0.1 Background

Bangalore city (12^0 $58^|$ N and 77^0 $35^|$ E) situated at 920 metres above MSL is the principal administrative, industrial, commercial, educational and cultural capital of Karnataka state, in the South-Western part of India. Blessed with a strong educational and technological base and agreeable climate, Bangalore is witnessing a tremendous growth in industry, trade and commerce leading to a rapid growth of the city and large scale urbanization. The population of Bangalore city stands at 5.7 million as per 2001 census records, and continuing with this growth rate, the city's population is expected to reach around 11 and 22 million in 2021 and 2041 respectively. This unprecedented growth is due to several factors, such as good infrastructure facilities, availability of abundant technical manpower and skilled labour and sound scientific and industrial base, a salubrious climate, and in recent times due to the coming of age of Information Technology (IT) which, today is the prime driving force, fuelling the growth of Bangalore city. While most of the infrastructure aspects such as energy supply, urban water supply and sewerage system, road and rail and air network, telecommunication systems etc. are reasonably met with in Bangalore, it is the domain of public transport, which appears to be woefully inadequate to meet even the existing demands, let alone meet the future requirements of this fast growing city. The city's mass transport system is presently operated by the state owned Bangalore Metropolitan Transport Corporation Ltd. (BMTC), which is exerting to do its best, but still unable to meet the rapidly rising commuter community's demand for a rapid, more efficient and user friendly mode of public transport system. This has led to an explosive growth of private vehicle population comprising of two wheelers which form the bulk, three wheelers, four wheelers, and other miscellaneous motor vehicles. The size of vehicle fleet operating in the urban area is around 1.8 million in the year 2003, and this large vehicle population has naturally had a spiraling effect on many aspects of city's life, namely (i) severe air pollution levels (ii) high congestion problems (iii) growing number of road accidents often resulting in human fatalities and injuries, (iv) more non-productive man hours during transit and waiting points etc., thus inviting the wrath of Bangalore citizen's community.

The Government of Karnataka also on its part, has been fully aware of the deteriorating Intra-city transport situation and realizing it's role as the key facilitator of public good, has desired to bring in a quantum improvement in the transportation sector in the city. After reviewing several alternatives to improve the lot of urban transportation including the proposal for putting up an Elevated Light Rail Transit System (ELRTS), the Government of Karnataka is presently favourably considering the establishment of a Metro Rail for easing the city transport sector bottlenecks, on the lines of the Delhi Metro Rail corporation (DMRC), which is a state-of-the-art technology in conformity with present International Standards.

0.2 Existing Transport Scenario

Bangalore city has a population of 5.7 million according to the census statistics for the year 2001, as against the city's earlier population of 2.92 and 4.13 millions in 1981 and 1991 respectively. This shows that the population is growing at a rapid pace and has nearly doubled in the last twenty years, and presently the growth rate is around 3.8% annually. The geographical boundaries of the city also are expanding fast, as evident from the census data, which showed the city areas as 386, 446 and 531 sq. km. during the years 1981, 1991 and 2001 respectively. With increasing population and reduced available land area the city's population density stood at 7983, 9260 and 10,710 persons/km^2 for the above corresponding period. It is further projected that the population size of Bangalore Urban Agglomeration (BUA) will be around 7.8 million in 2011 and 11.0 million in 2021. A large city of this size and a rapidly rising population of the above magnitude, demands a whole range of civic services, including the vital transportation sector. The present public transport infrastructure of Bangalore city is largely dependent upon the BMTC operated bus network facility, which is the mainstay for a population size of nearly six million. As the services offered by BMTC falls severely short of the public expectations and satisfaction, it has given rise to a situation in Bangalore where there is a preponderance of private transportation – mainly consisting of two wheelers and three wheelers, besides a good number of four wheelers and light vehicle population. Given this scenario, Bangalore city is also being promoted as a high-profile investment destination by Government, Private industries and Multi-Nationals and the good response thus received, has resulted in a chaotic situation as far as Urban Transport Sector is concerned. The present vehicular fleet on Bangalore roads is around 1.8 million vehicles traversing in the city area, in which 50 to 60% is accounted by two wheelers and the rest shared by three wheelers, cars and HMV's including buses. However the BMTC share of vehicle population on the city's roads is less than 2%, with which it practically carries most of the intra-city transport burden. Due to resource and management constraints, BMTC operations cannot match the raising demands of the city population, as evident from overcrowded buses, ever increasing average trip length with corresponding increase in average journey transit time exceeding even 60 minutes and more, and long waits at bus stops. As a sequel to this and to meet the genuine needs of a rapid, efficient and convenient mode of city transport, there is a growing trend to use personalized vehicles in Bangalore with attendant problems of high road congestions, large fuel consumption, heavy air pollution levels, besides growing number of accidents on the road as mentioned earlier. To address these problems singularly and collectively in order to bring in considerable relief to the travelling public, the Government of Karnataka has desired to introduce a Metro rail system for the benefit of the city's commuting population on the lines of the Metro rail at Delhi.

0.3 Project description of Bangalore Metro (Phase – I)

The metro rail system consists of two dedicated corridors, namely East-West from Baiyappanahalli to Mysore road (Pantharapalya) and North-South from Yeshwanthpur to J.P. Nagar (R.V. Road terminal).

The system involves predominantly elevated system of tracks located at 8.5 m above the ground with minimum clearance of 5.5 m above road level for allowing double decker buses supported duly by an arrangement of RCC piers generally at 25 m intervals. The viaduct consists of pre-stressed, precast U girder segments placed in position overhead and glued with epoxy and pre-stressed from one end. The bearings on piers are elastomeric bearings on pedestals. The piers in turn rest on a group of piles taken to soft rock/hard rock and anchored. Both the corridors cross at Majestic Station underground and serve as interchange station. The underground sectors of the corridors radiate towards North-South and East-West from this interchange station and switches over to elevated modes, through an intervening ramp of about 400 metres on all the four directions. The tracks run along the most busy business districts of Bangalore city. Majestic, Chickpet, City market, Vidhana Soudha, Central College and Railway station are the key areas served by underground tracks running through twin tunnels. The internationally accepted standard gauge of 1435 nm has been adopted for the Metro system. The following are the stations in E-W and N-S corridors

Table 1: Details of Stations in E-W and N-S corridors

E-W corridor	Station	N-S Corridor	Station
Mysore Rd Terminal	Elevated	Yeshwantpur	Elevated
Deepanjali Nagar	Elevated	Mahalaxmi	Elevated
Vijayanagar	Elevated	Rajajinagar	Elevated
Hosahalli	Elevated	Kuvempu Road	Elevated
Toll Gate Junction	Elevated	Malleswaram	Elevated
Magadi Road	Elevated	Swastik	Surface
City Railway Station	Underground	Majestic	Underground
Majestic	Underground	Chikpet	Underground
Central College	Underground	City Market	Underground
Vidhan Soudha	Underground	KR Road	Elevated
Cricket Stadium	Elevated	Lal Bagh	Elevated
MG Road	Elevated	South End Circle	Elevated
Trinity Circle	Elevated	Jayanagar	Elevated
Ulsoor	Elevated	RV Road Terminal (JP Nagar)	Elevated
CMH Road	Elevated		
Indira Nagar	Elevated		
Old Madras Road	Elevated		
Baiyyappanahalli	Surface		

Total elevated stations 23, Underground 7 and Surface stations are 2 in both the corridors (Table 1). The total length of E-W corridor is 18.1 Km and the length of N-S corridor is 14.9 Km. The Baiyappanahalli and Yeshwanthpur terminal stations are expected to serve as depots/yards where Rolling stocks will be stabled and maintained. The electrically tractioned high tech coaches are Air Conditioned. The elevated stations are provided with escalators in important stations and the necessary infrastructure for automatic ticket collecting systems and passenger facilities. The transit time on the average in each corridor from one end to other works out to about 30 minutes.

The entire system is operated with an integrated network of telecommunications, fare control, fire detection, fire fighting system as well as on-site and off-site emergency management systems.

0.4 Baseline Environmental Studies

In any major developmental initiative aimed at promoting the interests of the community or the State/Country, the associated environmental impacts – whether of a short term or long term nature, likely to affect the environment, ecology and health of the community, need to be seriously examined, before embarking on the proposed project. The primary objectives of the Environmental Impact Assessment (EIA) is to evaluate the existing pre-operational baseline environmental status at the proposed project site by field studies and data collection, and then carry out an objective assessment of the various impacts on the environment as a result of the proposed project activities. In the case of Bangalore Metro Rail Project (BMRP) the baseline environmental studies essentially include establishing the present status of the physico-chemical, biological and socioeconomic aspects of the city, in particular in those areas/parts of the city where the proposed metro rail project is being executed and put into operation in future.

As this is a major metropolitan infrastructure project for Bangalore it is imperative to conduct an Environmental Impact Assessment (EIA) to quantify the benefits accrued to the community as a result of the metro rail project, while at the same time analyzing carefully the impact aspects due to the project itself, during construction and operation phase cycles.

As these data are crucial for the planning and successful implementation of the project, various primary data were collected from extensive site studies in accordance with well established standard procedures. However, where such data were of a supplementary nature they were obtained by reference to existing records and reports etc.

Under the primary category, extensive field surveys were conducted along the East-west, North-south rail corridors to collect the environmental data relating to the following.

Environmental Data	**Socioeconomic**
i) Ambient air quality	i) Socioeconomic survey (including public opinion survey and interactive sessions)
ii) Water Quality	ii) Identification of project affected persons (PAPs)
iii) Soil	
iv) Noise Levels	**Others**
v) Green Cover	i) Traffic density survey
vi) Land use pattern	ii) Public Response survey

0.5 Environmental Features

Secondary data relating to environmental features of Bangalore city have been collected from various sources such as official reports, records and survey data available with official agencies, Government Departments and from discussions with officials etc. These are briefly summarized below:

Physiography

The Bangalore city forms an important and dominant part of Bangalore district of Karnataka and spread over a area of about 1279 sq. km as per revised CDP, Bangalore (GO No. HUD 139 MNJ 94 dated 05.01.1995) and is situated on a plateau. The topography of Bangalore is generally flat except for a small rise to form a ridge running through the middle. There are no major rivers flowing in the area. However River Arkavathi flowing for a small stretch in Bangalore North taluk and River Vrishabhavathi a tributary of Arkavathi which presently carries the bulk of city's sewerage are two small rivers flowing in the region. Bangalore also has a string of freshwater lakes and water tanks, dotting the city such as Bellandur, Ulsoor, Hebbal, Nagavara, Hennur lakes, Sankey, Madivala tanks etc.

Groundwater occurs in silty to sandy layers of the alluvial sediments and also in the jointed quartzite having secondary permeability under confined conditions. The weathered and fractured granites and gneisses constitute principal aquifers in the area. The chief source of recharge is seasonal rainfall and additional sources are seepage from reservoirs, tanks, lakes, rivers etc.

Geology

The area has mature topography with scattered isolated hillocks around, where rocks are exposed. The rock type exposed in the district belong to Saugar Group, Charnockite Group, Peninsular Gneissic Complex (PGC), Closepet granite and basic younger intrusives. Saugar group comprises ultramorphic rocks, amphibolites, Quartzite banded magnetites, quartzite occurring as small bands and lenses within the magmatites and gneisses. PGC is the dominant unit and covers about two-thirds of the area, which includes granites, gneisses and magmatites. The bed rocks essentially consist of granites and gneisses intruded by number of basic dykes. The soils of Bangalore district consist of red laterite and red fine loamy to clayey soils.

Climate

The district enjoys a very agreeable climate free from extremes. The climate of Bangalore is classified as the tropical wet and seasonally dry with four seasons. The dry season with clear bright weather is from December to February. The summer season from March to May is followed by South-West monsoon from June to September. The temperature varies from a mean maximum of 33.4^0 C in April/May to the mean minimum of 15^0 C in December/January. The mean monthly relative humidity ranges from 44% (min) in March to 85% (max) in October. Rainy season is characterized by spells during June to September and October to November, corresponding to South-West and North-East monsoon. The mean annual rainfall is reported to be 889 mm. The surface winds in Bangalore have a seasonal character with clear cut easterly and westerly predominant directions. The site meteorology has an important influence on the buildup, diffusion and transportation of atmospheric pollutants and therefore meteorological data was collected from India Meteorological Department (IMD) for a set of meteorological parameters from the IMD station at Bangalore (Meteorological data particulars are discussed in Chapter I, Environmental Baseline Report). During the period May to September, the winds are WSW to W, while during the period November to March, they are ENE to ESE. April and October are transition months when changeover from the Easterly to the Westerly wind regime and vice versa takes place.

Seismicity

Bangalore city has generally remained nearly untouched by major seismic activity due to its location in a seismically stable region (Zone II revised). Only mild tremors have been recorded in the city occasionally as per records of Directorate of Mines and Geology, Government of Karnataka and Bhabha Atomic Research Centre.

Land use pattern

The term land use is generally adopted to mean man's activities, which are directly related to the use of land as resource. Land use can therefore be defined as an activity or development which occupies land for a specific usage purpose. The land use pattern, and its continuous change over the years (Period: 1963 to 2001) are given in Table 2 along with the projected trend in land use in 2011 (Ref: BMP Master Plan).

Table 2: Trends in land use in Bangalore City

Land-use	Area (Ha) (1963)	%	Area (Ha) (1983)	%	Area (Ha) (1990)	%	Area (Ha) 2001	%	Area (ha) 2011	%
Residential	3449	42.49	5777.65	28.48	9877.65	34.78	17123	40.4	24369	43.16
Commercial	175	2.18	634.07	3.14	675.07	2.38	1159	2.7	1643	2.91
Industrial	1006	12.52	1956.61	9.65	2038.61	7.18	2941	6.9	3844	6.81
Public and semi public	667	16.30	2533.64	12.49	2615.64	9.21	5201	12.2	4908	8.69
Parks and open spaces	710	8.84	2050.16	10.41	2132.16	7.51	3520	8.2	7788	13.71
Unclassified	-	-	2114.24	10.42	2114.24	7.45	2164	5.3	2213	3.92
Transportation	710	8.84	5216.81	25.72	8946.63	31.49	10321	24.3	11697	20.71
Total	6717	100	20283.18	100	28400	100	42432	100	56462	100

0.6 Baseline Environmental Surveys

As the baseline environmental studies form a very vital component towards objectively assessing the environmental and socioeconomic impacts on Bangalore environs and the community, carefully designed surveys were organized by the Environmental Sciences Department to scientifically investigate and evaluate the existing scenario along the proposed Metro Rail alignments in the East-West and North-South Corridors. The environmental studies consisted of the following:

a. Air Pollution Surveys

The urban air pollution is contributed generally by a variety of sources such as industrial, commercial and transportation sectors. However, at Bangalore air pollution problems which are quite severe are mainly compounded by the transportation sector while the other sources such as industrial etc. are contributing less. As the core transportation sector presently consists mainly of petrol and diesel driven vehicles operating throughout the city, the major air pollutant components are contributed by the automobile exhaust emissions, which consist of; Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Oxides of Nitrogen and Sulphur, Carbon Monoxide etc. Presently many of these air pollutant concentrations are being monitored by the Karnataka State Pollution Control Board (KSPCB) at some locations and by the Central Pollution Control Board (CPCB) at some selected important intersections of the city. However, as these data were being collected with quite different objectives, actual primary site specific data for the proposed twin corridors were generated by organizing air pollution monitoring surveys by field teams by employing standard methods of sampling and analysis. Baseline air pollution concentration for above parameters were mapped at about 20 sampling stations covering both the proposed alignment tracks. Secondary data values collected from PCB sources for selected locations were also mapped to enable comparison of the both the data. Supplementary data relating to the vehicle demography- i.e. statistics of vehicle population over the years to the present day, vehicle category data, annual fuel consumption for the city vehicle population, pollution emission factors for various types of automobile fuels uses were collected to evaluate precisely the air pollution status at the proposed Metro rail corridors. The details of baseline (2003) AQI values and quality criteria at Metro corridors are given in Table 3. The accepted criteria for Air Quality Index is given in Table 4.

Table 3: Details of AQI values and Criteria at Metro Corridors

Name of Stations	AQI Values	Air Quality Criteria
Yeshwanthpur	256	Severe Air Pollution
Navarang Junction (Rajajinagar)	148	Severe Air Pollution
Seshadripuram / Swastik Cirlce	140	Severe Air Pollution
Anand Rao Circle	189	Severe Air Pollution
National College / Vanivilas Circle	238	Severe Air Pollution
South End Cirlce	173	Severe Air Pollution
KIMS Circle	146	Severe Air Pollution
Sri Aurobindo Circle (Jayanagar 5th block)	178	Severe Air Pollution
KIMCO Junction Vijay Bus Depot Mysore Road	256	Severe Air Pollution
Vijayanagar Tollgate (Magadi Junction0	140	Severe Air Pollution
Okalipuram	310	Severe Air Pollution
Anil Kumble Circle	76	Heavy Air Pollution
Shanthala Silks (Majestic)	314	Severe Air Pollution

Trinity Circle	232	Severe Air Pollution
Cauvery Bhavan (Mysore Bank Circle)	241	Severe Air Pollution
Old Madras Road	194	Severe Air Pollution

Table 4: Generally accepted criteria for AQI

Range	Criteria
0 to 25	Clean Air
26 to 50	Light Air Pollution
51 to 75	Moderate Air Pollution
AQI > 75	Heavy pollution
AQI > 100	Severe Air Pollution

From the results of survey it was concluded that the main pollutants contributing to air pollution like NOx, SPM, RSPM and CO are above permissible limits. In terms of Air Quality Index values (AQI), all stations except one displayed **severe air pollution** (>100) situation in the city.

b. Noise Pollution surveys

Noise pollution being an important component of urban life – together with air pollution problem – needs a through evaluation as part of the baseline environmental studies. Bangalore being in the throes of unprecedented growth is presently facing serious noise pollution problems, a substantial contribution coming from the automobile traffic segment. In the context of proposed metro rail network, systematic noise pollution surveys were carried out by the field survey teams using standard measurement techniques at regular intervals along the proposed twin corridors and the observed noise levels were recorded and analyzed with respect to various subcomponents (Tables 5 and 6).

Table 5: Noise Levels in East-West Corridor

S.No.	Location	Morning Peak (0830 hrs to 1130 hrs)		Lean Period (1430 to 1700hrs)		Evening peak (1700 hrs to 2000hrs)	
		L_{max} dB(A)	L_{min} dB(A)	L_{max} dB(A)	L_{min} dB(A)	L_{max} dB(A)	L_{min} dB(A)
1	KIMCO Junction/ Deepanjali Nagar	93.9	72.2	98.68	62.75	86.98	68.10
2	Vijayanagar/ Tollgate	95.79	68.4	94.37	63.8	95.46	64.96
3	Okalipuram Junction	98.9	67.98	97.98	66.48	98.15	67.82
4	Shantala Silks/Majestic	95.46	67.23	96.06	67.94	92.95	68.87
5	Cauvery Bhavan, Mysore/ bank circle	97.72	64.28	99.43	65.3	96.54	66.56
6	Anil Kumble Circle	91.79	61.81	86.15	60.13	94.53	68.24
7	Trinity Circle/ M.G. Road	96.43	67.57	95.58	67.54	96.25	68.72
8	Old Madras road/ Indira Nagar	100.68	67.04	98.68	62.75	100.27	66.86

Table 6: Noise levels in the North-South Corridor

S.No.	Location	Morning Peak (0830 hrs to 1130 hrs)		Lean Period (1430 to 1700hrs		Evening peak (1700 hrs to 2000hrs)	
		L_{max} dB(A)	L_{min} dB(A)	L_{max} dB(A)	L_{min} dB(A)	L_{max} dB(A)	L_{min} dB(A)
1	Yeshwantpur circle	97.19	64.86	92.25	62.42	92.92	64.78
2	Navrang circle	98.14	64.16	96.06	69.80	95.11	68.87
3	Seshadripuram circle	94.16	63.18	97.05	66.22	98.74	67.5
4	Ananda Rao Circle	97.41	66.06	100.56	66.16	86.98	68.10
5	National College Vani Vilas Circle	94.72	65.39	94.37	63.8	92.03	65.52
6	South End Circle	92.59	65.64	93.66	65.40	95.46	64.96
7	KIMS Circle	94.53	68.24	95.18	68.95	96.39	68.44
8	Jayanagar 5th Block SriAurobindo Circle	96.07	69.88	96.18	69.12	94.43	71.21

While in all the stations, the L_{max} was more than 65dB, in most of the stations, the L_{min} levels area were also higher than the permissible limits of 65 dB. With the coming into operation of Metro Rail, a significant reduction in vehicular traffic on the roads up to

30% may be expected with a corresponding decrease in vehicle related noise in the urban environment. The noise due to metro rail, itself could be less, as observed in Delhi metro and any increase above ambient noise due to metro rail running operations would be transient, lasting for a very short time and hence does not contribute to the background noise levels. Also the metro rail technology is a state of art nature with very good inbuilt sound reduction systems.

c. Traffic Density Surveys

This forms a valuable component and an important input in evaluating the traffic pattern scenario at the proposed metro corridors with twin objectives, namely, establishing the congestion status of the road network, and evaluating the vehicular contribution to the air pollution status in the area. To study the traffic density pattern, at chosen key locations along the corridors field survey teams carried out traffic census studies during peak and off peak hours of the day for different categories of vehicular flow in the area. The collected field statistics were analyzed and compared with the congestion index available for the city. The derived Congestion Index (CI) indicated far above the limiting value of 1.0. This is evident from some of important road links in the city network which are given in the Table 7 below.

Table 7: Congestion Indices of selected roads in Bangalore city

Name of the road	Peak hour service volume (PSV)	Practical capacity (PC)	Congestion Index (CI)
Platform Road	14,375	2,486	5.78
Seshadri Road	10,105	3,813	2.65
Race Course Road	7,375	1,371	5.38
Subedar Chatram Road	5,934	2,057	2.88
J.C. Road	11,813	4,971	2.30
Dickenson Road	5,511	1,971	2.80
Airport Road	7,767	2,900	2.68

The traffic pattern surveys along the proposed corridors brought out clearly the composition of vehicle population plying on the city roads. From the survey data, it was evident that the two wheeler population almost always exceeded 50% at most survey points, while the three wheelers were typically around 20%, which together accounted for over 70% of the total vehicle population. These findings have helped to confirm the total inadequacy of the present public transport system operating in the city.

d. Water and Soil Studies

The water and soil pollution aspects are not likely to be greatly influenced, unlike air pollution quality by the induction of metro rail in the city. However, there could be indirect impact on the water and soil components in the long run. Besides, during the construction phase, ground water usage/ depletion, soil excavation and disposal are likely which could affect the ground water quality and cause depletion both of which needs to be addressed. In view of this water and soil samples from bore well locations and geotechnical investigation sites at the proposed corridors were collected and analyzed by field survey teams. Analysis of the same was carried out by standards methods and compared with prevalent standards. The water analysis results showed that in almost all cases in both the corridors, the values remained within permissible drinking water limits (BIS). Soil sample analysis results are also within normally observed range of concentrations.

e. Green Cover Survey

Bangalore city, with its rich flora and abundant green cover and being host to Lalbagh and Cubbon park, which are renowned botanical gardens, is rightly called the Garden City of India. Bangalore City bagged the central government sponsored ‘Indira Priyadarshini Vruksha Mitra’ award in the late 1980s in recognition of its extensive green cover. But today, lung space is shrinking in the city and core areas have lost green cover with increase in concrete structures. A detailed tree census was carried out along the proposed alignment as part of environmental baseline studies for EIA purposes. A summary of the data of the affected trees is given in Table 8 below.

Table 8: Type of tree population within 0-5m from center in E-W and N-S corridor which get affected

Type of Tree	East-West corridor	North-South corridor	Total
1. Big canopy trees with girth >70cm at GBH	144	90	234
2. Medium canopy trees with girth 40 to 70 cm at GBH	95	23	118
3. Coconut	32	5	37
4. Small canopy trees and shrubs with girth <40 cm	12	11	23
Total trees to be cut	283	129	412
Bio mass (in tonnes)	310.6	235	545.6

Among the 412 trees to be cut in both the corridors additional survey confirmed that only 274 are healthy and the rest are either aged, stunted or mutilated (Table 9), which may need replacement in the near future. Also the total biomass loss is of the order of 545 .60 tonnes for a total of 412 trees which comes to 1.32 tonnes per tree which shows that the trees are on an average are medium size and not large ones. Considering the benefits of the project, and the compensatory afforestation plan envisaged, it has been observed with management plans consisting of planting of trees in the ratio of 1:10, proactive afforestation for green cover and development of green ribbon along the elevated stretch, it will be abundantly compensating the green cover.

Table 9: Health and Status of Trees in 0 -5 m in both the corridors

Type of Trees	Number	Status of trees on both the corridor			
		Healthy	Aged	Stunted	Broken, chopped
Big canopy trees	224	171	46	2	5
Medium Trees	119	78	11	20	10
Small trees and shrubs	32	8	0	21	3
Coconut	37	17	18	0	2
Total	**412**	**274**	**75**	**43**	**20**

0.7 Socio-Economic Impact Assessment an Outline Report

a. Purpose of the Study:

The main criteria for introducing metro rail system in Bangalore is the social benefits that the general public are going to derive from it. Socio-economic impact assessment of Bangalore metro rail system in particular and other developments that follow constitute an important and integral part of the environmental impact assessment studies. The nature and magnitude of impact that metro rail system might possibly engender on people, their living and working conditions has been an important issue. Socioeconomic impact assessment study of the proposed metro rail system has been basically conceived with the following objectives.

i) To identify the people affected by the project in terms of their socio economic characteristics. Two categories of people have been identified. a) persons who will be put to inconvenience and hardships due to environmental pollution and due to disruptions in the supply lines of essential services and traffic diversions because of their proximity to proposed alignments, b) Project affected persons (PAP) who will be losing their personal economic resources because of the alignment of railway lines.

ii) There is another category of people who may not be adversely affected, but they could be the potential users of the proposed metro system and they might have something to say. **Public opinion** survey has been conducted on the basis of a sample of cross section of intelligentsia drawn from lawyers, doctors, academicians, journalists etc., the opinion makers in urban situation. **Interactive sessions** with NGOs and various members of the city public and press also formed part of the exercise in this direction.

The above data collected by direct field measurements as primary data, and from secondary sources where they are supportive in nature to primary data, have been carefully scrutinized and evaluated before applying the same for the EIA studies using standard models.

b. Socioeconomic background of the sample

One fourth of the sample population in the East-West corridor comes from lower economic background and 41% in the North South corridor. Least percent of population belong to higher income group and highest percent populations belong to middle and lower income groups. 75% of the total sample in both the EW and NS corridors are business people. Only about 10% of the sample is employed in the organized sector. The remaining percentage of the sample seems to find the employment in the unorganized sector.

In terms of educational background 6.25% of the sample are illiterates in the East-West corridor and no illiterates in the North-South corridor. 29% of the sample in East-west corridor are graduates and almost 45% in the North-South corridor.

c. Social acceptability

Public opinion with regard to public projects cannot be ignored. It plays a very important role in the decision making process. Given the chaotic urban road traffic we have put a question to public opinion makers whether metro rail system would be a viable alternative to the existing modes of transport. It is indeed gratifying to note that 91% of the sample felt that it could be a viable, quick, comfortable and safe means of transport, and thus should be welcomed.

d. Socioeconomic impact analysis

i) **Positive Impact:** One of the very positive features of the metro rail system is the fact that relatively a small percentage of the population is directly effected i.e., very few people or a small section of the total population is losing property under the material resources. Of the total sampling of 788 households in the East-West and North-South corridors, 139 are found losing their property and are adversely affected. The remaining samples do not lose property.

ii) **Negative Impact:** From the primary data analysis one thing is worth noting – the project Authorities have taken maximum care to see that there is a minimum of negative impact on people.

Given the fact that some loss of property and inconvenience during construction phase are absolutely unavoidable, the question then is to find the manner in which the people react to these changes and how best we can work out appropriate strategies to mitigate the negative impact.

It can be found from the data analysis regarding the nature of property being lost, it shows that an overwhelming majority of sample of directly affected persons seem to be losing commercial property resources while only relatively less percentage of them are losing residential property. No matter how much property people lose, however, in terms of their perception of loss of property, they seem to be highly concerned. It is evident from the analysis that majority of the people prefer cash compensation and very few said, they would approach court in case they are losing their property.

e. Interactive Meeting

An interactive meeting was held with members of public, media and concerned environmental groups at Bangalore University Senate Hall, when the salient features of the metro rail project for Bangalore along its projected benefits to the community, environmental and socio economic impacts were explained by the project proponets. This was followed by intense discussions and question and answer session. On the basis of deliberations a consensus emerged from the meeting, that the metro rail project implementation would bring in a better mode of transport with a wide range of benefits to the community. This conforms to the global view that for a better urban mobility, the appropriate way requires a sustainable urban planning with metro rail as a backbone for the infrastructure.

f. Land Acquisition Aspects

i) East West Corridor

In the stretch covering a distance of 18.9 km between Mysore Road to Baiyappanahalli the land to be acquired is classified as follows (Table 10).

Table 10: Land classification for proposed acquisition

Type	Area (in sq m) Land and Building	Area in %
Residential	2094	6
Commercial	6609	19
Industrial	4331	12
Religious places	235	1
Institutional	15310	44
Others (category to be ascertained)	6075	18
TOTAL	**34654**	**100**

Based on the current estimates a majority of the commercial establishments (Appendix II1), mostly small time business establishments, are expected to be acquired mostly on Magadi Road and Swami Vivekananda Road. The institutional areas comprising of government and trust land that are mostly vacant account for about 44% of the total land area to be acquired. NGEF ground located near Baiyyappanahalli looses a large area for the depot besides a small stretch of commercial plantation along the Old Madras road. Among the residential class, a group of police quarters on Swami Vivekananda Road and a railway quarters in the Railway colony near Mysore deviation road would be acquired.

Among the public utilities, a petrol pump on trinity circle junction, a primary school on Mysore road, Corporation Hospital and Adi Vinayaka temple on Swami Vivekananda Road are affected. A number of residential cum commercial holdings would be acquired in Indiranagar locality. The total land area to be acquired for the project would be 34654 sq m.

ii) North-South Corridor

In a stretch covering 14.1 km at North- South corridor from Yeshwantapur to R. V. Road terminal the land acquisition is as below (Table 11).

Table 11: Land Classification for proposed acquisition

Type	Area (in sq m)	% land area
Residential	1450	6
Commercial	5538	22
Industrial	10784	44
Institutional	6873	27.5
Religious	35	0.14
TOTAL	**24680**	**100**

As per the current estimates the total land area that would be acquired for the project would be approximately 24680 sq m. (Appendix 2). Starting from north of Yeshwantapur area the alignment cuts some of the industrial areas of Yeshwantpur. Of the total area, about 10784 sq m of the area belong to Industries which are defunct while commercial and residential account for 5538 and 1450 sq m respectively. The institutional areas comprising of government and trust land account for about 27% of the total land area to be acquired. Among the public utilities to be affected, would be two petrol pumps near Vani Vilas Circle and the one near Lalbagh circle and a small temple near Mysore spinning mill.

iii) However, the requirement of land for acquisition is minimal and unavoidable for a project of this magnitude. With timely and proper compensation packages, to the people affected, the study favours that the project may be undertaken.

0.8 Environmental Impacts

The proposed metro rail project for Bangalore city – which is passing through a phenomenal growth rate and rapid urbanization – while providing a strong infrastructure and serve as a vastly efficient transportation system for the city, will also have implications on certain environmental fronts. While the accrued benefits to the urban community in terms of an alternative and superior mode of transportation would be sustainable and far reaching, the very size and nature of the project could have a significant bearing due to the numerous positive and negative environmental and socioeconomic impacts on the environment and the community. In the light of this, site specific environmental and socioeconomic assessment studies were carried out on the proposed project, and based on the study findings and observations, the impact aspects due to different project components are discussed here. Accordingly, the impact aspects could be attributed to the following:

i) Impacts due to project design
ii) Impacts due to project location
iii) Impacts due to project construction
iv) Impacts due to project operation

i) Impacts due to project design:

The E-W and N-S corridors are designed to run on a combination of elevated and underground track sectors with facilities for inter-transfer of passengers at the underground crossing station (Majestic). Due to the design of elevated and underground rail and associated infrastructure facilities like rail stations, depots, ticket counters and peripherals like public facilities counters, railway yards, offices, vehicle parking lots adjoining stations, cropping up of business establishments in rail station neighborhoods, certain qualitative and quantitative impacts on environmental and socioeconomic aspects are anticipated. Also heavy movement of metro commuters using an assortment of automobiles both private and public around station area and parking lots may influence the ambient air pollution levels in the vicinity. Likewise ambient noise levels may register an increase to a degree, due to vehicle movement at parking lots. Some change in the visual impacts due to elevated track stations may be anticipated like interference with natural scenery in some parts and on the contrary some of the ugly spots in urban landscape may be covered, improving the visual aesthetics.

ii) Impacts due to project location:

The potential major impacts due to location of the project could be attributed to the following:

a) change in land use pattern – at station areas and neighborhood, abutting the alignment elevated stations and ramp
b) at terminal depots (2 Nos)

Some sensitive receptor units along side East-West and North-South corridors, like schools (10), Colleges (8), Hospitals (6), Nursing homes (8), parks and monuments and temples (1) have been identified.

Another significant impact arising from project location is on the green cover aspects presently existing in some parts of the twin rail corridors, requiring appropriate remedial or restorative measures.

iii) Impact due to project-construction phase

On account of its size, nature and technological complexities the proposed metro rail project activity is likely to make certain impacts on the environment at the proposed site, which may be of both short and long term duration. The magnitude and intensity of these impacts, during the construction phase may however differ with respect to various components of the ecosystem. Although some of these aspects appear to be negative during construction phase, they cease to be so with completion of the construction phase and subsequently have the potential to develop into positive attributes during the operational phase of the project.

Some of the environmental components considered under this are;

1) Land clearing and excavation activities
2) Barricading of sites
3) Air quality
4) Noise levels
5) Water quality
6) Soil erosion and pollution
7) Water demands
8) Traffic diversions
9) Public utilities network

10) Disposal of excavated soil and debris
11) Health hazards

Most of the proposed project components will be in developed areas of the city with distinct land usage patterns ranging from residential to commercial to industrial activities under well established conditions. As construction activities are primarily land based many impacts can be identified in the soil component in the proposed area. Both elevated and underground excavation activities will produce a lot of rubble from demolished buildings and tunnel excavated soil, needing disposal. Air pollution level will go up due to dusty operations and due to heavy earth moving machinery exhaust emissions (e.g., SPM, RSPM, NOx, SOx, CO) etc. These have to be tackled with appropriate environmental management plans.

Barricading of construction sites is a major problem during construction phase as this will lead to drastic vehicle congestion on narrow roads, higher air pollution and noise levels, soil erosion and pollution, higher accident potential and possibly more fuel consumption. But these impacts last only during the construction phase, and is hence considered as short term duration impacts. However the most significant and difficult problem is to handle the disposal of huge volumes of excavated soil particularly from underground sections of the rail corridor and to some extent the debris from land cleared for elevated sections.

Another significant aspect of the metro rail induction in a crowded city scenario, would be its 'dislocation effect' on the existing public utilities like telephone and communications, cable network (including OFC), electrical system network (including street lighting), sewerage lines and water supply network etc. As the public utility network are very vital for a normal functioning of an urban metropolis, a detailed survey of existing utilities and their diversion or reinstallation on a temporary or permanent basis should be planned in a proactive manner and organized with minimum loss of time and inconvenience, to the community. The details of underground utilities in these corridors have been taken in the alignment survey by RITES and furnished in their report. .

Some health and sanitary problems in construction labour camps may arise due to the nature of such camps and the migratory behaviour of camp inmates and therefore good attention towards maintenance of health and hygiene and provision of all necessary facilities like drinking water, toilet facilities, health care centres, medical supervision etc. would be required to avoid health risks in the city. Comprehensive Environment Management Plan has been drawn up to address appropriate mitigating measures on these aspects.

Another important fall out of the project construction activity will be on the traffic diversion at many important city traffic intersections, which would cause inconvenience – temporary though, to the public. However these difficulties could be managed by a good traffic study, scientific planning in consultation with city traffic authorities to divert the traffic either partially or completely into other roads in the vicinity. Appropriate traffic diversion plans, signals and posting of traffic personnel/volunteers would be necessary.

However, the pollution of surface water bodies and underground waters are not expected to be significant due to the nature of the project. But as the project activities need substantial water quantities for construction processing, dust proofing, cleaning of vehicles and batch mixing etc. there could be considerable demands on water resources available. Necessary arrangements and contingency plans with BWSSB should be made to meet the water demands, without in any way affecting the city's normal water supply demands.

Some quantities of solid wastes and liquid wastes (oil etc.) although in small quantities may be generated during this phase, but they could be treated and disposed of appropriately by project authorities according to established procedures like in any other construction industry practice.

A Model of the 'Environmental Management Manuel' as adopted from DMRC, New Delhi is also furnished for adoption during construction.

iv) Impacts due to project operations

With the termination of construction phase activities along the East-West and North-South corridors, the metro rail system would be poised for trial-runs, followed by regular route operations carrying members of the public. At this stage of the project many environmental problems including socio-economic aspects arising out of construction activities would have come to terminal stages. What follows next, during the operational phase of metro rail, would be a set of environmental impacts which could be at variance with those of the construction phase of the project. It must be stated that while the environmental impacts during construction are of a temporary and transitory nature, the impacts of operations are long lasting and permanent in nature. Therefore it is essential to assess the nature and magnitude of environmental impacts on the contiguous environment and public, to draw up Environmental Management Plan to exclude or minimize any negative impacts.

Some of the possible negative impacts arising due to operational phase of the project are water demands, waste handling and disposal, noise etc. However these are not of a major nature in normal operations and can be effectively handled by metro rail authorities, as applicable in any similar industrial practice or procedures. However it is essential that an appropriate Environmental Management Plan with an efficient monitoring system shall be put in place for remedial measures.

0.9 Environmental Management Plan

Considering the above impacts in various phases of the project, an environmental management plan is drawn up covering various aspects of the environment for implementation as follows.

I) Pre Construction Phase
   a. Land Acquisition
   b. Green cover management

II) Construction Phase

a. Air Quality Management / Dust prevention
b. Noise Management
c. Water/ water table management
d. Surplus soil
e. Utilities Management
f. Traffic Diversion
g. Labour / Safety Management

III) Operation Phase

a. Water Table/ Air Quality/ Noise Management
b. Vibration Management
c. Waste Management and d) On site and Off site Emergency Management

0.10 Positive Impacts due to Metro Rail Project

The Metro rail project being an infrastructure project for Bangalore city designed to promote an efficient and commuter friendly transport sector for the benefit of the urban community is also expected to bring in a number of positive impacts on the environment and the general public. Depending upon their significance and magnitude, some of them could be considered as tangible while others could be viewed as intangible benefits. The positive impacts, as already visualized during the planning stages of metro rail project, would be steadily realized during sustained running operations of the metro rail system. Some of these positive benefits are:

1. Quick service and safety
2. Reduced traffic density on roads
3. Reduced fuel consumption by automobile sector and accompanying import savings
4. Reduction in road accidents
5. Reduction in air pollution and noise levels
6. Improvement in road conditions and extended life of roads
7. Benefits of transfer of technology
8. Employment opportunities
9. Enhanced rural economy
10. Saving in productive man-hours due to rapid mode of transport
11. Reduction in green house gases emission
12. Reduced need for expansion of roads, laying new roads, flyovers etc

13. Better environmental landscape, aesthetics
14. Boost to industry, trade, commerce, communication and culture

Further, In addition to these positive impacts listed above, with the operation of the metro rail system, a major positive contribution is reduction of consumption of fossil fuel. To estimate the possible saving of fossil fuels, it is to be brought out that from the public opinion survey conducted, about 50% of the two wheelers and three wheeler commuters expressed their willingness to shift to Metro Rail. So, even a conservative realistic figure would be 30% of two wheelers and 20% of three wheeler commuters would shift to Metro Rail. Based on this, the reduction in the consumption of fuel are worked out and furnished in the Table 12 below.

Table 12: Expected reduction of fuel consumption in 2011

Category of Vehicles	Number of Vehicles without Metro	Number of Vehicles with Metro	Fuel consumption with out Metro (litres)	Fuel Consumption with Metro (litres)	Fuel saved (litres)
Two Wheelers	2394075	1676137	1795556	1257102	538454
Three Wheelers	157224	125829	786120	629145	156975
Total Saving in Fuel, litres per day					**695429**

On the basis of current prices of petrol of Rs. 35 per liter, it is estimated that the savings would be Rs. 2.4 crores a day and Rs. 876 crores per year, which would contribute enormously to the national savings. In addition, with the reduction in fuel consumption, the release of air pollutants will be reduced as shown in Table 13.

Table 13: Estimated reduction of Air pollutant emission

Pollutant	Exhaust Factor* for petrol in kg/1000 litres	Total decrease in air pollutant release (in MT)
Carbon Monoxide	391.0	271
Hydrocarbons	34.0	23
Oxides of Nitrogen	19.2	13

Oxides of Sulphur	1.5	1
Particulate Matter	1.9	1
Total		**309**

Exhaust emission factor as per H.B. Mathur, 1984

In view of the expected all-round benefits to the environment and society as whole with the onset of metro rail operations, an attempt is made here to summarize some of these beneficial impacts at various levels which are presented in Table 14.

Table 14: Metro Rail Project "Matrix Impact Summary"

Sl.No.	Environmental Impact Criteria	Impact	Remarks
I	Global Sustainability		
1)	Transport energy efficiency (modes)	$	The well planned corridors provides encouragement to modal shift from private owned vehicles to Metro rail which operates on electrical traction
2)	Renewable energy potential	$	Corridors provide conservation of fossil fuel which is fast depleting
3)	CO_2 fixing	$	Increased potential for growing trees both along corridors and other selected areas of afforestation
4)	Transport energy efficiency (Trips)	$	The trips on metro rail will lower the traffic density on roads
II	Natural resources		
5)	Air Quality	$	The urban "pollution dome" due to fuel driven vehicles as expected to be diffused to a large extent by improving the air quality (CO_2, SO_2, NO_X, Pb reduction)
6)	Noise levels	$	The noise along corridors will be reduced as on-road vehicular population density goes down and the noise in other areas can be marginal due to overall reduction of density
7)	Land and Soil	*	No obvious impact
8)	Mineral conservation	*	No obvious impact
9)	Fossil fuel conservation	$	Huge reduction due to reduction of fueled vehicles and opting for electrical traction
III	Environmental Quality		
(i)	Landscape	@	The corridors will be visually reemphasized by green belts beneath

			the viaducts and the ramps also would be landscaped to reduce visual impacts
(ii)	Liveability	$	Quality of life improved by reduced vehicles on road, lesser pollution, lesser road accidents, quicker and comfortable mode of transport (A/C coaches)
(iii)	Cultural heritage	$	Urbanity enhanced, internal and external image of city enhanced
(iv)	Open space	@	As the tracks are either elevated or underground no major space loss except in ramps

* No relationship or insignificant impact

$ Significant beneficial impact

@ Likely, but marginal and selective positive impact

An Environmental Impact Checklist giving a cross-sectional view of the environmental impacts due to Metro Rail including the negative and positive ones are presented in Table 15.

Table15: Environmental Impact Checklist

S. No	Parameter	Negative Impact		Positive Impact	
		Short Term	Long Term	Short Term	Long Term
Impact due to project Design					
1	Drainage Impact	N	N	N	N
2	Station Location	L	L	N	M
Impacts due to project location					
1	Loss of trees	M	N	N	H
2	Loss of Utilities	M	N	N	N
3	Historical Monuments	M	N	N	L
4	Change of Land use	M	N	L	M
Impacts due to construction					
1	Impact on Air Quality	M	L	N	N
2	Noise	M	L	N	N
3	Water Quality	L	L	N	N
4	Soil	M	L	N	N
5	Traffic Diversion	H	L	N	N

6	Water Demand	H	M	N	N
Impacts during operational phase					
1	Air Quality	N (No negative Impacts)		M	H
2	Noise	N (No negative Impacts)		M	H
3	Health	N (No negative Impacts)		M	H
4	Effluents	N (No negative Impacts)		N	N
5	Quick Service	N (No negative Impacts)		M	H
6	Safety	N (No negative Impacts)		M	H
7	Fuel Consumption	N (No negative Impacts)		M	H
8	Traffic Congestion Reduction	N (No negative Impacts)		M	H
9	Road Quality	N (No negative Impacts)		M	H
10	Greenhouse gas emission	N (No negative Impacts)		M	H
11	Accident Reduction	N (No negative Impacts)		M	H
12	Travel Time	N (No negative Impacts)		M	H
13	Transfer of Technology	N (No negative Impacts)		M	M

Index - N: None, L: Low, M: Medium, H: High

0.11. EIU Quantification and Methodology

The impacts and benefits of Metro Rail project for Bangalore city was evaluated objectively using descriptive weighting and scaling technique. The methodology is **called Battelle Environmental Evaluation System (BEES), USA,** which is an accepted reference model. The evaluation process integrates all parameters such as physical, biological and socio economic components of the project location. The parameters of these components were identified using Checklist and Leopold matrix method (Leopold, 1971). The components and overall Environmental Quality (EQ) was evaluated for the baseline situation in Bangalore (2003) followed by assessment the impact on EQ with the introduction of Metro rail operations.

For describing the existing environment of the project location 40 parameters under 5 aspects of 3 components were selected. The Parameter Importance Unit (PIU) was assigned based on the experts' opinion and field inspections. To arrive at Environmental Impact Unit (EIU), the value function curve is plotted for each of the parameter data collected for the existing baseline Environmental Quality (EQ). The following relationship was used to compute the EIU.

$$\mathbf{EIU} = \sum_{i=n}^{n=1} EQ_{ij} \cdot PIU_i$$

EIU = Environment Impact Unit

EQ_{ij} = Environmental Quality i^{th} parameter j^{th} factor

PIU_i = Parameter Importance Unit i^{th} parameter

Impact Prediction and Evaluation

The initial prediction was made based on the project activities at various phases of project (Construction & Operation) using checklist and Leopold matrix. The cause and effect of all the parameters were predicted after a thorough analysis of baseline information and field survey. The EQ is obtained by plotting value function curve and PIU is arrived at by discussion with environmental specialists/experts before assigning the values for the ideal environmental scenario.

The major environmental components of the project location are taken up for consideration and interpreted here. Air quality remains a major realm in the project location. It is anticipated that if the present scenario continues, there will be a further substantial increase in pollutants, which in turn severely declines the ambient air quality. The PIU apportioned by the experts for ideal situation of the project location in terms of air quality is 395 out of 1000 PIU units. The computations showed that the existing scenario without project scores 202 and 158 and the EIU of air quality increased to 275 and 236 with the project and EMP for N-S and E-W corridor respectively. The projected net change in air quality has improved to +73 units (N-W) and +78 units (E-W) (Table 16).

Table 16: Evaluation of the Environmental Quality and Benefits (in terms of EIU)

Environmental Aspect and Components	PIU Assigned (Ideal)	EIU Without Project (As on 2003, Baseline)		EIU with Project (With EMP)		EIU Change due to Project (With EMP)	
		NS	EW	NS	EW	NS	EW
I. PHYSICAL							
a) Air Quality,	395	202	158	275	236	+73	+78
b) Water Table/ Quality	130	122	119	122	119	0	0
c) Land	40	39	35	38	34	-1	-1
II. BIOLOGICAL							
a) Terrestrial Ecosystem	150	139	147	149	149	+10	+2
b) Aquatic Ecosystem	15	12	13	14	14	+2	+1
III. SOCIO ECONOMIC (Traffic Congestion Fossil Fuels Quality of life Comforts etc)	270	51	48	228	236	+177	+188
Total PIU	1000	565	520	826	788	261	268
Average Values for both corridors	**1000**	**542.50**		**807.00**		**264.50**	

Note:

EIU = Environmental Impact Unit

PIU = Parameter Importance Unit (Ideal) assigned for each parameter for evaluation

NS = North – South Corridor

EW = East – West Corridor

EMP = Environment Management Plan

The other major domain of the project location, which covers a stretch of 33 km length and 10 m width of the land strip is in the terrestrial ecosystem, accordingly the assigned PIU is 150 units and in the absence of the project, expected disturbances such as occasional uprooting of trees due to thunderstorm, chopping/pruning of trees for other activities, aged, stunted, attacked by pests and diseased trees, which results in decreased EIU of 139 and 147 for N-S and E-W corridors respectively. Implementation of an Environmental Management Plan including a tree compensation programme, replantation activities, monitoring and maintenance by the project proponent as envisaged is to be taken proactively by compensating for the loss of with more healthy and beneficial trees from the initial stages of project itself. Hence, the EIU computed, is restored to 149 for both corridors. The net change in EQ is +10 and +2 for NS and EW corridor.

The primary objective of any infrastructural developmental project is to promote or enhance the socioeconomic benefit of the community. Due to the uniqueness, high acceptability and eco friendly nature of the project, the expert assigned weightage for the socio economic aspect and PIU value was 270 units. With the unabated growth of air pollution scenario and other negative impacts due to uncontrolled growth of vehicles, fossil fuel consumption and poor transportation scenario in the absence of metro rail, further degradation of quality of life, social values such as health of a community and economy would loom large. The EIU in the existing scenario scores 51 and 48 for NS and EW corridors respectively. With the introduction of Metro, the major benefit is accrued in this area because of fossil fuel saving, decongestion of traffic, reduction of on-road traffic, better commutation facilities and general health of the community, the gain in EIU is expected to be 228 and 236 for N-S and E-W corridors respectively once the project is commissioned. Thus, significant socioeconomic gain could be anticipated due to Metro rail system.

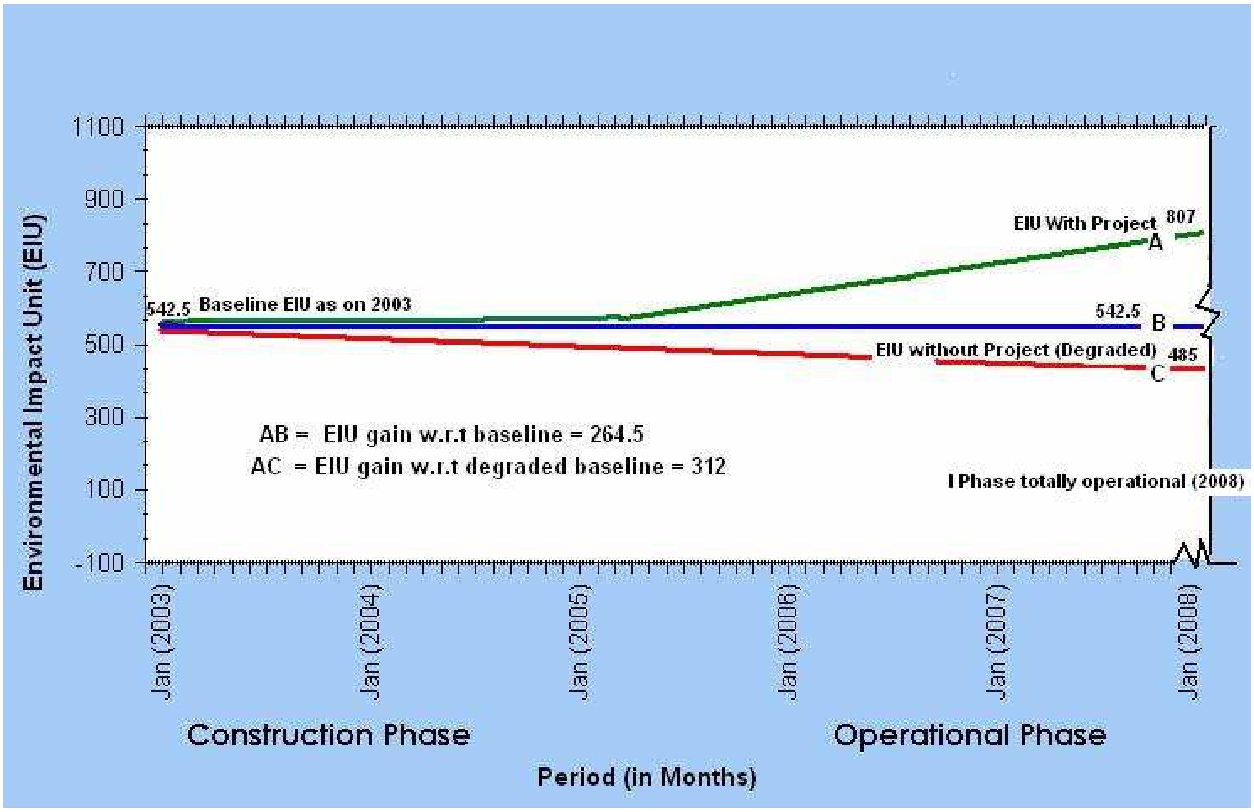
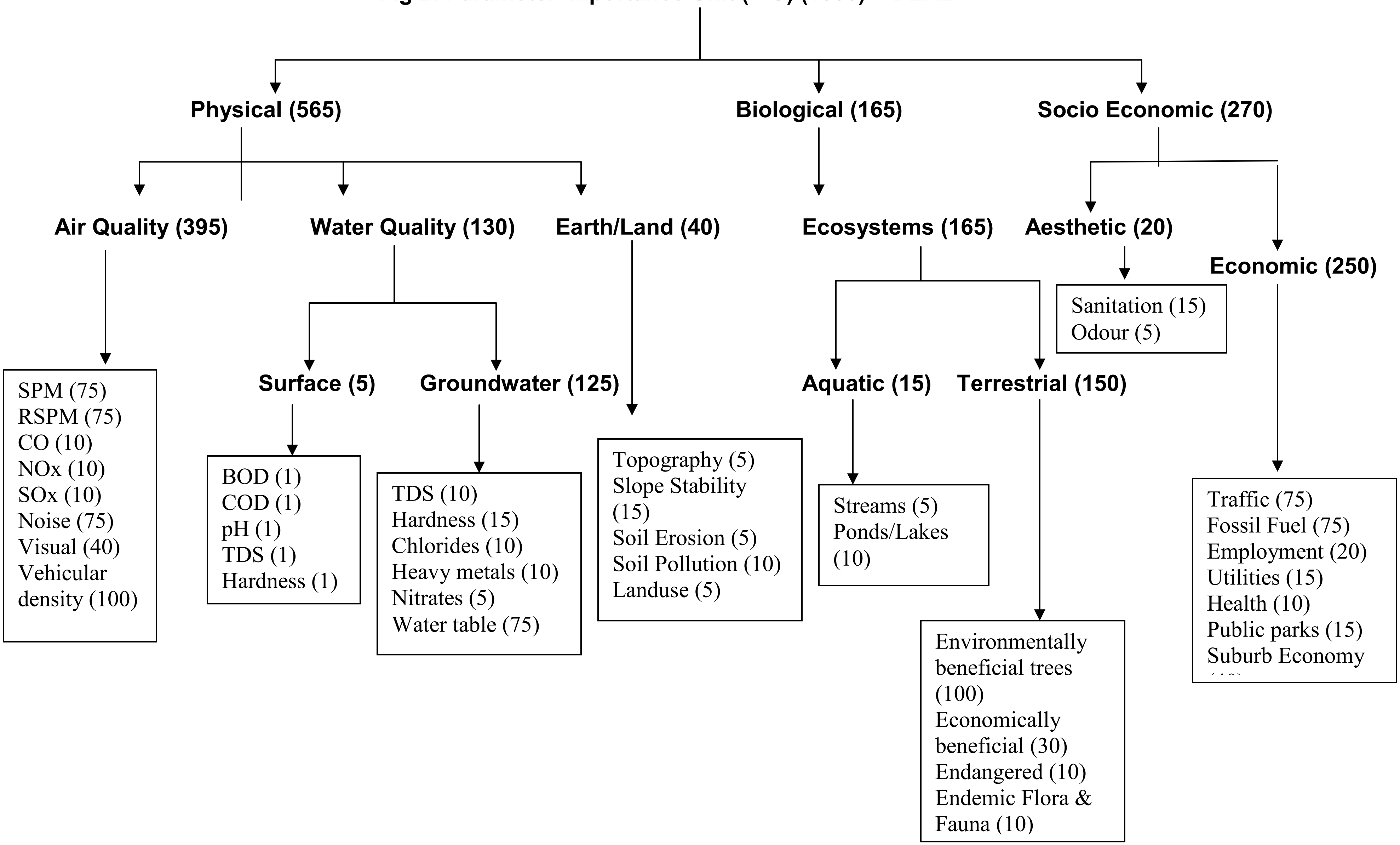


Fig. 1: Trends of Environmental Quality with and without proposed project

From the above exercise it emerges that the induction of the metro rail system in Bangalore City would be largely beneficial Against an ideal of 1000 units, for instance, the EIU which stands at 542.50 units presently in the absence of metro, goes up to 807 units following the introduction of metro rail accompanied by the implementation of a comprehensive environmental management plan, thus registering a mean net gain of 264.50 EIU units (nearly 50% gain) with respect to baseline (2003), demonstrating a net positive benefit to the community. Incidentally, the prevailing baseline EIU value of 542.50 (as on 2003) is likely to degrade over the next 5 years (up to 2008), till the metro is commissioned due to persistent growth of vehicles. The predicated value of EIU for the year 2008 is around 485 from the present 542. The overall benefit in EIU due to metro will be = 807-485 = 312 with reference to the predicted EIU value of 485 after five years i.e. virtual improvement of 64% of EIU Fig. 1 and 2).

Fig.2: Parameter Importance Unit (PIU) (1000) - IDEAL



0.12 Environmental Monitoring Plan

All urban infrastructure projects on account of their sheer size and complexity tend to be invariably accompanied by significant impacts on various components of the ecosystem, both during the construction and operation phases of the project. The nature of these impacts could be either negative or positive. Therefore, a comprehensive environmental monitoring plan has been prepared covering the construction and operation phase cycle of 2 years the Metro Rail project. The salient features of Environmental Monitoring Plan (EMP) as applicable the project is summarized in Tables 17 and 18.

Table 17: Monitoring Program during the construction stages

Environmental Aspect	Parameters	Monitoring Frequency	Method Recommended	Monitoring Stations
Ambient Air Quality	SPM	Twice/month	HVS	Ramp areas: 1) BWSSB Tank: Magadi road 2) Oberoi Hotel M.G. Road 3) Krishna Flour Mill 4) BIT Engi. College 5) Chikpet 6) CMH Road 7) Majestic Bus Stand 8) Bangalore Hospital 9) Vani Vilas Hospital 10) Maha Kavi Kuvempu Road
	SO_x	Twice/month	HVS	
	NO_x	Twice/month	HVS	
	CO	Twice/month	HVS	
Noise	Noise	Twice/month	Noise Level Meter	
Surface Water	pH	Once in 3 months	APHA Methods	Cubbon park pond + 2 cesspools = 3 samples
	Temperature			
	TDS			
	Conductivity			
	Dissolved Oxygen			
	BOD			
	COD			
	Nitrate			
	Sulphate			
	Phosphates			
	Chlorides			
	Potassium			
	Oil and			

	Grease			
	E. coli			
Ground Water	TDS	Once in a month	APHA Methods	
	Conductivity			
	Nitrate			
	Sulphate			
	Phosphates			
	Fluoride			
	Iron			
	Chromium			
	Lead			
	Zinc			
	Potassium			
	Chloride			
	Organic matter			

Table 18: Monitoring during the Operational Phase

Environmental Aspect	Parameters	Monitoring Frequency	Method Recommended	Monitoring Stations
Ambient Air Quality	SPM	Twice/year	HVS	Ramp areas: 1) BWSSB Tank: Magadi Road 2) Oberoi Hotel M.G. Road 3) Krishna Flour Mill 4) BIT Engi. College 5) Chikpet 6) CMH Road 7) Majestic Bus Stand 8) Bangalore Hospital 9) Vani Vilas Hospital 10) Maha Kavi Kuvempu Road
	SO_x			
	NO_x			
	CO			
Noise	Noise		Noise Level Meter	
Surface Water	pH	Twice/year	APHA Methods	
	Temperature			
	TDS			
	Conductivity			
	Dissolved Oxygen			
	BOD			
	COD			

	Nitrate Sulphate Phosphates Chlorides Potassium Oil and Grease E. coli			
Ground Water	TDS Conductivity Nitrate Sulphate Phosphates Fluoride Iron Chromium Lead Zinc Potassium Chloride Organic matter	Once in a month	APHA Methods	Tube wells to be established at 8 points around tunnel region
Wastewater	Characterization and quantification	Once in 6 months	APHA Methods	From Depots and underground stations

Environmental Costs

The approximate projected costs for the management plan operation are shown below

1. Compensation plan for the land and property lost
   a. East West Corridor
      Land and Built up area : Rs. 84.755 Crores

   b. North South Corridor
      i) Land and Built up area : Rs. 102.335 Crores

Total = Rs. 187.09 crores

2. Environmental Monitoring Plan

a) Construction Phase	: Rs. 54,79, 300
b) Operation Phase	: Rs. 42,49,320
Total	**= Rs. 97,28,620**

3. Green Cover

a) Compensatory afforestation for trees lost	: Rs. 24,72,000
b) Proactive compensation for loss of canopy cover	: Rs. 19,20,000
c) Creating Green belt below elevation track	: Rs. 41,49,166
Total	**= Rs. 85,91,166**

0.13 Environmental Auditing

A periodic auditing system is suggested to ensure that the environmental management plans are implemented and corrective measures are taken during the operation phase of metro rail, on a regular basis.