

India

FY2019 Ex-Post Evaluation of Japanese ODA Loan Project
“Bangalore Metro Rail Project/Bangalore Metro Rail Project (II)”

External Evaluator: Yumiko Onishi, IC Net Limited

0. Summary

In the beginning of the 1990s, traffic congestion was a serious issue in urban India, urgently requiring the establishment of a mass public transport system. Under such circumstances, by constructing a mass rapid transit (MRT) system (metro) in the southern city of Bangalore, the project was implemented with the objective to contribute to developing the regional economy and improving the urban environment through reducing traffic congestion and traffic pollution.

The urban transport sector, particularly the MRT system, has been considered important in India’s development policy from the time of the appraisal to the ex-post evaluation. Traffic congestion, particularly in the central part of the city, remains a serious issue even at the time of the ex-post evaluation. The need for the people to switch to rail-based transport, who were dependent on road transport, is recognized even now, and development needs on MRT continue to exist. The project was consistent with Japan’s ODA policy at the time of the appraisal, and the relevance is high.

According to the original plan, a MRT system with the total length of 33 km, comprising the East-West and South-North lines, was to be built. However, the project included the extension of the South-North line in 2011, and a network of 42.3 km in total was constructed. Because of limited ridership at the time of opening, less rolling stock was procured than originally planned. Although the project cost was within the plan, there was a significant delay in the project period caused by geological conditions not anticipated during the detailed design, such as uneven bedrock, which were found after the project started. This has made the efficiency of the project fair.

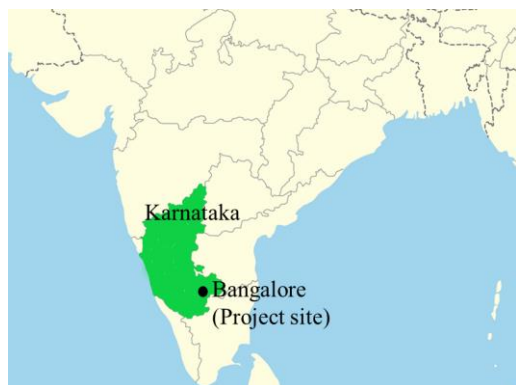
Regarding the achievement of operation and effect indicators, only the operating rate achieved the target, and other indicators achieved 29–77% of the targets owing to less ridership than the initial estimate. On the other hand, many metro users feel that the opening of metro has reduced the city’s traffic congestion and air pollution. With regard to the natural environment, necessary actions were taken during the implementation of the project. As regards land acquisition and resettlement, there are no specific issues. Therefore, the effectiveness and impacts of the project are fair.

In Bangalore Metro Rail Corporation Limited (BMRCL), the organization operating and maintaining Bangalore Metro, has necessary institutional arrangements for operating and maintaining the existing network, and its employees have necessary technical skills. BMRCL has an internal training system to maintain and improve the skill level of its employees. As regards the financial aspect, BMRCL is running a deficit, but its farebox revenue is at a

sufficient level to meet the operation and maintenance costs. Stations, trains, and other equipment are appropriately managed, and the sustainability of the project is high.

In light of the above, this project is evaluated to be satisfactory.

1. Project Description



Project Location



East-West line of Bangalore Metro constructed by the project

1.1 Background

The urban population of India, which was 217 million in 1991, recorded 285 million in 2001, and was expected to increase further.¹ With the rapid increase of the urban population, the number of registered vehicles and two wheelers was growing at an annual average of 11% from 2002.² In addition, the share of public transport in the number of instances of mobility³ in urban areas decreased from 69% in 1991 to 55% in 2001.⁴ On the other hand, because development of public transport infrastructure was not keeping up, traffic congestion due to the increase in the number of registered vehicles and two wheelers in urban India was a serious issue. An increase in the ratio of population owning vehicles with an increase in income, a reduction in the ratio of public transport for movement, and a shift from owning two wheelers to four-wheel vehicles are expected beyond 2006 as well, and a prompt response to traffic congestion was essential. Particularly, in large cities such as Delhi and Bangalore, congestion was worsening because of increasing demand on road transport. In addition, health problems arising out of air and noise pollutions from the vehicles, as well as economic loss, have become a serious issue. To reduce traffic congestion and automobile-related pollutions, it was necessary to develop a large-scale public transport system based on urban development plans.

¹ Ministry of Urban Development, India

² Ministry of Road Transport and Highways, India

³ Share of public transport such as buses, which people use when traveling, in the transport mode (means).

⁴ Ministry of Urban Development, India

1.2 Project Outline

The objective of this project is to cope with the increase of traffic demand in Bangalore by constructing a new mass rapid transportation system, thereby promoting regional economic development and improving the urban environment through mitigation of traffic jams and decrease of pollutions caused by increasing motor vehicles.

Loan Approved Amount/ Disbursed Amount	(I) 44,704 million yen / 38,181 million yen (II) 19,832 million yen / 19,659 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	(I) March 2006 / March 2006 (II) June 2011 / June 2011
Terms and Conditions	Interest Rate (I) 1.3%, (II) 1.4% (civil portion), 0.01% (consulting services) Repayment Period 30 years (Grace Period 10 years) Conditions for Procurement General untiled
Borrower / Executing Agency	The President of India / Bangalore Metro Rail Corporation Limited
Project Completion	June 2017
Target Area	Bangalore, Karnataka State
Main Contractors (Over 1 billion yen)	Alstom Transport SA (France)/Alstom India Ltd. (India)/Sumitomo Corporation (Japan)/Thales Portugal S.A. (Portugal), Soma Enterprise Limited (India)/CEC International Corporation (India) Pvt. Ltd. (India)/Continental Engineering Corporation (Taiwan), Blue Star Ltd. (India), Guangdong Yuantian Engineering Co. (China)/Coastal Projects Ltd. (India), Coastal Projects Ltd. (India)/Transtunnelstory Limited (Russia), ETA Engineering Pvt. Ltd. (India)/Emirates Trading Agency (U.A.E.), Kalindee Rail Nirman (Engineers) Limited (India)/Samsung SDS Co. Ltd. (South Korea)
Main Consultants (Over 100 million yen)	Systra S.A. (France)/RITES LTD. (India)/Oriental Consultants Co., Ltd. (Japan)/Parsons Brinckerhoff International, INC. (the U.S.)
Related Studies (Feasibility Studies, etc.)	2003: Feasibility Study (State Government of Karnataka), 2005: SAPROF
Related Projects	<u>Japanese ODA Loan</u> Delhi Mass Rapid Transport System Project Phase 1 (I)-(VI) (February 1997, March 2001, February 2002, March 2003, March 2004, March 2005) Delhi Mass Rapid Transport System Project Phase 2 (I)-(V) (March 2006, March 2007, March 2008, March 2009, March 2010) Kolkata East-West Metro Project (I)-(III) March

	2008, March 2010, September 2018) Chennai Metro Project (I)-(V) (November 2008, March 2010, March 2013, March 2016, March 2017) Delhi Mass Rapid Transport System Project Phase 3 (I)-(III) (March 2012, March 2014, October 2018) Mumbai Metro Line III Project (I) (II) (September 2013, March 2018) Ahmedabad Metro Project (March 2016) Chennai Metro Project Phase 2 (December 2018) <u>Asian Development Bank (ADB): Bangalore Metro Rail Transit System Project (2011-)</u> <u>European Investment Bank (EIB): Bangalore Metro Rail Project Line R6 (2017-)</u>
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2. Outline of the Evaluation Study

2.1 External Evaluator

Yumiko Onishi, IC Net Limited

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: July 2019–August 2020

Duration of the Field Study: November 24–December 6, 2019 and February 23–March 4, 2020

3. Results of the Evaluation (Overall Rating: B⁵)

3.1 Relevance (Rating: ③⁶)

3.1.1 Consistency with the Development Plan of India

Since the 1990s, various policies and development plans of the Indian government have recognized the importance of development of the urban transport sector to respond to mobility requirements caused by increase in the urban population as well as for solving traffic congestion triggered by increased demand on road transport. The *Tenth Five-Year Plan* (April 2002–March 2007) and the *Common Minimum Programme* of the Modi administration, which took office in 2014, pointed out the importance of developing urban transport infrastructure such as MRT systems.

The importance of the urban transport sector, particularly MRT systems, has not changed at the time of the ex-post evaluation. *Vision 2020*, made by the erstwhile Planning Commission of India, says that the development of a rail-based transport system is the most realistic option for solving urban transport issues in large cities in the long run. Moreover, the *National Urban Transport Policy*, formulated in 2014, regards the MRT system as the key to public transport.

⁵ A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

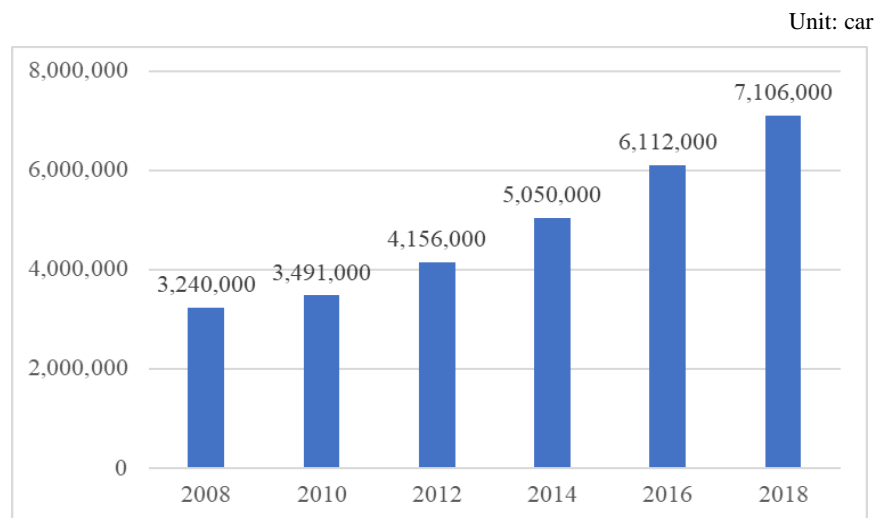
⁶ ③: High, ②: Fair, ①: Low

As of November 2019, Phase 2 of the project is in progress.⁷ In Phase 2, a new network is planned in addition to the extension of the existing network. From the time of the appraisal to the time of the ex-post evaluation, the project is consistent with the development policy of the Indian government.

3.1.2 Consistency with the Development Needs of India

Bangalore is called the Silicon Valley of India, and many companies including the software industries are operating there. With the booming of economic activities through the clustering of these industries, the population of Bangalore City increased from 3.0 million in 1981 to 5.7 million in 2001. The 2011 national census recorded the city’s population as 8.44 million, and the World Population Review estimates that it is increasing at the rate of 4% per annum.

The number of registered vehicles in the city also increased from 0.33 million in 1986 to 1.56 million in 2001 and 2.56 million in 2005. In addition, the urban transport network depending on surface transport was reaching its limits as there is little room for widening the existing road network because of limited land availability and the average vehicular speed in the city remained between 10–12 km/hour. The figure below shows changes in the number of registered vehicles in Bangalore from 2008 onwards.



Source: Karnataka Transport Department

Figure 1: Changes in Number of Registered Vehicles in Bangalore

The number of registered vehicles in the city has been increasing at the rate of about 10% per annum since 2008, and it is increasing faster than the city’s population. According to *Urban Master Plan 2031* of Bangalore, the average speed of buses at the time of the ex-post evaluation is 7–18 km/hour in the central part of the city. Moreover, because of the increase in road

⁷ As of February 2020, Phase 2 is not implemented by Japanese ODA but by other funding sources including ADB.

transport, air pollution caused by the poor quality of fuel and the use of outdated engines is a serious issue from the time of the appraisal to the ex-post evaluation.

According to the interviews with metro users at the time of the ex-post evaluation, some opined that they feel the traffic congestion in the city has somewhat eased after the operation of metro started, but the traffic congestion in places such as the central part of the city is still a serious issue even at the time of the ex-post evaluation. The need to shift from road transport, on which the people was dependent so far, to rail transport is still recognized; thus, the development need for an MRT system remains. Therefore, the project was consistent with the development needs of Bangalore at the times of both the appraisal and the ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

At the time of the appraisal, as focus areas of the *Medium-Term Strategy for Overseas Economic Cooperation Operations* (2005), “development of a foundation for sustained growth” and “assistance for global issues and peace building” were mentioned while “development of economic infrastructure” and “response to environmental problems” were cited in the *Country Assistance Strategy for India* as focus areas. In addition, in the *Country Assistance Policy for India* in 2005, the urban transport sector was part of the transport sector, which was the core sector for assistance to India. As a principle of assistance to the transport sector, the 2005 policy stated that assistance would be provided for developing urban transport infrastructures (including flyovers and bridges), particularly an MRT system, as they contribute to reducing traffic congestion and enhancing environmental protection by such means as reducing air pollution. The project is consistent with Japan's ODA policy at the time of the appraisal.

This project has been highly relevant to the country's development plan and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs (for details, see “Comparison of the Original and Actual Scope of the Project” on the last page of this report)

At the time of the appraisal in 2006, the scope of civil works for the project was a 33-km network of the East-West and South-North lines in total; however, it was decided thereafter to include in the scope the 9.3km extension of the South-North line based on the master plan of Bangalore City. The extended portion connects to the existing industrial and residential areas as well as areas newly planned for construction (see Annex 1 for the network map). In particular, the coming of many IT companies to the city since 2003 has increased the need for the extension, which was included in the project at the time of the Tranche II appraisal.



Figure 2: Maintenance at a Depot



Figure 3: Inside a Metro Station

Compared to the plan at the time of the Tranche II appraisal, output was almost as planned except the number of rolling stock procured. For the rolling stock, procurement of 168 coaches was planned, but because of the delay in the start of commercial operation, which will be described later, ridership was limited when the operation started; thus, the number of coaches procured was reduced 150.⁸

The extension of the South-North line resulted in an increase in the project cost. However, it was appropriate as it connected to the existing as well as planned industrial and residential areas based on the master plan of Bangalore.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The planned project cost at the time of the Tranche II appraisal was JPY 306,809 million, out of which JPY 67,482 million was foreign currency and JPY 239,327 million was local currency. The ODA loan was JPY 64,536 million, out of which JPY 18,639 million was foreign currency and JPY 45,897 million was local currency. In Tranche II, an additional loan of JPY 19,832 million was provided. In addition to the extension of the South-North line as described earlier, the main reasons for the provision of the additional loan included the escalation of the prices of materials and equipment due to the delay in the project and the cost of the additional underground civil works. With regard to the prices of major materials and equipment, taking 2005 as the base year, they fluctuated as shown in the table below as of 2010 when the necessity of Tranche II was considered.

⁸ As of February 2020, additional rolling stock have been procured in Phase 2 of the project, and all trains are operated with six coaches.

Table 1: Changes in Prices of Major Materials and Equipment

Material/equipment		FY 2010 index (compared to 2005)
Material	Cement	1.54
	Steel	1.93
	Aggregate	1.89
	Sand	7.7
Heavy equipment		1.24

Source: Karnataka Department of Industries and Commerce

Although the route passing through a park was agreed upon with local residents based on the discussions at the time of the appraisal, the additional underground civil works include the increase in works based on demand from the NGOs and citizens on route change for environmental conservation and the increase in the cost of works because of the discovery of bedrock that was more uneven than estimated at the time of detailed design.

The actual total project cost was JPY 235,498 million (out of which JPY 66,990 million was foreign currency and JPY 107,327 million was local currency) and the disbursement of the ODA loan was JPY 57,840 million (Tranche I: JPY 38,181 million; Tranche II: JPY 19,659 million), making the total project cost 77% of the plan. Although the reason for reduced cost borne by the executing agency has not been ascertained, for the ODA loan portion, one of the reasons why the actual project cost was within the planned one was that the consulting service fee was controlled. As described earlier, the number of rolling stock procured was short by 18 coaches compared to the plan; however, even if the 18 coaches were procured in the project, the project cost would have been within the plan.

3.2.2.2 Project Period

According to the plan at the time of the 2006 appraisal, the original project period was March 2006 (L/A) to April 2012 (6 years and 2 months, 74 months). However, at the time of the Tranche II appraisal in 2011, it was extended until June 2013 (7 years and 4 months, 88 months). Project completion was defined as the start of commercial operation. In reality, delays were caused by various reasons, and the actual project period was from March 2006 (L/A) to June 2017 (11 years and 4 months, 136 months), making it 155% of the plan. The following are the main reasons for and the durations of the delays.

- Delay in underground civil works caused by hard rocks (30 months)
- Breakdown of a tunnel boring machine (7 months)
- Delay in securing land for construction (27 months)
- Delay in relocating utilities such as water pipes and telephone lines (6 months)
- Contractors running short of funds (30 months)

Out of the above, regarding the hard rocks, bedrock that was more uneven than anticipated at the time of detailed design was found, while the geological survey at the time of detailed design was conducted at an interval which was normal by Japanese standards. Moreover, regarding the land for construction, metro construction was planned on the land owned by Indian Railways. While frequent coordination was attempted with Indian Railways to have it provide the land, it took time to obtain the consent of the organization. According to BMRCL, the executing agency, negotiations on land with Indian Railways were an important step in integrating the project with the railway as described later. The project's persistent effort to negotiate for the land so that metro users can come and go smoothly between the metro and railway stations is a major reason that the project's integration with other transport modes is working well today. Furthermore, although the project tried to implement prompt relocation of facilities such as water pipes through the coordination committee with relevant government departments, it took the committee some time to reach the final decision. Regarding shortage of funds of the contractors, to prevent further delay, BMRCL, the executing agency, approved frequent payments and paid the contractors directly.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

For the project, both the Financial Internal Rate of Return (FIRR) and the Economic Internal Rate of Return (EIRR) were calculated at the time of the appraisal as shown in the table below. In accordance with the ex-post evaluation reference, internal rate of return at the time of the appraisal has been calculated again taking the year of L/A as the first year from the materials in which the details at the time could be confirmed. As a result, the figures came out as shown in the table below. FIRR calculated at the time of ex-post evaluation was -4.81%. Reasons for gap between the FIRR at the time of appraisal and ex-post evaluation are that more investment has been made earlier than the plan at the time of the appraisal and that duration of benefit became shorter than the time of the appraisal because of delay in commercial operation. Regarding EIRR, it could not be calculated at the time of the ex-post evaluation because data from several sources are required for calculating actual and forecast for the benefits, and the data were not easily available.

Table 2: Internal Rates of Return at the Time of the Appraisal and Assumptions on Them

	FIRR	EIRR
IRR	At the time of the appraisal: -0.85% At the time of the ex-post evaluation: -4.81%	At the time of the appraisal: 8.13% At the time of the ex-post evaluation: Not recalculated
Cost	Project cost, operation and maintenance (O&M) cost	Project cost (excluding taxes and duties), O&M cost
Benefit	Farebox revenue, advertisement revenue, property development revenue	<ul style="list-style-type: none"> ▪ Saving of the cost for conventional transport modes and roads, saving of time of users of MRT and other

		transport modes, savings of operating costs for transport systems such as buses due to alleviation of road congestion, and reduction in accidents and pollutions
Project life	30 years	

Based on the above, although the project cost was within the plan, the project period exceeded the plan. Therefore, the efficiency of the project is fair.

3.3 Effectiveness and Impacts⁹ (Rating: ②)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

For evaluating the operation and effect indicators, figures set at the time of the Tranche II appraisal were taken as the project's target considering the final scope of the project. Ridership was not originally included in the indicators. However, since it is considered as a standard indicator that represents the effectiveness of the metro project, it was added as one of the operation indicators at the time of the ex-post evaluation.

Table 3: Operation and Effect Indicators

Indicator	Target	Actual			Achievement (Actual in FY 2019/Target)
	2015 (2 Years After Completion)	FY 2017 ¹⁰	FY 2018	FY 2019 (2 Years After Completion)	
Operating rate (%/year)	92	100	100	97	105%
Running distance (thousand km/day)	16.12*	10.20	12.37	11.78	73%
Number of running trains (two directions/day)	780**	505	586	542	70%
Volume of transportation (million man km/day)	10.12	2.72	3.46	3.74	37%
Income from passengers (INR million/day)	17.0	7.70	9.72	10.59	62%
Ridership (persons/day)	1,020,000	299,197	366,407	393,799	29%***

⁹ Sub-rating for Effectiveness is to be put with consideration of Impacts.

¹⁰ The fiscal year in India is from April to March of the following year.

Source: Materials provided by JICA, BMRCL

*At the time of the appraisal, it was calculated as network length x number of running trains x round trips x number of coaches = 48.3 thousand km/day. However, BMRCL normally uses the following formula: running distance = number of running trains x network length. Thus, the target anticipated at the time of the appraisal has been re-calculated.

**In the documents at the time of the appraisal, the number of running trains was 390 based on one-way trip (single direction), but round trip (two directions) was used to compare with the actual.

***Target was for the year of full commercial operation. Therefore, 2017 was used as the year of comparison for achievement.

Looking at the achievement against the target for each indicator, only the operating rate has achieved the target while the achievement rates for the other indicators are between 29 to 73%. Running distance, number of running trains, volume of transportation and income from passengers have not achieved the targets owing to less ridership than the original estimate. According to the 2011 estimate, 1,020,000 ridership was expected in the year of full commercial operation. However, according to the ridership revised in the detailed design of Phase 2 of the project, it is estimated to be 1,080,000 for the total length of 71.4 km, which includes the extension of the East-West and South-North lines, indicating that the ridership estimates of the project do not necessarily reflect the reality. When ridership is calculated for the project (a total length of 42.3 km) based on the conditions confirmed for Phase 2, it turns out to be 645,000 persons. Nevertheless, even if the target is revised, the actual ridership is only about half of it.

One of the reasons why ridership is less than the target is that people who do not live within the walking distance of the metro stations do not use the metro because last mile connectivity (linkage between a metro station and the destination or the point of departure) is not necessarily secured although the project is integrating the metro with other transport modes such as Indian Railways, long distance buses, and city buses. According to a metro passenger survey¹¹ by the Environmental Management and Policy Research Institute (EMPRI) in 2017, many of the metro users live within the walking distance of metro stations, revealing that use of metro by people living outside the walking distance to the metro stations is limited. Considering that an inclination many of the current metro users live within the walking distance of the nearest metro station and many people have pointed out that parking space is insufficient at metro stations, access to the metro stations is an issue to certain extent. However, according to the same survey, out of the 1,057 persons who responded to the questionnaire, 1,048 (99%) feel that using the metro has reduced the travel time.

BMRCL recognizes issues such as the lack of last mile connectivity mentioned above, which is detrimental to gaining ridership, and competition with app-based taxis that have become quickly and highly popular in India in recent years. Particularly, to improve access between the metro station and the destination or point of departure, BMRCL is setting up stands for auto rickshaws, which are a popular means of transport for people, and working with service

¹¹ EMPRI (2017). *Assessing metro railway system as a means of mitigation strategy to climate change*.

providers of rental bicycles and motorbikes.

Table 4: Integration with Other Transport Modes and Provision of Facilities at Metro Stations

Integration/facility	Number of metro stations
Bus terminal	3
Indian Railways	3
Feeder bus	18
Auto rickshaw stand	40
Parking	28

Source: BMRCL

BMRCL has integrated with Bangalore Metropolitan Transport Corporation from early on, and 36 routes of feeder buses are operating in the city. In addition, BMRCL is working with private rental cycle and motorbike agencies, and the passengers can rent cycles and motorbikes at the metro stations.



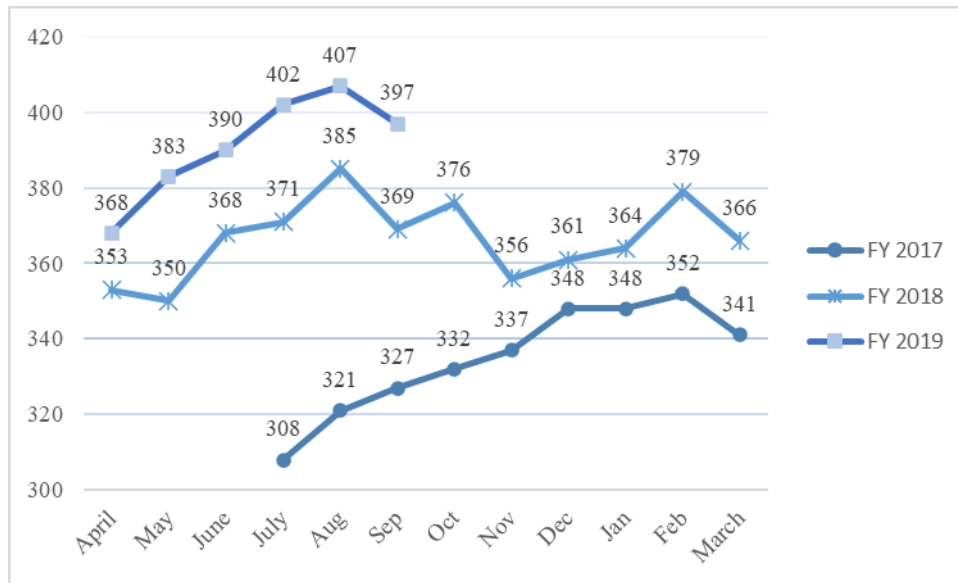
Figure 4: Signage for Transfer to Indian Railways



Figure 5: Auto Rickshaw Stand at a Metro Station

Because ridership was less than expected when commercial operation started, as of November 2019, the East-West line was operating with six coaches while the South-North line was operating with three coaches and partially with six coaches. The frequency of the trains was about every four minutes in peak hours and every seven to ten minutes during off-peak hours; this made the trains with three coaches very crowded. Initially, some passengers said that they do not use the metro because they do not like crowded coaches during peak hours; however, as the metro network expanded and people began to gradually recognize the convenience of the metro. In reality, average daily ridership is steadily increasing in the project since the opening of the metro. As of February 2020, all the trains have six coaches. Thus, improvement in ridership is expected in the future as well.

Unit: Thousand persons/day



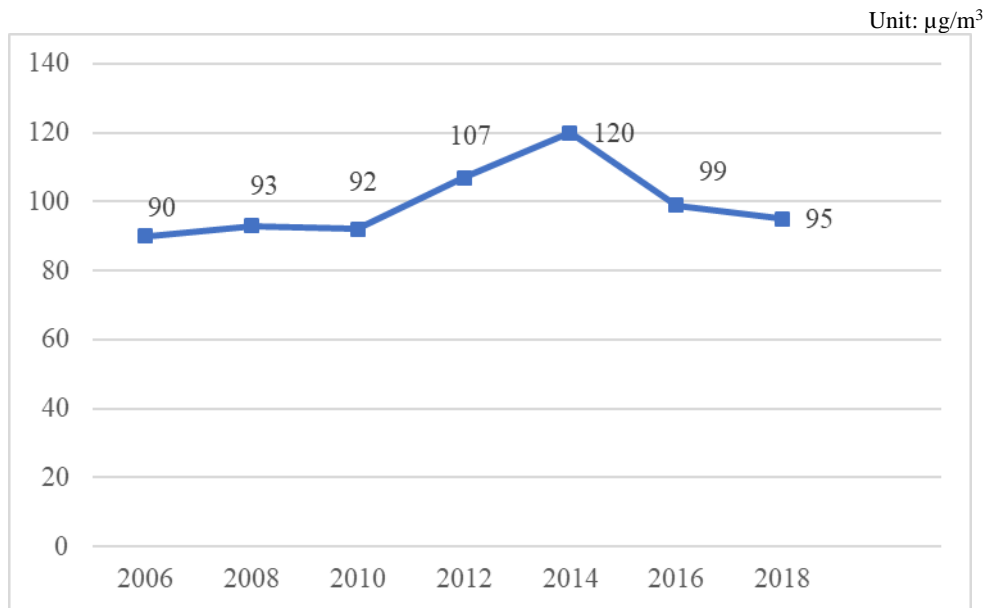
Source: BMRCL

Figure 6: Average daily ridership

3.3.1.2 Qualitative Effects (Other Effects)

The qualitative effects expected from the project were reduction of traffic congestion, improvement of the safety and comfort of urban life, and improvement of convenience by securing on-time mobility in Bangalore. The extent of the realization of qualitative effects has been checked based on the results of the previously mentioned survey by EMPRI in 2017 and by interviews with passengers at the time of the ex-post evaluation. Targeting 1,067 metro users, EMPRI surveyed socioeconomic changes brought by the metro operation and accessibility of the metro. In the survey, 53% of the users stated that traffic congestion decreased a little or partially in the city after the metro began operating. Moreover, 90% of the respondents felt that air pollution decreased a little or to a certain extent.

At the time of the ex-post evaluation, an interview survey was conducted with 18 users in the metro stations. The survey revealed that 11 of them felt metro operation helped ease the traffic congestion in the city somewhat. On the other hand, the opinions regarding air pollution were split: eight felt it decreased, six felt no change, and four said they do not know. The figure below shows the annual average of suspended particulate matter (SPM) in Bangalore since 2006.



Source: Created by the external evaluator based on data from the Central and State Pollution Control Board

Figure 7: Annual Average of SPM in Bangalore

According to the annual average SPM, there is an improving trend since the time of the appraisal; however, it cannot be concluded that the change was brought by the project. Nevertheless, with the construction of the MRT system, the people have gradually shifted from cars to the metro. As a result, the number of running vehicles has decreased somewhat, reducing air pollution to a certain extent. Thus, it is fair to say that the project contributed to the reduction of air pollution to some degree.

Regarding comfort and safety, all the respondents said that the metro is better than other transport means, while five respondents said that taxis and auto rickshaws are easier to use considering the crowded metro trains during peak hours and train frequency during off-peak hours. Other opinions are the following: using the metro has helped decrease travel time compared to before; people can travel on-time, and the use of the private car has decreased. Some users opined that, when they come to Bangalore from other regions, it is convenient to move to the metro from Indian Railways stations and bus terminals as the metro stations are connected to the railway and buses.¹²

As described above, many of the metro users feel that the opening of the metro has reduced traffic congestion somewhat. There are users who feel that air pollution has also decreased. Passengers have generally favorable impressions on the opening and use of the metro, and it is fair to say that the project has brought improvement to urban life to a certain extent.

¹² The responses from the interviewees and the reasons cited for the responses are not necessarily a collection of the results of one-on-one interviews.

3.3.2 Impacts

3.3.2.1 Intended Impacts

The impacts expected of the project were “promoting regional economic development and improving the urban environment through mitigation of traffic jams and decrease of pollution.” At the time of the ex-post evaluation, to confirm the contribution of the metro to the regional economy, interviews were conducted with seven industrial and commercial associations whose related businesses are located along the metro lines.¹³ From the start of the project, a shopping mall directly connected to a metro station invested in the construction of the station and advertisements to attract more customers, and started developing offices and residential complexes nearby. Regarding the businesses along the metro lines, some moved to locations nearby because of the metro construction, while others reported a decrease in revenues because the number of customers decreased owing to a long construction period and dust. On the other hand, economic associations have pointed out that the opening of the metro has enhanced the mobility of their employees and executives. Moreover, many interviewees cited a lack of parking space around the metro stations. The need for parking at the metro stations was pointed out in the EMPRI survey as well.

Some of the businesses that were forced to relocate because of the project have been affected adversely by the metro construction. However, the industrial and commercial associations have opined in general that the project, as a means of transport, has contributed to economic development to a certain extent. Thus, it is fair to say that the project is contributing to developing the regional economy and improving the urban environment of Bangalore.

3.3.2.2 Other Positive and Negative Impacts

Impacts on the Natural Environment

The project falls into the rail sector according to the JBIC Guidelines for Confirmation of Environmental and Social Consideration, and is classified as Category A because it included a large-scale involuntary resettlement.

During the construction, the contractors monitored such elements as air quality, noise, and water quality under the supervision of an environmental officer from BMRCL. Monitoring was conducted at the frequency of one to two weeks depending on parameters, and no issues were reported from this monitoring. An information board with the contact information of the officer in charge was displayed at each construction site. When there were complaints from people living in the vicinity regarding dust from the construction sites and vibration during excavation, BMRCL took proper actions such as watering regularly at the sites and stopping construction

¹³ ① Mantri Square Mall management office, ② Karnataka Small Scale Industries Association, ③ Brigade Road Trader’s Association, ④ CMH Road Shops and Establishments Association, ⑤ M.G.Road Trader’s Association, ⑥ Peenya Industries Association, ⑦ Karnataka Hosiery & Garment Association.

work at night.

Since the opening of the metro, no environmental monitoring has been conducted in the same areas. Rails were fitted with soundproof pads and measures against noise are taken.

While implementing the project, 950 trees were cut. To minimize the felling of trees, pruning and transplanting were practiced to the extent possible. For each tree cut, ten trees were planted in its place.

Resettlement and Land Acquisition

The total land area acquired for the project was 126 ha. The number of affected structures was 877 while the one of affected households was 2,288. Out of the affected households, 169 in the slum areas were moved to two locations provided by BMRCL. The remaining households received compensation money and relocated on their own. Resettlement plan was formulated based on *JBIC Guidelines for Confirmation of Environmental and Social Considerations* (April 2002). Compensation was provided in accordance with the *Karnataka Industrial Area Development Act* (1966). Guidelines on compensation and resettlement were prepared, and compensation money and allowance for the transition period were provided on the basis of the size of the affected land area and the way that the land had been used prior to the project.

Two resettlement sites provided by BMRCL were visited during the ex-post evaluation and interviews were conducted with the people affected by the project. The houses provided in both locations were constructed in the same layout as the adjoining BMRCL staff housing. The houses were registered in the names of the female heads of the households by BMRCL; BMRCL paid the cost of the registration. People who relocated to Peenya colony had lived in houses with asbestos, and the water came from the community tap while toilets were also shared with the community. However, in the relocation site, water supply and toilets are provided in each household and the people had no issues with water. The people relocated from the same original area, and many of them work as carpenters and household helps, and some of them landed work as household help in the BMRCL staff housing. The housing conditions in Srigandhakaval colony were essentially similar; however, Srigandhakaval was further away from the city center compared to the previous colony, and some said that their income decreased or they lost jobs because commuting became difficult. Moreover, access to the public bus network is bad from the resettlement site, and people seemed to be struggling with means of transport. In the project, BMRCL was to hire an NGO with its own funds and monitor the living conditions after the relocation, but the resettlement officer of BMRCL visited the relocation site regularly during and soon after the resettlement, and responded to requests and complaints from the project-affected people, and thus the monitoring by NGO was not conducted.



Figure 8: Resettlement Site



Figure 9: Temple Built at a Resettlement Site

Unintended Positive/Negative Impacts

In the construction phase of the project, Karnataka State AIDS Prevention Society implemented HIV prevention activities targeting migrant workers.

In addition, Samarthyam, an organization that supports the physically challenged, provided advice during the implementation of the project to make the stations and coaches accessible to such people. During a field visit, it was confirmed that elevators are installed in each station. Although tactile paths for the visually challenged are in place, it was observed in some of the stations that portions of the tactile paths are not continuous. A similar issue was pointed out in the metro survey conducted by the visually challenged in 2019.¹⁴ Space for a wheelchair is available in the first and last coaches.

In effectiveness, the operation and effect indicators have not achieved the targets except the operating rate because of less ridership than initially expected. On the other hand, initiatives such as improving access to the metro stations and adding coaches are taken, and the ridership has been increasing since the opening of the metro. The metro is becoming an important means of transport for the people of Bangalore, and thus, the improvement in a number of indicators is expected in the future. Moreover, the project has contributed to reducing the traffic congestion and air pollution in Bangalore a certain extent, as well as the development of the regional economy. This project has achieved its objectives to some extent. Therefore, the effectiveness and impacts of the project are fair.

3.4 Sustainability (Rating: ③)

3.4.1 Institutional/Organizational Aspect of Operation and Maintenance

The executing agency and operation and maintenance (O&M) organization of the project is

¹⁴ Varun and Vanitha (2019). *Study of challenges faced by visually impaired persons in accessing Bangalore Metro service.*

BMRCL, established in 1994 by the *Indian Companies Act (1956)*. In 2005, BMRCL became a fifty-fifty joint venture of the central government and the Karnataka state government. Headed by the Managing Director, the organization has a wing in charge of O&M of the network already in operation and a project wing in charge of the construction of a new network. The O&M wing is headed by the Director of O&M and has 1,375 personnel as of October 2019. The vacancy rate is about 15%, but according to an interview with BMRCL, there is no particular problem arising out of manpower shortage. Specifically, all the 143 Station Superintendent posts are vacant; however, these posts are currently looked after by 455 Station Controllers and Train Operators, and some of them will be promoted to be Station Superintendents. In the O&M wing, responsibilities are clearly divided based on job categories and train lines, and separation of duties is clear. The turnover rate since the start of commercial operation is about 4%, low compared to Indian average of 13%.¹⁵ The maintenance of such facilities as elevators and escalators as well as cleaning duties are outsourced to agencies.

As described earlier, BMRCL has strived to work with various transport related institutions in Bangalore from the project's planning and implementation stages. Even now, BMRCL is regularly coordinating with Bangalore Metropolitan Transport Corporation, Indian Railways, and the Urban Transport Department, and institutional arrangements for O&M are in place.

3.4.2 Technical Aspect of Operation and Maintenance

BMRCL has its own training institute located within the Baiyappanahalli depot. The training institute holds courses for new recruits and refresher training, and provides training for new metros in India. New recruits undergo several months of technical training according to job categories. Train Operators and Station Controllers are supposed to switch their duties every few years, and training programs for switching the jobs and for promotion are in place. According to the training records of the last three years at the institute, courses are conducted as per the training plan each year. This indicates that there is a system for learning, maintaining, and improving technical skills required for O&M within the organization.

From the beginning, BMRCL has recruited the engineers who retired from Indian Railways and engineers with working experience in Singapore MRT so as to meet the technical requirements for civil works and after starting commercial operation. Even at the time of the ex-post evaluation, many of the managerial-level personnel are those who came to BMRCL with experience in Indian Railways and central and state government agencies. New employees associated with O&M are required to have appropriate education and skills for their job, and have been hired through recruitment exams including written test and interview, and they receive training of a specific duration after taking up their job. No accidents have been reported

¹⁵ Oman Consultants (2019). *Increment Trend – 2019*.

in the project from the time of the opening to the ex-post evaluation. It has been reported that there is no issue with technical skills of employees, and the skills are at an appropriate level.

O&M manuals are prepared for each facility, while manuals for coaches are available for each part and equipment item. The O&M status of coaches is described in “3.4.4 Status of Operation and Maintenance.”

3.4.3 Financial Aspect of Operation and Maintenance

As shown in Table 5, BMRCL’s balance sheet for the last three years shows a loss. However, most of it is due to expenditures on O&M and depreciation.

Table 5: Balance Sheet of BMRCL

Unit: INR million

	FY 2016	FY 2017	FY 2018
Revenue			
Farebox	1,101	2,810	3,550
Advertisement	52	71	77
Property development	298	492	567
Reimbursement of cash loss	-	2,023	1,164
Total revenue	1,451	5,395	5,359
Expenditure			
O&M	1,723	2,629	3,352
Depreciation	3,642	5,158	5,839
Interest	662	1,118	1,125
Total expenditure	6,027	8,906	10,317
Profit/Loss	-4,576	-3,511	-4,958

Source: BMRCL

Current ratio of BMRCL is sound at 2.42 in FY 2017 and 1.82 in FY 2018. For repayment of debt, reimbursement for cash loss is provided by the Karnataka state government, in addition to repayment from BMRCL’s revenue. BMRCL requests the reimbursement for the loss for a particular fiscal year to the state government, and the budget provision is made by the government. Basically, the whole requested amount is sanctioned, but it is provided in phases from the state government’s budget in the subsequent fiscal year onwards.

As regards the passenger fare, it has not been revised for eight years since the metro started its commercial operation (in case of the token, the minimum fare is INR 10 and the maximum INR 42, while a 15% discount is applied for a ride using Smart Card). Fare structure for the metro is more expensive compared to city buses. For instance, traveling for distance of 3 km is

INR 15 for the metro while INR 10 for the bus, and it becomes INR 42 and INR 37 respectively for the distance of 18 km. In other cities in India, the metro fare is also more expensive than the bus fare. Fare revision is decided by the Fare Fixation Committee constituted by the central government. So far, BMRCL has requested a fare revision to the central government considering the price escalation since it started operating the metro and an increase in the O&M cost in the future, but there seems to have been no specific progress. On the other hand, the share of the fare revenue in the O&M cost was 64% in the opening year, and it has been more than 100% thereafter. Currently, the fare structure does not seem to pose any issue for meeting the O&M cost. However, as the O&M cost may increase gradually in the future, it is important to prepare for fare revision considering the market situation. Moreover, BMRCL is working hard to increase the advertisement revenue in the future, and its financial status appears to be sound.

3.4.4 Status of Operation and Maintenance

From a field visit during the ex-post evaluation, it was confirmed that the stations, coaches, and railway depots were properly maintained. Automatic vending machines procured with funds from the Indian side had problems with the coin slot, and were not installed at the stations at the time of starting commercial operation. By 2020, adjustments have been made to the machines and 11 of them have been installed at nine stations, and more machines are to be installed at other stations.

Coaches are cleaned and inspected every day and checked according to the check sheet before starting service. In addition, regular maintenance is performed based on the running distance of each coach.

None of the spare parts is difficult to procure in India, and the Indian metro projects in recent years have been procuring coaches and related parts from the manufacturers who have production units in the country. Thus, spare parts do not pose an issue.

No major problems have been observed in the institutional/organizational, technical, financial aspects, and the current status of the operation and maintenance system. Therefore, the sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

In the beginning of the 1990s, traffic congestion was a serious issue in urban India, urgently requiring the establishment of a mass public transport system. Under such circumstances, by constructing a metro in the southern city of Bangalore, the project was implemented with the objective to contribute to developing the regional economy and improving the urban

environment through reducing traffic congestion and traffic pollution.

The urban transport sector, particularly the MRT system, has been considered important in India's development policy from the time of the appraisal to the ex-post evaluation. Traffic congestion, particularly in the central part of the city, remains a serious issue even at the time of the ex-post evaluation. The need for the people to switch to rail-based transport, who were dependent on road transport, is recognized even now, and development needs on MRT continue to exist. The project was consistent with Japan's ODA policy at the time of the appraisal, and the relevance is high.

According to the original plan, an MRT system with the total length of 33 km, comprising the East-West and South-North lines, was to be built. However, the project included the extension of the South-North line in 2011, and a network of 42.3 km in total was constructed. Because of limited ridership at the time of opening, less rolling stock was procured than originally planned. Although the project cost was within the plan, there was a significant delay in the project period caused by geological conditions not anticipated during the detailed design, such as uneven bedrock, which were found after the project started. This has made the efficiency of the project fair.

Regarding the achievement of operation and effect indicators, only the operating rate achieved the target, and other indicators achieved 29–77% of the targets owing to less ridership than the initial estimate. On the other hand, many metro users feel that the opening of metro has reduced the city's traffic congestion and air pollution. With regard to the natural environment, necessary actions were taken during the implementation of the project. As regards land acquisition and resettlement, there are no specific issues. Therefore, the effectiveness and impacts of the project are fair.

In BMRCL, the organization operating and maintaining Bangalore Metro, has necessary institutional arrangements for operating and maintaining the existing network, and its employees have necessary technical skills. BMRCL has an internal training system to maintain and improve the skill level of its employees. As regards the financial aspect, BMRCL is running a deficit, but its farebox revenue is at a sufficient level to meet the operation and maintenance costs. Stations, trains, and other equipment are appropriately managed, and the sustainability of the project is high.

In light of the above, this project is evaluated to be satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

Currently, the farebox revenue from the project is at sound level compared to O&M cost. However, O&M cost may gradually increase in the future. Since fare revision may take more time than necessary for coordinating within the government, it is desirable to follow-up on fare

revision and to strengthen the revenue sources by increasing the revenue from advertisement and property development.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Coordination with other transport modes

From the time of project formulation, the project consciously coordinated with Indian Railways, long distance buses, and city buses while it was constructing the metro network and stations. This has resulted in several stations in the metro lines where transfer to other transport modes can be easily made. Integration between the metro and other transport modes is convenient for the users who come from outside the city, and it has contributed to gaining some degree of ridership. To integrate with other transport modes after the construction of metro lines requires changes in the design of stations. To connect to Indian Railways, land had to be provided by Indian Railways to construct a passageway from the metro on the land owned by the national railway company. Although it took time to secure the land, the project negotiated persistently and repeatedly with other transport institutions and enhanced the convenience and mobility of people using transport.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs	<p>a) Civil works</p> <ul style="list-style-type: none"> • East-West line: 18.1 km • South-North line: 24.2 km • 33 at-grade and elevated stations and 7 underground stations <p>b) Electric, communication and signaling systems</p> <p>c) Procurement of coaches: 168</p> <p>d) Construction of depots</p> <p>e) HIV prevention activities</p> <p>f) Consulting services</p> <ul style="list-style-type: none"> • Detail design, preparation of tender documents, assistance in bidding • Construction management, quality control, test drive • Preparation of O&M manuals, training program 	<p>As planned</p> <p>As planned</p> <p>150 coaches</p> <p>As planned</p> <p>As planned</p> <p>As planned</p>
2. Project Period	March 2006 – June 2013 (88 months)	March 2006 – June 2017 (136 months)
3. Project Cost		
Amount Paid in Foreign Currency	67,482 million yen	66,990 million yen
Amount Paid in Local Currency	239,327 million yen (127,301 million Indian rupees)	177,657 million yen (99,720 million Indian rupees)
Total	306,809 million yen	235,498 million yen
ODA Loan Portion	64,536 million yen	57,840 million yen
Exchange Rate	1 Indian rupee = 2.49 yen (As of September 2010)	1 Indian rupee = 1.90 yen (Average between January 2007 to December 2017)
4. Final Disbursement	September 2017	

【Column: Interaction with citizens through the metro】

Bangalore has many parks and is endowed with plentiful greeneries for a large city, which is why it is also known as Garden City. Cubbon Park, which is called the city's lung, is located in the central part of the city, and has the metro station with the same name. Anybody who sets foot in the Cubbon Park station is bound to be mesmerized by the colorful exterior of the station and the works of art installed inside the station. At the Cubbon Park, Chickpete, and Peenya stations, a local college is undertaking the "Art in Transit" initiative using the space in and out of the stations. By installing works of art in the metro, which is a public place, the initiative is using it for facilitating dialogue and interaction with the local people. The initiative provides opportunities for the people in transit to think and discuss Bangalore's history, identity, and social issues, while the works of students studying art, design, and technologies are displayed and the space is used for experiment. Some of the metro stations have entrances and exits that were built in anticipation of a future increase in passengers but are not currently used. Art in Transit uses such space as studios. At times, theater and workshops are conducted there, and some come to the stations for such events even if they do not use the metro.

The vicinity of the Peenya station is an industrial zone with a dusty and dim image. A student who took part in Art in Transit walked around the neighborhood of Peenya and photographed the colors of the area. From the photographs, she took out the vibrant hues of the area, and set up an art object in the station using them. The object helps passers-by feel at ease.



Walkway outside MG Road Station



Installation at Peenya Station

Art in Transit focus on more than just art. Recently, it conducted a questionnaire survey on the safety of women at specific stations, and studied their safety between the stations and their homes. The findings were shared with BMRCL and the local police. As a result, the Bangalore police launched an app for women SOS.

Furthermore, BMRCL uses the space under the elevated MG Road station as small theater, gallery and children's park. BMRCL turned the space, which had been a walkway before the metro construction, into new space for the community.

Annex 1: Bangalore Metro Network

