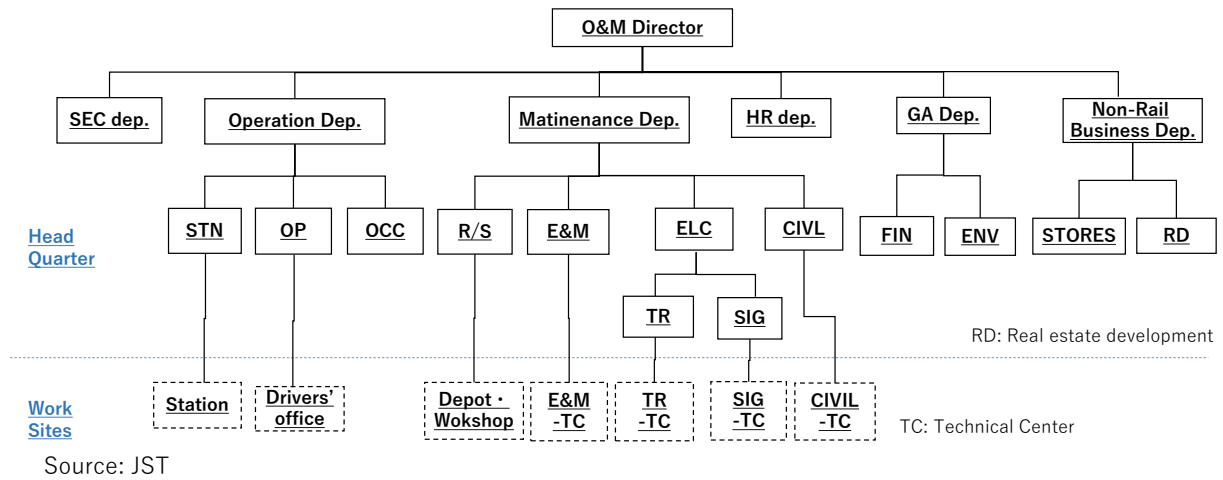


Figure 24-6: Organizational structure that we propose for PMRCL

Table 24-12: Proposed Major Segregation of Duties in PMRCL's O&M

Department/Division		Proposed Major Duties	
Head Quarter	Safety & Security department	Safety and cross-sectional technical management	
	Operation Department	Station affairs	Management of station operations
		Operation	Timetabling & Crew Scheduling
		OCC	OCC operations, operations management, signal handling, etc.
	Maintenance Department	Rolling Stock	Design management and maintenance planning of rolling stocks
		E&M	Maintenance plans for track and civil engineering structures
		Electric	Maintenance plans for power, signalling and telecommunications equipment, and station machinery and equipment
		Civil	Construction management of station improvement projects, etc.
	Human Resource	Personnel management throughout O&M	
	general affairs department	Finance	Procurement of equipment and budget management
		Environment	Promote SDGs, occupational safety and health management
Non-rail Business Department	Store Development	Planning and development of station-based business	
	Real Estate Development	Development of real estate near stations	
Work Sites	Station	Station operations such as ticket sales, passenger information, etc.	
	Operation	Drivers' office	Management of drivers
	R/S	Depot	Daily rolling stock inspections and management of outsourced operations

Department/Division			Proposed Major Duties
		Workshop	Heavy maintenance of rolling stocks, management of outsourcing
	E&M	E&M Tech. Centre	Inspection of track and civil engineering structures, management of outsourcing
	Electrical	Electrical Traction Tech. Centre	Inspection of electric power & traction facilities and management of outsourcing
		SIG & TEL Tech. Centre	Inspection of signalling and telecommunications equipment, management of outsourcing
	Civil	Civil Tech. Centre	Inspection of station machinery and equipment, supervision of station improvement work, etc., and management of outsourcing

Source: JST

(2) Verification of number of personnel

1) Number of personnel per department

In the DPR, the number of personnel required for O&M is estimated at 35 persons per line kilometer, for a total of 1,138 persons, which is the same thought in the DMRC. Therefore, we first verify whether the personnel composition of DMRC shown in Table 24-11 is appropriate by comparing it with that of Japanese subway operators.

Table 24-13 shows the results of a comparison of Japanese subway operators and DMRC in terms of the percentage of staff when categorized into administration, transportation, and maintenance.

Table 24-13: Comparison of Personnel Composition between Japanese subway Operators and DMRC

Business Entity	Number of personnel				Percentage of each division		
	Operation	Maintenance	Others	TOTAL	Operation	Maintenance	Others
Tokyo Metro	6,642	2,673	470	9,785	67.9	27.3	4.8
Sapporo city	317	139	84	540	58.7	25.7	15.6
Sendai city	259	138	34	431	60.1	32.0	7.9
Tokyo Metropolitan	2,201	1,107	152	3,460	63.6	32.0	4.4
Yokohama city	594	324	47	965	61.6	33.6	4.9
Nagoya city	1,681	880	157	2,718	61.8	32.4	5.8
Kyoto city	440	163	54	657	67.0	24.8	8.2
Osaka Metro	3,214	1,525	236	4,975	64.6	30.7	4.7
Kobe city	341	164	69	574	59.4	28.6	12.0
Fukuoka city	336	188	50	574	58.5	32.8	8.7
(1) Total/Average	16,025	7,301	1,353	24,679	64.9	29.6	5.5
DMRC	4,806	7,699	403	12,908	37.2	59.6	3.1
Triple the personnel of maintenance in (1)	16,025	21,903	1,353	39,281	40.8	55.8	3.4

Source: Compiled by JST from the Ministry of Land, Infrastructure, Transport and Tourism: Annual Report on Railway Statistics (2019), and materials provided by DMRC.

The table above shows that the ratio of maintenance personnel is much larger in DMRC than in Japan.

This is thought to be because the DMRC assumes direct management, while in Japan most of the actual work at maintenance sites is outsourced and only supervisors are directly managed. If maintenance personnel were directly managed in Japan, the number of required maintenance personnel would need to be three to four times larger.

Therefore, the staffing ratios in DMRC are considered to be generally appropriate.

Next, Table 24-15 compares Japanese subway operators and DMRC with respect to the ratio of the number of personnel on site in the maintenance department.

Table 24-14: Comparison of personnel composition between Japanese subway operators and DMRC in the maintenance sector

Business Entity	Number of personnel on-site sector in the maintenance department				Percentage of each division			
	E&M	Electric	R/S	Civil	E&M	Electric	R/S	Civil
Tokyo Metro	390	695	1,015	98	18	32	46	4
Sapporo city	0	0	71	0	0	0	100	0
Sendai city	31	47	36	24	22	34	26	17
Tokyo Metropolitan	244	342	316	0	27	38	35	0
Yokohama city	84	72	47	3	41	35	23	1
Nagoya city	209	167	324	0	30	24	46	0
Kyoto city	15	41	57	0	13	36	50	0
Osaka Metro	290	413	562	47	22	31	43	4
Kobe city	33	60	49	0	23	42	35	0
Fukuoka city	14	26	33	11	17	31	39	13
Total/Average	1,310	1,863	2,510	183	22	32	43	3
DMRC	1,402	3,116	2,618	563	18	40	34	7

Source: Compiled by JST from the Ministry of Land, Infrastructure, Transport and Tourism: Annual Report on Railway Statistics (2019), and materials provided by DMRC.

From Table 24-15, the staffing ratios for each department of DMRC are about the same as the average figure for Japanese operators, and the number of personnel in the maintenance department provided by DMRC is also considered to be about reasonable.

Table 24-16 shows the number of personnel and their ratios for each department in the working organization of the transportation division of Japanese subway operators. The table also shows the ratio when the number of conductors is set to zero, since DMRC operates as a one-man operation and does not require conductors.

Table 24-15: Number and Percentage of Personnel by Department on worksite organizations of Japanese subway operators

Business Entity	Number of personnel on-site sector in the operation department				Percentage of each division			
	driver	conductor	station	others	driver	conductor	station	others
Tokyo Metro	1,446	963	3,314	670	23	15	52	10
Sapporo city	198	0	96	3	67	0	32	1
Sendai city	105	0	100	25	46	0	43	11
Tokyo Metropolitan	647	234	1,053	181	31	11	50	9
Yokohama city	208	0	256	105	37	0	45	18
Nagoya city	492	99	422	627	30	6	26	38
Kyoto city	165	27	208	19	39	6	50	5
Osaka Metro	687	408	1,909	0	23	14	64	0
Kobe city	132	70	118	9	40	21	36	3
Fukuoka city	109	0	76	110	37	0	26	37
Total/Average	4,189	1,801	7,552	1,749	27	12	49	11
Without conductors	4,189	-	7,552	1,749	31	-	56	13

Source: Compiled by JST from the Ministry of Land, Infrastructure, Transport and Tourism: Annual Report on Railway Statistics (2019), and materials provided by DMRC.

Regarding PMRCL's 1,138 personnel in 2024 as indicated in the DPR, PMRCL has received a response that they have not studied the details of the breakdown by department.

On the other hand, assuming that the percentages in Table 24-14 and Table 24-15 at DMRC and the percentages of personnel per department within the transportation sector are the same as in Japan, Table 24-16 can be used to estimate the number of personnel per department at PMRCL.

Thus we obtained an estimate of the number of personnel by department in PMRCL's opening year (2024). The results are shown in Table 24-17

Table 24-16: Estimated number of personnel needed by department in DMRC and PMRCL (2024)

Department		DMRC	PMRCL	Remark
general affairs		403	36	
Operation	Drivers	1,492	132	including internal workers at the headquarters and at the on-site organization.
	Station	2,691	237	
	Others	623	55	
	Total	4,806	424	
Maintenance	E&M	1,402	124	ditto
	R/S	3,116	275	
	Electric	2,618	231	
	Civil	563	50	
	Total	7,699	679	
Grand Total		12,908	1,138	

Source: JST

Approximately 66% of the personnel in the operation departments in Table 24-16 are professionals, and if we assume that these are all drivers and the same percentage is assumed for PMRCL, then the number of drivers needed at the start of operations in 2024 will be around 88.

2) Number of drivers required

This section attempts to calculate the number of drivers required for the train operation plan proposed in Section 8.2 from the total labor hours estimated from the total train running time.

Table 24-17 and Table 24-18 show the number of trains operated by time of day on Corridor-1 and Corridor-2 in the DPR and JICA study team's proposed train operation plans.

Table 24-17: Number of trains in operation by time of day as proposed by DPR and JICA study Team (Corridor-1)

Time Zone		2024				2031				2041				2051			
		DPR		JST		DPR		JST		DPR		JST		DPR		JST	
From	To	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars
5	6	3	1	4	0	2	3	0	4	2	3	0	4	1	5	0	4
6	7	8	1	8	0	4	5	0	10	4	6	0	10.25	2	9	0	12
7	8	8	2	8.3	1.7	5	7	1.7	10.3	5	8	0	12	2	12	0	13.5
8	9	11	3	8.6	3.4	7	10	5	10	7	11	0	13.5	3	17	0	15
9	10	11	3	8.6	3.4	7	10	5	10	7	11	0	13.5	3	17	0	15
10	11	9	2	8.3	1.7	6	8	1.7	10.3	6	9	0	12	2	14	0	13.5
11	12	7	2	8	0	4	6	0	10	4	7	0	10.25	2	10	0	12
12	13	6	2	8	0	4	5	0	10	4	6	0	10.25	2	9	0	12
13	14	3	1	8	0	2	3	0	10	2	3	0	10.25	1	5	0	12
14	15	6	2	8	0	4	5	0	10	4	6	0	10.25	2	9	0	12
15	16	7	2	8	0	4	6	0	10	4	7	0	10.25	2	10	0	12
16	17	9	2	8.3	1.7	6	8	1.7	10.3	6	9	0	12	2	14	0	13.5
17	18	11	3	8.6	3.4	7	10	5	10	7	11	0	13.5	3	17	0	15
18	19	11	3	8.6	3.4	7	10	5	10	7	11	0	13.5	3	17	0	15
19	20	9	2	8.3	1.7	6	8	1.7	10.3	6	9	0	12	2	14	0	13.5
20	21	8	2	8	0	5	7	0	10	5	8	0	10.25	2	12	0	12
21	22	7	2	8	0	4	6	0	10	4	7	0	10.25	2	10	0	12
22	23	6	2	6	0	4	5	0	8	4	6	0	8	2	9	0	8
23	24	3	1	4	0	2	3	0	4	2	3	0	4	1	5	0	4

Time Zone	2024				2031				2041				2051				
	DPR		JST		DPR		JST		DPR		JST		DPR		JST		
From	To	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars
Total		143	38	145.6	20.4	90	125	26.8	177.2	90	141	0	200	39	215	0	226
Peak (/h)		11	3	8.6	3.4	7	10	5	10	7	11	0	13.5	3	17	0	15
Daytime (/h)		3	1	8	0	2	3	0	10	2	3	0	10.25	1	5	0	12

Source: DPR & JST

Table 24-18: Number of trains in operation by time of day as proposed by DPR and JICA studyStudy Team (Corridor-2)

Time Zone	From	To	2024		2031		2041		2051	
			DPR	JST	DPR	JST	DPR	JST	DPR	JST
			3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars
	5	6	4	4	5	4	5	4	6	4
	6	7	7	8	9	10	9	10	10	12
	7	8	9	10	12	12	13	13	14	16
	8	9	13	12	17	16	18	18.5	20	20
	9	10	13	12	17	16	18	18.5	20	20
	10	11	10	10	14	12	14	13	16	16
	11	12	8	8	10	10	11	10	12	12
	12	13	7	8	9	10	9	10	10	12
	13	14	4	8	5	10	5	10	6	12
	14	15	7	8	9	10	9	10	10	12
	15	16	8	8	10	10	11	10	12	12
	16	17	10	10	14	12	14	13	16	16
	17	18	13	12	17	16	18	18.5	20	20
	18	19	13	12	17	16	18	18.5	20	20
	19	20	10	10	14	12	14	13	16	16
	20	21	9	8	12	10	13	10	14	12
	21	22	8	8	10	10	11	10	12	12
	22	23	7	6	9	8	9	8	10	8
	23	24	4	4	5	4	5	4	6	4
Total			164	166	215	208	224	222	250	256
Peak (/h)			13	12	17	16	18	18.5	20	20
Daytime (/h)			4	8	5	10	5	10	6	12

Source: DPR & JST

As shown in Section 8.2, the one-way trip times for Corridor-1 and 2 are 32 minutes and 24.5 minutes, respectively, and assuming a minimum turnaround time of 3 minutes at the terminus station, whether at the stabling line or at the platform, the minimum round-trip trip times for Corridor-1 and 2 are 70 minutes and 55 minutes, respectively.

The number of rakes required for each time zone is calculated from dividing the minimum round trip time by the headway and converting to an integer. Table 24-19 shows the required number of rakes in the horizon year using the same method.

Table 24-19: Number of rakes required in the horizon year (proposed by JST)

Item	Corridor-1								Corridor-2			
	2024		2031		2041		2051		2024	2031	2041	2051
	3cars	6cars	3cars	6cars	3cars	6cars	3cars	6cars	3cars			
Peak train number	8.6	3.4	5	10	0	13.5	0	15	12	16	18.5	20
Headway (min)	7.0	17.6	12.0	6.0	-	4.4	-	4.0	5.0	3.8	3.2	3.0
Minimum round trip time (min)	70.0								55.0			
Required rakes	10	4	6	12	0	16	0	18	11	15	17	19

Source : JST

Next, the number of crew members needed is determined by adding up the total hours worked on the trains listed in Table 24-17 and Table 24-18. The results are shown in Table 24-20.

The concepts and assumptions used in the calculations in Table 24-20 are as follows;

- ✓ The total working hours of commercial train (⑤) is the sum of train hours (③) and estimate train-watching times (④).

- ✓ During shunting, the driver does not need to be in the cab, but is required to spend train-watching times (④). The average time of train-watching times is assumed to be 4 minutes per one-way trip.
- ✓ The difference between the number of rakes required during peak and daytime hours is equal to the number of trains entering to depot and leaving from depot before and after daytime hours. The driver is responsible for these in-and-out depot operations (⑥)
- ✓ Assume that rakes on Corridor-1 enter and leave the depot by out-of-service trains through Corridor-2. One out-of-service trains is expected to operate between Khemni Chak and New ISBT in 7 minutes. (⑦)
- ✓ Total driving hours (⑧) is the sum of total working hours of commercial train (⑤) and time for out-of-service trains (⑦).
- ✓ The following other than train driving hours are assumed to be counted as working hours for drivers (⑨)
 - Time to get ready for work: 30 minutes per one journey of crew
 - Walking time: 30 minutes per one journey of crew on average
 - Preparation time when arrive at depot: 30 minutes per arrive
 - Preparation time when departure from depot: 20 minutes per departure
- ✓ Total duty hours (⑩) is the sum of total driving hours (⑧) and other than train driving hours (⑨).
- ✓ Assuming that each person works 8 hours/day (⑪), the minimum number of employees required (⑫) is calculated.
- ✓ Assumes that in addition to the driver of the mainline train, two drivers per day each are required to shunt in the Depot (⑬) and for driving the maintenance cars (⑭).
- ✓ Minimum number of personnel per day (⑮) is the sum of ⑫ to ⑭.
- ✓ Assuming 80 days off per year and 365.25 total working days per year, the minimum number of holiday equivalent personnel is calculated (⑯)
- ✓ The total number of personnel (⑰) is the sum of the minimum number of personnel per day (⑮) and the minimum number of holiday equivalent personnel (⑯).
- ✓ Assuming that the overall margin ratio (⑱) is 5%, the number of personnel required (⑲) is calculated.
- ✓ The number of drivers required is the integer of ⑲ (⑳).

Table 24-20: Calculation of the Number of drivers required in horizon year

Item	Unit	Corridor-1				Corridor-2				
		2024	2031	2041	2051	2024	2031	2041	2051	
①	Number of trains per day, one-way	/day	166	204	200	226	166	208	222	256
②	One-way trip time	hour	0.533	0.533	0.533	0.533	0.408	0.408	0.408	0.408
③	Total train running time (Train hours)	h/day	177.1	217.6	213.3	241.1	135.6	169.9	181.3	209.1
④	Estimate train-watching times	h/day	8.3	10.2	10.0	11.3	8.3	10.4	11.1	12.8
⑤	Total working hours of commercial train	h/day	185.4	227.8	223.3	252.4	143.9	180.3	192.4	221.9
⑥	Number of in-and-out depot operations	/day	18	24	20	22	14	20	24	27
⑦	Total time for out-of-service trains	h/day	4.2	5.6	4.7	5.1	0.0	0.0	0.0	0.0
⑧	Total driving hours	h/day	189.6	233.4	228.0	257.5	143.9	180.3	192.4	221.9
⑨	Other than train driving hours	h/day	48.8	63.2	63.3	69.7	37.3	51.7	56.2	63.3
⑩	Total duty hours	h/day	238.4	296.6	291.3	327.2	181.2	231.9	248.6	285.2
⑪	Working hours per person per day	h/day	8	8	8	8	8	8	8	8
⑫	Min. number of employees required	person	29.8	37.1	36.4	40.9	22.7	29.0	31.1	35.7
⑬	Drivers for shunt in the Depot per day	person	2	2	2	2	2	2	2	2
⑭	Drivers for the maintenance cars	person	2	2	2	2	2	2	2	2
⑮	Min. number of personnel per day	person	33.8	41.1	40.4	44.9	26.7	33.0	35.1	39.7
⑯	Min. number of holiday equivalent personnel	person	9.5	11.5	11.3	12.6	7.5	9.3	9.8	11.1

Item	Unit	Corridor-1				Corridor-2				
		2024	2031	2041	2051	2024	2031	2041	2051	
⑰	Total number of personnel	person	43.3	52.6	51.8	57.5	34.1	42.2	44.9	50.8
⑱	Overall margin ratio	person	5%	5%	5%	5%	5%	5%	5%	5%
⑲	The number of personnel required (incl. margin)	person	45.4	55.2	54.3	60.4	35.8	44.4	47.2	53.3
⑳	The number of drivers required (conversion to an integer)		46	56	55	61	36	45	48	54
Total number of personnel for Corridor-1&2			82	101	103	115				

Source: JST

According to Table 24-20 the number of drivers required at PMRCL was generally calculated to be 82 persons in 2024, 101 persons in 2031, 103 persons in 2041, and 115 persons in 2051.

This result is almost consistent with the number of drivers obtained in 1).

Therefore, the number of drivers determined both in this section and in 1) are also considered to be generally appropriate.

25. Utilization of Japanese Technologies

25.1 Proposal

25.1.1 Track

(1) HH Rail

DPR proposes to use HH rails for the main line. There is one steel Indian company, Jindal Steel and Power, and some non-Indian companies, Mitsui, JFE steel, ArcelorMittal, Voestalpine and Evraz, are capable of delivering HH rails to India. Japanese steel companies have some delivery records, including Western Dedicated Freight Corridor, Bangalore Metro and Mumbai Metro etc. in the Indian rail market, which can lead Japanese companies to be still competitive.

(2) Composite sleeper

PSTM says that pre-stressed concrete sleepers or mono-block sleepers are used for turnouts in Indian Metro, but lack of flexibility in the construction and installation process is one of the drawbacks of these sleepers. On the other hand, composite sleepers are used primarily for special sections including, stations, bridges, turnouts and expansion joints in Japan. It is made of a continuous glass fiber reinforced polyurethane foam. The shape of the composite sleeper is similar to that of ordinary wooden sleepers. The construction and installation process is simple, and the composite sleepers can be sawed, planed, nailed, screwed and glued with standard woodworking tools. So, it makes installation process easier and faster. And it ensures long durability. So, JICA studyteam would like to propose using composite sleepers in Patna Metro, as well.

Composite sleepers are manufactured by some companies, including Japanese makers, Sekisui Chemical and Sumihatsu. They have the intention to expand their market to India. They have some delivery records in Asia and European countries, proving they have good competitiveness with other makers.

PMRCL states the intention not to use a composite sleeper in the talks during JICA study.



Source: SEKISUI FFU Synthetic Sleeper brochure site: <https://www.sekisui-rail.com/en/brochures-ffu-synthetic-wood.html>

Figure 25-1: Use of Composite sleepers

25.1.2 Signaling and Telecommunication

(1) Signaling

- JST has confirmed some Indian suppliers can manufacture Signalling devices/equipment, such as the Electric Point Machine. However, JST has also confirmed no Indian supplier can manufacture CBTC, including ATP.
- JST has confirmed that some Japanese suppliers can manufacture CBTC and have recently experienced Indian metro projects such as Dehli, Mumbai, Kolkata, Ahmedabad, etc.
- Therefore, JST has confirmed that CBTCs manufactured by Japanese suppliers have no concerns about Conformity to the International Standards/Regional Standards, The PMRCL's Signalling Facility Plan, etc. In addition, JST has guessed some Japanese suppliers could participate in the PMRCL project for CBTC.

- On the other hand, JST has also guessed it would be difficult for Japanese suppliers to manufacture Signalling devices/equipment, such as the Electric Point Machine, because they have to conform to Regional Standards such as domestic Standards of IRS or RDSO.

(2) Telecommunication

- JST has confirmed a joint venture company between Indian and Japanese suppliers has manufactured fiber optic cables in India.
- In addition, there are many competitive suppliers in the telecommunications sector throughout the world, including India.
- Therefore, JST has confirmed that it would be difficult for Japanese suppliers to participate in the telecommunication sector of the PMRCL project.

25.1.3 AFC

- There are mainly two types of fare media used in AFC System worldwide, Type-A (ISO/IEC 14443) and FeliCa (ISO/IEC 18092).
- FeliCa is the Japanese Technology, and Felica enables fare collection for many passengers at limited spaces (by the number of limited automatic gates) because FeliCa can read and write twice as fast as Type-A and recognize a fare media with a broader range than Type-A.
- Therefore, FeliCa is the fare media suitable for urban railways with high passenger volumes, and most Japanese urban railways have introduced FeliCa and proven its high reliability.
- However, FeliCa and Type-A are not compatible, and NCMC that PMRCL plans to introduce conforms to Type-A. It means Felica and NCMC are not also compatible.
- In addition, JST has confirmed that there would be no technical concerns and requirements PMRCL couldn't solve without introducing FeliCa.
- There are many competitive suppliers in the AFC system sector throughout the world, including India, if FeliCa isn't required.
- Therefore, JST has confirmed that it would be difficult for Japanese suppliers to participate in the AFC system sector of the PMRCL project.

25.1.4 Electrical and Mechanical System/Facilities

- In interview with manufacturers of electrical power product, it was found that Indian manufacturers are strong in AC equipment in India. However, Scott-connected transformer is not manufactured by Indian company, and Japanese companies have an advantage. In addition, Japanese companies have a track record of introducing Scott-connected transformers on the Western Dedicated Freight Corridor, so this point also has an advantage. Although Scott-connected transformer has the feature of reducing voltage unbalance, it is generally 1.5 to 2 times more expensive than Single-phase transformer. Therefore, it is important to consider the risks and costs caused by voltage unbalance and include it in the specification.
- Indian domestic companies are highly competitive in elevating equipment including lift and escalator. In recent years, Japanese companies have also stepped up their operations, but the installation is limited to specifications that require high safety and amenity such as luxury housing. Therefore it is difficult to use in public facilities due to the disadvantage in price competition.

25.1.5 Rolling Stocks

There are the following three possible methods of using Japanese technology for Rolling Stocks.

(1) Application of Advanced Japanese Systems or Components

Advanced Japanese systems or components are supplied to Indian car builders. The items to be supplied are propulsion system, auxiliary power supply system, TCMS, etc. The method has many examples of Indian metro projects, and it is reliable for the Indian rolling stock market.

(2) Cooperation with Indian Car Builder by Japanese Technology

The export of completed cars from Japan is disadvantageous in terms of competitive price power. Hence, cars designed in Japan may be assembled under Japanese quality control in cooperation with Indian car builders.

(3) Delivery of Completed Cars from Japan

As a leading step of above (2), there is a possibility of the completed car from Japan only for prototype. Delivery of all completed cars from Japan is unrealistic due to the cost issue.

25.1.6 Tunnel Boring Machine (TBM)

Japanese TBM technologies are numerous and also world-leading. Below companies are major Japanese TBM supplier company. One is JIM Technology Corporation (JIMT) other one is Underground Infrastructure Technologies Corporation (UGITEC) in Japan.

About JIMT

JIM Technology Corporation (JIMT) was established by IHI Corporation (IHI), JFE Engineering Corporation (JFE), and Mitsubishi Heavy Industries, Ltd. (MHI) by integrating their businesses in shield tunneling machines. Taking advantage of the three companies' experience of having delivered 4,000 units and the synergy among them, we at JIMT aim to become a leading company in the global market.

Source: JIMT Home page, <https://www.jimt.co.jp/en/company/02.html>

About UGITEC


Kawasaki Heavy Industries LTD, and Hitachi Zosen Cooperation integrated the TBM business and newly established "Underground Infrastructure Technologies Corporation"

Source: UGITEC Home page, <https://ugitec.co.jp/en/company/history/>

The below presentation slides show the proposals of Japanese TBM technologies for Patna Metro.

(1) Japanese TBM technologies by JIMT;

1) The simultaneous excavation system



JIMT) Simultaneous Excavation System

1. Overview

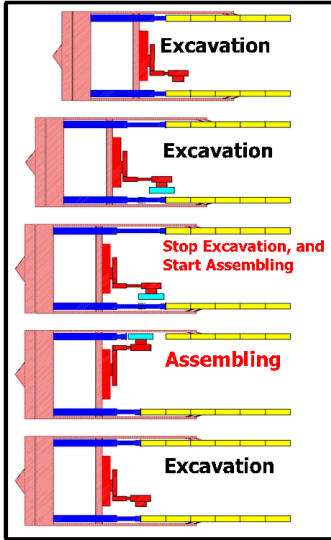
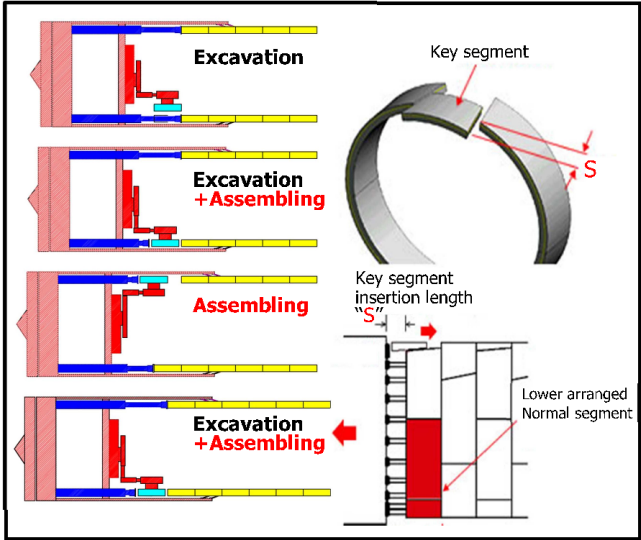
When we want to improve excavation and tunneling works more efficient and speedy, we have to

- ✓ increase excavation speed by high power and high rotation speed TBM,
- ✓ reduce downtime which caused by regular works such as conversion / maintenance and troubles, or
- ✓ **reduce Loss Time and Cycle Time for regular works such as assembling segments.**

The Simultaneous Excavation System can reduce the Loss Time and Cycle Time by assembling segments during the excavation of shield tunneling. Undesirable changes in shield TBM attitude and the jacking rate (excavation speed) due to assembly operation are prevented by optimizing each jack pressure. By using this Automated Pressure Control method for balancing the moment of thrust force, thrust jacks can be retracted for assembling segments while excavating. The simultaneous Excavation method is a widely applicable, economical technology to increase the advance rate.

2. Features

(1) Comparison of work flow

<div style="border: 1px solid gray; padding: 5px; margin-bottom: 5px; text-align: center;">Standard Excavation</div> <p style="font-size: small;">Segment assembling starts after the completion of excavation.</p> 	<div style="border: 1px solid gray; padding: 5px; margin-bottom: 5px; text-align: center;">Simultaneous Excavation</div> <p style="font-size: small;">Some segments can be assembled while excavation.</p> 
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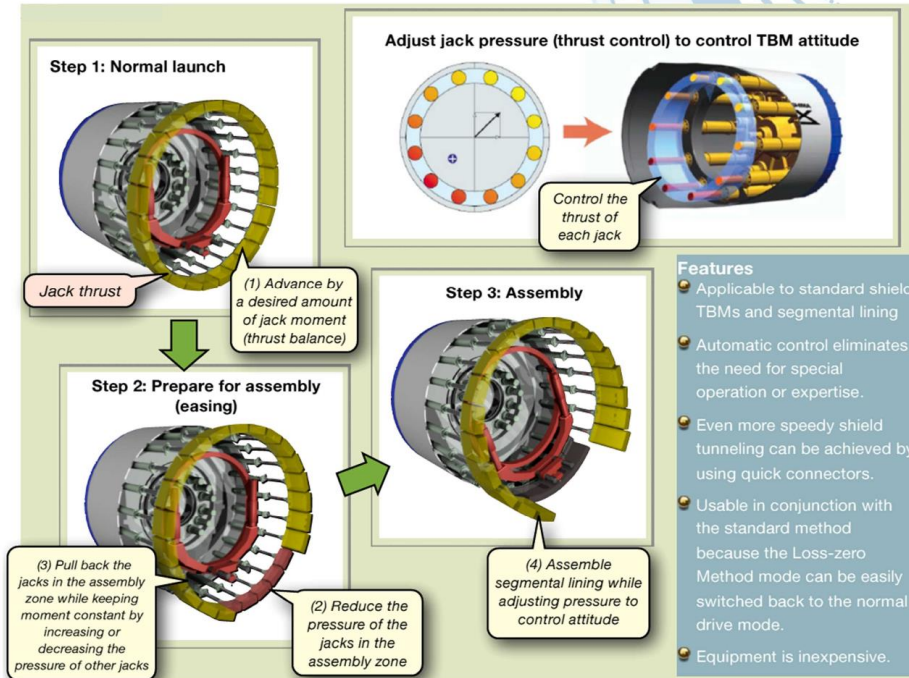
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10th floor, Cube Kawasaki Building,
 1-14 Nisshin-cho, Kawasaki-ku,
 Kawasaki, Kanagawa 210-0024, JAPAN
 Tel.+81-45-505-7435, Fax.+81-45-505-8902
 http://www.jimt.co.jp



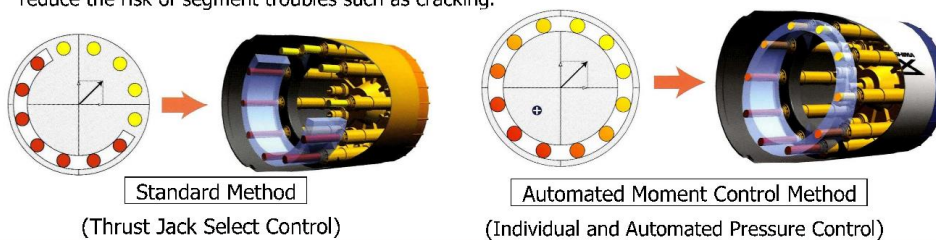
(2) Simultaneous Excavation Procedure



(3) Technologies

a) Automated Moment Control Method

To control the directions of TBM, we adjust the TBM attitude by selecting thrust jacks to be increased/decreased pressures and changing the moments. The moment Control Method can change the moments by adjusting thrust jacks pressure individually and automatically in real time. Accurate automatic directional control can be achieved because jack moment of any strength and in any direction can be set quickly. Therefore, the moment Control Method can improve tunnel alignment quality and reduce the risk of segment troubles such as cracking.

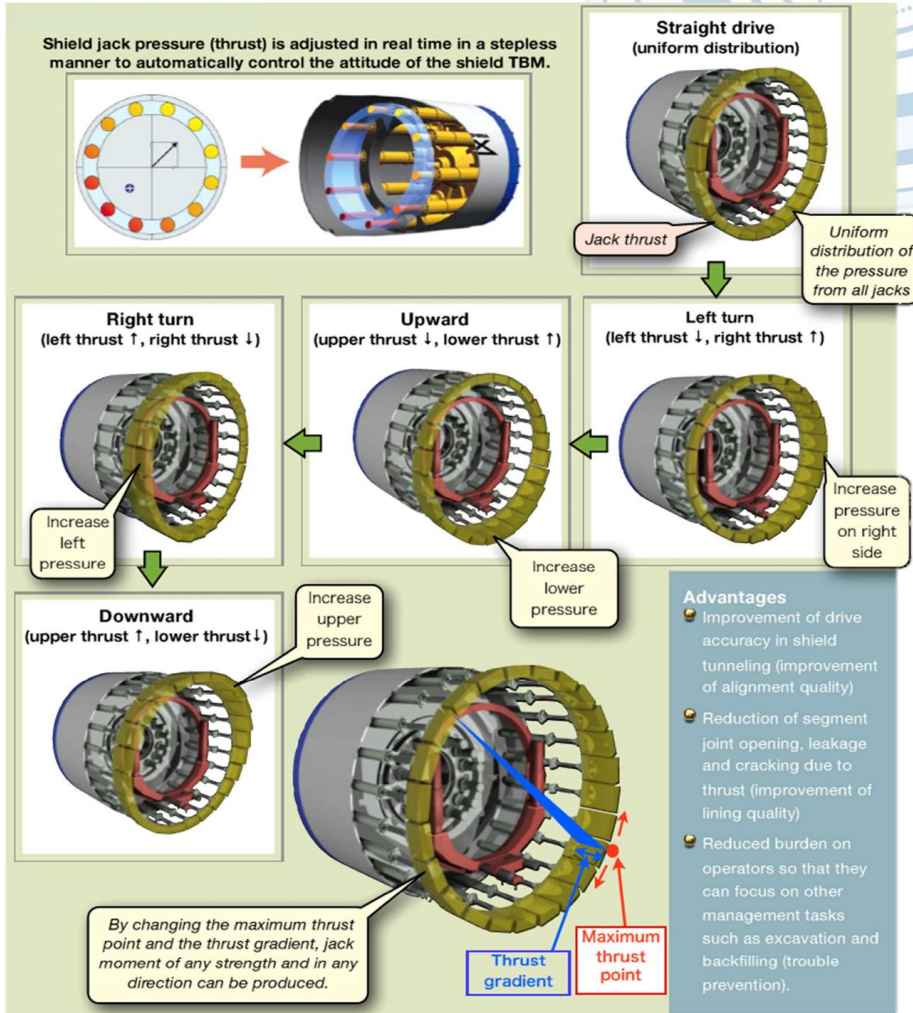


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Features of **Automated Moment Control Method**



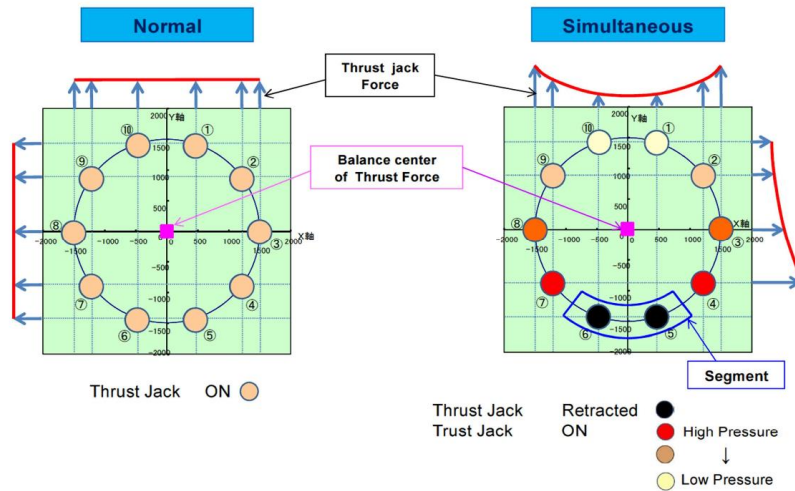
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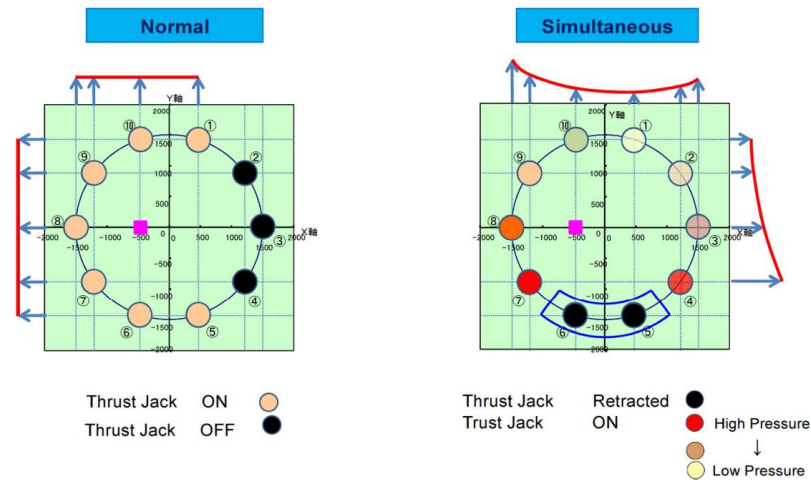


Flexible Jack Pressure Control

Excavation Straight



Excavation Right Curve




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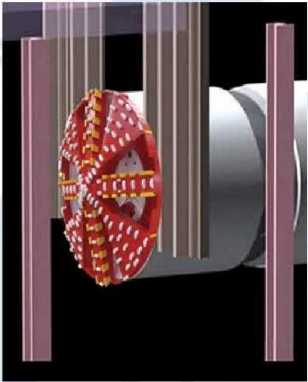

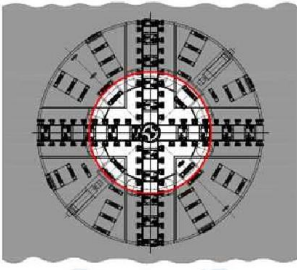
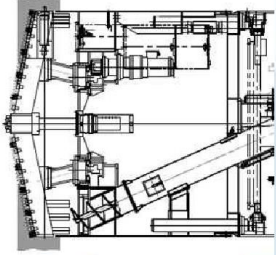
2) Obstacle Cutting Technology

Obstacle Cutting Technology




1. Purpose
 In case excavation in urban area by shield tunneling method, we some time encounter the obstacle like PC-Pile, Wood Pile, Concrete Wall, etc. If we can predict or assume these situations beforehand, we can take care of the specification and the device of machine.
 Here JIMT explains our special countermeasure and treatment.

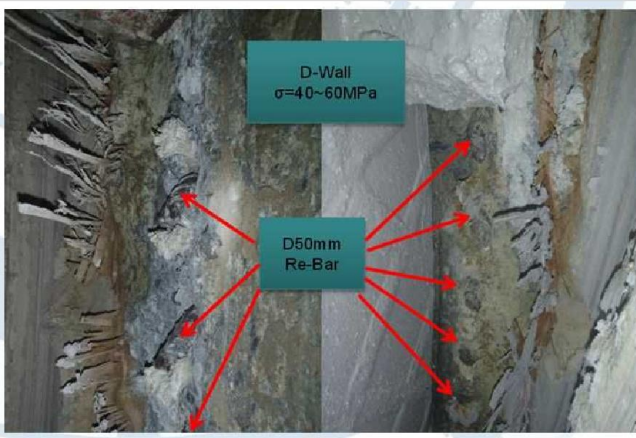
2. Inclined Cutter Head Design
 In order to reduce reaction cutting torque and to avoid the clogging of evacuation system, we apply "Inclined Cutter Head Design". Feature of this is "Step by Step Cutting" from center part to circumference.

Special Cutting Tools
 Depend on character of obstacle, JTSC carefully select the "adequate cutting tools" in accordance with our rich experience. Below are some samples.



Obstacle Cutting-Bit



D-Wall
 $\sigma=40\sim60\text{MPa}$

D50mm
Re-Bar

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3. Other Treatment

Mainly JTSC consider below points.

- 1) Bit layout and number
- 2) Prevention of material clogging to cutter and evacuation system
- 3) Precise control of advance speed
- 4) Secure the machine damage by obstacle
- 5) Safety work and operation



2.68m EPB Obstacle Cutting Type



2.69m SLURRY Obstacle Cutting Type



2.78m EPB Obstacle Cutting Type



4.24m EPB Obstacle Cutting Type



4.68m EPB Obstacle Cutting Type



6.44m EPB Obstacle Cutting Type

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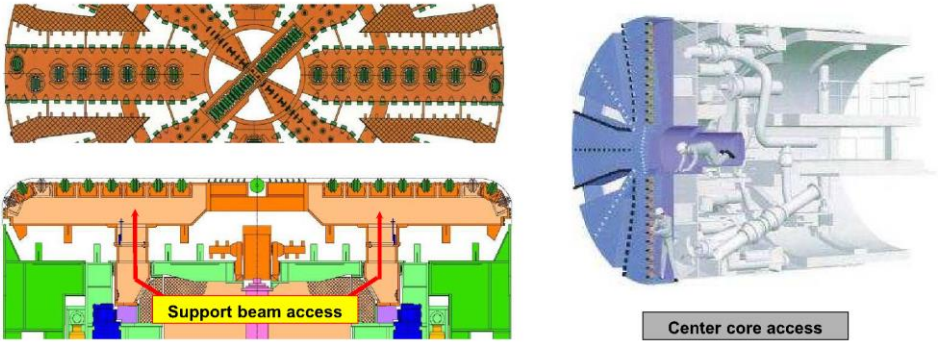
(2) Japanese TBM technology by UGITEC

1) Cutter Changing

II -1 Cutter Changing

■ Cutter head access

- Support beam access
 - ✓ Center part opening
 - ✓ Used 4 EPB projects
- Center core access
 - ✓ Standard
 - ✓ Used 9 EPB/Slurry projects



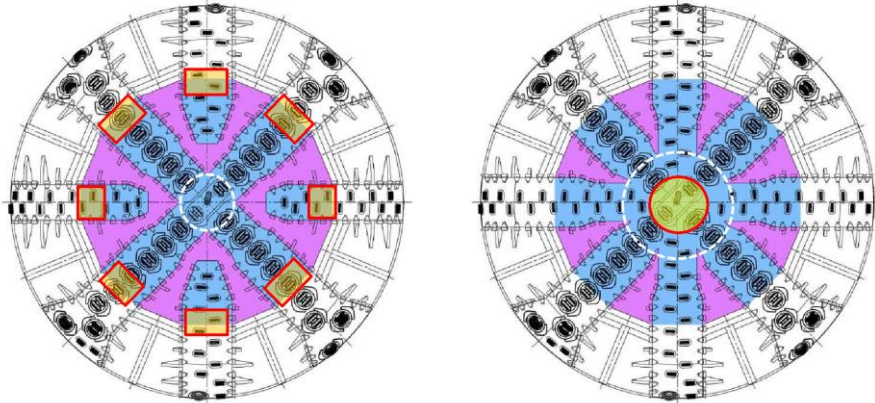
The diagrams illustrate two methods for cutter head access. The left side shows 'Support beam access' with a cross-section of a TBM cutter head and a corresponding tunnel layout. The right side shows 'Center core access' with a 3D cutaway view of the cutter head and a corresponding tunnel layout.

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II -1 Cutter Changing

■ Cutter head access

Comparison of center area openings

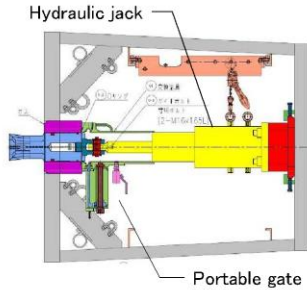


The diagrams compare the center area openings for two access methods. The left diagram, labeled 'Support beam access', shows a circular cutter head layout with four distinct openings. The right diagram, labeled 'Center core access', shows a similar layout with a central opening and four radial openings.

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II -1 Cutter Changing

Portable gate type for Pre-cutting bit

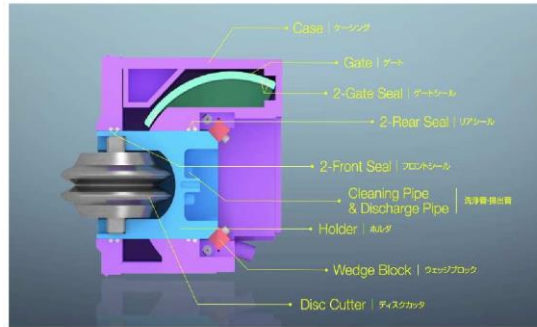


- ✓ 1.0MPa pressure test
- ✓ 1hr for 1 cutter changing
- ✓ Actual record ; 9 projects



II -1 Cutter Changing

Rotary gate type for DRC



- ✓ 17" double DRC (250kN)
- ✓ 1.0MPa pressure test
- ✓ 2.5hr for 1 cutter changing
- ✓ Actual record ; SR99 17.45m EPB





▶ II -1 Cutter Changing



■ Ball gate type for DRC

- ✓ 19" twin DRC (320kN x2)
- ✓ 2.0MPa pressure test
- ✓ 2.5hr for 1 cutter changing



1. Cutter holder retraction



2. Attach temporary cap


3. Ball rotation

4. Take out DRC

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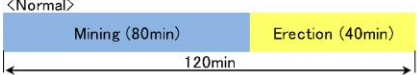

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2) Rapid Construction

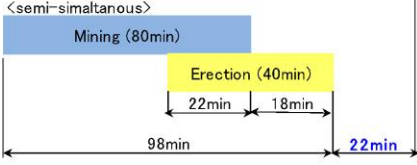
▶ II -2 Rapid Construction

■ Simultaneous excavation/erection system

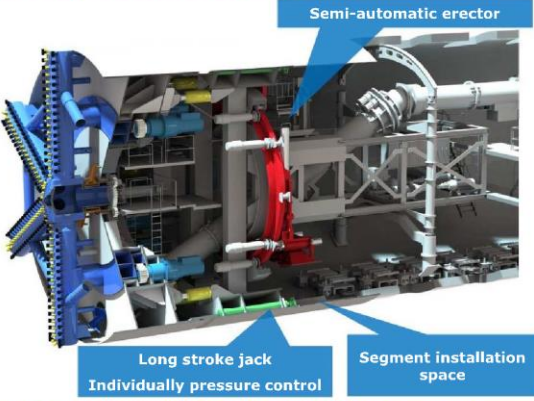
<Normal>



<semi-simultaneous>




L=2m, V=25mm/min



Actual record ; 14 projects

TYPE	TBM	PROJECT	PROGRESS (Monthly)
Long stroke type Semi-simultaneous	Φ12.55m EPB	Shinagawa highway project	Max.708m
Long stroke type Full-simultaneous	Φ16.1m EPB	Gaikaku-kanjo highway project	Max.320m (12hr/day limitation)

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II -2 Rapid Construction

■ Simultaneous excavation/erection system

Mining start (excavation speed 40mm/min) Thrust jack ST: 0mm	Start simultaneous excavation 1 st piece erection Thrust jack ST: 1450mm	Under simultaneous excavation 2 nd piece erection Thrust jack ST: 1550mm
<p>Segment Insert Space: 650, 2000</p>	<p>650, 1450, 2000, 2100</p>	<p>650, 1550, 2000, 2200</p>
	<p>Jack pressure control Moment balancing</p> <p>1st piece installation space</p>	<p>2nd piece installation space</p>