

**Ex-Post Project Evaluation 2010: Package II-7
(India)**

November 2011

**JAPAN INTERNATIONAL COOPERATION AGENCY
FOUNDATION FOR ADVANCED STUDIES
ON
INTERNATIONAL DEVELOPMENT**

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Preface

Ex-post evaluation of ODA projects has been in place since 1975 and since then the coverage of evaluation has expanded. Japan's ODA charter revised in 2003 shows Japan's commitment to ODA evaluation, clearly stating under the section "Enhancement of Evaluation" that in order to measure, analyze and objectively evaluate the outcome of ODA, third-party evaluations conducted by experts will be enhanced.

This volume shows the results of the ex-post evaluation of ODA Loan projects that were mainly completed in fiscal year 2008, and Technical Cooperation projects and Grant Aid projects, most of which project cost exceeds 1 billion JPY, that were mainly completed in fiscal year 2007. The ex-post evaluation was entrusted to external evaluators to ensure objective analysis of the projects' effects and to draw lessons and recommendations to be utilized in similar projects.

The lessons and recommendations drawn from these evaluations will be shared with JICA's stakeholders in order to improve the quality of ODA projects.

Lastly, deep appreciation is given to those who have cooperated and supported the creation of this volume of evaluations.

November 2011
Masato Watanabe
Vice President
Japan International Cooperation Agency (JICA)

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Ex-Post Evaluation of Japanese ODA Loan
“Delhi Mass Rapid Transport System (I)-(VI)”

External Evaluator: Keiichi Takaki and
Yoshimi Hayashi , FASID

0. Summary

Although this project has some issues of ridership and revenue that have not reached the original target, the number of train services, operational ratio, train kilo have been improved by 2010 as the new lines became operational, the number of operational cars increased, and the service interval became shorter. Sustainability is evaluated as high since the management of the executing agency and the operation of stations and train services are appropriate by effective decision making and information sharing through regular meetings, daily reports, and oral communication. In terms of human resource development, training programs are continuously improved so that they are responsive to the operational needs and skills of all staff are appropriately upgraded. Relevance and efficiency of this project are also evaluated as high. Passengers of Delhi Metro highly appreciate its comfort, cleanness, punctuality and frequency of operation except crowdedness at the peak hours. In light of the above, this project is evaluated to be highly satisfactory.

1. Project Description



1.1 Background

At the time of the appraisal of this project, buses were the only available transportation means in Delhi in spite of a rapid centralization of population accompanied by economic growth. This, together with the increase in the number of personal vehicles, drastically worsened traffic congestion, and their vehicle emission caused serious air pollution. To solve these problems, the public transportation had to be improved. Since the train system in Delhi was designed for long distance passenger travel and cargo transportation, the mass transport system for commuting was to be constructed in order to resolve traffic congestion and alleviate air pollution.

1.2 Project Outline

This project was planned and implemented with the objective of improving urban environment in Delhi, the capital city of India by constructing the mass rapid transport system totaling 58.6 km in length, thereby contributing to resolve traffic congestion and alleviate traffic pollution. The total plan of the mass rapid transport system has four Phases and this evaluation concerns Phase I. As indicated by Table 1 in the section of efficiency, Phase I constructed three lines of 58.6km in total that include 13.2 km metro corridor, 4.5 km ground corridor, and 40.9km elevated corridor, and this Phase I was completed in November 2006. The executing agency is Delhi Metro Rail Corporation Limited (DMRC). Line I (so called Red Line) was commissioned in March 2004, Line II (Yellow Line) was commissioned in July 2005, and Line III (Green Line) was commissioned in November 2006. Currently, Phase III is being planned.

Loan Approved Amount/ Disbursed Amount	I. 14,760 million yen / 14,759 million yen II. 6,732 million yen / 6,731 million yen III. 28,659 million yen / 28,650 million yen IV. 34,012 million yen / 33,582 million yen V. 59,296 million yen / 56,591 million yen VI. 19,292 million yen / 19,200 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	I. January, 1997/February, 1997 II. March, 2001/March, 2001 III. February, 2002/February, 2002 IV. March, 2003/March, 2003 V. March, 2004 /March, 2004 VI. March, 2005/March, 2005/
Terms and Conditions	Interest Rate: 1.8% Repayment Period: 30 years (Grace Period: 10 years) Conditions for Procurement: General Untied
Borrower / Executing Agency	President of India/ Delhi Metro Railway Corporation
Final Disbursement Date	June, 2010

Main Contractor (Over 1 billion yen)	<ul style="list-style-type: none"> • Abb Ltd. (India)/Best and Crompton Engineering Ltd. (India) • Alstom Transport SA (France)/Alstom Projects India Ltd. (India)/Sumitomo Corporation (Japan)/Thales Security Solutions and Services, S.A. (Portugal) • Thales Transportation Systems SA (France)/Thales Security Solutions and Services, S.A. (Portugal) • Dyckerhoff & Widman (Germany)/Ircon International Ltd. (India)/Larsen & Toubro Ltd. (India)/Shimizu Corporation (Japan)/Samsung Corporation (South Korea) • Hindustan Construction Company Ltd. (India)/Kumagai Gumi (Japan)/Itochu Corporation (Japan)/Skanska International Civil Engineering A.B. (Sweden) • Ircon International Ltd. (India)/Cobra S.A. (Spain)/Eliop S.A. (Spain) • Mitubishi Electric (Japan)/Mitsubishi Corporation (Japan)/Rotem (South Korea) • Kone Corporation (Finlad)/Kone elevator India Private limited (India) • Kalindee Rail Nirman(Engineering) Limited (India) • Thales Security Solutions and Services, S.A. (Portugal) • Abb Ltd. (India) • Siemens AG Transportation Systems TS RA (Germany)/Siemens Ltd. (India) • Bembl Limited (India)
Main Consultant (Over 100 million yen)	<p>Rail India Technical and Economic Services Ltd.(India)/Japan Railway Technical Service (Japan)/Pacific Consultants (Japan)/Tohnic Consultant (Japan)/Parsons Brinckerhoff International, inc.(U.S.A.) Arthur D Little Ltd.(U.K.)</p>

Feasibility Studies, etc.	“Master Plan for Delhi Perspective 2001 (prepared by Delhi Development Authority)” organization, month, year
Related Projects (if any)	None

2. Outline of the Evaluation Study

2.1 External Evaluator

Keiichi Takaki (Foundation for Advanced Studies on International Development)

Yoshimi Hayashi (Foundation for Advanced Studies on International Development)

2.2 Duration of Evaluation Study

Duration of the Study: November 2010 – October 2011

Duration of the Field Study: March 11, 2011-March 30, 2011 and July 17, 2011 – July 26, 2011

2.3 Constraints during the Evaluation Study (if any)

None

3. Results of the Evaluation (Overall Rating: A¹)

3.1 Relevance (Rating: ③²)

3.1.1 Relevance with the Development Plan of India

The Government of India has poverty elimination as its most important goal. The 8th five-year plan (April 1992 – March 1997) pertinent to the first tranche of this project aimed at meeting the basic needs, especially food and public health. In order to achieve this goal, the Government of India prioritized industrialization for which it emphasized upgrading infrastructure projects that include energy, transportation system, communication, irrigation facilities, and others. Subsequent plans from 9th five year plan to 11th five year plan (April 2007 – March 2012) have consistently put high priority on upgrading transportation sector for economic growth.

3.1.2 Relevance with the Development Needs of India

The population of India was 1.027 billion in accordance with census in 2001, and the United Nation forecasts that India will surpass China and become the most populous country. The population of Delhi has increased as the industrial structure has become more advanced. Her population was 9.42 million (Census 1991), 13.85 million (Census 2001), and 16.78 million (Provisional result of Census 2011).

¹ A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

² ③: High, ② Fair, ① Low

In terms of the transportation means that Delhi citizens were using in 1991, bus accounted for 60%, personal vehicles did for 39.5%, and railway only did for 0.5%, and the use of railway was much less common than other cities. For example, in Mumbai, the railway was the most common means of transportation as it accounted for 48% whereas bus did for 40%, personal vehicle did for 12%. The railway network in Delhi was meant for long distance passenger travel and cargo transportation, but not for short distance commuting. The number of bus was 37,000 in 1999 and was not sufficient to meet the increasing demand of commuters, which made the buses overcrowded. Private vehicles rapidly increased and the registered cars were 520,000 in 1980, 1.83 million in 1990, and 3.3 million in 1999. This caused heavy traffic congestion, and upgrading public transportation system became an urgent issue. Vehicle emission of more Vehicles caused environment problems such as air pollution. However, the number of vehicles could not be reduced, and the policy measures for the environmental protection had to be deliberated urgently. Under these situations, the need increased for the construction of mass transportation system that is punctual, and efficient, and can alleviate traffic congestion and solve environmental problems.

After the completion of Phase I, economic growth of India and the population of Delhi continued to increase, the needs for the means to alleviate traffic congestion and solve environmental problems were still high, and Phase II was completed with 83 km of tracks in August 2011.

3.1.3 Relevance with Japan's ODA Policy

The yen loan policy of 1996 for India at the time of appraising the first tranche of this project stated that “for India with the largest poor population in the world, the emphasis was put on the assistance to alleviate poverty, promote environmental protection and upgrade economic and social infrastructure necessary for self-sustained economic growth .”

Japan's ODA policy for India prepare by the Ministry of Foreign Affairs emphasized the assistance for upgrading infrastructure that includes power supply and transportation in particular that are the priority area of India's five year plans. Subsequently, the yen loan policy of April 2002 of Japan's ODA policy for India emphasized “upgrading badly insufficient economic infrastructure that include power supply and transportation” and “improving environment in urban areas where environmental and hygiene situations are drastically worsening.” In 2004, the assistance for poverty reduction through economic growth was emphasized. In particular, the infrastructure necessary for economic activities was emphasized as critical, and it was intended to increase the assistance to upgrade economic infrastructure with power supply and transportation as the main area.

From the above, this project is consistent with the development policies of the Government of India that has priority in the transportations, development needs of alleviating traffic congestion and air

pollution in Delhi, and Japan's ODA policy. Therefore its relevance is high.

3.2 Efficiency (Rating: ③)

3.2.1 Project Outputs

Table 1 indicates the plan and the actual of outputs (track length, the number of stations, and the number of rolling stocks) for each line, and they were produced mostly as planned.

Table 1. Plan and Actual of Outputs

	Track Length (km)		Number of Stations		Rolling Stocks	
	Plan*	Actual	Plan	Actual	Plan	Actual
Line I	22.00	22.056	18	18	280	280
Line II	11.00	11.008	10	10		
Line III	25.60	25.546	25	25		

*by the plan of year 2004 (Appraisal for the 6th tranche)

3.2.2 Project Inputs

3.2.2.1 Project Cost

Table 2 indicates the total budget and the actual expenditure. In terms of yen loan, 162,751 million yen was budgeted, and 159,513 million yen was actually disbursed, which makes plan ratio 98%. In terms of Indian government budget, 48,000 million rupee was planned, and 34,320 million rupee was actually spent, because of shortened construction period and other factors, which makes plan ratio 71.5%.

Table 2. Plan and Actual of the Project Budget

Total Project Cost	Plan	Actual
Yen Loan (million yen)	162,751	159,513 (plan ratio 98%)
Indian Government Budget (Million Rupee)	48,000	34,320 (plan ratio 71.5%)

Exchange rate: 1Rs=2.40 yen

3.2.2.2 Project Period

Table 3 concerns the plan and the actual of the project period. Line I was completed as planned. Line II was completed earlier than the plan by three months. The completion of Line III was delayed in some part because the government approval was delayed. (The delayed construction period for Line III was offset by the shortened construction period for Line, making plan ratio 100% in total.)

Table 3 Plan and Actual of Project Period

Commissioning Date of each line	Plan	Actual	Delay/No delay
Line I: Shahdara station-Rithala station)	1996— March 31, 2004	1996— March 31, 2004	No delay
Line II: Vishwa Vidyalaya station - Central Secretariat Station	1996— September 30, 2005	1996— July 3, 2005	No delay
Line III: Barakhamba Road station— Dwarka station	July 2002— December 31, 2005	July 2002— December 31, 2005	No delay
Line III: Barakhamba Road station— Indraprastha station	January 2004— March 31, 2006	October 2004— November 11, 2006	Delay due to delayed approval by the Indian Government

Table 1 shows that the track length, the number of stations, and the number of rolling stocks as the outputs of this project were produced mostly as planned. Table 2 indicates that expenditure of yen loan and Indian government was within the budget. As Table 3 indicates, the project period was mostly within the plan although there was delay in some part of Line III, it was offset by shortened period of Line II. In summary, both project cost and project input were mostly as planned, therefore efficiency of the project is high.

BOX1: “Work Culture” at DMRC

It is usually difficult in India to complete public works projects within schedule for various reasons. However, Delhi Metro project was mostly completed within the schedule. To find out the reasons, interviews were undertaken with 17 personnel of DMRC that include directors and chiefs of departments of finance, operation, engineering, and works. Below are summaries of what was told consistently in these interviews.

1. “Deadline is sacrosanct.”

DMRC people frequently mentioned that deadline is sacrosanct. To meet the deadline, daily work style, attitude of staff, ways of thinking are crucial. Below is what was told to make this possible.

2. “Success of contractor is ours, and failure of contractors is also ours.”

Public works project is implemented by private contractors who win bids. After the contracts signed, the completion of the work is usually left to the contractors. For example, railway construction project may require relocation of water and sewage facilities for the construction of tracks, for which permission needs to be issued by the water authority which may become available late, and this may delay the construction. Officials in charge of the project often leave the work completion to the contractors and do not help them.

However at DMRC, people say success of contractor is ours, and failure of contractors is also ours. DMRC officials do not leave the work solely to contractors, and make frequent contacts and cooperate with them as necessary in order to complete the project within the schedule. Within DMRC, officials are not left alone, provided with the effective working environment where their supervisors always monitor them, and provide advice as necessary.

When the construction for a project requires relocation of existing infrastructure such as electric poles and water supply pipes, other agencies in charge of the project may request the appropriate authority to do the relocation. The procedure and the relocation work may be delayed, and this in turn may delay the project completion. In order to avoid such situations, DMRC takes direct charge of relocation of existing infrastructure by keeping close contacts with the pertinent authority and contracting out the work to the private contractors. In this way, relocated infrastructure by DMRC is usually in the same or better conditions than before.

3. Factors that made "Work Culture" possible

Work culture at DMRC is unique in India. For this work culture to be present at DMRC, leadership was one crucial factor. Another factor is DMRC was a new organization founded specifically for this project, thus all the personnel were new to the organization at its beginning. At the time of their recruitment of personnel, emphasized was not only qualification in their technical specialties but also their strong motivation to practice the work culture discussed above.

3.3 Effectiveness (Rating: ②)

3.3.1 Quantitative Effects

3.3.1.1 Results from Operation and Effect Indicators

Table 4 shows the comparisons of operational objectives planned as of 2004 and actual performance data. The objective achievement, apart from transported passengers and annual fare revenue heavily influenced by transported passengers, were not fulfilled in 2008 but improved in 2010.

Regarding the operating rate, the achievement was 89% in 2006 and 93% in 2008 comparing to the objectives. The DMRC recurrently computes operation numbers most suitable to ridership, and designs operation plans such as the number of rolling stocks to own and operational intervals. Thus, the DMRC has increased the number of rolling stocks owned according to demands from the opened extension and new lines since 2006. The operating rate at 2009 had reached 94% with 280 rolling stocks, which was 102% achievement comparing to the objective. Likewise, car kilometre reached the target alongside of the operating rate. Since 2008 onwards, only Line III's car kilometre increased. This is more likely because a train service became from 4 cars to 6 cars on Line III in 2010. Although the targeted operation number was not met in 2006 and 2008, it was exceeded in 2010 with enhancement of operational intervals and the increased number of rolling stocks. The transported

passengers and the annual fare revenue performances were far from the targets. Details are described in 3.3.1.2 Results of Calculations of Internal Rates of Return (IRR).

Table 4. Operational Objectives and Performance

Indicators	Objective		Performance		
	2006	2008	2006	2008	2010
Operating rate (%/year)	92	92	82	86 (93% achieved)	----
Car Kilometre (km/day)	94.1	96.3	83.0	95.84 (99% achieved)	109.56
Line I	36.0	37.0	32.4	34.11	35.9
Line II	17.5	17.5	15.9	17.39	18.7
Line III	40.6	41.8	34.7	44.20	55.00
Operation numbers (trains/day, one direction) (Peak hour×minute head)	636	648	542	624 (96% achieved)	774
Line I	204(X=4)*	210(X=4)	184(X=4)	206(X=4)	229(X=4)
Line II	228(X=3)*	228(X=3)	194(X=4)	225(X=4)	310(X=4)
Line III	204(X=4)*	210(X=4)	164(X=4)	193(X=4)	235(X=4)
Transported passengers (Million passengers-km/day)	16.3	22.6	5.4	7.16 (32% achieved)	11.46
Line I	7.1	11.1	1.9	2.30	3.03
Line II	2.6	2.7	1.6	1.96	3.32
Line III	---	---	---	2.81	5.10
Annual fare revenue (Million Rps/Year)	16.3	22.6	5.43	6.79 (30% achieved)	13.17

(Source: DMRC, Nov, 2011)

1) Transition of Transportation Mode

Figure 1 shows the transition of passenger trips by transportation mode in the Delhi city. As inter modal and transportation capacity was enhanced, Metro's passenger trips started growing since 2004 about when most of Line I and part of Line II were commissioned.

Transportation by cars and motorbikes increased by 7% and 5.45% on annual average respectively parallel to population growth, while buses' passenger trips are rather constant in the last ten years. Most of the Metro and car users are upper middle classes increasing in the past recent years. Their changing life styles are mirrored to the mode of transport transition too. One of indicators, for example, shows 87% of the Metro passengers are in the transition of social strata from low income to middle income class, and their income is higher than Rp. 25,000 (CRRI, 2009). A survey conducted in 2009

by Central Road Research Institute (CRRI) states that more than 40% of cars running in the Delhi city were brand new used within three years. Chosen transport means shifted from buses or auto rickshaw to the Metro, buses or the Metro to motorbikes (purchase), and motorbikes to cars (purchase) between 2007 and 2009 (ibid).

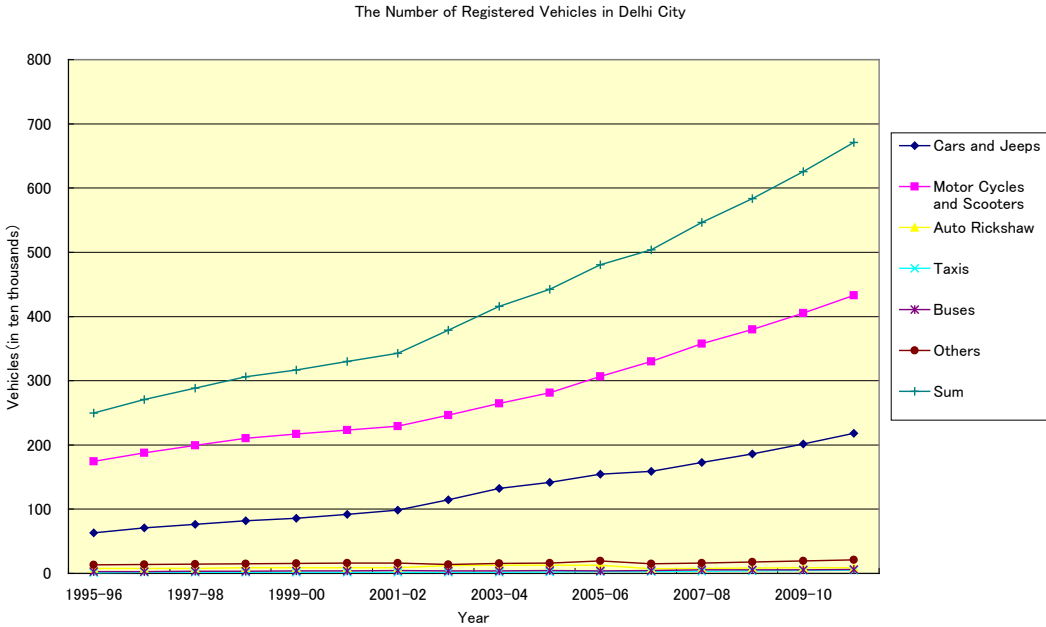


Figure 1. Passenger Trips by Mode

(Source: Figure was made by the author based on given data from DMRC, Mar, 2011)

2) Ridership

Figure 2 indicates the record that 26,000 passengers per day on average of weekdays and 33,000 on weekends in FY 2002 when the first line (Line I) was opened. The excess of passengers on weekends means that the Metro rides were more for special occasions and leisure purposes. There were voices from low income families expressing a Metro ride per se was equally an entertainment when the field survey of March 2011 for this post evaluation study. The gap between ridership of weekdays and weekends between 2002 and 2006 was few, and it has been growing since Line III was opened. The increased weekday ridership points out more people began to use the Metro for regular activities such as commuting to schools, work and businesses purposes. Also, Average taken distance by passengers on Feeder buses³ grew from 1.5km in 2007 to 3.6km in 2009 (CRRI, 2009). Seemingly the Metro has been gradually permeating into the Delhi citizens’ daily lives.

³ DMRC operates busses connecting to 22 stations through 17 routes by outsourcing Prasanna Purple Mobility Solution and Vijay Tour & Travels. Those buses are called Feeder Bus.

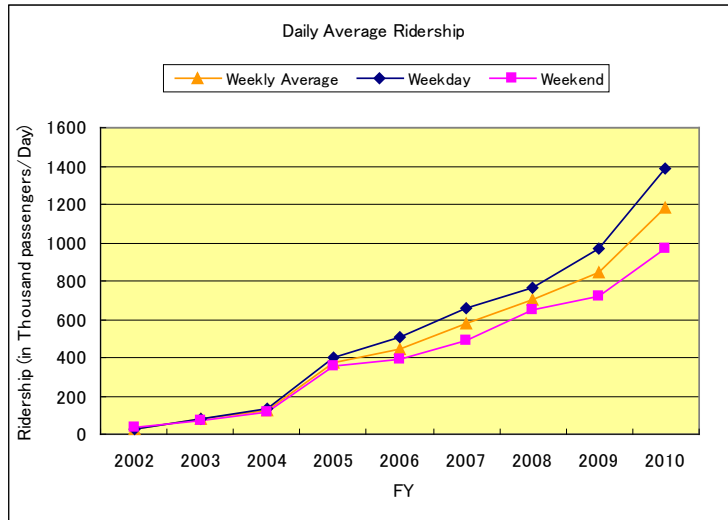


Figure2. Ridership Growth

(Source: Figure was made by the author based on given data from DMRC, Mar, 2011)

3) Lines and Demographic Distribution

Figure 3 indicates ridership transition and Figure 4 depicts the Metro line map (both by Phase I and Phase II). The ridership in 2010 on Line III and Line II shows remarkable gain. This is assumed to be affected by that the extension of Line III (from Yamuna Bank to Anand Vihar) connected to Line IV was opened in January 2010 and a part of Line V (from Central Secretariat to Sarita Vihar on the violet line on the map, Figure 3) towards the south was opened in October 2010.

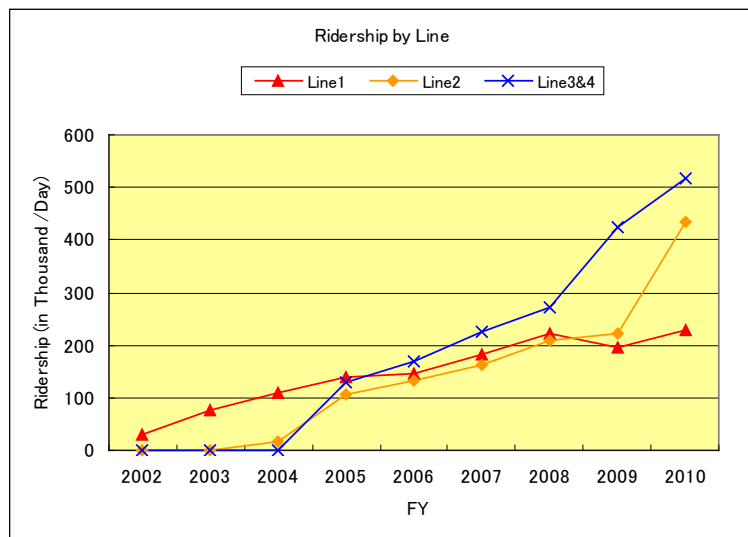


Figure 3. Ridership Transition by Line

(Source: Figure was made by the author based on given data from DMRC, Mar, 2011)

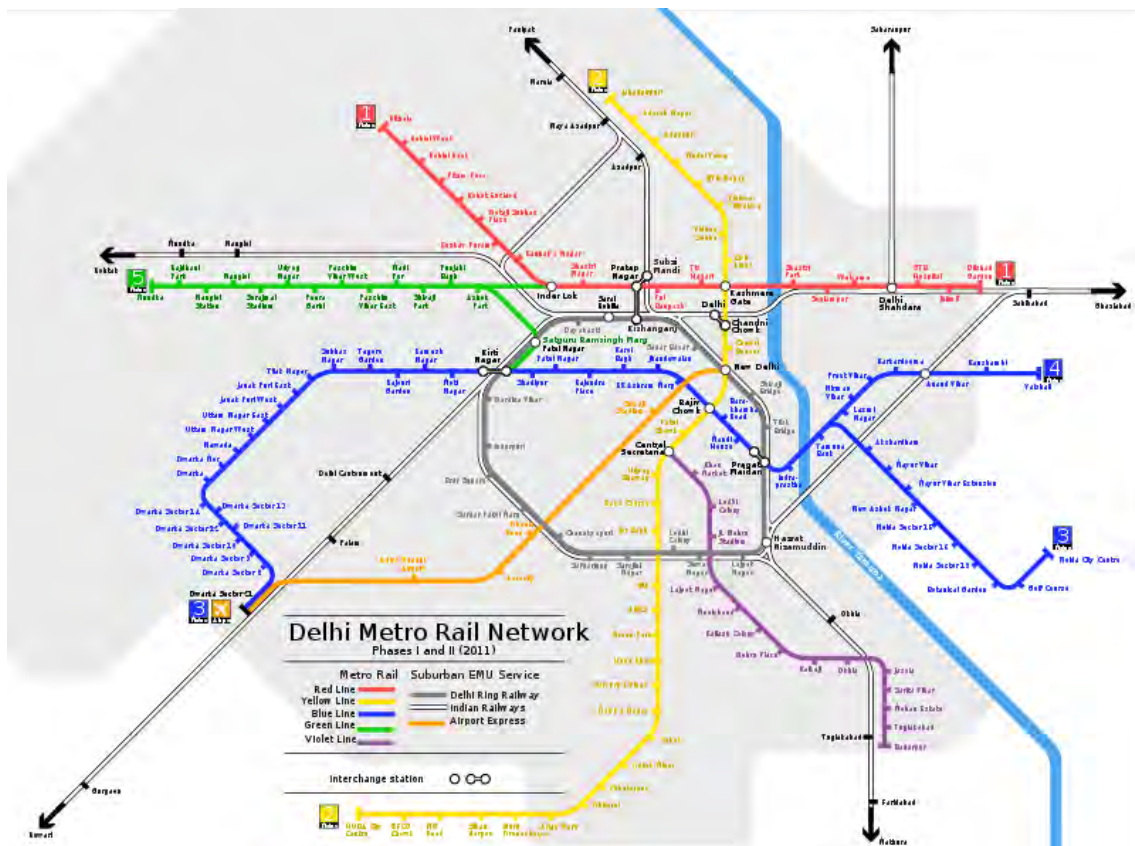


Figure 4. Metro Line Map (Phase I and Phase II)

(Source: http://ja.wikipedia.org/wiki/Delhi_metro_rail_network.svg)

The paper now looks at the relation of the Metro lines and demography after an overview of population distribution and socio-economic characteristics of the Delhi city. The Delhi city comprises of 9 districts (further divided into 27 sub-districts, 59 tehsils and 169 villages) as shown in Figure 5. The population is denser in the east side of the Yamuna river and disperses towards the north and the south. Commercial facilities and activities are centred to the Central and the New Delhi districts. Those areas have recently gradually spread to the North and the North West districts. Development in the southwest area from the Central district to Gurgaon has also widely proceeded. Commercial buildings related to IT (Information Technology) and engineering, public facilities, shops and mid to high-rise apartments for households transitioning to middle class from low income class have been built in 10 kilometre radial zone from the Central district towards the northwest. Rather young households apparently prefer moving into this area. In the southwest area between Line II and Line III and further south, there are embassies/high commissions close to the Central district, and serene neatly organized residential quarters and modern shopping malls towards the south spread. In the North East and the East districts where Line I and Line III lie, there low income households live densely and the Muslim rather remarkably reside.

Metro riders are more from the northwest, southwest and south districts where Line II and Line III run

than low income living areas that Line I passes. Overall, the relationship of demography and the metro ridership underpins the Delhi Metro is more attractive to the middle classes and the above.



Figure5. Districts of Delhi City
(Source: Government of Delhi, 2001)

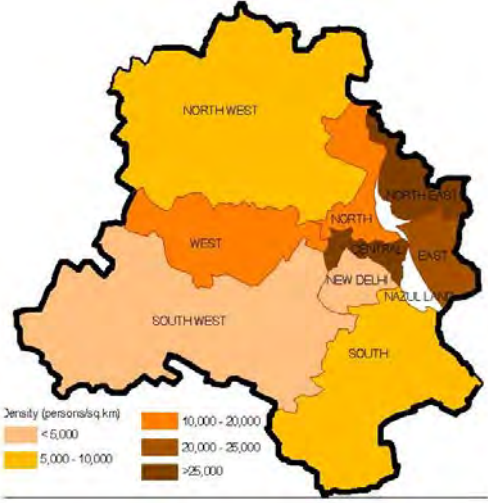


Figure6. Population Density of Delhi City
(Source: Government of Delhi, 2001)

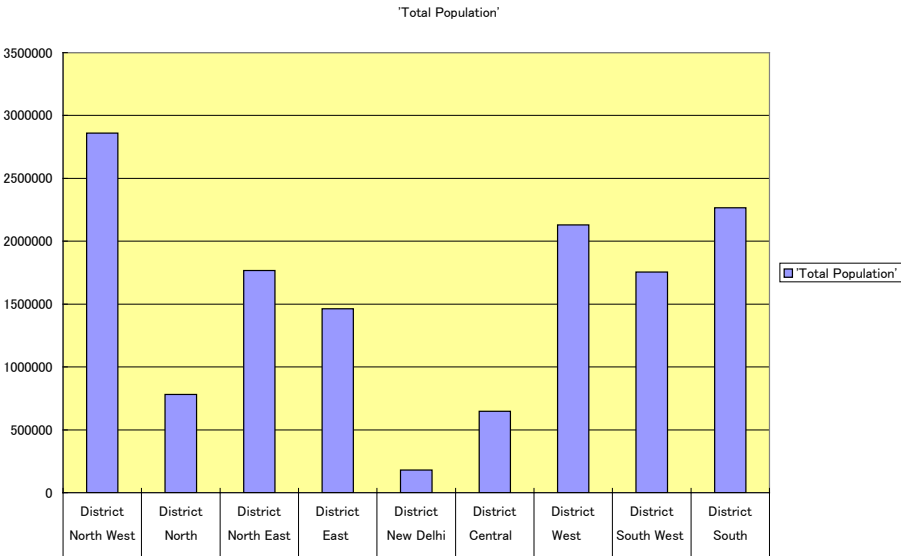


Figure7. Population by Word on Delhi City
(Source: Figure was made by the author based on 2001 census data by government of Delhi)

4) Operational Intervals

The Metro’s operational time schedule is planned at the Operation & Planning Department (OPD) by the DMRC. Operational intervals are programmed, as occasional demands by varying ridership monitored through the automatic ticket gates and the number of rolling stocks available for operation.

It was updated every three to six months in 2010. The interviewee (a schedule planner) from the OPD disclosed his feeling that Delhi citizens' life styles changed fast and those would affect the Metro ridership. Thus, the OPD had tried to optimize the number of rolling stocks owned and operational intervals more often on trial basis. There is not a time table posted in the stations and platforms, and the service dues are shown on electric displays.

The DMRC has introduced ATC (Automatic Train Control) ⁴including ATO (Automatic Train Operation), ATP (Automatic Train Protection and ATS (Automatic Train Signaling Systems) since 2008. ACT reduces physical and psychological stress on drivers, and helps them to move in to/out from stations in shorter time, and therefore shortens stopping time at platforms. The DMRC's effort with such effects by ATC resulted in shortening operational intervals since 2008 as Table5 shows. ATC is attached to 80% of trains as of Mar, 2011.

Table 5. Minimum Operational Intervals

Year	Line I	Line II	Line III
2006	4 min	3 min 48 sec	4 min 12 sec
2007	4 min	3 min 48 sec	4 min 12 sec
2008	4 min	3 min 48 sec	4 min 12 sec
2009	4 min	2 min 54 sec	3 min 36 sec
2010	3 min 50 sec	2 min 48 sec	3 min 12 sec
2011 (estimated)	3 min 50 sec	2 min 48 sec	2 min 54 sec

(Source: DMRC, Mar, 2011)

A challenge on operation is reducing congestion at rush hours (8-11am/5-8pm). During the peak hours, station controllers have to push passengers into a car by hands especially at interchange stations (Kashmere Gate on Line I and Line II and Rajiv Chowk on Line II and Line III). DMRC currently plans to increase the number of cars from four to six. Some services already use six cars by March 2011, and the plan is that all the services will use six cars by 2012.

3.3.1.2 Results of Calculations of Internal Rates of Return (IRR)

Internal Rate of Return presents considerable gaps between the projection and the performance, and therefore its achievement is quite low. Table 6 and Table 7 indicate IRRs for the Phase I (Line I, Line II and Line III). Given the applied calculative conditions, an obstacle in meeting the objective on IRR comes from fare income which depends on the number of passengers, and fare income must increase by double in order to reach the IRR projection. However, opening the extended three lines (by Phase I)

⁴ A train protection systems that automatically control to retain safety by taking certain distance from/to trains ahead or behind, maximum running speed, and signaling stop lines at platforms.

and the new three lines by Phase II resulted in the rapid increase of passengers, which implies a remarkable gain in income from fare and real estate development after the completion of the Phase III (the ring line).

The future traffic forecasts at the planning were derived from Four-step Models, so the gap between the ridership provision and the performance emerged in the modeling. Nonetheless, it is impossible to detect which parameters created more inaccuracy, as this current evaluation was not able to obtain the model data. Regarding the ridership gap between the projection and performance, the DMRC explains the cause comes from inadequate Feeder Bus services. Feeder Buses were expected to be operated in order to bring more Metro riders from wider locations by the Delhi Transport Corporation (DTC) which operated city buses as of the project planning phase. Likewise, it was negotiated competitive bus routes against the Metro lines would be demolished and DTC bus fares would be increased. However, the DTC has not operated any feeder bus to bring passengers to stations. DMRC purchased their own buses for Feeder Buses and has outsourced the operation to private corporations as explained in 3.5.3.3 Service Competition with Buses. The DTC has kept own routes and their bus fares have been subsidized to be the same level for 15 years, that lays competition against the Metro ridership.

Table 6. Financial Internal Rate of Return (FIRR)

	Projection as of 2004	Performance as of 2010
FIRR	4.50%	0.45%
Cost	Initial inputs + additional cost, Operation and Maintenance cost	Same as the left (calculation is based on performance until 2007 and estimation from 2008 onwards)
Benefit	Fare income, advertisement, real estate and development (limited to land lease and facilities development around the stations)	
Project Period	25 Years	25 Years (after lines opened)

(Source: DMRC, Mar, 2011)

Table 7. Economic Internal (EIRR)

	Projection as of 2004	Performance as of 2010
EIRR	17.60%	12.23%
Cost	Initial inputs after tax, Operation and Maintenance cost, land rent, capital and operational cost for bus operation necessary after the completion of Metro construction.	Same as the left (calculation is based on performance until 2007 and estimation from 2008 onwards)
Benefit	Time cost saved by Metro passengers, Time cost saved by road passengers, Fuel cost saved by Metro passengers, Fuel cost saved by road passengers, Vehicle operating cost saved by Metro passengers, Emission saving cost, Accident cost, Infrastructure maintenance Cost	
Project Period	25 Years	25 Years (after lines opened)

(Source: DMRC, Mar, 2011)

3.3.2 Qualitative Effectiveness

3.3.2.1 Safety Control

Safety control at stations is collectively managed in a Station Controller Room (SCR) at each station. There is a safety inspection room at ticket gates. All passenger belongings will be put under X ray inspection and passengers undergo a body check. Surveillance cameras are attached to all cars and data are sent to the monitoring rooms in real time. Passengers positively evaluated the safety at the Metro stations and in trains in 2007 and 2009 (CRRI, 2009), whilst safety inspection causes passengers' delays in going through at ticket gates at peak hours.

Regarding accidents resulting in injury or death, there are a few incidents that a passenger drops his/her belonging from a platform. DMRC controls the number of passengers by closing station gates at rush hours in order to avoid fall accidents due to over capacity of the platforms.

Both applications of body checks and passenger control at station gates bring a challenge in the future in terms of controlling safely and gaining ridership together.

3.3.2.2 Services

Train dues are displayed on electrical boards at the platforms. DMRC plans to introduce automatic voice announcement running in accordance with arrival information displays in cars. Device systems

are being designed and developed. It can be said that guidance in/around stations is limited overall if compared to metros in Japan, so there is space to improve, such as making announcement various languages. However, Delhi citizens and passengers are apparently satisfied with current state (see 3.4.1.3 beneficiary survey for more details).

From the point of view of accessibility in platforms and trains, there are lifts for passengers on wheelchair in each station. Textured Paving Blocks are laid for the visually disabled and cars accommodate space for keeping wheelchairs. Cars also offer courtesy seats for the seniors and the disabled. One of four cars is reserved for the female.

There is no fare discount for any category of passengers such as students and disabled citizens. However, ten percent discount is offered to all contactless smart card (Smart Card)⁵ users. A study on concession effect, for example, suggests discounts on passes and students, which can possibly lead to further services and thus more ridership.

To sum up, this project has brought about considerably high effectiveness. However, especially ridership is to improve as to meet the targeted operational indicators and IRRs. Hence, the effectiveness of this project is assessed fair.

3.4 Impact

3.4.1 Intended Impacts

3.4.1.1 Impacts on the natural environment

In terms of air pollutant, pollution level has been deteriorated gradually as the population grows and automobiles increases in the last ten years. However, the growing number of other transportation means used (Figure 1) underpins that air pollution would have been even more aggravated without Delhi Metro in the city.

Regenerative brakes were introduced to part of the Metro trains. A regenerative brake is an energy recovery mechanism; when it works, it converts kinetic energy into electricity which can be either used immediately or stored until needed. It is said a regenerative brake is able to save energy up to 33% comparing to a conventional system. Rolling stocks with regenerative brake installed were registered in the Clean Development Mechanism (CDM)⁶ in 2007 and have been thoroughly

⁵ Contactless smart card is a pre-paid card that can be used at the Metro automatic gates. It pays only Metro fares run by the DMRC, and not for Airport Link opened February 2011 as its operation is outsourced to a private corporation, Delhi Airport Metro Express Private Limited (DAMEL).

⁶ The Clean Development Mechanism (CDM) allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, which can be counted towards meeting Kyoto targets (UNFCCC). Japan is the

monitored since 2008. The monitoring report shows the Delhi Metro project reduced carbon dioxide (CO₂) as shown in Table 8.

Table 8. CO₂ Emission Reduction

Term	CO ₂ Reduction (t)
9 December, 2007 - 31 January, 2008	5,081
1 February, 2008 - 31 December, 2008	35,295
1 January, 2009 - 31 December, 2009	43,751

(Source: DMRC, 2008 and DMRC2010a)

3.4.1.2 Guidelines for Environmental and Social Assessment

Information pertinent to Guideline for Environment and Social Assessment of JICA was provided by JICA and DMRC, and confirms that there are no causes of concern. The details are as follows: The use of project facilities has not caused any air pollution. There were no negative effects of the project construction on aquatic organisms, fishing industry, and quality of downstream water due to waste water from the project facilities. The project construction did not cause any land deformation or any soil erosion from the bare soil. Noise and vibration during the project construction and in their operation have been adequately monitored. About effect on the ecosystem, when trees had to be cut for the construction of facilities, three trees were planted for each one tree cut. On the effect of existing infrastructure, if existing public utilities such as sewage, waterline, or telephone lines had to be relocated, they were restored to their original or better conditions.

3.4.1.3 Beneficiary Survey

A passenger survey was conducted on March 24 and 25 at ten stations (Inderlok, Pratap Nagar, Shastri Park, Welcome, Vidhan Sabha, Rajiv Chowk, Dwarka, Uttam Nagar West, Patel Nagar, Barakhamba Road) and fifty passengers were selected with the random sampling procedure to be the respondents for this survey.

As Table 9 shows, the number of female respondents was 13(26%), and that of male respondents was 37 (74%). Table 10 shows that the youngest respondent was 18 years, and the oldest one was 72 years old, and the average is 32.12 years old. Table 11 shows the educational level of the respondents. 3 respondents (6%) completed primary education, 9 (18%) completed secondary education, 27 (54%) completed graduate level, and 11 (22%) completed post graduate. Table 12 concerns income of the respondents. The minimum monthly income on average is Rs.3,500, the maximum is Rs. 50,000 and the average is Rs. 18,662.5.

Table 9. Sex

(Number of valid respondents: 50)

Sex	Number of persons	%
Women	13	26
Men	37	74
Total	50	100

Table 10. Age

(Number of valid respondents: 50)

	Youngest	Oldest	Average
Age	18	72	32.12

Table 11. Educational Level

(Number of valid respondents: 50)

Educational level	Number of persons	%
1. Primary education	3	6
2. Secondary Education	9	18
3. Graduate	27	4
4. Post graduate	11	22
Total	50	100

Table 12. Income per month (rupee)

(Number of valid respondents: 40)

	Minimum	Maximum	Average
Income	3,500	50,000	18,662.5

* Income statistics are based on 40 respondents as 10 are students without income.

Table 13 shows the purpose of Delhi Metro, and 46 (92%) responded that it is work related. Table 14 indicates the frequency of Delhi Metro use, and 34 respondents (68%) use it every day. Table 15 indicates main transportation means before Delhi Metro was available, and 24 (48%) mainly used buses, 11 (22%) used private cars, and another 11 (22%) used motor cycles. Table 16 shows reasonableness of fares, and 41 (82%) responded as reasonable, 8 (16%) responded as expensive, and 1 (2%) responded cheap.

Table 13. Purpose of using Delhi Metro

Purpose	Number of persons	%
work related	46	92
Leisure	1	2
Other	3	6
Total	50	100

Table 14. Delhi Metro Use Frequency

Frequency	Number of persons	%
Once in a month	3	6
Once in two weeks	1	2
Once in a week	5	10
Once in a few days	7	14
Everyday	34	68
Total	50	100

Table 15. main means of transportation
Prior to Delhi Metro

Means of transportation	Number of persons	%
Public bus	24	48
Private car	11	22
Auto rickshaw	4	8
Motor cycle	11	22
Total	50	100

Table 16. Reasonableness of Fare

	Number of persons	%
Cheap	1	2
Reasonable	41	82
Expensive	8	16
Total	50	100

Table 17 indicates the order of reasons for using Delhi Metro among six reasons (time saving, comfort, safety concern, certainty in schedule planning, security concern, and cost saving) for each respondent, 37 (74%) responded time saving as the most important, and 8 (16%) respondent comfort as the most important.

Table 17. Reasons of using Delhi Metro

Order	1 st	2 nd	3 rd	4 th	5 th	6 th	Total
Reasons							
Time Saving (number of persons)	37	8	1	1	3	0	50
(%)	74	16	2	2	6	0	100
Comfort (number of persons)	8	16	8	10	5	3	50
(%)	16	32	16	20	10	6	100
Safety Concern (number of persons)	1	7	18	12	8	4	50
(%)	2	14	36	24	16	8	100
Certainty in schedule planning (number of persons)	3	5	7	10	15	10	50
(%)	6	10	14	20	30	20	100
Security concern (number of persons)	0	6	10	11	12	11	50
(%)	0	12	20	22	24	22	100
Cost saving (number of persons)	1	8	6	6	8	21	50
(%)	2	16	12	12	16	42	100

Figure 7 shows the evaluation of stations and platforms by the respondents in 5 scale (5=excellent, 4=good, 3=OK, 2=poor, and 1=very poor). In terms of cleanliness, signage, and information of stations and platform, about 25 respondents evaluated as “good” and about 15 respondents evaluated them as “excellent.” In terms of assistance available at stations and platforms, 18 evaluated as “OK” and 10 evaluated “excellent.” In terms of toilet facilities, 9 respondents evaluated “very poor” and this indicates that toilet facilities need to be improved. Overall, the respondents evaluated stations and platforms as good.

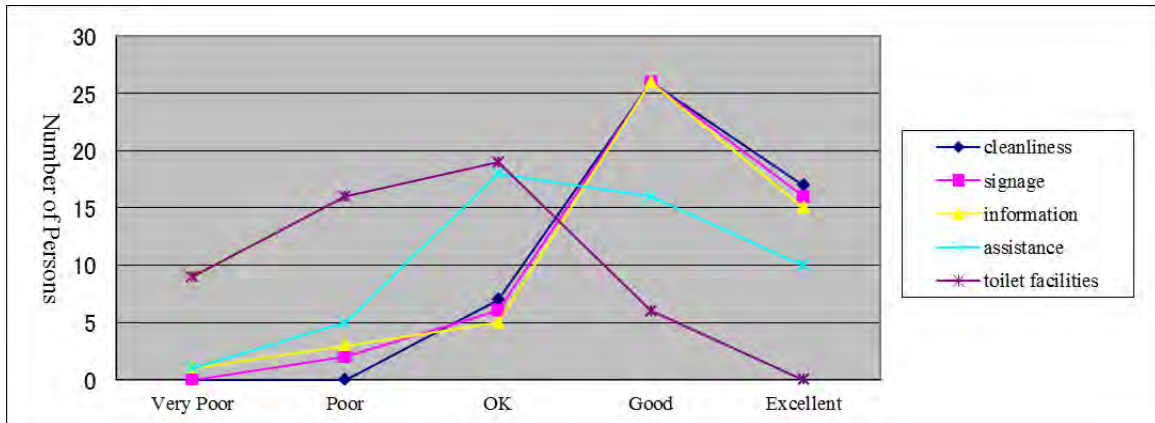


Figure 7 Evaluation of Station and Platform by Passengers

Figures 8 and 9 indicate evaluations of train service by the respondents, and many of them evaluate “good” or “excellent” for cleanliness, comfort, temperature, information, punctuality, and frequency of the trains. In terms of crowdedness, however, many evaluated crowdedness as “poor” or “very poor.” To reduce crowded, DMRC is increasing the number of cars from 4 to 6.

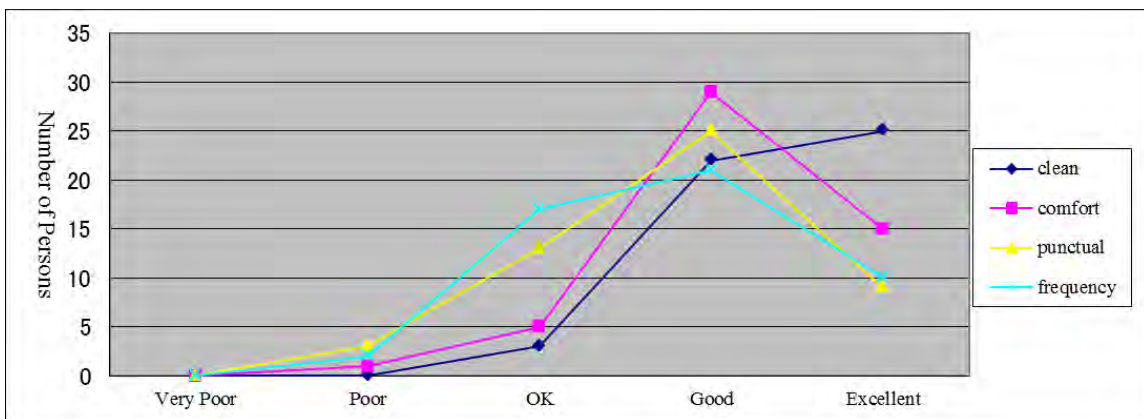


Figure 8 Evaluation of Train service by Passengers Part 1

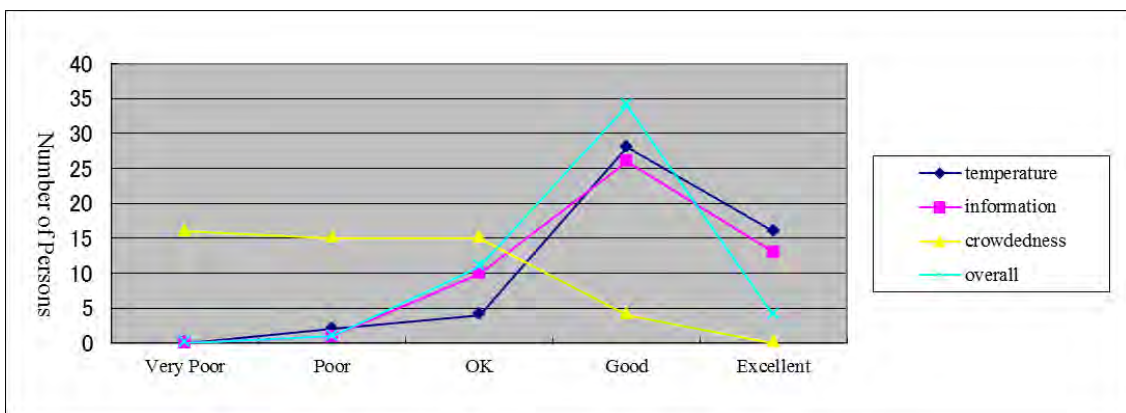


Figure 9 Evaluation of Train service by Passengers Part 2

3.4.2 Other Impacts

Table 18 shows that all the required land for this project was acquired. Table 19 indicates the required resettlement of residential and non-residential structures and the actual. As mentioned in the remarks, some businesses and slum residents were not relocated to the land or facilities provided by the project although they left the land acquired by the project.

Table 18. Plan and Actual of Land Acquisition

	Required land (hectare)	Acquired land (hectare)	Balance (hectare)
Line I	121	122	0
Line II	55	55	0
Line III	90	90	0
Total	265	265	0

Table 19. Resettlement of Residential and Non-residential structures

	Required Structure for resettlement		Actual (not resettled)	
	Residential and Non-residential	Slum	Residential & Non-residential	Slum
Line I	888	798	0	0
Line II	441	1,720	0	0
Line III	753	142	9	18
Total	2,082	2,660	9*	18**

* Businesses were required to pay Rs.900,000.- to occupy the allocated space of the business facilities newly constructed by the project. 9 businesses did not meet this requirement although they left the land acquired by the project.

**Slum residents were required to present ration cards issued by the government in order to be resettled in the land provided by the project. 18 households did not have this card and were not resettled in the land prepared by the project although they left the land acquired by the project, and this issue is under consideration at court.

Table 20 indicates the ratings of living conditions of the three resettlement locations (Holambi Kalan, Holambi Khurd, Narela) for slum resident as rated by DMRC officials in four scales (4=very good, 3=good, 2=poor, 1=very poor) on road conditions, sewage facilities, water supply, employment

opportunities for men and for women, educational opportunities for children, and all the ratings are either “very good” or “good.”

Table 20. Living Conditions of resettlement area for slum residents

Location	Items	Rating			
		4	3	2	1
Holambi Kalan	Road conditions	○			
	Sewage		○		
	Water supply	○			
	Employment opportunities for men	○			
	Employment opportunities for women	○			
	Educational opportunities for children	○			
Holambi Khurd	Road conditions		○		
	Sewage		○		
	Water supply		○		
	Employment opportunities for men	○			
	Employment opportunities for women	○			
	Educational opportunities for children	○			
Narela	Road conditions		○		
	Sewage		○		
	Water supply		○		
	Employment opportunities for men	○			
	Employment opportunities for women	○			
	Educational opportunities for children	○			

Three locations were visited and about 5 residents of each location were interviewed. Below are the interview responses. It indicates that living conditions are mostly better than before the resettlement.

“Before the resettlement, we were afraid of eviction as our occupation of the land was illegal. Here, land is ours and we can live without fear.” (residents of three locations)

“Since we have water supply and the toilet facility here, our living conditions are better than before the resettlement.” (residents of three locations)

“Income has increased since I can work at a factory in the neighborhood.” (A resident of Holambi Kalan)

“Some have their income increased and others have it decreased after moving in since employment opportunities are diverse.” (a resident of Hollambi Khurd)

“Since available public transportation is only bus, and their services are not frequent, it is not convenient to go to the central part of Delhi.” (A resident of Holammbi Khurd)

Since this project was to construct large facilities, environmental problems during the construction, land acquisition and resettlement was challenge. Environment situations that include air pollution during the construction were appropriately monitored. When trees had to be cut, more trees were planted. For the resettlement, adequate land was provided and the residents find resettlement locations better than previous ones. The project dealt with these challenges mostly adequately.

BOX2: Impact on the Socially Disadvantaged

Study was conducted for the purpose of finding out Delhi Metro's positive and negative impact on everyday lives and economic activities of the socially disadvantaged such as those of scheduled caste, and also for the purpose of finding ways to contribute to social development for these people. For this study, information was collected from people living in a slum near Shahdara Station of Line I as an intervention group, and those living in a slum called Sanjey colony as a contrast group. From each slum, fifty households were randomly sampled, totaling 100 households for the data collection for this study.

1. Metro use situations

21 respondents (48%) in the intervention group and 4 respondents (8%) in the contrast group use Delhi Metro more than once a week. 6 respondents (12%) in the intervention group and no one in the contrast group use it every day. 15 respondents (30%) in intervention group and 38 respondents (76%) in control group use it less than once in a month (including no use all). These indicate respondents in the intervention group use Delhi Metro more frequently than those in the contrast group. 35 respondents (50%) stated that their main purpose of using Delhi Metro is work-related and 26 respondents (37%) respondents stated that theirs is social such as seeing relatives and friends.

2. Impact of Delhi Metro on income

40 respondents (80%) in the intervention group stated the construction of Delhi Metro had no impact on their income, whereas 4 respondents (8%) stated it increased their income and 6 respondents (12%) stated it decreased their income. A respondent whose income increased mentioned that "a metro station was constructed and more people live here. This increased my sales." Another respondent whose income decreased mentioned that "because of the construction of Delhi Metro, the market where I was selling vegetable was destroyed." In the contract group, 49 respondents (98%) stated Delhi Metro did not change their income, and 1 respondent (2%) stated it decreased his income.

3. Other Impact of Delhi Metro

To the question of “what is the biggest change after the completion of Delhi Metro?” 49 respondents stated that they can shorten transportation time by using Delhi Metro. 32 respondents stated that Delhi Metro is comfortable, and 25 respondents stated that Delhi Metro is safer than bus and rickshaw. 5 respondents of which 4 are in intervention group mentioned that they lost their job because of the construction of Delhi Metro. Although 15 respondents in the intervention group mentioned that Delhi Metro is convenient, only 4 in the contrast group mentioned the same. This is because they live far from Delhi Metro stations and does not see any convenience.

Since the fare of Delhi Metro is expensive for the socially disadvantaged, use frequency and benefit are limited. However, many respondents see it as safer, faster, and more comfortable than conventional transportation means such as bus and rickshaw. From these responses, we can see that Delhi Metro is beneficiary for the socially disadvantaged.

Although use of Delhi Metro is not frequent, and benefit is limited for the socially disadvantaged, their use frequency of the social disadvantaged varies by their social characteristics. In particular, illiterate people find it difficult to use it since they need to understand written information at the stations and in the cars, which makes difficult for illiterate people to Delhi Metro.

In the intervention group who use Delhi Metro more frequently than the contrast group, 6 literate people use Delhi Metro everyday whereas no illiterate people use it every day. Those who use Delhi Metro less than once in a month are 4 out of 8 respondents (50%) for illiterate respondents and 10 out of 42 respondents (23.8%) for literate respondents. These ratios indicate illiterate people use Delhi Metro less frequently. Therefore, by providing necessary information by announcement at stations and in cars, illiterate people may be able to use Delhi Metro more frequently, and this may be able to contribute to increase the benefits of Delhi Metro for the socially disadvantaged.

BOX3: Study on behavioral changes of Delhi citizens

Study was conducted to find out effects of the project on changes in social class, urban living conditions, understanding of time among Delhi citizens. The study location was East Azad Nagar where residents are mostly of middle income group and is located about 1 km from Welcome Station of Line I. Respondents were selected by systematic sampling, selecting every five house from a pre-selected house. 88 respondents were selected: 38 (43.2%) were residents, 25 (28.4%) were business operators, and 25 (28.4%) were both residents and business operators. Below are summaries of the findings.

1. Use frequency and purpose of Delhi Metro

24 respondents (27.3%) use Delhi Metro once in a month, 10 respondents (11.4%) use it every day, and 18 respondents (20.5%) use it once in a week. 38 respondents (43%) stated their main use purpose of Delhi Metro is work related, and another 38 respondents (43%) stated theirs are for social purpose such as meeting relatives and friends.

2. Change in the use of time

82 respondents (92%) stated that Delhi metro changed their use of time whereas only 6 respondents (6.8%) stated it did not. Respondents of various occupations stated that punctual train services and shortened transportation time made their travel faster and predictable, and this improved their work efficiency. Below are concrete examples by the respondents.

“I can visit my patients by travelling in a shorter time, and this helps me.” (male, 55 years old, doctor)

“I work as a repairer, and it is very important to visit customers on time. Before Delhi metro was available, it was difficult because of traffic jam. Thanks to Delhi Metro, I can visit customers on time, and this helps me much.” (male, 24 years old, manufacturing)

“I commute to school by Delhi Metro, and this saves my time” (male, 20 years old, student)

Many respondents also mentioned changes in their social lives as their ways of time use changed. In particular, as the transportation time is shortened, many can visit their relatives whom they could not before Delhi Metro services were available. Below are examples by respondents.

“Before Delhi Metro was available, it took me two hours to visit relatives, and now it takes less than one hour thanks to Delhi Metro.” (female, 70 years old, housewife)

“Delhi metro is saving time for my son to commute. We also appreciate that we can go to our relatives’ house as we plan.” (female, 45 years old, business owner)

“I can now quickly visit my mother-in-law who lives in a distant location especially when there is an emergency situation thanks to Delhi Metro.” (female, 33 years, hairdresser)

3. Change in the ways of behavior and thinking of Delhi citizens

71 respondents (80.7%) think Delhi Metro changed the ways of behavior and thinking of Delhi citizens, and only 17 (19.7%) responded that it did not change them. Below are examples by the respondents.

“Delhi citizens are proud of having Delhi Metro which is fast, safe and comfortable. People have become more cooperative and kind.” (Male, 38 years old, construction business)

“People have become disciplined and keep time.” (Female, 53 years old, house wife)

“(When our public transportation was only bus,) people in the bus did not follow rules. After Delhi Metro became available, they do follow rules. They may have learned rules by waiting in line at the Metro stations.” (Male, 54 years old, retail business)

“People have become aware of keeping public space clean.” (Male, 45 years old, employee)

3.5 Sustainability (Rating : ③)

3.5.1 Structural Aspects of Operation and Maintenance

3.5.1.1 Working Structure and Membership

The DMRC is an institution established in 1995, in order to operate and maintain the Delhi Metro, funded (at 50:50) by the central Government of India (GOI) and the Government of National Capital Territory of India (GNCTD). The DMRC, as the main body of the Metro operation, is committed to obligation on reports towards both governments, whereas the governments are responsible for supervision and hold approval rights defined by Companies Act, 1956, as the founders. Although it had few board members only by names at its beginning, DMRC grew its human resource by recruiting 40 employees per one km operational. In 2010, it employed 4,750 personnel, which means they operate one kilometer by 35 staff from Line I to Lin VI. Employees at a station work at three shifts a day. Their shifting work seems smooth and moderate in terms of work load. Drivers and engineers are trained at an appropriate pace (see 3.5.2 Operation and Maintenance Techniques for more details), and thus DMRC has the appropriate human resource.

Recruitment by DMRC became more active in 2001. Initially, 20% of all were taken from experts at the Ministry of Urban development and the Ministry of Railways, and the rest were recruited through open competitions at the national level. There were 349 members by 2002 by when the Line I was opened. Since then, recruitment continued as Line II and III were planned and commissioned. As of 2006, when all the three lines of Phase I completed, DMRC had 2,642 personnel.

Table 21. DMRC member Structure

Department	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
Electrical	70	181	441	518	630	542	514	554	807
Civil	27	75	173	188	249	207	203	200	228
S&T (Signaling & Telcommunication)	57	127	251	306	496	457	460	488	855
RS (Rolling Stocks)	57	132	272	291	364	379	381	519	749
Operations	124	278	435	525	865	854	900	1,135	2,042
HR, Stores, Accts & Genl. Admn	14	21	25	25	38	69	44	51	69
Total (people)	349	814	1,597	1,853	2,642	2,508	2,502	2,947	4,750

(Source: Figure was made by the author based on given data from DMRC, Mar, 2011)

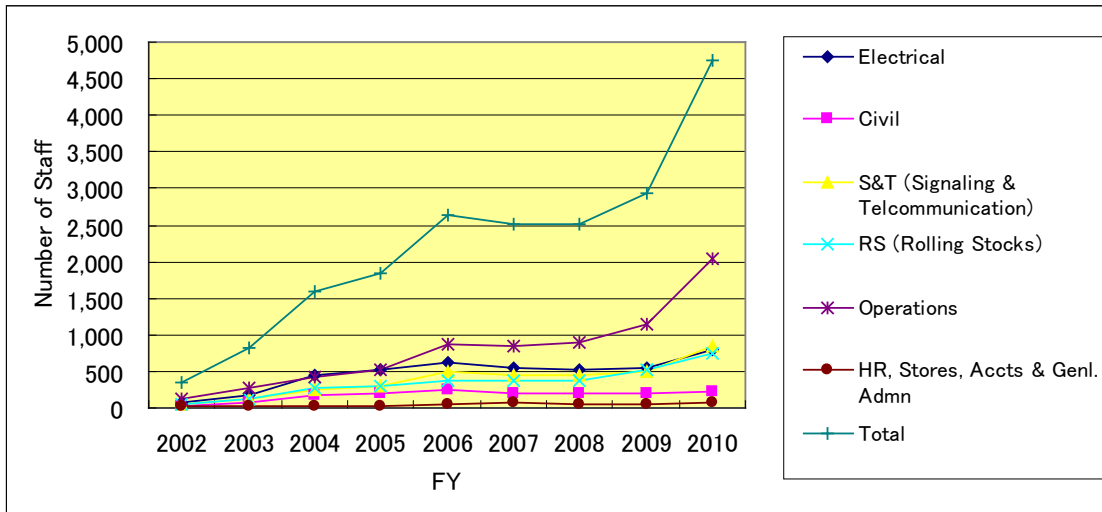


Figure11 Membership Transition

(Source: Figure was made by the author based on given data from DMRC, Mar, 2011)

3.5.1.2 Human Resources and Institutional Management

Information sharing systems are well established in the vertical and horizontal institutional structure of DMRC. Information on all working fields goes through by verbal reports (for shifting work), daily report, regular checks, and regular meetings. Such information is fully utilized for the institutional management and technical innovation at DMRC. All employees are trained to expand their capacities, which constantly and holistically strengthen institutional capacity as a whole. The DMRC shuffles its personnel deployment every 2 to 3 years in order to equip the staff with new skills and to expand the flexibility of deployment. Furthermore, the training ability of DMRC is as strong as providing consultancy services, transferring their techniques to other metro organizations all over India such as Bangalore Mass Rapid Transit Limited (BMRTL) and others.

Technical staff newly recruited undergo a seven-month-training at the training center in Shastri Park. They are assigned to a department after learning all foundational knowledge and techniques required in DMRC's work such as corporate policies, operational management, maintenance and etc. The training center provides four training programs; regular training once every 6 months, needs based training program (on leadership, technical and management at different levels, languages, customer cares and others), special classes for first aids, firefighting and so on. There are always 600 to 700 trainees taking training programs at the center.

A feedback system between operation staff (drivers / station controllers) and back office (HR and the training center) has been also established. Operation staff report on daily maintenance and safety checks. Drivers and station staff are technically evaluated twice a month. Such voices from operational sides and regular assessments are shared in the whole institution, conveyed to the training center and

utilized for reprogramming the training curricula, shuffling the staff and enhancement of organizational management of DMRC.

3.5.2 Technical Aspects of Operation and Maintenance

There seems to be constant improvement in the operational and technological capacities, for instance, the introduction to ATC in 2008 mentioned in 3.3.1.1 4) Operational Intervals, and the shortened distance for returning at the end of operation since 2009. As explained in the Effectiveness of this report, ATC is attached to 80% of trains and operational intervals have been shortened. DMRC decided in 2007 to procure new rolling stocks from Bobardia for Phase II, and began the operation in 2010, which evidences DMRC's high capacity on learning new techniques.

Operational plans are relatively frequently renewed (every a few months), by taking into account data of ridership collected from ticket gates in order to keep a high operational rate and serve demands. By doing so, DMRC has improved operational efficiency.

Control commands for operation, rolling stocks, power and station facilities are monitored and managed in the Station Controller Room (SCR) at each station. The controls have been systematically automated, and this has minimized required manpower on engineering. DMRC manages a station by a station manager (supervising two stations), a station controller, a building maintenance engineer, token⁷ sellers, safety inspectors and a few platform guides. Staff hands over her/his duties with a technical daily report and marked check list. Any remarkable issues are conveyed to the management department through supervisors as mentioned in 3.5.1.2 Human Resources and Institutional Management.

3.5.3 Financial Aspects of Operation and Maintenance

3.5.3.1 Financial Status

Regarding the total funding for the Delhi Metro project, Phase I was financed at 60:40 by the GOI and the government of Japan (through yen loan), Phase II 55:45, Phase III 40:60 (expected as of July 2011) respectively. As remarked above, the equity (funds by the own country) has gradually increased, so has the level of financial independence from a wider perspective. DMRC's own funding includes financial contribution by the municipal governments which have the Metro lines, namely Haryana which has Line II and New Okhla which has Line III.

For investigation in a narrower view, the latest profit-and-loss statement is shown in Table 22 and the balance sheet in Table 23. As Table 22 states, both year 2008 and year 2009 had operational profit. The ratio of current expenditure to current income (Ordinary Income / Ordinary Expenditure × 100%) was

⁷ A token is a coin type ticket with IC chips inside.

275 in 2008, 194 in 2009. The decline was due to temporary expenditure, and the ratio in each financial year is yet liquid. However, when viewing from middle to long term perspective, the net profit in 2009 turns to loss account after loss brought from the past. The percentage of accumulated net loss to the total assets was 0.6 in 2008 and 1.4% in 2009, so that it has slightly deteriorated in the last years. Even though the current loss has only limited impact on the entire financial management of DMRC, financial status should be continuously monitored.

Table 22. Profit-and-Loss Statement ⁸ (Rp.)

Financial Year	2008	2009
Operational Income	3,928,660,793	5,272,011,880
Traffic Earning	2,980,779,498	4,133,012,805
Feeder Bus Earning	26,591,346	26,789,648
Rental Earning	921,289,949	1,112,209,427
Operational Expenditure	2,286,890,481	2,889,863,785
Traffic Operations	2,286,890,481	2,889,863,785
Operational Profit	1,641,770,312	2,382,148,095
Other Incomes	3,315,256,380	2,106,601,937
Consultancy	281,331,396	321,915,668
Real Estate	2,449,949,686	292,749,297
External Project Works	–	835,879,636
Others	583,975,298	656,057,336
Other Expenditure	343,344,263	922,813,942
Consultancy	19,722,410	70,149,073
Real Estate	42,856,552	48,648,376
External Project Works	–	803,456,421
Decrease in the inventory (Land)	277,973,915	–
Miscellaneous Expense Written Off	2,791,386	560,072
Ordinary Profit	4,613,682,429	3,565,936,090
Other Expenditure (Other Incomes)	4,200,477,599	5,618,221,710
Depreciation	2,790,456,173	3,296,374,346
Interest & Finance Charges	1,032,423,680	1,164,506,727
Prior Period Adjustments	(113,570,279)	6,903,914
Provision for Taxation	491,168,025	1,150,436,723
Net Profit (Net Loss)	413,204,830	(2,052,285,620)
Brought Forward from Prior Period	(2,165,636,190)	(1,752,431,360)
Unappropriated Profit or Loss (Carried Forward to Next Period)	(1,752,431,360)	(3,804,716,980)

(Source: DMRC, 2010b)

⁸ The statement indicates not only the Phase I and the fiscal accounts.

Table 23. Balance Sheet (FY2009) (Rp.)

Assets	276,498,002,777	Capitals	110,973,397,115
Fixed Assets	253,305,996,923	Shareholder's fund	81,734,104,000
Gross Block	149,662,311,169	Share Application Money	973,000,000
Less: Depreciation	(14,366,778,607)	Deferred Grants	28,266,293,115
Capital Work-in-Progress	106,695,682,265		
Construction Stores & Advances	11,314,782,096		
Current Assets	23,192,005,854	Liabilities	169,329,322,642
Inventories	361,297,404	Unsecured Loans	145,506,402,060
Sundry Debtors	2,197,020,884	Net Deffered Tax Liability	3,522,066,010
Cash and Bank Balance	15,585,979,213	Current Liabilities	19,730,621,334
Other Current Assets	129,717,292	Provisions	570,233,238
Loans and Advances	4,917,991,061		
Profit and Loss Account	3,804,716,980		
Total Assets	280,302,719,757	Capitals and Liabilities	280,302,719,757

(Source: The balance was classified by the author based on DMRC, 2010b)

3.5.3.2 Other Incomes.

DMRC generates incomes by consultancy services and real estate development. It aims to earn 7% of all the initial cost of Phase I by real estate development. There are three kinds of real estate development plans as below. Furthermore, there was income from land sales granted by the GOI by 2008. Since then, selling granted land has been prohibited.

① Land/Space lease for shops in stations and trains

Examples: McDonald (Kashmir Gate), GE Money (Bank) (Rajiv Chowk), Kiosks on platforms

Term: 6 years (rent is raised by 20% every 3 years)

② Land/Space lease for adverts in stations and trains

Tenants: Advertising firms

Term: 2-3 years

③ Development in large scale (Outsourced to private developers)

Contract examples: Commercial buildings (Shahdara etc.), IT Exhibition centers (Shastri Park), Residential apartments and etc.

Term: 30 years at maximum

The total return of other incomes between 2002 and 2008 to all the investment, apart from O&M cost, marks 9%. It reaches 12%, including estimated income of 2010. The result is apparently fine; nevertheless, 94% of all comes from real estate program including sales by 2008. With consideration of the average net economic growth at 7.9% in the Delhi city between 2002 and 2008 (calculated by the author using OECD.StartExtracts, 2011), the result could have been increased by the economic growth. DMRC's real estate development is managed by the Operation Department, with MRT (Mass Rapid Transportation) projects in Hong Kong and Singapore as its reference. It is suggested that DMRC improve their know-hows in this area.

3.5.3.3 Service Competition with Buses

DMRC operates feeder buses that connect 22 Metro stations by outsourcing services to Prasanna Purple Mobility Solution and Vijay Tour & Travels. There are currently 17 routes running through rather populated areas. The average trip distance of passengers carried by Feeder Buses has been extended year by year (CRRI, 2009), which implies the bus services are enjoyed together with Metro rides and have enhanced the citizens' transport efficiency. To plan routes of the feeder bus services, DMRC conducts demand surveys on bus routes, and receives requests for opening new routes from residential associations and corporations. Taking into account such applications, DMRC have opened, rerouted, and demolished routes after surveys. However, feeder bus routes currently capture the North, Northwest and Southwest districts, and therefore there could be possibility in expansion of services. As mentioned in 3.3.1.2 Results of Calculations of Internal Rates of Return (IRR), feeder bus services should be cooperated with DTC. In practice, even though both are public corporations, DMRC and DTC are entrusted its operation independently, and thus competitive.

It was planned in 2004 a contactless smart card for feeder bus would be introduced. DMRC had sold 900 cards in total through the bus operators by January 2011. This contactless smart card is not compatible with the Metro or the Airport Link services. However, DMRC currently plans to install a common fare collection system. It is anticipated DMRC and its contractors will further cooperate closely when introducing a new system in between.

3.5.4 Current Status of Operation and Maintenance

DMRC made O&M manuals that standardize the number of technicians working on check-ups, roles of staff, required capacities, appropriate working hours on maintenance, check list conditions and etc. Operation and maintenance are made according to the manuals and there does not seem any problem with the O&M situation.

3.5.4.1 Rolling Stock Maintenance

Drivers assure the basic functions of rolling stocks such as a break and a wiper every day, obligated with daily check manual. Tests of mechanical and electrical systems, device degradation and parts replacement are made once a rolling stock runs every certain distance as follows. Running distance by rolling stocks used for Delhi Metro has not reached ⑤420,000km. Hence, the maintenance manuals for ⑤ onwards are under development.

- ① 5,000km : 2hrs by 4 technicians
- ② 15,000km : 8hrs by 7 technicians

- ③ 60,000km : 8hrs by 12 technicians
- ④ 120,000km : 8hrs, 2 kinds by 12 technicians
- ⑤ 420,000km : N.A
- ⑥ 840,000km : N.A
- ⑦ 2,100,000km : N.A

3.5.4.2 Maintenance of Parts and Other Equipment

The Operation & Maintenance Department (O&M) maintains parts and equipment. Stocks for replacement and maintenance tools are numbered and placed in designated shelves and rooms. There are inventory lists indicating the numbers of stocks and ordered dates hanged on each shelf. Also, work schedule and shifts are recorded and displayed in the warehouse. The staff uses inspection sheets for recording task completion status in order to avoid omissions. The managers of O&M confirm the status after an inspection and take a next necessary action.

In all, the sustainability of effectiveness emerging after the project is high, without remarkable difficulty in the institutional management, technical improvement, and financial management. Nonetheless, the DMRC's income and profit have not been constant and stable, and therefore continuous monitoring on the financial status is suggested.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

Although this project has some issues of ridership and revenue that have not reached the original target, the number of train services, operational ratio, train kilo have been improved by 2010 as the new lines became operational, the number of operational cars increased, and the services interval became shorter. Sustainability is evaluated as high since management of executing agency and operation of stations and train services are appropriate by effective decision making and information sharing through regular meetings, daily report, and oral communication. In terms of human resource development, training programs are always improved to be responsive to the operational needs and skills of all staff are appropriately upgraded. Relevance and efficiency of this project are also evaluated as high. Passengers of Delhi Metro highly appreciate its comfort, cleanness, punctuality and frequency of operation except crowdedness at the peak hours. In light of the above, this project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

The evaluation of effectiveness pointed out the difference of ridership between the plan and the actual as an important issue. Currently, DMRC is preparing plans for Phase III. In this planning, DMRC should set the more achievable goal by improving methods for projecting the ridership.

4.2.2 Recommendations to JICA

Profitability is important for the sustainability of the project like this one. If conditions necessary for profitability are not present, JICA should encourage concerned parties to ensure such conditions to be present. For example, as mentioned in the effectiveness section, the competition between DMRC and DTC is one factor causing the difference of ridership between the plan and the actual. These public transportation organizations were expected not to be in competition but in collaboration to constitute the system of urban transportation, so that public transportation is efficiently operated as a whole. Transport Department of the Government of Delhi owns and provides guidance to both DMRC and DTC, and JICA should ascertain with Transport Department and other concerned parties whether the collaboration between DMRC and DTC for the efficient operation of the public transportation is ensured, and if not, JICA should encourage them to have such collaboration.

4.3 Lessons Learned

DMRC has been upgrading human resource development system with its own resources since its foundation, which has contributed to organizational development. Understanding that human resource is the key for effective organizational management, DMRC has been recruiting well-qualified individuals from the broad base, and has built up excellent human resource development system through training facilities and on-the-job training so that staff are provided with training programs step by step at appropriate timings, and are reassigned to appropriate positions to constantly upgrade their skills.

DMRC also constructed the feedback system for training facilities from station staff and drivers so that trainees can work effectively immediately after the training. Inspection and Safety check is reported daily and technical evaluations of drivers and staff are carried out twice a month. These reports from the operation staff and the evaluation results of staff are provided to the training facilities as the feedback to improve training program. In other words, it has established PDCA (Plan-Do-Check-Action) system for human resource development. This can be good practice for other similar projects and should be promoted for effective and efficient management and sustainability of similar project.

References

- Central Road Research Institute (CRRI), 'Quantification of Benefits for Delhi Metro Phase I (2009 Review)', DMRC, 2009
- Delhi Metro Railway Corporation (DMRC), '1st Monitoring Report Version: 01', DMRC, 2008
- Delhi Metro Railway Corporation (DMRC), '2nd Monitoring Report Version: 03', DMRC, 2010a
- Delhi Metro Railway Corporation (DMRC), 'Annual Reports 2009-2010', DMRC, 2010b

Comparison of the Original and Actual Scope of the Project

Item	Original				Actual			
1. Project Outputs		Track length (km)*	Number of Stations	Rolling Stocks		Track length (km)*	Number of Stations	Rolling Stocks
	Line I	22.00	18	280	Line I	22.056	18	280
	Line II	11.00	10		Line II	11.008	10	
	Line III	25.60	25		Line III	25.546	25	
* by the plan of year 2004(Appraisal for the 6 th tranche)								
2. Project Period	Commissioning Date of each line		Plan		Commissioning Date of each line		Actual	
	Line I		1996— March 31, 2004		Line I		1996— March 31, 2004	
	Line II		1996— September 30, 2005		Line II		1996— July 3, 2005	
	Line III		July 2002— March 31, 2006		Line III		July 2002— November 11, 2006 *	
*Part of the line was delayed because of delayed government approval								
3. Project Cost								
Amount paid in Foreign currency	116,091 million yen				96,458 million yen			
Amount paid in Local currency	186,242million yen				176,002million yen			
	(59,312million rupee)				(67,433million rupee)			
Total	302,333million yen				272,460million yen			
Japanese ODA loan portion	184,069million yen				162,610million yen			
Exchange rate	1 rupee = 3.14 yen (As of May, 1996)				1 rupee = 2.61 yen (Average between May, 1996 and August, 2004)			