Joint Feasibility Study for Mumbai-Ahmedabad High Speed Railway Corridor

Final Report
Volume 5

July 2015

Japan International Cooperation Agency(JICA)
Ministry of Railways, Republic of India(MOR)

Japan International Consultants for Transportation Co., Ltd.
Oriental Consultants Global Co., Ltd.
Nippon Koei Co., Ltd

EI
CR(5)
15-137

Contents

Volume 1

Volume 5

Volume 6

Abbreviations

Abbreviations	Formal Name
A	Articulated
AC	Alternative Current
ADB	Asian Development Bank
AGV	Automotrice à Grande Vitesse
AP	Affected Person
ASI	Archaeological Survey of India
AT	Auto Transformer Feeding
ATC	Automatic Train Control System
ATP	Auto Transformer Post
AUDA	Ahmedabad Urban Development Authority
AVE	Alta Velocidad Española
BIS	Bureau of Indian Standards
BLT	Build, Lease & Transfer
BOT	Build, Operate & Transfer
BT	Booster Transformer Feeding
BT	Build & Transfer
BTO	Build, Transfer & Operate
CAI	computer-aided instruction
CAM	Cement Asphalt Mortar
CAPEX	Capital Expenditure
CB	Circuit Breaker
CBA	Cost Benefit Analysis
CD	Compact Disc
CDM	Clean Development Mechanism
CDP	City Development Plan
CER	Certified Emission Reductions
CIDCO	City and Industrial Development Corporation of Maharashtra Limited
CMDA	Chennai Metropolitan Development Authority
CMP	Comprehensive Mobility Plans
CMS	Centralized Information Monitoring System
COMTRAC	Computer Aided Traffic Control
CPCB	Central Pollution Control Board, India, India
CRIC	China Rail Investment Corporation
CRT	Cathode-Ray Tube display
CRZ	Coastal Regulation Zone
CTC	Centralized Traffic Control
CVC	Classified Volume Count
CVCF	Constant Voltage Constant Frequency
DB	Deutsche Bahn
DC	Direct Current
DCF	Discounted Cash Flow
DEA	Department of Economic Affairs
DFC	Dedicated Freight Corridor
DMIC	Delhi Mumbai Industrial Corridor development
DMRC	Delhi Metro Rail Corporation Ltd.
DNA-CDM	Designated National Authority-Clean Development Mechanism
DPR	Detailed Project Report
DSCR	Debt Service Coverage Ratio
EAC	Environmental Appraisal Committee, India
EC	Environmental Clearance
ECBs	External Commercial Borrowings
EIA/ESIA	Environmental Impact Assessment/Environmental and Social Impact

Abbreviations	Formal Name
	Assessment
EM&MP	Environmental Management & Monitoring Plan
EMP	Environmental Management Plan
EMU	Electric Multiple Unit
EPA	Environmental Protection Act
EPCS	Electric Power Control System
ERP	Electronic Road Pricing
ES	Executive Summary
EVT	Earthed Voltage Transformer
FEM	Finite Element Method
FMS	Facility Management System
FSI	Forest Survey of India
FSI	Floor Space Index
FTr	Feeding Transformer
GC	General Consultant
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIDC	Gujarat Industrial Development Corporation
GOI	Government of India
GRDP	Gross Regional Domestic Product
GUDC	Gujarat Urban Development Corporation
HDFC	Housing Development Finance Corporation Limited
HSR	High Speed Rail
HSRA	High Speed Rail Authority
HSRC	High Speed Rail Corporation of India Limited
HUDCO	Housing & Urban Development Corporation
ICC	Integrated Circuit Card
ICE	Inter City Express
ICT	Information & Communication Technology
IDC	Interest During Construction
IDFC	Infrastructure Development Finance Company
IEIA	Initial Environment Impact Assessment
IFCs	Infrastructure Finance Companies
IIFCL	India Infrastructure Finance Company Limited
IL&FS	Infrastructure Leasing & Financial Services Limited
IMF	International Monetary Fund
INR	Indian National Rupees
IOCC	Integrated Operations Control Center
IR	Indian Railway
IR	Involuntary Resettlement
IRFC	Indian Rail Finance Corporation Ltd.
IS	Indian Standard
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
JNR	Japanese National Railways
JR	Japan Railways
JRTT	Japan Railway Construction, Transport and Technology Agency
LA	Land Acquisition
LA	Lightning Arrester
LAN	Local Area Network
LARAP	Land Acquisition and Resettlement Action Plans
LBS	Load-Break Switch
LCC	Life Cycle Cost
LCX	Leaky Coaxial Cable

Abbreviations	Formal Name
LGV	Ligne à Grande Vitesse
MAP	Million Annual Passengers
METI	Ministry of Economy, Trade and Industry, Japan
MEGA	Metro Link for Gandhinagar and Ahmedabad
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MMDA	Madras Metropolitan Development Authority
MMRDA	Mumbai Metropolitan Region Development Authority
MMTS	Multi Modal Transport System
MOEF	Ministry of Environment and Forest, India
MOR	Ministry of Railways, India
MOU	Memorandum of Understanding
MOUD	Ministry of Urban Development
MPSEZ	Mundra Port and Special Economic Zone Ltd
MSK	Minimum Shift Keying
MTC	Metropolitan Transport Corporation
MWCS	Maintenance Work Control System
MoEF	Ministry of Environment and Forest, India
NA	Not Articulated
NATM	New Austrian Tunneling Method
NBFIs	Non-Banking Finance Institutions
NEAA	National Environmental Appellate Authority, India
NH	National Highway
NHAI	National Highways Authority of India
NHSRA	National High Speed Rail Authority
NOC	None Objection Certificate
NRSC	National Remote Sensing Centre
NUDP	National Urban Development Policy
NW-4	National Waterway
O&M	Operation & Maintenance
OCC	Operation Control Center
OCS	Overhead Catenary System
OD	Origin-Destination
ODA	Official Development Assistance
OFC	Optical Fiber Cable
OPEX	Operating Expenses
PAP	Project Affected Person
PAX	Passengers
PC	Power Concentration
PC	Pre-stressed Concrete
PCCP	Power Concentration Concentrated Power
PD	Power Distribution
PDDP	Power Distribution Distributed Power
PDL	Passenger Designated Lines
PE	Private Equity
PH	Public Hearing
PHC	Pre Hardened Copper
PIAs	Project Influenced Areas
PNB	Punjab National Bank
PPDPD	Person Per Day Per Direction
PPM	Post-Project Monitoring
PPP	Public Private Partnership
PPP	Purchasing Power Parity
PRC	Programmed Route Control

Abbreviations	Formal Name
PRIDe	Peninsular Region Industrial Development Corridor
PSU	Public Sector Unit
QC	Quality Control
RBI	Reserve Bank of India (Central Bank)
RC	Reinforced Concrete
RCC	Reinforced Cement Concrete
RDSO	Research Design & Standards Organization, India
RFF	Réseau Ferré de France
RFP	Request for Proposal
RLDA	Rail Land Development Authority
RO	Regional Office
ROB	Road Over Bridge
ROC	Republic of China
ROW	Right of Way
RP	Resettlement Plan
RPC	Railway static unbalanced Power Compensator
RS	Rolling Stock
RSCS	Rolling Stock Control System
RTRI	Railway Technical Research Institute
RVNL	Rail Vikas Nigam Limited
RUB	Road Under Bridge
RYWMS	Railway Yard Work Management System
SBI	State Bank of India
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SEA	Strategic Environmental Assessment
SEAC	State Level Expert Appraisal Committee, India
SEIAA	State Environmental Impact Assessment Agency, India
SFC	Single phase Feeding unbalanced power Conditioner
SHM	Stake Holder Meeting
SNCF	Société Nationale des Chemins de Fer Français
SOD	Schedule of Dimensions
SP	Sectioning Post
SPC	Special Purpose Company
SPCB	State Pollution Control Board, India
SS	Substation
SSB	Single Side Band
SSO	Single Sign-on
SSP	Sub Sectioning Post
SUICA	Super Intelligent Card
TAZ	Traffic Analysis Zone
TBM	Tunnel Boring Machine
TEU	Twenty-foot Equivalent Unit
TGV	Train à Grande Vitesse
THSRC	Taiwan High Speed Rail Corporation
TIFS	Tax Increment Financing Schemes
TOD	Transport Oriented Development
TPS	Transportation Plan System
TSC	Taiwan Shinkansen Consortium
TSI	Technical Specification for Interoperability
TSS	Traction Substation
UN	United Nations
UNFCC	United Nations Framework Convention on Climate Change
UPS	Uninterruptible Power Supply

Abbreviations	Formal Name
USD	United States Dollar
UTI1	Unit Trust of India
UTPCC	Union Territory Pollution Control Committee, India
VA	Volt Ampere
VCT	Voltage and Current Transformer
VFM	Value For Money
VGF	Viability Gap Funding
WACC	Weighted Average Cost of Capital
WPI	Whole Price Index
WTP	Willingness to Pay

Appendix 1 Comparison of Alternative Route

1.1 Travel Demand Forecast

1.1.1 Outline

Three alternative plans for HSR alignment corresponding operation plans are proposed. Based on the plans, preliminary passenger demand is forecasted for these three alternative plans.

1.1.2 Alternative Plan

Characteristics of three alternative plans are:

ALT1: HSR passes through the existing CBD area along the corridor except for Surat area:
ALT2: HSR passes through the existing CBD area along the corridor except for the section between Vadodara and Ahmedabad area:
ALT3: HSR passes through the existing CBD area along the corridor using existing line in major cities.

Proposed alignment, location of stations and average operation speed by alternative plan are summarized as below;

Table 1.1-1 Alternative Plans

ALT1		ALT2		ALT3	
Station	Mileage (km)	Station	Mileage (km)	Station	Mileage (km)
Mumbai(B.K.C)	0k000	Mumbai(B.K.C)	0k000	Mumbai (Lokmanya St.)	0k000
Thane	27k950	Thane	27k800	Thane (Existing St.)	16k440
Virar	65k170	Virar	65k300	Virar	57k000
Boisar	104k260	Boisar	104k700	Boisar	96k400
Vapi	167k940	Vapi	170k700	Vapi	162k400
Bilimora	216k580	Bilimora	218k300	Bilimora	210k000
Surat	264k580	Surat	271k400	Surat (Existing St.)	263k160
Bharuch	323k110	Bharuch	327k900	Bharuch	319k660
Vadodara	397k060	Vadodara	401k300	Vadodara (Existing St.)	393k720
Anand/Nadad	447k380	Anand/Nadad	443k500	Anand/Nadad	440k420
Ahmedabad	500k190	Bopal (Ahmedabad)	507k200	Ahmedabad (Existing St.)	494k500
Sabarmati	505k750	Sabarmati	521k000		
Ave. Speed (Express)(km/h)	239.2	Ave. Speed (Express)(km/h)	236.8	Ave. Speed (Express)(km/h)	172.5
Ave. Speed (Local)(km/h)	170.7	Ave. Speed (Local)(km/h)	172.7	Ave. Speed (Local)(km/h)	134.9

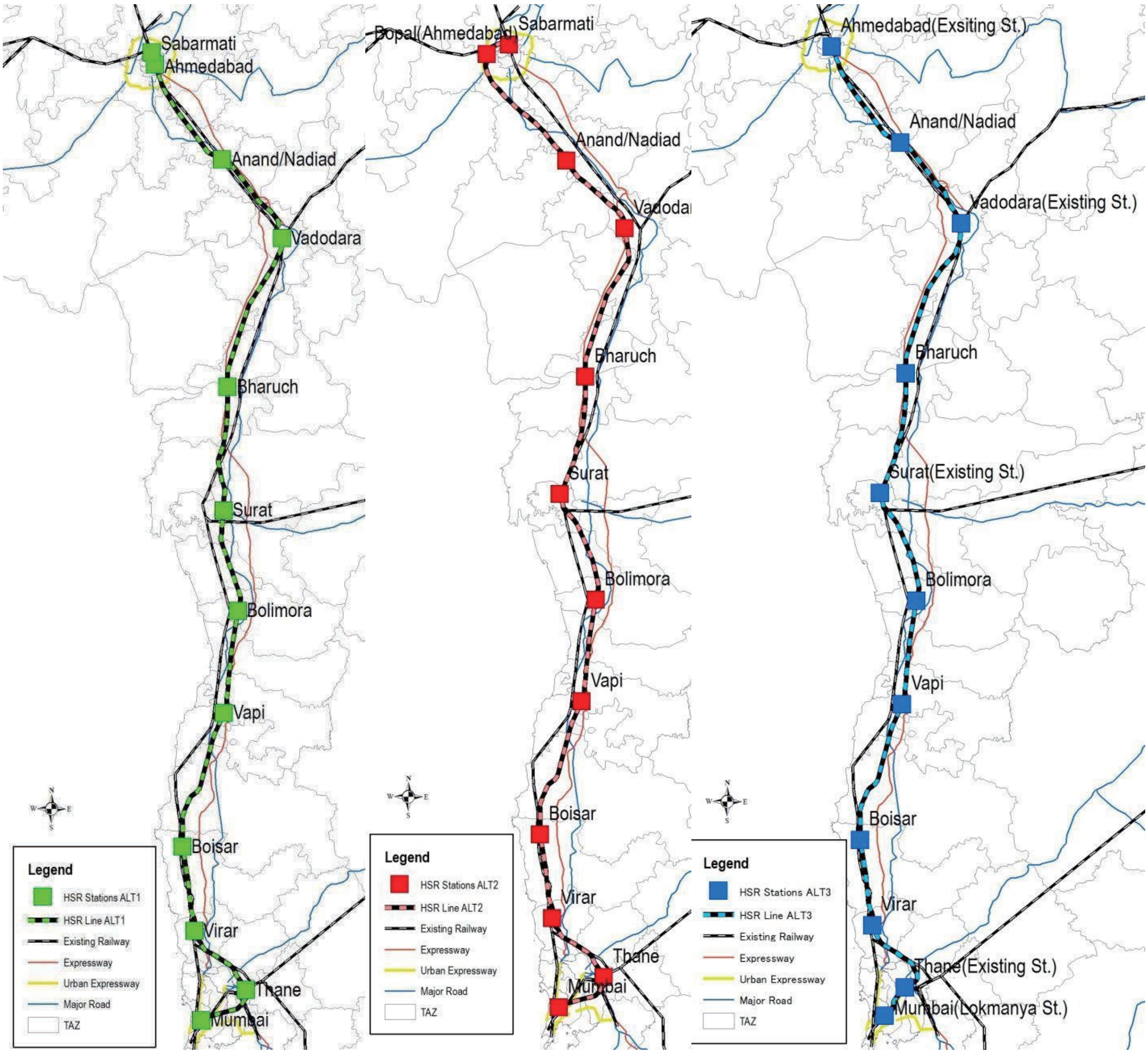


Figure 1.1-1 Alternative Plans

1.1.3 Demand Forecast by Alternative Plans

(1) Daily Boarding Passengers

Estimated boarding passenger is summarized in Table 1.1-2. Total daily boarding passenger in 2023 for ALT1, ALT2 and ALT3 is estimated at 40 thousands, 33 thousands and 34 thousands, respectively.

Table 1.1-2 Forecasted Daily Passenger Volume by Alternative Plans

Unit: Passengers / day

Year	ALT 1	ALT 2	ALT3
2023	39,688	32,760	33,535
2033	69,675	57,684	57,985
2043	124,065	102,966	101,785
2053	202,352	168,131	165,038

Source: JICA Study Team

(2) Cross Sectional Traffic

①Alternative 1

Following figure shows the daily cross sectional traffic for Alternative Plan 1 in 2023 and 2053. Maximum sectional traffic volume in 2023 and 2053 is 36 thousand passengers and 186 thousand passengers, respectively.

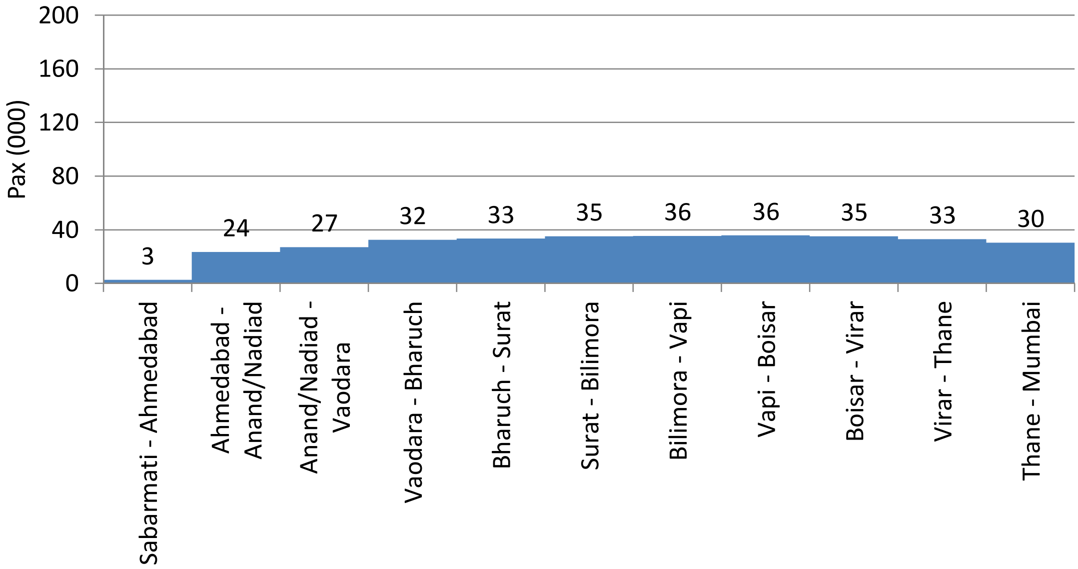


Figure 1.1-2 Cross Sectional Traffic for HSR (ALT1) in 2023 (1A*1.5 Case: Two-ways)

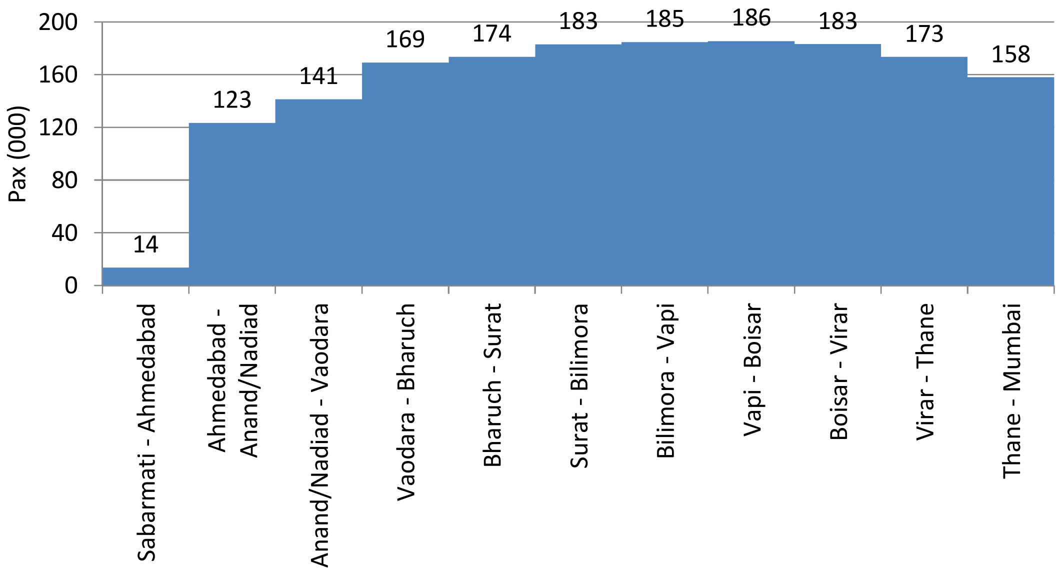


Figure 1.1-3 Cross Sectional Traffic for HSR (ALT1) in 2053 (1A*1.5 Case: Two-ways)

②Alternative 2

Following figure shows the daily cross sectional traffic for Alternative Plan 2 in 2023 and 2053. Maximum sectional traffic volume in 2023 and 2053 is 30 thousand passengers and 154 thousand passengers, respectively.

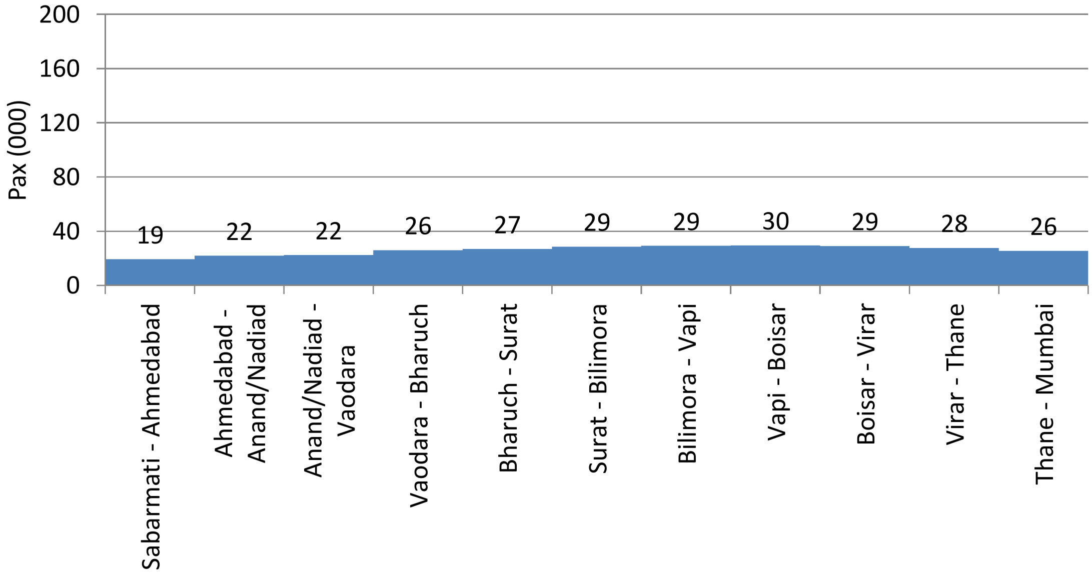


Figure 1.1-4 Cross Sectional Traffic for HSR (ALT2) in 2023 (1A*1.5 Case: Two-ways)

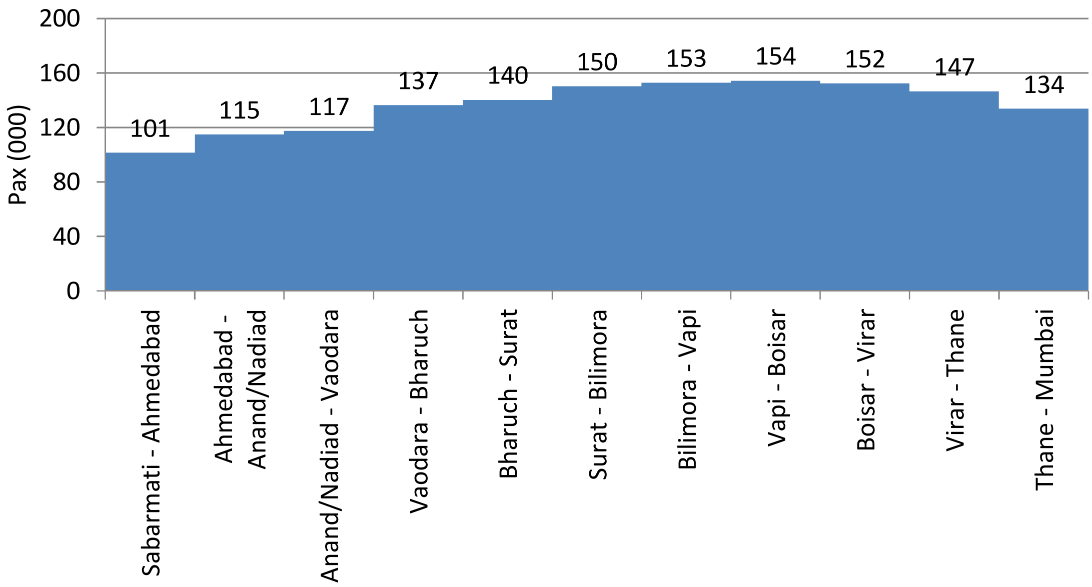


Figure 1.1-5 Cross Sectional Traffic for HSR (ALT2) in 2053 (1A*1.5 Case: Two-ways)

③Alternative 3

Following figure shows the daily cross sectional traffic for Alternative Plan 2 in 2023 and 2053. Maximum sectional traffic volume in 2023 and 2053 is 30 thousand passengers and 150 thousand passengers, respectively.

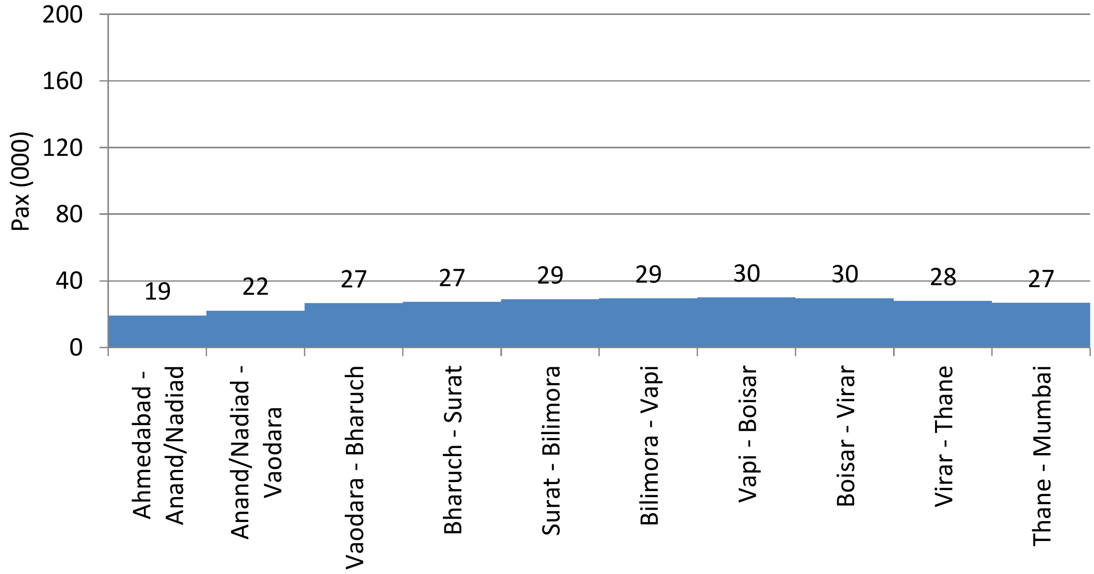


Figure 1.1-6 Cross Sectional Traffic for HSR (ALT3) in 2023 (1A*1.5 Case: Two-ways)

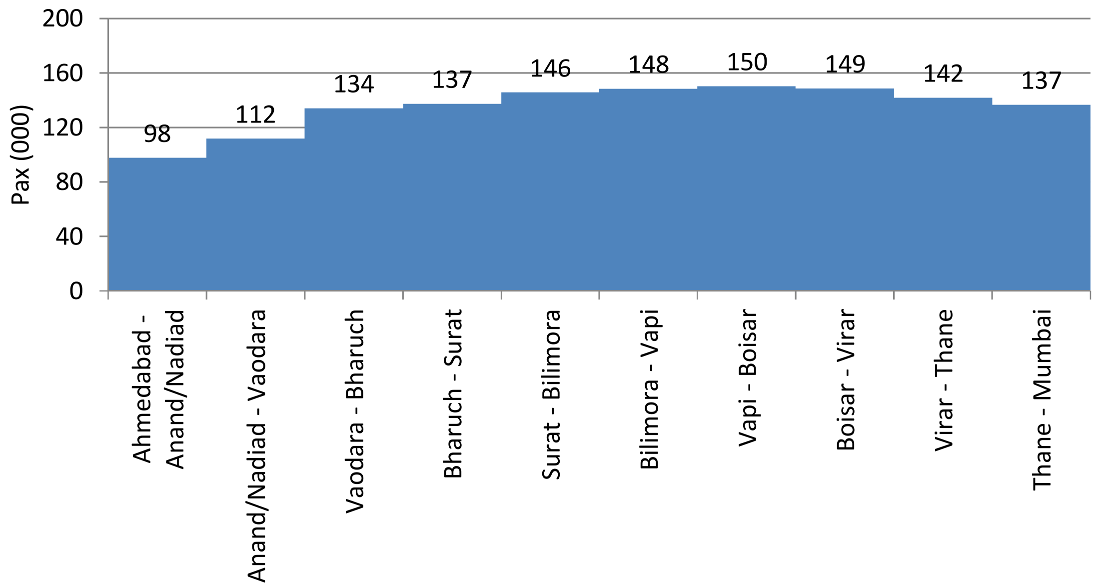


Figure 1.1-7 Cross Sectional Traffic for HSR (ALT3) in 2053 (1A*1.5 Case: Two-ways)

(3) Boarding Passenger by Stations

Total HSR passenger volume for boarding and alighting in 2023 and 2053 was estimated. As shown the figure, it is estimated that daily passengers in 2023 from /to Mumbai station for ALT 1, ALT2 and ALT3 is 30,000, 26,000 and 17,000, respectively. As for the Ahmedabad area, largest passenger volume is estimated at Ahmedabad station in ALT1 case and ALT3 case. On the other hand, maximum passenger volume within Ahmedabad area is estimated at Sabarmati station in ALT2 case since Bopal (Ahmedabad) station is located in suburban area of Ahmedabad city.

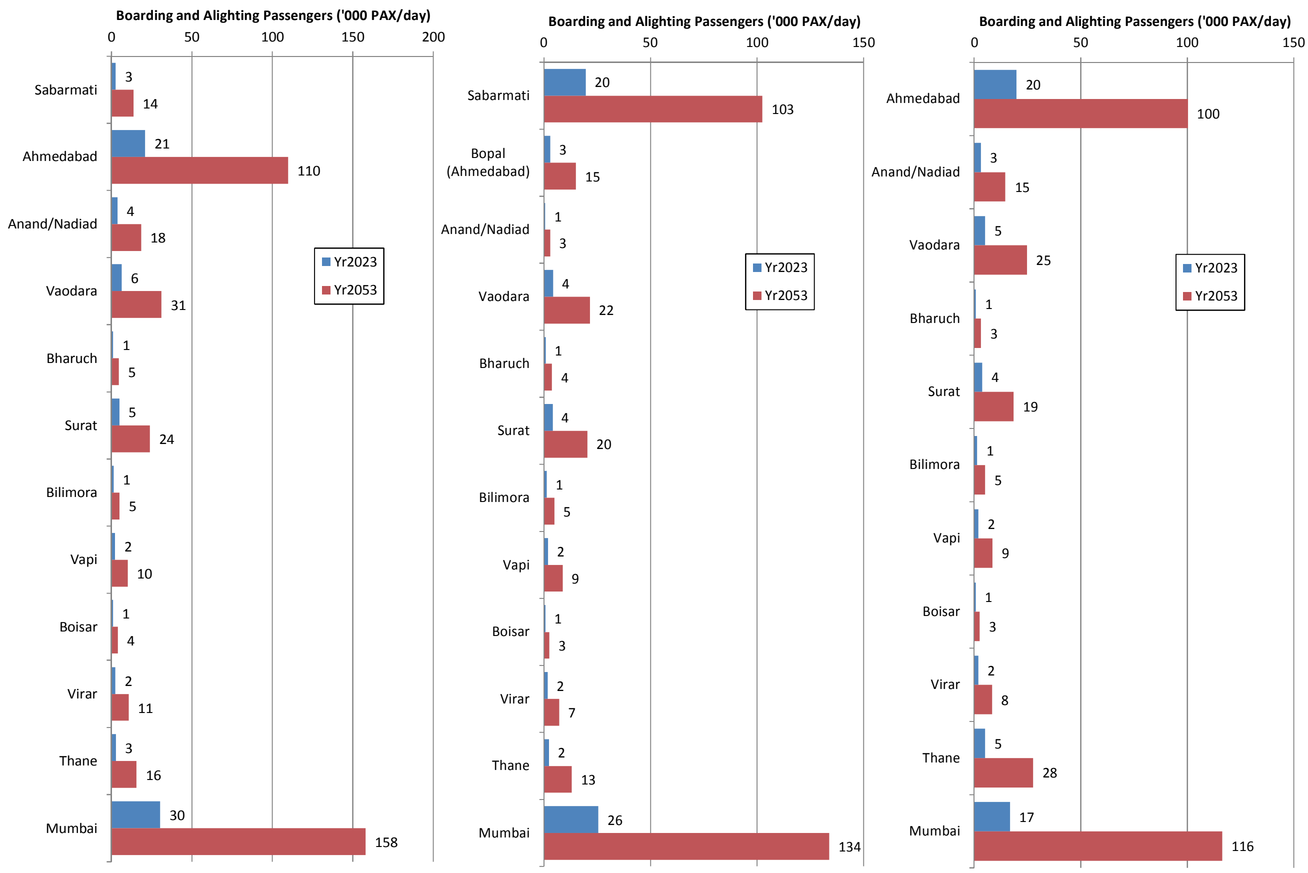


Figure 1.1-8 Boarding and Alighting Passenger for HSR in 2023 and 2053
(1A*1.5 Case: Total of Boarding and Aligning Passengers, Left: ALT1, Middle: ALT2, Right: ALT3)

(4) Indicators for Economic & Financial Analysis (Reference)

Fare:1.5*1A ALT1 Unit: PAX/day

PAX	Car	Air	Rail	Bus	HSR	Total
2023	308,287	41,955	39,644	26,886	39,688	456,459
2033	588,882	75,290	51,113	41,603	69,675	826,563
2043	1,116,324	135,102	62,154	67,034	124,065	1,504,679
2053	1,874,469	221,560	80,917	104,019	202,352	2,483,317

Unit:%

PAX	Car	Air	Rail	Bus	HSR	Total
2023	67.5%	9.2%	8.7%	5.9%	8.7%	100.0%
2033	71.2%	9.1%	6.2%	5.0%	8.4%	100.0%
2043	74.2%	9.0%	4.1%	4.5%	8.2%	100.0%
2053	75.5%	8.9%	3.3%	4.2%	8.1%	100.0%

Unit: PAX*Hour

PAX*Hr	Car	Air	Rail	Bus	HSR	Total
2023	2,356,694	164,547	439,388	180,270	123,557	3,264,457
2033	4,556,927	295,325	567,293	280,247	217,573	5,917,365
2043	8,738,701	530,354	671,546	451,300	388,410	10,780,311
2053	14,747,940	869,955	858,165	700,879	634,214	17,811,153

Unit: PAX*km

PAX*km	Car	Air	Rail	Bus	HSR	Total
2014	68,018,775	23,791,883	19,556,947	6,036,995	11,581,769	128,986,369
2023	134,891,725	41,883,426	24,006,175	10,824,681	17,245,214	228,851,221
2033	261,254,421	75,210,254	30,986,932	16,889,321	30,545,488	414,886,415
2043	501,678,315	135,612,261	36,558,230	27,263,509	54,807,018	755,919,333
2053	847,193,371	222,717,418	46,603,215	42,403,573	89,652,256	1,248,569,833

Unit: Rs./day

PAX*Fare					HSR	
2023					80,340,021	
2033					141,525,848	
2043					252,780,348	
2053					412,761,253	

Fare:1.5*1A ALT2 Unit: PAX/day

PAX	Car	Air	Rail	Bus	HSR	Total
2023	312,462	40,147	42,655	28,435	32,760	456,459
2033	596,707	72,530	55,685	43,957	57,684	826,563
2043	1,130,796	130,548	69,573	70,795	102,966	1,504,679
2053	1,898,399	214,499	92,481	109,807	168,131	2,483,317

Unit:%

PAX	Car	Air	Rail	Bus	HSR	Total
2023	68.5%	8.8%	9.3%	6.2%	7.2%	100.0%
2033	72.2%	8.8%	6.7%	5.3%	7.0%	100.0%
2043	75.2%	8.7%	4.6%	4.7%	6.8%	100.0%
2053	76.4%	8.6%	3.7%	4.4%	6.8%	100.0%

Unit: PAX*Hour/day

PAX*Hr	Car	Air	Rail	Bus	HSR	Total
2023	2,282,718	122,324	381,367	191,347	107,274	3,085,030
2033	4,376,872	221,309	504,312	297,126	189,480	5,589,100
2043	8,334,139	398,343	632,590	478,337	339,153	10,182,562
2053	14,022,764	654,648	845,619	742,547	554,407	16,819,986

Unit: PAX*km/day

PAX*km	Car	Air	Rail	Bus	HSR	Total
2014	66,095,321	11,839,001	16,891,678	6,484,904	10,116,270	111,427,174
2023	130,008,456	20,898,215	20,361,835	11,565,004	14,764,635	197,598,147
2033	249,500,410	37,916,360	26,958,814	18,019,974	26,220,685	358,616,242
2043	475,407,628	68,617,229	33,815,952	29,079,214	47,151,374	654,071,396
2053	800,197,505	112,992,466	45,218,038	45,205,481	77,200,880	1,080,814,371

Unit: Rs./day

PAX*Fare					HSR	
2023					68,036,803	
2033					120,211,319	
2043					215,250,591	
2053					351,868,656	

Fare:1.5*1A ALT3 Unit: PAX/day

PAX	Car	Air	Rail	Bus	HSR	Total
2023	311,225	41,271	42,221	28,207	33,535	456,458
2033	594,805	74,744	55,230	43,799	57,985	826,564
2043	1,128,074	134,724	69,141	70,954	101,785	1,504,679
2053	1,894,349	221,510	92,067	110,354	165,038	2,483,317

Unit:%

PAX	Car	Air	Rail	Bus	HSR	Total
2023	68.2%	9.0%	9.2%	6.2%	7.3%	100.0%
2033	72.0%	9.0%	6.7%	5.3%	7.0%	100.0%
2043	75.0%	9.0%	4.6%	4.7%	6.8%	100.0%
2053	76.3%	8.9%	3.7%	4.4%	6.6%	100.0%

Unit: PAX*Hour/day

PAX*Hr	Car	Air	Rail	Bus	HSR	Total
2023	2,276,299	126,314	377,944	189,573	125,386	3,095,517
2033	4,366,511	229,177	500,582	295,644	217,825	5,609,738
2043	8,318,530	413,190	628,895	478,777	383,920	10,223,312
2053	13,998,819	679,576	841,808	745,238	623,587	16,889,027

Unit: PAX*km/day

PAX*km	Car	Air	Rail	Bus	HSR	Total
2014	65,805,775	12,207,320	16,576,839	6,223,325	10,194,594	111,007,854
2023	129,628,683	21,410,428	20,191,812	11,474,384	14,275,463	196,980,769
2033	248,908,587	38,929,703	26,773,770	17,962,825	24,932,486	357,507,372
2043	474,565,753	70,535,428	33,633,962	29,174,593	44,149,183	652,058,918
2053	798,941,403	116,216,579	45,031,732	45,486,035	71,833,125	1,077,508,874

Unit: Rs./day

PAX*Fare					HSR	
2023					67,619,660	
2033					117,340,149	
2043					206,651,334	
2053					335,495,512	

Without

Unit: Pax/day

PAX	Car	Air	Rail	Bus	HSR	Total
2023	323,461	50,288	45,534	37,175	0	456,458
2033	620,474	90,527	58,272	57,291	0	826,563
2043	1,179,691	162,013	70,542	92,433	0	1,504,678
2053	1,983,039	265,599	91,383	143,297	0	2,483,317

Unit:%

PAX	Car	Air	Rail	Bus	HSR	Total
2023	70.9%	11.0%	10.0%	8.1%	0.0%	100.0%
2033	75.1%	11.0%	7.0%	6.9%	0.0%	100.0%
2043	78.4%	10.8%	4.7%	6.1%	0.0%	100.0%
2053	79.9%	10.7%	3.7%	5.8%	0.0%	100.0%

Unit: PAX*Hour/day

PAX*Hr	Car	Air	Rail	Bus	HSR	Total
2023	2,444,027	194,299	483,466	250,723	0	3,372,515
2033	4,744,422	349,734	621,031	387,825	0	6,103,011
2043	9,122,973	626,449	734,581	625,979	0	11,109,982
2053	15,411,020	1,027,216	936,991	971,340	0	18,346,567

Unit: PAX*km/day

PAX*km	Car	Air	Rail	Bus	HSR	Total
2014	70,056,845	27,248,153	22,385,233	8,873,051	0	128,563,282
2023	140,666,119	45,690,520	26,334,454	15,541,168	0	228,232,260
2033	273,677,936	82,190,749	33,824,309	24,102,008	0	413,795,002
2043	527,165,152	147,975,243	39,883,561	38,995,502	0	754,019,458
2053	891,181,227	242,970,282	50,758,887	60,583,809	0	1,245,494,204

Unit: Rs./day

PAX*Fare					HSR	
2023					0	
2033					0	
2043					0	
2053					0	

1.2. Train Operation Plan

In this Section, the operation plan of alternative route (ALT-1, ALT-2, ALT-3) shall be compared. The basic principle of the train operation plan is same as mentioned in Chapter 8.

1.2.1 Number of Trains

The number of trains in case of alternative route, ALT-1, ALT-2, and ALT-3, in 2023, 2033, 2043, and 2053 are calculated. The basic conditions of calculating the number of trains are same. They are shown as follows;

- Train capacity is the same as explained in Clause 8.2.4.
- 10-car train will be operated at the time of strat of HSR line. Later, as demand rises, the number of trains and the number of cars per train will be increased.
- At the time of increase of number of train sets and the number of cars per train set, , life of rolling stock shall be considered. Therefore, both 10-car trains and 16-car trains will co-exist in operation.
- From the result of demand forecast, the number of trains that will meet the maximum traffic volume are estimated.

The number of trains and train kilometer in case of alternative route, ALT-1, ALT-2, and ALT-3, in 2023, 2033, 2043, and 2053 are shown in Table 1.2-1.

Table 1.2-1 Number of Trains and Train Kilometer

Year		2023	2033	2043	2053
ALT-1 505.8km	Number of Trains	35	51	64	105
	Traffic volume	17,900	31,700	56,800	92,900
	Train kilometer	35448.0	51652.8	64819.2	106344.0
ALT-2 521.0km	Number of Trains	29	43	54	89
	Traffic volume	14,900	26,300	47,200	77,300
	Train kilometer	30218.0	44806.0	56268.0	92738.0
ALT-3 494.5km	Number of Trains	29	42	53	86
	Traffic volume	15,000	26,200	46,300	75,200
	Train kilometer	28681.0	41538.0	52417.0	85054.0
Train configuration (cars/train set)		10	10 and 16	16	16

Unit: Number of trains (trains/day/one-direction)
Traffic volume (persons/day/one-direction
Train kilometer (km/day)

1.2.2 Number of Required Train Sets (Cars)

The number of required train sets (cars) shall be calculated as per the method shown in Section 8.3. However, regarding ALT-3 the travelling time will increase considerably because the train runs through into convention line. Therefore, the number of required train sets (cars) shall be calculated in consideration of traveling time because the train sets are not used efficiently.

Table 1.2-2 shows the number of required train sets (cars) in 2023, 2033, 2043, and 2053.

Table 1.2-2 Number of Required Train Sets (Cars)

Year			2023	2033	2043	2053
ALT-1	Number of train sets	10 cars	24	24	-	-
		16 cars	-	11	44	71
	Number of cars		240	416	704	1136
ALT-2	Number of train sets	10 cars	21	21	-	-
		16 cars	-	10	38	62
	Number of cars		210	370	608	992
ALT-3	Number of train sets	10 cars	26	26	-	-
		16 cars	-	12	48	77
	Number of cars		260	452	768	1232

1.3 Economic Analysis

1.3.1 Objective

The objective of the part is to compare three alternative routes from the view of Economic Analysis.
Followings are comprehensive characteristics of the alternatives.

1) Alternative 1 (ALT1): Dedicated route for which new terminal station is proposed at Mumbai , crossing Thane Creek by tunnel, connecting with new suburban station in Surat and juxtaposed to existing stations at Vadodara & Ahmedabad.
2) Alternative: Dedicated route for which new terminal station is propose at Mumbai, crossing Thane Creek by Viaduct, juxtaposed to existing station at Surat and connecting with new suburban stations at Vadodara and Ahmedabad.
3) Alternative 3 (ALT3): ALT3 route considers interoperability with existing railway line in Mumbai, Surat, Vadodara and Ahmedabad areas.

1.3.2 Methodology

The comparison is carried out from qualitative side and quantitative side. The methodology of comparison of three routes as quantitative is comparing EIRR of these routes. EIRR of Alt 2 and Alt 3 are carried out by simple way, as arrange the data of Alt 1 in expenditure items and benefit items. Expenditure of Alt 2 & 3 is assumed using ratio below to justify.

・Number of train sets in 2053
・Project cost without rolling stock
・Train km in 2053

Benefit is of Alt 2 & 3 is also assumed using ratio below to justify.

・Train km in 2053

The result of quantitative analysis is shown in Table 1.3-1.

Table 1.3-1 Comparison of Route Alternatives

	Alternative 1	Alternative 2	Alternative 3
EIRR	11.8%	10.9%	10.3%
Expenditure of Alt 2 & 3 is assumed using ratio below			
Number of rolling stock in 2053	1,136	992(87%)	1,232(108%)
Capital cost (INR)	709,151	694,968(98%)	666,602(94%)
Train km in 2053 (km/ day)	106,344	92,738(87%)	85,054(80%)
Benefit of Alt 2&3 is assumed using ratio below			
Train km in 2053 (km/ day)	106,344	92,738(87%)	85,054(80%)

Source: JICA Study Team, PwC and TERI

The comparison of indicators is shown that Adopted Route (Alternative 1) is the suitable route for national economy.

Appendix 2 Workshop for HSR Subsystem

JICA study team and India Ministry of Railways held a workshop related to the subsystem of the high-speed railway construction in between Mumbai and Ahmedabad. They Understood greatly deepen mutual.

2.1 Out-line

Study team was planning to hold the workshop for the high-speed rail. Because understanding for the Indian side deeply. Therefore, the letter concerning the workshop has been submitted by name of Mr. Mathur, Evaluate of the study team to Mr. Bhawan, the Indian Ministry of Railways Executive Director.

Workshop started and closed on time schedule. At first Japanese Experts explained their presentation for each specialized field, after then Indian participants gave some questions. Questions, which included detail and technical matters, were very helpful and show the height of the interest of the Indian side. Remarkably, each proposal of the Japanese side were almost accepted positive and favorably.

These results will be summarized and reflected in the Interim Report 2 until this November.

Figure 2.1-1 Opening Remark Dr. TAKATSU Vice-president JIC

Figure 2.1-2 Presentation

Figure 2.1-3 Lunch session

Figure 2.1-4
Closing Remark Mr. Mathur
System Evaluate, Study Team Railway

2.2 The Official Letter Concerning Work shop

Consortium of Japan International Consultants for Transportation, Oriental Consultants and Nippon Koei
Ground Floor of Commercial Complex JMD Pacific Square,
Sector 15, Part II, Gurgaon, Haryana – 122001 India

No. JIC/HSR Study/WORKSHOP

13th Aug'2014

Our Ref: 130205-70

Mr. Mukul S. Mathur IRTS
Executive Director (Traffic)/PPP
Ministry of Railways
Rail Bhawan, Raisina Road,
NEW DELHI - 110001

Sub: **JOINT FEASIBILITY STUDY FOR MUMBAI – AHMEDABAD HIGH SPEED RAIL CORRIDOR**
- **WORKSHOP ON HSR SUB-SYSTEMS**

Dear Shri Mathur,

As a part of the HSR Study prior to submission of our Interim Report 2 we would like to conduct a Workshop for about 30 participants on various sub-systems such as Power Supply, Signalling & Telecom, and Rolling Stock etc. The benefit of the Workshop would be to deepen understanding of various aspects of the subsystems among participants. The exchange of views will also help us finalize system specifications for ITR2.

We would like to conduct the Workshop on 8th September 2014 between 1100 hrs and 1700 hrs with a Lunch Break in between. The Sessions shall be of about an hour's duration with Presentation of about 25 minutes by the Study Team Expert followed by a Q&A session. The sessions shall be as under:

1.	Introduction: Main Characteristics of HSR and Operation Plan	1100 to 1130
2.	Rolling Stock Plan	1130 to 1230
3.	Maintenance Equipment for Rolling Stock	1230 to 1330
	LUNCH	1330 to 1430
4.	Power Supply System	1430 to 1530
5.	Signalling & Telecommunication	1530 to 1630
6.	Working of Operations Control Center	1630 to 1730

It is requested that appropriate officers (including counterparts) from Railway Board and RDSO may be nominated from various disciplines (Mechanical, Electrical, S&T and Traffic). It is requested about 4 to 5 officers from each area may be nominated.

We would also appreciate if the Railway Board's Conference / Board Room could be booked for this purpose.

Sincerely Yours

V.N. Mathur
Formerly Member Traffic Railway Board
& Consultant JIC Consortium

Source：Study Team

2.3 Participants List

Participants of work shop were officers from MOR (Ministry of Railway India), RDSO(The Research Design and Standards Organization)and JICA India Office. Total number was 29 persons and showing participants List, as follows.

No.	Name/Position	Organization
1	Mr. Rajneesh Kumar (Director)	RDSO
2	Mr. Hari Om Kushwala (Director , Signal)	RDSO
3	Mr. S.C. Shukla	RDSO
4	Mr. Nasimuddin	RDSO
5	Mr. P. Mishra	RDSO
6	Mr. Kaushal	RDSO
7	Mr. A.K. Mavinim	RDSO
8	Mr. Yogesh Mohan	RDSO
9	Mr. Mohd. Gaqurb	RDSO
10	Mr. Pranai Prabhakar (CTPM , Western Railway)	WR
11	Mr. Mani Jit Singh (CTPM, Western Railway)	WR
12	Mr. Parmanand (CDE/RCF)	
13	Mr. S.J. Sinha	MOR
14	Mr. Shobham Chaudhari	MOR
15	Mr. Prashant Kumar	MOR
16	Mr. P.K. Goyal	MOR
17	Mr. S.B. Bhamu	MOR
18	Mr. Vinay	MOR
19	Mr. M.M. Hussain	MOR
20	Mr. Sushil	MOR
21	Mr. S.K. Saxena (EDEE)	MOR
22	Mr. D.C. Pandey	RVNL
23	Mr. Sanjay Durgrakoti	RVNL
24	Ms. Monica Agnihotri	RVNL
25	Mr. Ajit Kumar	RVNL
26	Mr. Rajesh Kumar (ED, HSRC)	HSRC
27	Mr. Arvind Nautiyal (Dy, CME)	NR
28	Mr. Akira Sato	JICA
29	Mr. Sanjeev Moholkar(Principle Dev. Specialist)	JICA
30	Dr. Takatsu (Vice President and Team Leader)	JIC
31	Mr. Vinoo Mathur (Railway System Evaluation)	JIC
32	Mr. Osawa (Acting Leader/ HSR System)	JIC
33	Mr. Otsuki (HSR Ticketing Planning)	JIC
34	Mr. Igarashi (Train Operation Control Planning)	JIC
35	Mr. Saito (Power Suppy Planning)	JIC
36	Mr. Umehara (Signal and Telecommunication Planning)	JIC

37	Mr. Endo Tomoyuki (Rolling Stock Planning)	JIC
38	Mr. Yasuo Tateishi (Train operation Planning)	JIC
39	Mr. Ishikawa (Assistant HSR Planning)	JIC
40	Mr. Ravinder Katiyar (Country Manager)	JIC
41	Mr. Fujiwara	OJT
42	Mr. Sekine	OJT
43	Mr. Sato	OJT
44	Mr.Terao	OJT
45	Mr. Yuki	OJT
46	Mr. Gaurav Kohli (Project Coordinator)	JIC

2.4 Speech and Presentation

First of beginning, Mr. Vinoo Mather, Evaluate of Study Team, introduced about work shop briefly. After then Dr. Toshiji TAKATSU, vice president of Japan International Consultants for Transportation was greeted as follows.

Opening Remarks：

Ladies and Gentlemen, Thanks so much for joining the session on workshop. And also thanks sincere to Mr. Pillai as Chairman of the Joint Monitoring Committee, Mr. Sato, and Mr. Panjaiee for their presence in the workshop and gave special thanks to Mr. Mathur for his valuable contribution for the ongoing study. The study is being undertaken following a Joint Statement in May 2013 by the Prime Ministers of Japan and India, a Memorandum of Understanding was signed between Japan International Cooperation Agency (JICA) and the Ministry of Railways in October 2013 for conducting a Joint Study for the Ahmedabad - Mumbai High Speed Rail Corridor. Dr. Takatsu informed the participants that our study started in December 2013 and Interim Report-1 submitted in July 2014 has been approved and Interim Report -2 would be submitted in November 2014.

In first week of September Indian Prime Minister Mr. Modi and Japanese Prime Minister Mr. Shintaro Abe met to discuss the ongoing HSR feasibility project and in the joint official statement said they look forward for the completion of the Joint Feasibility Study on High Speed System on Ahmedabad –Mumbai corridor. Once again thanks all the participants and today’s workshop will be fruitful and successful for both the sides.

And end of the Work shop, Mr. Mathur, from said the closing words of as follows.

Closing Remarks：

For the day by thanking each of the participants from respective offices of EOJ, MOR, WR, NR, RDSO, RVNL and the study team for the full day seminar and useful suggestions from participants. The study team during the last 8 to 9 months has worked extensively for the ongoing feasibility study and what has been done till now is in synergies and consultation with various interactions with MOR officials and State Government of Gujarat and

The various suggestions to the extent possible will be incorporated in the report to be submitted.

Appendix 3 Workshop on Proposed SOD for HSR

3.1 Objective of SOD Workshop

The purpose of the workshop was to explain main items of Schedule of Dimensions proposed in ITR3 by Study team experts and attendance of Indian-side to understand the details of them.

3.2 The Official Letter for Workshop on Proposed SOD for HSR

Figure3.2-1 shows the official letter for announcement of SOD workshop.

NIPPON KOEI

Consortium of Japan International Consultants for Transportation,
Oriental Consultants and Nippon Koei
Ground Floor of Commercial Complex JMD Pacific Square,
Sector 15, Part II, Gurgaon, Haryana – 122001 India

No. JIC/HSR Study/WORKSHOP

1st Apr'2014
Our Ref: 130205-87

Mr. Girish Pillai IRTS
Advisor Planning, Ministry of Railways,
Room 101-A, Rail Bhawan,
NEW DELHI - 110001

Sub: **JOINT FEASIBILITY STUDY FOR MUMBAI – AHMEDABAD HIGH SPEED RAIL CORRIDOR**
- **WORKSHOP ON PROPOSED SCHEDULE OF DIMENSIONS FOR HSR**

Dear Mr. Pillai,

As a part of the HSR Study prior to submission of our Final Report we would like to conduct a brief Workshop for about 20 participants on the Schedule of Dimensions that are being recommended for High Speed Railways by the Study Team. The benefit of the Workshop would be to enable participants to appreciate the basis on which the Study Team is recommending the proposed Schedule of Dimensions for the HSR Corridor.

We would like to conduct the Workshop on 15th or 16th April 2015 between 1030 hrs and 1330 hrs or any 3 hour slot convenient to you. There shall be four presentations each followed by a short Q&A session. Each presentation including the discussion shall be of about 45 minutes. The topics covered shall be as under:

1. Introduction & Outline – Loading Gauge and Structural Gauge
2. Dynamic Gauge – Maximum Moving Dimensions
3. Spacing of Tracks (including Minimum distance between Track Centers, Formation Width and Turnouts)
4. Curves (including Maximum Cant, Maximum Cant Deficiency, Horizontal Curve Radius and Vertical Curve Radius and gradients)

It is requested that appropriate officers (including counterparts) from Railway Board, RDSO and RVNL may be nominated from various disciplines (Civil, Mechanical, Electrical, S&T and Traffic). The Workshop will be of primary interest to Civil and Rolling Stock Engineers.

We would appreciate if the Railway Board's Conference / Board Room could be booked for this purpose. Kindly confirm date, timing and venue.

With best regards

Sincerely Yours

V.N. Mathur
Formerly Member Traffic Railway Board
& Consultant JIC Consortium

Figure 3.2-1 The Official Letter for SOD Workshop

3.3 Schedule of SOD Workshop

SOD Workshop was scheduled as Table 3.3-1.

Table 3.3-1 Schedule of SOD Workshop

Date	Attendants	Place
April 15, 2015	MOR and RDSO members	Civil Service Officer's Institute
April 16, 2015	RVNL members	F254 Meeting room in RVNL

3.4 Programme

Figure3.4-1 shows the detailed schedule of SOD Workshop on April 15th 2015.

Workshop on proposed schedule of dimensions for HSR
Date: 15/04/2015
Place: Civil Service Officer's Institute

DETAILED SCHEDULE

Time		Contents(Title)	Presenter
11:00	*11:05*	*Opening Speech*	*Dr. Toshiji Takatsu* *(Team Leader/ JICA Study Team)*
11:05	*11:10*	*Speech from Ministry of Railway*	*Mr. Girish Pillai* *(Adviser Planning/ MOR)*
11:10	*11:15*	*Project Introduction Movie*	—
11:15	*11:20*	*Introduction of Speakers*	*Mr. V.N.Mathur* *(Railway System Evaluation/ JICA Study Team)*
11:20	*11:55*	*1. Introduction & Outline* *- Loading Gauge and Structural Gauge*	*Mr. Mitsuyuki Osawa* *(Acting Leader of HSR System/ JICA Study Team)*
11:55	*12:30*	*2. Dynamic Gauge* *- Maximum Moving Dimensions*	*Mr. Toru Yoshikawa* *(Rolling Stock Planning/ JICA Study Team)*
12:30	*13:05*	*3. Spacing of Tracks*	*Ms. Ryoko Nakano* *(Maintenance & Safety control Planning/ JICA Study Team)*
13:05	*13:40*	*4. Curves*	*Mr. Michio Kato* *(Technical Standards/ JICA Study Team)*
13:40	*13:50*	*Closing Speech*	*Mr. V.N.Mathur* *(Railway System Evaluation)*
13:50	~	*Lunch*	

Figure 3.4-1 Programme of SOD Workshop (April 15th 2015)

3.5 Attendants List

Table3.5-1 and 3.5-2 shows the attendants of SOD workshop.

Table 3.5-1 Attendance List of Workshop on April 15th (MOR, RDSO)

No.	Organization	Name		Position
1	Railway Board	Mr.	Girish Pillai	Advisor of Infrastructure
2	Railway Board	Mr.	Achal Khare	ED/Civil/Infra
3	Railway Board	Mr.	Vijay Kumar	ED/Mech/Infra
4	Railway Board	Mr.	Tarun Beniwal	Director PSU
5	Railway Board	Mr.	Sudheer Kumar	EDEE/Development
6	Railway Board	Mr.	Pankaj Tyagi	Director CE(P)
7	Railway Board	Mr.	T.K Pandey	Director Track (MC)
8	Railway Board	Mr.	Parag Kumar Goyal	Director (PROJ/S&T)
9	RDSO	Mr.	Kaushal Kumar	Director/S&T/UTHS, RDSO
10	RDSO	Mr.	Inderjeet Singh	Exec. Dir. Carriage, RDSO
11	RDSO	Mr.	Nasimuddin	Exec. Dir. PS & EMU, RDSO
12	RDSO	Mr.	S.K. Pandey	Exec. Dir. Track Design, RDSO
13	RDSO	Mr.	A.K. Dadria	Exec. Dir. Bridges, RDSO
14	RDSO	Mr.	Rajeev Kumar	Dir. Track II, RDSO
15	Railway Board	Mr.	Manoj Garg	Dir. Track (P)
16	Railway Board	Mr.	S.S. Gupta	Ex.Dir. Civil Engineering (Plg.)
17	Integral Coach Factory, Perambur, Chennai	Mr.	S. Srinivas	Chief Design Engineer, ICF
18	Study Team	Dr.	Toshiji Takatsu	Team Leader
19	Study Team	Mr.	V. N. Mathur	Railway System Evaluation
20	Study Team	Mr.	Mitsuyuki Osawa	Acting Leader/ HSR System
21	Study Team	Mr.	Toru Yoshikawa	Rolling Stocks Planning
22	Study Team	Mr.	Michio Kato	Technical Standards
23	Study Team	Ms.	Ryoko Nakano	Maintenance and Safety Planning
24	Study Team	Mr.	Hitoshi Seiji	Execution Scheme/ Structure Planning
25	Study Team	Mr.	Masatoki Sato	Execution Scheme/ Structure Planning
26	Study Team	Mr.	Norikazu Ishikawa	Operational coordination/ Assistant HSR Planning
27	Study Team	Mr.	Gaurav Kohli	Project Coordinator

Table 3.5-2 Attendance List of Workshop on April 16th (RVNL)

No.	Organization	Name		Position
1	RVNL	Mr.	Vijay Anand	Director, Projects
2	RVNL	Mr.	Mr. V.K.Singh	CEO HSRC
3	RVNL	Dr.	H.R. Yadav	GM , Metro
4	RVNL	Mr.	Pramod K. Jain	Group GM, Design
5	RVNL	Mr.	Mr. Dinesh Kumar	GM, Finance
6	RVNL	Mr.	Mr. S.K. Dhiman	ED, Projects
7	RVNL	Mr.	Mr. P.K. Singh	ED, Infra
8	RVNL	Mr.	D.C. Pandey	GGM, Electrical
9	RVNL	Mr.	Arun Kumar	EDW
10	RVNL	Mr.	Sanjay Dungrakoti	Signaling and Telecom

11	RVNL	Mr.	Mr. N.K. Singh	
12	RVNL	Mr.	S.K. Aich	GM, Metro, SAT
13	RVNL	Mr.	Hari K. Barjatya	GM, Architecture
14	RVNL	Mr.	D. Mehrotra	
15	RVNL	Mr.	Mr. Ajay Bhardwaj	
16	Study Team	Dr.	Toshiji Takatsu	VP, Team Leader
17	Study Team	Mr.	Vinoo Mathur	Railway System Evaluation
18	Study Team	Mr.	Mitsuyuki Osawa	Acting Leader/ HSR System
19	Study Team	Mr.	Toru Yoshikawa	Rolling Stocks Planning
20	Study Team	Mr.	Michio Kato	Technical Standards
21	Study Team	Ms.	Ryoko Nakano	Maintenance and Safety Planning
22	Study Team	Mr.	Norikazu Ishikawa	Operational coordination/ Assistant HSR Planning
23	Study Team	Mr.	Gaurav Kohli	Project Coordinator

3.6 Photos

Figures 3.6-1 and 3.6-2 shows the photos of workshop.

(Speech from Mr. Pillai, Railway Board)

Figure 3.6-1 The SOD Workshop on April 15th, 2015 (Civil Service Officer's Institute)

Figure 3.6-2 The SOD Workshop on April 16th, 2015 (RVNL)

Appendix4 Environmental Impact Assessment

Report of EIA (Environmental Impact Assessment) is attached from next page.

Ministry of Railways (MoR)
Government of India

Joint Feasibility Study
for
Mumbai – Ahmedabad High Speed Railway Corridor

Environmental Impact Assessment (EIA) Report

On behalf of

The Consortium of
Japan International Consultant for Transportation
Oriental Consultants Global
Nippon Koei

Ground Floor, JMD Pacific Square, Sector 15, Part II, Gurgaon, Haryana – 122001

Consultants
GPS Technologies Pvt. Ltd.
Engg. Consultants I Environmental Engg. I Green Buildings I Hydro Power I Health Consultants I Staffing Solutions
Corp. Office: 1208, 12th Floor, Hemkunt House,6, Rajendra Place, New Delhi – 110008, India
Ph. & Fax : 011-25811229, 25816389, Website:www.gpstpl.com, e-mail : contact@gpstpl.com

Table of Contents

Page

Page

Page

Tables

Page

Page

Page

Page

Page

Figures

Page

Page

Page

Page

Page

Page

Abbreviation

ACCCRN	: Asian Cities Climate Change Resilience Network
ADB	: Asian Development Bank
AIDS	: Acquired Immune Deficiency Syndrome
ALT	: Alternative
APHA	: American Public Health Association
ATS	: Anti Terror Squad
AWS	: Automatic Weather Station
AWWA	: American Water Works Association
BDI	: Biodiversity index
BKC	: Bandra Kurla Complex
BOD	: Biochemical Oxygen Demand
CBR	: Crude Birth Rate
CBSE	: Central Board of Secondary Education
CDM	: Clean Development Mechanism
CDR	: Crude Death Rate
CEC	: Central Empowered Committee
CEL	: Centre for Environmental Law
CEPT	: Centre for Environmental Planning & Technology
CGWB	: Central Ground Water Board
CHC	: Community Health Centre
CISCE	: Council for the Indian School Certificate Examinations
CM	: Carbon Monoxide
CMP	: Conservation and Management Plan
CMR	: Child Mortality Rate
CO	: Carbon Monoxide
CPCB	: Central Pollution Control Boards
CPSTPL	: GPS Technologies Pvt. Limited
CRZ	: Coastal Regulation Zone
CZMA	: Coastal Zone Management Authorities
CZMP	: Coastal Zone Management Plans
DA-IICT	: Dhirubhai Ambani Institute of Information and Communication Technology
DFC	: Dedicated Freight Corridors
DTEPA	: Dahanu Taluka Environment Protection Authority
ECR	: East Central Railway
EIA	: Environmental Impact Assessment
EMCBF	: Eastern Margin Cambay Basin Fault
EMCBF	: East Cambay Basin Boundary Faults
EMP	: Environmental Management Plan
EMP	: Environmental Monitoring Plan
EPA	: Environment (Protection) Act
ERF	: Environment Relief Fund
ESA	: Eco Sensitive Area
FEM	: Federal Equivalent Method
FRM	: Federal Reference Method
FRU	: First Referral Unit
FS	: Feasibility Study

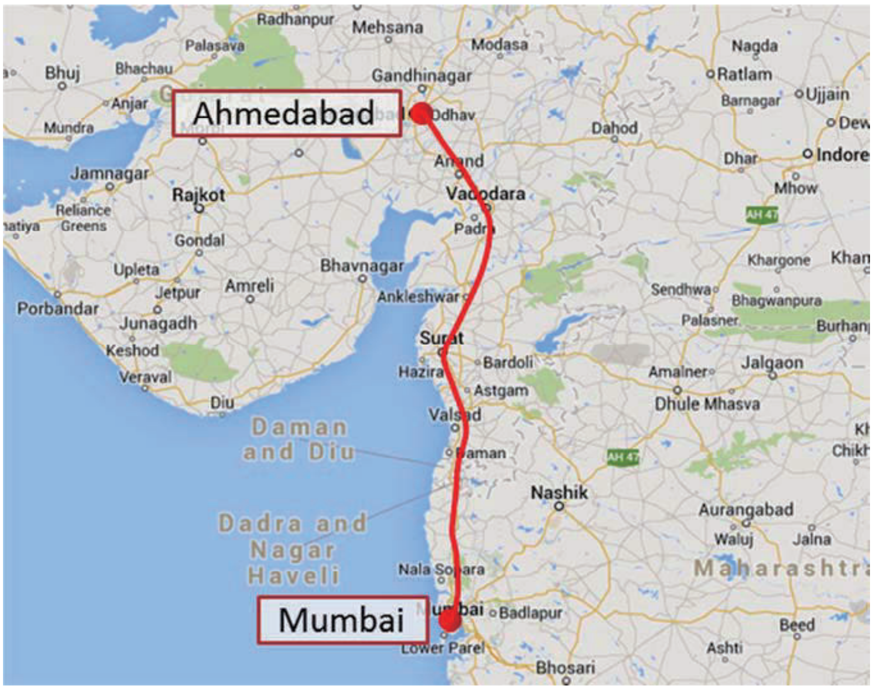
FTA	: Federal Transit Administration
GCZMA	: Gujarat Coastal Zone Management Authority
GRM	: Grievance Redress Mechanism
GSHSEB	: Gujarat Secondary and Higher Secondary Education Board
HIV	: Human Immunodeficiency Virus
HSR	: High Speed Railway
HST	: High-Speed Train
HTL	: High Tide Line
IBA	: Important Bird Area
IRMA	: Institute of Rural Management Anand
ISR	: Institute of Seismological Research
ISRO	: Indian Space Research Organisation
JBIC	: Japan Bank for International Cooperation
LDCE	: Lalbhai Dalpatbhai College of Engineering
LEB	: Life Expectancy at Birth
LTL	: Low Tide Line
MAHSRC	: Mumbai-Ahmedabad High Speed Railway Corridor
MCZMA	: Maharashtra Coastal Zone Management Authority
MEEP	: Municipal Energy Efficiency Programme
MEMU	: Mainline Electric Multiple Unit
MF	: Membrane Filter
MICA	: Mudra Institute of Communications Ahmedabad
MMR	: Maternal Mortality Rate
MOEF	: Ministry of Environment and Forests
MOEFCC	: Ministry of Environment, Forests and Climate Change
MOHFW	: Ministry of Health and Family Welfare
MOR	: Ministry of Railway
MPCB	: Maharashtra Pollution Control Board
NAAAQS	: National Ambient Air Quality Standards
NACO	: National AIDS Control Organisation
NCZMA	: National Coastal Zone Management Authority
NDIR	: Non-dispersive Infra Red Absorption
NEP	: The National Environmental Policy
NFHS	: National Family Health Survey
NIC	: Nature Interpretation Centre
NID	: National Institute of Design
NIO	: National Institute of Oceanography
NIOS	: National Institute of Open School
NMA	: National Monument Authority
NNM	: Neo-Natal Mortality
NNW	: North-North-West
NO	: Oxide of Nitrogen
NRHM	: National Rural Health Mission
NTU	: Nephelometric Turbidity Unit
NW	: North West
NWDA	: National Water Development Authority
PAP	: Project Affected Persons
PDPU	: Pandit Deendayal Petroleum University
PF	: Protected Forest

PHC	: Primary Health Centre
PHC	: Primary Health Centre
PIU	: Project Implemen-tation Unit
PM	: Particulate Matter
PNNM	: Post Neo-Natal Mortality
PTFE	: Polytetrafluoroethylene
RAC	: Resident Additional Collector
RAP	: Resettlement Action Plan
RCCF	: Regional Chief Conservator of Forest
RCS	: Replacement Cost Survey
RF	: Reserved Forest
ROR	: Records of Revenue
SAC	: Space Applications Centre
SC	: Schedule Cast
SCM	: Social and Environmental Management Unit
SCZMA	: State Coastal Zone Management Authorities
SE	: Site Engineer
SGNP	: Sanjay Gandhi National Park
SHM	: Stakeholder Meeting
SO2	: Sulphur Dioxide
SPCB	: State Pollution Control Boards
SPL	: Sound Pressure Level
SSA	: Sarva Shiksha Abhiyan
ST	: Schedule Tribe
SVNIT	: Sardar Vallabhbhai National Institute of Technology
TBM	: Tunnel Boring Machine
TCLP	: Toxicity Characteristics Leaching Procedure
TCM	: Tetrachloromercurate
TDS	: Total Dissolved Solids
TFR	: Total Fertility Rate
TSDF	: Treatment, Storage & Disposal Facilities
TSS	: Total Suspended Solids
TWLS	: Tungareshwar Wildlife Sanctuary
USDA	: United States Department of Agriculture
VCTC	: Voluntary Counseling and Testing Centres
VJTI	: Veermata Jijabai Technological Institute
VNIT	: Visvesvaraya National Institute of Technology Nagpur
WB	: World Bank
WFF	: World Forum of Fish Harvesters and Fish Workers
WHO	: World Health Organization
WMCBF	: West Cambay Basin Boundary Fault
WNW	: West-North-West
WPCF	: Water Pollution Control Federation
ZOI	: Zone of Influence

Chapter 1
Project Description

1.1 The Project Location

The region targeted by the study is a corridor having a length of approximately 500 km that links the city of Mumbai and Ahmedabad. The study area comprises of 250 m both side from the centre line along the proposed Mumbai-Ahmedabad High Speed Railway Corridor (MAHSRC) alignment. The planned route is located between latitude 19003'58.52"N-longitude 72005'47.48"E and latitude 23005'39.78" N-longitude 72034'33.48"E, stretching from the coastal plain bordering the Arabian Sea, located in the Mumbai urban conglomerate of Maharashtra State and to the west of the Western Ghats, to the Ahmedabad, central region of Gujarat State. Adjacent to the proposed route from Mumbai to Thane, there are two important ecologically sensitive fragile areas- the Sanjay Gandhi National Park (SGNP) and the Tungareshwar Wildlife Sanctuary (TWLS). Measures are being planned to minimize alterations in these areas. Moreover, due to the existence of mangrove wetlands within Thane Creek East of Mumbai, plans are being made to adopt a tunnel structure in order to avoid alterations. There is another ecologically sensitive fragile area through which the proposed MAHSRC passes is Dahanu Taluka, about 120 km from the Mumbai.



Source: Study Team

Figure 1.1.1: Proposed Alignment of MAHSRC

1.2 Project Background

India has undergone rapid economic growth in recent years, and along with this growth has come a sharp rise in the volume of people and goods being transported in the country. To meet this demand, Dedicated Freight Corridors (DFC) are being constructed to haul freight from Delhi to Mumbai and Kolkata. As for passenger transport, the Indian Ministry of Railway (MOR) prepared the "Indian Railways Vision 2020" in December 2009. In the Vision, the comparison between Railway Transport and Road Transport or Aviation has conducted and concluded that Railway Transport takes advantage of less emission of greenhouse gas, high capacity of passenger transport etc. The Vision identified the need for introducing High Speed Railway (HSR). HSR is needed as a measure to archive several goals and demands indicated in Railway Vision 2020 with its various features. Six (6) main items which HSR will satisfy requirements are presented as follows:

(1) Safety is the top priority of HSR
(2) High Capacity
(3) High Frequency
(4) Network Expansion
(5) High Energy Efficiency and Low Emission of greenhouse gas (CO_2)
(6) Strong Infrastructure and HSR System for Natural Disaster

Pre-feasibility studies are now being started in sequential order on seven routes which are candidates for the construction of HSR. Furthermore, a report issued by an expert committee on modernization of India's national railways that was established by MOR designates the line between Mumbai and Ahmedabad (approximately 500 km long) as the first HSR section planned to be constructed. A pre-feasibility study for this line was conducted by RITES of India, Systra of France and others in fiscal year 2009. India and Japan issued a joint statement on May 29, 2013, that included a decision to conduct a joint Feasibility Study (FS) on the construction of HSR between Mumbai and Ahmedabad by reviewing the conclusion described in the Vision, considering the alternatives and prepare HSR plan necessary for its preparation, implementation, operation and maintenance.

1.3 Importance of the Project

1.3.1 Indian Railways Vision 2020

MOR in India formulated the "Indian Railways Vision 2020" in December 2009 as a long-term vision up to the year 2020. The Vision was formulated to address four national goals: (1) Inclusive Development, both Geographically and Socially; (2) Strengthening National Integration; (3) Large-Scale Generation of Productive Employment; and (4) Environmental Sustainability. An investment as much as 14 trillion rupee (Rs) is planned for the next ten years. Specifically, the vision sets the objectives to drastically increase revenue, expand the network and transport capacity, enhance safety and environmental sustainability, and reform passenger services. It also sets targets for business development in various fields, including passenger services on the conventional railway, HSR and rail freight, luggage, advertisements, telecommunication, and so on.

1.3.2 High-Speed Railway Vision

For HSR that operates at the maximum speed of 250–350 km/h, the vision plans to implement projects for at least four corridors by 2020. Furthermore, it will also make plans for multiple routes to connect the commercial centers, tourist spots, pilgrimage destinations, and so on. Figure 1.3.1 and Table 1.3.1 shows the seven corridors of the planned HSR routes (Indian Railways Vision 2020 put forth six corridors but the Delhi - Jaipur - Jodhpur section was added later to total seven corridors). MOR is conducting pre-feasibility studies of these routes sequentially.

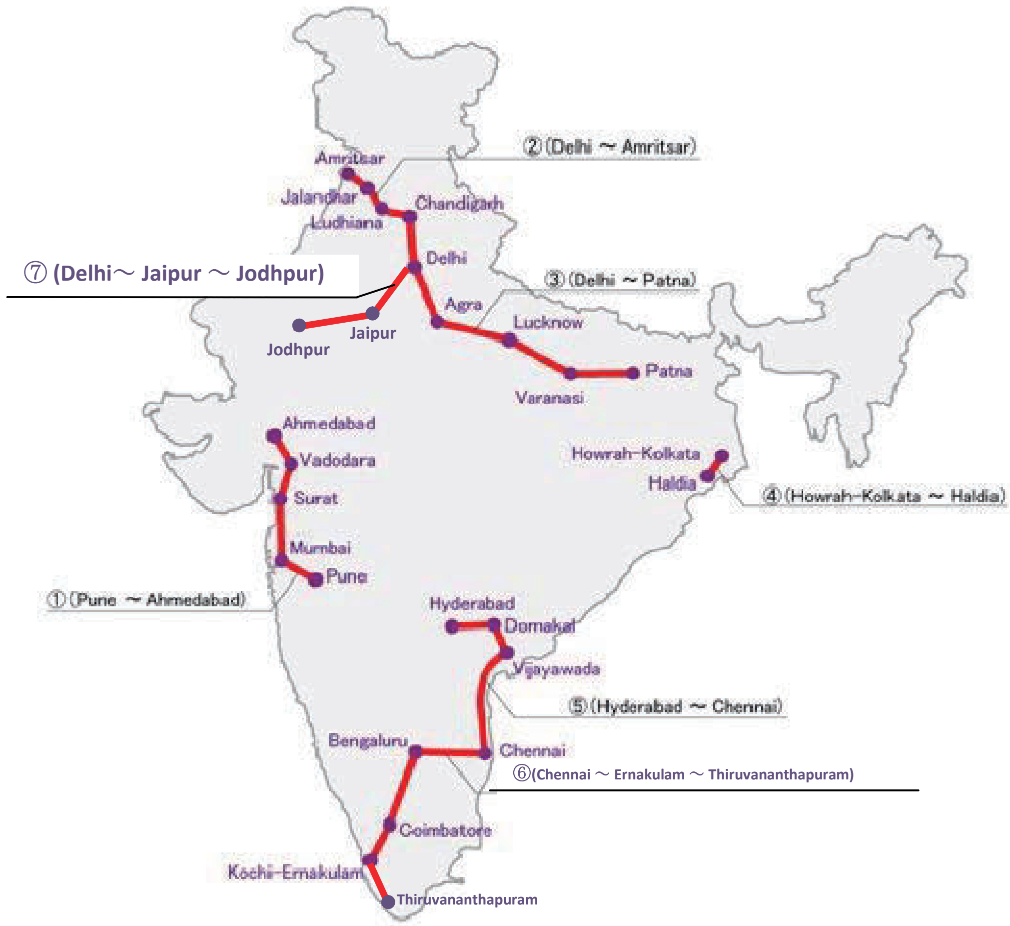


Figure 1.3.1: Seven Corridors for the Pre-feasibility Studies of HSR in India

Table 1.3.1: Seven Corridors Planned for HSR in India

Corridor	Route	Length
①	Pune–Mumbai–Ahmedabad	Approx. 680 km
②	Delhi–Chandigarh–Amritsar	Approx. 480 km
③	Delhi–Agra–Lucknow–Varanasi–Patna	Approx. 1,000 km
④	Howrah–Haldia	Approx. 140 km
⑤	Hyderabad–Dornakal–Vijayawada–Chennai	Approx. 780 km
⑥	Chennai–Bengaluru–Ernakulam–Thiruvananthapuram	Approx. 1,020 km
⑦	Delhi–Jaipur–Jodhpur	Approx. 530 km
Total		Approx. 4,630 km

Source: Study Team

1.3.3 A report by an expert committee on modernization of Indian National Railway.

A 2012 report by an expert committee on modernization of India’s national railways that was established by the Indian Minister of Railways designates a route between Mumbai and Ahmedabad (approximately 500 km) as the first high-speed railway section to be constructed. The following is an excerpt from the Report of the Expert Group for Modernization of IR (New Delhi, date: 25 Feb. 2012).

High Speed Passenger Train Corridors
Construct a HSR line between Ahmedabad and Mumbai with speed of 350 km/h. Undertake detailed studies for 6 other HSR corridors already identified. These include:
(1) Delhi-Chandigarh-Amritsar (450 km);
(2) Hyderabad-Dornakal-Vijayawada-Chennai (664 km);
(3) Howrah-Haldia (135 km);
(4) Chennai-Bangalore-Coimbatore-Ernakulam (850 km);
(5) Delhi-Agra-Lucknow-Varanasi-Patna (991 km)
(6) Ernakulam-Trivandrum (194 km).

1.4 Objective of the Project

According to the GOI’s Environmental Impact Assessment Notification issued by the Ministry of Environment and Forests (MOEF), New Delhi on 14th September, 2006 under the Environment (Protection) Act, 1986, railway and bridge construction projects do not require the conduct of Environmental Impact Assessment (EIA) studies including preparation of an Environmental Management Plan (EMP) was conducted in order to mitigate potential negative environmental impacts for the MAHSRC.
The main objective of the EIA study is to conduct the baseline data generation of the environmental attributes to know the existing scenario of the environmental parameters. In order to identify the environmental impacts due to the construction and operation of the proposed MAHSRC and associated facilities (Depot, Railway Stations and Maintenance Depot *etc.*), an EIA study is proposed to be undertaken. The aim of the study is to establish the existing environmental conditions, predict impacts of the running of the high speed train, and associated facilities and formulate the EMP. The EIA report is required for the Joint Feasibility Study for the said MAHSRC. The EIA Study has been conducted in accordance with the latest Guidelines of Japan

International Corporation Agency (JICA) on Environmental and Social Considerations.

1.5 Willingness to Pay

The questionnaire was made to confirm the willingness to pay from every income level those residing along HSR. Furthermore, considering the future income standards, passengers' demand on HSR are distributed among airline, highway express bus and existing railway following their income.

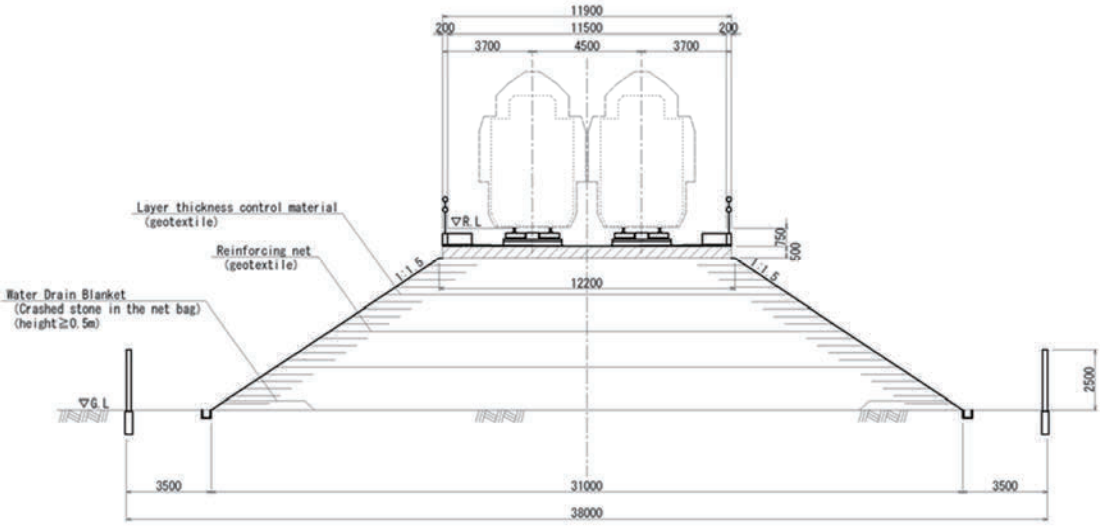
1.6 The Executing Ageccy of the Project

The project proponent is the MOR, Government of India. It is tentatively indicated for descriptive purpose that RVNL/HSRC will be the Governmental agency to implement construction, operation, and maintenance.

Chapter 2
Analysis of Alternatives, Impact Identification and Scoping Matrix

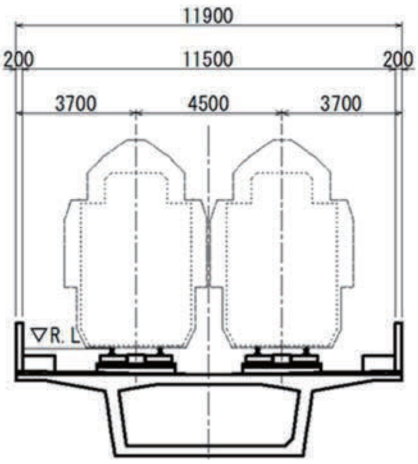
2.1 Analysis of Alternatives

The Ministry of Railway (MOR), Government of India, proposes to construct, operate, and maintain an electric-powered high-speed train (HST) system from Mumbai to Ahmedabad. When completed, the nearly 508.5 km railway corridor would provide new passenger rail service. The HST would be capable of up to 300-350 km-per-hour (kmph) operating speeds, with state-of- the-art safety, signaling, and automated train control systems. The HST System would connect and serve the major metropolitan areas of Gujarat and Maharashtra, extending from Mumbai to Ahmedabad. The HSR line will connect Mumbai (population if 12 million) which is the capital city of the State of Maharashtra and the second most populous metropolitan area in India with Ahmedabad (population of 5.5 million) which is the metropolis in the State of Gujarat. The approximately 500 km long line consists of High-speed Railway vision running along the Arabian Sea coast side and connecting with Surat (population of 4.5 million) and Vadodara (population of 3.6 million) stations which are the second and third largest city in the State of Gujarat. Three alternatives and "No Action Plan" are prepared and reviewed considering convenience of transport network, passengers demand, technical issues related to operation, safety, cost and environmental & social consideration point of view. Generally, railway structures are classified into three (3) major types, which are: At Grade Structure Type, Elevated Structure Type (Viaduct) and Underground Structure Type (Tunnel). The type of railway structure is based mainly on urban/rural characteristics of along a proposed route, considering construction cost, construction period of scheme, advantages to people (scheme users), environmental consideration, and operation and maintenance. And those structural types are considered in the preparation of alternatives. Embankment material is planned to be gathered from some points, which points are 2 – 30 km away from planned HSR route as well as DFC Project. On Indian provisions, it is possible to mine till depth of 1.5 m from ground surface without permission. Under 1.5m from ground surface, it is necessary to purchase a permission from environmental authority. Emissions soil from Tunnel and Cutting are planned to re-use within the project site. If unavoidable, the surplus soils are planned to gather to quarry site near the planned HSR route.



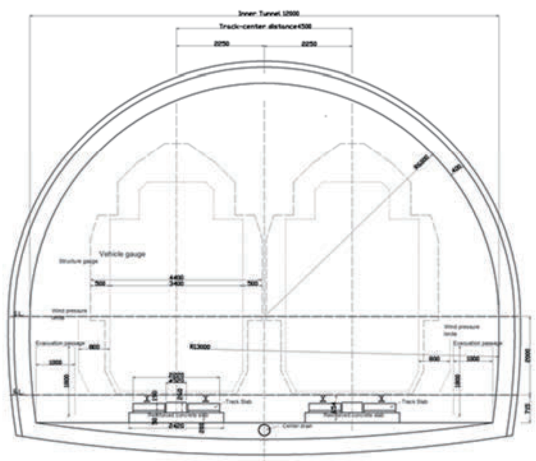
Note: All dimensions are tentative

Figure 2.1.1: Standard Cross-section of Typical Embankment



Note: All dimensions are tentative

Figure 2.1.2: Standard Cross-section of Typical Viaduct



Note: All dimensions are tentative

Figure 2.1.3: Standard Cross-section of Tunnel

2.1.1 Comparison of Alternatives

When selecting the alternatives, as described in 4.7.3 (3) and (4), they were considered in Mumbai, Surat, Vadodara and Ahmedabad, which are major cities. As important aspects for selecting the alternatives, 1) Connectivity with other transportation, 2) Attractiveness, 3) Natural and social environmental issues, 4) Technical, 5) Promptness are considered.
Based on these aspects, site survey and meetings with both state governments and regional railways and so on, firstly some HSR station candidate locations were selected in each major city, next comparisons were carried out with considering the routes to proposed stations. Based on the above studies, combination of station candidate locations and routes with higher validity was set as Alternatives of all whole section.
Moreover, regarding selecting the alignment between main cities, it is expected that there will be no impacts of environmental social consideration in particular. And also a comparison regarding impacts of forests and Thane Creek was carried out.
Followings are comprehensive characteristics of the alternatives:

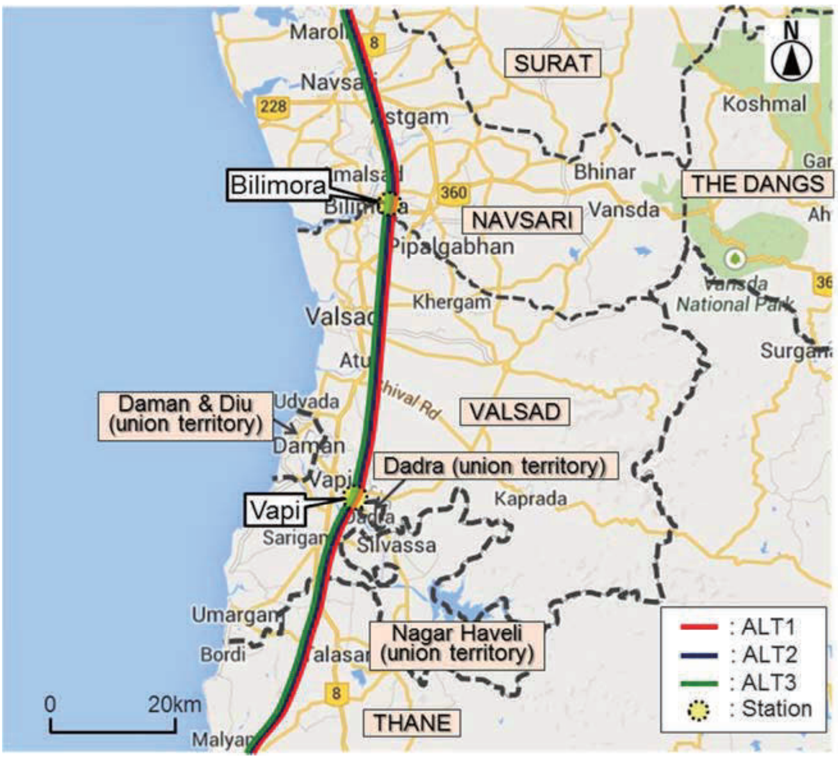
1) Alternative 1 (ALT1) presented in red line from Figure 2.1.4 to Figure 2.1.7: Dedicated route for which new terminal station is proposed at Mumbai , crossing Thane Creek by tunnel, connecting with new suburban station in Surat and juxtaposed to existing stations at Vadodara & Ahmedabad. High speed operation is available through all whole section.

2) Alternative 2 (ALT2) presented in blue line from Figure 2.1.4 to Figure 2.1.7: Dedicated route for which new terminal station is propose at Mumbai, crossing Thane Creek by Viaduct, juxtaposed to existing station at Surat and connecting with new suburban stations at Vadodara and Ahmedabad. High speed operation is available through all whole section.

3) Alternative 3 (ALT3) presented in green line from Figure 2.1.4 to Figure 2.1.7: ALT3 route considers interoperability that HSR and existing railway are mixed in Mumbai, Surat, Vadodara and Ahmedabad areas. High speed operation is difficult in some sections.

Source: Study Team

Figure 2.1.4: Comparison of Alternatives between Mumbai and Boisar

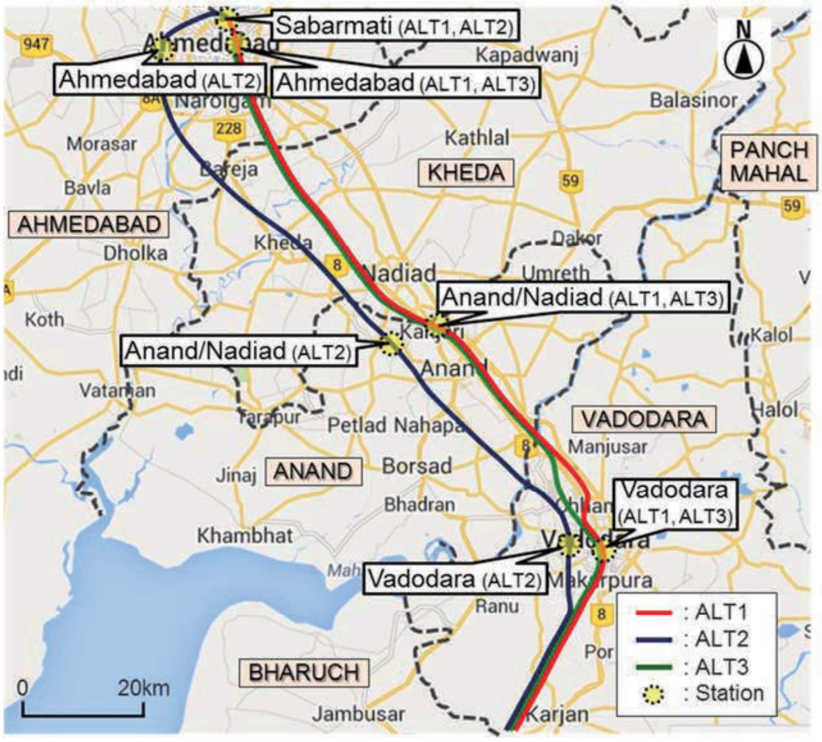


Source: Study Team

Figure 2.1.5: Comparison of Alternatives between Thane and Navsari

Source: Study Team

Figure 2.1.6: Comparison of Alternatives between Surat and Bharuch



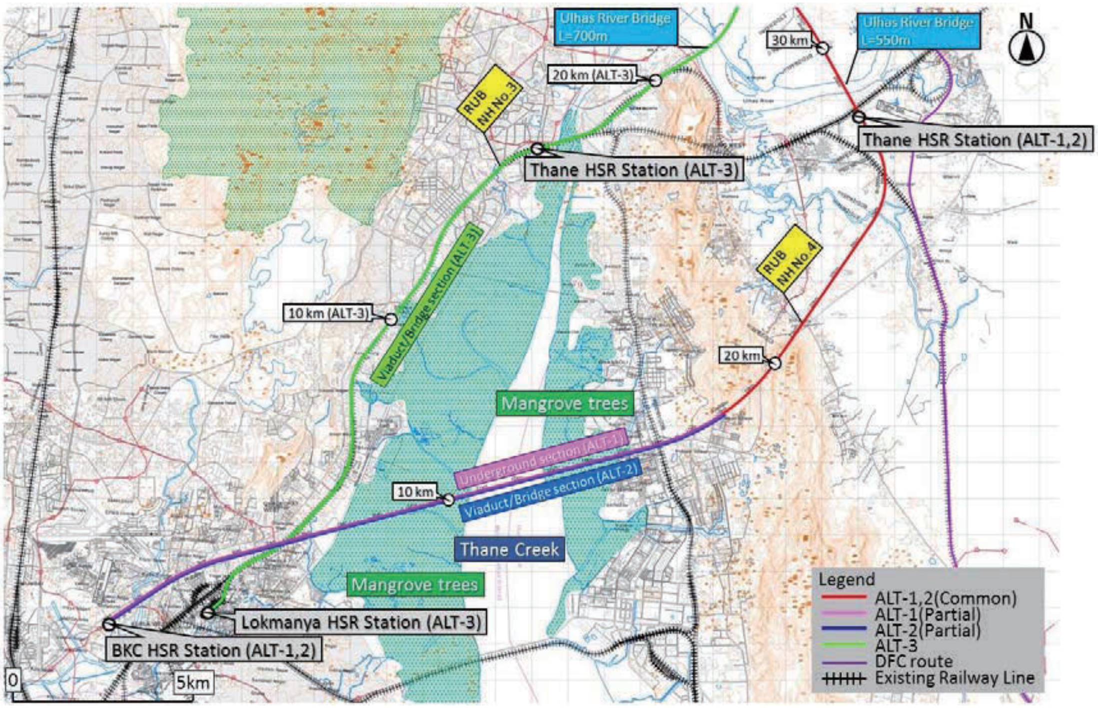
Source: Study Team

Figure 2.1.7: Comparison of Alternatives between Bharuch and Ahmedabad

Detail characteristics of each alternative are described as follows:
As shown in following figures, alternative 1 (ALT1) presented in pink line partially, alternative 2 (ALT2) presented in blue line partially, alternative 3 (ALT3) presented in green line partially and also common route of all alternatives presented in red line.

Between Mumbai and Thane

- Regarding ALT1 and ALT2 in Mumbai suburban district, the HSR station location was planned at Bandra Kurla Complex, which is Central Business District. On the other hand, regarding ALT3, the HSR station was planned to utilize Lokmanya existing station and the HSR route was planned to parallel existing line from Lokmanya Station to Kalwa station (northeast side of Thane existing station) considering interoperability that HSR and existing railway are mixed.
- Regarding ALT1 and ALT2 between Mumbai and Navi Mumbai area (Navi Mumbai is area on east side of Thane Creek), ALT1 route passes through Thane Creek at underground and ALT2 route passes at elevated. It would be necessary to compare with them in the viewpoint of environmental issues.
- In the case of passing Thane Creek by bridge, it is impossible to avoid modification of Mangrove trees. On the other hand, in the case of passing Thane Creek by tunnel, the construction cost of tunnel is higher than that of bridge. In the viewpoint of environmental issues, crossing Thane Creek by tunnel was selected.
- Thane HSR station on ALT1 and ALT2 was planned to be connected with the existing line, on the other hand, Thane HSR station on ALT3 was planned to utilize Thane existing station considering interoperability.



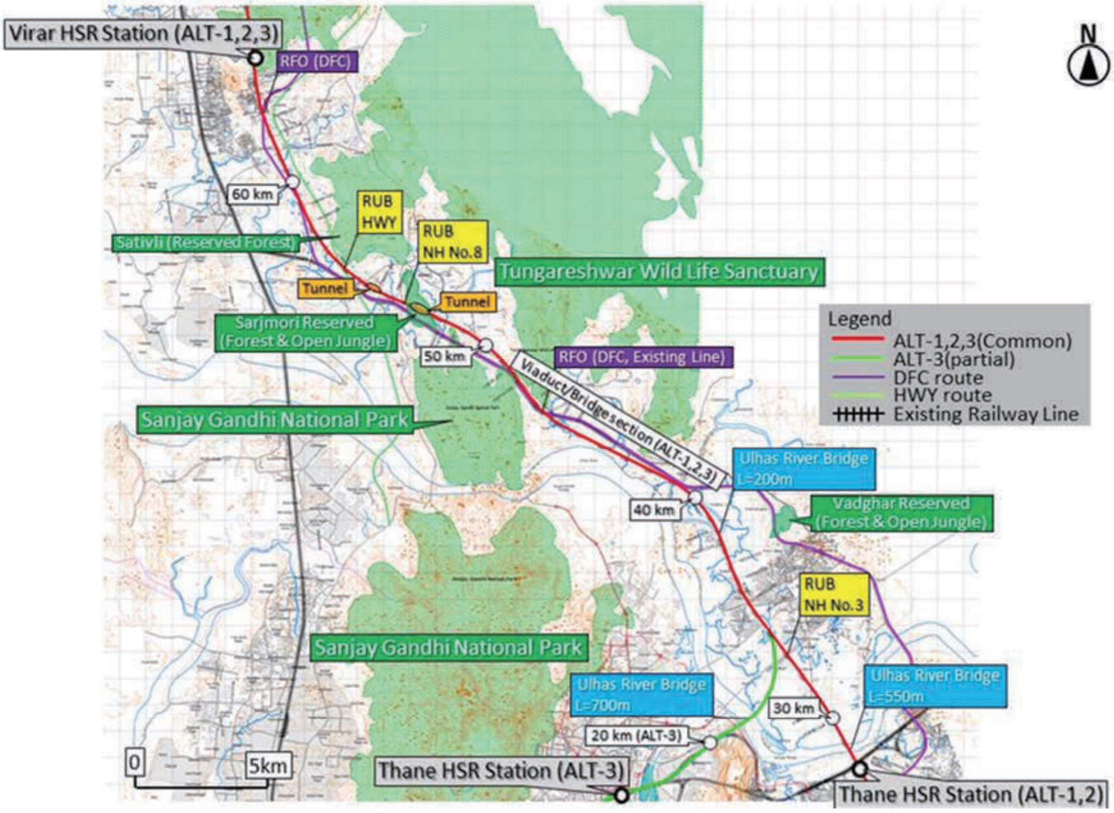
Note: Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.8: Comparison of Alternatives between Mumbai and Thane

Between Thane and Virar

- Between Thane HSR station and Virar HSR station, there are Sanjay Gandhi National Park and Tungareshwar Wildlife Sanctuary. The HSR route was planned to avoid these areas by utilizing some curves. If the impact is predicted by EIA, the monitoring would be considered.

- In the section between Thane HSR station and Virar HSR station, viaduct structure was mainly planned due to some residential areas and passing by Ulhas River except some mountains.
- Virar HSR station location was planned at vacant green field on south side of mountains and away from Virar city. New road for access to HSR station would be necessary.

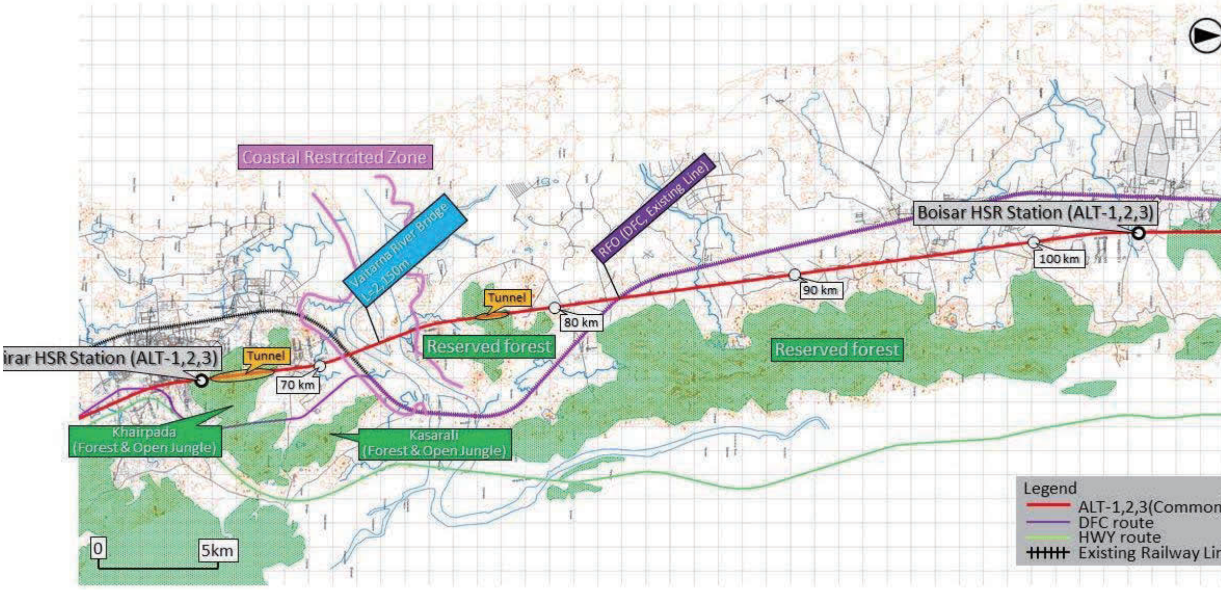


Note: Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.9: Comparison of Alternatives between Thane and Virar

Between Virar and Boisar

- In the section between Virar HSR station and Boisar HSR station, embankment structure was mainly planned due to many green fields, except crossing Vaitarna River, DFC & existing lines and mountains.
- Boisar HSR station location was planned at vacant green field on the east side of Boisar city. There are some industrial areas in Boisar.

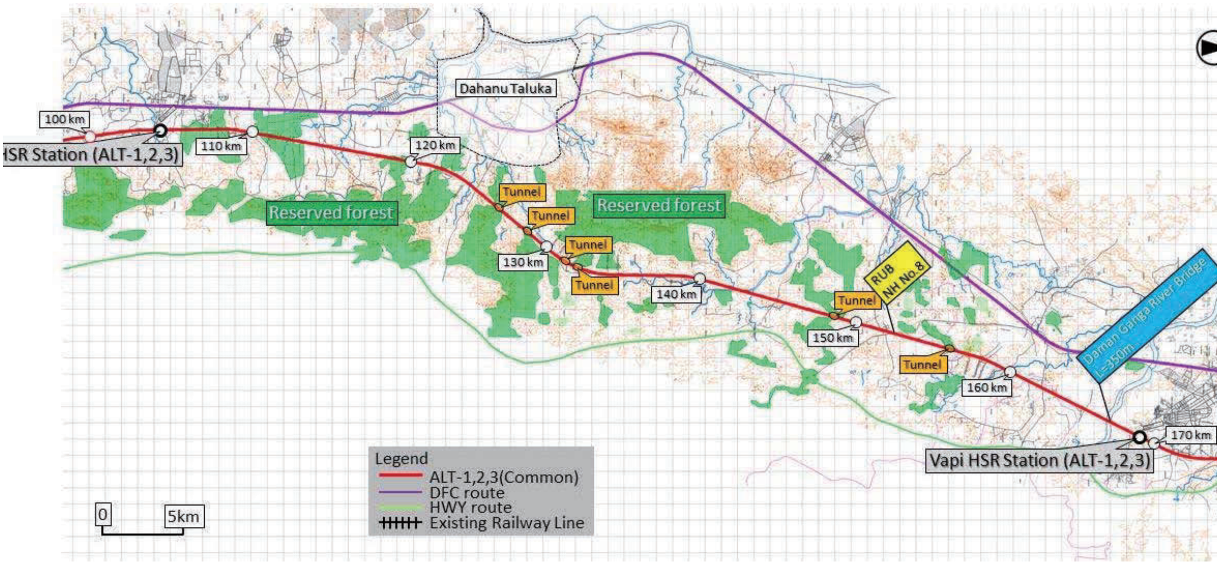


Note) Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.10: Comparison of Alternatives between Virar and Boisar

Between Boisar and Vapi

- In the section between Boisar HSR station and Vapi HSR station, embankment structure was mainly planned due to many green fields, except crossing rivers, roads such as National Highway and mountains.
- The HSR route was planned to avoid mountainous areas as possible from 130 km to 140 km.
- Vapi HSR station location was planned near State Highway No.185 at suburb of the southeast side of Vapi city.

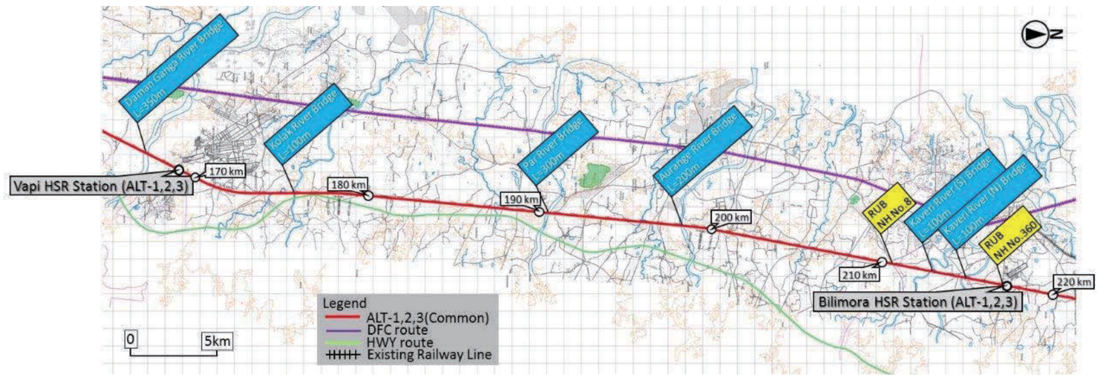


Note: Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.11: Comparison of Alternatives between Boisar and Vapi

Between Vapi and Bilimora

- In the section between Vapi HSR station and Bilimora HSR station, embankment structure was mainly planned due to many green fields, except crossing rivers and roads such as National Highway.
- Bilimora HSR station location was planned near National Highway No.360 at suburb of the east side of Bilimora city.

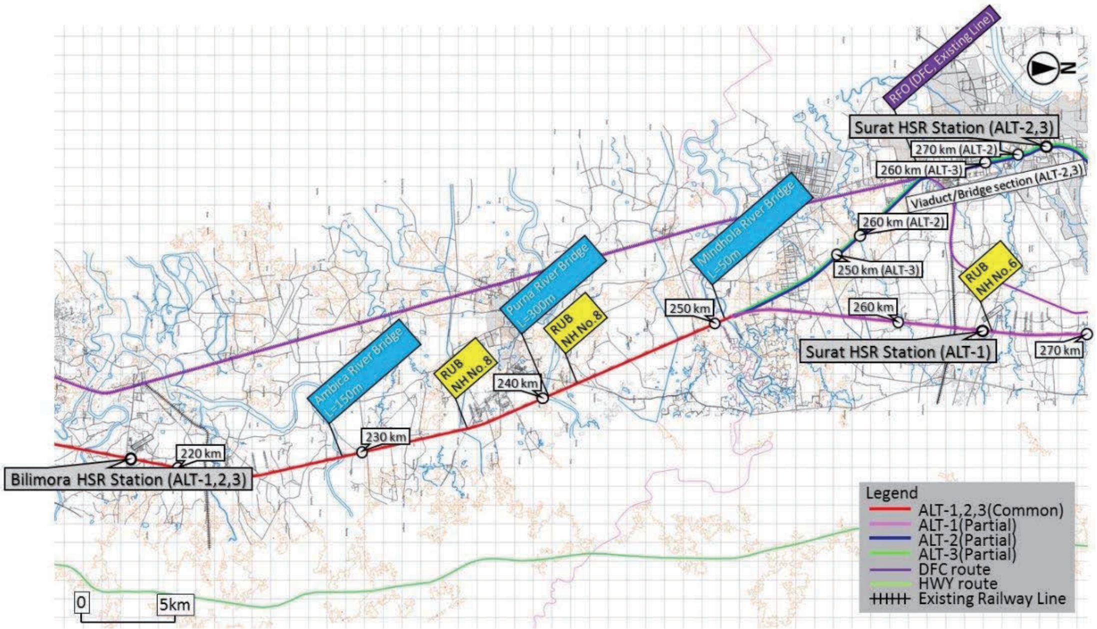


Note) Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.12: Comparison of Alternatives between Vapi and Bilimora

Between Bilimora and Surat

- In the section between Bilimora HSR station and Surat HSR station, embankment structure was mainly planned due to many green fields, except crossing rivers, roads such as National Highway and before and after Surat city area.
- Regarding ALT1, the HSR station location was planned near National Highway No.6 at suburb of the east side of Surat city center. On the other hand, regarding ALT2, the HSR station was planned to be juxtaposed with Surat existing station and the HSR route was planned to parallel existing line at elevated. Regarding ALT3, the HSR station was planned to utilize Surat existing station and the HSR route was planned to parallel existing line before and after Surat city area considering interoperability that HSR and existing railway are mixed.

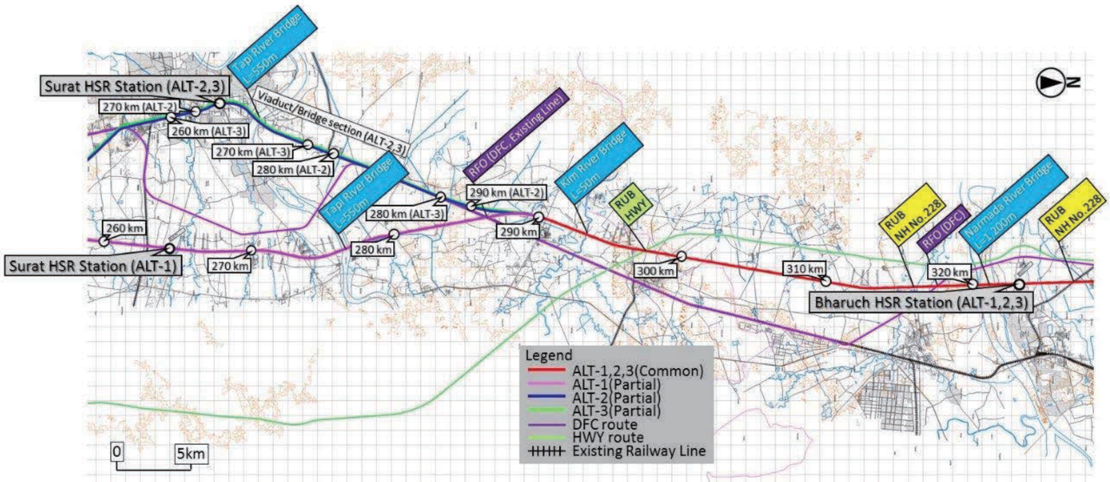


Note: Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.13: Comparison of Alternatives between Bilimora and Surat

Between Surat and Bharuch

- In the section between Surat HSR station and Bharuch HSR station, embankment structure was mainly planned due to many green fields, except crossing rivers, DFC & existing lines and roads such as National Highway.
- Bharuch HSR station location was planned near State Highway No.6 at suburb of the west side Bharuch city.



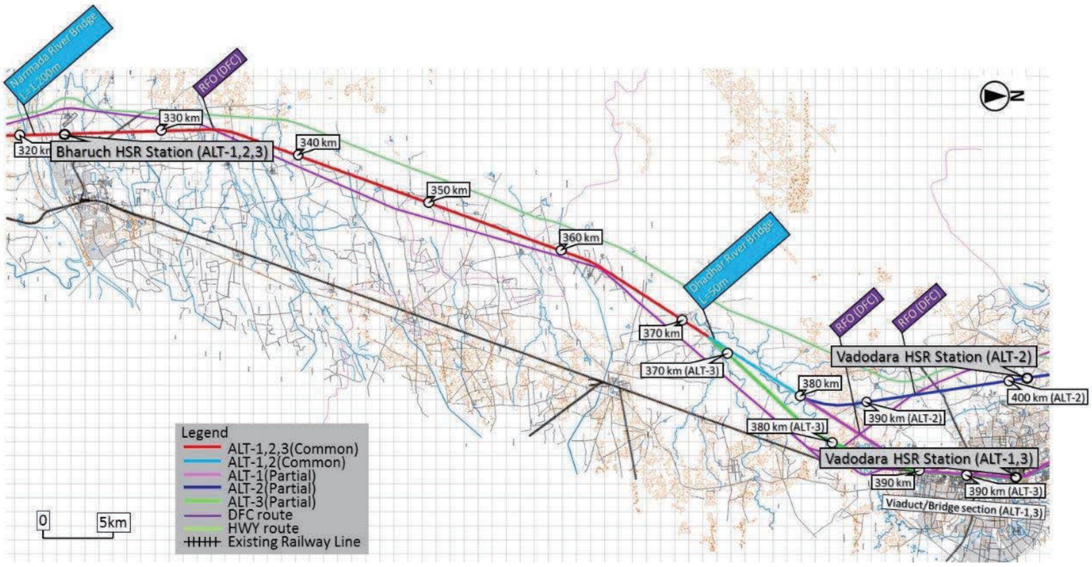
Note) Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.14: Comparison of Alternatives between Surat and Bharuch

Between Bharuch and Vadodara

- In the section between Bharuch HSR station and Vadodara HSR station, embankment structure was mainly planned due to many green fields, except crossing rivers, DFC & existing lines, roads such as National Highway and before and after Vadodara city area.

Regarding ALT1, the Vadodara HSR station was planned to be juxtaposed with Vadodara existing station and the HSR route was planned to parallel existing line at elevated. On the other hand, regarding ALT2, the HSR station location was planned near State Highway No.11 at suburb of the west side Vadodara city center. Regarding ALT3, the HSR station was planned to utilize Vadodara existing station and the HSR route was planned to parallel existing line before and after Vadodara city area considering interoperability that HSR and existing railway are mixed.

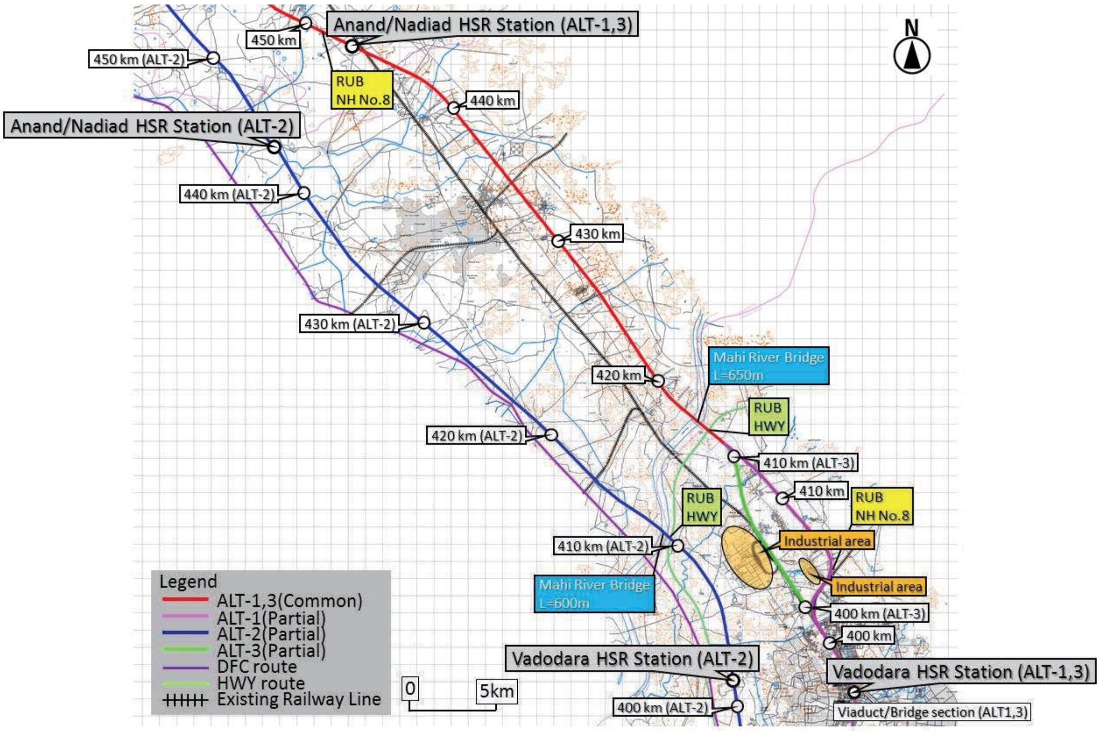


Note: Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.15: Comparison of Alternatives between Bharuch and Vadodara

Between Vadodara and Anand/Nadiad

- In the section between Vadodara HSR station and Anand/Nadiad HSR station, embankment structure was mainly planned due to many green fields, except crossing rivers, DFC & existing lines, roads such as National Highway and before and after Vadodara city area.
- Anand/Nadiad HSR station location of ALT1 and ALT3 was planned near State Highway No.150, nearly half between Anand and Nadiad city. On the other hand, in the case of ALT2, the location was planned near state highway No.139 away from Anand and Nadiad city.

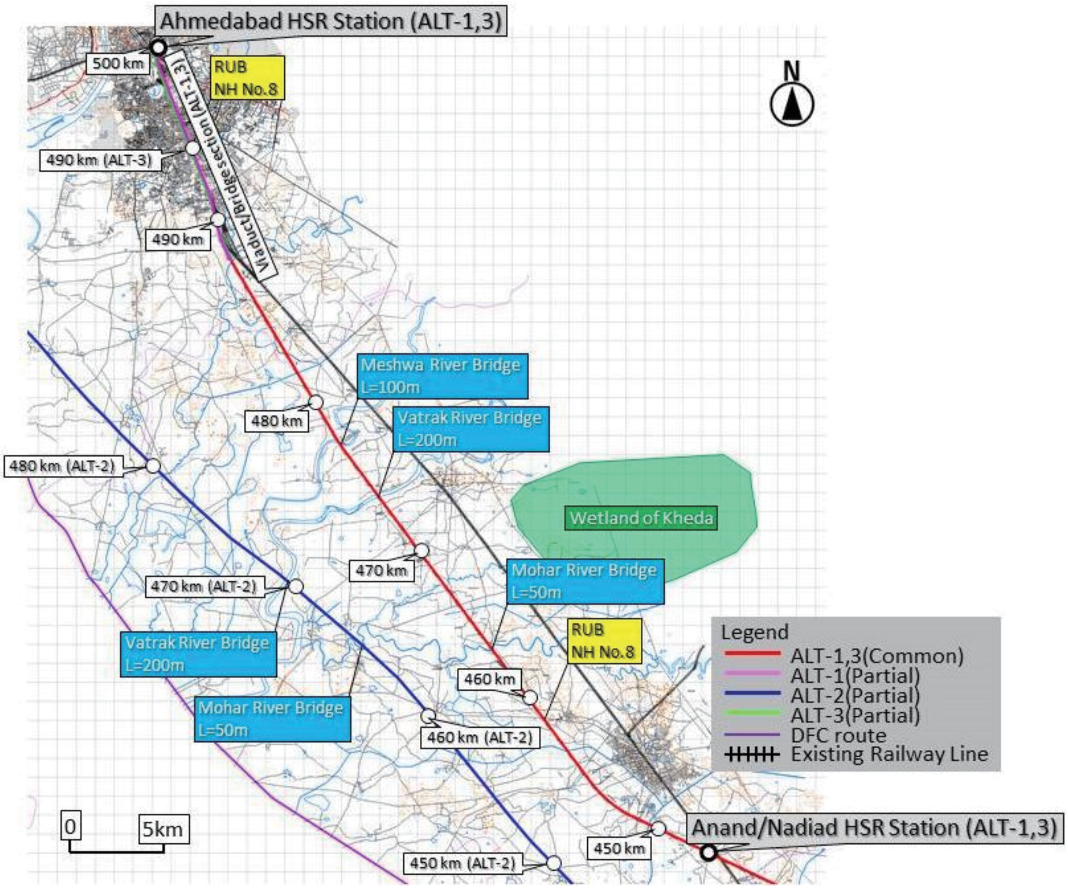


Note: Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.16: Comparison of Alternatives between Vadodara and Anand/Nadiad

Between Anand /Nadiad and Ahmedabad

- In the section between Anand/Nadiad HSR station and Ahmedabad HSR station, embankment structure was mainly planned due to many green fields, except crossing rivers, roads such as National Highway and before and after Ahmedabad city area.
- Regarding ALT1, Ahmedabad HSR station was planned to be juxtaposed with Ahmedabad existing station and the HSR route was planned to parallel existing line from south side in city area. On the other hand, regarding ALT2, the HSR station location was planned at green field near Bopal city at suburb of the west side Ahmedabad city center. Regarding ALT3, the HSR station was planned to utilize Ahmedabad existing station and the HSR route was planned to parallel existing line from Sardar patel ring road considering interoperability that HSR and existing railway are mixed.

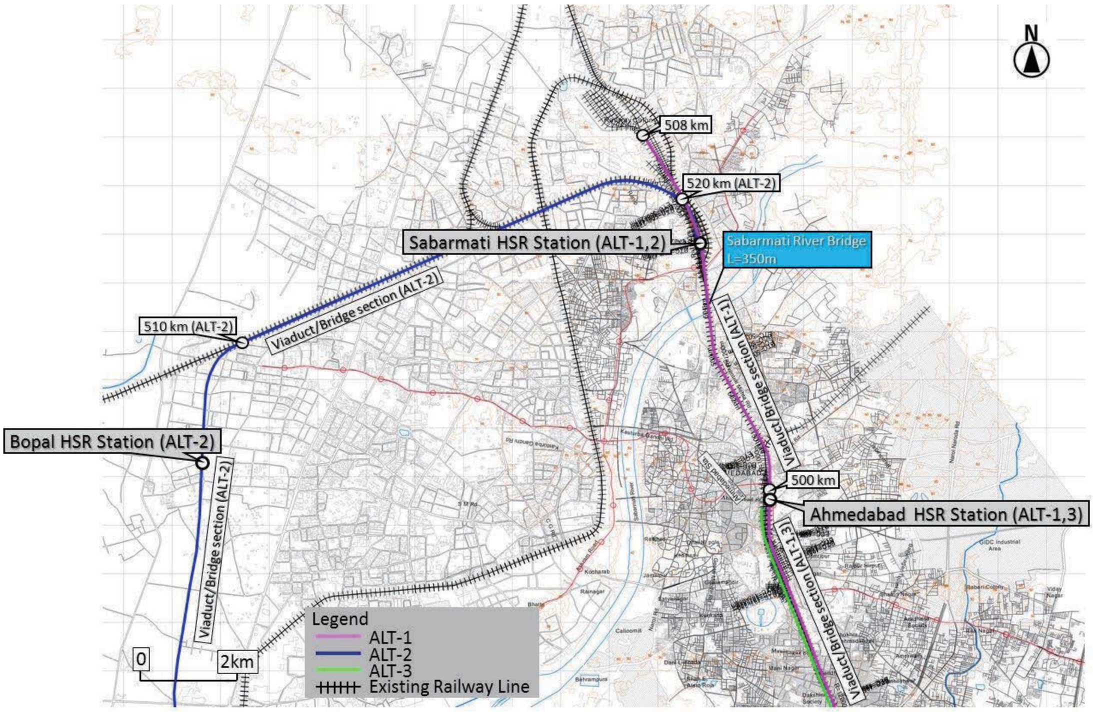


Note: Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.17: Comparison of Alternatives between Anand/Nadiad and Ahmedabad

<u>Between Ahmedabad or Bopal and Sabarmati</u>

- In the section between Ahmedabad HSR station or Bopal HSR station and Sabarmati HSR station, viaduct structure was planned due to going above the existing line mainly.
- Regarding ALT1, Sabarmati HSR station was planned to be set between both east and west of sabarmati existing station and the HSR route was planned to go the east along existing line at elevated. On the other hand, regarding ALT2, the HSR route was planned to go the south along existing line after passing Bopal HSR station.



Note: Chainages without ALT-2, 3 indicate those of Alternative 1.
Source: Study Team

Figure 2.1.18: Comparison of Alternatives between Ahmedabad or Bopal and Sabarmati

2.2 No Action Plan

"No Action Plan" is carried out to grasp whether the passenger demand is sharing how to other transportation and also what kind of impact in environmental aspects in the future, if High-speed Railway network is not built.

High-speed Railway network will be not formed and it seems that burden to the project cost and environment is the least than that of Alternatives in a short-term. However, the brisk economic activities require the improvement of other transportation means, such as air and ground transport which will result the burden to the cost and environment in a middle/long term. Thus, comprehensive comparison of Alternatives is summarized in Table 2.2.1.

Table 2.2.1: Comparison of Alternatives

		ALT1		ALT2		ALT3		No Action Plan	
Route overview	Length	508.5km		521km		496km		N/A	
Route overview	Number of Station	12 nos.		12 nos.		11 nos.		N/A	
Route overview	Structural Feature	At grade: 341 km Viaduct/Bridge: 140 km (Continuous elevated section: 123 km, River section: 13 km/37 number, RUB section: 4 km/121 number) Underground: 27.5 km	-	At grade: 342 km Viaduct/Bridge: 171 km (Continuous elevated section: 152 km, River section: 12 km/33 number, RUB section: 7 km/162 number) Underground: 8 km	-	At grade: 314 km Viaduct/Bridge: 177 km (Total length of mixed train operation: 72 km) (Continuous elevated section: 161 km, River section: 8 km/35 number, RUB section: 8 km/129 number) Underground: 5 km	-	No improvement	-
Route overview	Time required	Super express (Stop at 3 stations): 2 hours 07 min. Local train (Stop at every station): 2 hours 58 min.	A	Super express (Stop at 3 stations): 2 hours 12 min. Local train (Stop at every station): 3 hours 01 min.	B	Super express (Stop at 3 stations): 2 hours 52 min. Local train (Stop at every stations): 3 hours 40 min.	C	No improvement	D
Transport network		A high speed operation is possible throughout the whole section. Thane/Vadodara/Ahmedabad/Sabarmati: connected to existing railway. Other Stations: New stations A transfer to Indian Railway is needed.	A	A high speed operation is possible throughout the whole section. Thane/Surat/Sabarmati: connected to existing railway. Other Stations: New stations A transfer to Indian Railway is needed.	A	A high speed operation is difficult in the section on which HSR and existing railway are mixed. A transfer to Indian Railway is not needed.	C	No improvement	D

Technical side	Passenger demand	Boarding Passenger: 40 thousand PAX/day (2023), 202 thousand PAX/day (2053). Huge demands on Mumbai, Ahmedabad and Vadodara station are expected.	A	Boarding Passenger: 33 thousand PAX/day (2023), 168 thousand PAX/day (2053). Less demands on Ahmedabad and Vadodara station because each station is in the suburban area, and passenger is required to transfer.	B	Boarding Passenger: 34 thousand PAX/day (2023), 165 thousand PAX/day (2053). Although the location of each station is better than ALT1/ALT2, the arrival time between each station is longer than ALT1/ALT2 due to mixed operation with HSR and existing railway.	C	No change	D
	Technical issues related to operation	High speed operation is available due to the dedicated line.	A	High speed operation is available due to the dedicated line.	A	The railway capacity for HSR is less because many kinds of train are operated on same railway. The system including signals and rolling stocks for mixed operation of HSR and local trains is needed.	C	N/A	-
	Safety	A high safety is kept because of full dedicated railway line.	A	A high safety is kept because of full dedicated railway line.	A	A safety level is lower than dedicated railway because HSR and local train are mixed on a same track.	B	A safety is as same as current situation.	C
	Cost	709,151 (million INR).	C	684,194 (million INR).	B	656,038 (million INR).	A	N/A	-

Environmental and social considerations	Natural Conservation: Some forests are affected but Thane creek is not affected. Resettlement: it would be accompanied with 1,120 resettlement in total.	C	Natural Conservation: 7 km long of Thane creek is affected. Resettlement: It would be accompanied with 1,556 resettlement in total.	D	Natural Conservation: Some of forest is affected but Thane creek is not affected. Resettlement: It would be accompanied with 946 resettlement in total.	B	The impact is the least. It is not accompanied with resettlement.	A
Total evaluation	The HSR system can be introduced throughout whole section. High safety and efficiency are kept. It is possible that the characteristic of HSR is exerted most. High demand is expected because major stations are in the urban area. In Mumbai area, the impacts of resettlement and natural environment are less because HSR is underground. The impact to natural environment is the least because the number of bridges to be constructed is less among alternatives. **This is the most desirable plan.**	A	The HSR system can be introduced throughout whole section. High safety and efficiency are kept. It is possible that the characteristic of HSR is exerted most. The demand expectation is less than ALT1 because major stations are in the suburban area. In Mumbai area, natural environmental along 7 km long of Thane creek is affected. This plan is inferior to ALT1.	B	The HSR system cannot be introduced throughout whole section (It is assumed HSR considering interoperability with existing railway served with cases in Europe). High safety and efficiency cannot be kept. Shortage in railway capacity. The time required is longer than ALT1 or ALT2. Modal shift is less. This plan is inferior to T1 or ALT2.	C	It is impossible that HSR is introduced in existing railway. The demand is lower because there is competition with other modes. The high safety cannot be kept.	D

Source:Study Team

2.3 Impact Identification and Scoping Matrix

Selection result of project items of impact are displayed in Table 2.3.1. Based on JICA's guidelines items of impact were selected which was discussed in 7.4, and TOR were evaluated based on scoping results.

Table 2.3.1: Scoping of the Proposed Project

No.	Items of Impact	Predicted Impact				Reason of Prediction
		Before/During construction stage		Operation stage		
		Positive	Negative	Positive	Negative	
[Anti-Pollution Measures]						
1	Air pollution	D	B	C	D	During construction stage: There might be air pollution by an operation of construction machineries. Operation stage: The modal shift of transportation, such as bus/ vehicle will be expected to decrease the pollution level of ambient air.
2	Water pollution	D	B	D	B	During construction stage: There might be water pollution by drainage from construction site. Operation stage: Impact due to the effluent from facilities of rolling stock inspection and repair is assumed.
3	Soil pollution	D	B	D	D	During construction stage: Impacts are assumed when fuel/oil leakage might be occurred. Operation stage: No impact is assumed.
4	Waste	D	B	D	B	During construction stage: Surplus soil and waste material are discharged. Operation stage: Impacts due to the waste from facilities of rolling stock inspection and repair is assumed.
5	Noise and vibration	D	B	D	A	During construction stage: There might be noise and vibration by an operation of construction machineries. Operation stage: There are noise, vibration and tunnel sonic boom by the HSR

						operation.
6	Ground subsidence	D	C	D	D	During construction stage: Impact due to the tunneling work is not clear at this moment. Operation stage: Risk of the above will not remain.
7	Offensive odors	D	D	D	D	During construction stage: Construction works to cause offensive odors are not assumed. Operation stage: Ditto
[Natural Environment]						
1	Topography and geology	D	B	D	D	During construction stage: Embankments, cuttings, and tunnel excavation may change the topography. Soil erosion may occur during rain. Operation stage: No action that will have impact is anticipated.
2	Bottom sediment	D	D	D	D	During construction stage: Possibility to cause bottom sediment including hazardous substances is predicted very small.
3	Biota and ecosystem	D	A	D	B	During construction stage: Splitting of habitats due to construction work on the ground and the impact to ecological system due to improvement work in the river can be expected. There is a possibility that the movement of fauna will be hampered due to the constructed facilities.
4	Hydrology	D	B	D	D	Construction stage: There is a possibility of an impact on Hydrology by the bridges construction on rivers and by the Thane tunnel construction. Operation stage: Risk of the above will not remain.
5	Protected area	D	A	D	B	During construction stage: Impact to national park/sanctuary is assumed between Mumbai and Thane station.

						Operation Stage: Impact will partially remain.
[Social Environment]						
1	Water use	D	B	D	B	During construction stage: Impacts to the wells/irrigations/rivers/reservoirs are assumed those locate along the HSR alignment. Furthermore, impact due to new mountain tunnel is assumed. Operation stage: Among above impacts, the impact due to new tunnel may remain.
2	Involuntary resettlement	D	A	D	D	Before construction stage: Structures including residences, shops, factories, warehouses etc. must be displaced due to the HSR project. Adverse impacts will not remain.
3	Local economies, such as employment, livelihood, etc.	B	A	A	B	Before/during construction stage: Some project affected persons (PAPs) will forced to change/lose their jobs, on the other hand, the construction activity will create job opportunities to the local people. Operation stage: The HSR project is expected to enhance the local economy significantly as well as to create job opportunities by inducing overseas railway related companies to establish new offices/factories along the HSR line. On the other hand, it is assumed that there might be a possibility of residual impact to aforesaid PAPs.
4	Land use and utilization of local resources	D	A	B	D	Before/during construction stage: Present land use, such as agriculture, grazing, manufacturing, commerce etc. will be affected due to the HSR project. Operation stage: The HSR will require the minimum

						space compared with other ways of transportation (highway/airport) and effective urban/local development will be enhanced. Problems in large city, such as urban transportation/drinking water/waste those arisen especially in Mumbai will be mitigated by relocating some of its function near the HSR station.
5	Social institutions, such as social infrastructure and local decision-making institutions Existing social infrastructures and services	D	A	D	D	Before/during construction stage: Many aboveground/underground utilities or schools/clinics etc. must be removed prior to start the construction activity. Operation stage: Those infrastructures and facilities will be properly relocated prior to start the construction activities, therefore the impact will be small. Furthermore, the HSR will shorten the trip hour greatly and enhance the movement of people easier.
6	Poor	D	A	D	A	Before/during construction stage: Impact to poverty group is assumed when the compulsory displacement is required. Operation stage: The poverty group will become poorer if the compensation to displacement or rehabilitation of livelihood measures are not taken.
7	Indigenous or ethnic minority people	C	C	C	C	Before/during construction stage: Distribution of indigenous or ethnic minority groups is not identified at this moment. Operation stage: Ditto
8	Misdistribution of benefits and damages	D	B	D	B	During construction stage: It is assumed that some people will be profited, on the other hand some will be damaged due to the HSR project.

						Operation stage: it is assumed that the impacts will still remain in operation stage.
	Local conflicts of interest	D	B	D	B	Before/during construction stage: It is assumed that the HSR alignment requires splitting the villages due to the displacement. This will result the gaps between displaced villagers and not displaced ones from the financial/convenience aspect. Operation stage: It is assumed the conflict will still remain in operation stage.
10	Gender	D	B	D	D	Before/during construction stage: It is assumed that the opportunities of social participation by women groups are not widespread in local areas. Adverse impacts will not remain.
11	Children's right	C	C	C	C	During construction stage: The impact is not clear at this moment. Operation stage: Ditto
12	Cultural heritage	D	B	D	D	Before/during construction stage: It is expected that there is a religious facility for inhabitants who takes root in the community. Operation stage: Adverse impacts will not remain.
13	Infectious diseases, such as HIV/AIDS	D	B	D	B	During construction stage: Though it might be not significant scale, the influx of workers those will join the HSR project may cause the spread of the infectious diseases. Operation stage: Influx of population due to local/urban development will cause other risks of spreading infectious diseases.
14	Landscape	D	D	D	B	During construction stage: The HSR will not run within/near the landscape

						protection area, therefore impact might be very small. Operation stage: Landscape impacts are assumed by appearance of new structures for HSR.
15	Working conditions	D	B	D	B	During construction stage: safety measures to the workers needs to be taken by the contractors. Operation stage: Impact to the workers those working at facilities of rolling stock inspection and repair is assumed.
16	Social consensus	A	A	B	D	Before/during construction stage: Obtaining the consensus/understanding from wide ranged stakeholders or local stakeholders is crucial to implement the HSR project smoothly as scheduled, otherwise serious issues will arise those will hamper the project implementation. Operation stage: Adverse impacts will not remain.
[Others]						
1	Accident	D	B	D	A	During construction stage: Accidents due to construction activities might occur. Operation stage: There is a possibility of the accident by the railway's high speed operation.
2	Sun shading	D	D	D	B	During construction stage: It is assumed that impact might occur very in short period. Operation stage: Sun shading might occur by new viaducts.
3	Radio disturbance	D	D	D	B	During construction stage: It is assumed that impact might occur very in short period. Operation stage: Radio disturbance might occur due to the HSR operation and new viaducts.

4	Climate change Global warming	D	D	B	D	During construction stage: It is assumed that impact might occur very in short period. Operation stage: The modal shift of transportation such as bus and vehicle can contribute to resolving global warming.

Source: Study Team
Note: A: Remarkable Impact is predicted.
B: Impact is expected to some extent.
C: Extent of Impact is unknown. (A further examination is needed and the impact could be defined as study progresses)
D: Impact is very small or nil and further survey is not required

2.4 TOR for EIA and, Socio-economic Survey

EIA study will be conducted in accordance with JICA's Guidelines and related regulations/guidelines in India and the TOR for its survey is presented in Table 2.4.1.

Table 2.4.1: TOR for EIA

Items of impact	Items of survey	Approach method
Air pollution	1. Confirm environmental standards in India 2. Confirm the present air quality level 3. Clarify the location s of residence are, school and hospital those neighbor to the HSR 4. Clarify the adverse impacts due to the construction machinery which work in the construction stage	1. Review existing information 2. Review existing information and conduct the site survey where new/improvement of stations are anticipated ・baseline survey of emission air ・12 places, once 3. Conduct site survey 4. Predict magnitude of impacts due to the construction machinery
Water pollution	1. Confirm environmental standards in India 2. Confirm the present water quality level in main rivers 3. Confirm the present river water use for daily life 4. Forecast the adverse impacts mightly arisen in construction stage	1. Review existing information 2. Review existing information and conduct the site survey where HSR cross main rivers ・base line survey of water quality ・19 places, once 3. Conduct site survey and hearing from neighbors 4. Predict magnitude of impacts due to the construction activities
Soil Pollution	1. Confirm environmental standards in India 2. Confirm the present soil pollution level	1. Review existing information 2. Review existing information and conduct site survey
Waste	1. Confirm environmental standards in India 2. Confirm the present waste treatment	1. Review existing information 2. Review existing information and conduct site survey

	condition	
Noise and vibration	1. Confirm environmental standards applied both in India and other countries on HSR 2. Confirm the present noise and vibration level 3. Clarify the location s of residence are, school and hospital those neighbor to the HSR 4. Predict noise and vibration level in construction and operation stage	1. Review existing information 2. Review existing information and conduct the site survey where new/improvement of stations are anticipated ・baseline survey: Laeq ・12 places, once 3. Conduct site survey 4. Predict noise and vibration level in construction and operation stage based on anticipated parameters
Ground subsidence	1. Confirm environmental standards in India 2. Confirm the areas where ground subsidence might be anticipated	1. Review existing information 2. Review existing information and conduct site survey.
Topography and geology	1. Confirm the situation of Topography and geology	1. Review existing information and conduct site survey.
Biota and ecosystem	1. Clarify the precious species and related laws and regulations in the two States 2. Confirm the distribution of fauna and flora 3. Confirm the information on river ecosystem (situation and environment of inhabiting)	1. Review existing information and data collection from the concerned agencies 2. Review existing information and conduct site survey. 3. Review existing information and conduct site survey
Hydrology	1. Confirm the hydrological environment around rivers crossing HSR route	1. Conduct site survey
Protected area	1. Confirm the legislative system on Protected Area 2. Confirm the location of Protected area or Reserved Forests	1. Review existing information and data collection from the concerned agencies 2. Review existing information and conduct site survey.
Water use	1. Confirm the situation of Water use	1. Review existing information and conduct site survey.
Involuntary resettlement	1. Confirm the magnitude of land acquisition and resettlement and prepare RAP	1. Gap between JICA's Guideline and related Law/Guidelines in India 2. Satellite photograph in target area 3. Census and socio-economic survey 4. RAP which conforms to World Bank's Safeguard Policy OP 4.12 Annex A

Local economies, such as employment livelihood, etc.	1. Clarify assumed affected private properties 2. Identify PAPs	1. Census and socio-economic survey 2. Entitlement eligibility in line with JICA's Guidelines 3. Livelihood restoration program in RAP
Existing social infrastructures and services	1. Clarify the existing residence, school and medical facility	1. Review the existing information 2. Census and socio-economic survey
Land use and utilization of local resources	1. Existing land use	1. Census and socio-economic survey
Social infrastructure and local decision-making institutions. Existing social infrastructure and services	1. Confirm the affected schools, community centers, local clinics	1. Census and socio-economic survey
Poor	1. Questionnaire to PAPs 2. Definition of poor	1. Review the existing information 2. Census and socio-economic survey
Indigenous or ethnic minority people	1. Questionnaire to PAPs 2. Definition of Indigenous people	1. Review the law on indigenous people 2. Census and socio-economic survey
Misdistribution of benefits and damages	1. Confirm if HSR facilities will affect urban/local communities or not	1. Confirm at the local SHM in D/D stage
Local conflicts of interest	1. Confirm if HSR facilities will affect urban/local communities or not	1. Confirm at the district level SHM
Gender	1. Confirm gender issues are still remaining or not	1. Confirm at the district level SHM
Children's right	1. Confirm schools will be affected due to HSR	1. Confirm through the census and socio-economic survey
Cultural heritage	1. Confirm the location of cultural heritage.	1. Review existing information.
Infection diseases, such as HIV/AIDS	1. Confirm the morbidity rate	1. Review the existing information
Landscape	1. Confirm the situation of Landscape	1. Review existing information
Working conditions	1. Way to improve the workers' safety 2. Way to prevent accident which will involve the third person	1. Review the existing law/regulation
Social consensus	1. 1st stage: State level (1) SHM with selected people 2. 2nd stage: District and union territory level (1) When scoping is prepared	1. SHMs with institutional and non-institutional persons were held on 2nd of April, 27th of May and 30th of May, 2014 2. (1) SHM with local neighbors at district level had held in Dec. 2014 and,

	(2) When draft report is prepared	(2) SHM with local neighbors at district level will be in Feb. – Mar. 2015
Accident	1. Confirm the accident cases on HSR project 2. Confirm distribution of houses and various facilities around HSR route	1. Collect similar cases 2. Conduct site survey
Sun shading	1. Confirm standards and guarantees in India 2. Confirm situation of houses around HSR route	1. Review existing information. 2. Conduct site survey
Radio disturbance	1. Confirm standards and guarantee in India 2. Confirm the locations of transmission station for TV around HSR route	1. Review existing information. 2. Review existing information and conduct site survey
Climate change Global warming	1. Confirm situation of Climate change and Global warming in India.	1. Review existing information.

Source: Study Team

Chapter 3
Applicable Environmental Laws and Legal Framework

Environmental protection cannot be isolated from and must be regarded as synonymous with societal development. Therefore environmental conservation and protection should be an integral in all spheres of human and socio-economic development (especially including the development of industry and infrastructure). Over the years, together with spreading of environmental consciousness, there has been a change in the traditionally held perception that there is a trade-off between maintaining environmental quality and achieving economic growth as people have come to believe that the two should be regarded as necessary and complimentary objectives. Environmental legislation has developed considerably in India since 1970 and plays an important role in ensuring that environment protection measures are incorporated in the plans, programs and projects advancing the socio-economic development of the nation. The implementation of such laws assists in promotes sustainable development as well as protecting human health and property. The Ministry of Environment, Forests and Climate Change (MoEFCC), the State and Central Pollution Control Boards (CPCB) represent the principal administrative and regulatory bodies responsible for ensuring environmentally sustainable development in the country. There are numerous important pieces of environmental legislations which are relevant to the MAHSRC. Some legislation is applicable before the execution of the project in terms of getting clearances/permissions from the statutory authorities before the implementation of the project meanwhile other legislation needs to be followed at the time of implementation of the project.

3.1 Applicable National Policy and Regulations

Environment (Protection) Act, 1986
This act was enacted with the objective of providing for the protection and improvement of the environment. It empowers the Central Government to establish authorities [under section 3(3)] charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems relevant to different parts of the country. Under this Act, the Central Government is empowered to take measures necessary to protect and improve the quality of the environment by setting standards for emissions and discharges; regulating the location of industries; management of hazardous wastes, and protection of public health and welfare. From time to time, the Central Government issues Notifications under the Environment (Protection) Act (EPA) for the protection of ecologically-sensitive areas or issues guidelines for matters under the EPA. The Act was last amended in 1991.

Environment Impact Assessment Notification 2006 and Amendment
The Environmental Impact Assessment Notification issued by the MOEF governs all developmental interventions taking place in the country. This notification was initially issued by the then MOEF now MOEFCC in 1994 and later replaced in 2006 based on revisions to the procedure and process. The purpose of this notification is to specify procedures for imposing certain restrictions and prohibitions on the new project

activities or expansion and modernization of existing projects or activities based on their potential environmental impacts as indicated in Schedule [list of project activities with threshold limit requiring environmental clearance] to the notification, being undertaken in any part of India, unless act was enacted with the objective of providing for the protection and improvement of the environment. According to the latest EIA Notification, railway projects do not appear in the list of Schedule to the notification and as such, are exempted from the environmental clearance process.

The Indian Forest Act, 1927

The Indian Forest Act, 1927 was enacted after repealing the Indian Forest Act, 1878 for the purpose of consolidating the law relating to forests, the transit of forest produce and the duty levied on timber and other forest produce. The Act makes various provisions for the conservation of forests and also provides for the State Government to constitute any forest land or waste land as reserved forest which is the property of Government or over which the Government has proprietary rights, or the whole or any part of the forest produce of which the Government is entitled. The preamble and other provisions of the Forest Act are wide enough to cover all categories of forests including reserved forests, village forests, protected forests, *etc.*

The Forest Conservation Act, 1980 and Its Amendments

This Act provides for the conservation of forests and regulates the diversion of forest lands for non-forest purposes. When any project falls within forestlands, prior clearance is required from the relevant authorities under the Forest (Conservation) Act, 1980. The respective State Governments cannot de-reserve any forestland or authorize its use for any non-forest purposes without approval from the Central Government. The forest authorities conduct a cost-benefit analysis to assess the loss of forest produce, loss to environment *vis-à-vis* benefits of project. Compensatory afforestation schemes are prepared to compensate any loss of vegetation. The forest authorities identify the degraded forestland of twice the area of the affected land to develop compensatory forest. Once the submitted proposals are reviewed, they forward the proposals to the Principal Chief Conservator of Forests and to the State Secretariat. The State Government recommends the proposals for further processing and approval to the concerned Regional Offices of the MoEFCC. In case the total forest area affected is less than 40 ha, otherwise the proposals go to the MoEF at the Central level.

The Forest Conservation Rules, 2003 and Its Amendments

According to the Forest (Conservation) Rules, 2003 as amended up to February 2004, the project requires forestry clearance if forest land acquisition is involved. In case of forest land, if acquisition is less than 40 ha (other than mining project), decision will be taken by Regional Chief Conservator of Forest (RCCF), and if acquisition is more than 40 ha, the proposal will be sent to MoEFCC for their approval.

The Supreme Court Orders on Forest Conservation and Protected Areas (in the Thirumulpad Forest Case), 1996 and 2000

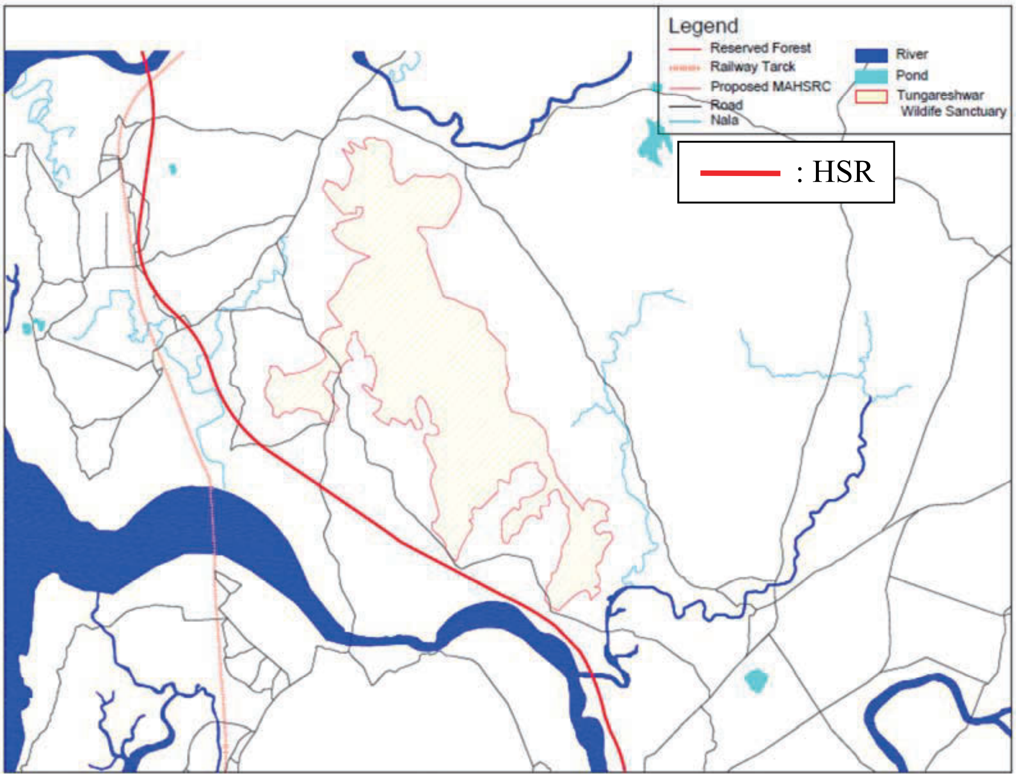
The Supreme Court began by reinterpreting the meaning of “forest” as defined in the Forest Conservation Act, 1980. The Act essentially requires the Central Government approval for conversion of forest land to non-forest purposes. Until 1996, the Forest Conservation Act was assumed to apply only to reserved forests. The Supreme Court said the Act applied to all forests regardless of their legal status or ownership. It also redefined what constituted “non-forest purposes” to include not just mining but also operation of sawmills. But it did not stop at reinterpreting the law for the cases at hand. The Supreme Court ordered all such non-forestry activities anywhere in the country that had not received explicit approval from the Central Government to cease immediately. It also suspended tree felling everywhere, except in accordance with working plans approved by the Central Government. By virtue of the Supreme Court's order dated on 13th of November, 2000, no Forest, National Park or Sanctuary can be de-reserved without the approval of the Supreme Court. No non-forest activity is permitted in any National Park or Sanctuary even if prior approval under the Forest (Conservation) Act, 1980 has been obtained. The interim order dated on 14th of February, 2000 prohibited the removal of any dead or decaying trees, grasses, drift wood etc. from any area comprising a National Park or a Sanctuary notified under Section 18 or 35 of the Wildlife (Protection) Act, 1972. It was also directed that if any order to the contrary has been passed by any State Government or other authorities, the operation of the same shall be stayed. In order to advise the Supreme Court on the various issues concerning forest and wildlife conservation, the Central Empowered Committee was set up as an authority under Section 3 (3) of the EPA, 1986 to adjudicate on forest and wildlife related issues.

The Biological Diversity Act, 2002 and its Rules, 2007

This Act was born out of India's attempt to realize the objectives enshrined in the United Nations Convention on Biological Diversity, 1992 which recognizes the sovereign rights of states to use their own Biological Resources. This Act provides for the conservation of
biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto. As per the provision of Act, certain areas which are rich in biodiversity and encompass unique and representative ecosystems are identified and designated as biosphere reserve to facilitate its conservation. All restrictions applicable to protected areas such as National Park and Sanctuaries are also applicable to the reserves.

The Wildlife (Protection) Act, 1972 and its Amendment, 2002

The Act was enacted with the objective of effectively protecting the wildlife of the country and to control poaching, smuggling and illegal trade in wildlife and its derivatives. The Act provides for protection to the listed endangered flora and fauna and ecologically important protected areas. It empowers the Central and State Governments to declare any area as a wildlife sanctuary, national park or closed area. It provides for authorities to administer and implement the Act; regulate the hunting of wild animals; protect specified plants, sanctuaries, national parks and closed areas; restrict trade or commerce in wild animals or animal articles; and miscellaneous matters. The portion of the alignment passing between TWLS and SGNP at Borivalli in Mumbai comes under the purview of this Act. Figure 3.1.1 shows the TWLS and the portion of the proposed MAHSRC alignment.



Source: Maharashtra Forest Department

Figure 3.1.1:TWLS and proposed MAHSRC Alignment

The demarcation of the boundary of safety zone for the SGNP and TWLS are yet to be done by the Maharashtra State Government. In absence of the demarcation of the boundary, a distance of 10-km is to be adhered to while taking any construction activity in the vicinity of the Eco Sensitive Area (ESA). The procedure for taking approval from the National Wildlife Board and Guidance Document for the same is attached described in the Annexures.

The Biological Diversity Act, 2002 and its Rules, 2007

This Act was born out of India's attempt to realize the objectives enshrined in the United Nations Convention on Biological Diversity, 1992 which recognizes the sovereign rights of states to use their own Biological Resources. All restrictions applicable to protected areas such as National Park and Sanctuaries are also applicable to the reserves.

Noise Pollution Regulation and Control Rules, 2000

As a result of considering the deleterious and psychological effects of the noise pollution on human well-being, the rules for noise pollution came into force in 2000. According to the provisions of the Rules, a person could make a complaint to the designated authority in the event that the actual noise levels exceed the ambient noise standards by 10 dB or more as compared to the standards prescribed in the Schedule of the Rules.

Air (Prevention and Control of Pollution) Act, 1981

This Act provides for the prevention, control and abatement of air pollution. It is applied when air polluting activity in an air pollution control area or when emissions of any air pollutants into the atmosphere exceed the standards set by the Central and State Boards.

Water (Prevention and Control of Pollution) Act, 1974

The Water (Prevention and Control of Pollution) Act, 1974 resulted in the establishment of the Central and State level Pollution Control Boards which responsibilities include managing water quality and effluent standards, as well as monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of certain facilities.

Ancient Monuments & Archaeological Sites & Remains Act, 1958

The Archaeological Survey of India administers the Ancient Monuments and Archaeological Sites and Remains Act, 1958 and subsequent amendments to provide for prohibited and regulated areas around monuments of national importance. According to this act, the area falling within 100 m radius from the peripheries of the protected monument is declared as prohibited area and to the extent of 200 m as a regulated area. No development activity is permitted within a 100 m radius and for the radius between 100 to 200 m; construction could be made only in accordance with the terms and conditions of the license granted by the Director General of the Archaeological Survey of India. Conservation for the designated protected monuments/sites/remains is addressed by the existing legislation. (However, there are several cultural properties in the project area that are not "protected", but are of significant cultural or religious value to the community. No procedure exists at present for conservation of these "smaller" cultural properties.)

Ancient Monuments & Archaeological Sites & Remains (Amendment and Validation) Act, 2010

This act has been enacted to amend the Ancient Monuments and Archaeological Sites and Remains Act, 1958 to make provision for validation of certain actions taken by the Government under the principal act and came into force on January 23, 2010. The limits of prohibited area and regulated area around the monuments, archaeological sites and remains as 100 m and 200 m, respectively, may be further extended on the basis of gradation and classification of the monuments, archaeological sites and remains by the National Monument Authority (NMA) to be constituted by the Government under this amended act.As per the provisions of this act, no permission for construction of any public projects or any other nature shall be granted in the prohibited area of the protected monument and protected area. However, permission for repair and renovation could be granted on the recommendation of the NMA, subject to the condition that the building or structure is pre-1992 or permission for construction or reconstruction of such building or structure was granted by the Archaeological Survey of India. In respect of regulated area, permission may be granted for construction, reconstruction, repair and renovation on the basis of recommendation of the NMA duly taking into account heritage bye-laws which shall be prepared in respect of each protected monument and protected area.

Cultural Environment Related Act, 1958

As a result of growing interest in cultural heritage in the nation, both government agencies and NGOs concerned with the preservation and conservation of this heritage. The Archaeological Survey of India under the Ministry of Culture is the primary organization for the archaeological researches and protection of the cultural heritage of the nation. Maintenance of ancient monuments and archaeological sites and remains of national importance is a principal concern of the organization. It regulates all archaeological activities in the country as per the provisions of the Ancient Monuments and Archaeological Sites and Remains Act, 1958 as well as Antiquities and Art Treasure Act, 1972.

Regulation / Act Governing Vibration

There is no prevailing regulation/standard in India governing train induced ground vibrations. Regulations/standards prevailing in other countries such as USA, Japan, and Sweden, etc. have been reviewed and compared with the findings of vibration monitoring in its respective chapter. Vibration Regulation Law in Japan issued by Ministry of the Environment, Government of Japan stipulates to preserve the living environment and contribute to the protection of the people's health by regulating vibration. As per this law, standards for vibration emitted from specified construction works and limits for motor vehicle vibration have been provided for different land use patterns. As per USA Federal
Transit Administration, the criteria for environment impact from ground-borne vibration are based on the maximum root-mean- square vibration levels for repeated events from the same source. Experience based on international standards provides a good foundation for predicting and controlling annoyance from ground-borne vibrations in residential areas as well as interference with vibration- sensitive activities.

Public Liability Insurance Act, 1991 and its Amendment, 1992

This act imposes on the owner the liability to provide immediate relief in respect of death or injury to any person or damage to any property resulting from an accident while handling any of notified hazardous chemicals. This relief has to be provided on a "no fault" basis. Owner handling hazardous chemicals has to take an insurance policy of an amount equal to its "paid up capital" or up to Indian Rupees 500 million, whichever is less. The policy has to be renewed every year. New undertakings have to take this policy before the commencement of the activity. The owner also has to pay an amount equal to its annual premium to the Central Government's Environment Relief Fund (ERF). The payment under the Act is only for the immediate relief; owners shall have to provide the final compensation, if any, arising out of the legal proceedings.

National Green Tribunal Act, 2010

The National Green Tribunal has been established on October 18, 2010 under the National Green Tribunal Act, 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues. The Tribunal is not bound by the procedure laid down under the Code of Civil Procedure, 1908, but shall be guided by the principles of natural justice. The Tribunal's dedicated jurisdiction in environmental matters shall provide speedy environmental justice and help reduce the burden of litigation in the higher courts. The Tribunal is mandated to make and endeavor for disposal of applications or appeals finally within 6 months of filing of the same.

National Green Tribunal (Practices and Procedure) Rules, 2011

National Green Tribunal (Practices and Procedure) Rules, 2011 have been notified by the MoEFCC on 4th April, 2011 through GSR No. 296 (E). These Rules describe the procedure in detail to follow the National Green Tribunal Act, 2010. As per the Rules, an application or appeal where compensation has been claimed shall be accompanied by a fee of equivalent to one percent of the amount of compensation claimed and an application or appeal where no compensation has been claimed shall be accompanied by a fee of one thousand Rupees. The Chairperson may constitute a bench of two or more members consisting of at least one Judicial Member and one Expert Member. Apart from procedure for application, hearing, filing of reply and Inspection of records, the Rules describes the details of compensation process. Form II of the Rules is for application of relief and compensation and Form I is for Memorandum of Application/Appeal.

National Environmental Policy (NEP), 2006

The National Environmental Policy (NEP), 2006 is a response to national commitment to clean environment mandated in the Indian Constitution and is intended to mainstream environmental concerns in all development activities.

National Forest Policies

The Ministry of Food and Agriculture formulated the National Forest Policy to be followed in the management of State Forests in the country long time back in 1952. The policy envisages in enhancing the forest coverage of the country to 33% of total geographical area of the country.

Fly Ash Utilization Notification, 1999 and its Amendment, 2003

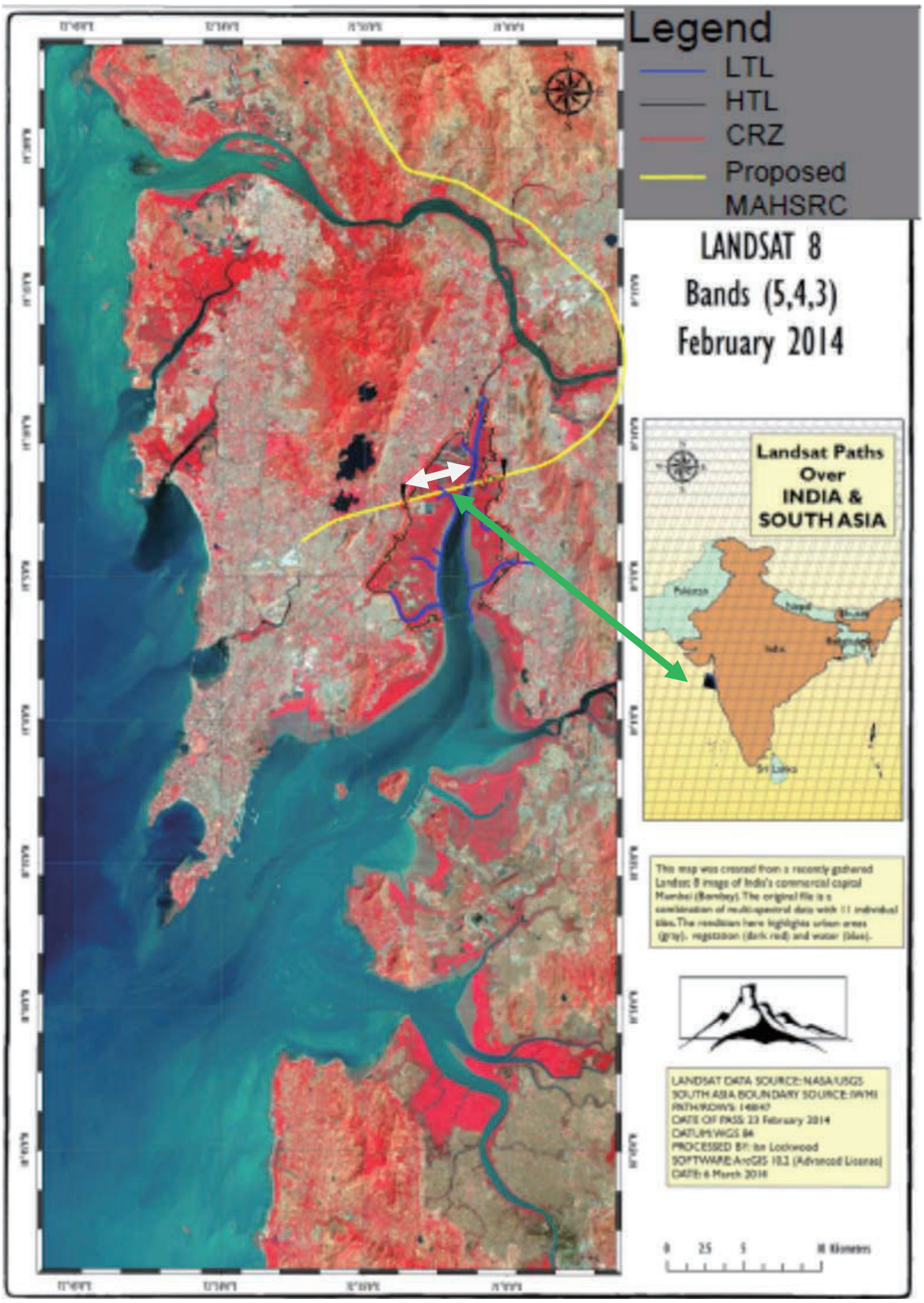
It is mandatory that every agency, person or organization shall utilize fly ash for construction of roads or flyovers or embankments or any other construction activity from the thermal power plants located within a radius of 100 kilometers of the construction site. This Notification recognizes that it is necessary to protect the environment, conserve top soil and prevent the dumping and disposal of fly ash discharged from coal or lignite based thermal power plants on land.

Hazardous Wastes (Management, Handling and Trans boundary Movement) Rules, 2008 and its Amendments

The management of hazardous waste is a complex set of rules which together combine to form the legal regime. The objective of these rules is to ensure environmentally sound management of all hazardous materials and to enable recovery and/or use of useful materials from hazardous waste destined for final disposal. Under these rules the definition of hazardous waste is divided into two definitions: hazardous waste and hazardous material. The rules establish the responsibility for the safe and environmentally sound handling of environmental waste by any ‘occupier’ of hazardous waste. An occupier is a person who has under his charge, any plant or factory producing hazardous waste or who holds hazardous waste. ‘Recycling’ is defined as reclamation or reprocessing of hazardous waste in an environmentally sound manner for the original purpose or for other purposes. ‘Reuse’ means the use of a hazardous waste for a purpose of its original use or other use. Hazardous waste held by an ‘occupier’ must be sent or sold to a recycler or re-processor who is authorized to dispose of it in the proper manner. Furthermore, a person engaged in the generation, processing, treatment, package, storage, transportation, use, collection and destruction, conversion, offering for sale and any occupier must obtain an authorization from the respective State Pollution Control Board.

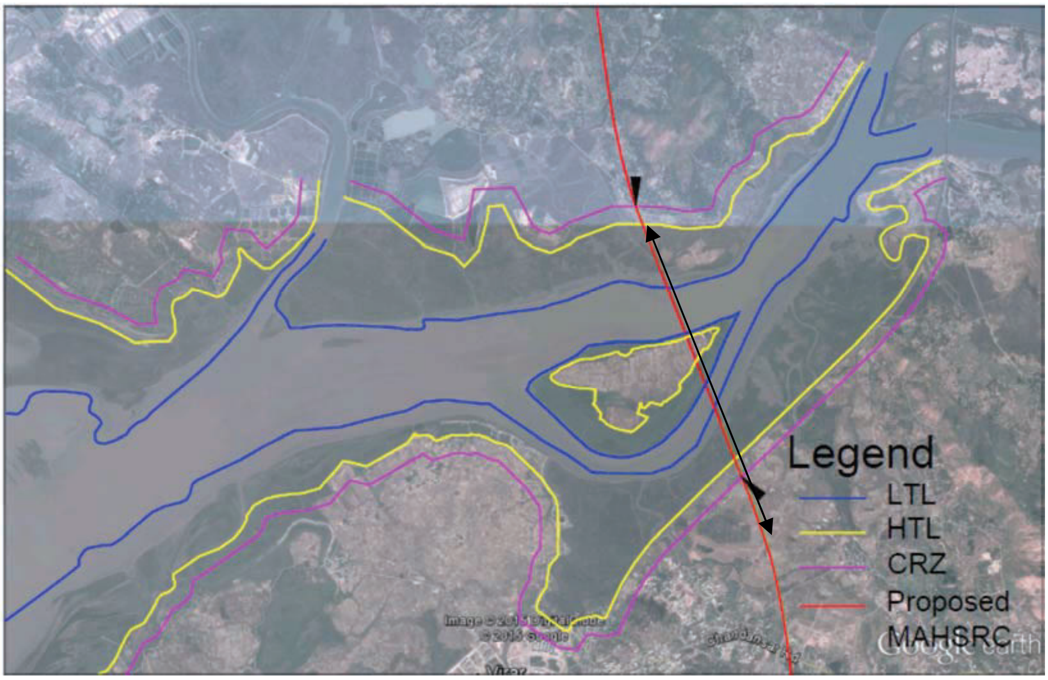
Coastal Regulation Zone (CRZ) Notification, 2011

The definition of CRZ has been widened to include the land area from "High Tide Line" (HTL) to 500 m on the landward side, as well as the land area between HTL to 100 m or width of the creek, whichever is less, on the landward side along tidal influenced water bodies connected to the sea. The CRZ also includes, for the first time, water area up to 12 nautical miles in the sea and the entire water area of a tidal water body such as creek, river, estuary without imposing any restrictions of fishing activities. The CRZ map of the Mumbai region placed at Figure 3.1.2 and Figure 3.1.3 shows the demarcation of Low Tide Line (LTL) and HTL CRZ area and superimposed proposed MAHSRC alignment. On perusal of the map it is evident that the proposed MAHSRC alignment measuring 6.71 km passes through the CRZ and also through the dense patches of mangroves. The proposed MAHSRC alignment between Gaskopari and Tembhikhodave measuring 2.71 km passes through the CRZ. In this case, both CRZ clearance and Forest clearance have to be obtained from the respective authority as per the detailed procedure are described in the Annexures of CRZ Notification in 2011.



Source: NRSA, Nagpur

Figure 3.1.2:CRZ Map of Mumbai Region with superimposed proposed MAHSRC Alignment



Source: NRSA, Nagpur

Figure 3.1.3:Detailed CRZ Map between Gaskopari and Tembhikhodave with superimposed proposed MAHSRC Alignment

Procedure for CRZ Clearance

Unlike the 1991 Notification which did not lay down the process for obtaining CRZ clearance, a specific procedure has been provided in the CRZ Notification 2011 for obtaining such clearance. This procedure is as follows:

(i) The project authorities shall submit the proposal to the concerned State/UT CZMA along with the following documents/reports,-

- Form-1 (Annexure-IV of the Notification);
- Rapid EIA Report including marine and terrestrial EIA. Comprehensive EIA and cumulative studies for port and foreshore requiring projects as per guidelines issued by MoEFCC from time to time;
- Disaster Management Report and Risk Management Report;
- CRZ map indicating HTL and LTL demarcated by an authorized agency (1:4000 scale);
- Project layout superimposed on the above mentioned map;
- The CRZ map shall normally indicate a 7 km radius around the project site.
- The CRZ map shall indicate the CRZ-I, II, III and IV areas;
- No Objection Certificate from the concerned Pollution Control Boards or Committees for the projects which envisage discharge of effluents, solid wastes, sewage *etc.* (NOC from the Pollution Control Boards or Committees has been made mandatory in view to minimize pollution in the coastal waters).

(ii) The concerned CZMA shall examine the above documents in accordance with the approved CZMP and CRZ Notification and make recommendations within a period of sixty days from date of receipt of above document to,-

- SEAC or EAC in case of the project attracting EIA Notification, 2006;

- MoEFCC or State Government for the project attracting CRZ Notification;

(iii) MoEFCC or State Government shall consider such projects based on the recommendations of the concerned CZMA within a period of sixty days.

Validity
The clearance accorded to the projects under the 2011 Notification shall be valid for the period of five years from the date of issue of such clearance.

MoEFCC Eco-sensitive Area Notifications
MoEFCC, from time to time, has brought out various Notifications on ESA across the country. These Notifications clearly mentions the prohibitive/ restricted activities and the minimum distance to be maintained for any sort of activities. These include non-establishment of any industrial unit adjacent to the eco-sensitive zone, no construction activities to be entertained in the vicinity and quarrying and mining to be strictly prohibited. In addition to the above activities tree felling, ground water extraction, increased noise levels, discharge of effluent and solid waste disposal are also strictly restricted activities in the ESA.

Dahanu ESA Notification, 1991 and its Amendments
Dahanu area which comes under the Thane district in the State of Maharashtra has mangrove forests, which is considered to be ESA and several legislations are supporting to safeguard of the mangrove areas in the district. Through this Notification, the Central Government in consultation with the Government of Maharashtra declared entire Dahanu Taluka as an ecologically fragile area and to impose restrictions on the setting up of industries which have detrimental effect on the environment. Further, an Authority known as Dahanu Taluka Environment Protection Authority (DTEPA) was constituted to exclusively monitor the activities in the area and implement all provisions as mentioned in the Notification.

Maharashtra Felling of Trees (Regulation) Act, 1964 and its Amendments
This Act makes better provision for regulating the felling of certain trees in the State of Maharashtra, for the purpose of the preservation thereof, and for the protection of the soil against erosion. There are restrictions on felling of 16 species of trees which are specified in the Schedule of the said Act (called as “Scheduled Trees”) in urban areas without the previous permission of the ‘tree officer’. An application made to a Tree Officer for felling a tree should contain the name of the owner of land on which the tree stands; number of trees to be felled; and the purpose for felling the trees. The application should be accompanied by a site plan, indicating the position of the trees required to be felled.

Mumbai High Court Order on Mangrove Areas
The Mumbai High Court has recently banned non-forest activities in the coastal areas of Maharashtra where mangroves are growing. A division bench of the Court ruled that “no non-forest activities shall be permitted throughout the state in mangrove areas” and such areas shall be treated as deemed ‘reserved forests’ and attract all provisions of the Forest Conservation Act, 1980.

Office Memorandum of MoEFCC on Order of Hon'ble Supreme Court

According to an office memorandum of the MoEFCC dated 18 May 2012 in order to ensure compliance of the Hon'ble Supreme Court's order of 27 Feb 2012, it is now mandatory to seek environmental clearance under the Environmental Impact Assessment Notification 2006 for mining of minor mineral materials such as sand, ordinary earth, stone, moorum, aggregate on land parcels of any area. It means the DFC project while identifying the possible sources of 'Borrow areas and Quarry sites' should ensure that any identified agency has a valid licensed lease to extract sand, moorum and other materials as well as has also obtained environmental clearance from the concerned department for the leased area and is complying with all stipulated conditions of the clearance letter.

Railways (Amendment) Act, 2008

The Railways Act, 1989 was amended in 2008, which is called the Railways (Amendment) Act, 2008 (RAA 2008). The RAA 2008 provides land acquisition process and procedures for special railway projects such as the MAHSRC, including valuation methodologies for land compensation.

Land Acquisition Act, 1984 and its Amendment

In India, land may be acquired by the Government for a public purpose under the principles of eminent domain, that is, the Government has the first right for land. Land is acquired by the Government most commonly under the Land Acquisition Act of 1894 modified in 1984. The amendment of 1984 extended the scope of the definition of public purpose and some of its norms related to time, amount and procedures of compensation. However, the Act in essence remains unchanged. The Act is applicable to the whole of country except the State of Jammu and Kashmir. The land needed for the DFC project will be acquired under the Act of 1894 and compensated as per the provisions of Act unless decided otherwise by the Government. Land acquisition under the Act on average takes two or three years. However, there is provision of an emergency clause under the Land Acquisition Act. This clause is not invoked to acquire land. The compensation as per the Land Acquisition Act includes the award amount, 30% solatium and interest of 12% from the date of issue of the notification under Section 4 of the Act. The valuation of trees and other immovable properties on the land is compensated based on the rates decided by the competent authority in consultation with concerned departments for the purpose of payment of compensation. However, this Act is not be applicable to MAHSRC project.

Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Social Impact Assessment and Consent) Rules, 2014 and Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (30 of 2013)

G.S.R. 574(E).—Whereas certain draft rules, namely the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Social Impact Assessment and Consent) Rules, 2014 were published as required under section 112 of the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (30 of 2013), vide notification of the Government of India in the Ministry of Rural Development (Department of Land Resources), number G.S.R. 101(E), dated the 20th February, 2014 in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (i) dated the 20th February, 2014 for inviting objections and suggestions from all persons likely to be affected thereby before the expiry of a period of thirty days from the date on which copies of the Gazette containing the notification were made available to the public. However, this Act is not be applicable to MAHSRC project.

Applicable Cross-Sectorial Laws

There are a number of laws that cut across all sectors and relate to development processes in the country. Some of these are directly relevant especially during the construction stage and are listed in Table 3.1.1.

Table 3.1.1: Applicable Cross-Sectorial Laws

Applicable Acts	Year	Objective
Minimum Wages Act	1948	As per this act, the employer is supposed to pay not less than the minimum wages fixed by appropriate Government.
Child Labor (Prohibition and Regulation) Act	1986	This Act prohibits employment of children below 14 years of age in building and construction industry covering Railway.
The Labors Act	1988	The health and safety of workers employed in construction work *etc.*
The Factories Act	1948	Health and safety considerations for workers
Workmen's Compensation Act	1923	This act provides for compensation in case of injury by accidents arising out of and during the course of employment.
Contract Labor (Regulation and Abolition) Act	1970	This act provides for certain welfare measures to be provided by the contractor to contract labor.
The Building and other Construction Workers Act	1996	All the establishments who carry on any building or other construction work and employ 10 or more workers are covered under this Act. The employer is required to provide safety measures at construction work site and other welfare measures such as canteens, first-aid facilities, ambulance, housing accommodation for Workers near the workplace *etc.*

Source: Study Team

3.2 Applicable Guidelines and Policies/Strategies

JICA Guidelines for Environmental and Social Considerations, April 2010

JICA enforced the new guidelines on environmental and social considerations in April 2010. As per this guideline, JICA supports the recipient governments by offering cooperation projects into which JICA incorporates appropriate environmental and social considerations so as to avoid or minimize development projects' adverse impacts on the environment and local communities. JICA thus promotes sustainable development in developing countries. JICA recognizes the following seven principles to be very important under environmental and social considerations of a project.

- Coverage of a wide range of environmental and social impacts to be addressed.
- Implementation of measures for environmental and social considerations at an early stage in project cycle based on analysis of alternatives.

- Incorporation of the outcome of environmental and social considerations in the implementation of projects after cooperation projects is terminated.
- Paying attention to accountability and transparency when implementing cooperation projects.
- Ensuring the meaningful participation of stakeholders in order to take consideration of environmental and social factors and to reach consensus accordingly.
- Disclosing information on environmental and social considerations in order to ensure accountability and to promote participation of various stakeholders.
- Capacity building of organizations to consider environmental and social factors appropriately and effectively at all times.

JICA classifies projects under three categories (A, B and C) according to extent of environmental and social impacts similar to the funding agencies categorization like World Bank (WB), Asian Development Bank (ADB) and Japan Bank for International Cooperation (JBIC). To make this classification, JICA takes into account an outline of the project, the scale, site condition, and environmental and social consideration study scheme in host countries. As per JICA guidelines, the impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety as well as the natural environment. Impacts on the natural environment include trans-boundary or global-scale impacts through air, water, soil, waste, accidents, water usage, climate change, ecosystems and biodiversity. The impacts to be assessed also include social impacts, which include the migration of populations and involuntary resettlement; local economy such as employment and livelihood; utilization of land and local resources; social institutions such as social infrastructure and local decision-making institutions; existing social infrastructures and services; vulnerable social groups such as the poverty level and indigenous peoples; equality of benefits and losses and equality in development process; gender; children's rights; cultural heritage; local conflict of interests and infectious diseases such as HIV/AIDS. In addition to the direct and immediate impacts of projects, derivative, secondary and cumulative impacts are also to be assessed in regard to environmental and social considerations within the extent possible. JICA takes into account the importance of good governance surrounding projects so that measures for appropriate environmental and social considerations are implemented. JICA respects the principles of internationally established human rights standards like the International Convention on Human Rights, and gives special attention to the human rights of vulnerable social groups – including women, peoples, persons with disabilities, and minorities-when implementing cooperation projects. JICA obtains country reports and information issued by related institutions about human rights, and JICA understands local human rights situations by disclosing information about cooperation projects. JICA discloses the information after making inquiries to the recipient governments and related organizations.

The National Environmental Policy (NEP), 2006

The NEP, 2006 is a response to a national commitment to a clean environment mandated in the Indian Constitution and is intended to mainstream environmental concerns in all development activities. NEP recognizes environmental degradation as a major causal factor in enhancing and perpetuating poverty particularly among the rural poor. One of the key objectives of NEP is to integrate environmental concerns into policies, plans, programs and projects for economic and social development. This policy has evolved from the recognition that only development which respects environmental concerns and ecological processes is sustainable. In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

National Forest Policies, 1952

The Ministry of Food and Agriculture formulated the National Forest Policy to be followed in the management of State Forests in 1952. However, forests in the country have been seriously degraded over time. As a result, the Forest Policy was revised in 1988 to review the situation and to evolve a new strategy of forest conservation. The principal aim of new Forest Policy is to ensure environmental stability and maintenance of ecological balance including atmospheric equilibrium which is vital for sustenance of all life forms, human, animal and plant. The derivation of direct economic impact must be subordinated to this principal aim. The policy aims at restoring forest coverage to 33% of the total geographical area of the country.

National Rehabilitation and Resettlement Policy, 2007

There is no comprehensive legislation, as yet, at the National or State level that governs the resettlement and rehabilitation of Project Affected Persons (PAPs). Ministry of Rural Development (Department of Land Resources), Government of India, approved a National Resettlement and Rehabilitation Policy (NRRP for PAFs, 2003, published in the Gazette of India on 17th February 2004. It recognizes the following essential features:

- That PAPs not only lose their lands, other assets and livelihoods, they also experience adverse psychological and social/cultural consequences;
- The need to minimize large-scale displacement and where displacement is inevitable, resettlement and rehabilitation has to be handled with utmost care. This is especially necessary for tribal, small and marginal farmers and women;
- That cash compensation alone is often inadequate to replace lost agricultural land, homesteads and other resources. Landless laborers, forest dwellers, tenants, artisans are not eligible for cash compensation;
- The need to provide relief especially to the rural poor (with no assets), small and marginal farmers, SCs/ STs and women;
- The importance of dialogue between PAPs and the administration responsible for resettlement for smoother implementation of projects and R&R;
- The policy is in the form of broad guidelines and executive instructions and will be applicable to projects displacing 500 families or more in plain areas and 250 families or more in hilly areas.

3.3 Applicable State Level Legislations

In Gujarat, felling and removal of trees from private lands have been governed by the Saurashtra Felling of Trees Act (1951). There are restrictions on felling of 26 species. As shown in Table 3.3.1, these species are divided into two categories, *i.e.* reserved and non-reserved.

Table 3.3.1:
Tree Species Listed in Saurashtra Felling of Trees (Infliction of Punishment) Act, 1951

Category	Local Name	Scientific Name
Reserved	Saag / Teak	*Tectona grandis*
	Seasam	*Dalbergis latifolia*
	Mahudo	*Madhuca latifolia*
	Chandan	*Santalum Album*
	Kahair	*Acacia catechu*
Non-Reserved	Timru	*Diospyros melanoxylon*
	Simlo / Semul	*Bombax Ceiba*
	Sadad	*Terminalia tomentosa*
	Karanj	*Pongomia pinnata*
	Kanji	*Holoptelea integrifolia*
	Sevan	*Gmelina arborea*
	Biyo	*Pterocarpus marsupium*
	Eboni	*Diospyros ebenum*
	Rohan	*Soymida febrifuga*
	Kadayo	*Sterculia urens*
	Kalam	*Mitrogynae parviflora*
	Haldarvo / Haldu	*Adina cardifolia*
	Harde	*Terminalia chebula*
	Dhavado	*Anogeissus latifolia*
	Aambo	*Mangifera indica*
	Taad	*Borassus flabelifer*
Non-Reserved	Khajuri	*Phoenix sylvestris*
	Jambu	*Syzygium cuminii*
	Desi Babul	*Acacia nilotica*
	Limbo / Neem	*Azadirachta indica*
	Khijado	*Prosopis cineraria*

Source: Gujarat Forest Department

For felling a reserved tree, prior permission of the Deputy Conservator of Forest, in writing, is mandatory. A royalty is charged for felling a reserved tree. In case of non-reserved category, written permission by the Deputy Conservator of Forest/Mamlatdar is required. However, regarding Limbo, Desi Baval, Kanji, Khijdo, Ambo and Amli found/grown on private non forest lands, the relaxation from above permission is admissible on certain conditions by the notification No.SFT-302004-393-G.1(1), 2008.

3.4 Role of Concerned Authorities

Ministry of Environment, Forests and Climate Change (MoEFCC)

MoEFCC is the nodal agency in the administrative structure of the central government for planning, promotions, co-ordination and overseeing the implementation of India's environmental and forestry policies and programs. The major responsibilities of MoEFCC include:

- Environmental resource conservation and protection, including EIA, clearance of developmental projects;
- Co-ordination with the other ministries and agencies, voluntary organizations and professional bodies for environmental action plans;
- Promotion of research and development, manpower planning and training and creation of environmental awareness;

- Liaison and coordination with international agencies involved in environmental matters.

Central and State Pollution Control Boards

The CPCB is responsible for pollution control throughout the country. In addition to the control of air, noise and water pollution it is also responsible to ensure effective control of disposal of hazardous wastes and storage and handling of hazardous chemicals and substances. With the enactment of air and water pollution laws, states have set-up their own State Pollution Control Boards (SPCB) to monitor industrial emissions and effluents and to approve the operation of new industries after careful scrutiny. The functions of the SPCBs include:

- The planning of comprehensive state programs for the prevention and control of air and water pollution and to ensure the implementation thereof;
- Inspection of pollution control equipment/ plants for monitoring of their efficiency.
- The SPCB in consultation with the CPCB may establish norms for air quality, gaseous emission and noise level *etc.*

Indian Boards for Wildlife and State Boards for Wildlife

Wildlife Division in the Ministry is responsible for carrying out the activities relating to Wildlife conservation with the State Governments and to provide financial and technical assistance to them for scientific management of the wildlife resources in the country. It is also responsible for carrying out the activities related to wildlife research and training of personnel involved in wildlife management through Wildlife Institute of India. Presently Wildlife Division is headed by the Addl. Director General of Forests (Wildlife) who is also Director, Wildlife Preservation and the Management Authority of Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Forest Department Gujarat And Maharashtra Forest Department

Both State Forest Department are entrusted with the prime responsibility of protection, conservation and development of the forests and wildlife of the state.

- Protection, Conservation and development of forests and wild life, the adoption of measures of soil conservation, moisture conservation and increasing soil fertility.
- The utilization of the forest so as to obtain the maximum yield consistent with their permanent maintenance and the supply of the needs of the people, agriculture, industry and defense.
- To conduct research into silviculture, utilization and other problems affecting the regeneration and development of the forests.
- To achieve the goals of National Forest policy 1988 and to cover the maximum area under forests.
- To create awareness among the people about the forests and environment.
- To increase the active participation of the local people in protection and conservation of forest with special emphasis on tribal, poor and women.

Supreme Court of India

Since 1996, the Supreme Court of India has assumed the role of the principal decision maker so far as issues relating to forests and wildlife are concerned. This has been due to Supreme Court's intervention through the following cases:

- The T. N. GodavarmanThirumulkpad vs Union of India and ores (WP No 202 of 1995) concerning the implementation of the Forest Conservation Act, 1980.
- The Centre for Environmental Law (CEL), WWF vs Union of India and ores (WP No 337 of 1995) concerning the issue of settlement of Rights in National Parks and Sanctuaries and other issues under the Wildlife (Protection) Act, 1972.

These cases are being heard for the last nine years and are a part of what is termed as "continuing mandamus", whereby the Courts, rather than passing final judgments, keeps on passing orders and directions with a view to monitor the functioning of the executive. They have led to fundamental changes in the pattern of forest governance and decision making. Some examples include:

- By virtue of the Supreme Court's order dated 13.11.2000 in the CEL WWF case (W.P. No. 337 of 1995), no forest, National Park or Sanctuary can be deserved without the approval of the Supreme Court.
- No non-forest activity is permitted in any National Park or Sanctuary even if prior approval under the Forest (Conservation) Act, 1980 has been obtained.
- The interim order dated 14.2.2000 prohibited the removal of any dead or decaying trees, grasses, drift wood etc. from any area comprising a National Park or a Sanctuary notified under Section 18 or 35 of the Wildlife (Protection) Act, 1972.

It was also directed that if any order to the contrary has been passed by any State Government or other authorities the operation of the same shall be stayed. In order to advise the Supreme Court on the various issues concerning forest and wildlife conservation, the Central Empowered Committee (CEC) was set up as an authority under Section 3 (3) of the EPA, 1986 to adjudicate on forest and wildlife related issues. Despite its wide impact and implication on forest management and governance most environment, human rights and activists groups and also the Government are not generally aware of the current developments in the Courts. Existing methods of reporting of Court's orders and judgments are generally inadequate and do not reach the concerned the groups in time. An Information Dissemination Service is therefore been envisaged as a neutral body that will keep a watch on the happenings in the Supreme Court and disseminate information through electronic as well as other means to interested groups and individuals on all decisions concerning the above two cases.

Maharshtra Coastal Zone Management Authority

It was in the year 1998 that the MoEF (under orders from the Supreme Court of India in 1996) constituted the Coastal Zone Management Authorities (CZMA) for each State having coastline (SCZMA) and National Coastal Zone Management Authority (NCZMA) to ensure the implementation of CRZ Notification, 1991.

Formation of MCZMA:

In exercise of the powers conferred by sub-sections (1) & (3) of Section-3 of the EPA, 1986, the Central Government has constituted Maharashtra Coastal Zone Management Authority (MCZMA).

Main functions of MCZMA:

- To take measures for protecting and improving the quality of the coastal environment

Examination of proposals for changes or modification in classification of CRZ areas;
- Enquiry into cases of alleged violation of the provisions of the CRZ Notification, 1991 and take appropriate decision under Section-5, 10 & 19 of EPA, 1986;
- To examine all projects proposed in CRZ areas and give their recommendations
- To identify ecologically, economically and highly vulnerable areas of the coastal zone and formulate area specific management plans.

National Coastal Zone Management Authority

1. S. O.991 (E).-In exercise of the powers conferred by sub-sections (I) and (3) of section 3 of the EPA, 1986 (29 of 1986) (hereinafter referred to as said Act) and in supersession- of the Order of the Government of India in the MOEF number J-17011/18/96-lA-III dated 13th August, 1998, except as respects things done or omitted to be done before such supersession, the Central Government hereby constitutes an authority to be known as the NCZMA (hereinafter referred to as the Authority) consisting of the following persons, for a period of two years, with effect from the date of publication of this Order in the Official Gazette, namely:

- Additional Secretary, (Impact Assessment), MOEF, New Delhi- Chairman
- Chief Town Planner, Member. Ministry of Urban Affairs and Employment, New Delhi.
- Director General (Tourism), Member. Ministry of Tourism, New Delhi,
- Fisheries Development, Member. Commissioner, Ministry of Agriculture.
- Joint Secretary (Ports), Member Ministry of Surface Transport, New Delhi.
- Director, Member National Institute of Oceanography, Panjim, Goa.
- Director, Member Central Marine Fisheries Research Institute, Cochin.
- Father Thomas Kocherry, Member Coordinator, World Forum of Fish Harvesters and Fish Workers (WFF), Valiathura, Thiruvananthapuram.
- Shri Bal Mane, Member President, Ratnagiri District Fishermen's Association, Ratnagiri, Maharashtra.
- Shri Shiga Kashinath Naik, Member Sarpanch Shioroda Kerwadi, Tehsil Vengurla, District Sindhudurg, Maharashtra.
- Shri Rajaram Gadhekar, Member Mukteshwar Sansthan, Apoogaon, Malad (West), Mumbai.
- Deputy Secretary, Member Secretary Impact Assessment, MOEF, New Delhi. Member, Secretary

2. The Authority shall have the power to take the following measures for protecting and improving the quality of the coastal environment and preventing, abating and controlling environmental pollution in coastal areas, namely:-

- Co-ordination of action by the SCZMA and the Union Territory CZMA under the said Act and the rules made thereunder, or under any other law which is relatable to the objects of the said Act.

- Examination of the proposals for changes and modifications in classification of CRZ areas and in me CRZ Plans received from the SCZMA and the Union Territory CZMA and making specific recommendations to the Central Government.

(a) Review of cases involving violations of the previous of the said Act and the rules made thereunder, or under any other law which is relatable to the objects of the said Act and, if found necessary, issue directions under section 5 of the said Act.

(b) Review of cases under (iii) (a) either suo-moto, or on the basis of complaint made by an individual or a representative body, or an organization functioning in the field of environment.

- File complaints, under section 19 of the said Act in cases of non-compliance of the directions issued by it under sub-paragraph (iii) (a) of paragraph II of the Order.

- To take action under section 10 of the said Act to verify the facts concerning the issues arising from sub-paragraphs (i), (iii) and (iii) of paragraph II of the Order.

3. The Authority shall provide technical assistance and guidance to the concerned State Government, Union Territory Governments/Administrations, the SCZMA, the Union Territory CZMA, and other institutions/organization as may be found necessary, in matters relating to the protection and improvement of the coastal environment.

4. The authority shall examine and accord its approval to area specific management plans, integrated CZMA and Union Territory CZMA.

5. The Authority may advise the Central Government on policy, planning, research and development, setting up of Centres of Excellence and funding, in matters relating to CRZ Management

6. The Authority shall deal with all environmental issues relating to CRZ which may be referred to it by the Central Government.

7. The Authority shall furnish report of its activities and the activities of the SCZMA and Union Territory CZMA at least once in six months to the Central Government.

8. The foregoing powers and functions of the Authority shall be subject to the supervision and control of the Central Government.

9. The Authority shall have its headquarters at New Delhi.

10. Any matter specifically not falling within the scope and jurisdiction of the Authority as so constituted shall be dealt with by the statutory authorities concerned.

Gujarat Coastal Zone Management Authority (GCZMA)

The MoEFCC, Government of India constituted the GCZMA for a period of three years vide Order dated 16th OCT, 2013.The main functions of the GCZMA are as follows:

1. The Authority shall have the power to take the following measures for protecting and improving the quality of the coastal environment and preventing, abating and controlling environmental pollution in areas of the State of Gujarat, namely:

(i) examination of proposals for changes or modifications in classification of CRZ areas and in the Coastal Zone Management Plan received from the State Government of Gujarat and making specific recommendations from CRZ point of view as per the provisions of the notification of the Government of India in the MOEF number S.O. 19 (E), dated the 06th January, 2011 published in the Gazette of India, Extraordinary, Part II, Section 3, Subsection

(ii) (a) inquiry into cases of alleged violation of the provisions of the said Act or the rules made thereunder or any other law which is relatable to the objects of the said Act and, if found necessary in a specific case, issuing directions under section 5 of the said Act, in so far as such directions are not inconsistent with any direction issued in that specific case by the NCZMA or by the Central Government;

(b) review of cases involving violations of the provisions of the said Act and the rules made thereunder or under any other law which is relatable to the objects of the said Act, and if found necessary referring such cases, with comments, for review to the NCZMA:

Provided that the Authority may take up the cases under clauses (a) and (b) of this sub-paragraphs, *suo motu* or on the basis of complaint made by an individual or a representative body or an organization;

(iii) filing complaints, under section 19 of the said Act, in cases of non-compliance of the directions issued by it under sub-paragraphs (i) and (ii);

(iv) To take action under section 10 of the said Act to verity the facts concerning the issues arising from sub-paragraphs (i) and (ii).

2. The Authority shall deal with environmental issues relating to CRZ which may be referred to it by the State Government of Gujarat, the NCZMA or the Central Government, as the case may be.

3. The Authority shall identify ecologically sensitive areas in the CRZ and formulate area-specific management plans for such identified areas.

4. Authority shall co-ordinate for implementing conservation projects or projects related to uplift fitment of coastal population protection, etc.

5. The Authority shall identity coastal areas highly vulnerable to erosion or degradation and formulates area-specific management plans for such identified areas and arrange for funding for the implementation of the same.

6. The Authority shall identity economically important stretches in the CRZ and prepares integrated Coastal Zone Management Plans (CZMP) for the same.

7. The Authority shall submit the plans prepared by it under paragraphs 4, 6 and 7 above and modifications thereof to the NCZMA for examination and its approval.

8. The Authority shall ensure compliance of all specific conditions that are laid down in the approved Coastal Zone Management Plan of Gujarat and the notification of the Government of India in the MOEF number S.O. 19(E), dated the 06th January, 20 II published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (ii).

9. The Authority shall furnish report of its activities at least once in six months to the NCZMA and the MOEF.

10. The quorum of the meeting of the Authority shall be one third of the total number of the members and in case the quorum is not available, the meeting shall be adjourned for thirty minutes and shall be reconvened. The Authority shall have its Bank Account in the National Bank to deposit the funds or fees received from the State Government, funding agencies or project authorities, etc. The State Government shall ensure that sufficient resources, manpower, funds are available to the Authority to discharge its functions effectively as specified in this order and the said Act.

11. The Authority shall take all necessary measures and initiatives including program execution, research, information dissemination, training, awareness day to day functioning, and advocacy etc. and adopt suitable procedures and means including raising resources, funding, *etc.,* for the same.

12. The Authority shall prepare and submit CRZ maps of the coastal areas in the State as per the procedure laid down in the notification of the Government of India in the MOEF number S.O. 19 (E), dated the 06th January, 2011 published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (ii) to the NCZMA and theMOEF.

13. The Authority shall regularly review the functioning District Coastal Zone Monitoring Committees.

14. The Authority shall direct all concerned planning authorities, field agencies, district collector to ensure the compliance of provisions of the notification of the Government of India in the MOEF number S.O. 19 (E), dated the 06th January, 2011 published in the Gazette of India, Extraordinary, Part II**,** Section 3, Sub-section (ii) and take suitable action in case of violations or non-compliance.

15. The pay and allowances such as Traveling Allowance, Dearness Allowance, Seating Fees, Field visit fees, *etc.*, shall be as per the norms decided by the Central Government.

16. The Authority, whenever required shall invite other expert as a member during its meeting.

17. Any matter specifically not falling within the scope and jurisdiction of the Authority shall be dealt with by the statutory authorities concerned.

18. The Authority may levy scrutiny fees as a polluter pays principle in consultation with the Environment Department.

19. The Authority shall process all the matters, proposals received, referred to or placed before it for CRZ Clearance as per the procedure laid down in the notification of the Government of India in the MOEF number S.O. 19 (E), dated the 06th January, 20 II published in the Gazette of India, Extraordinary, Part n, Section 3, Sub-section (ii) and clarifications and guidelines issued by MOEF. The Powers of issuing directions under section 5 of the EPA, 1986, read with the notification of the Government of India in the MOEF number S.O. 19 (E), dated the 06th January, 2011 published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (ii) are delegated to the Authority and the Chairman of the Authority and in case the directions are issued by the Chairman, such directions shall be placed before the Authority in its next meeting along with a report specifying the reasons for issuing of the directions and status thereof.

20. To maintain transparency in the working of the CZMP it shall be the responsibility of the Authority to create a dedicated website and post the agenda, minutes, decisions taken, clearance letters, violations, action taken on the violations and court matters including the Orders of the Hon'ble Court as also the approved CZMP of the State Government.

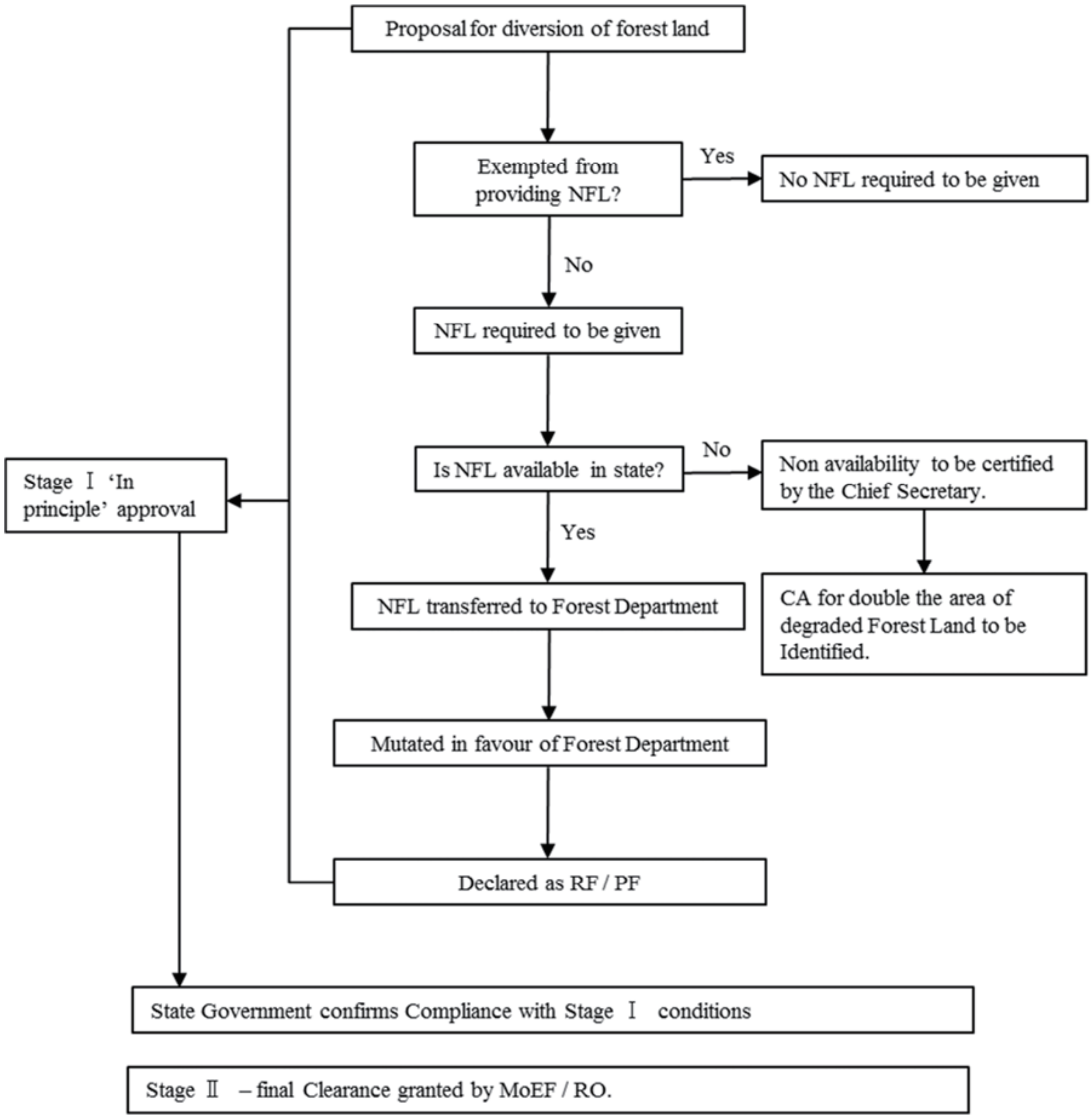
21. The foregoing powers and functions of the Authority shall be subject to the supervision and control of the Central Government.

22. The Authority shall have its headquarters at Gandhinagar.

3.5 Flow Chart for Various Clearances

Flow Chart for Granting Permission for Diversion of Forest Land

The flow chart for getting forest clearance (both for mangrove areas and other RF and PF) is shown in Figure 3.5.1.



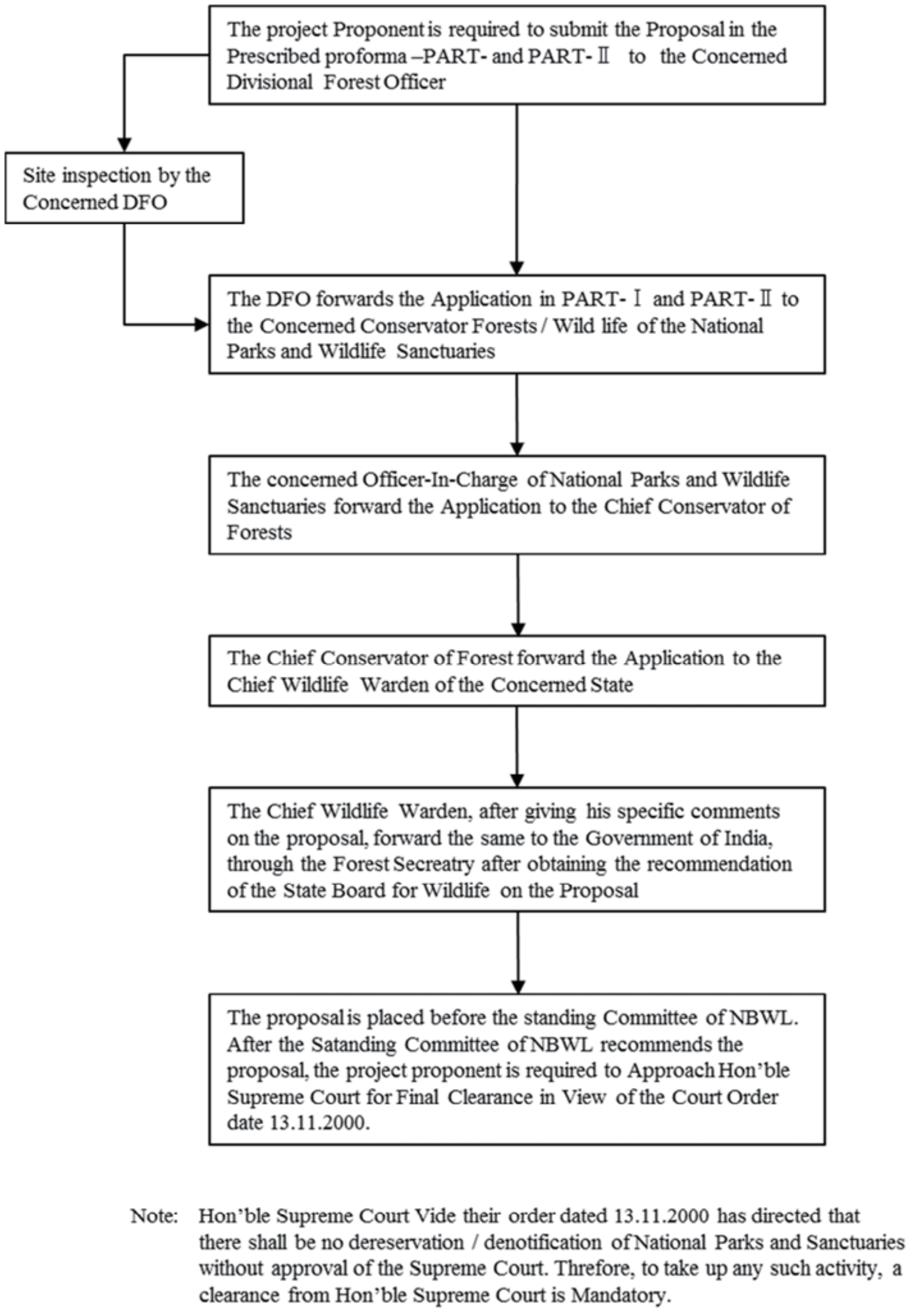
Note: NFL–Non forest land, CA–Compensatory Afforestation, PF-Protected Forest, RF-Reserve Forest

Source: Maharashtra Forest Department

Figure 3.5.1: Flow Chart for Granting Permission for Diversion of Forest Land

Procedure to be followed for Activities Inside National Parks/Wildlife Sanctuaries

In case the project site is located within the eco-sensitive zone or 10-km in absence of delineation of such a zone from the boundaries of National Parks, Wildlife Sanctuaries, the user agency, in this case the project proponent shall seek prior clearance from the Standing Committee of NBWL and the procedure shown in Figure 3.5.2 shall be followed.

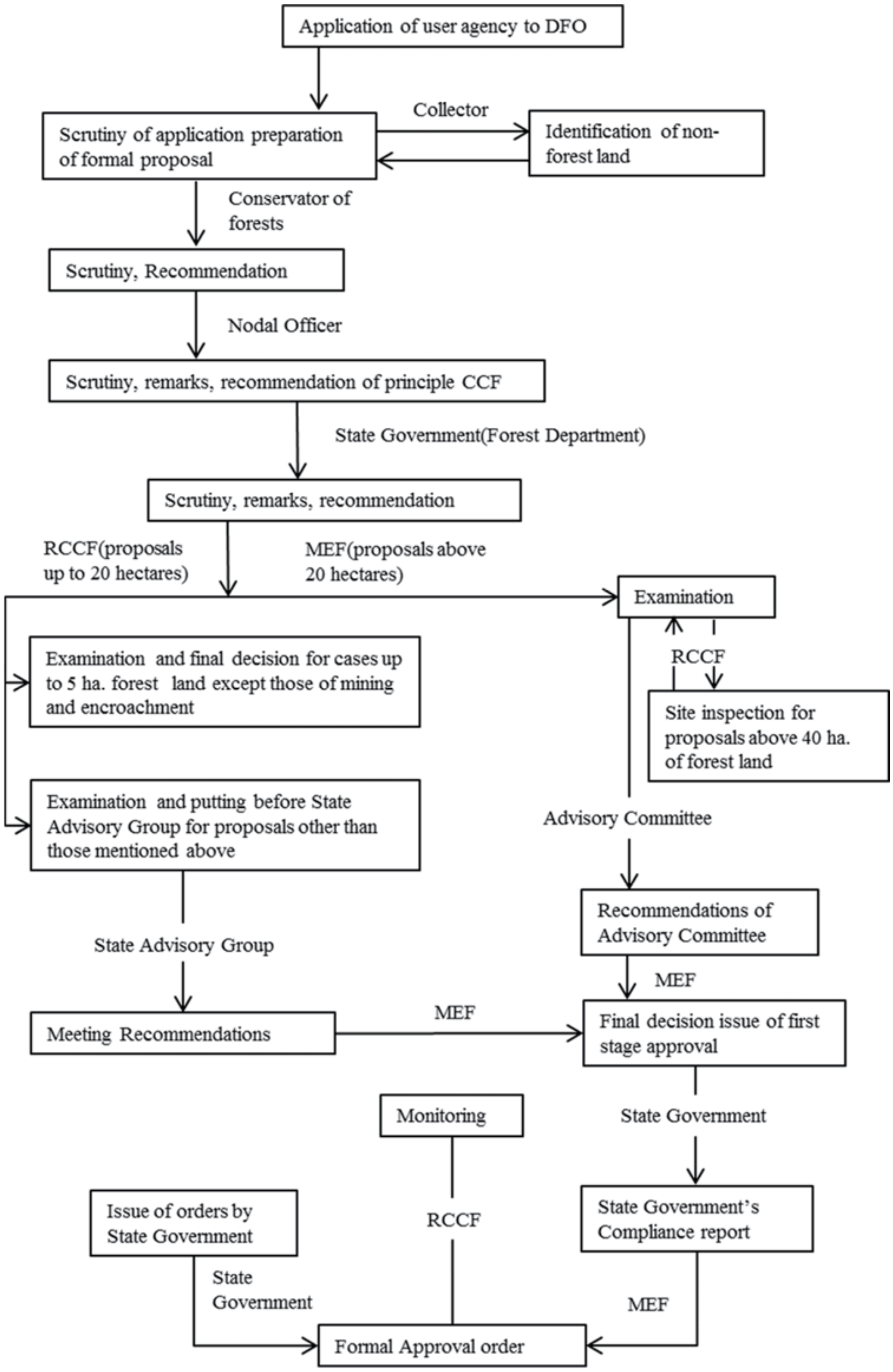


Source: Guidance Document issued by the MoEFCC

Figure 3.5.2:
Procedure to be followed for Activities Inside National Parks/Wildlife Sanctuaries

Flow Chart for Forest Clearance

The process flow chart for the forest clearance is shown in Figure 3.5.3.

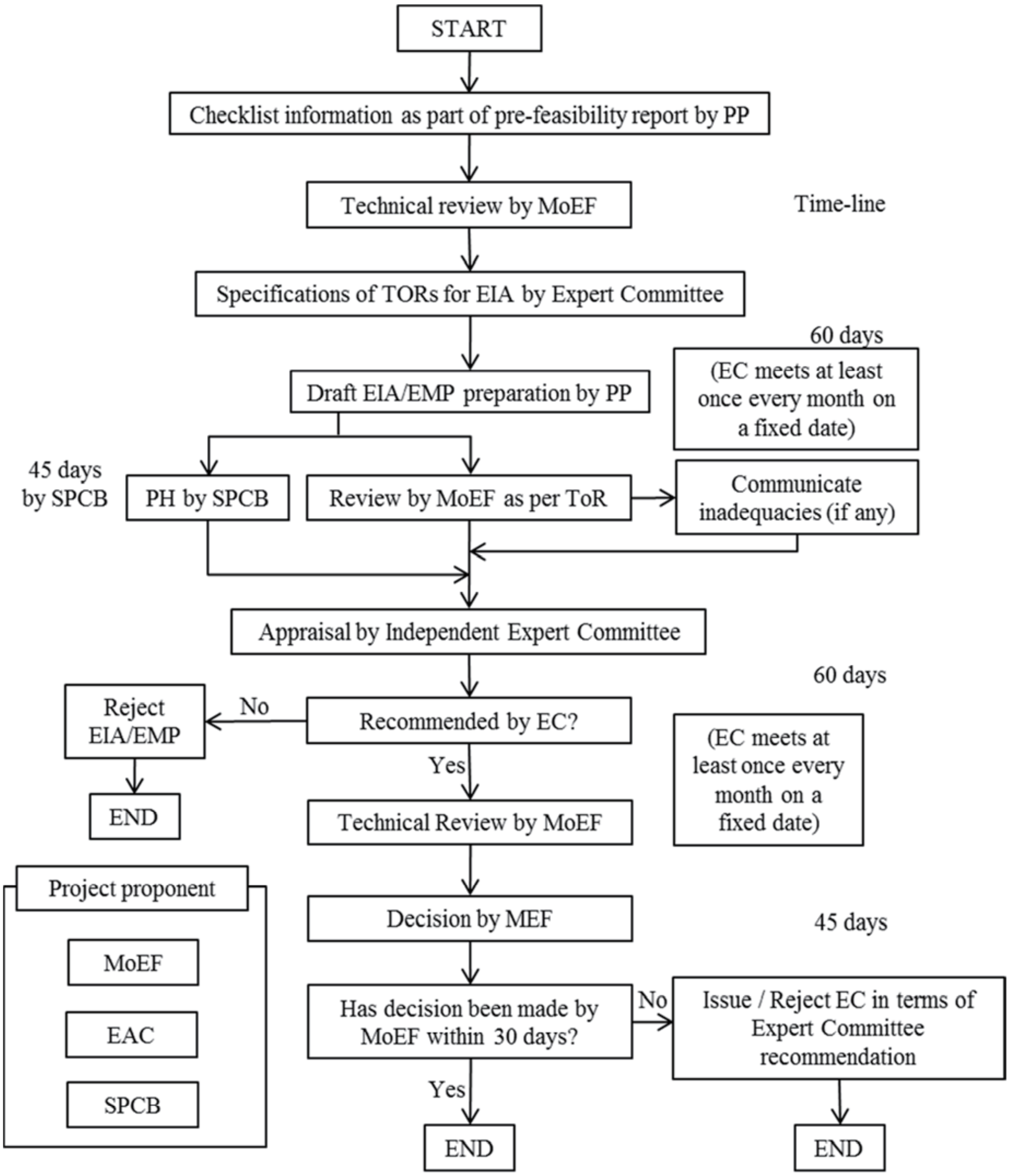


Source: Maharashtra Forest Department

Figure 3.5.3: Flow Chart for Forest Clearanc

Flow Chart for Environmental Clearance

The process flow chart for the Environmental Clearance is shown in Figure 3.5.4.



Source: EIA Notification 2006

Figure 3.5.4: Flow Chart for Environmental Clearance in India

Flow Chart for CRZ Clearance

The process flow chart for the CRZ Clearance is shown in Figure 3.5.5. The detail of the procedures followed for CRZ clearance is discussed in details in subsequent para. MCZMA is the CRZ authority within the state of Maharashtra for all projects whether in the government sector or those funded by private parties. All states of India have CZMA's and any two states can have a common CZMA, all of which report to the National CZMA chaired by the Secretary, MOEF. At the state level MCZMA is headed by the. Secretary, Environment Department, Government of Maharashtra and its primary function is in appraising project details received and recommendations towards CRZ approvals. Towards this purpose MCZMA demarcates the mangrove areas and CRZ boundaries. Necessary topographic maps and tidal variation data in this regard are obtained by employing approved agencies. All relevant local level details required by MCZMA are sourced through constituted district level committees of fisher folk and other community members and chaired by the District Collector of the coastal district who reports to MCZMA. Such a committee is also charged with enforcement & monitoring functions. The prescribed procedure for seeking CRZ clearance to any coastal project has been summarized as follows:

The project proponent should get a pre - feasibility level report and submit this to MCZMA along with;

- Project details in a fixed format (Form-1) which is actually a questionnaire of about 100 questions broadly divided into 3 categories, namely, basic project parameters, project activity details and perceived environmental sensitivity of the area concerned.

- Rapid EIA or Comprehensive EIA study should be carried out (depending on the type of project and erosion potential of the coastline) which must also address Disaster and Risk Management aspects of the project.

- CRZ mapping of an area covering up to a limit of 7 km radius showing the HTL / LTL and the proposed layout marked on such CRZ map in 1/4000 scale.

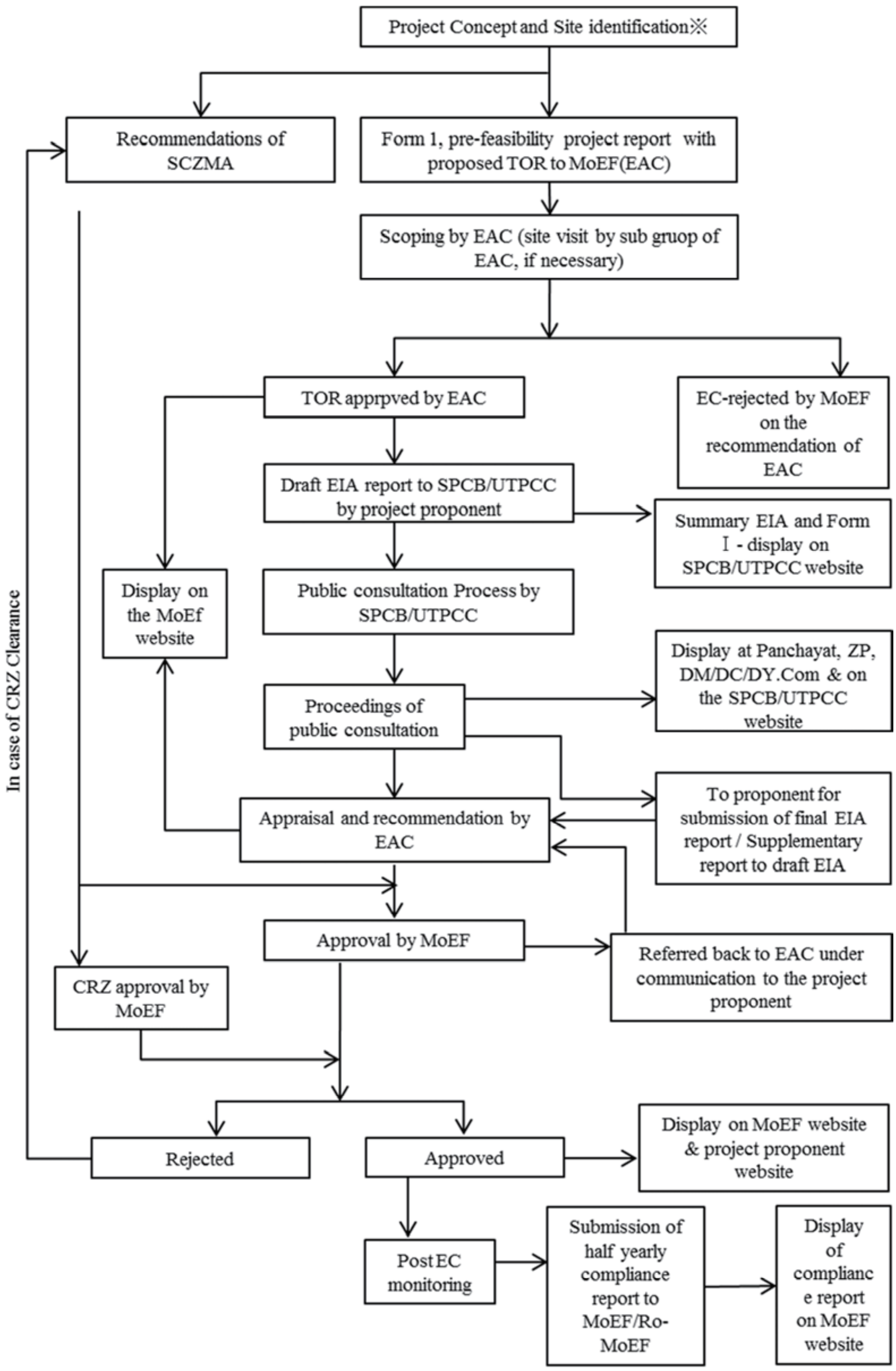
- NOC from the Maharashtra Pollution Control Board (MPCB) in respect of discharge of wastes / sewage / effluents. For this purpose where applicable, the PP must get a scientific study of oceanographic environment through a reputed agency like the National Institute of Oceanography, Goa (NIO) for submission to MPCB.

The MCZMA on receipt of all project details sought will then initiate necessary appraisal which interlaid, include appraisal with respect to CZMP available with them. MCZMA may also invite public representations for taking on board any local objections/suggestions to the proposed project and only after conclusion of evaluations forward to MoEFCC or SEIAA as applicable, their recommendation for CRZ clearances to the project. MoEFCC or SEIAA will then advise the concerned CZMA their approvals along with compliance requirements. A primary requirement of MCZMA is the maintenance of transparency and for ensuring the same MCZMA maintains a dedicated web site. CZMP is an important document for CRZ clearance. Responsibility for preparation of CZMP vests with the State Governments. Within Maharashtra, draft CZMP's are prepared by the State Environment Department (ED) through a body of experts constituted for the purpose and it is finalized after wide consultations with scientific community including reputed institutes and also among all stakeholders. The Coastal Zone Management Maps are prepared using the Survey of India topo sheets (1:25,000) showing details form an important component showing interlaid,

- HTL / LTL:
- CRZ's demarcated
- Local level CZP's
- Hazard Mapping taking into sea level rise , coastal erosion, tsunami waves
- Local fisher community dwellings
- No development / Future development zones
- Mangrove areas, Reserve Forests, National Parks, Wildlife Sanctuaries and other ecologically sensitive areas as applicable
- Defense and other security establishments as applicable

The draft CZMPs along with Maps as prepared at the state level and sent to MCZMA for their appraisal and .after MCZMA's appraisal to MoEFCC/SEIAA for final approval. Thus the coastal zone management map is an important document in the process.

The NCZMA is the apex body constituted by MoEFCC for reviewing functions of each CZMA through periodic meetings. NCZMA also reviews cases of CRZ approvals as well as acts as adjudicating authority in disposing complaints from public on SCZMA orders. NCZMA's brief also includes monitoring of demolition activities ordered by SCZMA's towards CRZ compliance. Due to rapid urbanization several outlying villages get amalgamated into city boundaries. In this regard, NCZMA has the duty to regulate shift in the CRZ boundaries with respect to city development plans. As apex national body, NCZMA's role is also for ensuring uniformity in the formulation of CZMP's from national perspective.



Source: Ministry of Environment, Forest and Climate Change

Figure 3.5.5: Flow Chart for CRZ Clearance in India

Chapter 4
Existing Environment of the Project Area

4.1 Natural Characteristic

This chapter describes the existing environmental conditions of the study area, which covers an area within 250 m of the either sides of the proposed alignment from the centre line for MAHSRC. The methodology of establishing baseline environmental scenario has been briefly described in this Chapter and further details of data generation/collection; analysis and interpretation are presented in the respective sections.

4.1.1 Climate and Temperature

The climatic conditions of the area are strongly influenced by its geographical setting. The study area can be divided into two parts-(i) the stretch of alignment which falls in the State of Gujarat and (ii) the alignment which falls in the State of Maharashtra. The area falling in the mainland of Gujarat has different weather condition in comparison to the area of Deccan Trap of Maharashtra and coastal region in the vicinity of Mumbai and Thane. In the subsequent section the general climate of the study area has been discussed. As per the Indian Meteorological Department, a year can be divided into following seasons in the Indian sub-continent:

Summer (Pre-monsoon):	March-to-May
Monsoon Season:	June–to-September
Post-monsoon Season:	October-November
Winter Season:	December-to- February

There are seven meteorological observatories operating in the study area-

- Ahmedabad
- Vadodara
- Surat
- Bharuch
- Mombai
- Mumbai (Santa Cruz)
- Dahanu (in Thane District)

<u>The Climate-Maharashtra Region</u>
In the study area, the climate of the area in the vicinity of Mumbai and Thane are more or less controlled by the coastal feature. The climate is characterized by an oppressive summer, dampness in the atmosphere nearly throughout the year, and heavy southwest monsoon rainfall. The cold season from December to February is followed by the summer season March to June. The period from June to about the end of September constitutes the southwest monsoon season. October and November form the post monsoon season.

<u>The Rainfall</u>

The average annual rainfall is about 2000 mm. The variation in the rainfall from year to year is quite appreciable. The highest annual rainfall was 167% of the annual normal, which occurred in 1917, whilst the lowest was only 51% of the normal, which occurred in 1905. About 94 per cent of the annual rainfall is received during the southwest monsoon from June to September. July is the rainiest month when about one third of the annual rainfall is received. Some rainfall mostly as thundershowers is also received during May and in the post monsoon months. During the period December to April there is very little rainfall. On an average there are 73 rainy days in a year (*i.e.* days with rainfall of 2.5 mm or more in a day)

The Temperature

There are three meteorological observatories in the Maharashtra region of the study area. The records of these observatories may be taken as fairly representative of the meteorological conditions in the area. But in the interior parts of the district (Thane), temperatures are likely to be slightly lower in the cold season and higher in the hot season than at Dahanu. Being coastal district, the variation of temperature during the day and between the three seasons is not large. After February temperature progressively increases till May which is the hottest month with the mean daily maximum temperature 33.3^{0}C and minimum temperature in May is 26.9^{0}C. In the summer season and in June before the onset of the monsoon day temperature may sometimes go above 37^{0}C in the coastal parts while in the interior it may be a couple of degree higher. On certain days the maximum temperature may occasionally go up to 40^{0}C. The oppressive heat is on most of the days, relieved by cool sea breezes particularly in the coastal regions. The afternoon thunder-showers on some days during the hot season also bring welcome relief. On the onset of the south-west monsoon by about the first or second week of June the temperature decreases a little. After the onset of the monsoon by about beginning of June, the weather becomes progressively cooler. But, towards the end of the southwest monsoon season, day temperature begins to increase slightly and a secondary maximum in day temperature is reached in November. Nights, however, become progressively cooler after the withdrawal of the monsoon. After November the day temperature also begins to decrease. January is generally the coldest month when mean daily maximum temperature is 29.1^{0}C; and minimum temperature is 19.4^{0}C. From about beginning of October when the south-west monsoon withdraws day temperature increases, and in October and November days are nearly as hot as in the summer, while nights become progressively cooler. After November, temperature decreases and in January which is the coldest month, the mean daily maximum temperature is 27.7^{0}C and the mean daily minimum 16.8^{0}C. In the cold season cold wave sometimes affect the district when the night temperature may go down to less than 10^{0}C. The highest maximum temperature recorded at Dahanu was 40.6^{0}C on 19^{th} April 1955 and lowest minimum was 8.3^{0}C on 8^{th} January 1945. The highest maximum temperature recorded was 40.6^{0}C in 1955. The lowest minimum temperature recorded was 7.4^{0}C in 1962.

The Relative Humidity

During June to September the relative humidity is above 75 per cent. The driest part of the year is during the period November to March with relative humidity between 50 and 65 percent.

The Cloudiness

During the southwest monsoon months, the sky is generally overcast. Cloudiness decreases after the withdrawal of the southwest monsoon towards the end of September. During the period December to march, normally clear or lightly clouded skies prevail. Later cloudiness increases with the progress of the season.

The Winds

Winds are generally moderate with appreciable increase in force during the monsoon month. Winds during May and the southwest monsoon season are mainly from directions between southwest and northwest (from the coast towards the land). For the rest of the year, winds blow from directions between north and east in the mornings and between west and north in the afternoons.

Special Weather Phenomena-Cyclones

During the pre and post monsoon months, the area experiences very strong winds, sometimes reaching gale force particularly near the coast and heavy rain in association with cyclonic storms, which develop in the Arabian Sea and move in the close proximity to the coast. Thunderstorms are common in the post-monsoon months and the later part of the hot season.

The Climate-Gujarat Region

Gujarat, being located on the Tropic of Cancer, falls in the sub-tropical climatic zone and a large part of the state lies between 35^0C and 45^0C isotherms. The rainfall in the state is moderate as it forms a transitional zone between the heavy monsoon area of Konkan (Maharashtra) in the South and the arid areas of Rajasthan in the North.On the basis of climate, Gujarat is divisible into following five regions:

- Sub- humid South Gujarat (Surat, Valsad, Dangs),
- Moderately humid Central Gujarat (Bharuch, Vadodara, Panch Mahals, Sabarkantha and parts of Ahmedabad),
- Humid and sultry South-facing coastal region of Saurashtra,
- Semi-arid North Gujarat (parts of Sabarkantha and Ahmedabad and Gandhinagar),
- Arid North Gujarat (Mehsana and Banaskantha).

March onwards the temperature starts rising till it reaches the maximum, as high as 45°C, in some parts of the state. January is the coldest month when the maximum temperature never exceeds 300C and the minimum temperature remains around 8°C to 10°C. The region receives much of its rainfall from the southwest monsoon during the period between June and September. It's maximum intensity being in the months of July and August. The rainfall gradually decreases northward; in the southernmost part (Valsad and Dangs) it is around 2000 mm, while in the extreme north it is as low as 300 mm. The relative humidity in all parts of the state is low, though in the coastal areas it is moderately high. The winds are generally light to moderate, increasing in intensity during the late summer and monsoon season. Coastal areas experience stronger winds. The winds blow from W or SW during the monsoon months and NE to NW from October to April. The part of the study area falls within the arid and semi-arid zones and is marked by the variability of annual rainfall and high annual temperature extremes. The climate in general is dry except for the monsoon season. The winter season starts from December and extends upto February. Summer approaches from March and peaks in May and June. The monsoon rain starts from the middle of June and continues upto September. The rainfall pattern (continuity, intensity and frequency) is of great importance for the Gujarat plains, particularly as they are situated on the margins of the Thar Desert. During the summer months, the mean daily maximum temperature is around 400C and mean daily minimum temperature around 250C, although temperatures touching peaks of 44-450C are not uncommon. Clear skies, low humidity and light northeasterly, northerly and northwesterly winds characterizes the winter season. During the coldest month of January the normal minimum temperature varies from 70C to 180C (mean around 140C); occasionally the mercury dips below to 3-40C.

(1) Data Collected

Climatological data for the period 1983 to 2005 of different meteorological observatories located in the study area like Dahanu, Ahmedabad, Surat, Bharuch, Vadodara, and Mumbai has been collected and used to bring out the synoptic features of the area (Table 4.1.1 to Table 4.1.6).

(2) Temperature

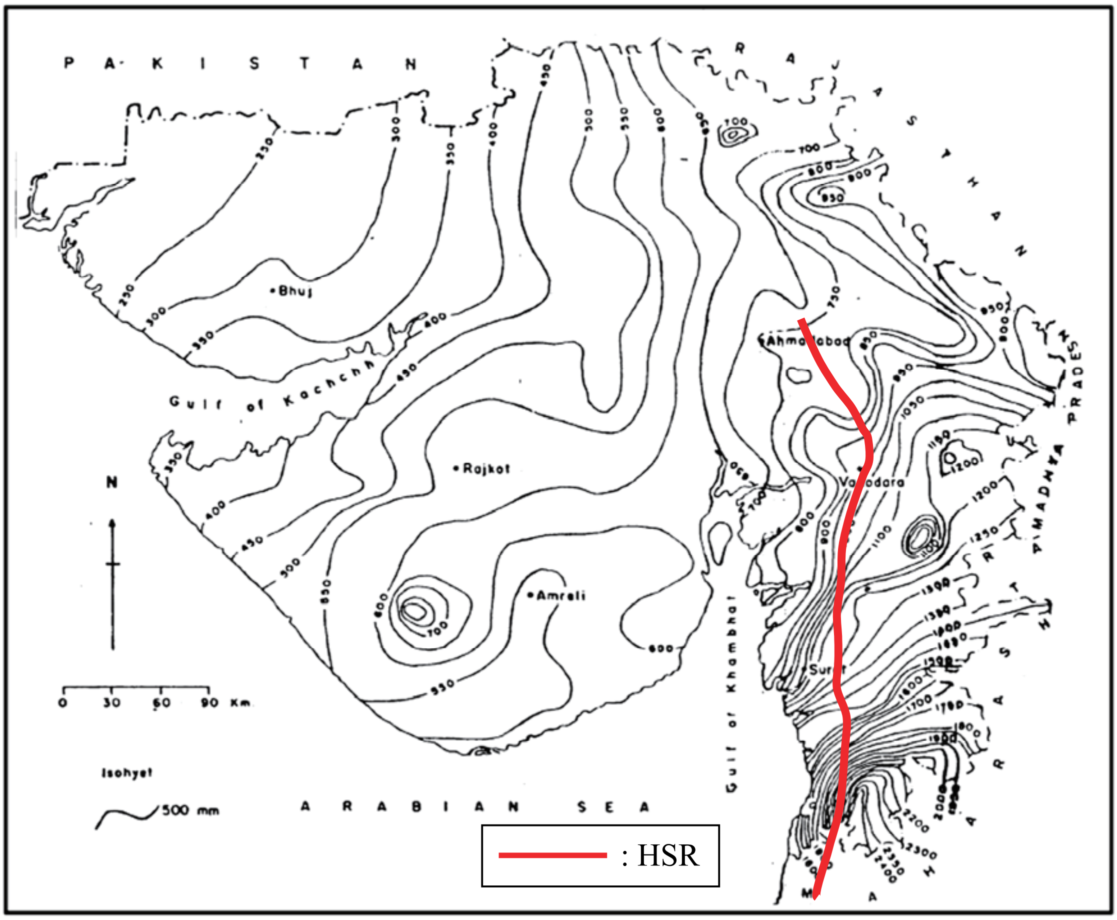
The temperature of the study area shows two different characteristics. The mean monthly temperature of the area falling in the Gujarat region varies from 7.3^{0}C to 44.7^{0}C, while same of the region falling close to Mumbai, varies from 15.8^{0}C to 36.8^{0}C. May is the hottest month of the year with mean monthly maximum temperature of 44.7^{0}C and January is the coldest month with mean monthly temperature of 7.3^{0}C reported in the Gujarat region of the study area. In the study area falling in the Maharashtra, the highest temperature 36.7^{0}C recorded at Dahanu meteorological observatory in the month of May, while the lowest temperature 15.8^{0}C at Mumbai in the month of January. The arid zone of Gujarat shows the extreme climate while the Maharashtra region shows tropical wet and dry climate. Mumbai's climate can be best described as moderately hot with high level of humidity. Its coastal nature and tropical location ensures temperatures won't fluctuate much throughout the year. Temperature gradually decreases with the onset of monsoon. With the passage of monsoon, in October, both day and night temperature further lowers gradually.

(3) Rainfall

The perusal of Table 4.1.1 to Table 4.1.6 indicates that long term rainfall (1983-2005) is erratic in Gujarat region while in Mumbai region the rainfall is on higher side in the monsoon months. The official date for the monsoon to hit the Mumbai region is 10th June. This period is marked by thunderstorms and often windy conditions as the monsoon establishes itself over the region. Rainfall activity intensifies as the month goes on, leading into wettest month, July. In the month of July, the region and especially the Mumbai city receive the maximum amount of rain. July and August are characterized by almost non-stop rain and weeks of no sunshine. A continuous monsoon current covers the entire western coast of India during this period. Rainfall activity is less stormy and more constant with a relatively constant breeze from the West or South West. It is not uncommon for parts of the city to be waterlogged during periods of persistent heavy rain. This affects the city's public transport system often leading to long delays. During periods of severe precipitation, the city's commuter rail system is often suspended because of water logging and poor visibility. The highest rainfall in the history of Mumbai was recorded on 26 July 2005. On this day, a record 944 mm rainfall fell over the city, causing large scale flooding, claiming several lives and causing large scale property damage. Contrary to the above, the Gujarat region receives abysmal rainfall. As per the records of the meteorological observatory, located in the Gujarat region, the annual rainfall to the tune of 1209.4 mm, 922.7 mm, 803.4 mm and 954 mm were recorded at Surat, Vadodara, Ahmedabad and Bharuch respectively. Surat being nearer to the coast, Gulf of Khambhat, the rainfall is slightly higher in comparison to other cities. As per the Agro-Climatic Zone, the proposed Navsari and Valsad Railway Stations fall in South Gujarat Heavy Rainfall Zone, where the annual rainfall to the tune of 1793 mm is received. The annual isohyte of Gujarat is depicted in Figure 4.1.1 The Isohyte map of Maharashtra for the year 2007 and 2008 are illustrated in Figure 4.1.2 and Figure 4.1.3.

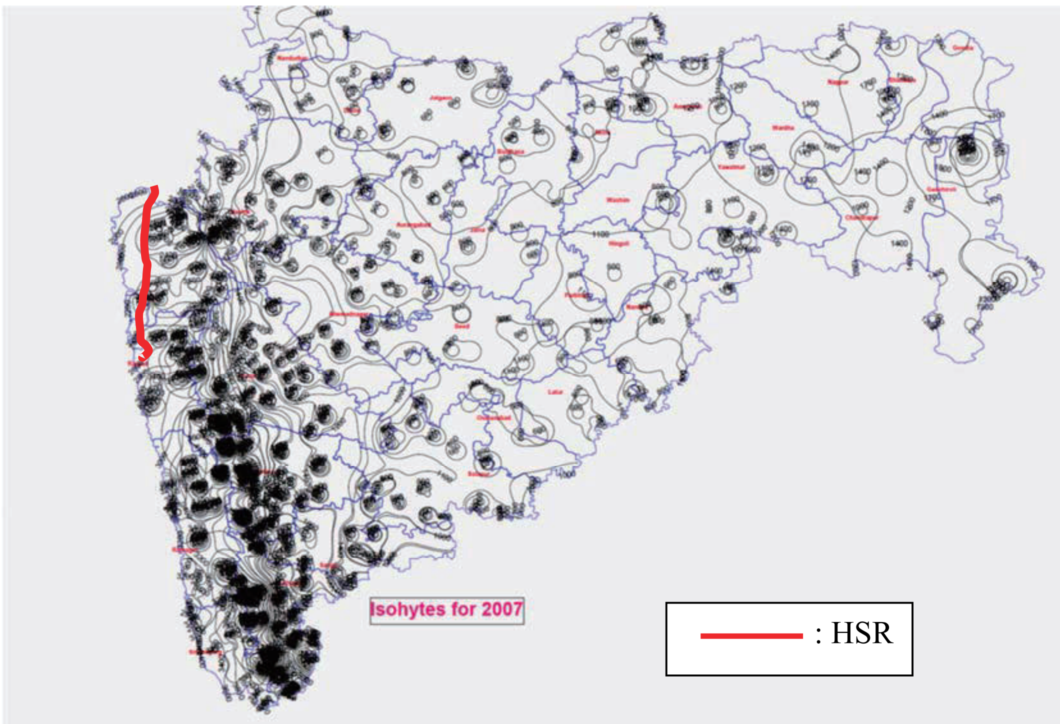
(4) Relative Humidity

Relative humidity measures the actual amount of moisture in the air as a percentage of the maximum amount of moisture the air can hold. It is expressed in terms of per centage. Generally, the relative humidity is minimum in January, February and March. The relative humidity increases as the temperature moves upward and maximum in June, July and August. In the study area, in Gujarat region, the relative humidity varies from 37 per cent to 84 per cent. The maximum relative humidity 84 per cent was recorded at Bharuch in the month of July, at Surat in the month of July and August respectively. In the Mumbai region, the humidity level is almost on higher side due to proximity of the sea. In this region, the relative humidity varies from 44.1 per cent to 87 per cent. The lowest relative humidity was recorded as 44.1 per cent at Dahanu in the month of February and the highest 87 per cent in the month of July and August at the same place.



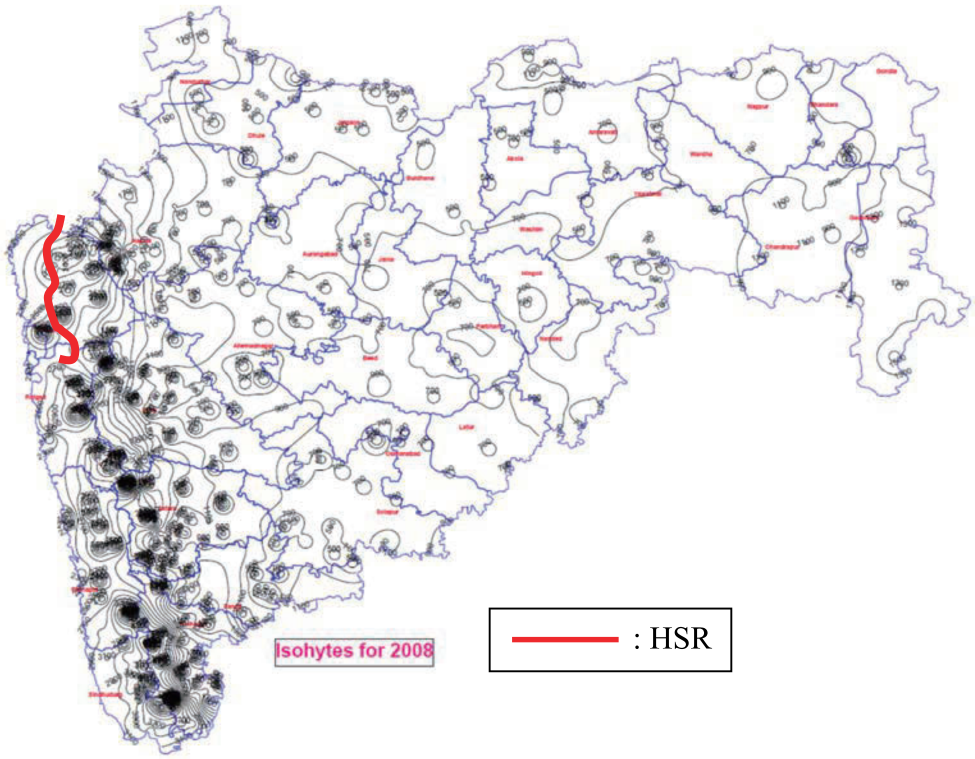
Source: www.imdpune.gov.in/

Figure 4.1.1: Isohyte Map of Gujarat



Source: www.imdpune.gov.in/

Figure 4.1.2: Isohyte Map of Maharshtra-2007



Source: www.imdpune.gov.in/

Figure 4.1.3: Isohyte Map of Maharshtra-2008

(5) ATMOSPHERIC PRESSURE

The diurnal variation of atmospheric pressure reveals that the barometric pressure is highest during early morning and gradually decreases as the earth's surface starts warming up through absorption of solar radiation to reach a minimum at or immediately after sunset. This diurnal variation has been observed to be true, irrespective of the season. As regards monthly variation, it has been observed that barometric pressure is lowest in the month of June and July and highest in December and January. On perusal of the Tables 4.1.1 to 4.1.6, the lowest atmospheric pressure was observed as 995.2 hPa (8.30 HRS IST)-992.1 hPa (17.30 HRS IST) at Ahmedabad in the month of July and the highest was recorded as 1013.3 hPa (8.30 HRS IST)-1009.9 hPa (17.30 HRS IST) at Bharuch in the month of January.

(6) WIND SPEED AND DIRECTION

In the coastal region the wind speed is good throughout the year. The monthly mean wind speed varies from 6.7 km/hr to 17.9 km/hr. In view of the good wind speed, dispersal of gaseous releases will be good. In the mainland of Gujarat the mean monthly wind speed varies from 3.0 km/hr to 14.7 km/hr. Throughout the study area, the annual mean wind speed varies from 5.5 km/hr (IMD, Vadodara) to 10.5 km/hr (IMD, Dahanu).

In the coastal region of Mumbai, the general direction of wind is from Northwest. The direction of wind varies with the change of season. In the dry season, from February to May, the wind is from northwest (NW); from June to September (the monsoon months), the wind is from west-north-west (WNW); and from October to January (post-monsoon and winter seasons), the wind is from north-north-west (NNW). In the mainland of Gujarat, the Winds blow from W and SW for most part of the year. During the winter months, the wind is from northeast corridor. The records of the meteorological observatories of the study area of Gujarat reveal that the wind is from southwest corridor in most part of the year. However, in the months of October to December, it is from northeast. The annual wind rose diagrams of all IMD stations of the study area are shown in Figure 4.1.4 to Figure 4.1.9. However, the current wind rose diagram based on the Automatic Weather Station (AWS) data for the month of November 2014, for different stations-Bharuch, Vadodara, Panch Mahals, Surat, Thane and Mumbai of the study area has been plotted and illustrated in Figure 4.1.10 to Figure 4.1.15.

(7) CONCLUSIONS

The following conclusions can be drawn from the long term climatological data:

- The area is sub-tropical and humid;
- The area receives rainfall mainly during the southwest monsoon months;
- The wind is gentle with low to moderate strengths;
- The area falling in the Gujarat region prone to draught.

Table 4.1.1: Climatological Data of IMD, Dahanu (1983-2005)

Month	Minimum Temp (^oC)	Maximum Temp (^oC)	Mean Monthly Relative Humidity (%)	Monthly Atmospheric Pressure (hPa)		Monthly Mean Wind Speed (km/hr)	Monthly Rainfall (in mm)
				8.30 IST	17.30 IST		
January	19.5	32.8	44.9	1013.1	1010.1	7.5	0.6
February	19.2	30.5	44.1	1012.0	1008.9	8.4	1.5
March	23.5	32.8	46.0	1010.6	1007.3	9.3	0.1
April	24.2	36.8	54.2	1008.7	1005.2	10.4	0.6
May	24.8	36.7	66.9	1006.6	1003.6	11.9	13.2
June	24.4	32.0	83.1	1003.5	1001.3	15.0	574.1
July	23.8	26.2	87.0	1002.7	1001.1	17.9	868.3
August	23.3	25.9	87.0	1004.2	1002.4	15.7	553.0
September	22.7	26.5	84.0	1007.0	1004.5	10.0	306.4
October	23.0	29.5	67.5	1009.5	1006.5	6.8	62.9
November	22.8	30.4	48.4	1011.8	1008.7	6.7	14.9
December	21.4	29.4	44.8	1013.0	1010.0	6.8	5.6
Total/ Average	**22.7**	**30.8**	**63.3**	**1008.6**	**1005.8**	**10.5**	**2422.1**

Source; Climatological Data Book of IMD

Table 4.1.2: Climatological Data of IMD, Mumbai (1983-2005)

Month	Minimum Temp (^oC)	Maximum Temp (^oC)	Mean Monthly Relative Humidity (%)	Monthly Rainfall (in mm)	Monthly Mean Wind Speed (km/hr)	Monthly Atmospheric Pressure (hPa)	
						8.30 IST	17.30 IST
January	15.8	33.7	67	0.5	8.0	1013.2	1010.3
February	16.8	34.5	67	1.0	8.6	1012.1	1009.2
March	20.0	34.9	68	0.3	9.3	1010.8	1007.7

April	22.9	34.7	70	1.9	9.5	1009.0	1005.6
May	24.8	34.7	69	11.0	9.3	1007.0	1004.0
June	23.4	34.4	78	583.6	11.9	1003.8	1001.7
July	23.4	31.9	85	750.4	14.2	1003.1	1001.5
August	23.3	31.3	82	460.9	13.3	1004.6	1002.9
September	23.0	32.2	77	258.6	9.2	1007.3	1004.8
October	22.3	35.6	70	64.9	6.9	1009.7	1006.7
November	20.6	35.6	69	10.4	6.7	1011.9	1009.0
December	17.9	34.6	68	3.1	7.3	1013.1	1010.2
Total/ Average	**15.4**	**36.9**	**72.5**	**2146.6**	**9.5**	**1008.8**	**1006.1**

Source; Climatological Data Book of IMD

Table 4.1.3: Climatological Data of IMD, Bharuch (1983-2005)

Month	Minimum Temp (^oC)	Maximum Temp (^oC)	Mean Monthly Relative Humidity (%)	Monthly Rainfall (in mm)	Monthly Mean Wind Speed (km/hr)	Monthly Atmospheric Pressure (hPa)	
						8.30 IST	17.30 IST
January	7.9	34.9	52	1.2	5.9	1013.3	1009.9
February	9.8	38.4	45	1.0	6.2	1011.8	1008.1
March	14.1	41.7	44	0.8	7.0	1010.0	1005.9
April	19.5	43.6	56	1.0	8.8	1007.6	1003.4
May	23.4	44.4	70	12.5	12.4	1005.0	1001.0
June	23.0	39.8	81	121.0	14.7	1001.3	998.1
July	23.5	35.9	84	307.6	13.2	1000.0	997.7
August	23.4	34.4	76	243.1	11.5	1001.6	999.0
September	22.7	36.5	60	197.6	8.6	1005.1	1002.1
October	17.3	38.4	58	35.2	5.7	1008.7	1005.1
November	13.1	37.4	55	3.7	4.7	1011.8	1008.5
December	9.7	35.0	54	0.1	5.2	1013.4	1010.1
Total/ Average	**7.4**	**44.8**	**61.25**	**954.6**	**8.7**	**1007.5**	**1004.1**

Source; Climatological Data Book of IMD

Table 4.1.4: Climatological Data of IMD, Ahmedabad (1983-2005)

Month	Minimum Temp (^oC)	Maximum Temp (^oC)	Mean Monthly Relative Humidity (%)	Monthly Rainfall (in mm)	Monthly Mean Wind Speed (km/hr)	Monthly Atmospheric Pressure (hPa)	
						8.30 IST	17.30 IST
January	7.3	32.1	43	2.6	5.8	1009.7	1006.7
February	8.5	35.7	36	1.1	5.9	1008.2	1004.8
March	13.1	40.2	32	1.0	6.3	1006.0	1002.2
April	19.1	43.2	35	0.9	7.0	1003.3	999.0
May	22.7	44.7	43	6.0	9.2	1004.4	995.4
June	23.4	42.4	60	108.7	10.1	996.6	992.2
July	23.7	37.6	76	265.3	8.7	995.2	992.1
August	23.2	35.2	79	219.8	7.2	997.0	994.0
September	22.0	37.3	71	171.9	6.0	1001.0	997.6
October	16.6	38.2	51	10.8	4.3	1005.2	1001.9
November	12.6	36.0	43	8.9	4.6	1008.5	1005.3
December	8.6	32.7	45	2.6	5.3	1010.0	1006.8
Total/ Average	**6.4**	**44.9**	**51.17**	**803.4**	**6.7**	**1003.4**	**999.8**

Source; Climatological Data Book of IMD

Table 4.1.5: Climatological Data of IMD, Vadodara (1983-2005)

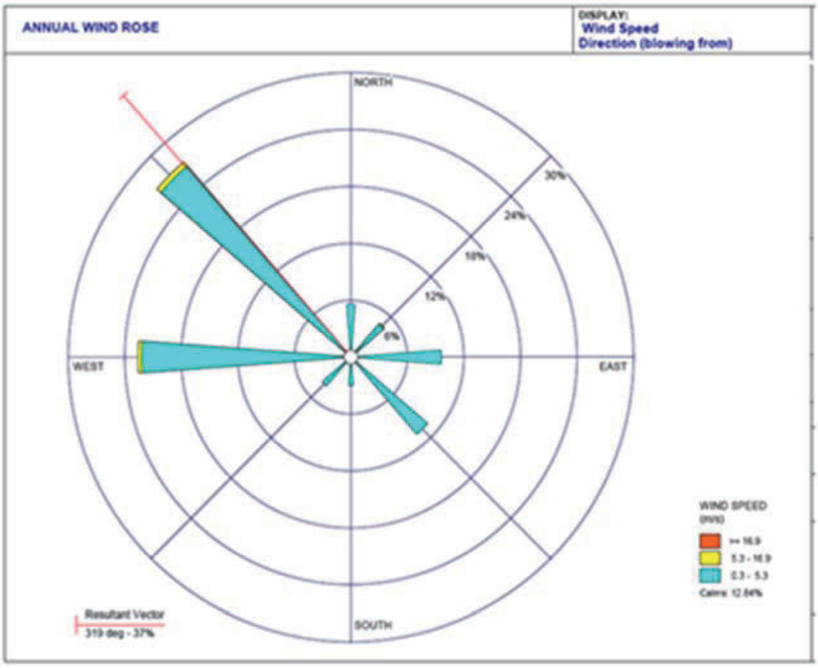
Month	Minimum Temp (°C)	Maximum Temp (°C)	Mean Monthly Relative Humidity (%)	Monthly Rainfall (in mm)	Monthly Mean Wind Speed (km/hr)	Monthly Atmospheric Pressure (hPa)	
						8.30 IST	17.30 IST
January	7.5	34.3	50	1.2	4.0	1011.8	1008.5
February	8.9	37.9	43	0.6	4.1	1010.3	1006.7
March	13.1	41.5	37	2.2	4.2	1008.5	1004.3
April	18.4	43.9	37	0.9	4.8	1005.9	1001.4
May	23.2	44.5	46	4.4	8.7	1003.1	998.3
June	23.5	41.5	64	146.8	10.3	999.4	995.4
July	23.5	36.9	80	297.6	8.4	998.1	995.3
August	23.4	34.6	82	284.7	7.1	999.8	997.0
September	22.4	37.0	75	141.7	5.1	1003.6	1000.2
October	16.7	38.5	58	22.0	3.0	1007.5	1004.0
November	12.9	37.2	53	16.2	3.0	1010.5	1007.2
December	9.6	34.5	55	4.4	3.6	1011.9	1008.7
Total/ Average	**6.9**	**44.8**	**56.67**	**922.7**	**5.5**	**1005.9**	**1002.3**

Source; Climatological Data Book of IMD

Table 4.1.6: Climatological Data of IMD, Surat (1983-2005)

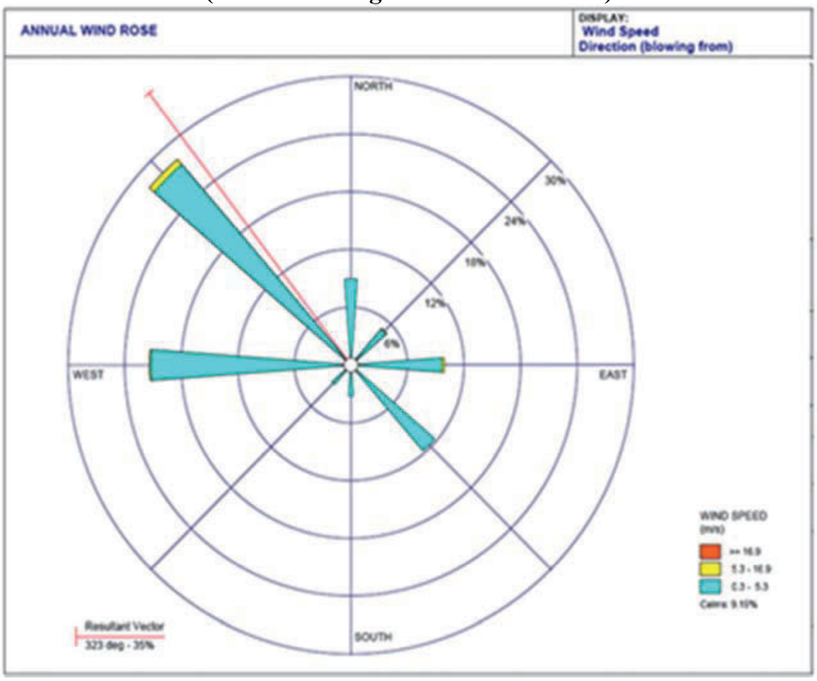
Month	Minimum Temp (°C)	Maximum Temp (°C)	Mean Monthly Relative Humidity (%)	Monthly Rainfall (in mm)	Monthly Mean Wind Speed (km/hr)	Monthly Atmospheric Pressure (hPa)	
						8.30 IST	17.30 IST
January	10.3	35.5	52	0.0	6.9	1014.2	1010.9
February	11.5	38.1	48	0.4	7.1	1021.9	1009.3
March	15.7	41.0	48	1.5	7.5	1011.2	1007.2
April	20.3	42.4	52	0.3	8.3	1008.8	1004.7
May	23.5	41.9	57	7.3	1.9	1006.2	1002.6
June	23.4	37.4	75	249.3	13.5	1002.4	999.8
July	23.3	34.4	84	417.7	12.6	1001.3	999.1
August	23.2	33.2	84	299.4	11.0	1003.0	1000.8
September	22.5	36.4	73	190.7	7.9	1006.5	1003.5
October	19.4	38.7	61	27.2	6.2	1010.1	1006.6
November	15.5	37.7	52	13.0	6.6	1012.9	1009.5
December	12.1	35.9	54	2.6	7.2	1014.2	1010.9
Annual Average	**9.7**	**43.3**	**61.67**	**1209.4**	**8.9**	**1006.5**	**1005.4**

Source; Climatological Data Book of IMD



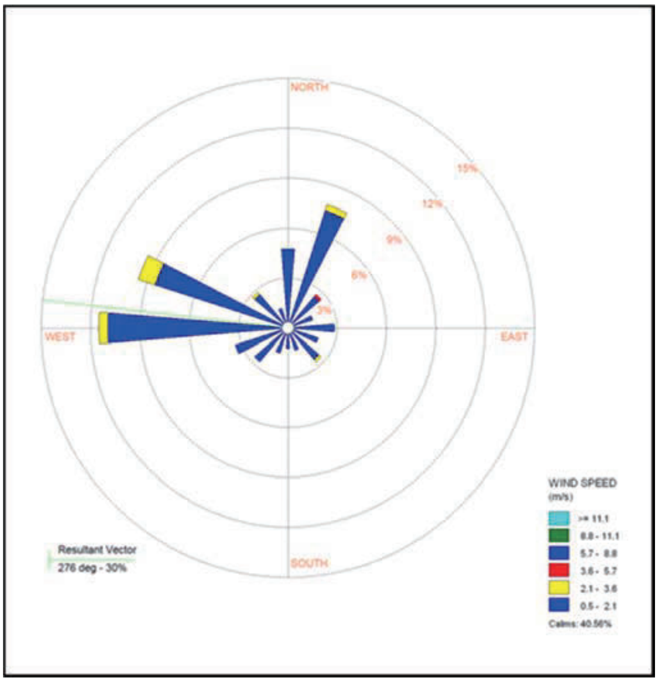
Source: Prepared by Study Team-GPSTPL

Figure 4.1.4: Annual Wind Rose Diagram of Dahanu (Based on Long Term Data of IMD)



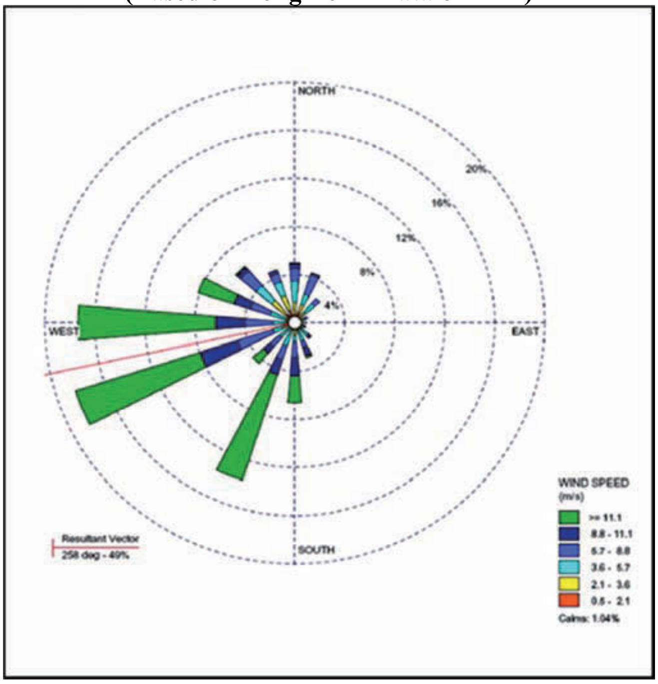
Source: Prepared by Study Team-GPSTPL

Figure 4.1.5: Annual Wind Rose Diagram of Mumbai (Based on Long Term Data of IMD)



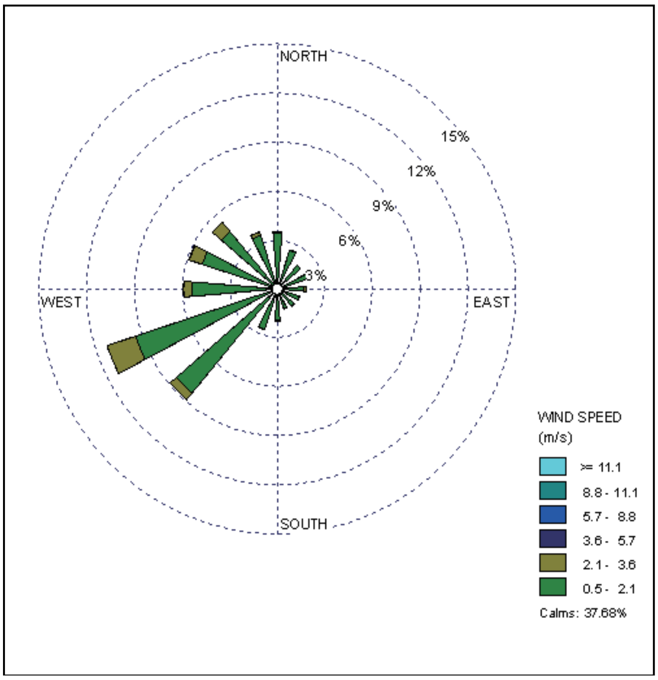
Source: Prepared by Study Team-GPSTPL

Figure 4.1.6: Annual Wind Rose Diagram of Ahmedabad (Based on Long Term Data of IMD)



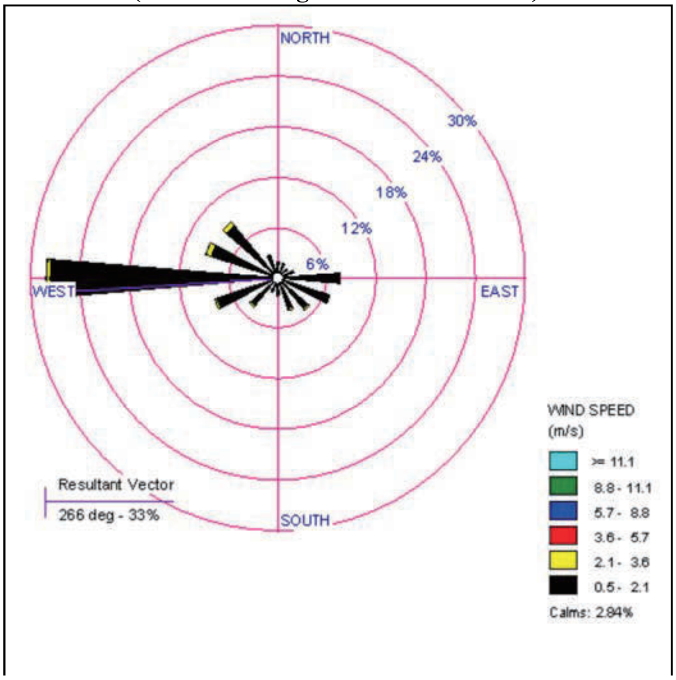
Source: Prepared by Study Team-GPSTPL

Figure 4.1.7: Annual Wind Rose Diagram of Vadodara (Based on Long Term Data of IMD)



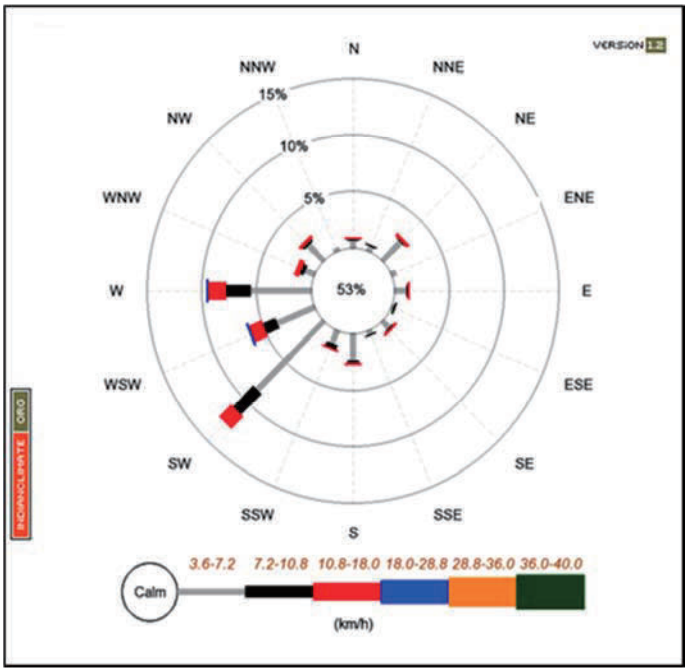
Source: Prepared by Study Team-GPSTPL

Figure 4.1.8: Annual Wind Rose Diagram of Bharuch (Based on Long Term Data of IMD)



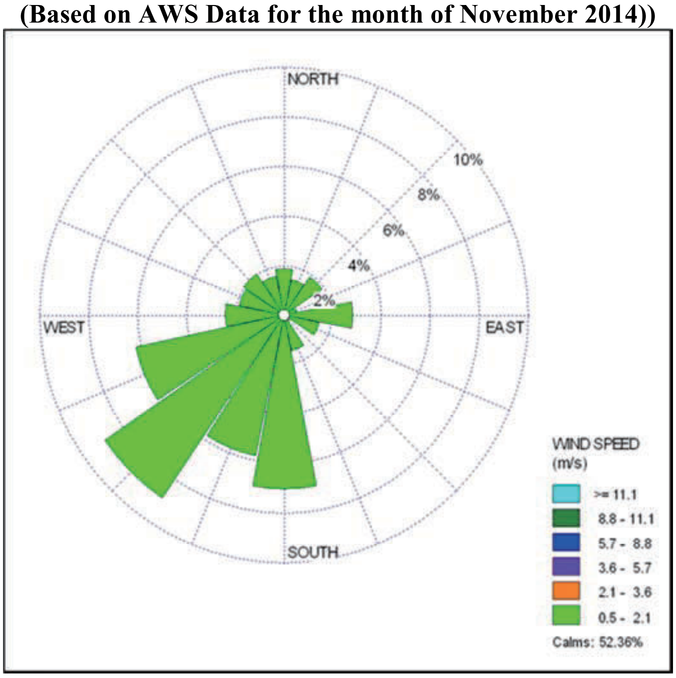
Source: Prepared by Study Team-GPSTPL

Figure 4.1.9: Annual Wind Rose Diagram of Surat (Based on Long Term Data of IMD)



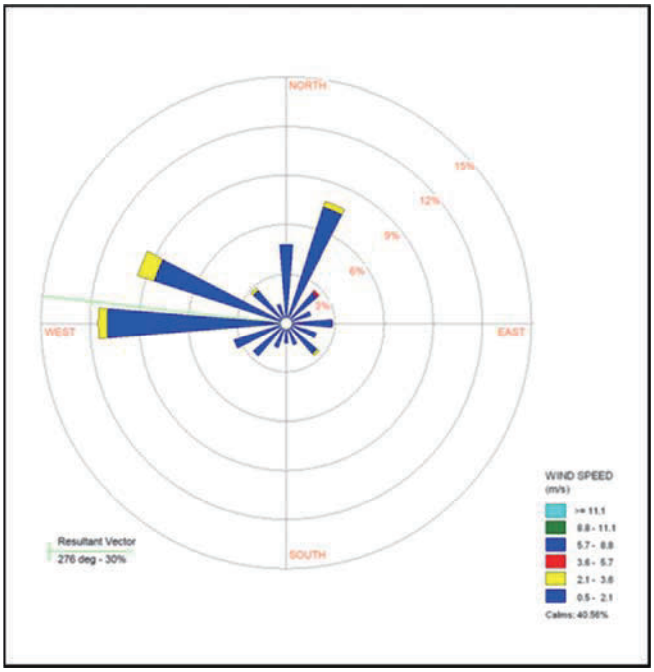
Source: www.imdpune.gov.in

Figure 4.1.10 :Wind Rose Diagram of Surat
(Based on AWS Data for the month of November 2014))



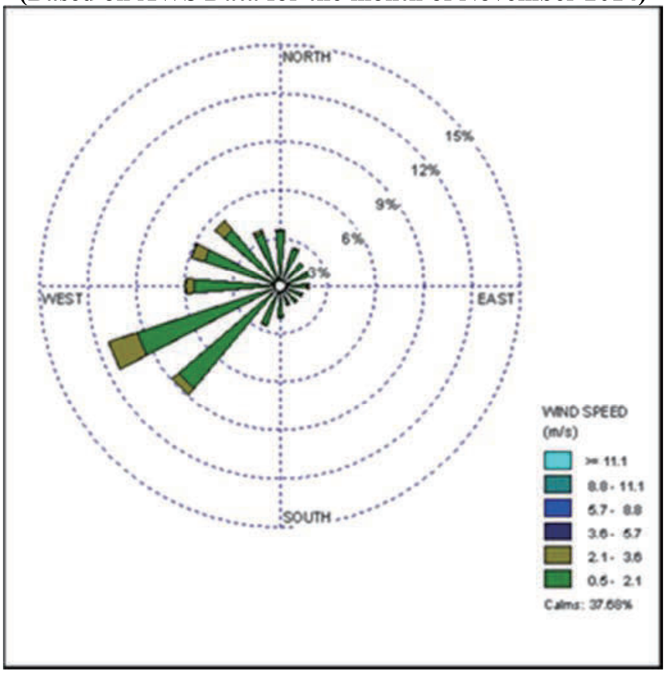
Source: www.imdpune.gov.in

Figure 4.1.11: Wind Rose Diagram of Bharuch
(Based on AWS Data for the month of November 2014)



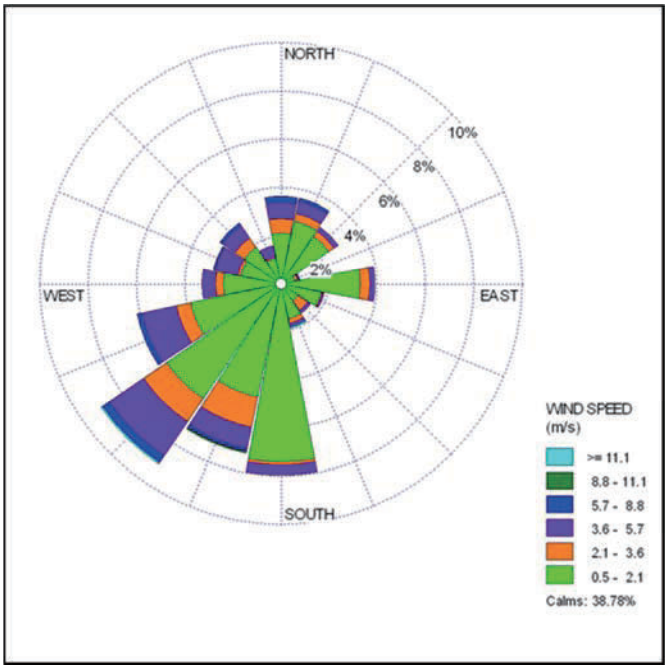
Source: www.imdpune.gov.in

Figure 4.1.12: Wind Rose Diagram of Panch Mahals
(Based on AWS Data for the month of November 2014)



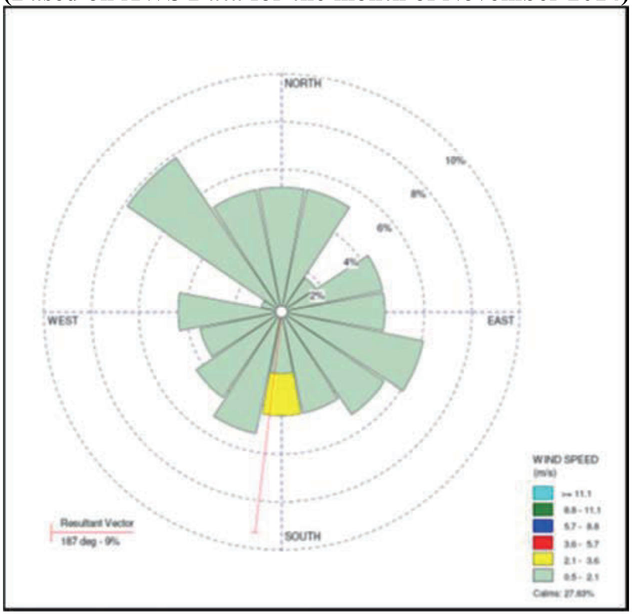
Source: www.imdpune.gov.in

Figure 4.1.13: Wind Rose Diagram of Vadodara
(Based on AWS Data for the month of November 2014)



Source: www.imdpune.gov.in

Figure 4.1.14: Wind Rose Diagram of Thane
(Based on AWS Data for the month of November 2014)



Source: www.imdpune.gov.in

Figure 4.1.15: Wind Rose Diagram of Mumbai
(Based on AWS Data for the month of November 2014)

4.1.2 Topography and Geology

(1) Topography

Proposed alignment for MAHSRC originates from about one kilometre west of Kurla (W) Railway Station on Andheri – Kurla Route of Central Railway. It is along the BKC Road and is named as Mumbai Station-Bandra Kurla Complex (KKC) of proposed route. After this, the alignment crosses a nallah at Km 1. The terrain is generally flat up to 7km and country is congested with thick habitation. The alignment crosses the existing railway line between 5km and 6km where the proposed MAHSRC is in heavy cutting. Hence proposed alignment will pass under the existing railway track.From 7km to 15km, alignment passes through Mangrove and enters again into built up area at Sector-20 of MIDC Industrial Area. The area is flat up to 17km after which, the alignment passes through a hill range where maximum elevation rises from about 20m to 220m. The high ground continues up to 21km where alignment crosses SH - 76. The terrain is generally flat after this and alignment crosses a river at 25km, and existing railway track two times at 26km and 28.1Km. Another station named Thane is proposed at 27.9km after which the alignment crosses Ulhas River at 28.8Km. Alignment runs through barren and flat terrain up to 34.5km before which, it crosses NH-3 at 33km.

Alignment passes through built up area up to 38km and then crosses a tributary of River Ulhas at 38.5km. From 39km to 48km, alignment runs through flat terrain with a small hillock at 42.2km. From 46km to 51km, alignment passes between SGNP and TWLS without crossing either of these.
The alignment crosses the proposed DFCC alignment at 46.5km, before crossing a hill at 53km where level rises from 20m to 80m and another hill at 54.8km where height is 60m above msl. In between above two hillocks, the alignment crosses NH -8 (Mumbai-Ahmedabad) at 53.4km. From 56km to 61km, alignment runs through flatter terrain where level difference is around 10m. After this, the alignment crosses built up area of Vasai from 60km to 65km where station Virar is proposed. The alignment crosses DFCC alignment again at 62.9km.

From 65.3km to 67.9km, the alignment crosses a reserve forest where there are high hills and the maximum height is around 170m. From 69km onwards, alignment passes through relatively flatter terrain where level difference is around 10m before entering again in to reserve forest at 76.2km and coming out at 78.2km. In the forest area, the alignment crosses higher ground where height reaches 60m from normal 20m. After coming out of the reserve forest, the alignment again runs through flatter terrain up to 95.5km and crosses DFCC alignment third time at 82.6km. The difference between maximum and minimum height in this stretch is around 10m. From 95.5km to 96km, the alignment passes through built up area of Palghar. From 96km onwards, alignment runs through flatter terrain with level difference of 10m up to 105.6km. In this stretch, the alignment crosses two natural streams at 97.6km and 104km. It also crosses 9city roads and a Station named Boisar is proposed at 104.35km. From 105.6km to 108.6km, the alignment runs through reserve forest where terrain is same as outside it. After this, the alignment passes through barren flatter terrain before entering again into reserve forest at 110.4km. It remains within the forest area up to 112.5km, within which alignment crosses a river at 112.2km. From 112.2km to 118.4km, alignment runs through vacant land which is flat with level difference of less than 10m. In this

6km stretch, the alignment crosses SH -74 at 114.8km and a river at 115.7km.From 118.4km to 129km, the alignment runs through rolling terrain where ground level varies from 10km to 50km. In this stretch of around 10km, alignment crosses Reserve forest three times: from 118.4km to 120.1km, from 125.9km to 126.3km and from 128km to 128.8km. Also, the alignment crosses a river at 124km and SH – X at 124.4km.From 129km to 148km, the alignment runs through vacant but rolling terrain where height varies from 30m to 110m with maximum height at 131.6km. Although this stretch is 17km long, but only two roads, one city road and another SH – 29 are crossed at 131km and 144.9km respectively. Similarly, alignment crosses only three rivers at 136.3km, 142.5km and 143.3km respectively.

Alignment again enters into reserve forest at 148.3km and runs through it up to 149km. From 149km to 155.7km, the alignment runs through undulating terrain with level difference of 20m. In this section, the alignment crosses a major city road at 152.3km. Alignment crosses reserve forest again from 155.7km to 156.3km. From 156.3km to 166.6km, alignment runs through semi-populated undulating terrain and encounters 20m high hillock at 156.8km. Alignment crosses five city roads and SH – 185 at 162.2km. Also, alignment crosses a river at 159.9km. Alignment crosses Damanganga River after this at 166.8km. After crossing the River, alignment crosses urban settlement of Vapi up to 174km. Vapi Station is proposed at 168.9km. In this section, alignment crosses SH -185 and SH - 5 at 168.7km and 170.9km respectively apart from crossing five other city roads. Terrain is relatively flat with variation in level of less than 10m. From 174km to 185km, the alignment runs across flat and vacant land. There are eleven city road crossings in this stretch and a crossing of Kolak River at 176km. Alignment from 186km to 196km runs through relatively vacant and flat terrain and is entirely on embankment. It crosses SH – 186 at 188.7km and nine other roads in this section. Alignment crosses river Par at 190.5km and two other small rivers at 187.5km and 195.9km.

Alignment continues in flat terrain with average height of 25m up to 204km. It crosses river Auranga at 198.3km. Alignment cross two state highways, SH-X and SH -67 at 196.5km and 201.2km respectively along with eight other roads. There is one river crossing as well at 196.5km. From 204km onwards, alignment proceeds in same kind of terrain as before up to 210km with average height of 25m. Alignment crosses five roads in this section including one SH - X at 206.1km. It also crosses a river at 205.7km. From 206km to 216km, the alignment runs through flatter terrain with some habitated sections in between near 211km and 213km to 216km. The topography is flat with height difference of 10m. There are seven road crossings in this section including major crossing where alignment crosses NH -8 second time at 210.6km. Famous river Kaveri takes a U – turn in this part of the country, and as such, the alignment crosses it two times at 212.9km and 214.8km. Alignment after this continues to traverse sparsely habitated but flat terrain up to 222km. The level difference in this stretch is less than 10m. Bilimora station is proposed in this section at 217.3km. It also crosses NH -360 at 217.1km along with six other city roads in this section. There is one more major crossing at 221.4km where alignment crosses existing Railway line. There is a river crossing as well at 222.0km. From 222km onwards, the alignment travels through flat terrain up to 232km. There is no appreciable level difference in this section. Alignment crosses SH -703 at 224.2km and Ambica River at 228.9km. It also crosses eight other city roads in this stretch. Alignment continues in similar terrain up to 240km where it encounters higher ground.

There are many important crossings in this section. Alignment crosses NH -8 third time at 235.6Km near Bhattal. It crosses SH-180 and SH -88 at 236.8km and 238.4km respectively. It also crosses a canal at 235.3km.

After this, the alignment runs through vacant and flat terrain up to 249.4km. It crosses NH – 8 fourth times at 242km. It also crosses SH -195 at 248.8km and four more roads in this section. A canal crossing is also present at 247.8km. Up to 260km, the alignment remains in flatter terrain with number of road crossings. It crosses SH -170 at 255.8km along with eight more road crossings. A river crossing exists at 250.6km. A small habitation is encountered at 255.3km, besides which the section is vacant. From 260km to 278km, alignment runs in flat terrain with intermittent habitations. It crosses SH – 167 three times in this stretch, at 273.6km, 276.9km and 277.6.km Alignment also crosses fourteen other roads in this section. There are five river crossings also, including at four small rivers at 265.1km, 266km, 271.1km and 274.4km, and one big at River Tapi at 276.5km. There are habitations near SH crossings.

After 278km, the alignment runs in flatter terrain up to 297km, where height difference is around 10m. Alignment crosses three canals at 278.4km, 283.4km and 266.4km. There is a crossing at SH – 65 at 290.4km and SH – X at 296.6km also. Alignment is also crossing two rivers at 289.4km and 293.3km. Major crossing is where alignment crosses proposed alignment for DFC at 286.3km. There are nine road crossings at city roads at various locations. 297km onwards, the alignment runs towards north in flatter terrain with no habitation along the route. The ground is slopping towards west. There are two river crossings at 308km and 308.8km. Alignment also crosses SH – 166 at 298.4km along with eleven other roads at various locations. There is a crossing of proposed expressway route at 297.5.km

After this, the alignment runs in flat terrain up to 334km, with lower ground near river Narmada which crosses the alignment at 320.6km. There are five more river crossings at 316.4km, 317.2km, 324.3km, 332.8km and 334km. There is a canal crossing as well at 326.8km. Alignment also crosses proposed DFC line third time in this section at 318.4km. There are fourteen road crossings in this stretch at various locations. Proposed station Bharuch falls in this section at 322.96km.

From 335km to 353km, the alignment runs through flat terrain with level difference of less than 10m between highest level and lowest level. There are two river crossings in this section at 337.5km and 339.2km. There are two canal crossings as well at 336.7km and 344km. There are number of city roads crossings the alignment, fifteen in all. From 354km to 371km, alignment runs through absolutely flat terrain which is vacant also and rises gradually towards north. Alignment crosses a canal at 360.3km and there are thirteen city road crossings as well besides SH – 161 at 359km. After this, the alignment runs through flatter terrain up to 390km with higher ground from 383km to 388km where ground level rises by about 10m. There are five river crossings in this stretch at 372.8km, 376.6km, 386.2km, 387km and 387.9km respectively. There are four road crossings as well. The alignment enters Vadodara City after this.

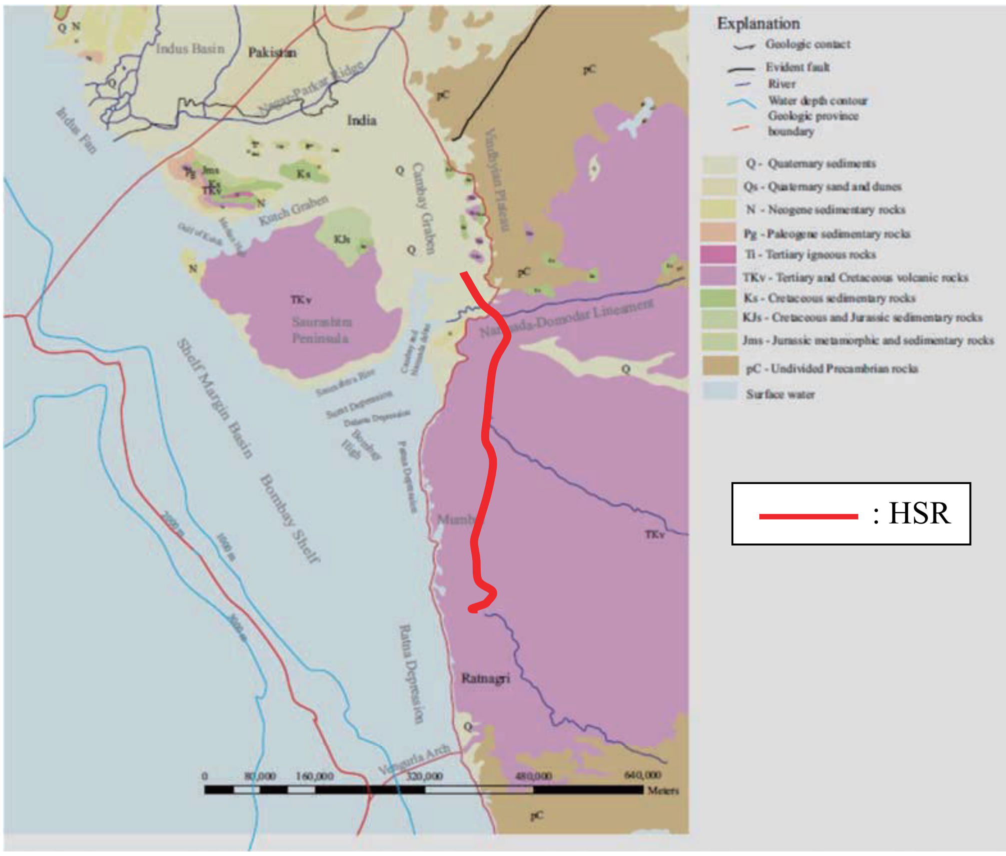
From 390km to 408km alignment runs through thickly habitated Vadodara City and remains close to existing Ahmedabad – Mumbai Railway track up to 404km from where it diverts away. The terrain in this section is generally flat with higher ground at 397km where ground rises by about 10m. The proposed Vadodara Station has been kept along the existing Vadodara Station. There are two highway crossings, of SH – 11 at 398km and NH – 8 at 404.2km. There is a crossing on river at 394.7km. There is a crossing of canal also at 401.3km. Since the alignment passes through thickly populated area, there are number of city road crossings. Alignment after this passes through partly flat and partly undulating terrain up to 427km. The terrain is flat up to 416km and undulating after that. There are two river crossings; one minor at 412km and one major at Mahi River at 416.8km. A canal also crosses the alignment at 426.1km. Alignment crosses SH – 188 at 420.5km and about twenty roads in this section.

The terrain between 427km and 445km is full of intermittent undulations and habitations. The alignment in this section runs parallel to Ahmedabad – Vadodara Expressway. There are three canal crossings at 436.4km, 438.4km and 441.7km. There are two State highway crossings as well. SH – 83 crosses the alignment at 432.1km and SH- 60 crosses it at 435.8km. Apart from this, there are plenty of other city road crossings; 32 in all. Proposed Station Anand/Nadiad is planned at 444.6km in this section.

Alignment crosses the similar kind of terrain from 445km onwards up to 464km and bypasses Nadiad City in this stretch. Two canals cross the alignment at 450.3km and 456.2km. There is a crossing at Mohut River as well at 462.8km. Three state highways cross the alignment. SH -160 at 446.8km, SH - 89 at 450.8km and SH – 119 at 454.7km. There is one more major crossing where alignment crosses existing Railway Track at Km 446.8 before Nadiad. Apart from this, there are about twenty city road crossings also in this section. From 464km to 483km, the alignment runs through slightly undulating and intermittently habitated terrain. Three rivers cross the alignment in this section. One at 467km, second Vatrak River at 473km and third Meshwa River at 476.4km. SH -60 cross the alignment at 470.6km while SH -144 cross it at 482.5km.

(2) Geology

Geologically the entire proposed alignment for MAHSRC can be divided into two segments-Alluvial plains of Gujarat and Paleogene sedimentary rocks of Maharashtra, Vindhyan formation. In this section, the geological formation of the proposed stations, the entire alignment of high speed rail corridor has been discussed in details. In the beginning, the geological succession history of Indian continent is discussed in brief in the succeeding paras. The area that is today the Indian basin was a shallow continental shelf accumulating shales, sands and carbonates. This carbonate-dominated shelf environment persisted at least intermittently on the western part of the shelf through the Late Jurassic and is evidenced in part by the interbedded shales and thick limestone of the Patcham Chari, and Katrol Formations in the Kutch area (Biswas and Despande, 1983) and the Springwar and Sulaiman Limestone Groups in the area that is now the Indian Basin. Formed near the intersection of three orogenic trends during the separation of the Indian and African plates, the Kutch Graben is filled with Jurassic to Recent sediments. During Early Cretaceous time, the Indian plate drifted northward entering warmer latitudes. In the Kutch area, shallow-marine shales and sandstones were being deposited, and, by Late Cretaceous time, regressive sandstones such as the Bhuj, Lumshiwal, and Pab Formations on the western Indian Shelf and Tura Formation on the eastern part of the shelf were being deposited. During latest Cretaceous time, the Indian plate continued drifting northward toward the Asian plate, the seafloor of the Bengal Basin began to form, and flysch accumulated on all sides of the Indian plate. Northward plate movement continued during the Late Cretaceous and a transform fault became active along the Ninety-East Ridge. In the Assam area, a south-easterly dipping shelf developed. Rifting between Madagascar and the Seychelles initiated formation of the Mascarene Basin. The general geomorphology of the entire stretch of High Speed Rail Corridor is illustrated in Figure 4.1.16

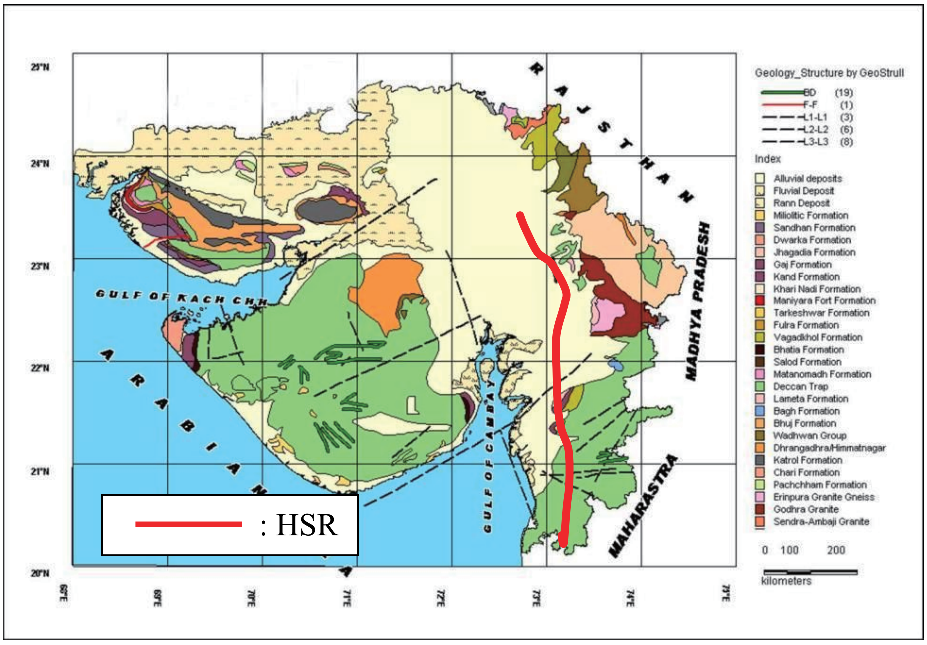


Source: www.portal.gsi.gov.in/

Figure 4.1.16: General Geomorphology of the Entire of Proposed Alignment

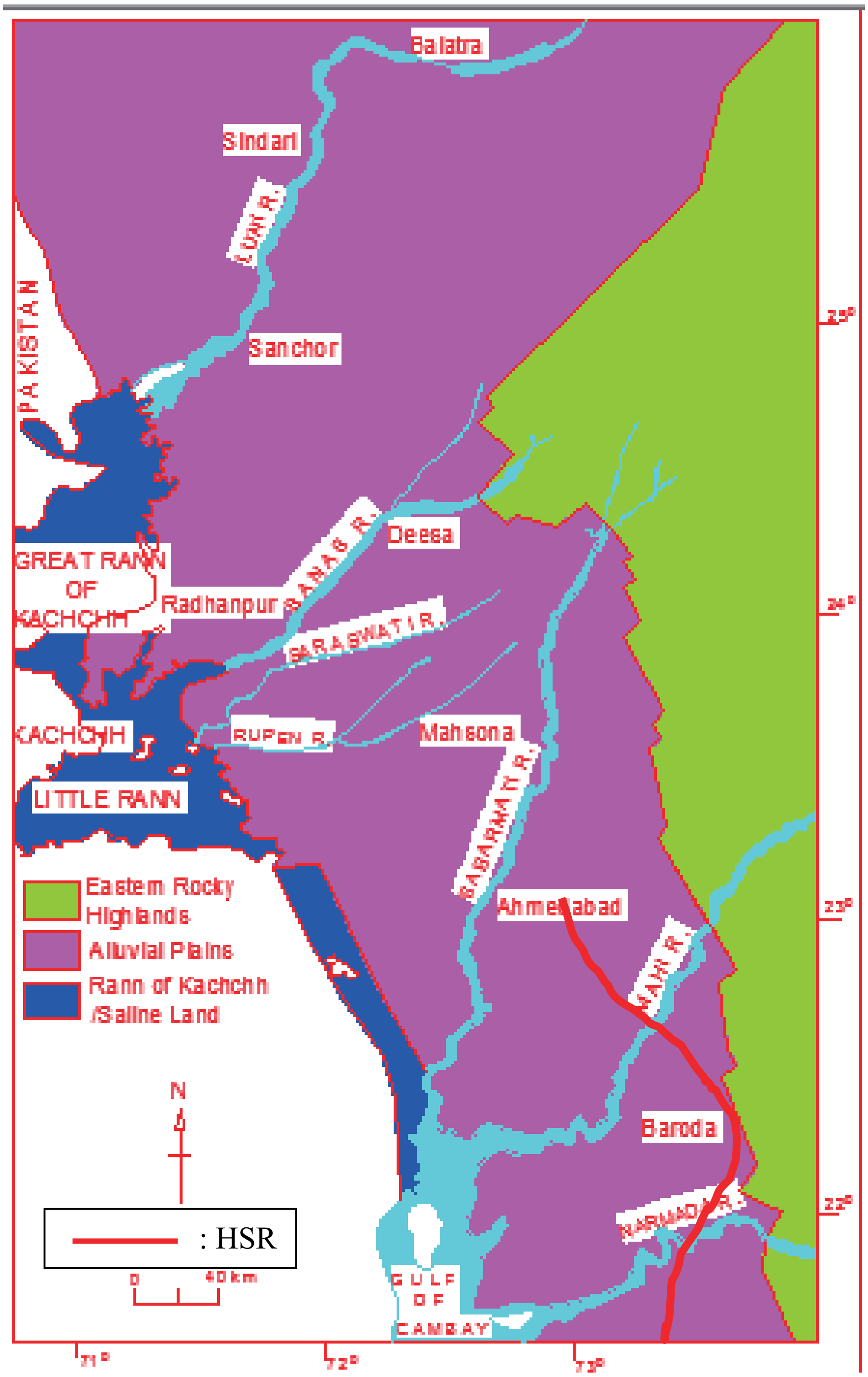
(3) Geology of Gujarat

The Mainland Gujarat is further divisible into two well-defined zones: (i) the Eastern Rocky Highlands and (ii) the Western Alluvial Plains. The Eastern Rocky Highlands that show an altitude variation from 300 to 1,100m are the extensions of the major mountains of western India - the Aravalli, Satpura and the Sahyadri. The hilly areas of the north form the SW extremity of the Aravalli Mountain. The geological map of Gujarat is illustrated in Figure 4.1.17 and major geomorphic division of Gujarat is shown in Figure 4.1.18. The Aravalli hills within the Gujarat state do not show any well-defined directions, but regionally they conform to the NE-SW trends. The rocks belong to the Delhi and Aravalli Supergroups with associated intrusives. A majority of the hills fall within an altitude range of 300 to 600 m. The central part of the hilly terrain, lying between the Mahi and Narmada rivers, referred to as Vindhyan range provides an example of topography typical of Archean metamorphics and granitic rocks; specific trend is observed. The altitude ranges between 150 and 500 m, the average heights being -350 m. The rocky area to the south of Narmada is included in Sahyadri, and the area especially beyond Tapi River is characterized by E-W trending hill ranges of basalt: from north to south shows a progressive increase in altitude with a step-like topography. Elevationwise, a major par~ of the trappean highland shows an altitude variation from 150 to 300m.The Western Alluvial Plains are made up of a thick pile of unconsolidated sediments deposited by a combination of fluvial and aeolian agencies during the Quaternary period. Forming the western half of the Mainland Gujarat, the altitude variation of the plains ranges from 25 to 150m with a gradual seaward slope. These plains of North and Central Gujarat in their deepest parts are very thick and could be as deep as 500m or even more at places. Across these plains flow the major rivers of Gujarat.



Source: www.portal.gsi.gov.in/

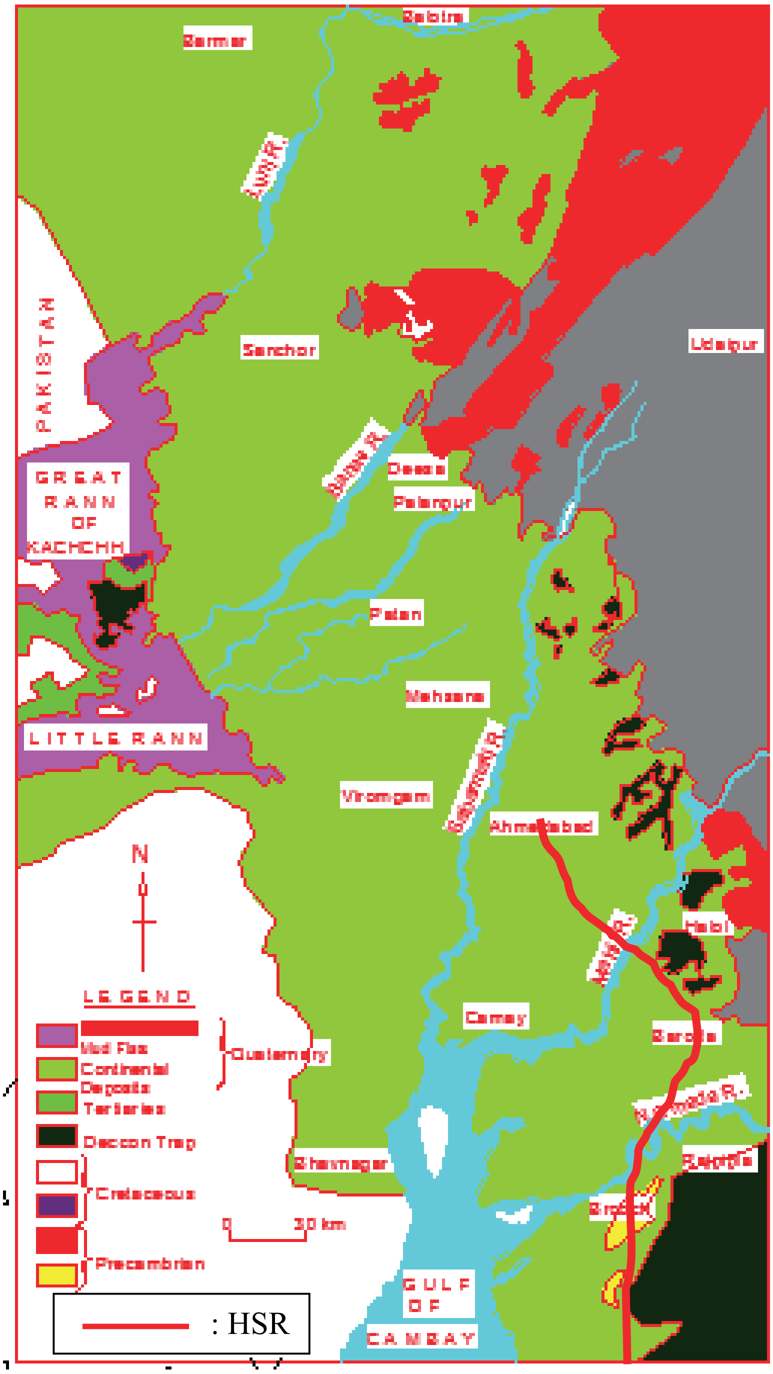
Figure 4.1.17: The Geological Map of Gujarat



Source: www.portal.gsi.gov.in/

Figure 4.1.18: The Major Geomorphic Divisions of Gujarat

The geology of Gujarat comprises a Precambrian basement over which younger rocks commencing with Jurassic, continuing through Cretaceous, Tertiary and Quaternary have given rise to varying sequences in different parts. Thus the rocks of Gujarat belong to formations ranging in age from the oldest Precambrian to Recent. Stratigraphically, the record is incomplete as the rocks of Paleozoic Era are totally absent. The sedimentary and volcanic rocks rest over the southwesterly extended Proterozoic rocks of Rajasthan and the post Triassic. The major geological events of Gujarat thus are confined to Mesozoic and Cenozoic Eras. The geological evolution of Gujarat initiated in the Triassic with the break-up of Gondwanaland and the subsequeritgeological history is related to the northward drift of the Indian subcontinent.The Mesozoic and Cenozoic tectonism related to the break-up of the Western Continental Margin and the subsequent drift of the. Indian Subcontinent has mainly controlled the geological evolution of Gtijarat. The depositional history and Deccan volcanism are part of this major tectonic phenomenon". The structural set-up is controlled by a number of Precambrian basement tectonic lineaments, trending (i) NE-SW and (ii) E-W to ENE-WSW and (iii) NW-SE. Narmada geofracture forms an important tectonic feature of Gujarat. Reactivated movements along these Precambrian trends due to break up of the Gondwanaland (and the subsequent NNE drift of the Indian landmass) gave rise to thr important basins of Kachchh, Cambay and Narmada, which in turn, controlled the geological. Evolution of the three distinct parts of Gujarat, *viz.* Kachchh, Saurashtra and Mainland".The geology of Mainland Gujarat is represented by Precambrian crystallines, sedimentary rocks of Cretaceous, Tertiary and Quaternary periods and the Deccan trap. A generalized geological map of Mainland Gujarat based on the work of Geological Survey of India is illustrated in Figure 4.1.19 and the stratigraphy of Mainland Gujarat is presented in Table 4.1.7.The geological evolution of its northern and eastern parts has been controlled by the Precambrian orogenies-Aravalli and Delhi cycles, and the older crystalline rocks ideally show folds, faults and magmatism related to the two orogenies. The major portion of the Mainland however, exhibits imprints of the Mesozoic and Cenozoic events, and the various rock formations reflect the uplifts and subsidences along the two major lineaments, Narmada and Cambay rift systems. The Cretaceous and Tertiary sedimentary basins are fault controlled and manifest the tectonism related to these two major fracture trends. Whereas the Cretaceous sedimentation and existing distribution and outcrop pattern clearly show an E-W trending fault control, the Tertiary rocks are deposited in the tectonic basins bound both by N-S and E-W faults.A major part of the Mainland falls within the Cambay and the Narmada grabens and the eastern and the northeastern Precambrian rocks mark a tectonic boundary. The Eastern Cambay Basin Bounding fault extends almost N-S across the middle of the Mainland broadly delineating the Quaternary deposits from older rocks. ·The structure is reflected in the topography which typically show progressive stepping down from south to north along E-W faults and from east to west along N-S faults. The coastline is again a fault-line feature.



Source: www.portal.gsi.gov.in/

Figure 4.1.19: Generalized Geological Map of Mainland Gujarat

Table 4.1.7: Stratigraphy of Mainland Gujarat

Era	Period	Age		Group / Formation	Lithology
Cenozoic	Quaternary	Holocene		Gujarat Alluvium / Narmada FM	Sand, Silt, Clays With Gravel Beds
		Pleistocene	U	Jambusar FM (Not Exposed)	
			L		Coarse, Sand, clays, Kankars
	Tertiary	Pliocene	U	Bharuch FM (Not Exposed)	Claystone, Sandstone
			L	Jhagada FM	Conglomerate Sandstone
		Miocene	U	Kand FM	Conglomerate, Fossil, Limestone, Calc, Sandstone,
			L	Babaguru FM	Conglomerate Sandstone
		Oligocene			
		Eocene	U	Dinod FM	Fossil, Limestone, Marl
			L	Vagadkhol FM	Conglomerate Grit Sandstone, Clay, Siltstone
		Palaeocene	U	Laterite	Bauxite Bentonite
			L	Deccan Trap	Tholeitte & Alkali Basalt
Mesozoic	Cretaceous		U	Decccan Trap / Lamenta	Flows & Intrusives / Limestone
			L	Bagh Beds / Nimar Sandstone	Limestone, Mari, Sandstone
	Jurassic		U		
			M		
			L		
Proterozoic	Post Delhi Magmatism			Malani Volcanic	Andesite Albitised Basalt
				Erinpura Granite	Potash Granite, Micro-Granite, Granite Porphyry
				Godhra Granite	Granite, Granite gneiss
				Post-Delhi Pre Erinpura Granite Phase	Meta-Gabbro Meta-Dolerite, Epidiorite
	Delhi Supergroup			Sirohi Group	Phyllite, Mica-Schist, Calc Schist
				Ambaji Granite	Granite Granodioritte Granite Gneiss
				Kumbhalgarh Group	Calc Schist, Calc Gneiss, Mica Schist, Marble
				Cogunda Group	Quartzite Slate, Calc Schist
	Aravali Super Group			Lunavada Group	Phyllite, Biotite Schist, Quartzite, Dolomite
				Rakhadev Ultramafic Suite	Talc-Serpentine Schist with Tremolite, Actinolite
				Jharol Group	Phyllite,Chlorite Schist, Quartzite Cryst, LST
	Age Uncertain			Basement	Granite and Gneiss

Source: www.portal.gsi.gov.in/

Foote surveyed the area falling within the former Gaekwad's state of Baroda (Vadodara) and described the various alluvial and sub-aerial formations of some of the major rivers. His is the· first ever detailed description of the alluvial horizons exposed in thecliff sections of the Sabarmati and Mahi rivers. Emphasizing on the Sabarmati cliff sections he opined that the rivers Sabarmati and Mahi at present are more destructive than constructive and the extent of deposition is negligible. Sankalia studied Sabarmati from the archaeological point of view and fixed a Lower Paleolithic age limit for the base of the exposed succession on the basis of lower Paleolithic tools recovered from the basal gravels. Zeuner was the first worker to provide details of the Pleistocene chronology of Gujarat. He investigated the deposits exposed in the valleys of Sabarmati, Mahi and Narmada and paid greater attention to the de osits of Sabarmati valley. The Orsang river, a tributary of Narmada was also studied in detail, where stratigraphic and climatic sequences identical to those of Narmada were recognized. Zeuner envisaged climatic changes during the deposition of the entire continental succession comprising repeated oscillations between dry and wet climatic conditions. Wainwright" described the Pleistocene deposits of the Lower Narmada valley and gave details of the cliff sections and emphasized the role of sea-level in the deposi tion of the sediments. The work of A1lchin *et al*, which deals with the entire Thar Desert of Rajasthan and the arid plains of North Gujarat, provides an excellent perspective of the Quaternary aeolian deposits of Western India in terms of pre-history. They provided a good insight into the diversity of environment during which the early man lived in this part of the sub-continent, Chose *et al* 10, suggested that none of the present day rivers in south Rajasthan played any significant role in the formation of the alluvial plains of the region. These authors visualised existence and role of a Himalayan river in the alluviation process in the Luni basin. Their observations in Lower Luni basin and Sabarmati Rivers furnish valuable information relevant to the present study. Wasson et aLII, who mapped the Thar dune-fields found that the dunes overlap sandy alluvial deposits and the entire succession underlying the dunes in North Gujarat is fluviatile. Rajaguru" and Misra and Rajaguru studied in detail the problem of late Pleistocene aridity. Whereas most previous workers mentioned above invoked the factor of climate late Pleistocene humidity followed by pre-Holocene (Terminal Pleistocene) aridity to explain the phenomena of drainage disruption and evolution of the present day landscape. Ahmad added a new dimension to this problem by invoking the dominant role played by Holocene tectonism. He contended that the rivers changed their courses in response to epeirogenic activity and the deposition of the alluvial fans, their shapes and rates of deposition depended dominantly upon epeirogeny. Karl has critically evaluated the phenomena of drainage disruption, climate-related fluvial processes and role of neotectonism in the Thar Desert and highlighted the tectonic control in the evolution of ancient and modern drainage systems. Subsequent studies mostly by geologists and physicists have aimed at precise dating of the various formations and also to understand the depositional processes and environments. Studies by Singhvi et al.", mainly pertain to the application of Thermoluminescence methods in dating the various aeolian phases and to understand the chronology of paleoclimatic changes. The continental Quaternary deposits of Gujarat in recent years have received significant attention. Studies carried out by Chamyal and associates mainly pertain to the depositional succession, gross-lithology and paleoclimatic evidence as revealed in the various river sections of the Narmada, Mahi and Sabarmati. Sareen *et al*. have attempted to provide a tentative chronological succession for the Sabarmati deposits using Thermoluminescence and the role of Quaternary tectonism in shaping the present landscape. Sridhar *et al* have provided more details on North Gujarat. These authors have invoked non-marine (mostly fluvial) sedimentation in a huge graben bounded by Cambay Basin related faults. The alluvium is as thick as 300 m even in the areas devoid of any present day drainage; obviously the entire alluvial succession was a product of an ancient-fluvial system which has since been partly destroyed. A combination of neotectonic activity in the Cambay Basin, glacio-eustatic sea-level changes and paleoclimatic fluctuations appear to have played a major role in controlling the depositional history of the fluvial sequence and the disruption of the super-fluvial drainage system.

Geomorphology

The vast alluvial plains look uninteresting and monotonous but a careful and in-depth appraisal of the terrain with the help of topographical sheets, satellite images and field studies reveal very interesting details. They show an array of geomorphic features which are the reflections of the various tectonic, erosional and depositional processes of the late Quaternary. The Gujarat plains are situated in a geological setting flanked by Precambrian rocks in the east and by the Mesozoic rocks, comprising both sedimentaries as well as volcanics, in the west and south. The overall topography is a product of a combination of numerous tectonic lineaments (faults, joints *etc.*) which mark the limits of the rocky highlands and also con trol the. Behaviour of most of the rivers.

Alluvial Plains

Commonly referred to as Gujarat Alluvial Plains, these form the median part of Mainland Gujarat extending from Narmada River in the south to the Luni river in the north. A generalised geomorphic map based on satellite images, topographic maps and field surveys show the landscape diversity of these plains. Showing a gradual slope from ENE to WSW, the plains range in altitude from 150 m to almost sea level. They are broadest between Mahi and Banas rivers. From the gradient point of view these plains could be divided into four segments, the terrain between the rivers *Narmada* and *Mahi* has an undulating hummocky surface with a regional slope towards SW. It is flanked to the east by the Panchmahal uplands. Most of the tributaries of the Narmada (Orsang, Heran, Men and Karjan) and the Mahi (Anas, Panam, Karad and Mini) originate in these uplands. The Dhadhar and the Vishwamitri constitute the other rivers of this segment. These follow generally either a NNE-SSW or E-W course. Pavagadh (~857m), Phenai-Mata (~481m) and Ambadungar (~611m) stand out as the discrete rocky elevations within this segment. The slope of the plains between *Mahi* and *Sabarmati* is SSW-ward and shows a drop of almost 50m in a distance of 40 km. The various smaller rivers that drain this segment follow a south-southwesterly course; in lower reaches however, all the rivers take a westerly trend before finally meeting the Sabarmati. This phenomena perhaps is due to a westerly slope. The segment between Sabarmati and Banas, though showing an overall slope to the SW tends to show increasing gradient from E to W. This factor of slope is well illustrated in the various rivers which, irrespective of their place of origin flow SW and W and either meet Banas River or the Little Rann. The gradient in the upper part of the segment is relatively high but in the lower reaches the slope tends to decrease considerably almost showing negligible values-a drop of only 100m in a distance of 100 km. The plains lying between the rivers Banas and Luni are also characterized by a very gentle slope due west. Except for the eastern part of the segment where the slopes are slightly higher, its major portion shows a very low gradient. A characteristic feature of this segment is the near total absence of any southwest flowing rivers. The overall landscape tends to be increasingly dunal from SE to NW. The surface topography between Mahi and Sabarmati is typically flat and featureless but on crossing Sabarmati, preceding northwards, the plains become increasingly undulating and are endowed with numerous dunal mounds. The landscape is hills rise several meters above the ground level (Diodhar~73m, Ogadpura~109m, Tharad~59m, Langhnaj~79m). A characteristic feature of the area south and west of Luni within Gujarat is replete with stabilised dunes dissected by ill defined stream courses. These dunes are stabilised and indicate a period of aridity followed by a phase of increased humidity. North of Banas right upto Luni and beyond, dunes and sand ridges of unconsolidated fine sand, are very common. In fact these dunes are the indicators of the northern limit of the Gujarat plains, beyond which they go below the sands of the Thar Desert. The nature of topography in the extreme' north marking the boundary of Gujarat is also of some interest. Whereas north of the boundary, the terrain has a better development of consolidated and unconsolidated dunes, southward in Gujarat except for a few sporadic stabilised dunes the unconsolidated sand accumulations are much less. Altitudewise, the Gujarat portion is somewhat higher by about 10m; the rise is abrupt and more or less coincides with the State border.

Tectonic Framework

Interaction between sedimentation and tectonics is now an established fact, though the phenomenon is not yet fully understood. However, the effectiveness of tectonic factor is implicit on two counts:

(i) A basin providing a site for the accumulation of sediments; and
(ii) An uplifted area from where sediments could be derived.

Tectonism has played an important role in the evolution of Gujarat plains at all stages. The control exercised by the various structural lineaments was quite effective and dominant all-throughout the Tertiary and Quaternary and the sediment accumulated in structural basins that developed at the close of Cretaceous. All along, especially during Quaternary, the factors of glacio-eustasy and palaeoclimate combined to sustain and control the deposition. According to Biswas, the tectonic activity was initiated as early as the close of Triassic when the Gondwanaland started breaking up, and sometime in the late Cretaceous the western continental margin developed a major rift, as a result of which a regional structural fault-bound depression extending from Rajasthan southward to Narmada and beyond, came into existence. Referred to as Cambay Basin in Gujarat, it consists of two large fault bound depressed blocks N-S Cambay and E-W Narmada grabens. Initially, marine deposition took place.in the basin during major part of the Tertiary, but in its later evolutionary phase, during the Quaternary, the filling up was mainly by the fluvial and aeolian sediments, consequent upon the withdrawal of the Tertiary sea. Whereas, the main bulk is a Tertiary sequence" confined to the limits of the Cambay Basin, the overlying Quaternary deposits are seen to have overfilled the main basin, spilled over the Tertiary basin crossing the Eastern Margin Cambay Basin Fault (EMCBF) and deposited even beyond, resting directly over the basement. A subsidence of the basin concomitant with the accumulation of sediments facilitated deposition of enormous quantity of sediments. This progressive deepening coincided with the uplift of the Saurashtra horst in the west, rejuvenation of the Aravalli in the NE and the uplift of the area to the south of Narmada (during Quaternary). The vast thickness and lateral expanse of the Quaternary sediments thus took place in a partially filled basin of phenomenal dimension, mainly because of the reactivation of pre-Quaternary faults and development of new faults. A large part of the younger sediments IS confined to eastern flank of the basin and is dominantly fluvio-marine, fluvial and aeolian.

Structural Control

The Carnbay Basin extends broadly in a NNW-SSE direction in the onshore and offshore parts of Gujarat. Northward, it swings due SW-NE merging into 'the Rajasthan Basin. Data generated by the ONGC, mainly on the Tertiary sediments, adequately reveal the basement configuration and the control exercised by cross-faults in dividing the basin into several tectonic blocks or sub-basins. Each tectonic block behaved somewhat differen tly during the deposition, on account of differen tial uplifts along the various bounding and transecting faults. The basement typically comprised fault-bound uneven surfaces made up of horst and grabens. Movements along faults parallel as well as oblique to the main basin, controlled the thickness of sediments, even the Quaternary deposits in the different parts of the Cambay Basin and its eastern margin show variable thicknesses. The cross-section showing thickness data brings out the role of tectonism prior to and during deposition of Tertiary as well as Quaternary sediments. The varying thick nesses thus are obviously due to the fact that the sediment accumulation took place in various fault bound depressions. The depositional sites continued to be unstable during the filling up of the basin, as the limiting faults, of the main basin as well as of the sub-basins, have affected the Quaternary sediments, their reactivation even after the deposition, has been well established. From the deep sounding seismic survey of Saurashtra and Mainland Gujarat. A perusal of the lineament of the Gujarat and SW Rajasthan points to the close genetic relationship between the Cambay Basin tectonism and the Precambrian basement fracture pattern. The two Cambay Basin bounding faults (EMCBF and WMCBF) by and large, follow one or other structural trends; and so do the faults that dissect it into the sub-basins. The various post-depositional faults, responsible for the development of new drainage and the two Rann of Kachch, also conform to the basement fracture trends.

Tectonic History

The structural history of the depositional basin since its inception right upto almost Sub-Recent, can be chronologically arranged as under:

i) Post Mesozoic reactivation of N-S and NNW-SSE Precambrian faults and Narmada Geofracture

This event gave rise to Cambay Basin a structural depression. This happened at the advent of the Cenozoic. Two regional faults that limited the down faulted block, have been (delineated by the ONGC) referred to as West Cambay Basin Boundary Fault (WMCBF) and East Cambay Basin Boundary Faults (EMCBF). Varying trend of these two bounding faults from south to north and even those of the Rajasthan Basin, is a very clear manifestation of the combination of faults with different trends, following one or other directions of fracturing. Whereas smaller faults were responsible for the horst and graben topography of the Cambay Basin basement over which Tertiary sediments were deposited, somewhat larger faults trending NE-SW divided the main basin into 4 sub-basins. Several step faults east of and parallel to

EMCBF, also simultaneously developed, thereby providing a wide expanse of low ground, which later on became the site of Quaternary deposition.

ii) Differential movement along the various faults all- throughout the Tertiary and Quaternary deposition

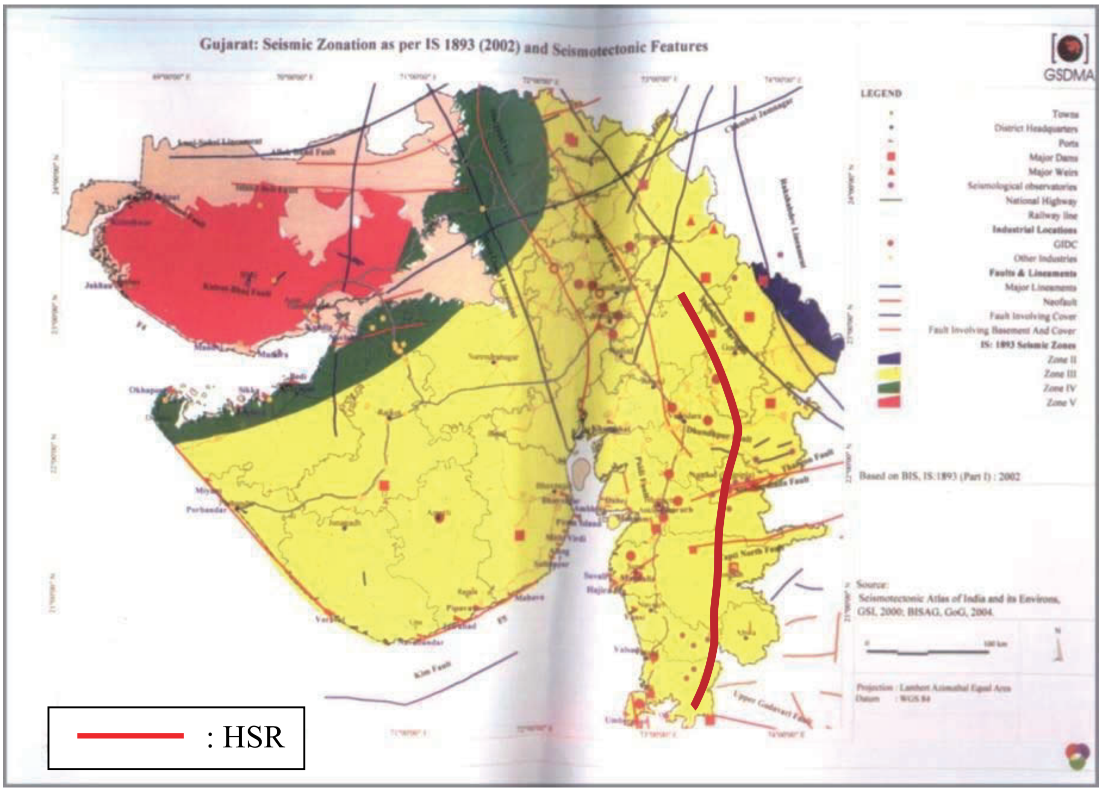
Thickness variation and lateral differences in lithofacies in the Tertiary sediments are attributed to this syn-depositional tectonism. Variable thickness of Quaternary deposits in the different structural blocks, indicate continued vertical movement during their accumulation. It however appears that the intensity of this tectonic activity gradually decreased so much So that during upper Pleistocene and Holocene, it practically died down or at least considerably reduced.

iii) During (Quaternary E- W to ENE-WSW fracture trends continued to be effective in the manner that they provided preferred directions for the various rivers of the older drainage system

The older rivers flowing SW to W from the eastern rocky highland impinged into the basin, crossing successively the various step faults finally transected the EMCBF; depositing their debris such that the Quaternary sediments rested over Tertiaries. The older fluvial system (which now stands disrupted), points to a control exercised by the regional westward slope and the E-W to NE- SW fractures. Almost entire part of the sediment thickness (mostly fluvial) was the result of these ancient rivers. The process of fluvial aggradation came almost to a close with the onset of the Terminal Pleistocene aridity.

iv) Next and the last major phase of tectonic activity took place, sometime in early Holocene, after the aridity

During this tectonic event, numerous. NNW-SSE trending fracture zones developed and these dissected the earlier deposited continental sequence, disrupted the older rivers, deflected their courses, such that Sabarmati and Mahi started flowing along new channels and the Orsang river (relicts of which are seen as the Dhadhar river) instead of flowing towards W, swung anticlockwise towards Narmada to finally meet it. This phenomenon is very well reflected in the development of vertical cliffs and deeply cut ravines, sinuous channels of trunk stream as well as those of major tributaries. Cliffy channels of Sabarmati, Mahi and Narmada that flow in a *zig-zag* manner, simulating entrenched meanders, in fact reflect the influence of intersecting or en-echelon fractures that developed during this late tectonism. The rivers flowing along these fractures (mostly joints), in due course have given rise to loops and curves which resemble and behave and look to a certain extent like true meanders, making it difficult to recognise the tectonic control. All the rivers-Luni, Sukri, Banas, Sabarmati, Mahi and Narmada, show a gentle northwesterly tilt of the newly faulted blocks. As a result, there occur no tributaries on the respective right banks in each case and the smaller streams meet the main rivers along the left banks. Also, the areas to the west of the middle segment of Sabarmati and lower reaches of Mahi, are totally devoid of any drainage and represent uplifted terrain's with a slight NW tilt. Subsurface information also indicates uplift. Obviously, the uplift and tilting were related to this Holocene fracturing. Seismic and tectonic map of Gujarat is shown in Figure 4.1.20.



Source: www.portal.gsi.gov.in/

Figure 4.1.20: Seismic and Tectonic Map of Gujarat

Lithostratigraphy and Field Description

The Quaternary continental deposits of the Main land consist of a succession of layered sediments of marine, aeolian and fluvial origins. A total maximum thickness of over 800 m of Quaternary sediments has been computed on the basis of exposed sequences and sub-surface bore hole data. The nature of the base of Quaternary deposits however is not fully understood and little information is available to delineate the boundary between the Quaternary and the Tertiary. It may be pointed out that the lower part of the Quaternary sequence remains un-investigated and the only available information is that provided by Chandra and Chowdhary. These workers of the ONGC have given a Pleistocene age to their Jambusar Formation of Ahmedabad-Mehsana, Cambay-Tarapur and Jambusar- Bharuch tectonic blocks of Cambay Basin. In the Tharad-Serau block further north, the upper part of Budhanpur Formation has been considered to comprise Lower Pleistocene; or in this formation Pliocene is perhaps gradually changing over to Pleistocene, the entire sequence mostly being fluviatile. In the sub-surface on the western margin of the Cambay Basin in the Dhanduka block (Saurashtra). A conglomerate resting directly over Deccan Trap perhaps represents Lower Pleistocene. In the Viramgam section an undifferentiated sequence resting over the Oligocene Khora Formation could also in part be of Lower Pleistocene age. The agate bearing conglomerates of the coastal areas of Saurashtra and the conglomeratic horizons of the Jhagadia Formation exposed on the Mainland along the eastern margin of the Carnbay Basin have been considered as Lower Pleistocene.The base of the huge fluvio-aeolian sequence exposed in the various river sections is a bluish green clay. These clays show well developed rhizocretions and greyish-green drab haloes, indicating sub-aerial activity prior to the deposition of the overlying fluvial sediments. In the subsurface bore-hole data, the Irrigation Department of the Government of Gujarat has shown these clays at the base of the sand-silt-gravel horizons and has erroneously called them as Tertiary marine clays. Merh has described them as clays of m trine origin deposited during the Middle Pleistocene transgression, stratigraphically comparable with the Miliolites of Saurashtra. A characteristic feature of these clays is a typical mottled appearance with numerous carbonate tubes, pipes and strings with veins intruding this horizon". These calcrete structures abruptly terminate against the overlying gravels suggesting that they pre-dated the gravel-sand. There was a considerable time gap between the deposition of these clays and that of the overlying gravel; the intervening period giving rise to pedogenetic calcretization. The sequence that overlies these clays and referred to as Gujarat Alluvium and Narmada formation range in age from Upper Middle Pleistocene to Recent. Ideal exposures of the sediments in the major river sections dating back to Middle Pleistocene have provided a dependable sequential stratigraphy.

Narmada River Basin

Taking into account twelve well exposed lithounit sections along the Narmada River, a composite lithostratigraphic succession has been prepared. Three major stratigraphic formations *viz.* Tilakwada formation, Ambali formation and Bharuch formation have been recognised.

Tilakwada Formation

The Tilakwada formation marks the base of the total exposed Quaternary sediment succession in the Lower Narmada valley and comprises five major horizons- *(i)* bluish pedogenised and mottled clay, *(ii)* cobblyto bouldery gravel (Gms- facies/ Gravel-I), *(iii)* coarse reddish sand, *(iv)* Laminated/stratified pedogenised silty mud and *(v)* cross-stratified gravel (Op-facies/Oravel-Il). The bluish pedogenised clay forms the base with an exposed thickness of 2 to 3 m and is overlain by a poorly sorted 5 to 6 m thick horizon of cobbly to bouldery gravel (G-I); it shows inverse grading at places. It is ideally exposed at Tilakwada and Rampura. The gravels are overlain by sand-sheets and trough cross-stratified beds of around 4 m thickness; these at places are replaced by stratigraphic equivalent units of laminated mud. Above this horizon, cross- stratified gravel of about 5 to 6m in thickness (G-II) is encountered; this gravel at places shows planar cross-stratification.

Ambali Formation

The Ambali formation overlies the gravel (G-II) and ranges in thickness between 13 and 15 m. It comprises 4 major units; *(i)* laminated pedogenised mud; *(ii)* sandy gravel (Gravel-III); *(iii)* silty sand and *(iv)* rubified silty sand. The pedogenised laminated mud, 4 m thick, directly rests over Gravel-II and is devoid of any sedimentary structure. The mud is overlain, by 3 m thick sandy gravel (G- III). Silty sand of about 2 to 2.5 m thickness overlie this horizon, which at places is replaced by a stratigraphically equivalent unit of pedogenised mud. The topmost part of this formation is 3 to 4 m thick silty sand which is brownish red in colour. More or less, structureless, this rubified unit is at places demarcated from the underlying silty sand horizon by a concentration of ca1cretic layers.

Bharuch Formation

This formation forms the upper portion of the Narmada succession, and has a thickness range of 10 to 12m. It is made up of five major units, *viz. (i)* weakly pedogenised laminated mud; *(ii)* pedogenised silty sand; *(iii)* pale yellow coloured silt (loess-like); *(iv)* pedogenised silt and *(v)* fine dunal sand. The weakly pedogenised laminated mud unit (1.5-2 m) forms the base of the formation, and rests over the rubified horizon of the Ambali formation. The mud, at places is seen to change over laterally to trough cross-stratified sand. This laminated mud/cross- stratified sand is overlain by 2 to 3 m thick fine loess-like silt, which is structureless and easily recognised by yellowish buff colour. This succession is finally capped by a aeolian sand horizon of 2 to 8 m thickness, which has given rise to a characteristic typical dunal topography.

1) Locationwise Description

Bharuch Section
This section is located on the right bank of Narmada, 25 km upstream from the mouth. The exposed cliffs in this area range in height between 18 and 20 m and show only the Bharuch formation which is represented by fluvial silts and the uppermost aeolian sand.

Nikora Section
This is located 10km upstream of Bharuch on the right bank of the Narmada. The section varies in thickness from 17 to 18m. The basal pedogenised clay is followed by the Ambali formation (l2m) and capped by, the laminated mud and dunal sand of Bharuch formation (3m). Tilakwada formation except the basal clay is absent at this location.

Kanjetha Section
This section is located 8 km upstream of Nikora on the right bank. The section height varies between 28 and 30 m. It begins with Tilakwada fo mation (10 m) and is overlain by Ambali formation (12 m). The youngestis the Bharuch formation and is 6 m thick.

Ambali Section
This section located 12 km upstream of Kanjetha on the right bank of Narmada is 20, to 22m thick. The Tilakwada formation (7 m) marks the base; in turn it is overlain by 8 m thick Ambali formation. This unit is followed upwardsby the Bharuch formation and is 7 m thick.

Sankheda Section
The section is located 15 km upstream of Chandod on the left bank of Orsang River. The cliff height here ranges between 12 and 14 m. The basal part is represented by 7 m thick Tilakwada formation, Ambali formationis absent and the Bharuch formation (5m) directly overlies the Tilakwada formation.

Chandod Section
A more or less complete sequence is seen in this section, exposed on the left bank of the Orsang River at its confluence with the Narmada. The cliff height is around 1·8m and the section comprises Tilakwada formation (7 m), Ambali formation (6 m) and Bharuch formation (9 m).

Tilakwada Section

This section is exposed at the confluence of the rivers Men and Narmada. The 25 m left bank section is represented by 20 m thick Tilakwada formation overlain by 5 m of Bharuch formation.

Rampura Section
Located upstream of Tilakwada on the left bank of Narmada, the 19 m section is made up of a lower 13 m thick Tilakwada formation, followed upwards directly by 4 m thick Bharuch formation represented by Aeolian sediments.

Mahi River Basin
The Mahi river provides very good sections all along its course, and on the basis of the exposed lithounits studied at 10 locations, a composite stratigraphy could be prepared. The exposed sequence resting over the basal clays, has been divided into three formations *viz,* Rayka, Shihora and Singrot.

Rayka Formation
The Rayka formation is seen to rest over the basal clays and shows an overall thickness of 10 to 11m. The formation is made up of two members:

(a) Vasad Member; and
(b) Poicha Member

The Sabarmati River provides very good cliff sections revealing almost en tire exposed sequence whereas the rivers further north show only the upper part of the succession. On the basis of a critical appraisal and synthesis of information obtained from a number of exposed sections in the Sabarrnati, Rupen, Khari, Saraswati, Banas and Luni, supported by sub-surface bore-hole data, a composite stratigraphy for these northern rivers has been worked out.

2) Sabarmati River Basin

The Sabarmati river basin reflects an alluvial fan environment quite similar to that of the Narmada. The various horizons exposed in the river valley with their characteristic features point to a deposition in, a combination of fluvial and aeolian environments. The oldest exposed Quaternary horizon in the study area is the basal bluish clay, correlatable with the comparable formations in Mahi and Narmada. This horizon comprises 70-75 % of clay and is rich in chlorite and montmorillonite. Subsequent to their deposition, these were exposed to subaerial weathering processes, during which they underwent pedogenisation. This is evidenced by the development of calcrete veins, strings and tubes. The high CaO content is also attributed to these phenomena.

3) Facies Description

Matrix Supponed Gravel-(Gms)
The overall geomorphic setting of thisgravel facies marks the onset of fluvial sedimentation. The oldest exposed gravel is seen to comprise clastic grains showing a size variation ranging from cobbles to fine sand; at many places, the gravels tend to be clast supported, whereas at other places, the coarser clastics are embedded within a matrix of finer particles which may or may not show cementation. In case of

cementation, either it is calciteorferruginous matter. The gravels are crudely stratified and show both normal and inverse graded bedding. In hand specimens the clasts are found to be mostly of quartzite with some granite. Thin section study of the finer clastics (matrix) reveals quartz and microcline feldspar. The quartz grains are of two varieties-rounded to sub- rounded and angular to sub-angular. The feldspar is almost invariably sub-angular. The cementing agency is calcite. The depositional direction was southwesterly. As the mean direction of the longest axes of the gravels is also NE-SW, the original flow direction was oblique to the present day river flow.

The gravel characteristics point to their formation by the process of a low viscosity debris flow47.58.91.92. The range of phi and the inclusive graphic standard deviations fall very well within the one suggested by Bull", according to whom the phi deviation for the mud (debris) flow deposits ranges from 4.1 to 6.2 for semi-arid alluvial fans. That the gravels originated mainly by a combination of debris and muddy stream flows is evidenced by the fact that they fulfil the various criteria postulated by Ballance, Bu1l Hooke, McArthur and Pierson" for invoking a debris flow deposition. According to Pierson such deposits are formed during flood events in a humid climate when the gravelly channel oscillates between a very muddy stream flow to a debris flow. Fractured mud horizon which overlies this gravel indicates that the energy conditions of the depositing streams progressively weakened and finally the deposition stopped and exposed to weathering. The pedogenisation of this mud points to the period of non-deposition before the onset of the next fluvial cycle.

Planar Cross-Stratified Gravel-(Gp)

The overlying gravel which marks the beginning of the second fluvial cycle is separated from the underlying gravel by a pedogenised mud horizon and the Gp facies shows a sharp contact at places with the Gins facies. It is typically characterized by cross-stratification and numerous interbeds of finer gravel and coarse sand which shows normal as well as inverse graded bedding. The gravel lithounit shows planar cross-stratification. The parting plane of the stratification are marked by the lenses of clayey laminae occurring parallel to the bedding planes. The bounding surface between the underlying pedogenised muds is sharp and at places shows undulatory erosional contact. The foresets of the cross-stratified horizon dip at an angle of 10^0 to 12° due SW. At places the shape of the laminae changes from tangential to concave upward and show decrease in the foresets dip angle. The nature of this gravel is quite different from the underlying one. Though it shows presence of clasts with a wide range of variation from cobbles to coarse sand, the main bulk of coarser fragments is of pebblesize, large size fragments being scarce. Significantly this gravel bed is highly compact, almost rock like and could very well be termed a conglomerate. The coarser clastics are embedded in finer matrix and at places are cemented by calcium carbonate. The pebbles are of mostly quartzite with a conspicuous proportion of granite calc-silicate, feldspar (microcline and perthite), agate, jasper and chert. The calcareous cement is indicative of diagenesis by water rich in calcium carbonate occupying the interstices and subsequently precipitating sparitic calcite. This feature has considerable significance from the point of view of provenance rocks and the subsequent physico-chemical conditions responsible for the $CaCO_3$ precipitation. The various characteristics of this facies point to their being a product of stream flow deposits.

Trough Cross-Stratified Gravel Lithofacies-(Gt)

This lithofacies shows well developed trough foresets with shallow concave upward bounding surfaces; with a dip of about 10 -12 which upward becomes planar to horizontal. Gt-facies at places shows planar foresets which were eroded by later phase of deposition, marked by tangential relationship with planar and trough beds. The stratified Gt-facies shows typical fining upward interbeds of coarse and fine packages. The coarser bands are of 8-10 inches in thickness, and shows clustering along the beds. The clasts size ranges from 1 to 1.5 cm comprising mainly of granite, jasper, chert and flints, they are sub-rounded to round the larger clasts showing clustering are mainly of carbonates and the size ranges between 2 to 2.5 cm. The trough foresets are well developed where the lithounits attain its maximum thickness. This lithofacies is the product of sedimentation of a high flow ·regime. The erosive nature of the contact is indicative ·of high energy flow regime as well as represents lateral migration of bars with curved shallow channel scours or by minor shallow channel- fi1ls[64].[67]. As the trough axes of the foresets are taken as the channel orientation with high angle values of plane beds, suggests that these were deposited under bar morphology due to Increase in channel gradient or were deposited by low sinuous channel under high energy flow. The concave upward base of trough beds, which shows vertical as well as lateral accretion indicatetypical deposits of low-sinuosity channel morphology.

Sandy Gravel Sheet Facies-(Gs)

The gravelly sand occurs as a sheet like body. It mainly comprises the carbonate and basaltic clasts. The grain size finesand becomes finer as coarse sand where it merges with the silts and clay assemblages. The Gs-facies occurs in association with the Gt-facies. But is more calcretized than that of the Gt-lithofacies. The gravelly sand sheet pinches out and mergesinto the fine sand, silts and clay sediments assemblages. The Gs-facies conformsits deposition over the channel margins. The greater compaction of Gs-faciessuggests that during the shifting of the channel this portion was exposed to weathering and chemical precipitation earlier than that of the Gt-lithofacies.

Overbank Accntion Facies-(FI)

The lithofacies occurs over the Gp-facies, owes its sedimentation by overbank deposition due to gradual vertical aggradation of sediments from suspension following the flooding-events. giving rise to alternate layers of sand, silt and clay. The contact .between FI and Gp facies is slightly undulatory and at places erosive. The overall facies thickness varies from 3 to 4 m. Calcrete bands act as lithological boundaries, which could be products of fluctuating groundwater levels during 'the waning flood conditions. As the Fl- facies does not show any well developed pedogenic feature, it seems that the surface might not have remained exposed for long period to sub-aerial weathering and the vegetal growth, the latter fact is marked by low density of buried rootlets, This is overlain by a pedogenised mud horizon, whose thickness is not uniform, suggest an uneven topography over which the deposition of fine clay sediments

Geology of Ahmedabad

Ahmedabad is main city and the industrial capital of Gujarat. Population of the city is about 45 lacs. There are 11 talukas and 556 villages in this district. Total area of the district is 7932-43 sq. km and as per 2001 census report population is 58,08,378 souls.

Average rainfall of ten years is 637 mm. Main River is Sabarmati, which originates from Aravalli Ranges of Rajasthan and meeting to sea in the bay of Cambay. Geologically the area consists of Quaternary alluvium. The south west area *viz.* Part of Barvada, Ranpur, and Dhandhuka is made up of Basalt Rock. While rest area of the district consist of alluvial formation.Which is made up of alternate beds of clay and sand. Geohydrologically, major parts of the district consist of alluvial formation. Alluvial formation is made up of Sand, clay, kankars, silt and gravels. In this formation water is available under confined and unconfined conditions. Remaining area is made up of Basalt. Which is very poor in ground water availability and yield. Sufficient discharge is available from alluvial formation. Thickness of Alluvium in north- west part of the area is more. Average depth of tube-well in eastern part ranges from 90-120m and in northwest part it is 350 to 400 m.

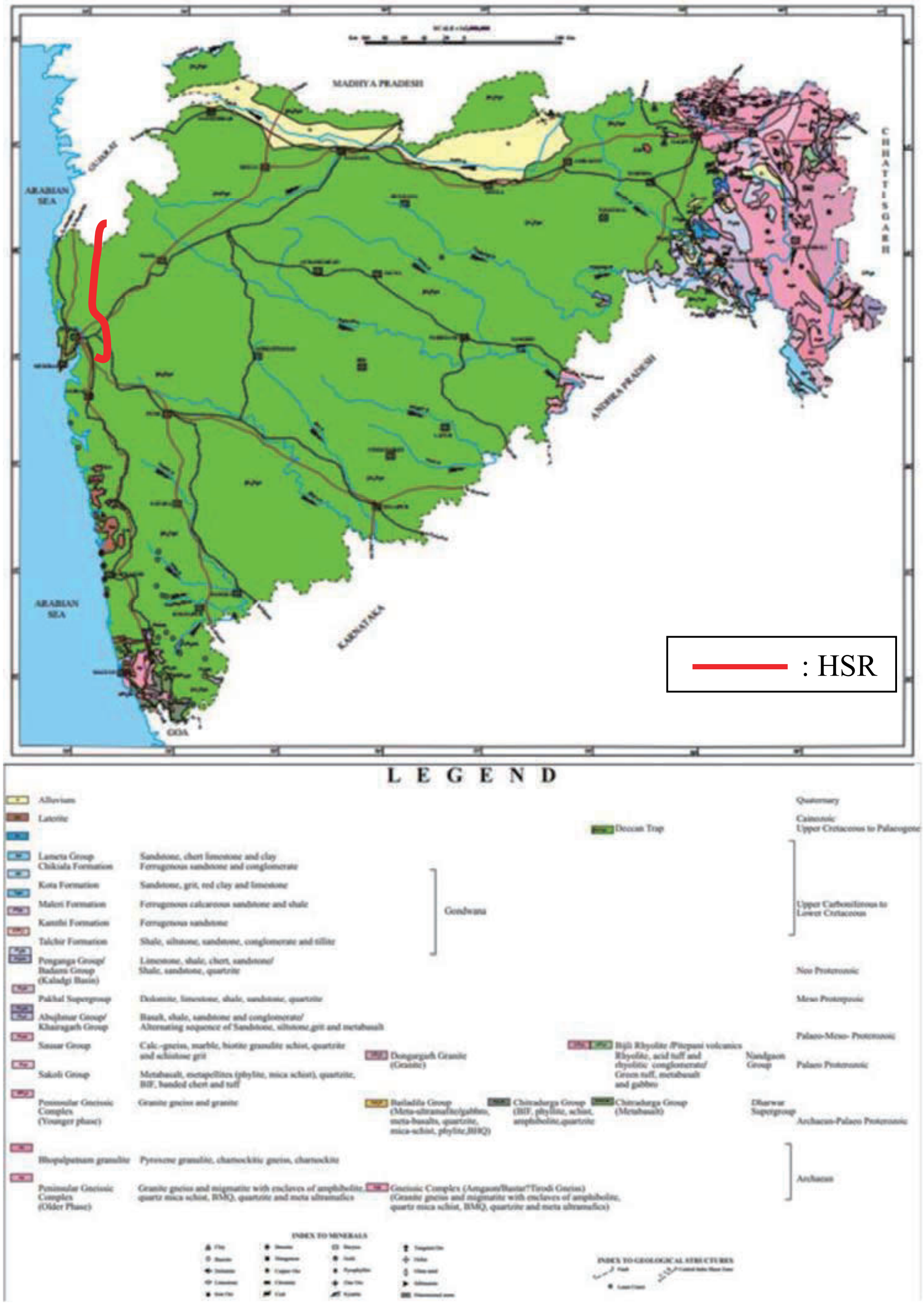
Anand
Geologically the area is mostly comprised of Quaternary Alluvium (clay & sand). The alluvium formations consist of clay, sand, kankars and gravels. The sand and gravel beds are the water bearing formations. The ground water occurs under confined and semi confined conditions. Generally tube wells are drilled in the depth range of 60 to 150 meters in Anand, Umreth, Anklav, Borsad & Petlad talukas.

Bharuch
Geologically, the district is mainly divided in to two types of rocks. Western side taluka of Bharuch district such as Jambusar, Amod, Vagra, Bharuch, Ankleshwar & Hansot represent alluvial formation. The strata made up mainly of black and yellow clay and layers of different size of sand. The eastern side of Valia and southwest part of Zagadia taluka is made up of Basalt rocks. At places like East of Zagadia & south, south-west of Rajpardi Lignite type of coal is available whereas in south-west of Zagadia Agate stone also mined. Geohydrologically the coastal area of Bharuch district falls in saline zone due to its location on the Coast of Arabian Sea. While the western part, away from coast, comprises of alluvial formation and yields potable water. Bores are drilled up to 90 to 120 Mts. depths. In hard rock area (South-West part of Zagadia and East part of Valia) DTH bores are drilled for installation of hand pumps. The depth of bores is 80.0 to 90.0 m.

Valsad
Geologically the area is composed of igneous rocks, mainly Deccan trap basalt & is overlain by thin layer of alluvium (Clay, Sand, silt & Gravels) The Dharampur & Kaprda Taluka's are hilly and rocky. The Valsad, Pardi & Umargam Talukas are covered by Alluvium (Clay, Silt & Sand) & underlain by basalt. There is less overburden in the Dharampur and Kaprada taluka's. Recent alluvium formation contains sand silt, clay & gravels. Ground water occurs in weathered portion, cracks, fissures and joints. Excessive runoff causes soil erosion and less recharge. Valsad, Pardi and Umargam talukas contains Alluvium & Basalt, while Dharampur & Kaprada Talukas are rocky & hilly feasible for drilling of bores (60 to 90 m deep) by DTH Rig. Western part is feasible for drilling by DTH / MDR rig. Salinity prevails in the coastal area, as a result now; the area is covered under regional water supply schemes for supply of drinking water. In the Dharampur and Kaprada taluka rocks are fresh and massive as a result bores and wells become seasonal and dry up during summer.

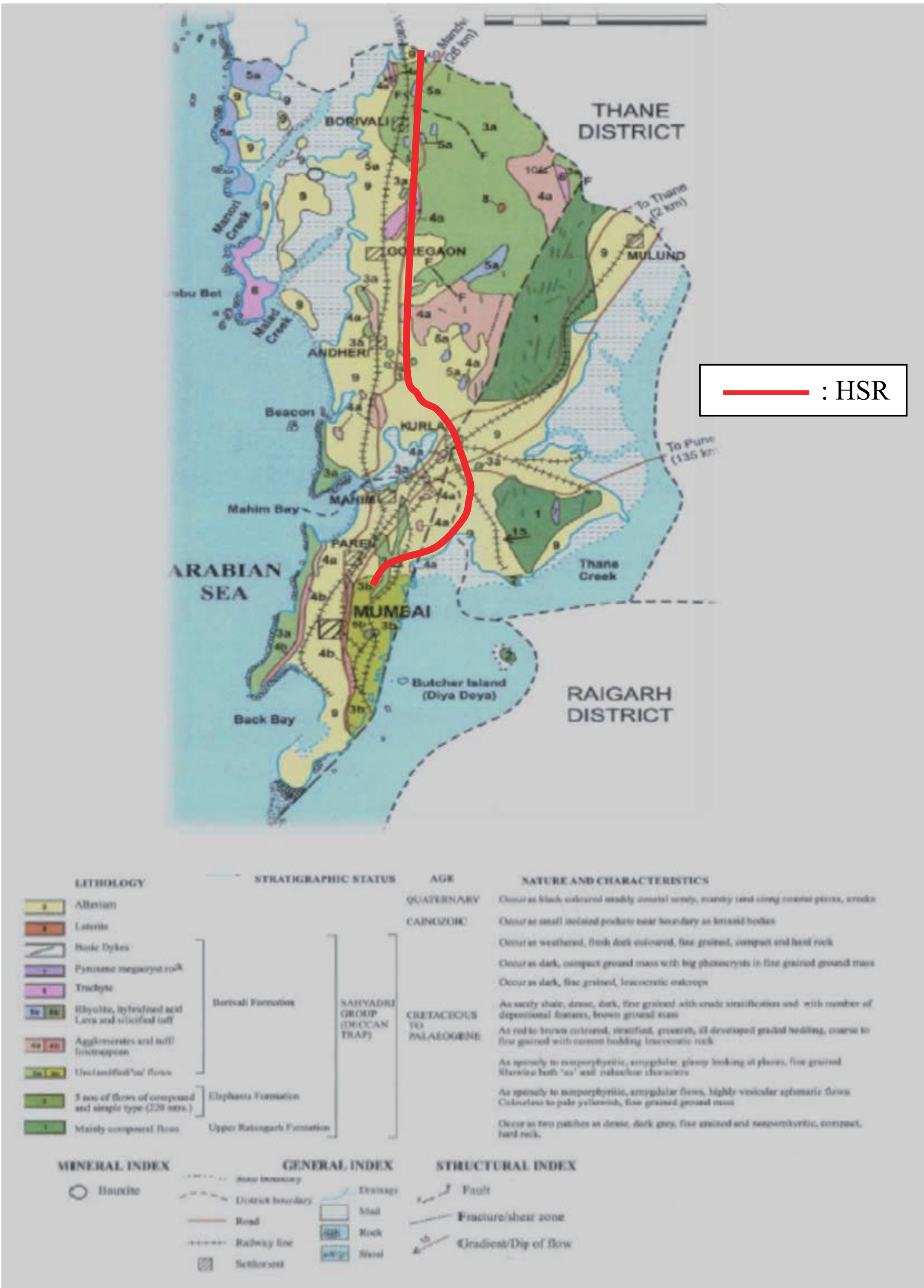
(4) Geology of Mumbai

The entire district is underlain by basaltic lava flows of upper Cretaceous to lower Eocene age. The shallow Alluvium formation of recent age also occurs as narrow stretch along the major river flowing in the area. A map depicting the geological feature of Maharshtra is shown in Figure 4.1.21, geological feature of Mumbai is shown in Figure 4.1.22 and hydrogeological feature of the Mumbai is illustrated in Figure 4.1.23.



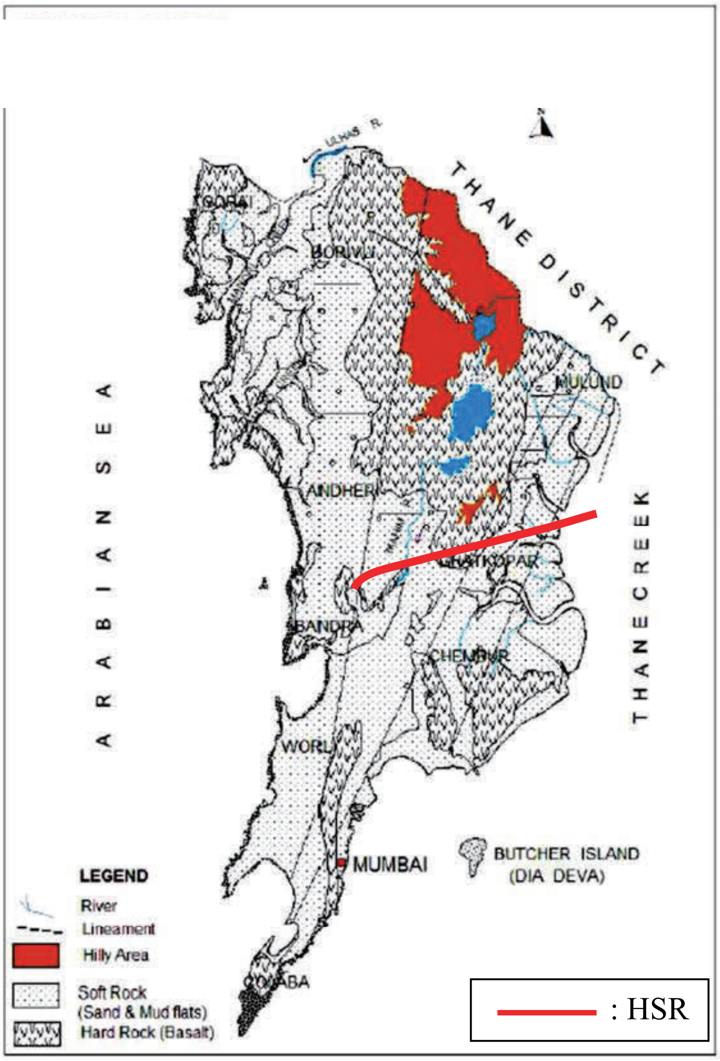
Source: www.portal.gsi.gov.in/

Figure 4.1.21: Geological Map of Maharashtra



Source: www.portal.gsi.gov.in/

Figure 4.1.22: Geological Map of Mumbai



Source: www.portal.gsi.gov.in/

Figure 4.1.23: Geohydrological Map of Mumbai

Deccan Trap Basalt

The 'Pahoehoe' flows in the district consists of highly vesicular bottom layer having closely spaced horizontal joints but the thickness is generally less. The vesicles are generally filled with secondary minerals and green earths. In such cases, they do not serve as aquifer. However, such vesicular zones are weathered in most part of the area, thus, making them moderately permeable. But if, vesicles are not filled, they act as highly permeable aquifers. The simple and compound "Pahoehoe" flow comprises a basal vesicular zone, middle relatively massive portion followed by a vesicular top. The vesicles of "Pahoehoe" flows are generally not interconnected and thus there is a variation in water holding capacity from the base to the top of the flow. The ground water exists in fractures, joints, vesicles and in weathered zone of Basalt. The occurrence and circulation of ground water is controlled by vesicular unit of lava flows and through secondary porosity and permeability developed due to weathering, jointing, fracturing *etc.*, of Basalt. The ground water occurs under phreatic, semi confined and confined conditions. The leaky confined conditions are also observed in deeper aquifers. Generally, the phreatic aquifer range down to depth of 15 mbgl. The water bearing zone down to depth of 35m bgl forms the semi confined aquifer and below this deeper aquifer down to depth of 60m bgl is observed. The yield of the dugwells varies form 10 to 1000 m^3/day, whereas that of borewells ranges between 50 and 1000 m3/day. It is expected that the potential of deeper aquifers would be much more limited as compared to the unconfined/phreatic aquifer.

Soft Rock Areas
River Alluvium patches along the course of rivers and Marine Alluvium in the coastal area, are highly potential aquifer but with limited areal extent. The ground water occurs under water table condition in sandy / gritty layers. The alluvial fill of low lying areas underlain by weathered basalt has relatively better ground water potential.

(5) Geology of Thane

The region is underlain by basaltic rocks. Basalt flow forms the predominant formation capped at a few places by laterite at higher levels. A number of hot springs occur in Thane district which have positive relation with the geology of the area. The hill ranges in the area are predominantly aligned north-south and have more or less escarpments. Basalt flows, popularly known as Deccan traps, forms the predominant formation. It is capped by laterite on a few high plateaus and covered by shore sands along the coast.A general geological sequence is as follows:
Shore sand- Recent, Laterite-Pleistocene and Basalt-Eocene.

Deccan Traps
The Deccan trap has been divided into three major groups, *i.e.*upper, middle and lower. The Bombay basalt flows have been grouped into upper traps on the basis of the inter-trappean and ash beds present in them (Krishnan, 1968). Being in the contiguous area, the Deccan traps in the district can also be grouped with the upper flows. There are number of dyke's criss-crossing the area. The general trend is however, north-northwest south-southeast and north-northeast south-southwest, dipping steeply to the east. The thickness seldom exceeds six meters. The dykes send out offshoots of different sizes, at places enclosing lenticular wedges of country rock. Chilled margins are seen along dykes flow contact.The dykes vary from coarse dolerite to fine grained basalts. Most of the dykes are porphyritic of feldspars.

Laterite
Few high basalt plateaus of the district are capped by laterites. These are Boundongri ($19^0$10'N: $75^0$57'E) and Bombassadongri ($19^0$11'N: $75^0$57'E) 430 meters, Kanheri ($19^0$13'N: $72^0$58'E) 510 meters, and Tungar ($19^0$26'N: $72^0$55'E) 665 meters hills. The Kanheri and Tungar laterites have conspicuous development of bauxite.

Shore Sands
The sea coast of the district stretching several kilometers along the western boundary is covered by sands.

Thermal Springs
There are about thirty three hot springs which are described under five groups based on their location.

- **Vajreshwari Group**: i) Ganeshpuri area ($19^0$29'N: $73^0$01'E)-There are thermal springs, most of these occurring on medium to coarse grained dykes.

ii) **Akloli area** ($19^0$29'N: $73^0$02'E)-There is linear cluster of six thermal springs near the left bank of Tansa river. They occur at the eastern margins of fine grained dolerite dykes trending towards east.

- Sativli Group: ($19^0$38'N: $72^0$55'E) There are about six springs in this group. They occur at about a kilometer west of sativli village, near Vadvali.
- Haloli group : ($19^0$40'30"N: $72^0$51'30"E) There are four hot springs at Haloli occurring in a paddy field 0.1 km west of the new highway.
- Paduspada springs: ($19^0$41'30"N: $72^0$55'30"E).The four springs in this group are seen in the soil covered left bank of Vaitarna river.
- Most of the thermal springs are seen on the fringe of dykes. The temperatures of the spring vary from 30^0 C to 70^0 C. Most of the springs are of sodium chloride. These waters are proved to have therapeutic values. Most of the springs give out gases from the orifice of the springs at periodic intervals.

Economic Mineral Deposits

i) Bauxite Deposits

Tungar plateau is the most promising of all the aluminous laterites reported in the district. The plateau rises to an elevation of about 665 meters and is situated about 14.5 kilometers north-west of Bassein ($19^0$20'N: $72^0$48'E).

ii) Common Salt

Common salt is collected in artificial evaporation pans along the coast. It is thriving industry.

(6) Seismic Consideration of the Prposed Alignment

Seismic Zonation map of a country is a guide to the seismic status of a region and its susceptibility to earthquakes. India has been divided into five zones with respect to severity of earthquakes. Of these, Zone-V is seismically the most active where earthquakes of magnitude 8 or more could occur recent strong motion observations around the world have revolutionized thinking on the design of engineering structures, placing emphasis also on the characteristics of the structures themselves it should be realized that in the case of shield type earthquakes, historic data are insufficient to define zones because recurrence intervals are much longer than the recorded human history this may often give a false sense of security. Occurrence of the damaging earthquake at Latur, falling in Zone-I is a typical example of this situation.

On perusal of Seismic Zoning Map of India, 2002 (Figure 4.1.24), the entire stretch of the proposed MAHSRC alignment falls in the intensity Zone-III as per IS 1893:2002. Zone –III represents area of moderate risk zone. However, all the structure of the station building and depots shall be designed taking care of the seismic intensity.

Cause of Earthquake

The earth's crust is a rocky layer of varying thickness ranging from a depth of about 10kilometers under the sea to 65 kilometers under the continents. The crust is not one piece but consists of portions called **'plates'** which vary in size from a few hundred to thousands of kilometers. The '**theory of plate tectonics'** holds that theplates ride up on the more mobile mantle,and are driven by some yet unconfirmed mechanisms, perhaps thermal convection currents. When these plates contact each other, stress arises in the crust. These stresses can be classified according to the type of movement along the plate's boundaries:

a) Pulling away from each other;
b) Pushing against one another; and
c) Sliding sideways relative to each other.

All these movements are associated with earthquakes.The areas of stress at plate boundaries which release accumulated energy by slipping or rupturing are known as 'faults'. The theory of 'elasticity' says that the crustis continuously stressed by the movement of the tectonic plates; it eventually reaches a point of maximum supportable strain. A rupture then occurs along the fault and the rock rebounds under its own elastic stresses until the strain is relieved. The fault rupture generates vibration called seismic (from the Greek 'seismos' meaning shock or earthquake) waves, which radiates from the focus in all directions. The point of rupture is called the 'focus' and may be located near the surface or deep below it. The point on the surface directly above the focus is termed as the epicenter' of the earthquake

Magnitude
It is a quantity to measure the size of an earthquake and is independent of the place of the observation.

Richter scale
The local magnitude is defined as the logarithm of the maximum amplitude measured in microns on a seismogram written by Wood-Anderson seismograph with free period of 0.8 second, magnification of 2,800, damping factor of 0.8 calculated to be at a distance of 100 kms. The relative size of events is calculated by comparison to a reference event of ML=0, using the formula, ML=log A-log Ao Where, A is the maximum trace amplitude in micrometer recorded on a standard seismograph and Ao is a standard value which is a function of epicentral distance (Δ) in kilometers. India has witnessed some of the most devastating earthquakes during the last century like the one in Kangra (1905), Bihar-Nepal (1934) and in Assam (1950). In the recent past, earthquakes have caused havoc in Uttarkashi (1991), Latur (1993), Jabalpur (1997), Chamoli (1999) and in Bhuj (2001).

Classification of Earthquakes	
Category	**Magnitude on Richter Scale**
Slight	Upto 4.9
Moderate	5.0 to 6.9
Great	7.0 to 7.9
Very Great	8.0 and more

Source: www.imd.gov.in

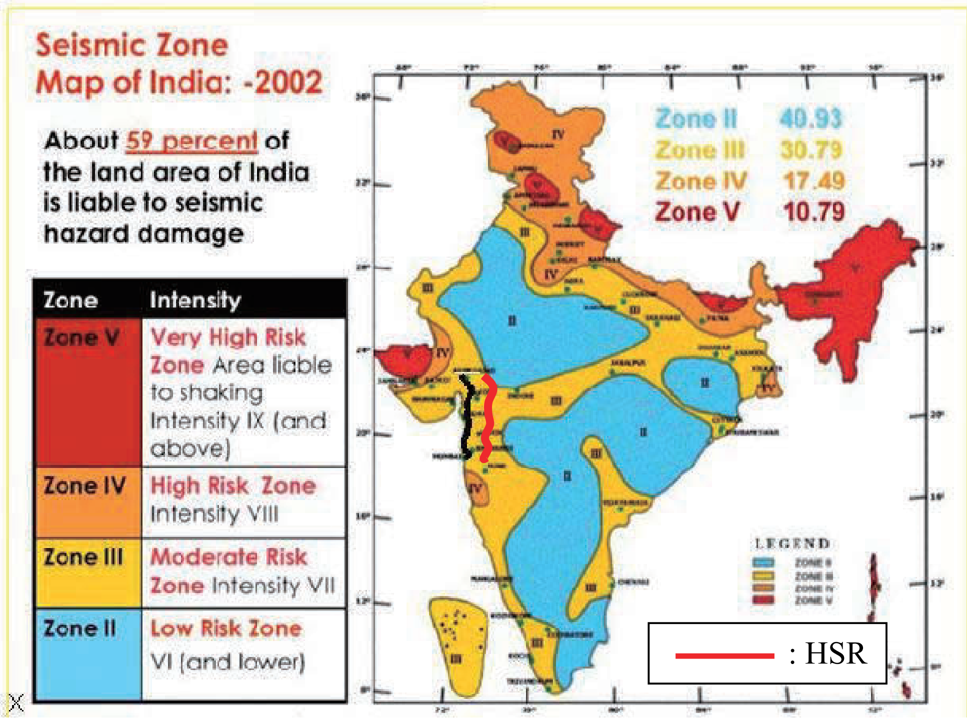
On 26th January 2001, India experienced one of the worst earthquakes in recent times. Measuring 6.9 on the Richter scale, the earthquake caused incalculable damage not just to its epicenter, Bhuj but also to other towns of the district of Kutch and to about 500 villages out of the total of 900 villages. The reported damage to property in Gujarat was about Rs.21, 000crore and the number of human lives lost were about 14,000. Of these, more than 500 deaths were reported from Ahmedabad, situated at a distance of about 350 kms from Bhuj. In the same city, close to 150 multi-storied buildings crumbled down. Cities far away from the epicenter, like Surat, too reported damage to property. Table 4.1.8 shows some damaging earthquakes took place in India.

Table 4.1.8: Occurrence of Major Earthquakes in India

Year of Occurrence	Place of Occurrence	Intensity on Richter Scale		Others
1618	Bombay	-	-	2000 lives lost
1720	Delhi	6.5	-	Some lives lost
1737	Bengal	-	-	300,000 lives lost
1803	Mathura	6.5	-	The shock felt up to Calcutta.
1803	Kumaon	6.5	-	Killed 200-300 people.
1819	Kutchch	8.0	XI	Chief towns of Tera, Kathara and Mothala razed to the ground.
1828	Srinagar	6.0	-	1000 people killed.
1833	Bihar	7.7	X	Hundreds of people killed
1848	Mt.Abu, Rajasthan	6.0	-	Few people killed
1869	Assam	7.5	-	Affected an area of 2,50,000 Sq. miles.
1885	Srinagar	7.0	-	Kamiarary area destroyed.
1897	Shillong	8.7	XII	Wide spread destruction in Shillong.
1905	Himachal Pradesh	8.0	XI	Thousands of people killed.
1906	Himachal Pradesh	7.0	-	Heavy damage.
1916	Nepal	7.5	-	All houses collapsed at Dharchulla.
1918	Assam	7.6	-	Heavy damage.
1930	Dhubri, Meghalaya	7.1	IX	Heavy damage in Dhubri.
1934	Bihar, Nepal	8.3	XI	Large number of border area people killed.
1935	Quetta (in Pakistan)	7.5	IX	25,000 people killed
1941	Andaman	8.1	X	Very heavy damage.
1947	Dibrugarh	7.8	-	Heavy damage.
1950	Assam	8.6	XII	Heavy damage to life and property.
1952	NE India	7.5	-	Heavy damage.
1956	Bulandshahar, U.P.	6.7	VIII	Many people killed
1956	Anjar, Gujarat	7.0	VIII	Hundreds of people killed
1958	Kapkote, U.P.	6.3	VIII	Many people killed
1967	Koyna,	6.1	VIII	Koyna Nagar razed.

1969	Bhadrachalam	6.5	1	Heavy damage.
1986	Dharamshala (H.P)	5.7	VIII	Lots of damage.
1988	Assam	7.2	IX	Few people killed
1988	Bihar- Nepal	6.5	VIII	Large number of people killed.
1991	Uttarkashi	6.6	VIII	Lots of damage to life and property.
1993	Latur	6.4	VIII	Heavy damage to life and property about, 000 people killed.
1997	Jabalpur	6.0	VIII	Lots of damage to property, about 39 lives lost.
1999	Chamoli	6.8	VIII	Lots of damage to property about 100 people lost lives.
2001	Bhuj	6.9	X	Huge devastation, about ~ 14000 people lost lives

Source: www.imd.gov.in



Source: www.imd.gov.in

Figure 4.1.24: Seismic Zoning Map of India

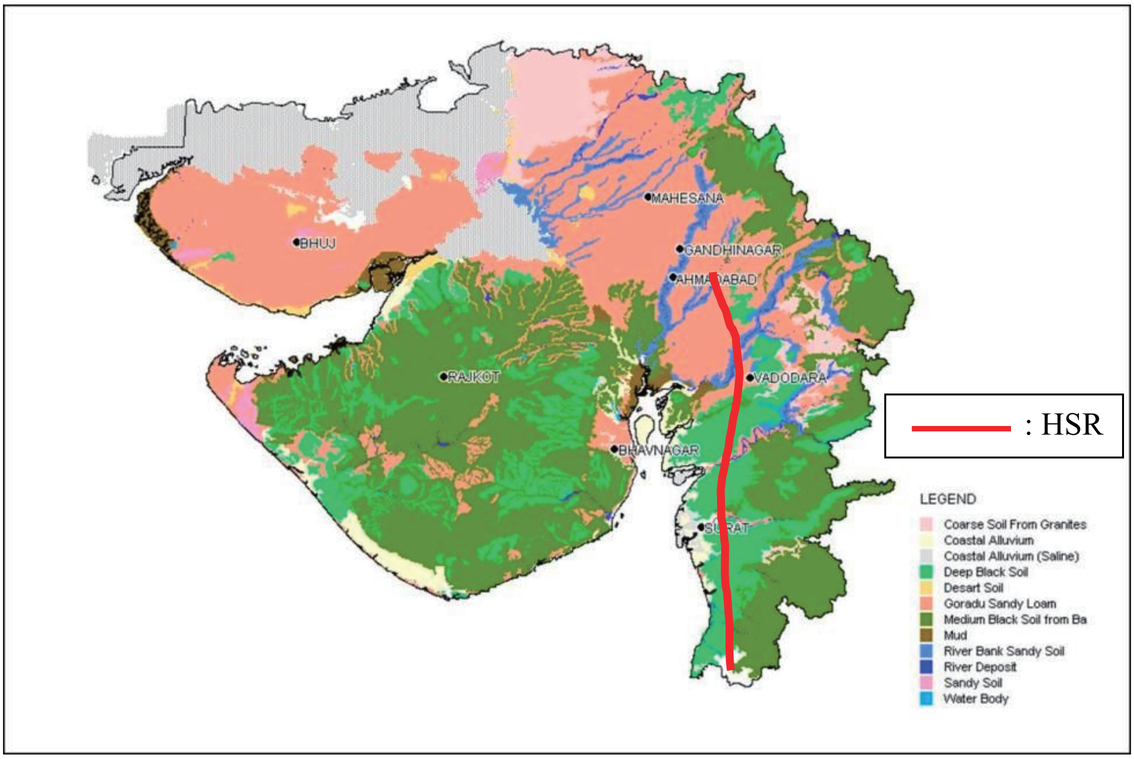
4.1.3 Soil Quality

The entire stretch of the proposed alignment can be divided into two parts on the basis of the soil characteristics- the alignment falling in the Gujarat and second one the alignment falling in the Maharashtra, close to Mumbai and Thane.

(1) Soil of Gujarat Region

Central Gujarat comprises Vadodara, Kheda, Anand, Dahod and Panchmahal district. The soil of central Gujarat varies from shallow to deep soil depth class. The deep & very deep soil depths are found in western part, where as shallow soil depth belongs to eastern part. The soils are fine to coarser and well to moderately drained in general and observed somewhat excessive drained also. The Soils are slilght to moderate saline having slight sodicity. The distribution of district wise area mapped characteristic wise.The Soils of Vadodara, Panchmahal and Dahod district belong to shallow to deep in soil depth class, whereas they vary from moderately deep to very deep in Anand & Kheda district. The soil map of Gujarat is illustrated in Figure 4.1.25. The Soils of Central Gujarat belongs to fine to coarser in general. The soils of Anand, Kheda, Panchmahal, Dahod districts are dominantly medium textured (Loamy) followed by fine textured (Clayey) .The soils adjoining to Anand, Kheda, Panchmahal and Dahod districts are coarser (Sandy). In Vadodara district the soils are dominantly fine textured (clayey) followed by medium textured (loamy) and towards adjoining Vadodara and Dahod district boundary the soils are coarser (sand).Soil drainage in Anand, Kheda and Panchmahal are well to moderately drained whereas in Vadodara and Dahod district varies from well drained to moderately drained followed by somewhat excessive drained. The soils of western parts of Anand districts are medium saline in nature and towards north slightly saline in nature. Whereas, towards Khambhat creek the soils are moderately saline. The soils in Kheda district belong to slight to moderate saline and the soils of Vadodara district towards western part ranges from slight to moderate saline. The Soil Salinity in Vadodara, Anand, Kheda are slighter to moderately saline whereas in Panchmahal & Dahod the Soil Salinity belongs to moderately saline. The soil sodicity in general is slight sodic in all districts of Central Gujarat.

South Gujarat region comprises of Bharuch, Narmada, and Surat, Tapi, Navasari, Valasad and Dang districts. Dominantly the soils are very deep, well drained and fine and medium textured. They are slightly alkaline, slight to strong saline. The Soil characteristics like Soil depth, Soil texture, Soil drainage, Soil Salinity and Sodicity District wise is mapped characteristic. Soil depth in South Gujarat is well distributed in two parts. The Soils in western side are dominantly very deep followed by moderately deep and in eastern part soils are dominantly shallow followed by moderately shallow.The Soils in Bharuch, Narmada, Surat, Navasari and Valasad District dominantly distributed to very deep soil depth class followed by shallow depth Moderately deep soil are also observed, Where as in Tapi district the soil depth are dominantly shallow followed by very deep. In Dang district the soils are dominantly distributed in shallow soil depth class.Soils in South Gujarat in general varies from fine to medium textured (Clayey to loamy clay), except in Dang District. In Dang the soils are medium textured. Soil drainage in South Gujarat is well to moderately drain in general. In Dang district the soil drainage is well drained.Soil salinity in South Gujarat varies from slight to strong salinity class.In Bharuch District soil salinity belongs to slight to moderate and severe towards coastal. In Narmada, Tapi and Dang district soil salinity is moderate. The Soil salinity in Surat, Navasari and Valasad belongs to slight to strong salinity class.



Source: www.gujarat.gov.in

Figure 4.1.25: Soil Map of Gujarat

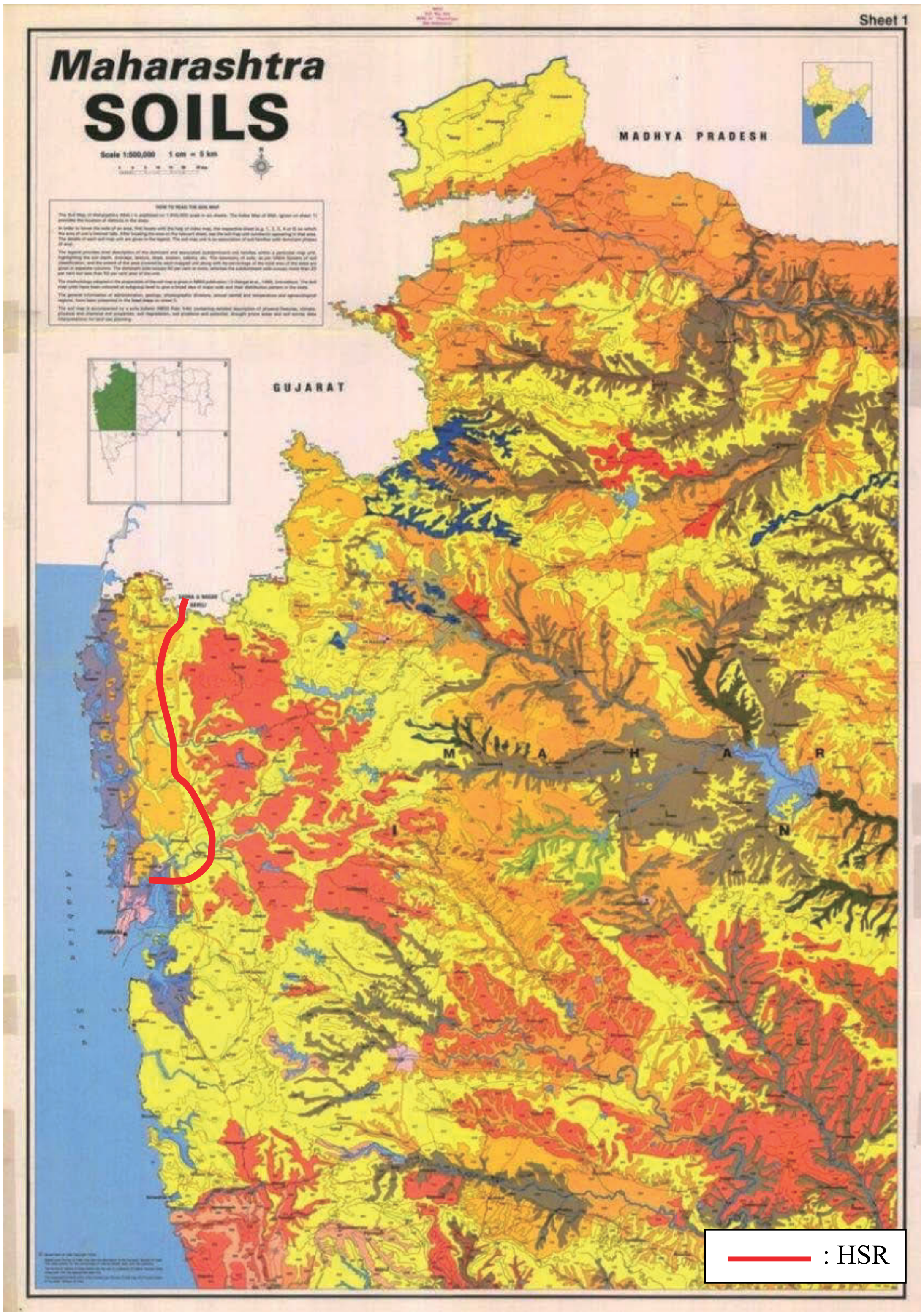
The Soil Sodicity in South Gujarat in general belongs to slight sodicity class except in Navasari where soil sodicity varies from slight to moderate. Ahmedabad, along with Banaskantha, Patan, Mehasana, Sabarkantha, Gandhinagar, Surendranagar districts falls in the North Gujarat Region of Gujarat State. In this region, major area falls into 'very deep' soil. However, ‘deep’ soil is in major area of Surendranagar district and in few area of Ahmedabad and Patan district. There are 'moderately deep' soils in few area of Surendranagar, Patan and Ahmedabad district and in North-East of Sabarkantha district.There are 'very shallow' to 'shallow' soil in North-East part (Sabarkantha district) and South West (Surendranagar district) part of the region. Rock outcrops are also found in some part of the region especially in North-East (Banaskantha and Sabarkantha district) & South - West (Surendranagar District) of the region. However, the rocks are not found in Ahmedabad area. A major texture of the soil in the region is 'Loamy'. However, in South-West part (in Ahmedabad and Surendranagar district) a soil texture in few area is found to be 'Clayey'. It is also 'Sandy' soil in some area of the Northern part (Banaskantha district) of the region. Major area of the region is having 'Well’ drained soil. However, in some area of region especially in central part (Adjoining area of Mehsana, Sabarkantha and Gandhinagar district.) and eastern part of Banaskantha and Western part of Surendranagar district is representing 'Somewhat excessively' drained soil. A very few areas of southern part of the region (Adjoining area of Ahmedabad and Surendranagar district) and in Western part (Patan district) is showing 'moderately well' drained soil.

In few area of middle part of Ahmedabad district and Eastern part of Surendranagar district is 'Slightly Saline'. A considerable area of Eastern part of Patan and Western part of Mahesana, a southern part of Ahmedabad district and North-West part of Banaskantha district is representing 'Moderate’ salinity of the soil. ‘Strongly’ saline soil is observed in South-West part of Banaskantha and Western part of Patan district.

Very few areas have 'Severe' saline soil in Southern part of Ahmedabad district. Slight sodicity is found in central part of the region (In Patan, Mahesana and Ahmedabad district) and in North-East part of Surendranagar district. In west part of the region (Banaskantha, Patan, Surendranagar and Ahmedabad district). 'Moderate' to 'strong' sodicity of the soil is found in the region.

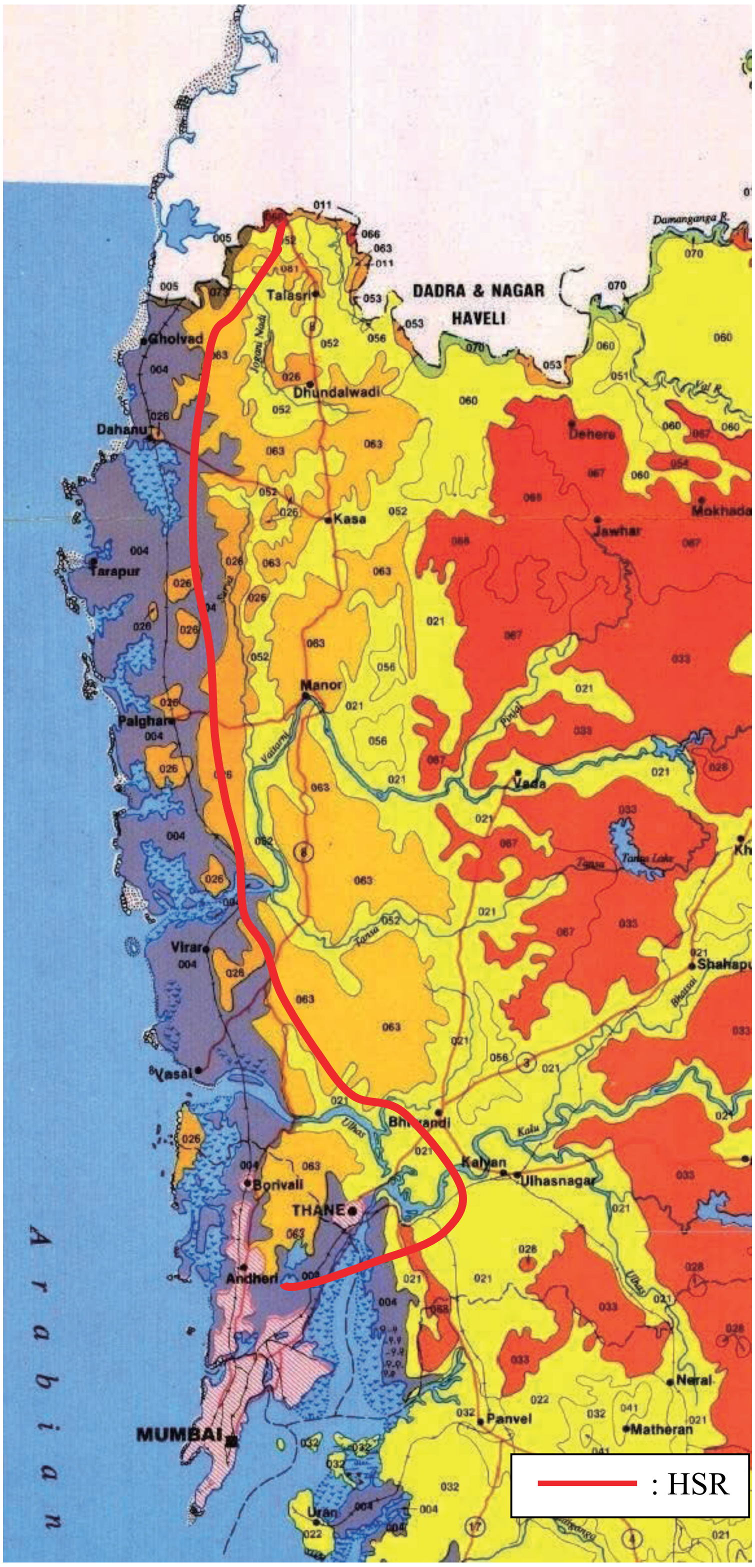
(2) Soil of Maharashtra Region

The soil status of Maharashtra is residual, derived from the underlying basalts. In the semi-dry plateau, the regur (black-cotton soil) is clayey, rich in iron and moisture-retentive, though poor in nitrogen and organic matter. When re-deposited along the river valleys, the kali soils are deeper and heavier, better suited for Rabi crops. Farther away, with a better mixture of lime, the morand soils form the ideal Kharif zone. The higher plateau areas have pather soils, which contain more gravel. The soil and vegetation of Maharashtra are related to the climate and the geology. The soil in the Deccan plateau is made up of black basalt soil. This type of soil is rich in humus. The soil is commonly known as the black cotton soil because it is best suited for the cultivation of cotton. The soil map of Marashtra and Mumbai Region with superimposed HSR alignment is illustrated in Figure 4.1.26 and 4.1.27 respectively. The volcanic action which had taken place in the Deccan region has given rise to the soil texture and composition. These igneous rocks break down into the black soil which is very fertile. The black soil is rich in N, P and K nutrients. By and large, the soils of Maharashtra are shallow and of somewhat poor quality. Soil cover in the city region is predominantly sandy due to its proximity to the sea. In the suburbs the soil cover is largely alluvial and loamy.



Source: European Soil Portal

Figure 4.1.26: Soil Map of Maharashtra (Upto Mumbai)



Source: Source: European Soil Portal

Figure 4.1.27: Soil Map of Study Area (Maharashtra Region)

LEGEND

001	Extremely shallow, somewhat excessively drained, loamy soils on moderately sloping lands with residual hills with severe erosion and strong stoniness; associated with extremely shallow, somewhat excessively drained, loamy soils on gently sloping lands with severe erosion and strong stoniness.	o Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents o Loamy, mixed, isohyperthermic, Lithic Ustorthents
002	Very shallow, well drained, loamy soils on moderately sloping lands with residual hills with moderate erosion and moderate stoniness; associated with rock outcrops.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Rock outcrops
003	Very shallow, well drained, loamy soils on moderately sloping lands with residual hills with severe erosion and slight stoniness; associated with moderately shallow, well drained, loamy soils on gently sloping lands with moderate erosion and slight stoniness.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Loamy-skeletal, mixed, isohyperthermic, Udic Rhodustalfs
004	Slightly deep, poorly drained, fine soils on very gently sloping lands with residual hills with slight erosion and strong salinity; associated with moderately deep, well drained, fine soils on gently sloping lands with moderate erosion.	o Fine, montmorillonitic, calcareous, isohyperthermic, Vertic Halaquepts o Fine, montmorillonitic, calcareous, isohyperthermic, Entic Chromusterts
005	Very deep, moderately well drained, calcareous, fine soils on nearly level lands with residual hills with slight erosion, associated with very deep, moderately well drained, calcareous, very fine soils on very gently sloping lands with slight erosion.	o Fine, montmorillonitic, calcareous, isohyperthermic, Typic Chromusterts o Very fine, montmorillonitic, calcareous, isohyperthermic, Typic Chromusterts
006	Slightly deep, well drained, loamy soils on moderately sloping undulating lands with mesas and narrow valleys with moderate erosion and slight stoniness; associated with slightly deep, well drained, loamy soils on gently sloping lands with moderate erosion and slight stoniness.	o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs o Loamy-skeletal, mixed, isohyperthermic, Typic Ustropepts
007	Moderately deep, well drained, loamy soils on moderately sloping undulating lands with mesas and narrow valleys with moderate erosion and moderate stoniness; associated with shallow, well drained, loamy soils with moderate erosion and strong stoniness.	o Fine-loamy, mixed isohyperthermic, Ultic Haplustalfs o Loamy, mixed, isohyperthermic, Lithic Ustropepts

Source: European Soil Portal

008	Very shallow, well drained, loamy soils on moderately sloping undulating lands with mesas and narrow valleys with severe erosion and moderate stoniness; associated with very shallow, well drained, loamy soils with severe erosion and strong stoniness.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Loamy-skeletal, mixed, iso-hyperthermic, shallow, Typic Ustorthents
009	Very shallow, well drained, loamy soils on steeply sloping lands with mesas and narrow valleys with severe erosion; associated with well drained, loamy soils on moderately sloping lands with severe erosion.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Loamy-skeletal, mixed iso-hyperthermic, Lithic Ustropepts
010	Shallow, somewhat excessively drained, loamy soils on moderately sloping undulating lands with mesas and narrow valleys with moderate erosion and moderate stoniness; associated with shallow, well drained loamy soils with moderate erosion and moderate stoniness.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Loamy, mixed, isohyperthermic, Lithic Ustropepts
011	Moderately deep, well drained, fine soils on very gently sloping undulating lands with mesas and narrow valleys with moderate erosion and slight stoniness; associated with very deep, moderately well drained, fine soils with moderate erosion.	o Fine, montmorillonitic, isohyperthermic, Vertic Ustropepts o Fine, montmorillonitic, isohyperthermic, Typic Chromusterts
012	Shallow, well drained, loamy soils on moderately steeply sloping undulating lands with mesas and narrow valleys with severe erosion and slight stoniness; associated with very shallow, well drained, loamy soils on moderately sloping lands with severe erosion and slight stoniness.	o Loamy-skeletal, mixed, isohyperthermic, shallow, Typic Ustropepts o Loamy, mixed, isohyperthermic, Lithic Ustorthents
013	Slightly deep, well drained, loamy soils on moderately sloping undulating lands with mesas and narrow valleys with severe erosion and moderate stoniness; associated with shallow, well drained, loamy soils with severe erosion.	o Fine-loamy, mixed, isohyperthermic, shallow, Typic Ustropepts o Loamy, mixed, isohyperthermic, shallow, Typic Ustropepts
014	Deep, well drained, loamy soils on gently sloping undulating lands with mesas and narrow valleys with slight erosion.	o Fine-loamy, mixed, isohyperthermic, Typic Ustropepts
015	Moderately deep, well drained, loamy soils on gently sloping valley lands with moderate erosion; associated with deep, well drained clayey soils with moderate erosion.	o Fine-loamy, mixed, isohyperthermic, Ultic Haplustalfs o Fine, mixed, isohyperthermic, Typic Haplustalfs
016	Very shallow, well drained, loamy soils on gently sloping valley lands with moderate erosion and slight stoniness; associated with moderately deep, well drained, loamy soils on moderately sloping lands with severe erosion and slight stoniness.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs

Source: European Soil Portal

017	Very shallow, somewhat excessively drained, loamy soils on steeply sloping lands with severe erosion; associated with shallow, somewhat excessively drained, loamy soils on moderately steeply sloping lands with severe erosion.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Loamy, mixed, isohyperthermic, shallow Typic Ustropepts
018	Shallow, well drained, loamy soils on moderately sloping valley lands with severe erosion and slight stoniness; associated with moderately deep, well drained, loamy soils with moderate erosion.	o Loamy, mixed, isohyperthermic, shallow Typic Ustropets o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs
019	Deep, well drained, clayey soils on gently sloping valley lands with slight erosion; associated with deep, well drained, loamy soils, with slight erosion.	o Fine, mixed, isohyperthermic, Typic Ustropepts o Fine-loamy, mixed, isohyperthermic, Typic Ustropepts
020	Deep, well drained, loamy soils on gently sloping valley lands with slight erosion and strong salinity; associated with deep, well drained, loamy soils with slight erosion.	o Fine-loamy, mixed, isohyperthermic, Typic Ustropepts o Fine, mixed, isohyperthermic, Typic Ustropepts
021	Extremely shallow, somewhat excessively drained, loamy soils on moderately steeply sloping undulating and rolling lands with severe erosion; associated with slightly deep, moderately well drained, loamy soils on very gently sloping lands with moderate erosion.	o Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents o Fine-loamy, mixed, isohyperthermic, Typic Ustropepts
022	Very shallow, well drained, loamy soils on very gently sloping undulating and rolling lands with moderate erosion; associated with moderately deep, well drained, clayey soils on very steeply sloping lands with severe erosion and moderate stoniness.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Clayey-skeletal, mixed, isohyperthermic, Typic Ustropepts
023	Very shallow, somewhat excessively drained, loamy soils on moderately steeply sloping elongated ridges with hills with severe erosion and strong stoniness; associated with rock outcrops.	o Loamy, mixed isohyperthermic, Lithic Ustorthents o Rock outcrops
024	Shallow, well drained, loamy soils on moderately sloping elongated ridges/hills with moderate erosion and strong stoniness; associated with rock outcrops.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Rock outcrops
025	Very shallow, well drained, loamy soils on very steeply sloping elongated ridges/hills with very severe erosion; associated with shallow, moderately well drained, clayey soils on very gently sloping lands with moderate erosion.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Clayey, montmorillonitic, isohyperthermic, shallow, Typic Ustorthents

Source: European Soil Portal

026	Moderately deep, moderately well drained, clayey soils on gently sloping elongated ridges/hills with moderate erosion; associated with very shallow, somewhat excessively drained, clayey soils on moderately steeply sloping lands with severe erosion and strong stoniness.	o Fine, montmorillonitic, isohyperthermic, Vertic Ustropepts o Clayey-skeletal, mixed, isohyperthermic, shallow, Typic Ustorthents
027	Shallow, well drained, clayey soils on steeply sloping elongated ridges with stoniness; associated with slightly deep, well drained clayey soils with severe erosion and strong stoniness.	o Clayey-skeletal, mixed, isohyperthermic, Typic Ustropepts o Clayey-skeletal, mixed, isohyperthermic, Typic Rhodustalfs
028	Moderately deep, well drained, loamy soils on gently sloping elongated ridges/hills with moderate erosion; associated with shallow, well drained, loamy soils with moderate erosion.	o Fine-loamy, mixed, isohyperthermic, Typic Ustropepts o Loamy, mixed, isohyperthermic, Lithic Ustropepts
029	Deep, well drained, clayey soils on moderately sloping uplands with narrow valleys with severe erosion; associated with slightly deep, well drained, loamy soils on moderately steeply sloping lands with severe erosion and slight stoniness.	o Fine, mixed, isohyperthermic, Udic Haplustalfs o Loamy-skeletal, mixed, isohyperthermic, Typic Ustropepts
030	Extremely shallow, somewhat excessively drained, loamy soils on gently sloping uplands with narrow valleys with moderate erosion; associated with rock outcrops.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Rock outcrops
031	Moderately deep, well drained, clayey soils on steeply sloping uplands with narrow valleys with severe erosion; associated with shallow, well drained, loamy soils with severe erosion.	o Clayey-skeletal, mixed isohyperthermic, Typic Ustropepts o Loamy, mixed, isohyperthermic, Lithic Ustropepts
032	Very shallow, somewhat excessively drained, loamy soils on moderately steeply sloping dissected hills and intervening valleys with severe erosion; associated with moderately deep, moderately well drained, clayey soils on very gently sloping lands with moderate erosion.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Fine, montmorillonitic, isohyperthermic, Vertic Ustropepts
033	Shallow, well drained, loamy soils on moderately steeply sloping dissected hills and intervening valleys with severe erosion; associated with very shallow, well drained, loamy soils on gently sloping lands with moderate erosion.	o Loamy, mixed, isohyperthermic, Typic Ustropepts o Loamy, mixed, isohyperthermic, Lithic Ustropepts
034	Shallow, well drained, loamy soils on moderately steeply sloping undulating western foothill slopes and narrow valleys with severe erosion and moderate stoniness; associated with shallow, well drained, loamy soils on very steeply sloping lands with very severe erosion and moderate stoniness.	o Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents o Loamy-skeletal, mixed, isohyperthermic, shallow, Typic Ustropepts

Source: European Soil Portal

035	Very shallow, somewhat excessively drained, loamy soils on moderately steeply sloping undulating western foothill slopes and narrow valleys with severe erosion and strong stoniness; associated with shallow, somewhat excessively drained, loamy soils with severe erosion and strong stoniness.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents Loamy, mixed, isohyperthermic, shallow Typic Ustropepts
036	Shallow, somewhat excessively drained, loamy soils on moderately steeply sloping undulating western foothill slopes and narrow valleys with severe erosion and strong stoniness; associated with very shallow, well drained, loamy soils with severe erosion and strong stoniness.	o Loamy-skeletal, mixed, isohyperthermic, shallow, Typic Ustropepts o Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents
037	Shallow, moderately well drained, loamy soils on very gently sloping undulating western foothill slopes and narrow valleys with moderate erosion; associated with shallow, well drained, loamy soils on gently sloping lands with severe erosion.	o Fine-loamy, mixed, isohyperthermic, Typic Ustropepts o Loamy, mixed, isohyperthermic, Lithic Ustorthents
038	Moderately deep, well drained, loamy soils on moderately sloping spurs with severe erosion and moderate stoniness; associated with moderately deep, well drained, clayey soils on moderately steeply sloping spurs with severe erosion and moderate stoniness.	o Fine-loamy, mixed, isohyperthermic; Udic Rhodustalfs o Clayey-skeletal, mixed, isohyperthermic, Typic Ustropepts
039	Deep, somewhat excessively drained, fine soils on moderately steeply sloping spurs with moderate erosion and strong stoniness; associated with slightly deep, somewhat excessively drained, fine soils with severe erosion and strong stoniness.	o Fine, mixed, isohyperthermic, Udic Rhodustalfs o Fine, mixed, isohyperthermic, Typic Ustropepts
040	Shallow, well drained, loamy soils on moderately sloping spurs with severe erosion and strong stoniness; associated with slightly deep, loamy soils with severe erosion and strong stoniness.	o Loamy-skeletal, mixed, isohyperthermic, shallow, Udic Haplustalfs o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs
041	Very shallow, somewhat excessively drained, loamy soils on moderately steeply sloping spurs of north Sahyadri with severe erosion and moderate stoniness; associated with rock outcrops.	o Loamy-skeletal, mixed isohyperthermic, Lithic Ustorthents o Rock outcrops.
042	Very shallow, somewhat excessively drained, loamy soils on moderately sloping spurs with moderate erosion and strong stoniness.	o Loamy, mixed, isohyperthermic, Lithic Ustropepts
043	Moderately deep, well drained, loamy soils on moderately sloping spurs with moderate erosion and strong stoniness; associated with deep, well drained, loamy soils with moderate erosion.	o Fine-loamy, mixed isohyperthermic, Typic Ustropepts o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs

Source: European Soil Portal

044	Very deep, well drained, loamy soils on gently sloping eastern hill slopes and narrow valleys with moderate erosion; associated with shallow, well drained, loamy soils on steeply sloping lands with very severe erosion.	o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs o Loamy-skeletal, montmorillonitic, isohyperthermic, shallow, Typic Ustropepts
045	Deep, well drained, loamy soils on moderately steeply sloping narrow valleys on eastern slopes of Sahyadri with severe erosion; associated with shallow, well drained, loamy soils with very severe erosion and moderate stoniness.	o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs o Loamy-skeletal, mixed, isohyperthermic, shallow, Typic Ustropepts
046	Very deep, well drained, loamy soils on gently sloping narrow valleys with moderate erosion; associated with shallow, well drained, loamy soils on moderately sloping hill slopes and narrow valleys with very severe erosion and moderate stoniness.	o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs o Loamy, mixed, isohyperthermic, shallow, Typic Ustropepts
047	Moderately shallow, well drained, loamy soils on moderately steeply sloping eastern slopes and narrow valleys with severe erosion and moderate stoniness; associated with moderately shallow, well drained, clayey soils with severe erosion and slight stoniness.	o Fine-loamy, mixed, isohyperthermic, Udic Rhodustalfs o Clayey-skeletal, mixed, isohyperthermic, Typic Ustropepts
048	Moderately deep, somewhat excessively drained, fine soils on moderately steeply sloping eastern slope and narrow valleys with severe erosion and strong stoniness.	o Fine, mixed, isohyperthermic, Udic Rhodustalfs
049	Shallow, well drained, loamy soils on moderately steeply sloping Sahyadri eastern slopes and narrow valleys with severe erosion; and strong stoniness; associated with shallow, somewhat excessively drained, loamy soils with severe erosion and strong stoniness.	o Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents o Loamy, mixed, isohyperthermic, shallow, Typic Ustropepts
050	Very shallow, well drained, loamy soils on moderately steeply sloping Sahyadri eastern slopes with very severe erosion and strong stoniness; associated with rock outcrops.	o Loamy, mixed, isohyperthermic, Lithic Ustorthents o Rock outcrops.
051	Shallow, somewhat excessively drained, clayey soils on moderately sloping eastern slopes of highly dissected hill range with severe erosion and strong stoniness; associated with shallow, well drained clayey soils with moderate erosion and moderate stoniness.	o Clayey, mixed, isohyperthermic, Lithic Ustorthents o Clayey, mixed, isohyperthermic, shallow, Typic Ustropepts
052	Very shallow, moderately well drained, clayey soils on gently sloping narrow valleys with moderate erosion; associated with shallow, moderately well drained, clayey soils with moderate erosion.	o Clayey-skeletal, mixed, isohyperthermic, shallow, Typic Ustorthents o Clayey, mixed, isohyperthermic, shallow, Typic Ustropepts

Source: European Soil Portal

053	Moderately deep, well drained, fine soils on very gently sloping foot hills with moderate erosion and slight stoniness; associated with very deep, moderately well drained, fine soils with moderate erosion.	o Fine, montmorillonitic, isohyperthermic, Vertic Ustropepts o Fine, montmorillonitic, isohyperthermic, Typic Chromusterts.
054	Shallow, excessively drained, clayey soils on moderately steeply sloping Sahyadri eastern slopes with severe erosion and strong stoniness.	o Clayey, montmorillonitic, isohyperthermic, shallow, Typic Ustropepts

055	Shallow, well drained, loamy soils on moderately steeply sloping dissected hills and narrow valleys with severe erosion and moderate stoniness; associated with shallow, well drained loamy soils with severe erosion and moderate stoniness.	O Loamy, mixed, hyperthermic, Lithic Rhodustalfs O Loamy, mixed, hyperthermic, Lithic Ustochrepts
056	Very shallow, somewhat excessively drained, loamy soils on moderately steeply sloping dissected hills and narrow valleys with severe ercsion and strong stoniness; associated with rock outcrops.	O Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents O Rock outcrops
057	Shallow, somewhat excessively drained, loamy soils on moderately steeply sloping dissected hills and narrow valleys with severe erosion and strong stoniness; associated with shallow, somewhat excessively drained, loamy soils on moderately steeply sloping lands with severe erosion and strong stoniness.	O Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents O Loamy, mixed, isohyperthermic, Lithic Ustorthents
058	Very shallow, well drained, loamy soils on steeply sloping elongated ridges of Sahyadri with severe erosion and moderate stoniness; associated with moderately deep, well drained, loamy soils with severe erosion and slight stoniness.	O Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents O Loamy-skeletal, mixed, isohyperthermic, Typic Ustropepts
059	Very shallow, somewhat excessively drained, loamy soils on gently sloping dissected hills/narrow valleys with severe erosion; associated with shallow, well drained, clayey soils with moderate erosion.	O Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents O Clayey, mixed, isohyperthermic, shallow, Typic Ustropepts
060	Extremely shallow, somewhat excessively drained, clayey soils on moderately steeply sloping dissected hills/narrow valleys with severe erosion and strong stoniness; associated with very shallow, somewhat excessively drained, clayey soils with severe erosion and moderate stoniness.	O Clayey-skeletal, mixed, isohyperthermic, Lithic Ustorthents O Clayey-skeletal, mixed, isohyperthermic, shallow, Typic Ustorthents
061	Very shallow, well drained, loamy soils on very steeply sloping dissected hills/narrow valleys with very severe erosion; associated with very shallow, well drained, clayey soils with severe erosion.	O Loamy, mixed, isohyperthermic, Lithic Ustorthents O Clayey, mixed, isohyperthermic, Lithic Ustorthents

Source: European Soil Portal

062	Very shallow, somewhat excessively drained, clayey soils on moderately steeply sloping dissected hills/ narrow valleys with severe erosion and moderate stoniness; associated with shallow, somewhat excessively drained, clayey soils with severe erosion and moderate stoniness.	o Clayey, mixed, isohyperthermic, Lithic Ustorthents o Clayey, mixed, isohyperthermic, shallow, Typic Ustorthents
063	Shallow, somewhat excessively drained, loamy soils on moderately steeply sloping dissected hills/narrow valleys with severe erosion and moderate stoniness; associated with very shallow, somewhat excessively drained, clayey soils with severe erosion and strong stoniness.	o Loamy-skeletal, mixed, isohyperthermic, shallow, Typic Ustorthents o Clayey-skeletal, mixed, isohyperthermic, shallow, Typic Ustorthents
064	Very shallow, well drained, clayey soils on moderately sloping dissected hills/narrow valleys with severe erosion and strong stoniness; associated with very shallow, well drained, clayey soils with severe erosion and strong stoniness.	o Clayey-skeletal, mixed, isohyperthermic, shallow, Typic Ustorthents o Clayey, montmorillonitic, isohyperthermic, Lithic Ustorthents
065	Shallow, somewhat excessively drained, loamy soils on moderately steeply sloping dissected hills/narrow valleys with severe erosion and strong stoniness; associated with moderately deep, somewhat excessively drained, loamy soils with severe erosion and strong stoniness.	o Loamy, mixed, isohyperthermic, Lithic Ustropepts o Fine-loamy, mixed, isohyperthermic, Typic Ustropepts
066	Shallow, well drained, clayey soils on very gently sloping dissected hills/narrow valleys with moderate erosion and moderate stoniness; associated with deep well drained fine soils with moderate erosion and slight stoniness.	o Clayey, mixed, isohyperthermic, Lithic Ustropepts o Fine, montmorillonitic, isohyperthermic, Vertic Ustropepts
067	Shallow, well drained, loamy soils on moderately sloping dissected hills/narrow valleys with moderate erosion; associated with extremely shallow, excessively drained, loamy soils with severe erosion and strong stoniness.	o Loamy, mixed, isohyperthermic, Typic Ustropepts o Loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents
068	Moderately shallow, well drained, loamy soils on moderately sloping dissected hills/narrow valleys with moderate erosion; associated with shallow, well drained, loamy soils with moderate erosion.	o Fine-loamy, mixed, isohyperthermic, Typic Ustropepts o Loamy, mixed; isohyperthermic, Lithic Ustropepts
069	Very shallow, somewhat excessively drained, loamy soils on moderately steep dissected hills/narrow valleys with severe erosion and moderate stoniness; associated with shallow well drained, loamy soils on moderately sloping lands with severe erosion and moderate stoniness.	o Loamy-skeletal, mixed, hyperthermic, Lithic Ustochrepts o Loamy, mixed, hyperthermic, Lithic Ustochrepts

Source: European Soil Portal

070	Shallow, well drained, loamy soils on gently sloping dissected hills/narrow valleys with moderate erosion and moderate stoniness; associated with shallow well drained, clayey soils with moderate erosion and moderate stoniness.	o Loamy, mixed, hyperthermic, Lithic Ustochrepts o Clayey, montmorillonitic, hyperthermic, Lithic Ustochrepts
071	Shallow, well drained, loamy soils on gently sloping dissected hills/narrow valleys with severe erosion and moderate stoniness; associated with shallow, well drained, clayey soils with moderate erosion and moderate stoniness.	o Loamy, mixed, hyperthermic, Lithic Ustochrepts o Clayey, montmorillonitic, hyperthermic, Lithic Ustochrepts
072	Deep, well drained, fine soils on very gently sloping foothills with moderate erosion; associated with shallow, well drained, clayey soils on gently sloping lands with moderate erosion and slight stoniness.	o Fine, montmorillonitic, hyperthermic, Vertic Ustochrepts o Clayey, montmorillonitic, hyperthermic, Lithic Ustochrepts

Source: European Soil Portal

4.1.4 Ambient Air Quality

The earth is surrounded by the air constituting the environment up to about 1600 kilometers from its surface. The atmosphere is a reservoir of several elements essential to life and it serves many purposes and functions. It contains life saving gases like oxygen for human beings and animals, and carbon dioxide for plants to perform the process of photosynthesis. As per a rough estimate it has 5× 1018 cubic meters of air and contains oxygen (21%), nitrogen (78%), carbon dioxide (0.3%), and hydrogen (0.7%) in a fixed proportion. However, anthropogenetic activities on the surface of the earth are causing an increase in the proportion of gases except O_2 in our atmosphere, thereby polluting the air which is so precious for life. There are many types of causative agents called pollutants creating air pollution. The pollutants exert different types of visible and invisible biological effects. Hence, it is necessary to have an equal understanding of both environment and organisms. For our better living standards we need pure clean air, pure water, nutritious foods, clothes and space etc. which are the basic needs for life. But the quality of air and water is likely to deteriorate because of population explosion, rapid industrialization and urbanization. Environmental pollution and human efforts for the betterment of living standards are the two sides of the same coin. In the wake of rapid industrialization, consequent urbanization and ever increasing population, the basic amenities of life, viz. air, water and land, are being populated continuously. Industrial complexes have become the focus of environmental pollution. Air may be regarded as polluted when it is changed in its quality and composition as a result of human activities. The release of low amount of pollutants into the air does not lead to any serious effects because the atmosphere has a considerable absorptive capacity. Various industrial installations such as asphalt plants, brick chimney plants, boiling and heating installations, cement manufacturing, fertilizer manufacturing, mineral acid manufacturing, paper and pulp manufacturing, thermal and nuclear power plants, sewage treatment plants, engineering workshops *etc.* form the stationary sources of the urban air pollution. The automobiles such as cars, scooters, motors, trucks and buses moving on the urban roads form the mobile sources of air pollution. The prime objective of the baseline study with respect to ambient air quality is to establish the present air quality and its conformity to ambient air quality standards. The sources of air pollution in the region are vehicular traffic, emission from the existing industrial units and domestic fuel burning. The ambient air quality monitoring was carried out in the post-monsoon season (from 28/10/2014 to 12/11/2014) at 12 selected locations along the proposed alignment. At all these sampling stations the pollutants like $PM_{2.5}$, PM_{10} as well as gaseous pollutants like SO_2, NOx, CO and trace element Pb (Lead) were monitored on 24 hourly basis. The data collected was subjected to statistical analysis. The monitoring locations and its justification for selection are presented in Table 4.1.9. The photographs showing the monitoring locations are illustrated in Figure 4.1.28. The results were also compared with ambient air quality standards. Existing Information and result of field survey is shown in below paragraph. Also, For Existing information surveys were collected year-round data, including the monsoon season.

(1) CRITERIA FOR SELECTION OF MONITORING LOCATIONS

The ambient air quality monitoring locations has been established on the basis of the following considerations:

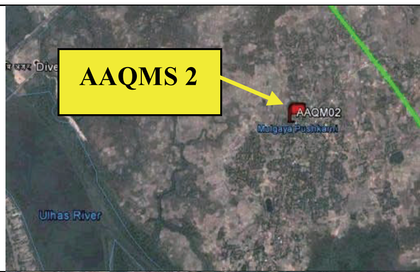
- Meteorological conditions;
- Topography of the area;
- Sensitive locations;
- Representativeness of locations for obtaining baseline status; and
- Representativeness of likely affected area.

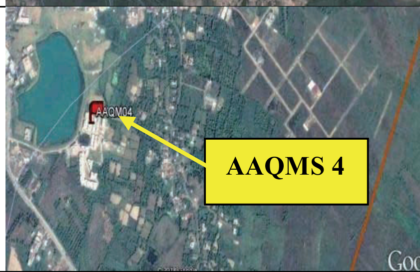
Table 4.1.9: Tentative Ambient Air Quality Monitoring Locations

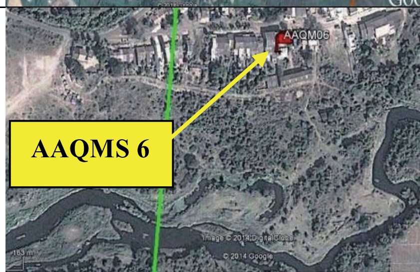
Location Code	Location	Geo-coordinates		Distance & Direction w.r.t. proposed MAHSRC	Justification
		Latitude (N)	Longitude (E)		
AAQMS1	Bandra Kurla Complex	19^{0}4’ 6.80”	72^{0}52’15.52”	0.24 Km/E	Nearest Habitation in the downwind direction
AAQMS2	Thane-Mulgaya Pushkarni	19^{0}12’ 58.99”	73^{0}2’17.76”	0.81 Km/ W	East of Ulhas River
AAQMS3	Virar Stn-Bapne	19^{0}21’ 28.93”	72^{0}53’8.13”	0.16 Km/N	Near Forest
AAQMS4	Vapi Stn-Nearest Habitation	20^{0}20’ 38.24”	72^{0}56’27.90”	1.2 Km/W	Near Pond Dominant Upwind direction
AAQMS5	Valsad Stn-Ujjwal Nagar Society	20^{0}37’ 11.64”	72^{0}58’17.69”	0.85 Km/W	Close proximity to the Estuary
AAQMS6	Surat Jn-Near NH-6, Oviyan	21^{0}11’ 25.45”	72^{0}56’18.48”	0.11 Km/E	North of flowing river
AAQMS7	Bharuch Stn-Dehgam	21^{0}41’ 48.96”	72^{0}56’28.65”	0.44 Km/W	North of River and Nearest Habitation in the Upwind direction
AAQMS8	Vadodara Stn-Nand Nagar Chhani Lake	22^{0}22’ 8.44”	73^{0}10’6.80”	0.47 Km/E	North of Chhani Lake in the Dominant downwind direction

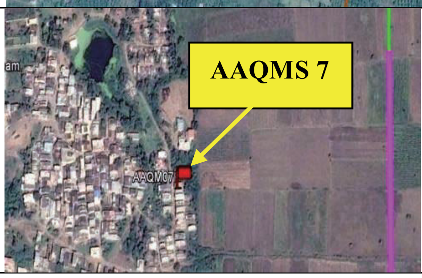
AAQMS9	Vasad –Sardar Vallabhbhai Institute of Technology	22^{0}28’ 10.51”	73^{0}4’35.37”	0.74 Km/E	West of River Tapi
AAQMS10	Nadiad Rly Stn-Bhumel Bus Stand Near Lake	22^{0}38’ 7.58”	72^{0}54’53.39”	0.22 Km/SW	Close to Lake and habitation
AAQMS11	Ahmedabad Rly Stn.-Near Victoria Jubiliee Hospital	23^{0}1’ 34.12”	72^{0}35’57.68”	0.33 Km/W	Near Victoria Jubilee Hospital, Sensitive location
AAQMS12	Sabarmati-Marudhar Society	23^{0}52’ 32.00”	72^{0}35’10.76”	0.26 Km/EEN	Nearest Habitation in the dominant downwind direction-Marudhar Society

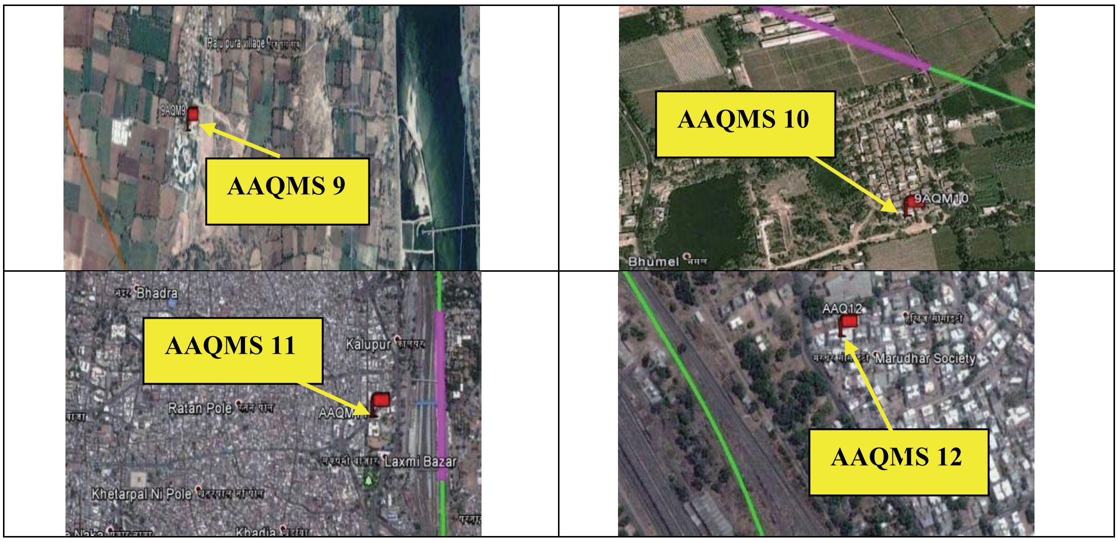
Source: GPSTPL Study Team











Source: GPSTPL Study Team

Figure 4.1.28: Ambient air Quality Monitoring Locations

(2) Methodology

Upon finalization of Ambient Air Quality Monitoring Locations, adequate no. of APM 540 equipment shall be mobilized and deployed at the selected monitoring locations. The monitoring shall be carried out in accordance with the CPCB Guidelines. The samples collected shall be analyzed in the laboratory for the following parameters SPM, $PM_{2.5}$, PM_{10}, SO_2 and NO_2. The technical protocol for the analysis is given in Table 4.1.10.

Table 4.1.10: Technical Protocol for Ambient Air Quality Monitoring & Analysis

Parameter	Methodology	Protocol	Instrument
SO_2	Modified West & Gaeke Method	IS: 5182 Part 2	APM 540/RDS
NO_2	Modified Jacobs & Hochheiser Method	IS 5182 Part 6	APM 540/RDS
PM_{10}	Gravimetric Method	IS 5182 Part 23	APM 540/RDS
$PM_{2.5}$	Gravimetric Method)	$PM_{2.5}$ Gravimetric Analysis - Revision 7, August 14, 2003, Page 2 of 24 RTI (Research Triangle Institute, US)	APM 540 FRM (Federal Reference Method) or FEM (Federal Equivalent Method)
CO	Non-dispersive Infra Red Absorption (NDIR) method	IS 5182 (Part 10) 1999	NDIR Gas Analyzer
Pb	Gravimetric Method followed by Atomic Absorption Spectroscopy (AAS)	IS 5182 Part 23 Cyclonic flow Technique	APM 540/RDS

Source: CPCB

SO_2

Sulphur dioxide from air is absorbed in a solution of potassium tetrachloromercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely coloured pararosaniline methylsulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer

NO_2

Ambient nitrogen dioxide (NO_2) is collected by bubbling air through a solution of odium hydroxide and sodium arsenite. The concentration of nitrite ion (NO**-2**) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)- ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 nm.

PM_{10}

Air is drawn through a size-selective inlet and through a 20.3 x 25.4 cm (8 x 10 in) filter at a flow rate, which is typically 1132 L/min. Particles aerodynamic diameter less than the cut-point of the inlet are collected, by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM_{10} in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

$PM_{2.5}$

An electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7 lpm) maintained by a mass flow/volumetric flow controller coupled to a microprocessor into specially designed inertial particle-size separator (*i.e.* cyclones or impactors) where the suspended particulate matter in the $PM_{2.5}$ size ranges is separated for collection on a 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter. The mass concentration in the ambient air is computed as the total mass of collected particles in the $PM_{2.5}$ size ranges divided by the actual volume of air sampled, and is expressed in $\mu g/m^3$. The microprocessor reads averages and stores five-minute averages of ambient temperature, ambient pressure, filter temperature and volumetric flow rate. In addition, the microprocessor calculates the average temperatures and pressure, total volumetric flow for the entire sample run time and the coefficient of variation of the flow rate.

Pb (Lead)

Element analysis was carried out using Inductively Coupled Plasma - Atomic Emission Spectroscopy High quality glass wares were preferred, throughout the sampling, digression and analysis steps, to prevent any metal contamination. The filter paper were digested with concentrated nitric acid (Merck) in Teflon vessel in a microwave digestion chamber (ETHOS make-milestone, Italy).The sample was digested for twenty minutes and then filtered through Whatman 42 (Ashless filter papers 125mm, cat No 1442 125) filter paper into properly cleaned volumetric flask. Calibration standards of 0.5ppm, 1ppm and 2ppm were prepared through serial dilution of standard stock solution of multi element having concentration of 1000 mg/lit (Merck, Cat No.1.11355.0100) and used for the calibration of the instrument. Samples were analyzed by spiking with a known amount of elements to calculate recovery efficiencies. The analysis procedure for the recovery test is the same as that described for the field samples. The recovery tests of elements were 102%, 95.5%, 106.5%, 94%, 98.0 114%, 103.5%,96.5 %, 94.5%, 98.0%, 90.0%, 93.0% and 95.5 %

for Pb. The reproducibility test indicates the stability of the instruments. Analysis of elements of the same concentration standard solution is repeated for manytimes. The standard solution of 0.5 mg/lit was repeated and reproducibility of results indicates that 103.9%, 96.65%, 96.61%, 97.5%, 99.40%, 96.02%, 99.2%, 99 %, 97.24%, 98.62%,94.4%, 96.6% and 98.02 % for Pb was observed.

CO (Carbon Monoxide)
Sampling begins with conditioning a sampling train and then gas analyzer. Pressure system is preferred to condition the sampling train by installing pump before the analyzer. Reducing valve needs to be fitted between the analyzer and pump to eliminate the pulsing effect of pump on the analyzer. Flow meter is installed just before the analyzer. A fibre filter is used to capture the particulate matter prior to the optical cell to prevent its interference, as it often accumulates on the optical cell reducing its efficiency. To eliminate the interference of water vapour, refrigeration or desiccant with magnesium perchlorate is used. Continuous analysis is carried out at the flow rate of about 100 ml/min to 1000 ml/min (depending upon the pollution level near the sampling location) for the desired sampling period.

(3) Frequency and Parameters for Monitoring

Ambient air quality monitoring has been carried out with a frequency of 24 hourly samples at each location during the post-monsoon season. The baseline data of ambient air has been generated for the following parameters:

- Particulate Matter ($PM_{2.5}$);
- Respirable Particulate Matter (PM_{10});
- Sulphur Dioxide (SO_2);
- Oxides of Nitrogen (NOx);
- Carbom Monoxide (CO); and
- Lead (Pb)-trace elements

(4) Instrument Used for Sampling

Respirable Dust Samplers APM-451 and APM 550 of Envirotech Instrument Pvt. Ltd. make were installed for monitoring Fine Particulate Matter ($PM_{2.5}$), Respirable Particulate Matter (PM_{10}) and gaseous pollutants like SO_2 and NOx. For monitoring of CO, Non-dispersive Infra Red Absorption Gas Analyzer (NDIR) was used.

(5) Results and discussion

The date wise result of respective AAQ monitoring location for pollutants PM_{10}, $PM_{2.5}$, SO_2, NO_X, CO and Pb during the study period (post-monsoon season) are presented in Table 4.1.11. The National Ambient Air Quality Standards (NAAQS) have been presented in Table 4.1.12.

(6) Fine Particulate Matter ($PM_{2.5}$)

The statistical analysis of ambient air quality results revealed that the maximum and minimum $PM_{2.5}$ concentration was observed as 24.5 $\mu g/m^3$ and 14.4 $\mu g/m^3$ at Bandra

Kurla Complex and Thane respectively. The highest value at BKC reveals that the pollution level is slightly on higher side in comparison to other locations.

(7) Respirable Particulate Matter (PM_{10})

The maximum concentration of PM_{10} was observed at Bandra Kurla Complex as 65.0 $\mu g/m^3$ whereas the minimum as 35.0 $\mu g/m^3$ at Dehgam near Bharuch.

(8) Sulphur Dioxide (SO_2)

The highest concentration of SO_2 was reported as 12.3 $\mu g/m^3$ at Bandra Kurla Complex heavy traffic and the lowest concentration was recorded as 6.3 $\mu g/m^3$ at Victoria Jubilee Hospital at Ahmedabad during the field study (October-November).

(9) Oxide of Nitrogen (NOx)

The highest concentration of NOx was reported as 16.2 $\mu g/m^3$ at Ujjawal Nagar Society due to proximity of highways and lowest as 12.5 $\mu g/m^3$ at Victoria Jubilee Hospital at Ahmedabad during the post-monsoon season.

(10) Carbon Monoxide (CO)

The highest concentration of CO was reported as 3.5 mg/m^3 at Bandra Kurla Complex (BKC) due to vehicular traffic and lowest as 3.2 mg/m^3 at Sardar Vallabh Bhai Institute of Technology near Vadodara during the post-monsoon season.

(11) Lead (Pb)

The highest concentration of Pb was reported as 0.12 $\mu g/m^3$ at Bandra Kurla Complex and lowest as 0.02 $\mu g/m^3$ at Valsad during the post-monsoon season.

(12) Conclusions

On the basis of results presented in Table 4.1.11, it can be concluded that the concentration of pollutants (particulate matter, gaseous and trace elements) like $PM_{2.5}$, PM_{10}, SO_2, NOx, CO and trace element -Pb in ambient air in the study area are well below the stipulated National Ambient Air Quality Standards of CPCB for industrial, residential, rural and sensitive areas.

Table 4.1.11: Ambient Air Quality Status at All the Locations ***(value in $\mu g/m^3$)***

Stations	Location Code	$PM_{2.5}$	PM_{10}	SO_2	NOx	CO mg/m^3	Pb
Bandra Kurla Complex	AAQMS1	24.5	65	12.3	12.9	3.50	0.12
Thane-Mulgaya Pushkarni	AAQMS2	14.4	62	12.1	13.6	2.50	0.11
Virar Stn - Bapne	AAQMS3	18.0	45	10.8	14.2	2.01	0.08
Vapi Stn - Nearest Habitation	AAQMS4	22.1	61	6.9	13.8	2.00	0.05
Valsad Stn - Ujjiwal Nagar Society	AAQMS5	17.2	42	8.0	16.2	1.85	0.02

Surat Jn - Near NH-6, Oviyan	AAQMS6	16.0	38	7.5	14.1	3.10	0.03
Bharuch Stn - Dehgam	AAQMS7	15.0	35	6.5	13.8	2.40	0.04
Vadodara Stn - Nand Nagar Chhani Lake	AAQMS8	16.5	41	8.2	14.5	2.60	0.08
Vadodara - Sardar Vallabhbhai Institute of Technology	AAQMS9	21.2	52	7.8	13.4	3.20	0.01
Nadiad Rly Stn - Bhumel Bus Stand Near Lake	AAQMS10	23.2	58	6.7	12.8	2.15	0.05
Ahmedabad Rly Stn - Victoria Jubilee Hospital	AAQMS11	24.8	61	6.3	12.5	2.14	0.08
Sabarumati - Marudhar Society	AAQMS12	24.0	60	7.4	13.6	1.85	0.04

Source: Study Team-GPSTPL

Table 4.1.12: National Ambient Air Quality Standards

S. No.	Pollutants	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	ESA (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), µg/m^3	Annual*	50	20	-Improved West and Gaek, -Ultraviolet fluorescence
		24 hours **	80	80	
2	Nitrogen Oxide (NO_2), µg/m^3	Annual*	40	30	-Modified Jacob & Hochheiser (No Arsenite) -Chemiluminescence
		24 hours **	80	80	
3	Particulate Matter (size less than 10µm) or PM_{10} µg/m^3	Annual*	60	60	-Gravimetric -TOEM -Beta attenuation
		24 hours **	100	100	
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ µg/m^3	Annual*	40	40	-Gravimetric -TOEM -Beta attenuation
		24 hours **	60	60	
		1 hour**	04	04	
5	Ozone (O_3) µg/m^3	8 hours**	100	100	-UV photometric -Chemilminescence -Chemical Method
		1 hour**	180	180	
6	Lead (Pb) µg/m^3	Annual*	1.0	0.50	-AAS method after sampling using EPM 2000 or equivalent filter paper
		24 Hours	1.5	0.75	
7	Carbon Monoxide (CO) mg/m^3	8 hours**	5.0	1.0	-Non-dispersive Infra Red Absorption (NDIR)
		1 hour**	10.0	2.0	

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring

Source: The principal rules were published in the Gazette of India, Extraordinary vide number S.O 844 (E) dated the 19th November, 1986; and subsequently amended vide numbers S.O. 433 (E), dated the 18th April, 1987; G.S.R. 176 (E), dated the 2nd April 1996; and were recently amended vide numbers G. S.R. 97(E), dated the 18th February, 2009; G. S.R. 149(E), dated the 4th March 2009; G.S.R. 512(E), dated the 9th July 2009; G.S.R. 543(E) dated the 22nd July, 2009; G.S.R. 595 (E), dated the 21st August, 2009; and G.S.R. 794 (E), dated the 4th November, 2009.

4.1.5 Water Quality

A watershed is a valuable resource for any country. More, so far a country like India, which is essentially agrarian and a vast majority of its population derives its sustenance from agriculture. Adequate knowledge of water bodies is necessary for rational formulation of water management policies. Moreover, unplanned population growth along river basins have led to large scale river pollution, which prevents beneficial use of river waters. There are two major river basins in the entire stretch of the proposed alignment of MAHSRC Narmada and Tapi Basins. Most of the nallahs and rivers which cross the alignment are the tributaries of Narmada and Tapi basins except few of them. Geologically, the river bed and the adjoining regions are part of the Paleogene sedimentary rocks of Maharashtra consisting of hard and undulating laterite and basalt formations with scattered laterite and Alluvial plains cover of varying thickness in the Maharashtra region of the proposed alignment. The part of the proposed alignment which falls in Gujarat is covered by the alluvial plain. Existing Information and result of field survey of each river is shown in below paragraph. Also, For Existing information surveys were collected year-round data, including the monsoon season.

The Narmada Basin

Naramada is the seventh largest, probably the holiest of the rivers of India. Archaeological investigations have revealed human habitations along its bank even earlier than 5000 B.C. Narmada is an interstate river and flows through the three states of Madhya Pradesh, Maharashtra and Gujarat. The basin covers 23 districts (20 of Madhya Pradesh, 2 of Gujarat and one of Maharashtra). Though, it is one of the main rivers of central India, the river basin has only a few urbanized and industrialized pockets. The total length of Narmada is 1312 km, of which 1077 km in Madhya Pradesh, 30 km along the common border of Madhya Pradesh and Maharashtra, 39 km along Maharashtra and Gujarat, and 166 km along Gujarat. The total basin area is approximately 98,800 km^2, out of which 85860 km^2 lies in Madhya Pradesh, 1540 km^2 in Maharashtra, and 11400 km^2 in Gujarat.

The Tapi Basin

The Tapi is a major west flowing river in the western part of India. It originates from a tank in the Satpura mountains in Betul district of Madhya Pradesh at an elevation of 752 m above Mean Sea Level. The river flows through rocky terrain in Nimar in Madhya Pradesh and thereafter through the fertile plains of Khandesh in Maharashtra and again the western ghats in the State of Gujarat, meeting the Gulf of Khambhat. Total length of the river Tapi is 724 km of which the first 282 km lies in Madhya Pradesh, of which 54 km forms the common boundary with Maharashtra. The stretches in Maharashtra and Gujarat are 228 and 214 km respectively. The river is joined by its most important tributary Purna which also rises in the Betul district of Madhya Pradesh. The northern part of the basin after the confluence of Purna is narrow and steep.

The Ulhas River

The Ulhas River originates in a valley north of the Rajmachi hills formed by mountain streams draining the northern slope of those hills which are part of the Sahyadri range of the Western Ghats in the Raigad district of Maharashtra. From the point of origin the river flows north turning left where it is joined by River Salpe, its right-bank tributary. It then begins its north-eastward journey and passes the Anglo-Eastern Maritime Academy which is situated on its right bank at Khandpe village. The river bypasses the Palasdhari village where it receives the discharge from the Palasdhari Dam starting a northward course beyond this point coming to lie parallel to the rail tracks only to be distracted by the town of Karjat. Meandering through Karjat, it reaches further north synapsing with River Peg between Bhivpuri road and Neral. Continuing its run along Neral, it is joined by River Poshir, another right-bank tributary at Nikhop village. It flows north skirting Badlapur where it receives the run-off from Chikoli Dam. Near Raw water pump house of MIDC Jambhul the river meets Barvi Dam discharge water also called as Barvi River. The confluence is a tourist and fishing hub for villagers around. The river flows through Ulhasnagar to which it gives its name. It then passes under the rail bridge connecting Ambivali and Shahad and shortly after confluences with its biggest tributary formed by merging of River Bhatsa and River Kalu which together account for 55.7% of the total catchment area of River Ulhas. Beyond Kalyan the river, nearly flowing at sea level, merges with the creek waters and its flow comes to be dictated by the tidal forces. From hereon it forms an estuary and also supports a mangrove forest near Diva-Dombivali. In rainy season and during low tide the river continues to flow till Thane where splits into two branches which flow west and south, respectively, around Salsette Island, on which lies the metropolis of Mumbai. The main branch turns northwestward to Ghodbunder, where it opens into the estuary of Vasai Creek. Thane Creek flows south to empty into Bombay Harbour. The estuary of the Ulhas is the site of the historical ports of Kalyan, Kopri (Chersonesus/Coprostaneum) and Shurparaka (now Sopara).

The Daman Ganga River

The Daman Ganga is a river in western India. It originates from the western slope of the Western Ghats range, and it flows west into the Arabian Sea. The river flows through Maharashtra and Gujarat states, as well as the Union territories of Daman and Diu and Dadra and Nagar Haveli. The industrial towns of Vapi, Dadra and Silvassa lie on the north bank of the river, and the town of Daman occupies both banks of the river's estuary. The river supplies drinking water to Vapi. The Government of India's National Water Development Authority (NWDA) has proposed the Daman Ganga-Pinjal River Linking Project, which would build a new aqueduct linking the Daman Ganga river to the Pinjal River to the south, allowing water from the Daman Ganga to be diverted south to Mumbai *via* the Pinjal. In April 2003 the State Government of Gujarat raised objections to the proposal. Daman Ganga is also the most polluted of Indian rivers according to participants of the *Machhimar Adhikar Rahstriya Abhiyan* or the national campaign to save the coast and fishworkers rights in India (June 2008) from Kutchch to Kanyakumari. Vapi, which is on the banks of this river has a lot of chemical and pharmaceutical companies, releasing unprocessed and hazardous chemicals into the river which creates a lot of problems for the residents near the river and it looks like only dirty water and chemicals flowing instead of the River Water. Fishworkers protested against the effluents discharged into the "pinkish red" river where there are no fish left. Leaking pinelines carrying chemical effluents mostly from dye manufacturing industries, near the river have caused domesticated livestock and goats to die as well. Locally it has recently come to be known as the dead river with floating dead fish.

The Sabarmati River

The Sabarmati river is one of the biggest rivers of Gujarat. It originates in Dhebar lake in Aravalli Range of the Udaipur District of Rajasthan and meets the Gulf of Cambay of Arabian Sea after travelling 371km in a south-westerly direction. The Sabarmati basin has a maximum length of 300km. and maximum width of 105km. The total catchment area of the basin is 21674km^2 out of which, 4124km^2 lies in Rajasthan State and the remaining 18550km^2 in Gujarat State. It is believed that earlier the river used to flow from Manek Chowk. The National Water Quality Programme led by Central Pollution Control Board (CPCB) positions Sabarmati River as one of the most polluted rivers in India. Sabarmati River Basin is situated in the mid-southern part of Rajasthan. To its east lie the Banas and Mahi Basins, to its north the Luni Basin and to its west the West Banas Basin. Its southern boundary is the border with Gujarat State. The Sabarmati river basin extends over parts of Udaipur, Sirohi, Pali and Dungarpur Districts. Orographically, the western part of the Basin is marked by hilly terrain belonging to the Aravali chain. East of the hills lies a narrow alluvial plain with a gentle eastward slope. The main tributaries of the Sabarmati river are Wakal river and the Sei Nadi, which also rise in the Aravali hill range west of Udaipur city and flow south-westwards in courses generally parallel to the Sabarmati river, up to their confluence with the river (in Gujarat). Ahmedabad and Gandhinagar, the commercial and political capitals of Gujarat, were established on the banks of Sabarmati river. During India's independence struggle, Mahatma Gandhi established Sabarmati Ashram as his home on the banks of this river. The Govt. of Gujarat has developed the river front of Sabarmati as a place of tourist interest.

The River Mahi

The river Mahi, the third largest river of Gujarat after Narmada and Tapi, rise from about 556m above sea-level in the Malwa region around Sardarpur in Madhya Pradesh. It flows for about 180 km in Gujarat before emptying into the Gulf of Khambhat. The lower course of the river for about 70 km is characterized by heavily gullied cliffy sand-banks and ravines. Further south, of the river Dhadhar rising from the Shivrajpur hills also flows into the Gulf of Khambhat. This river is met by a major tributary Visvamitri, 25 km Southwest of Vadodara.

The River Meshow and Vatrak

The plains of Central Gujarat lying between Sabarmati and Mahi are drained by a number of tributaries of Sabarmati, *viz*., Khari, Shedhi, Mejan, Andheri, Meshwo and Vatrak.Of these, Meshwo and Vatrak are the major ones. Meshwo originates in Dungarpur district of Rajasthan and meets the Vatrak river. The Vatrak also rises from the Dungarpur hills and meets Sabarmati at Vautha. The river Shedhi which forms the chief drainage of the alluvial plains between Sabarmati and Mahi originates from the eastern hills of Panchmahals district and meets Vatrak at Kheda.

The Dhadar Basin

The Dhadhar River is one of the west flowing rivers in Gujarat state. It originates from the Pavagadh Hills of Gujarat state and flows through Vadodara and Bharuch districts. The river Dhadar after flowing 87 Km. receives Vishwamitri tributary from right bank at Pingalwada village 500 m. up stream of Gauge and Discharge site. After flowing another 55 km. it falls in to the Gulf of Khambhat. The total length of the river from its source to outfall in the Gulf of Khambhat is about 142 km. The important tributaries of the Dhadar River are Vishwamitri, Jambuoriver, Dev and Surya River. The catchment area of the Dhadar basin is 3423 sq.km and catchment area up to the site is 2400 sq.km.

The Purna Basin

Purna river is an important west flowing river with its catchment in Gujarat and Maharashtra. The river Purna rises in the Saputara hills of the Western Ghats near the village Chinchi in Maharashtra. The length of the river from its source to outflow in the Arebean Sea is about 180 km. The important tributaries of the river are Dhodar nalla, Bardanala, Nagihpar nala, Girna river, Zankari river and Dumas khadi.The catchment area of the Purna basin is 2431 sq. km.

The River Vaitarana

The Vaitarana, the largest of Konkan rivers, rises in the Tryambak hills in the Nasik district, opposite the source of the river Godavari, and enters Thane at Vihigaon near Kasara, after passing through a deep gorge while descending the plateau top to the Konkan lowland. For about forty kilometers, the Vaitarana flows west through a deep defile among high hills. From Kalambhai at the eastern border of Vada, the river flows for about thirty kilometers west across a more or less level country, till near the ancient settlement of Gorha, the great spurs of the great Takmak range drives its course north-west for about sixteen kilometers till it flows past settlement of Manor. Within three kilometers of Manor, the stream meets the tidal wave and is navigable for small crafts. Near Manor, the river after skirting the northern spur from Takmak, flows initially south-west for about ten kilometers and then to the south for twenty kilometers before sharply turning to the right, and for the last twelve kilometers west to enter the sea through wide estuary off Arnala. In the last stretch of thirty kilometers the Vaitarana passes through a country of great beauty in-between two ranges and has a fine broad river which in many places has a good depth of water and a fairly flat-bottomed valley with meander terraces on either side. The Vaitarana is 154 kilometers long and has a drainage area that practically covers the northern sections of the district. It has a number of tributaries, the most important of which are the Pinjal, the Surya and the Tansa. Physico-chemical parameters have been determined to establish the baseline status of the existing sources of surface water. Samples were collected during post-monsoon season (28 October 2014 to 12th November 2014). Sampling locations for surface water quality monitoring are illustrated in the Figure 4.1.29 and enlisted in Table 4.1.13. The illustration of sampling is shown in photograph placed as Figure 4.1.30.

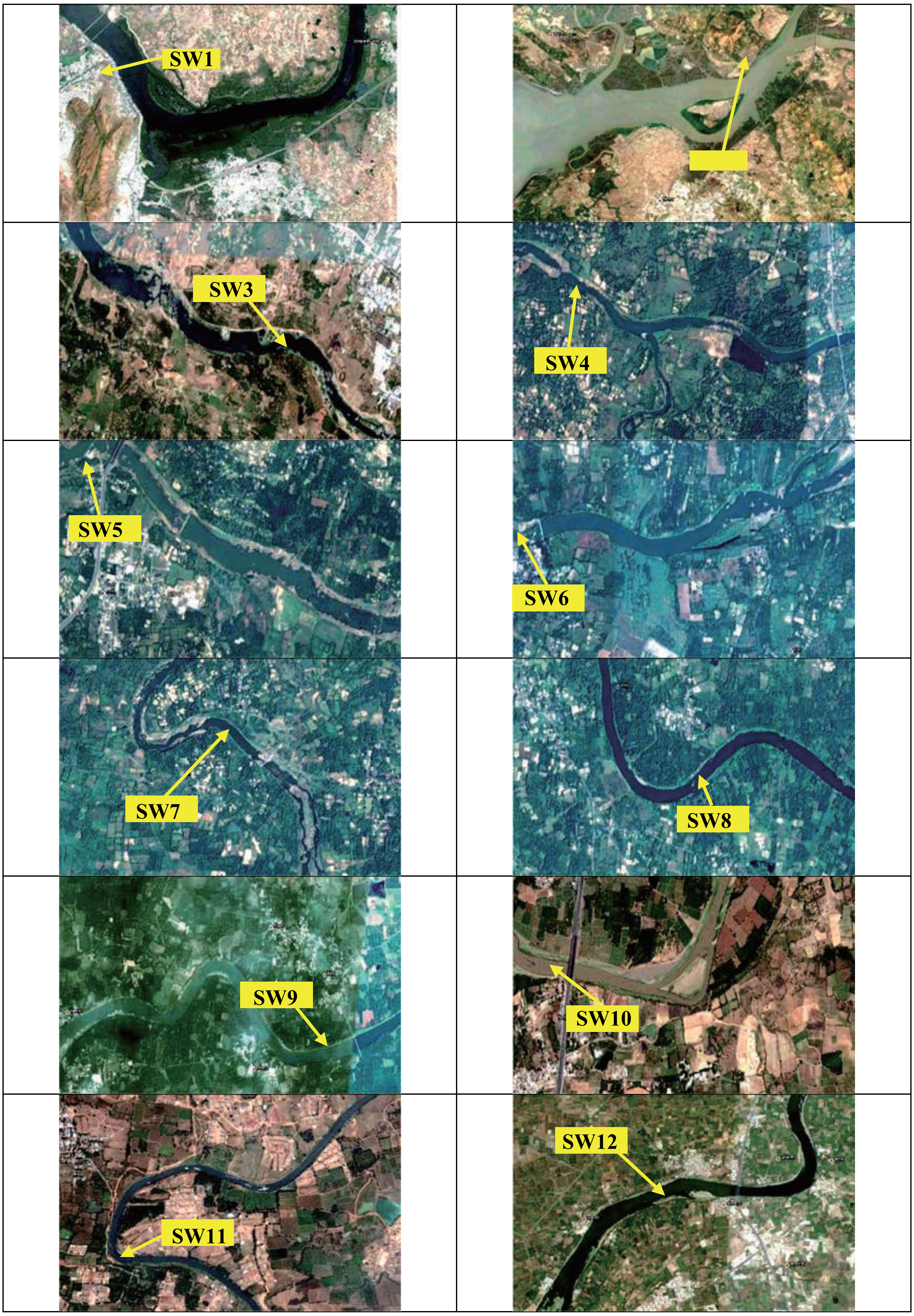
(1) Methodology of Sampling and Analysis

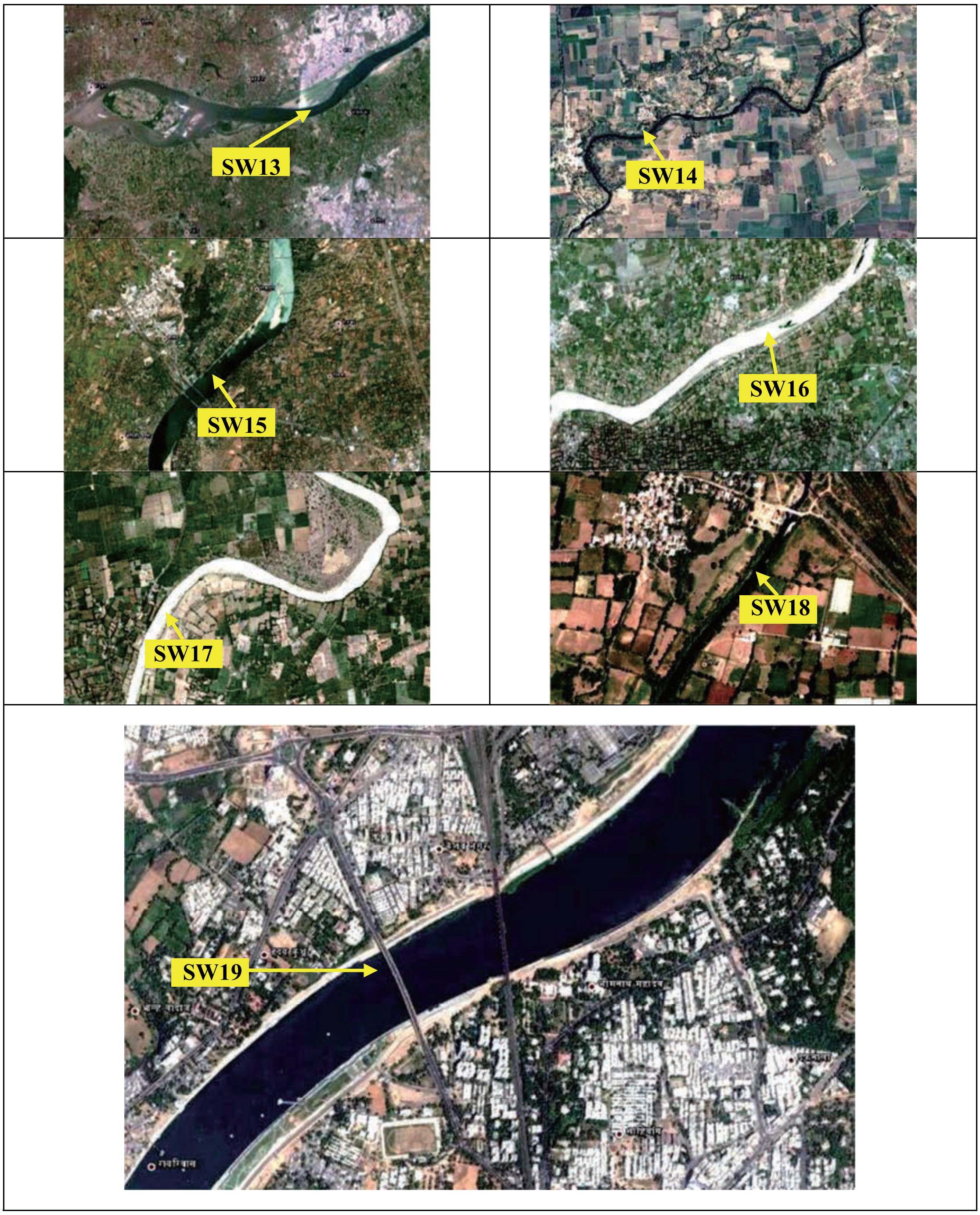
The water samples collected analyzed for selected physico-chemical and biological parameters. The parameters such as pH, temperature and DO were analyzed at the site itself at the time of collection of sample (with the help of water testing kit developed by CPCB) while for other parameters, samples were preserved and analyzed in laboratory. Samples were collected, preserved and analyzed as per Standard Methods for the Examination of Drinking and Waste Water developed by American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WPCF). In order to assess the quality of surface water, water samples were taken from 19 selected stations in the surface water bodies which intersect the proposed MAHSRC alignment at different locations.

Table 4.1.13: Water Quality Sampling Locations

Location Code	Location	Section	Geo Coordinates		Sampling Date
			Latitude	Longitude	
SW1	Ulhas River	Mumbai - Thane - Virar	19°12'8.54"N	73° 3'21.84"E	12/11/14
SW2	Vaitarna River	Virar - Dahanu	19°30'22.37"N	72°49'15.75"E	11/11/14
SW3	Damanganga River	Dahanu-Vapi	20°18'59.93"N	72°56'23.80"E	10/11/14
SW4	Kolak River	Vapi - Valsad	20°23'39.88"N	72°57'39.55"E	08/11/14
SW5	Par River	Vapi - Valsad	20°31'35.09"N	72°58'13.05"E	07/11/14
SW6	Auranga River	Vapi - Valsad	20°34'48.58"N	72°58'29.29"E	07/11/14
SW7	Kaveri River	Valsad - Surat	20°35'46.58"N	72°58'35.06"E	06/11/14
SW8	Ambica River	Valsad - Surat	20°44'34.46"N	73° 0'10.71"E	06/11/14
SW9	Purna River	Valsad - Surat	20°52'5.84"N	73° 0'17.48"E	06/11/14
SW10	Mindhol River	Valsad - Surat	20°57'57.86"N	72°58'21.40"E	06/11/14
SW11	Tapi River	Surat - Bharuch	21°16'59.22"N	72°56'6.86"E	05/11/14
SW12	Kim River	Surat - Bharuch	21°25'47.67"N	72°55'23.68"E	04/11/14
SW13	Narmada River	Surat - Bharuch	21°40'28.39"N	72°56'48.89"E	04/11/14
SW14	Dhadar River	Bharuch - Vadodara	22° 8'46.53"N	73° 6'33.50"E	03/11/14
SW15	Mahi River	Vadodara - Anand - Nadiad	22°27'10.95"N	73° 5'18.21"E	02/11/14
SW16	Mohur River	Anand - Nadiad - Ahmedabad	22°48'53.02"N	72°43'10.66"E	01/31/2014
SW17	Vatral River	Anand - Nadiad - Ahmedabad	22°55'29.49"N	72°38'32.70"E	29/10/2014
SW18	Meshwo River	Anand - Nadiad - Ahmedabad	22°50'23.02"N	72°41'55.28"E	28/10/2014
SW19	Sabarmati River	Anand - Nadiad - Ahmedabad	23° 3'47.05"N	72°35'22.81"E	28/10/2014

Source: GPSTPL Study Team


SW1
SW3
SW4
SW5
SW6
SW7
SW8
SW9
SW10
SW11
SW12



Source: GPSTPL Study Team

Figure 4.1.29: Water Quality Sampling Locations

Source: EIA Study team-GPSTPL

Figure 4.1.30: Illustration -Water Quality Sampling at Different Locations

(2) PHYSICO-CHEMICAL CHARACTERISTICS

Physico-chemical parameters along with biological indicators of pollution have been estimated for ascertaining the baseline status of water environment during post-monsoon season and presented in Table 4.1.14.

(3) Surface Freshwater (Other than Estuarine Water-SW6, SW7, SW9, SW10, SW11, SW12, SW13, SW14, SW15, SW16, SW17, SW18 and SW19

Physical Parameters

In post-monsoon season, for surface water the values of physical parameters *viz.* pH, temperature, turbidity, TSS and TDS were found in the range as follows (Table 4.1.14).

- pH = 7.4-7.93
- Temperature = 22.2-24.2^{0}C
- Turbidity = 3.6-12.8 NTU
- TSS = 3-84 mg/l
- TDS = 181-750 mg/l

Inorganic Parameters

In summer season, for surface water, Inorganic parameters viz. total alkalinity, total hardness, chlorides, sulphate, sodium and potassium were found in the range as follows (Table 4.1.14).

- Total alkalinity = 120-217 mg/l
- Total hardness = 115-160 mg/l
- Chlorides = 24-52 mg/l
- Sulphate = 11.4-54.6 mg/l
- Sodium = 18.6-32.8 mg/l
- Potassium = 10.7-22 mg/l

Nutrient Parameters

In summer season, for surface water, nutrient and demand parameters *viz.* nitrate, total phosphate, dissolved oxygen, chemical oxygen demand and biochemical oxygen demand were in the range as follows (Table 4.1.14).

- Nitrate = 0.11-31 mg/l
- Total phosphate = 0.1-0.4 mg/l
- Dissolved Oxygen = 6.3-7.10 mg/l
- Chemical Oxygen Demand = 12-25.8 mg/l
- Biochemical Oxygen Demand = 2.3-8 mg/l

Trace Elements

Concentrations of trace metals in water are often close to the background level due to their efficient removal from the water column through hydrolysis. The bioavailability and toxicity of trace metals such as Cd, Cu, and Zn are related to the activity of the free metal ion rather than the total metal concentration. For Cd it is the Cd C_{12} complex that predominates in seawater. Therefore, salinity is the overriding factor which can alter free Cd ion activity $\{Cd^{2+}\}$, and hence, bioavailability and toxicity in marine systems. The cadmium concentration in the sea water was below detectable limit at all locations. The concentration of mercury and chromium were below detectable limit at all locations.

(4) Estuarine Water –SW1, SW2, SW3, SW4 and SW8

Temperature

It affects many chemical and biological parameters (*Gupta, 2004*). As the temperature increases molecular motion of water increases and due to evaporation solubility of gases reduced. In present study temperature ranges from 22.6 to 25.8^{0}C at all the sampling locations.

pH

pH indicates the presence of acidic or alkaline nature of water. It ranges from 7.1 to 8.8 for all the locations of estuarine water.

Turbidity

It measures the scattered light at right angle of the path of incident light. Turbidity shows presence of settled particles, garbage and other pollutants. It measures in nephelometric turbidity unit (NTU). In the present study, as evident from the Table 4.1.14 (A) (B) and (C), the observed value of turbidity ranges from 3.4 to 11.0 NTU for all the sampling locations of estuarine water.

Total Dissolved Solids (TDS)

The standard range of TDS is 100 to 600 mg/L. The values are found more than desirable range. The increase in amount of TDS in samples is due to presence of algal cell in the effluents. In present study TDS were recorded as 660 to 20787 mg/L. The highest value of TDS was reported in Ulhas river which is due to the pollution load and discharge of sewerage and other garbage.

Total Suspended Solids (TSS)

In the present study, TSS was recorded as 10-120 mg/L for all the sampling locations among the estuarine water. The physical characteristics *i.e.* pH, temperature, turbidity, total suspended solids (TSS), and total dissolved solids (TDS) were observed to be in the range as follows [Table 4.1.14 (A) (B) (C)].

Parameter	Estuarine Water
pH	7.1-8.8
Temperature	22.6^0C -25.8^0C
Turbidity	3.4-11.0 NTU
Total Suspended Solids (TSS)	10-120 mg/l
Total Dissolved Solids (TDS)	660-20787 mg/l

Inorganic Parameters

In post-monsoon season, for estuarine water, inorganic parameters *i.e.* total alkalinity; chloride, sulphate and salinity were observed to be in the range as follows [Table 4.1.14 (A) (B) (C)].

Parameter	Estuarine Water
Total Alkanity	150-187 mg/l
Chloride	250-2450 mg/l
Sulphate	42- 210 mg/l
Salinity	4-32%

Nutrient Parameters

In post-monsoon season, for estuarine water, nutrient and demandparameters *viz.* nitrate, total phosphate, dissolved oxygen, and Biochemical Oxygen Demand (B.O.D.) were in the range as follows [Table 4.1.14 (A) (B) (C)].

Parameter	Estuarine Water
Nitrate	0.21-0.42 mg/l
Total Phosphate	0.1 – 0.4 mg/l
Dissolved Oxygen (DO)	6.0 – 7.8 mg/l
Biochemical Oxygen Demand (BOD)	2.5-3.54

Bacteriological Characteristics

The coliform group of bacteria is significant as a principal indicator of degree of pollution of water and is also indicative of the sanitary quality. The coliform density is now a criterion to assess the suitability of water for domestic and recreational uses. The coliform group belongs to the family of Enterobacteriaceae and includes all aerobic and facultative anaerobic, gram-negative, non-spore forming, rod-shaped bacteria that ferment lactose with gas and acid formation within 48 hrs at 35°C. For estimation of bacterial contents in water samples, the standard test for the coliform group was carried out by the membrane filter (MF) technique. The MF technique involves direct plating for detection and estimation of total coliform and faecal coliform densities.

Fresh Water

In post-monsoon season the total coliform density in surface water was observed to be in the range of 170-5004 CFU/100 ml. The water quality satisfies the Class C of surface water (Drinking water source with conventional treatment followed by disinfection) (IS 2296: 1982). The levels of total coliform and faecal coliform are at normal level with slight organic pollution.

Estuarine Water

In post-monsoon season the total coliform density in the estuary was observed to be in the range of 250-65810 CFU/100 ml, 140-690 CFU/100 ml respectively. These values indicated some amount of organic contamination in sea water.

Trace Elements

Concentrations of trace metals in water are often close to the background level due to their efficient removal from the water column through hydrolysis. The bioavailability and toxicity of trace metals such as Cd, Cu, and Zn are related to the activity of the free metal ion rather than the total metal concentration. For Cd it is the Cd C_{12} complex that predominates in seawater. Therefore, salinity is the overriding factor which can alter free Cd ion activity {Cd^{2+}}, and hence, bioavailability and toxicity in marine systems. The cadmium concentration in the estuarine water was found below detectable limit all locations. The concentration of mercury and chromium were also below detectable limit at all locations.

Conclusions

The surface water quality of the fresh river water was good with no organic pollution and very less nutrients especially nitrates. The Drinking Water Quality Standards is presented in Table 4.1.15 and Indian Standards for Industrial and Sewage Effluents Discharge is given in Table 4.1.16. The physico-chemical characteristics of the sea water and estuarine water at all the three stations are within normal range of sea water.

Table 4.1.14 (A): Surface Water Quality during the Post-monsoon Season (October-November 2014)

Parameters	Unit	SW1	SW2	SW3	SW4	SW5	SW6	SW7
pH		8.8	8.2	7.1	7.2	7.6	7.4	7.7
Temperature	^0C	22.6	25.8	24.6	23.8	22.8	23.2	24.6
Dissolved Oxygen	mg/l	7.2	6.0	7.2	6.5	6.5	7.1	7.0
Total Suspended Solids	mg/l	11	16	10	25	3	24	35
Total Dissolved Solids	mg/l	20787	16540	785	660	558	632	550
Conductivity	µmhos/cm	33527	26677	1266	1064	915	1019	887
Turbidity	NTU	11.0	8.0	6.0	5.0	4.5	6.2	5.8
Alkalinity (as $CaCO_3$)	mg/l	180	187	155	150	141	134	120
Hardness (as $CaCO_3$)	mg/l	608	195	185	165	125	121	115
Calcium (as Ca^{+2})	mg/l	366	240	120	21	18	16	58
Magnesium (as Mg^{+2})	mg/l	1050	550	62	52	24	32	15
Sodium (as Na^{+})	mg/l	3000	1500	150	45	56	48	24

Potassium (as K^+)	mg/l	325	12	14	16	22	14	11
Nitrate (as NO_3^-)	mg/l	0.22	0.41	0.33	0.21	0.55	0.64	0.38
Phosphate (as PO_4^{-2})	mg/l	0.4	0.2	0.3	0.1	0.2	0.3	0.4
Chloride (as Cl^-)	mg/l	2450	506	310	250	24	52	26
Salinity	%	32	15	5	4	5	3	6
Sulphate (as SO_4^{-2})	mg/l	210	190	160	42	20	38	39
Oil & Grease	mg/l	0.3	0.1	0.2	<.01	<.01	<.01	<.01
Phenolic Compounds (as C_6H_5OH)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Biochemical Oxygen Demand	mg/l	80	42	5	15	6	4	8
Chemical Oxygen Demand	mg/l	220	110	15	24	16	12	22
Arsenic (as As)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (as Pb)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium (as Cd)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexavalent Chromium (as Cr^{+6})	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Chromium (as Cr)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper (as Cu)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (as Zn)	mg/l	<1	<1	<1	<1	<1	<1	<1
Selenium (as Se)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron (as Fe)	mg/l	0.72	0.52	0.14	0.21	0.24	0.26	0.11
Total Coliform (MPN)	/100 ml	500	250	350	254	578	260	223

Source: EIA Study team-GPSTPL

Table 4.1.14 (B): Surface Water Quality during the Post-monsoon Season (October-November 2014)

Parameters	Unit	SW8	SW9	SW10	SW11	SW12	SW13
pH		8.2	7.8	7.7	7.93	8.1	7.6
Temperature	^0C	24.8	24.2	23.9	23.09	22.6	22.2
Dissolved Oxygen	mg/l	7.8	6.4	6.3	7.10	7.2	6.7
Total Suspended Solids	mg/l	120	84	74	24	23	25
Total Dissolved Solids	mg/l	4822	280	750	181	650	620
Conductivity	µmhos/cm	7778	452	1210	294	1048	998
Turbidity	NTU	3.4	4.2	3.8	3.6	4.1	12.8
Alkalinity (as $CaCO_3$)	mg/l	150	217	142	210	156	175
Hardness (as $CaCO_3$)	mg/l	185	160	144	136	140	
Calcium (as Ca^{+2})	mg/l	31.5	42.8	28.9	28.05	27.6	38.2
Magnesium (as Mg^{+2})	mg/l	28.4	12.5	10.9	42.6	38.6	11.8
Sodium (as Na^+)	mg/l	46.2	32.8	22.6	21.9	20.9	18.6
Potassium (as K^+)	mg/l	12.3	11.4	10.9	11.2	10.7	11.9
Nitrate (as NO_3^-)	mg/l	0.42	0.32	0.22	0.11	0.24	0.33
Phosphate (as PO_4^{-2})	mg/l	0.2	0.1	0.3	0.2	0.1	0.4
Chloride (as Cl^-)	mg/l	610	48.9	42.7	50.0	42.8	30.5
Salinity	%	5	4	3	4	3.1	
Sulphate (as SO_4^{-2})	mg/l	22.1	31.0	22.7	12.0	11.4	54.6
Oil & Grease	mg/l	0.2	0.4	0.3	0.2	0.1	0.2
Phenolic Compounds (as C_6H_5OH)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Biochemical Oxygen Demand	mg/l	4.4	7.0	3.9	2.70	3.2	2.3
Chemical Oxygen Demand	mg/l	18.8	25.8	16.4	13.5	16.4	31.73
Arsenic (as As)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (as Pb)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium (as Cd)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexavalent Chromium (as Cr^{+6})	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Chromium (as Cr)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper (as Cu)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (as Zn)	mg/l	<1	<1	<1	<1	<1	<1
Selenium (as Se)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron (as Fe)	mg/l	0.38	0.13	0.21	0.23	0.31	0.35
Total Coliform (MPN)	/100 ml	6581	170	251	960	1089	5004

Source: EIA Study team-GPSTPL

Table 4.1.14 (C): Surface Water Quality during the Post-monsoon Season (October-November 2014)

Parameters	Unit	SW14	SW15	SW16	SW17	SW18	SW19
pH		7.2	8.1	7.8	7.7	7.9	8.0
Temperature	^0C	24.6	22.0	23.6	24.2	25.6	26.0
Dissolved Oxygen	mg/l	6.5	8.3	10.0	6.1	7.2	8.1
Total Suspended Solids	mg/l	108	11	31	15	15	23
Total Dissolved Solids	mg/l	228	318	125	134	350	279
Conductivity	µmhos/cm	348	513	190	210	565	425
Turbidity	NTU	6	5	5	4	11.7	13.1
Alkalinity (as CaCO3)	mg/l	71.1	51.2	63.7	52.6	245	290
Hardness (as CaCO3)	mg/l	283	283	158	190	180	179
Calcium (as Ca+2)	mg/l	26.9	26.9	24.3	18.8	20.4	18.7
Magnesium (as Mg+2)	mg/l	45	45	41	21.4	34.3	31.7
Sodium (as Na+)	mg/l	5	5-6	4	3	3	2
Potassium (as K+)	mg/l	4	4-8	5.0	6.2	5.1	4.7
Nitrate (as NO3-)	mg/l	0.4	0.36				0.95
Phosphate (as PO_4-2)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride (as Cl-)	mg/l	29.1	32.0	21.0	15.3	13.4	29.1
Salinity	%	4	3	2	2	3	5
Sulphate (as SO4-2)	mg/l	23.9	28.4	12.3	15.5	19.3	23.9
Oil & Grease	mg/l	<.01	<.01	<.01	<.01	<.01	<.01
Phenolic Compounds (as C6H5OH)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Biochemical Oxygen Demand	mg/l	2.0	3.0	2.	2.4	2.7	5
Chemical Oxygen Demand	mg/l	7.1	8.6	6.5	11.1	9.2	14
Arsenic (as As)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (as Pb)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Cadmium (as Cd)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexavalent Chromium (as Cr+6)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Chromium (as Cr)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper (as Cu)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (as Zn)	mg/l	<1	<1	<1	<1	<1	<1
Selenium (as Se)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron (as Fe)	mg/l	0.16	0.14	0.15	0.18	0.08	0.32
Total Coliform (MPN)	/100 ml	108	94	24	30	23	14000

Source: EIA Study team-GPSTPL

Table 4.1.15: Indian Standards/Specifications for Drinking Water (IS: 10500-1991)

S. No.	Substances or Characterstic Max.	Requirement (Desirable limit)	Undesirable effects outside the desirable limit	Permissible limit in absence of alternate source	Method of Test CI Ref of IS:3025	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Essential Characteristics						
1	Colour, Hazen unit	5	Above, consumer acceptance decreases	25	4 of 3025, 1983	Extended upto 25 only if toxic substances are not suspected in absence of alternate source
2	Odour		Unobjectionable	-	5 of 3025, 1983	(a) Test cold and when heated (b) Test at several dilutions
3	Taste		Agreeable	-	-	Test to be conducted only after safety has been established
4	Turbidity, NTU	5	Above, consumer acceptance decreases	10	8	-
5	pH Value	6.5-8.5	Beyond this range the water will affect the mucous membrane and/or water supply system	No relaxation	8	-
6	Total hardness, mg/L as $CaCo_3$	300	Encrustation on water supply structure and advere effects on dometic use	600	-	-
7	Iron (as Fe), mg/L	0.3	Beyond this limit, taste/appearance are affected, has adverse effect on domestic uses and	1.0	32 of 3025, 1964	-

			water supply structures & promotes iron bacteria			
8	Chlorides (as Cl), mg/L	250	Beyond this limit, taste, corrosion and palatability are affected	1000	32 of 3025, 1988	-
9	Residual free chlorine, mg/L	0.2	-	-	26 of 3025, 1986	To be applicable only when water is chlorinated Tested at consumer end, when protection against viral infection is required, it should be min. 0.5 mg/L
Desirable Characteristics						
10	Dissolved solids, mg/L	500	Beyond this palatability decrease and may cause gastrointestinal irritation	2000	16 of 3025, 1984	
11	Calcium (as Ca), mg/L	75	-	200	40 of 3025, 1984	
12	Copper (as Cu), mg/L	0.05	Astringent, taste discoloration of pipes, fitting and utensils will be caused beyond this	1.5	36 of 3025, 1964	
13	Manganese (as Mn), mg/L	0.1	Astringent taste, discoloration of pipes, fitting and utensils will be caused beyond this	0.3	35 of 3025, 1964	
14	Sulphates (as SO_4), mg/L	200	Beyond this causes gastro intestinal irritation when magnesium or sodium are present	400	24 of 3025, 1986	May be extended upto 400 provided (as Mg) does not exceed 30 mg/L
15	Nitrates (as NO_3), mg/L	45	Beyond this methaemoglobine-mia takes place	100	-	-
16	Fluoride (as F), mg/L	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis	1.5	23 of 3025, 1964	-
17	Phenolic substances, mg/L (as C_6H_5OH)	0.001	Beyond this, it may cause objectionable taste and odour	0.002	54 of 3025, 1964	-

18	Mercury (as Hg), mg/L	0.001	Beyond this, the water becomes toxic	No relaxation	See note mercury ion analyzer	To be tested when pollution is suspected
19	Cadmium (as Cd), mg/L	0.01	Beyond this, the water becomes toxic	No relaxation	See note mercury ion analyzer	To be tested when pollution is suspected
20	Selenium (as Se), mg/L	0.01	Beyond this, the water becomes toxic	No relaxation	28 of 3025, 1964	To be tested when pollution is suspected
21	Arsenic (as As), mg/L	0.05	Beyond this, the water becomes toxic	No relaxation	37 of 3025, 1988	To be tested when pollution is suspected
22	Cyanide (CN), mg/L	0.05	Beyond this, the water becomes toxic	No relaxation	27 of 3025, 1986	To be tested when pollution is suspected
23	Lead (Pb), mg/L	0.05	Beyond this, the water becomes toxic	No relaxation	Refer note 86	To be tested when pollution plumbosolvency is suspected
24	Zinc (as Zn), mg/L	5	Beyond this limit it can cause astringent taste and an opalescence in water	15	30 of 3025, 1964	To be tested when pollution is suspected
25	Anionic detergents, mg/L (as MBAS)	0.2	Beyond this limit, it can cause a light froth in water	1.0	Methylene blue extraction method	To be tested when pollution is suspected
26	Chromium (as Cr+6), mg/L	0.01	May be carcinogenic above this limit	0.05	28 of 3025, 1964	To be tested when pollution is suspected
27	Polynuclear aromatic hydrocarbons (as PAH), mg/L	-	May be carcinogenic	-	-	-
28	Mineral oil, mg/L	0.01	Beyond this limit undesirable taste and odour after chlorination takes place	0.03	Gas chromato-graphic method	To be tested when pollution is suspected
29	Pesticides, mg/L	Absent	Toxic	0.001	58 of 3025, 1964	-
30	Radioactive materials					
	(a) Alpha emitters Bq/L	-	-	0.1	-	-
	(b) Beta emitters pci/L	-	-	1.0	-	-

31	Alkalinity (as CaCO3), mg/L	200	Beyond this limit, taste becomes unpleasant	600	13 of 3025, 1964	-
32	Aluminium (as Al), mg/L	0.03	Cumulative effect is reported to casuse dementia	0.2	31 of 3025, 1964	-
33	Boron (as B), mg/L	1	-	5	29 of 3025, 1964	-

Table 4.1.16: Indian Standards for Industrial and Sewage Effluents Discharge (IS: 2490-1982)

S. No.	Parameters	Industrial Effluent			
		Into Inland Surface Water	On land for Irrigation	Into Marine Coastal Area	Into Public Sewers
1	Colour/Odour	-	-	-	-
2	Suspended Solids, mg/l	100	200	100 (For process waste)	600
3	Particulate Size Suspended Solids	Shall pass 850 micron IS sieve	-	Floatable Solids Max 3mm Settleable Solids Max 850 microns	-
4	Dissolved Solids (inorganic) mg/l, Max.	2100	2100	-	2100
5	pH Value	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0
6	Temperature ^{0}C	Shall not exceed 40 in any section of the stream within 15 mts downstream from the effluent outlet	-	45 at the point of discharge	-
7	Oil & Grease, mg/l, Max.	10	10	20	20
8	Total residual Chlorine, mg/l, Max.	1	-	1	-
9	Ammonical Nitrogen (as N) mg/l, Max.	50	-	50	50
10	Total Kjeldahl Nitrogen (as N) mg/l, Max.	100	-	100	-
11	Free Ammonia (as NH_3) mg/l, Max.	5	-	5	-
12	Biochemical Oxygen Demand (5 Days at 20^{0}C), Max.	30	100	100	350
13	Chemical Oxygen Demand, mg/l, Max.	250	-	250	-
14	Arsenic (as As), mg/l, Max.	0.2	0.2	0.2	0.2
15	Mercury (as Hg), mg/l, Max.	0.01	-	0.01	0.01
16	Lead (as Pb), mg/l, Max.	0.1	-	1.0	1.0
17	Cadimium (as Cd), mg/l, Max.	2	-	2	1

18	Hexavalent Chromium (*as Cr6+), mg/l, Max.	0.1	-	1	2
19	Total Chromium (as Cr) mg/l, Max.	2	-	2	2
20	Copper (as Cu), mg/l, Max.	3	-	3	3
21	Zinc (as Zn), mg/l, Max.	5	-	15	15
22	Selenium (as Se), mg/l, Max.	0.05	-	0.05	0.05
23	Nickel (as Ni), mg/l, Max.	3	-	5	3
24	Boron (as B), mg/l, Max.	2	2	-	2
25	Percent Sodium, Max.	-	60	60	-
26	Residual Sodium Carbonate, mg/l, Max.	-	50	-	-
27	Cyanide (as CN), mg/l, Max.	0.2	0.2	0.2	0.2
28	Chloride (as Cl), mg/l, Max.	1000	600	-	1000
29	Fluoride (as F), mg/l, Max.	2	-	15	15
30	Dissolved Phosphate (as P), mg/l, Max.	5	-	-	-
31	Sulphate (as SO_4), mg/l, Max.	1000	1000	-	1000
32	Sulphide (as S), mg/l, Max.	2	-	5	-
33	Phenolic Compounds (as C_6H_5OH), mg/l, Max.	1	-	5	6
34	Radioactive materials				
	(a) Alpha emitters µc/ml, Max.	10^{-7}	10^{-8}	10^{-7}	10^{-7}
	(b) Beta emitters µc/ml, Max.	10^{-6}	10^{-7}	10^{-6}	10^{-6}
35	Manganese (as Mn), mg/l	2	2	-	2
36	Iron (as Fe), mg/l	3	3	-	3
37	Vandium (as V), mg/l	0.2	-	0.2	0.2
38	Nitrate Nitrogen, mg/l	18	20	-	0.2

Source: CPCB

4.1.6 Waste Generation and Management

Thousands of small scale and bigger industrial units simply dump their waste, more often toxic and hazardous, in open spaces and nearby water sources. Over the last three decades, many cases of serious and permanent damage to environment by these industries have come to the fore. Rapid industrialization has resulted in the generation of huge quantity of wastes, both solid and liquid, in industrial sectors such as sugar, pulp and paper, fruit and food processing, sago / starch, distilleries, dairies, tanneries, slaughterhouses, poultries, etc. Despite requirements for pollution control measures, these wastes are generally dumped on land or discharged into water bodies, without adequate treatment, and thus become a large source of environmental pollution and health hazard.

Classification of Industrial Waste

In a broad sense, industrial wastes could be classified into two types.

1. Hazardous Industrial Waste
2. Non-hazardous Industrial Waste

Hazardous Industrial Waste

Hazardous wastes, which may be in solid, liquid or gaseous form, may cause danger to health or environment, either alone or when in contact with other wastes. Various agencies have defined hazardous wastes in different ways and as such, there is no uniformly accepted international definition so far. It is presumed that about 10 to 15 percent of wastes produced by industries are hazardous and the generation of hazardous wastes is increasing at the rate of 2 to 5 percent per year.

Hazardous industrial wastes in India can be categorized broadly into two categories.

i) Hazardous wastes generated from various industries in India
ii) Hazardous industrial wastes imported into India from Western Countries for re-processing and recycling.

Inventorisation of hazardous wastes generating units and quantification of wastes generated in India are being done by the respective State Pollution Control Boards (SPCBs). Hazardous waste in particular includes products that are explosive, flammable, irritant, harmful, toxic, carcinogenic, corrosive, infectious, or toxic to reproduction. Table 4.1.17 shows the source of various Hazardous Waste.

Table 4.1.17: Potential for Recovery of Energy from Industrial Wastes

Hazardous Waste Component	Source
Heavy Metal	
Arsenic	Mining, non anthropogenic geo-chemical formation
Cadmium	Mining, fertilizer industry, battery waste
Chromium	Mining areas, Tanneries
Lead	Lead acid battery smelters
Manganese	Mining areas
Mercury	Chlor-alkali industries, healthcare institutes
Nickel	Mining, metal refining
Hydrocarbons	
Benzene	Petrochemical industries, solvents
Vinyl chloride	Plastics
Pesticides	Insecticides
Organic Chemicals	
Dioxins	Waste incineration, herbicides
PCBs	Fluorescent lights, e-waste, Hydraulic fluid

Use of Hazardous Wastes As Alternate Fuels

In the European Union, about 3 million tons of hazardous waste from cement works has been used as an alternate fuel. There are a large number of hazardous wastes generating units located in India. 11,138 units have been given authorization by

SPCBs under Hazardous Waste (Management and Handling) Rules, 2003, mostly for temporary storage of hazardous wastes within the plant premises. In India, about 4.43 million tons of hazardous wastes are generated annually, out of which 71,833 tons are incinerable (as per the reports of SPCBs submitted to the Supreme Court of India). There is a need to explore the possibility of using such wastes by other industries.

Incineration

Incineration serves the dual purpose of reduction of both the toxicity and the volume of the waste, which is an important consideration when the disposal of wastes is finally destined for landfills. Most of the process wastes from chemical unit operations can very well be treated in properly designed incinerators.

Hazardous Wastes (Secured) Landfill

Hazardous waste landfill site is designed scientifically to have an impervious stratum at bottom to stop leachates percolation, and thus to avoid soil and water pollution/contamination in the vicinity of the landfill site. HDPE lining is used in making the landfill impervious. There are arrangements made for collection and treatment of leachates from the hazardous wastes. Various reports indicate that more than 19 Treatment, Storage & Disposal Facilities (TSDF) have been created in Gujarat alone. Many other states are following the similar action to establish such facilities. However, some kind of risk will always be there for the people and ecosystem by these operating and closed TSDFs.

Non-Hazardous INDUSTRIAL Waste

Non-hazardous or ordinary industrial waste is generated by industrial or commercial activities, but is similar to household waste by its nature and composition. It is not toxic, presents no hazard and thus requires no special treatment.

In particular, it includes ordinary waste produced by companies, shopkeepers and trades people (paper, cardboard, wood, textiles, packaging, *etc.*). Due to its non-hazardous nature, this waste is often sorted and treated in the same facilities as household waste.

TREATMENT OPTIONS FOR NON-HAZARDOUS INDUSTRIAL WASTE

Non hazardous industrial wastes being diversified in their chemical nature, physical texture and moisture content and calorific values *etc.* demand distinct treatment options which are broadly classified in the Table 4.1.18.

Table 4.1.18: Waste Generation and Treatment Methods

Industries	Prominent Waste Generated	Treatment Option	Application
Sugar	Sugar bagasses	Combustion and Gasification	Heat and power
	Pressmud	Composting	Fertilizer
	Sugar molasses	Fermentation	Ethanol synthesis
	Fermentative Yeast biomass	Biomenthanation	Biogas production and digestate
Slaughter Houses	Organs, Tissues, Blood, Hides, Animal excreta and Carcass etc	Biomenthanation	Biogas production and digestate
Paper Mills	Pulp	Biomenthanation	Biogas production and digestate
	Paper shaving	Combustion	Heat and power
	Wood waste and paper	Combustion and Gasification	Heat and power

	boards		
Dairy Plants	Whey and Milk cream	Biomenthanation	Biogas production and digestate
Sago Factories	Starch materials and peels	Biomenthanation	Biogas production and digestate
Tanneries	Hides and skins	Acid treatment and Biome	Biogas production and digestate
Animal Husbandries	Animal excreta and body fluids	Biomethanation	Biogas production & digestate
Fruits and Vegetables Processing Units	Pulp wastes	Biomethanation	Biogas production & digestate

Source: Source: Energy Alternatives India

Table 4.1.19 shows the list of waste treatment plant installed enroute proposed MAHSRC.

Table 4.1.19: List of Waste Treatment Plant Installed enroute proposed MAHSRC

Location	Capacity	Type of Plant
Vadodara Municipal Corporation, Vadodara, Gujarat	52,000 m^3/day	Sewage Treatment Plant at Tarsali for combined domestic sewage and industrial waste water.
Baroda Municipal Corporation, Baroda, Gujarat.	28,000 m^3/day	Sewage Treatment Plant at Wadi for combined domestic sewage and industrial waste water
Baroda Municipal Corporation, Baroda, Gujarat.	9,000 m^3/day	Sewage Treatment Plant at Tarsali for combined domestic sewage and industrial waste water.
City and Industrial Development Corporation, Vashi - New Bombay, Maharashtra.	4,500 m^3/day	Sewage Treatment plant.
Krishak Bharati Co-operative Limited (KRIBHCO), Hazira, Surat	3,000 m^3/day	Sewage Treatment plant.
Gujarat Narmada Valley Fertilizers Co. Ltd., Bharuch, Gujarat.	1,200 m^3/day	Sewage Treatment Plant for GNFC Township.
Gujarat Narmada Auto Limited. Chanderia, Bharuch, Gujarat.	350 m^3/day	Sewage Treatment plant.
M/s. IOT Infrastructure & Energy Services Limited, (for CAIRN Energy India Ltd., BARMER TO SALAYA PIPELINE Project, Viramgam, Gujarat), Mumbai	72 m^3/day	Sewage Treatment plant.
Kvearner, Bharuch	2.5 m^3/day	Sewage Treatment plant.
Bajuwa Gram Panchayat, Baroda, Gujarat.	1000 m^3/day	Sewage Treatment plant.
Pirana, Ahmedabad	106 MLD	Sewage Treatment plant.
Vasna, Ahmedabad	126 MLD	Sewage Treatment plant.
Atladara, Vadodara	86 MLD	Sewage Treatment plant.
Tarsali, Vadodara	52 MLD	Sewage Treatment plant.
Gajarwadi, Vadodara	66 MLD	Sewage Treatment plant.
Anjana, Surat	82.5 MLD	Sewage Treatment plant.
Bhatar, Surat	120 MLD	Sewage Treatment plant.
Singanapore, Surat	100 MLD	Sewage Treatment plant.
Adharwadi, Kalyan	16 MLD	Sewage Treatment plant.
Triambak, Nashik	22 MLD	Sewage Treatment plant.
Nashik	78 MLD	Sewage Treatment plant.

Kopri ,Thane	54 MLD	Sewage Treatment plant.
Surat Municipal Corporation	200 TPD	Solid Waste
Gujarat Urban Development Corporation (GUDC), Ahmedabad	200 TPD	Solid Waste
Surat Municipal Corporation	600 TPD	Solid Waste
Aurangabad Municipal Corporation(AMC)	360 MT/ day.	Solid Waste
Nanded Waghala City Municipal Corporation	250 TDP	Solid Waste
Municipal Corporation of Greater Mumbai (MCGM)	600 TPD	Solid Waste
Ahmedabad	1.11 miliion Tonne per annum	Solid Waste
Vadodara	1.11 miliion Tonne per annum	Solid Waste
Surat	1.11 miliion Tonne per annum	Solid Waste
Vapi	1.11 miliion Tonne per annum	Solid Waste
Mulund	650 MT/Month	Solid Waste
Deonar	650 MT/Month	Solid Waste
Kanjur	650 MT/Month	Solid Waste
Navi Mumbai-Turbine Municipal Solid Waste Processing Waste Disposal Facility	650 MT/Month	Solid Waste
Thane-Diaghar	650 MT/Month	Solid Waste
Mira-Bhayander (Thane)	315 MT/Month	Solid Waste
Vasai-Virar	Gokhiware village-550 MT/Month	Solid Waste
Kalyan-Dombivali	Village-Umbarde- 550 MT/Month	Solid Waste
Ulhasnagar	500 MT/Month	Solid Waste
Bhiwandi Nizampur City	Dapode village-300 MT/Month	Solid Waste

Source: Mumbai Metropolitan Regional Development Authority (MMRDA), Maharashtra
CPCB website
Data base on Hazardous Waste Management in India

(1) Solid Waste Disposal

This section describes the regulatory setting and affected environment associated with hazardous materials and wastes, the potential project impacts related to hazardous materials and wastes, and the mitigation measures that would reduce these impacts. Construction and operation of the MAHSRC could cause ground disturbance (including disturbance of groundwater or surface water) near a known contaminated site or sites or where contamination could exist in the study area. Construction and operation of the project could also involve the use, storage, and disposal of hazardous materials and wastes in the study area. Under the existing planning phase, type of construction waste which is expected to generate are asphalt or concrete chunks, surplus soil, construction scrap materials and others. Although the amount and percent composition of construction waste is not clear in this phase, surplus soil is planned to be reused as much as possible in construction of the MAHSRC embankment. In addition, all other construction waste is also planned to comply with relevant Center or State laws pertaining to the waste management. According to JICA's Guideline and MOR's Environmental Policy, concept of waste utilization will be promoted by encouraging recycling and reuse. The project therefore will inbuilt such measures to reduce overall volume of waste generated from different construction sites linearly along the proposed alignment. In principle, most of metal scrap and other saleable wastes are received by authorized dealers. However, concrete and masonry wastes which constitute a major part of construction wastes are currently not recycled. At present, private contractors remove this waste to privately own low-lying land for a price or more commonly, dump it in an unauthorized manner along roads or other public land. Small quantities of construction waste usually get mixed with domestic waste due to lack of segregated storage and collection facilities. These improper practices shall be improved in the Project by promoting separate collection, site storage and disposal of debris and bulk wastes. Some part of these wastes can be used in embankment and in road making along the embankment. Other non-usable part of such concrete and masonry waste shall be disposed of in only designated low-lying sites which have been already identified by the local municipal council or committee of falling along the alignment. Burning of debris, vegetation, rubber or any other form of construction waste is prohibited as per the existing legislation and no such practice shall be allowed in the project. Other form of waste such as non-recyclable waste, packaging waste, e-waste (used cartridges, toners, wires, computers, printers *etc.*) generated from the site offices and labour camps shall be disposed of as per the existing laws. The tunnel sectional area shall be minimized as far as possible to cut the construction cost. Thus, MAHSRC Study team recommended a tunnel inner void space of 80 m^2 including a margin. The longest tunnel in the proposed MAHSRC has been envisaged from proposed Bandra Kurla Complex Railway Station to Shilphata with a length of 21.3 km. The tunnels have been proposed in the Mumbai region. Based on the geological formation of the region, the area is underlain by Basaltic rocks. Therefore, during the construction of the tunnel, the waste shall be generated in the form of rocks only. These rocks shall be used in the construction after crushing to the desired size. There is no tunnel in Gujarat region on the proposed alignment. The rocks of the tunnel shall be stored at designated location with easy access along the proposed HSR alignment. The soil/debris generated during the cutting, shall be used for embankment on the proposed alignment of HSR.

(2) Municipal Waste

The proposed Railway Stations and Maintenance Depots on the MAHSRC shall be located in the cities and in some cases out skirt of the cities. The municipal waste generated at these stations and maintenance depots shall be handled as per the prevailing statutory rules and regulations. Municipal Solid Wastes (Management & Handling) Rules, 2000 (MSW Rules) are applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid. The municipal authority shall comply with these rules as per the implementation schedule laid down in Schedule I shown in Table 4.1.20

Table 4.1.20: Schedule I (Related to implementation Schedule)

No.	Compliance Criteria	Schedule
1	Setting up of waste processing and disposal facilities	By 31.12.2003 or earlier
2	Monitoring the performance of waste processing and disposal facilities	Once in six months
3	Improvement of existing landfill sites as per provisions of these rules	By 31.12.2001 or earlier
4	Identification of landfill sites for future use and making site (s) ready for operation	By 31.12.2002 or earlier

Management of Municipal Solid Wastes

Any municipal solid waste generated in a city or a town, shall be managed and handled in accordance with the compliance criteria and the procedure laid down in Schedule-II shown in Table 4.1.21.

Table 4.1.21:
Schedule II (Specifications Relating to Collection, Segregation, Storage,Transportation, Processing and Disposal of Municipal Solid Waste)

No.	Parameters	Compliance criteria
1	Collection of municipal solid wastes	1. Littering of municipal solid waste shall be prohibited in cities, towns and in urban areas notified by the State Governments. To prohibit littering and facilitate compliance, the following steps shall be taken by the municipal authority, namely: - i. Organising house-to-house collection of municipal solid wastes through any of the methods, like community bin collection (central bin), house-to-house collection, collection on regular pre-informed timings and scheduling by using bell ringing of musical vehicle (without exceeding permissible noise levels); ii. Devising collection of waste from slums and squatter areas or localities including hotels, restaurants, office complexes and commercial areas; iii. Wastes from slaughter houses, meat and fish markets, fruits and vegetable markets, which are biodegradable in nature, shall be managed to make use of such wastes; iv. Bio-medical wastes and industrial wastes shall not be mixed with municipal solid wastes and such wastes shall follow the rules separately specified for the purpose; v. Collected waste from residential and other areas shall be transferred to community bin by hand-driven containerised carts or other small vehicles; vi. Horticlutural and construction or demolition wastes or debris shall be separately collected and disposed off following proper norms. Similarly, wastes generated at dairies shall be regulated in accordance with the State laws; vii.Waste (garbage, dry leaves) shall not be burnt; viii. Stray animals shall not be allowed to move around waste storage facilities or at any other place in the city or town and shall be managed in accordance with the State laws. 2. The municipal authority shall notify waste collection schedule and the likely method to be adopted for public benefit in a city or town. 3. It shall be the responsibility of generator of wastes to avoid littering and ensure delivery of wastes in accordance with the collection and segregation system to be notified by the municipal authority as per para 1(2) of this Schedule.
2	Segregation of municipal solid wastes	In order to encourage the citizens, municipal authority shall organise awareness programmes for segregation of wastes and shall promote recycling or reuse of segregated materials. The municipal authority shall undertake phased programme to ensure community participation in waste segregation. For this purpose, the municipal authorities shall arrange regular meetings at quarterly intervals with representatives of local resident welfare associations and non-governmental organizations.
3	Storage of municipal solid wastes	Municipal authorities shall establish and maintain storage facilities in such a manner as they do not create unhygienic and in sanitary conditions around it. Following criteria shall be taken into account while establishing and maintaining storage facilities, namely: - i. Storage facilities shall be created and established by taking into account quantities of waste generation in a given area and the population densities. A storage facility shall be so placed that it is accessible to users;

		ii. Storage facilities to be set up by municipal authorities or any other agency shall be so designed that wastes stored are not exposed to open atmosphere and shall be aesthetically acceptable and user-friendly; iii. Storage facilities or 'bins' shall have 'easy to operate' design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black; iv. Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.
4	Transportation of municipal solid wastes	Vehicles used for transportation of wastes shall be covered. Waste should not be visible to public, nor exposed to open environment preventing their scattering. The following criteria shall be met, namely:- i. The storage facilities set up by municipal authorities shall be daily attended for clearing of wastes. The bins or containers wherever placed shall be cleaned before they start overflowing; ii. Transportation vehicles shall be so designed that multiple handling of wastes, prior to final disposal, is avoided.
5	Processing of municipal solid wastes	Municipal authorities shall adopt suitable technology or combination of such technologies to make use of wastes so as to minimize burden on landfill. Following criteria shall be adopted, namely:- (i) The biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes. It shall be ensured that compost or any other end product shall comply with standards as specified in Schedule-IV;
		(ii) Mixed waste containing recoverable resources shall follow the route of recycling. Incineration with or without energy recovery including pelletisation can also be used for
		processing wastes in specific cases. Municipal authority or the operator of a facility wishing to use other state-of-the-art technologies shall approach the Central Pollution Control Board to get the standards laid down before applying for grant of authorisation.
6	Disposal of municipal solid wastes	Land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing. Land filling shall also be carried out for residues of waste processing facilities as well as pre-processing rejects from waste processing facilities. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing. Under unavoidable circumstances or till installation of alternate facilities, land-filling shall be done following proper norms. Landfill sites shall meet the specifications as given in Schedule –III.

Source: Municipal Solid Wastes (Management and Handling) Rules, 2000

Hazardous Wastes
List of Waste Constituents with concentration limits shown in Table 4.1.22.

Table 4.1.22: Waste Constituents with Concentration Limit

No.	Constituents	Concentration limit
1	(Iso-and thio-) cyanates	5, 000 mg/kg
2	Acid amides	20, 000 mg/kg
3	Acid anhydride	20, 000 mg/kg
4	Amines	5, 000 mg/kg
5	Ammonia and ammonium compounds	20, 000 mg/kg
6	Anthracene	50 mg/kg
7	Antimony and antimony compounds	50 mg/kg
8	Aromatic compounds other than those listed under A12 to A18	20, 000 mg/kg
9	Arsenic and arsenic compounds	50 mg/kg
10	Asbestos	5, 000 mg/kg
11	Barium compounds except barium sulphate	20, 000 mg/kg
12	Benzene	50 mg/kg
13	Beryllium and beryllium compounds	50 mg/kg
14	Bromates, (hypo-bromites)	20, 000 mg/kg
15	Bromine	5, 000 mg/kg
16	Cadmium and cadmium compounds	50 mg/kg
17	Carcinogenicity, Mutagenecity and Endocrine disruptivity Wastes contaminated or containing established carcinogens, mutagens and endocrine disruptors.	※[1]
18	Chlorates, (hypo-chlorites)	20, 000 mg/kg
19	Chlorine	5, 000 mg/kg
20	Chromium (III) compounds	5, 000 mg/kg
21	Chromium (VI) compounds	50 mg/kg
22	Chrysene, benzo (a) anthracene, fluoranthene, benzo (a) pyrene, benzo (K) fluoranthene, indeno (1, 2, 3-cd) pyrene and benzo (ghi) perylene	50 mg/kg
23	Cobalt compounds	5, 000 mg/kg
24	Copper compounds	5, 000 mg/kg
25	Corrosive Wastes which may be corrosive, by chemical action, will cause severe damage when in contact with living tissue.	※[1]
26	Explosive Wastes which may explode under the effect of flame, heat or photochemical conditions. Any other waste of explosive materials included in the Indian Explosive Act.	※[1]
27	Ferro-silicate and alloys	5, 000 mg/kg
28	Flammable wastes with flash point 65.6^{o} C or below.	※[1]
29	Flourine	5, 000 mg/kg
30	Fluorine compounds	20, 000 mg/kg
31	Halogenated aliphatic compounds	5, 000 mg/kg
32	Halogenated aromatic compounds	50 mg/kg
33	halogenated compounds of aromatic rings, *e.g.* polychlorinated biphenyls, polychloroterphenyls and their derivatives	50 mg/kg
34	Halogen-containing compounds which produce acidic vapours on contact with humid air or water, *e.g.* silicon tetrachloride, aluminium chloride, titanium tetrachloride	5, 000 mg/kg
35	Halogen-silanes	5, 000 mg/kg
36	Hydrazine (s)	5, 000 mg/kg
37	Hydrides	50, 000 mg/kg
38	Inorganic cyanide compounds	50 mg/kg
39	Inorganic peroxides	20, 000 mg/kg
40	Inorganic Tin compounds	5, 000 mg/kg
41	Iodates	20, 000 mg/kg

42	Lead and lead compounds	5, 000 mg/kg
43	Manganese-silicate	5, 000 mg/kg
44	Mercaptans	5, 000 mg/kg
45	Mercury and mercury compounds	50 mg/kg
46	Metal carbonyls	50 mg/kg
47	Metal hydrogen sulphates	50, 000 mg/kg
48	Molybdenum compounds	5, 000 mg/kg
49	Napthalene	50 mg/kg
50	Nickel compounds	5, 000 mg/kg
51	Nitrates, nitrites	20, 000 mg/kg
52	Nitrides	50, 000 mg/kg
53	Nitriles	5, 000 mg/kg
54	Organic azo-and azooxy compounds	5, 000 mg/kg
55	Organic nitro-and nitroso-compounds	5, 000 mg/kg
56	Organic nitrogen compounds expressed as nitrogen	50, 000 mg/kg
57	Organic oxygen compounds	50, 000 mg/kg
58	Organic silicone compounds	20, 000 mg/kg
59	Organic sulphur compounds	20, 000 mg/kg
60	Organo phosphorus compounds B13 Organic peroxides	5, 000 mg/kg
61	Organo-chlorine pesticides	50 mg/kg
62	Organo-tin Compounds	50 mg/kg
63	Oxides and hydroxides except those of hydrogen, carbon, silicon, iron, aluminum, titanium, manganese, magnesium, calcium	50, 000 mg/kg
64	Phenanthrene	50 mg/kg
65	Phenol and phenolic compounds	5, 000 mg/kg
66	Phosphate compounds except phosphates of aluminium, calcium and iron	20, 000 mg/kg
67	Salts of per-acids	20, 000 mg/kg
68	Selenium and selenium compounds	50 mg/kg
69	Silver compounds	5, 000 mg/kg
70	Sulphides	20, 000 mg/kg
71	Tellurium and tellurium compounds	50 mg/kg
72	Thallium and thallium compounds	50 mg/kg
73	Total hydrocarbons other than those listed under A12 to A18	50, 000 mg/kg
74	Total Sulphur D2 Inorganic acids	50, 000 mg/kg
75	Toxic Wastes containing or contaminated with established toxic and or eco- toxic constituents.	※[1]
76	Tungsten compounds	5, 000 mg/kg
77	Vanadium compounds	5, 000 mg/kg
78	White and red phosphorus	5, 000 mg/kg
79	Zinc compounds	20, 000 mg/kg

Note: ※[1]: Regardless of concentration limit, classified as hazardous wastes if the waste exhibits any of the following Characteristics.
Waste constituents and their concentration limits given in this list are based on erstwhile BAGA (the Netherlands Environment Protection Agency) List of Hazardous Substances. In order to decide whether specific wastes listed above is hazardous or not, following points be taken into consideration:

- If a component of the waste appears in one of the five risk classes listed above (A,B,C,D) and the concentration of the component is equal to or more than the limit for the relevant risks class, the material is then classified as hazardous waste.

- If a chemical compound containing a hazardous constituent is present in the waste, the concentration limit does not apply to the compound, but only to the hazardous constituent itself.
- If multiple hazardous constituents from the same class are present in the waste, the concentrations are added together.
- If multiple hazardous constituents from different classes are present in the waste, the lowest concentration limit corresponding to the constituent(s) applies.

- For determining the concentration of the hazardous constituents in the waste "Toxicity Characteristics Leaching Procedure (TCLP) as per ASTM-D5233-92 should be adopted.

Source: Hazardous Waste (Management, Handling &Transboundary Movement) Rules, 2008

4.1.7 Noise and Vibration

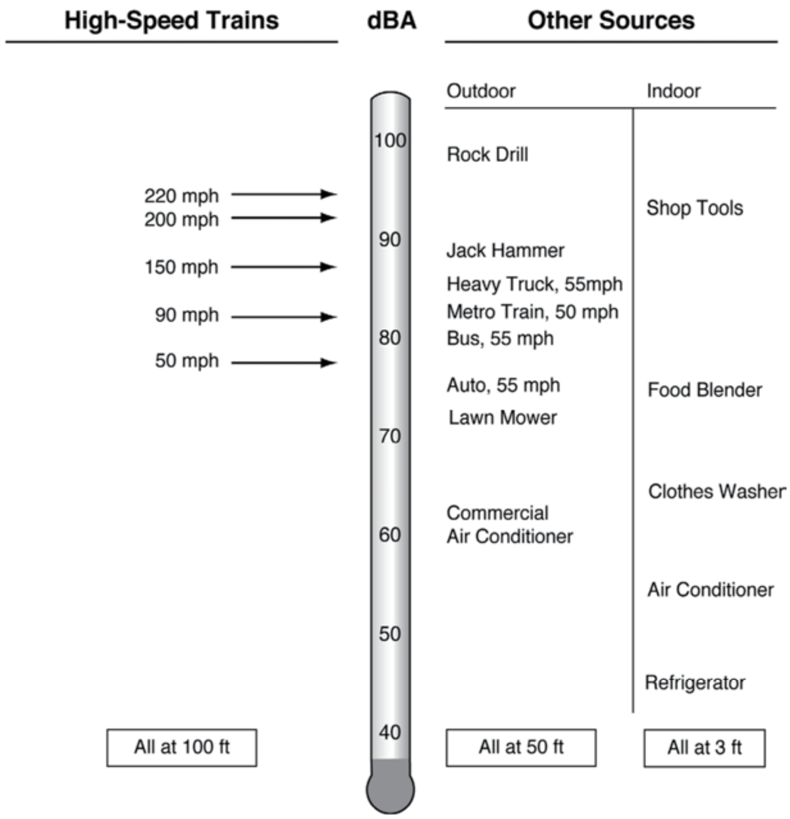
(1) Ambient Noise

Noise from an HSR system is expressed in terms of a "source-path-receiver" framework. The "source" generates noise levels that depend on the type of source (*e.g.,* a high-speed rail) and its operating characteristics (*e.g.,* speed). The "receiver" is the noise-sensitive land use (*e.g.,* residence, hospital, or school) exposed to noise from the source. In between the source and the receiver is the "path," where the noise is reduced by distance, intervening buildings, and topography. Environmental noise impacts are assessed at the receiver. Noise criteria are established for the various types of receivers because not all receivers have the same noise sensitivity. Analysts use three primary noise measurement descriptors to assess noise impacts from traffic and transit projects. They are the equivalent sound level (L_{eq}), the day-night sound level (L_{dn}), and the sound exposure level (SEL):

- L_{eq}: The level of a constant sound for a specified period of time that has the same sound energy as an actual fluctuating noise over the same period of time. The peak-hour Leq is used for all traffic and light rail noise analyses at locations with daytime use, such as schools and libraries.

- L_{dn}: The Leq over a 24-hour period, with 10 dB added to nighttime sound levels (between 10 p.m. and 7 a.m.) as a penalty to account for the greater sensitivity and lower background sound levels during this time. The L_{dn} is the primary noise-level descriptor for rail noise in residential land uses. Figure 4.1.31 shows typical L_{dn} noise levels.

- SEL: The SEL during a single noise event is the primary descriptor of a single noise event, and used to describe noise from an HST passing a location along the track. SEL is an intermediate value in the calculation of both Leq and Ldn. It represents a receiver's cumulative noise exposure from an event (train pass-by) and represents the total A-weighted sound during the event normalized to a 1-second interval.



Source: FRA

Figure 4.1.31: Typical Maximum A-weighted Sound Pressure Levels

Ambient noise level were measured in the study area in the post-monsoon season (from 28/10/2014 to 12/11/2014) to assess the background noise levels in different areas *viz;* Residential, Industrial, Commercial and Silence zones as per the Gazette Notification dated 14.02.2000 of MoEF on ambient noise standards.

In the present study, Sound Pressure Level (SPL) was measured by a sound level meter (Integrating Sound Level Meter Cygnet, Model 2031A). Since loudness of sound is important by its effects on people, the dependence of loudness upon frequency must be taken into account in environmental noise assessment. This has been achieved by the use of A-weighting filters in the noise measuring instrument which gives a direct reading of approximate loudness.

1) Selection of Measurement Locations

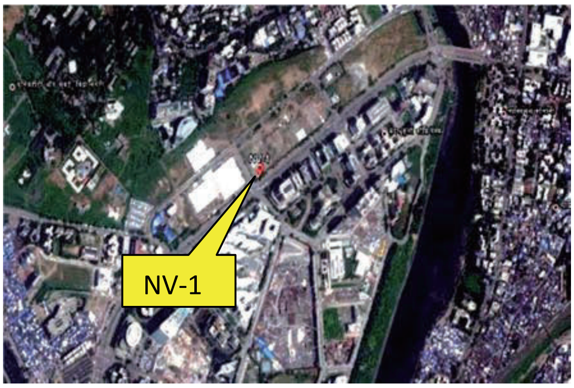
Noise Study Area

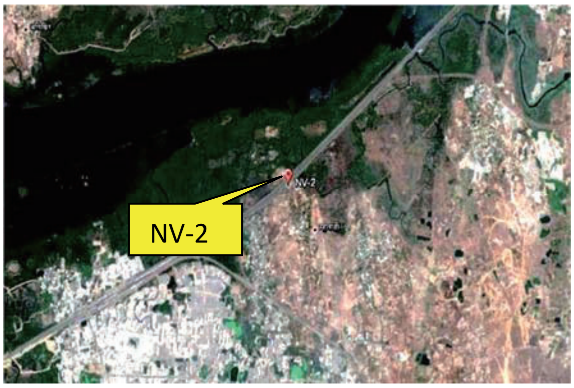
The noise study area of the proposed project includes sensitive receivers that are located up to approximately 250 m from the proposed track centerline. This study area has been determined based on a screening distance corresponding to known conditions in the corridor. The noise study area defined by the screening distance is sufficiently large to include all receivers that may potentially be exposed to noise impact. Consistent with CPCB guidelines, the screening distance of 250 m was determined based on project-specific conditions and all noise-sensitive receivers within this distance were further evaluated for potential impact. The study area extends farther than typical screening distances primarily because existing noise conditions in some areas are relatively low, there would be a greater number of MAHSRC operations, and train speeds would be higher. To establish a baseline of existing environmental noise levels for project noise impact assessment, project analysts took a series of noise measurements according to CPCB guidelines at selected sites along the proposed corridor between October 28, 2014 and November 12, 2014, The measurements consisted of long- term (24 hours in duration) and short-term (generally 15 to 60 minutes in duration) monitoring of the A-weighted sound level at representative noise-sensitive locations. The noise measurements were taken at locations selected to be representative of the noise environment throughout the study area, and especially at those locations most likely to be affected by MAHSRC noise. Long-term measurements were taken at residential properties including single-family homes, multifamily buildings, and hospitals. Short-term measurements were taken at noise-sensitive institutions and residences. At each site, the instrument was positioned to characterize the exposure of the site to the dominant noise sources in the area. Figure 4.1.32 shows the locations of the measurement sites and the measurement locations are show in Table 4.1.23. The photograph of the Noise measurement location (measurement in progress) is show in Figure 4.1.33.

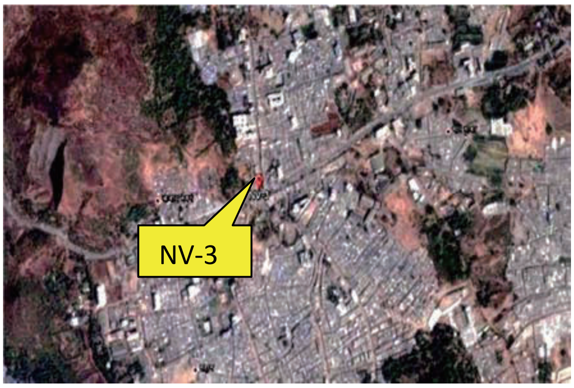
Table 4.1.23: Noise and Vibration Measurement Locations

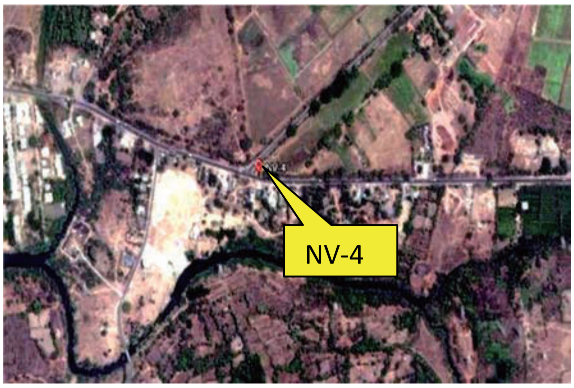
Location Code	**Category**	**Location**	**Geo-coordinates**		**Measurement date**
			Latitude-N	Longitude-E	
NV1	Commercial	Mumbai - Proposed Railway Stn	19° 04'5.04"	72°51'57.79"	12/11/2014
NV2	Commercial	Thane - Proposed Railway Stn	19°11'45.39"	73° 03'35.77"	11/11/2014
NV3	Commercial	Virar - Proposed Railway Stn	19°26'12.00"	72°50'18.32"	09/11/2014
NV4	Residential	Bolsar - Proposed Railway Stn	19°47'11.68"	72°46'32.11"	08/11/2014
NV5	Commercial	Vapi - Proposed Railway Stn	20°20'03.28"	72°56'55.82"	07/11/2014
NV6	Residential	Bilimora - Proposed Railway Stn	20°45'57.60"	73° 00'25.74"	06/11/2014
NV7	Residential	Surat - Proposed Railway Stn	21°10'56.65"	72°56'11.78"	05/11/2014
NV8	Residential	Bharuch -Proposed Railway Stn	21°41'43.04"	72°56'43.51"	04/01/2014
NV9	Commercial	Vadodara - Proposed Railway Stn	22°18'39.60"	73°10'47.30"	02/11/2014
NV10	Residential	Anand - Proposed Railway Stn	22°38'20.78"	72°54'40.41"	31/10/2014
NV11	Commercial	Ahmedabad-Proposed Railway Stn	23° 01'37.26"	72°36'08.89"	29/10/2014
NV12	Commercial	Sabarmati - Proposed Railway Stn	23° 04'29.04"	72°35'16.14"	28/10/2014

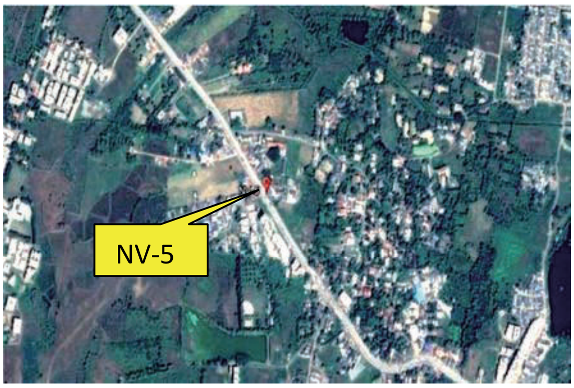
Source: GPSTPL Study Team

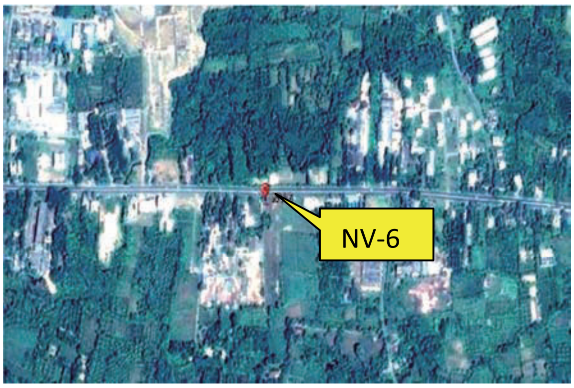

NV-1

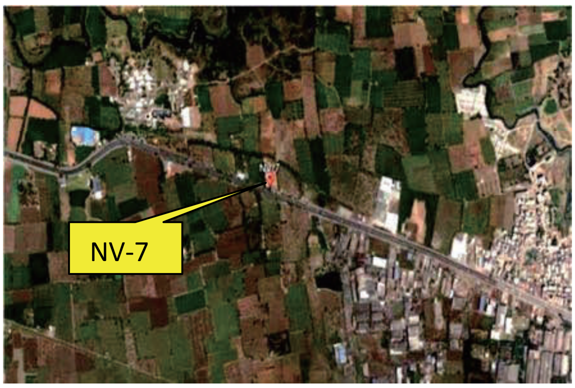

NV-2

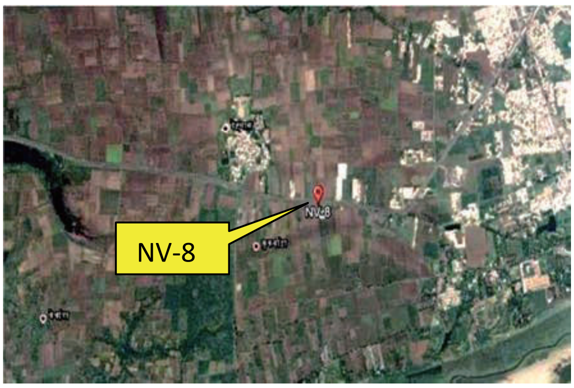

NV-3

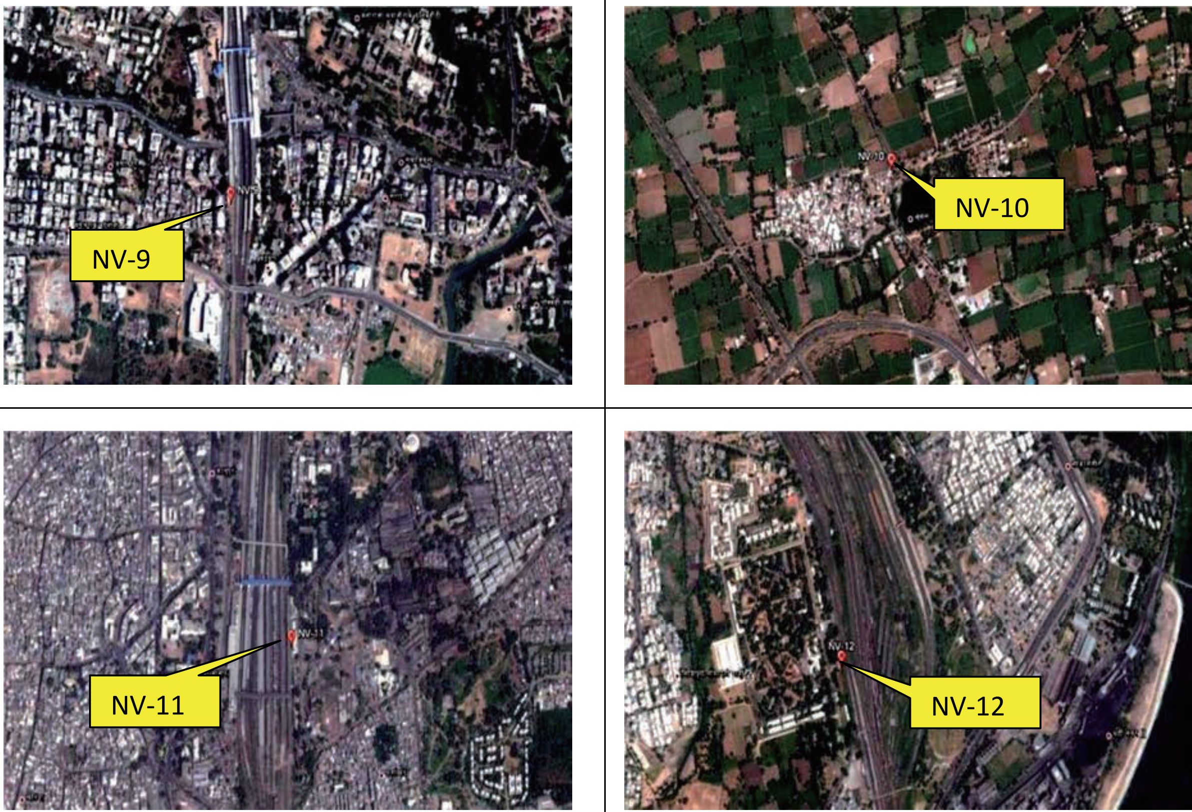

NV-4


NV-5


NV-6

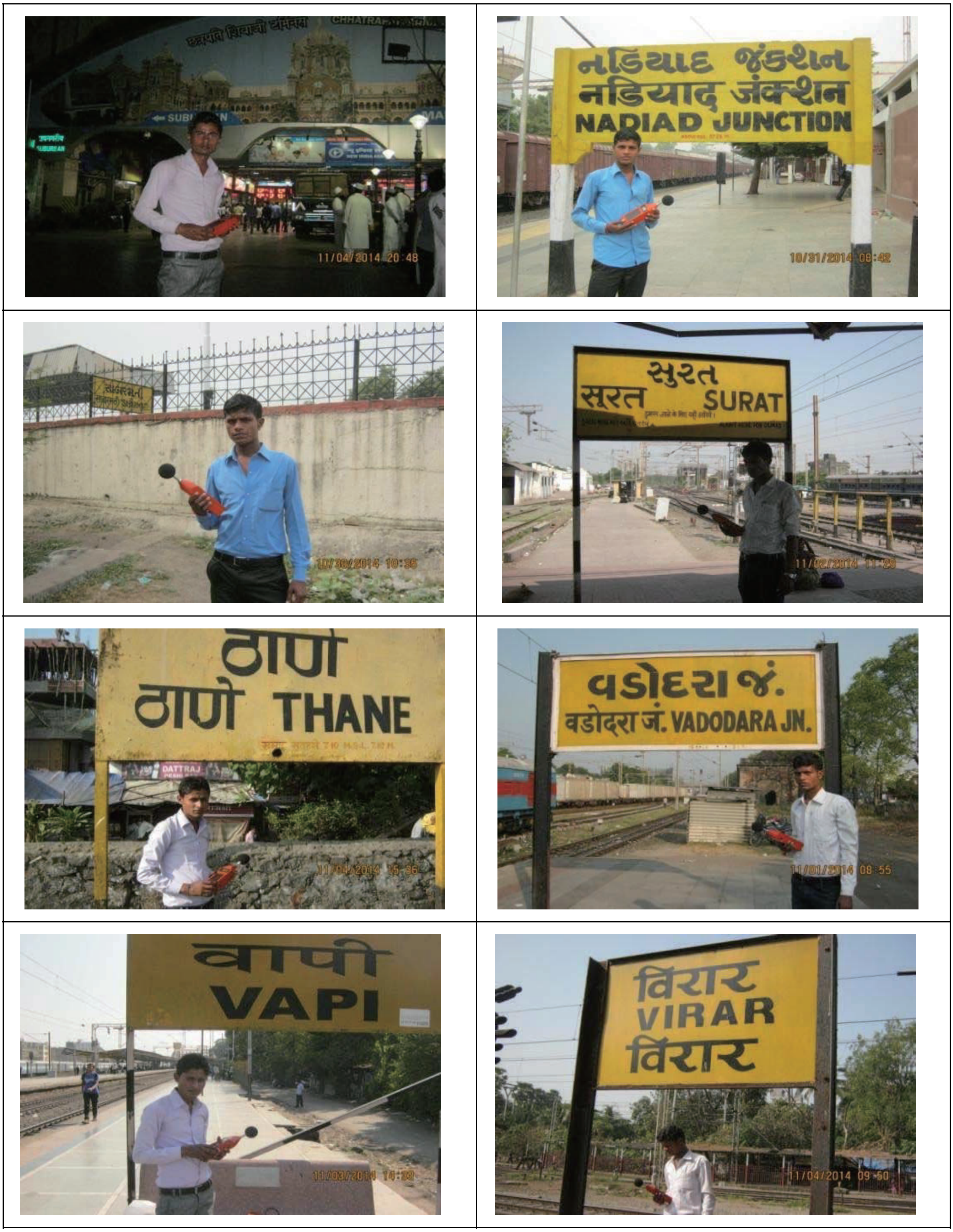

NV-7


NV-8



Source: Prepared by Study Team-GPSTPL

Figure 4.1.32: Noise and Vibration Measurement Locations in the Study Area



Source: Photograph by Study Team-GPSTPL

Figure 4.1.33: Illustration Showing Noise Measurement

2) Results and Discussions

As a result of measurement at the vicinity of 12 planned station locations along the planned route, near Mumbai station the LAeq during the daytime was 73dB which exceeded India's Area "B" (Commercial Area) noise standards of 65dB. It can be surmised that this is a result of mostly noise from automobiles due to the location being an urban area. Similarly, the LAeq near Ahmedabad station during the daytime was also high at 61dB. However, levels at other areas were mostly low at 40dB or less. There is different type of fields for measuring the ambient noise level, which can be categorized as free field, near field and far field.

Free Field

The free field is defined as a region where sound wave propagates without obstruction from source to the receiver. In such case, the inverse square law can be applied so that the sound pressure level decreases by 6 dB (A) as the distance is doubled.

Near Field

The near field is defined as that region close to the source where the inverse square law does not apply. Usually this region is located within a few wavelengths from the source.

Far Field

The far field is defined as that region which is at a distance of more than 1meter from the source.

3) Parameters Measured

The important parameters measured are L_{eq}, L_{day} and L_{night}.

L_{eq}: Noise monitoring equipments have the facility for measurement of L_{eq} directly. However, L_{eq} can also be calculated using the following equation:

$$L_{eq\,(hrly)} = L_{50} + (L_{10} - L_{90})^2 / 60$$

Where,

L_{10} *(Ten Percentile Exceeding Level)* is the level of sound, which exceeds 10% of the total time of measurement.

L_{50} *(Fifty Percentile Exceeding Level)* is the level of sound, which exceeds 50% of the total time of measurement.

L_{90} *(Ninety Percentile Exceeding Level)* is the level of sound, which exceeds 90% of the total time of measurement.

L_{day} : This represents L_{eq} of daytime. L_{day} is calculated as Logarithmic average using the hourly L_{eq}'s for day time hours from 6.00 A.M to 10.00 P.M

L_{night}:This represents L_{eq} of nighttime. L_{night} is calculated as Logarithmic average using the hourly L_{eq}'s for nighttime hours from 10.00 PM to 6.00 A.M.

4) Method of Measurement

Ambient noise level measurement was carried out continuously for 24-hours at the identified locations. During each hour, parameters like L_{10}, L_{50}, L_{90} and Leq were directly computed by the instrument based on the Sound Pressure Levels (SPL). Measurement was carried out at 'A' weighting and in fast response mode.The summary of measured parameters like L_{eq}, L_{day}, L_{night}, L_{10}, L_{50}, L_{90} for all the locations in the post-monsoon season, are presented in Table 4.1.24. The overall L_{eq} value varied between 35.7dB (A) to 70.6dB (A) in all locations. Day time and night time L_{eq} value varied between 30.1dB (A) to 55.8dB (A) and 36.2dB (A) to 72.6dB (A) respectively. The highest L_{eq} value 70.6dB (A) was recorded at Bandra Kurla Complex (BKC) due to running of various equipment and the lowest L_{eq} value 35.7dB (A) was recorded at Virar. The highest L_{day} 72.6dB (A) was recorded at BKC and lowest value of L_{day} 36.2dB (A) at Virar.

Table 4.1.24: Ambient Noise Levels at the Selected Stations

Code	Station's Name	Noise Level in dB(A)					
		Post-Monsoon Season					
		L_{10}	L_{50}	L_{90}	L_{eq}	L_{day}	L_{night}
N1	Mumbai - Proposed Railway Station	72.5	65.8	55.6	70.6	72.6	55.8
N2	Thane - Proposed Railway Station	52.6	41.5	36.1	41.5	41.8	34.3
N3	Virar - Proposed Railway Station	48.7	35.7	32.1	35.7	36.2	30.1
N4	Bolsar - Proposed Railway Station	51.3	39.3	38.9	39.3	40.1	35.6
N5	Vapi - Proposed Railway Station	51.4	40.2	38.1	40.2	40.6	35.8
NV6	Bilimora - Proposed Railway Station	50.5	39.6	37.6	39.6	40.2	35.1
NV7	Surat - Proposed Railway Station	50.6	39.8	32.8	39.8	40.5	34.2
N8	Bharuch - Proposed Railway Station	48.4	37.6	34.7	37.6	37.9	31.6
N9	Vadodara - Proposed Railway Station	50.7	37.5	33.7	37.5	37.8	32.1
N10	Anand - Proposed Railway Station	50.2	38.7	34.6	38.7	39.2	34.8
N11	Ahmedabad - Proposed Railway Station	68.2	45.6	41.8	57.2	61.2	55.7
N12	Sabarmati - Proposed Railway Station	55.2	41.6	37.2	47.0	49.7	38.9

Source: GPSTPL Study Team

5) Ambient Noise Standards

The Ambient Air Quality Standards with respect to Noise have been stipulated by Government of India vide Gazette Notification dated 14.2.2000 and The Noise Pollution (Regulation and Control) (Amendment) Rules 2010 and given in Table 4.1.25.

Table 4.1.25: Ambient Air Quality Standards with Respect to Noise*

Area Code	Category of Area	Limits in dB(A), L_{eq}	
		** Day time	#Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone @	50	40

* Environment (Protection) Third Amendment Rules, 2000.
Gazette Notification Government of India dated 14.2.2000 and The Noise Pollution (Regulation and Control) (Amendment) Rules 2010.

** Day Time: 6.00 AM to 10.00 PM

\# Night Time: 10.00 PM to 6.00 A.M

@ Silence zone is defined as an area up to 100 meters around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by the competent authority; Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.

(2) Vibration

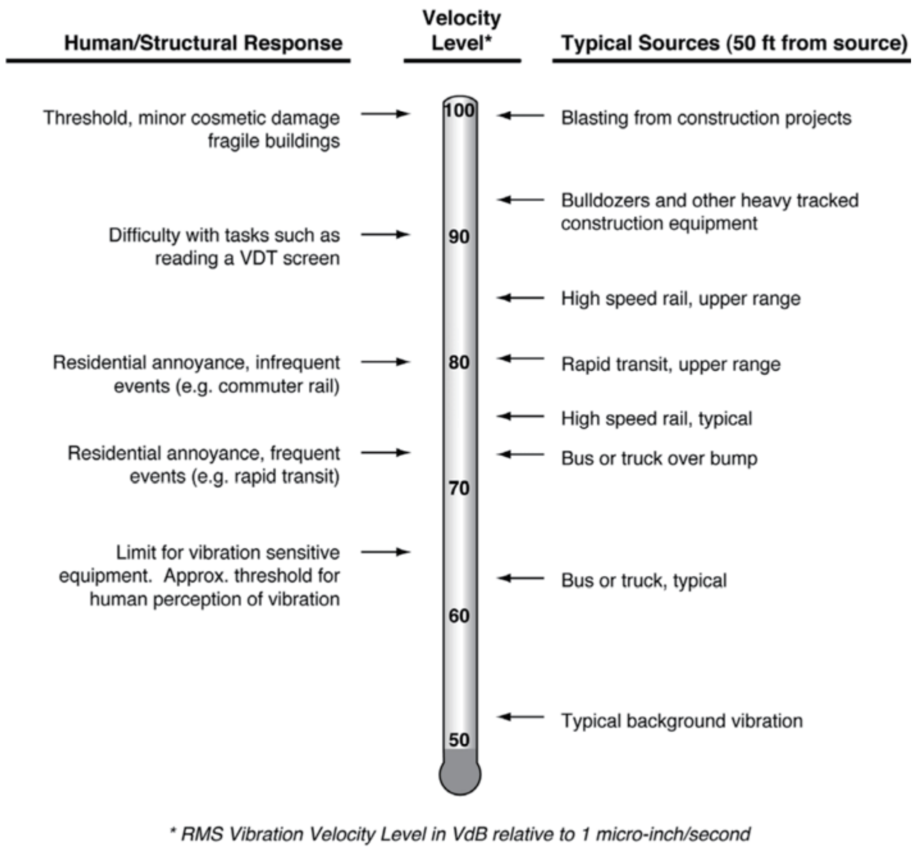
1) Introduction

Vibration from an HSR system is also expressed in terms of a “source-path-receiver” framework. The “source” is the train rolling on the tracks, which generates vibration energy transmitted through the supporting structure under the tracks and into the ground. Once the vibration gets into the ground, it propagates through the various soil and rock strata the “path” to the foundations of nearby buildings—the “receivers.” Ground-borne vibrations generally reduce in levels with distance depending on the local geological conditions. A “receiver” is a vibration-sensitive building (*e.g.,* residence, hospital, or school) where the vibrations may cause perceptible shaking of the floors, walls, and ceilings and a rumbling sound inside rooms. Not all receivers have the same vibration-sensitivity. Consequently, vibration criteria are established for the various types of receivers. Ground-borne vibration can be described in terms of displacement, velocity, or acceleration for evaluating impacts from transit projects. Ground-borne noise occurs as a perceptible rumble and is caused by the noise radiated from the vibration of room surfaces. Vibration above certain levels can damage buildings, disrupt sensitive operations, and cause annoyance to humans within buildings. Figure 4.1.34 illustrates typical ground- borne vibration velocity levels for common sources and thresholds for human and structural response to ground-borne vibration. As shown, the range of interest is from approximately 50 to 100 vibration velocity level (VdB) (*i.e.,* from imperceptible background vibration to the threshold of damage). Although the threshold of human perception to vibration is approximately 65 VdB, annoyance does not usually occur unless the vibration exceeds 70 VdB.

Vibration Study Area
For the proposed project, the study area for vibration is as follows:

- HST station study area: 50 m from the station boundary.
- MAHSRC study area, including existing railroads: up to 90 m from the edge of the right-of- way.

The vibration impact assessment uses the FRA screening procedure. Screening distances indicate the potential for vibration impact on vibration-sensitive receivers. FRA guidance has determined that receivers located beyond the screening distances are not likely to be affected by the MAHSRC.



Source: FRA (2005)

Figure 4.1.34: Typical Levels of Ground-Borne Vibration

The sources of the vibration and noise are due to operation of Tunnel Boring Machine (TBM) during construction of tunnel. Vibration induced by the high speed train during operation is mainly due to the rolling stock, track and the interaction between them. Continuous effect of vibration on the buildings can cause damage buildings. Building subjected to the vibration effect with more than 50 mm/s would receive structural damage. Historic buildings are more susceptible to vibration effect due to type of building material and design. The vibration induced by the operation of train first causes the vibration of track structure as well as tunnel structure, and then, propagate through the strata to the surrounding environment.

Human response to vibration is subjective and will be different for different people. When the vibrations reach the floors and walls it may result in perceptible vibration depending on the amplitude and frequency of the vibrations. Rattling of windows, dishes, and similar parts may also result in audible noise which is called ground-borne noise. People may be more annoyed if they are exposed to both noise and vibration compared to when only vibration is felt. According to the U.S. Department of Transportation, (1998) the perception threshold of humans for peak particle velocity is about 0.04 mm/s (65VdB with reference 1 e-6 inch/sec). To know the impact of vibration due to TBM operation on the existing structures and due to high speed train operation has been studied at twelve locations by selecting the most sensitive area falling on the proposed metro line alignment. The monitoring was carried out using the Nomis Seismographer equipment which can measure the radial, transverse and vertical vibration of ground borne vibration. The detail of location where vibration monitoring has been carried out is given in Table 4.1.23 and shown on Google map as

Figure 4.1.32. The hard rock structure will be considered while predicting the vibration impact as the proposed underground station would be 18 to 20 m below the ground level. The subsequent section describes the results of field monitoring, vibration analysis, and impact assessment with the prediction of vibration due to TBM and train traffic. The vibration studies have been conducted to know the existing vibration cause due to the road traffic. The study has been conducted during the busy traffic hours in the morning and evening.

Measurement
As discussed in the earlier sections, the proposed track runs in two different alignments.

A. One parallel to the existing track, which could involve:

- Higher amplitude vibrations impacting the buildings now coming closer to railway vibrations (within critical distance) on the side of new track;
- Higher amplitude vibrations impacting all close buildings and human inmates due to instances of multiple trains running at same instance of time;
- Higher frequency of such multiple train running instances resulting to higher time of exposure
- Increased impact due to increased speeds of High Speed Train.
- Increased impact due to higher no. of High Speed Train running closer.

B. Detours from the existing track passing through areas of different land use::
On detours, there are no existing tracks at the moment. This will necessitate *abinitio* laying of the track which will involve movement of High Speed Trains. In addition, there will be impact due to construction activity itself. Finally there will be impacts due to MAHSRC operations which will be in the form of:

- Creation of a new Vibration environment along the detour effecting the building and inmates present within the critical distance of impact of vibrations
- Impacts due to trains running at higher speeds.

As part of the base line analysis of vibration levels, data was collected through measurement of vibration levels at several locations along parallel tracks asmwell as detour locations, covering all the possible scenarios mentioned above.
The data collected along with the patterns of vibration propagation within distance, speed, for single, dual and multiple train operations have been estimated. The same data has been used to predict impacts on sensitive locations along the entire corridor. The highest vibration values based on the 330 km/hr speed of High Speed Passenger Train have been used for the prediction of impacts.

2) Standard for Vibration Measurement for Rail Projects

In absence of any Indian standard on vibration, international standards (as indicated below) have been referred for evaluating the potential impacts for building damage and also the human response.

- ISO Standards on vibration (ISO 2631/2- 1989, ISO 8041-1990, and ISO 4866-1990)

- JIS Z-8735 (Method of measurement for vibration levels) and JIS C-1510 (Standard for Vibration level meter).
- BS 6472
- DIN 4150

While each of the above standards have specific approach to the measurement and assessment of vibration impacts, considering the fact that the FS for the project was carried out based on Japanese standards (JIS 8735 and JIS 1510) and MOR is also implementing same standards in the MAHSRC, the same standards have also been in the current study. The important features of GIS 8735 are:-

- depend on one single parameter *i.e.* L_{peak} as against multiple parameters such as (VDV and PPV);
- does not require further calculations after the collection of data;
- the standards suggests single parameter to assess the vibration impacts on buildings and the residents with one common parameter.

Considering the above, the above JIS Z 8735 have been following for measuring and prediction of vibration impacts of the project.

3) Methodology

The ambient vibration levels and railway vibration levels were measured as part of the base line surveys. While railway vibrations were measured for various train types and speeds at varying distances, the ambient vibrations were measured on Sensitive Receptors.

4) Measurement Instrument

As according to JIS C 1510, vibration meter 1220E manufactured by IMV Japan, was chosen for measuring vibration. The instrument provides vibration measurements in all the three axes and also measures velocity or acceleration parameters. The instrument, also captures and stores values at predefined intervals and calculates maximum and minimum or percentile values. Specifications of the selected instrument are presented below:

Source: From Web Page

- Conforms to JIS C1510-1995.
- Measures vibration pollution from factory, construction site and traffic

- Calculates Vibration level L_v, Vibration acceleration level L_{va}, Max. value L_{max}, Min value L_{min}, Time rate vibration level (L_x: 5-value), Power averaged level (Leq) in 3-direction and displays with selection

Model	VM 1220 E
Frequency Range	1-80 1-80 Hz
Measuring Range	80 30-120 dB
Level Range	20 dB step, 2-range 30 -90 dB, 50 -110 dB
Linearity	75dB
Measured Item	Vibration level L_v, Vibration acceleration level L_{va}, Max. value L_{max}, Min value L_{min}, Time rate vibration level (L_x: 5-value), Power Averaged Level (L_{eq})
Measuring Time	1s, 3s, 5s, 10s,1min, 5min, 10min, 15min, 30min, 1h, 8h,24hManual (Max 199 h 59 min 59s)
Ambient Condition	Temperature Range: 10 -50^{0}C Humidity: 30 - 90% (not dew condensation)

5) Results and Discussion

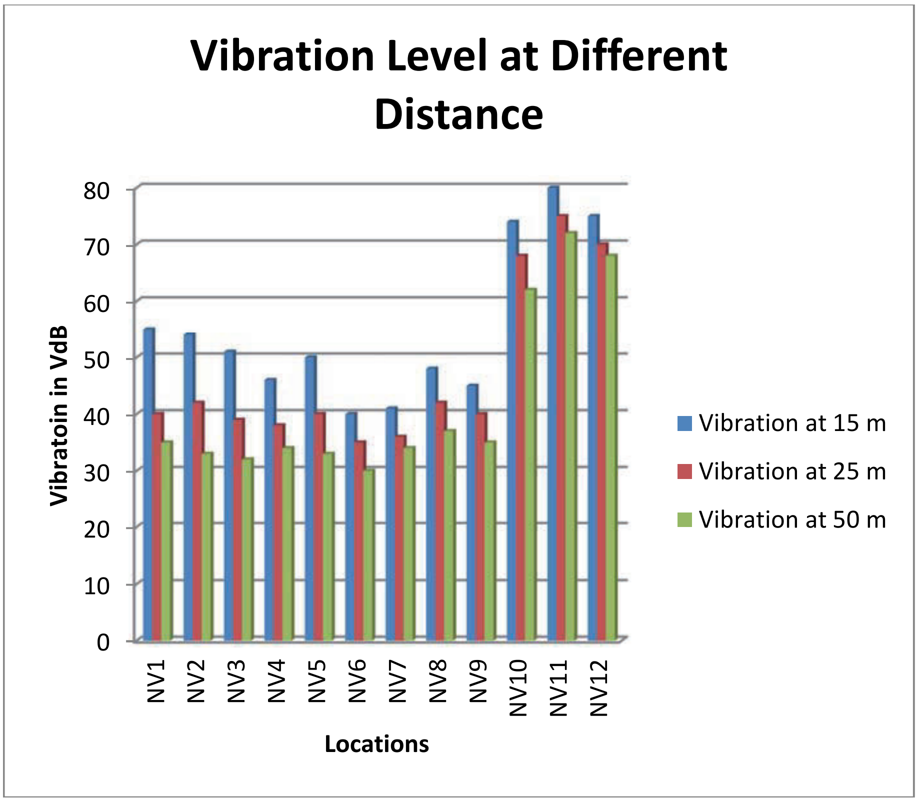
The results of the vibration measurement at selected locations during period 28/10/2014 to 12/11/2014 (in the post-monsoon season) are presented in Table 4.1.23 It can be deciphered from the Table 4.1.26, that the average overall ground-borne vibration levels measured at the high density traffic area from trains ranged from 80 VdB at 15 m to 72 VdB at 50 m; the measured levels at Ahemedabad from trains ranged from 84 VdB at 15 m to 70VdB at 50 m. Ground-borne vibration was also measured for road traffic by the side of the proposed alignment at approximately 50 m from the highway centerline. The overall vibration levels, ranging from about 35 to 55 VdB, are well below the 65 VdB threshold of perception. Therefore, road traffic is not considered to affect the vibration analysis in the MAHSRC. The measured vibration levels are from trains traveling at various speeds; these vibration levels were normalized to 50 mph for comparison to each other. The vibration data for each community along the corridor closely matched the levels of typical trains found in the guidance manual. In addition to measurements of vibration from existing sources, vibration measurements for the project focused on characterizing the way ground-borne vibration is transmitted through soil at representative locations along the alignments. Nine vibration propagation test sites (these locations are shown in Figure 4.1.32 (NV1 to NV9)) were selected to represent the range of soil conditions in areas along the corridor where there are a significant number of vibration-sensitive receivers. At each of these sites, ground-borne vibration propagation tests were conducted by striking the ground and measuring the input force and corresponding ground vibration response at various distances. The resulting force-response transfer function can be combined with the known input force characteristics of the MAHSRC to predict future vibration levels at locations along the alignment. The measured results are shown in graphical form in Figure 4.1.35.

Table 4.1.26: Measured Levels of Ground-Borne Vibration

Location Code	Location	Vibration at 15 m	Vibration at 25 m	Vibration at 50 m
NV1	Mumbai – Bandra Kurla Complex-	55	40	35

	Proposed Railway Stn			
NV2	Thane - Proposed Railway Stn	54	42	33
NV3	Virar - Proposed Railway Stn	51	39	32
NV4	Bolsar - Proposed Railway Stn	46	38	34
NV5	Vapi - Proposed Railway Stn	50	40	33
NV6	Bilimora - Proposed Railway Stn	40	35	30
NV7	Surat - Proposed Railway Stn	41	36	34
NV8	Bharuch -Proposed Railway Stn	48	42	37
NV9	Vadodara - Proposed Railway Stn	45	40	35
NV10	Anand - Proposed Railway Stn	74	68	62
NV11	Ahmedabad-Proposed Railway Stn	84	75	70
NV12	Sabarmati - Proposed Railway Stn	75	70	68

Source: Study Team-GPSTPL



Source: Photograph by Study Team-GPSTPL

Figure 4.1.35: Measured Levels of Ground-Borne Vibration

4.1.8 Ground Subsidence

SUBSIDENCE is the sinking or settling of the ground surface. It can occur by a number of methods. Ground subsidence can result from the settlement of native low density soils, or the caving in of natural or man-made underground voids. Subsidence may occur gradually over many years as sags or depressions form on the ground surface. It's more infrequent, but subsidence can occur abruptly-virtually instantly-as dangerous ground openings that could swallow any part of a structure that happen to lie at that location, or leave a dangerous steep-sided hole. There are several distinct types of natural processes and man's activities that may produce ground subsidence. These are discussed and explained below under separate headings. In general, the type and severity of surface subsidence is governed by the amount ground surface and the location of removal or compression, and the geologic conditions of a particular site. Some examples of the types of ground subsidence, and how they are affected or produced by geologic conditions are explained below.

(1) Severity of the Problem

Geologic conditions conducive to all of the basic types of subsidence described above along the alignment. There has been several cases of rock fall/sliding in the Konkan belt of Maharashtra.

(2) Criteria for Recognition

The criteria for recognition of actual or potential ground subsidence conditions include a careful evaluation of all pertinent historic, geologic, and hydrologic factors or the area, and/or actual periodic measurements. Onset of actual or observed subsidence is in many cases related to changes in land use; accordingly land use changes in areas identified as having potential for subsidence should be carefully scrutinized. Historic evidence includes common knowledge of long term area residents concerning characteristics of land under present and past usages. This kind of information is important but must be carefully evaluated for accuracy and objectivity.

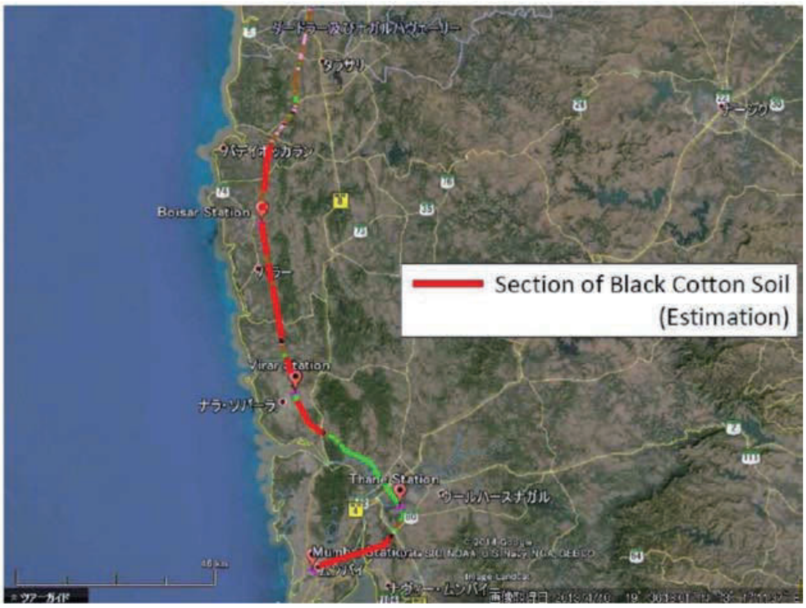
(3) Consequences of Improper Utilization

The consequences of improper utilization of land subject to ground subsidence will generally consist of excessive economic losses. This includes high repair and maintenance costs for buildings, irrigation works, highways, utilities and other structures. At times, structures are condemned because of the damage. This results in direct economic losses to citizens, and indirect losses through increased taxes and decreased property values. Spontaneous ground openings can be dangerous if a sinkhole were to open below a occupied structure. A High Speed Railway, specially the MAHSRC is the start of Indian HSR era, with the world's most advanced non-ballasted track technology. The subsidence along the high speed railway would cause subsidence damage and give rise to huge security risk especially to this 300-330 km/h high speed railway. Detecting the subsidence of railway, therefore, is a very important task. To arrive at the conclusion, it is necessary to know the soil profile of the regions through which the proposed MAHSRC would pass. The proposed alignment of MAHSRC passes through two different provinces Maharashtra and Gujarat. The soil conditions are different from each other as described in the subsequent sections.

Black Cotton Soil

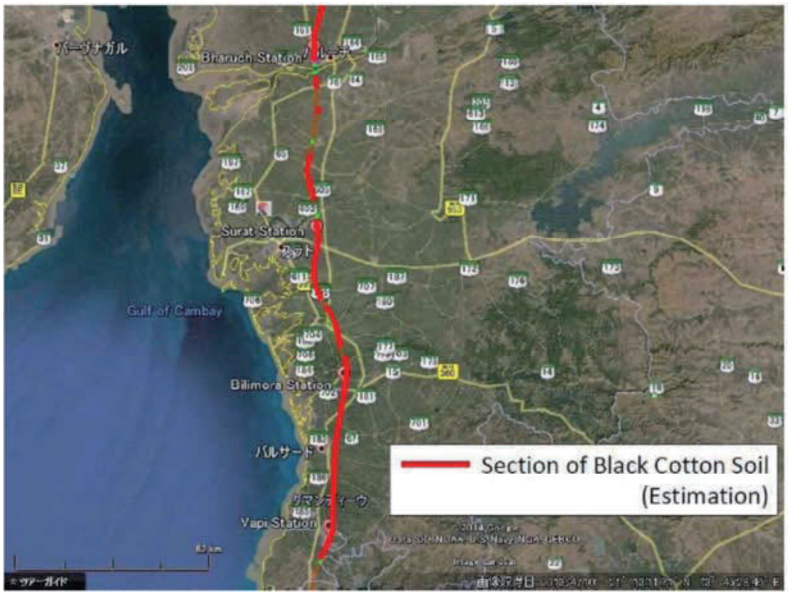
According to the analysis of the specimens Nos. 10, 32, 33, 34 and 38, the values of free

swelling index (FSI) exceed 35, a yardstick value to indicate high "expansibility," with the values of specimens Nos. 33 and 34, in particular, exceeding 50 to suggest extremely high expansibility. Measurement by boring surveys indicate that the underground water level is lower than a depth of 8 m or over, with only small water content existing in and around the surface layer. To suppress the effect of the black cotton soil in the surface layer on the embankments, therefore, it is important to prevent invasion of water including rainwater from outside. As current surveys don't provide the definite scope of distribution of black cotton soil, Study team estimated the ratios of its distribution between stations based on literature (soil maps). Kindly refer Figure 4.1.36 through Figure 4.1.38 and Table 4.1.27 for the scope of distribution and ratios of distribution between stations, respectively.



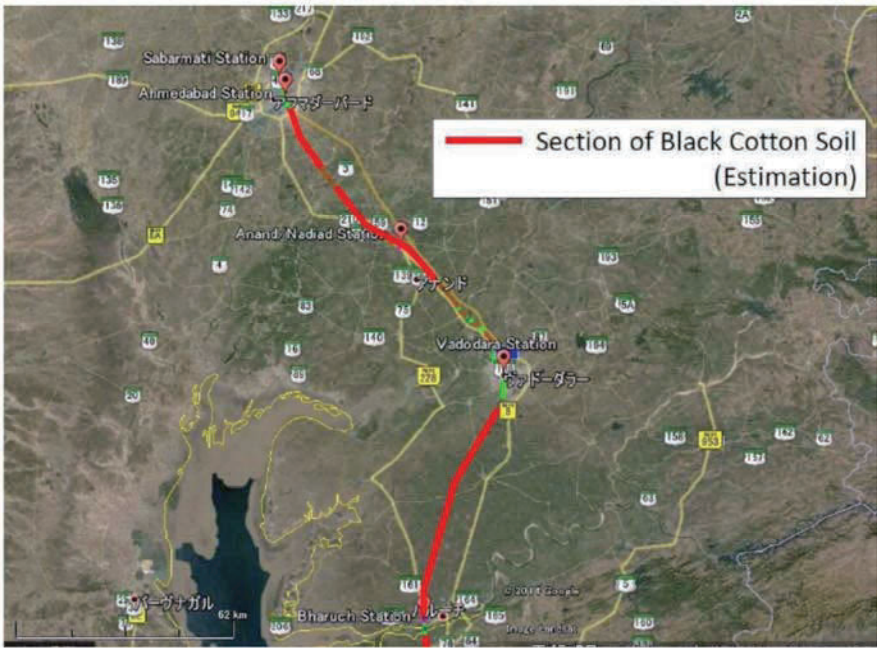
Source: National Bureau of Soil Survey and Land Use Planning

Figure 4.1.36: Section of Black Cotton Soil-(A)



Source: National Bureau of Soil Survey and Land Use Planning

Figure 4.1.37: Section of Black Cotton Soil–(B)



Source: National Bureau of Soil Survey and Land Use Planning

Figure 4.1.38: Section of Black Cotton Soil–(C)

Table 4.1.27:
Percentage Distribution of Black Cotton Soil in the proposed alignment

Section	Percentage (%)
Mumbai - Thane	75%
Thane - Virar	30%
Virar - Boisar	65%
Boisar - Vapi	30%
Vapi - Bilimora	100%
Bilimora - Surat	90%
Surat - Bharuch	55%
Bharuch - Vadodara	90%
Vadodara - Anand / Nadiad	30%
Anand / Nadiad - Ahmedabad	85%
Ahmedabad - Sabarmati	0%

Source: National Bureau of Soil Survey and Land Use Planning

Soft Ground

The strength required for railway subgrades is N-value 4 or over. Subgrades of which the N-value is lower than 4 require soil improvement work. However, there are no layers having an N-value smaller than 8 found in the surveys implemented this time or in the surveys in the past, either. Accordingly, the study team assumes in this report that there are no sections where countermeasures against soft grounds are required.

(4) Result and Discussion

It is evident from the above that most of the stretches of the proposed alignment either passes through the basaltic rock or black cotton soil. The abstraction of ground water is also minimal in the cities where the stations have been proposed. Only concern pertaining to ground subsidence/land subsidence is the stretch of Konakn, where the history says that there have been several instances of rock sliding causing the train disruption. Another concern is the proposed tunnel in the Mumbai of about 21.2 km which will be carried out in the basaltic rock. The void so created may laead to ground subsidence. Proper measures shall be taken.during tunneling.

4.1.9 Offensive Odour

During the field survey of environmental attributes, offensive odour problem was not encountered at any location along the proposed MAHSRC alignment. During construction phase due to nearby flowing drain and rivulets it may be encountered, particularly in the cities like Mumbai, Thane, Virar, Bharuch, Surat, Ahmedabad. Cleanliness shall be maintained at construction sites during the construction phase and at the proposed stations, maintenance depots during the operation phase to avoid any foul odour.

4.1.10 Bottom Sediment

(1) Present Condition

Bottom sediments comprise of particles that have been transported by water and air and deposited on a floor of river in addition the deposited particles some more particulate matter is added up by the chemical and biological processes. Bottom sediment samples were also collected from all the major rivers at the upstream, centre and the downstream while water quality sampling of the rivers. Bottom sediment samples were analyzed for river bed characteristics. The important component of the river bed characteristics is determined in the form of Particle Size Distribution using the mechanical analysis. To study the river bed characteristics, ten sampls from each sampling sites as shown in Figure 4.1.29 and presented in Table 4.1.13 were collected and mechanical analysis for particle size distribution was carried out. The result of the particle size distribution at sampling sites is presented in Table 4.1.28. Value of d_{10} refers to grain diameter at 10 cumulative percent by weight. Based on the analysis of the river bed samples, soil of all the river bed can be categorized as sandy. However, the rivers of Damanganga and Vaitarna have coarse sand to gravely bed.

Table 4.1.28: Particle Size Ananlysis Results of the River Beds in the Study Area

Location Code	Location	Section	d_{10}	d_{50}	d_{75}
SW1	Ulhas River	Mumbai - Thane - Virar	0.1017	0.1915	0.3388
SW2	Vaitarna River	Virar - Dahanu	0.1142	0.2512	0.5675
SW3	Damanganga River	Dahanu-Vapi	0.1622	1.5525	4.3784
SW4	Kolak River	Vapi - Valsad			
SW5	Par River	Vapi - Valsad	0.0676	0.1951	0.3914
SW6	Auranga River	Vapi - Valsad	0.0715	0.1850	0.3244
SW7	Kaveri River	Valsad - Surat	0.1205	0.1995	0.3760
SW8	Ambica River	Valsad - Surat	0.1001	0.1944	0.3454
SW9	Purna River	Valsad - Surat	0.0850	0.1844	0.3544
SW10	Mindhol River	Valsad - Surat	0.1017	0.1990	0.3625
SW11	Tapi River	Surat - Bharuch	0.0695	0.1925	0.3712
SW12	Kim River	Surat - Bharuch	0.0685	0.1895	0.3712

SW13	Narmada River	Surat - Bharuch	0.0666	0.1944	0.3585
SW14	Dhadar River	Bharuch - Vadodara	0.0850	0.1855	0.3256
SW15	Mahi River	Vadodara - Anand - Nadiad	0.0758	0.1785	0.2959
SW16	Mohur River	Anand - Nadiad - Ahmedabad	0.0820	0.1678	0.3211
SW17	Vatral River	Anand - Nadiad - Ahmedabad	0.0812	0.1652	0.3130
SW18	Meshwo River	Anand - Nadiad - Ahmedabad	0.0650	0.1585	0.3125
SW19	Sabarmati River	Anand - Nadiad - Ahmedabad	0.0738	0.1903	0.3222
SW14	Dhadar River	Bharuch - Vadodara	0.0850	0.1855	0.3256
SW15	Mahi River	Vadodara - Anand - Nadiad	0.0758	0.1785	0.2959
SW16	Mohur River	Anand - Nadiad - Ahmedabad	0.0820	0.1678	0.3211
SW17	Vatral River	Anand - Nadiad - Ahmedabad	0.0812	0.1652	0.3130
SW18	Meshwo River	Anand - Nadiad - Ahmedabad	0.0650	0.1585	0.3125
SW19	Sabarmati River	Anand - Nadiad - Ahmedabad	0.0738	0.1903	0.3222

Source: GPSTPL Survey Team

The median particle diameter is chosen for texture size selection because it is used in empirical relations to predict other soil properties, and as such is a useful parameter to know. Particles are grouped according to their size into what are called soil separates. The smallest particles are *clay* particles and are classified by the United States Department of Agriculture (USDA) as having diameters of less than 0.002 mm. Texture is combination of the most abundant particle sizes. The classification of the soil on the basis of USDA is presented in Table 4.1.29.

Table 4.1.29: Soil Classification based on Size as per USDA

Soil	Diameter in mm
Clay	Less than 0.002
Silt	0.002-0.05
Ver fine Sand	0.05-0.10
Fine Sand	0.10-0.25
Medium Sand	0.25-0.50
Coarse Sand	0.50-1.00
Very Coarse Sand	1.00-2.00

Source: USDA

On the basis of the soil texture classification of USDA, most of the soil at bridges construction site falls under the category of fine sand. Few sites come under category of very coarse sand (River Damanganga).

4.1.11 Fauna and Flora

(1) The Study Area

India has rich diversity of flora and fauna like the diverse culture, religion, climate and soil. The Indian flora and fauna are an eye candy for the nature lovers. Nearly 23.68 per cent of the gross physical area of India is covered under forest. The forest types vary from region to region and each one has some unique features, be flora or fauna, both terrestrial and aquatic, and estuarine ecosystems. The Indian flora and fauna include around 15,000 species of flowering plants, 400 species of mammal, 1250 species of bird, 10,000 species of insect, 2546 species of fish, 197 species of amphibian and 408 reptile species.

(2) Aim of the Study

The aim of the proposed study is to assess the status of biodiversity in different habitats within and around the proposed MAHSRC alignment covering about 500 km stretch, and to prepare Biodiversity (Wildlife) Conservation and Management Plan [B (W) CMP] for overall biodiversity, including the threatened species and area of conservation significance, *i.e.,* ESA.

(3) Scope of the Study

It is covered under the following heads/components:

(a) <u>Flora</u>

- To assess the status of major floral components (tree, shrub, herb including grass, mangroves and climber) within the ZOI of the proposed MAHSRC alignment;
- Identification, listing and quantification of floral species of conservation significance (RET species) in accordance with WCMC and BSI, and preparation of floral biodiversity index (BDI) for different habits of flora across the habitats/ecosystems of the study area
- Collection and compilation of secondary information on the status of flora in Reserved (RF) and Protected Forests (PF) located in the study area

<u>Fauna</u>

- To assess the status of major faunal groups (Butterfly, Amphibian, Reptile, Bird and Mammal) in the ZOI of MAHSRC
- Identification, listing and quantification of fauna of conservation significance (RET species) in accordance with IUCN, CITES, CAMP and Wildlife Protection Act, 1972 of MoEFCC (GOI) in the study area, and preparation of faunal biodiversity index (BDI) across the habits/ecosystems of the study area
- Collection and compilation of secondary information on the status of fauna in Reserved and Protected Forests located in the study area

(b) <u>Ecologically-Sensitive Areas (ESAs)</u>

- Identification of ESAs of State/local compliance, such as, Wetland, Community conserved reserve, area of aesthetic values (*e.g.,* sacred groves, temple and archeologically-sensitive area), breeding/nesting colonies of birds existing in the vicinity in the study area
- Identification of ESAs of National Compliance [*e.g.,* Protected area, National Park, Sanctuary, Biosphere Reserve and Important Bird Area (IBA)] and major Wildlife migratory routes existing in the study area

- Identification of ESAs of International compliance (*e.g.,*Ramsar site, World heritage site of IUCN) existing in the study area

(c) <u>Habitat and Mapping</u>

- Preparation of general base map of different habitats/ecosystems of the study area
- Identification and mapping of any bird and wildlife migratory routes/corridors that exist within the study area
- Preparation of map showing spatial distribution of ESAs of Local, State, National and International importance in the study area

(4) Impact Assessment

- Assessment of possible impact of the construction of the proposed MAHSRC and operation of the High Speed Train
- Assessment of possible impact on the ecosystem of the study area due to construction and operation of the various facilities like Station and Maintenance Depot *etc.*

(5) Mitigation and Management Plan (MMP)

- Suggest conservation and management plan (CMP) to improve the habitat quality of the stucy area to enhance the overall biodiversity (flora and fauna)
- Suggest Species-specific Biodiversity (Wildlife) Conservation and Management Plan [SSB (W) CMP] for Threatened, Critically-endangered and Endangered faunal species (Schedule-I), if any, reported within the study area of the Local, State, National and International compliance
- Suggest Biodiversity (Wildlife) Conservation and Management Plan [B (W) CMP] specific to any critical habitat/ecosystem(s) identified to enhance their ecosystem services
- Provide technical input for the approval of [B (W) CMP] by the concerned State Forest Department Authority.

(6) Approach and Field-Level Methodology of the Study

<u>Macro-Level Approach</u>

(a) <u>Reconnaissance Survey</u>

- Rapid survey of the study site to identify and understand the existing habitats and bio-physical and socio-economic attributes of the study area (10 km radius)
- Interaction with the project proponent to obtain information about the Project and associated activities
- Determine appropriate sampling locations and sample numbers to study diverse biodiversity components falling under the scope of the study

(b) <u>Collection of Secondary Data</u>

- Collection and collation of the Project-related secondary information from the Project proponent in the form of base maps, technical reports and EIA Report
- Collection and collation of information related to flora and fauna (occupying different habitats) from the State and Divisional Office of the Forest Department and other stakeholders, and published literature, electronic media, *etc.*

Existing information surveys were collected year-round data including the monsoon season.

(c) **Delineation of the Study Area**

- Core Zone: The proposed HSR alignment
- Buffer Zone: Vicinity area 250 m either side of the core zone

Micro-Level Approach

(a) **Collection of Field Data**

- Inventorization of the biodiversity (flora and fauna) in the study area in terrestrial and aquatic ecosystems habitat-wise through actual field surveys
- Interaction with local people, experts and rural development agencies and collection of secondary information from the State Forest Department and published literature to present overall status of biodiversity
  Existing information surveys were collected year-round data, including the monsoon season.

(b) **Flora**

- Collection of primary data through ground surveys for angiospermic plant diversity (tree, shrub, herb, grass and climber) both qualitatively and quantitatively using standard ecological methods and field surveys in different habitats in land and water ecosystems

(c) **Fauna**

(i) **Mammals/Primates**

- Qualitative and quantitative information about mammalian diversity in the study area using line transect/road count in different habitats
- Relative abundance of mammalian fauna through 20 m radius plots in each sampling location for indirect evidences, such as, pellets, dung, droppings, scats and other tracks and signs

(ii) **Avifauna**

- Assessment of bird diversity in terrestrial and aquatic ecosystems using point count/ perambulation technique and flock count method, respectively
- Survey of the study area to identify the presence of breeding/nesting sites and roosting sites of the avifauna

(iii) **Herpetofauna**

Assessment of the status of reptiles in the study site using Intensive Time Constrained Searth Method in different habitats

(iv) **Amphibians**

Ground-level search around hedges in the aquatic habitats to study occurrence of amphibians

(v) **Butterfly**

Qualitatively and quantitative study of butterfly diversity in the study area in diverse habitats following Perambulation technique

(d) **RET Species**

Identification of RET (Rare, Endangered and Threatened) species of wild plants and animals from the information on biodiversity gathered through field surveys and secondary sources utilizing authorized references, such as, WCMC, BSI, ZSI, WPA, *etc.*

Status of Floral Diversity

- Taxonomical Status, Species Diversity, Importance Value Index, Life-Form Status and Abundance Status (density for common and wild tree species)

Status of Faunal Biodiversity

- Taxonomical status, species diversity (for avifauna), abundance status (for herpatofauna and mammals), and migratory status and foraging guild (for bird species)

Occurrence of RET Species

- Status of RET flora and fauna; Conservation significance of Local, State, National and Global level; Areas of conservation significance, *e.g.*, breeding/nesting sites; flocking/roosting sites of terrestrial and aquatic birds; any critical habitat/ecosystem at local level; and wildlife corridor and linkages

(7) Expected Output of the Study

Status of Floral Diversity

- Taxonomical Status, Species Diversity, Importance Value Index, Life-Form Status and Abundance Status (density for common and wild tree species)

(8) Field Surveys

Reconnaissance-Level Surveys

The potential for project impacts on biological resources depends largely on the presence of suitable habitat in and adjacent to areas that would be affected by the project. Reconnaissance-level field surveys involved preliminary data gathering for the purpose of recognizing and identifying resources that warrant additional or more focused surveys (*e.g.,* for special-status plants, as described below). Project ecologist along with scientist conducted these reconnaissance-level field surveys to determine the presence or absence of biological resources, and to document the location of any biological resources through habitat characterization and mapping. All habitat characterization and mapping was done from publically accessible roads along or near the MAHSRC. The results of these surveys provided background for the focused special-status plant surveys. Habitat types identified during the reconnaissance-level field assessments were compared against the known habitat requirements for each special-status plant species with potential to occur in the regional area. The potential for a particular special-status species to occur within the special-status plant species study area was then assessed and ranked as either no potential, future potential, unlikely potential, low potential, moderate potential, or high potential.

(9) Terrestrial Ecology

Methodology used for the study of various organisms has been provided under different section of group of species. Species order has been followed of classical evolutionary system, such as, flora, invertebrates and vertebrates. Entire vicinity area of MAHSRC was surveyed extensively for socio-economic analysis of human settlements (villages) and biodiversity assessment. Terrestrial and aquatic species are described under respective sections of habits and habitat of the particular species. Biodiversity assessment of MAHSRC area was conducted quantitatively by a team of GPS Technologies Pvt. Limited (GPSTPL), New Delhi, by visiting the area in post-monsoon season (September 2014-October 2014) to describe first hand information about flora and fauna of the HSR alignment as well as the its vicinity area. Using information on geographical locations, the maps were prepared. The present study highlights floristic diversity and the faunal wealth, including ethno-botanical and silvicultural issues, in the study area. Accordingly, for the ecological study, the total area has been sub-divided into habitats as follows:

- Natural vegetation
- Vegetation of the proposed alignment
- Forest area (Protected/Reserved)
- Road side plantation
- Near human habitation
- Agriculture
- Mangrove Ecosystems
- Creek Ecosystems
- Ecosystems of National Parks and Wildlife Sanctuaries
- ESA like Dahanu Taluka in Thane District

The ecological study of the area has been conducted in order to understand the status of the existing flora and fauna to generate baseline information and evaluate the probable impacts of MAHSRC on the biological environment.

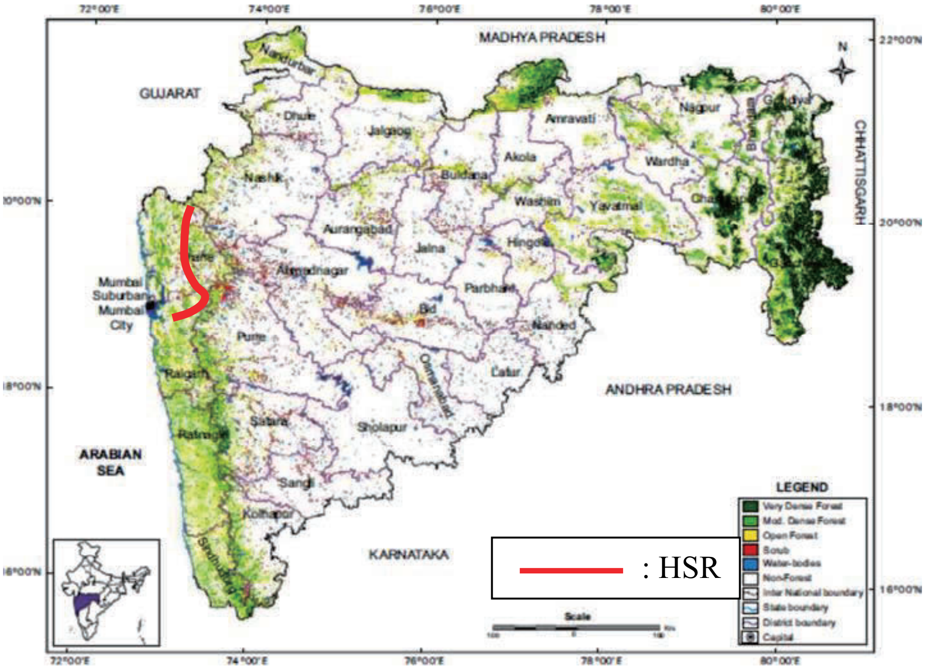
(10) Bio-Geographic Setting & Forest Type Maharshtra Region

Biogeography is the study of the distribution of living organisms, and the natural processes that affect these distributions. It forms a basis to classify the biosphere into distinct physical and biological entities that contain distinct biotic communities. As every living species is an integral component of some ecosystem or ecosystems, it follows that its conservation is dependent on the survival of those ecosystems or biotic communities. Within the context of the World Conservation Strategy (IUCN, 1980), a system of selecting protected areas on the basis of well-founded biogeographic principles is an important tool for evaluating conservation efforts and for determining priorities for future action. The biogeographic classification developed by the WII (Wildlife Institute of India) Dehradun has recognized 10 broad bio-geographical zones of India. Within these zones, there are 25 biotic provinces. According to the biogeographic classification, the Maharashtra Region of ZOI belongs to 5 A - Malabar Plains. The present coverage of Malabar plains by protected areas in India is only 0.4 per cent against the proposed area of 1.1 % by Wildlife Institute of India, Dehradun in 1988. Looking into the forests of SGNP & Tungareshwar there is, therefore, a need to augment the area of SGNP and Tungareshwar Sanctuary by adding the contiguous forest areas which are with the

FDCM and the Thane Territorial Division. According to revised forest types (Champion and Seth, 1968) the study area of Maharashtra region, falls in:

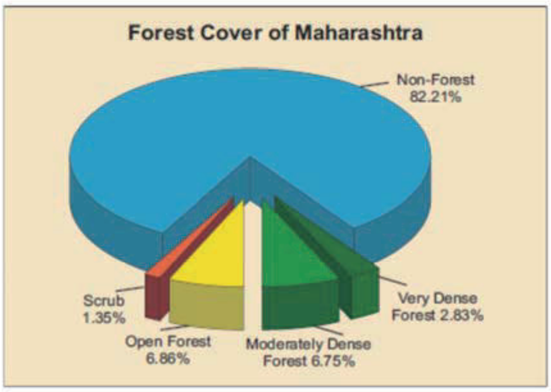
- 3 B/C1 Southern moist teak bearing forests;
- 3 B/C2 Southern moist mixed deciduous forests;
- B/TS1 Mangrove scrubs;
- 8 A/C2 Western sub-tropical hill forests.

The mangrove vegetation is evergreen with entire leathery leaves. Soft tidal mud submerged by salt water is common. The forest cover map of Maharshtra is shown in Figure 4.1.39.



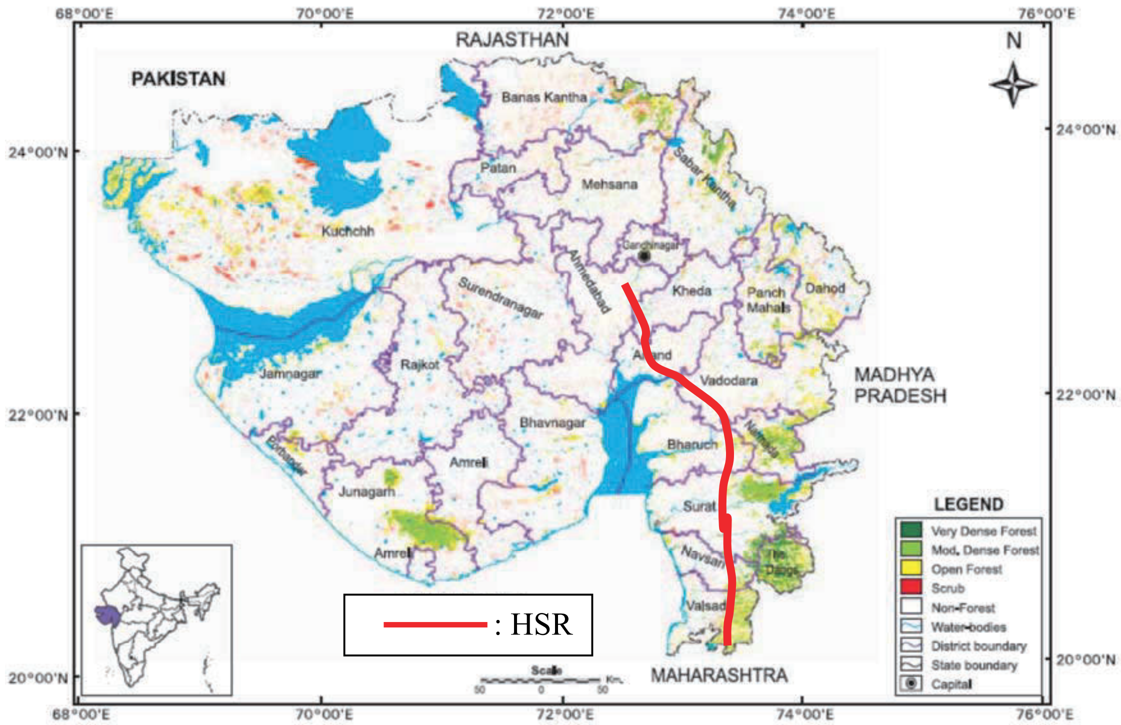
Source: Forest Survey of India 2013

Figure 4.1.39: Forest Cover Map of Maharashtra



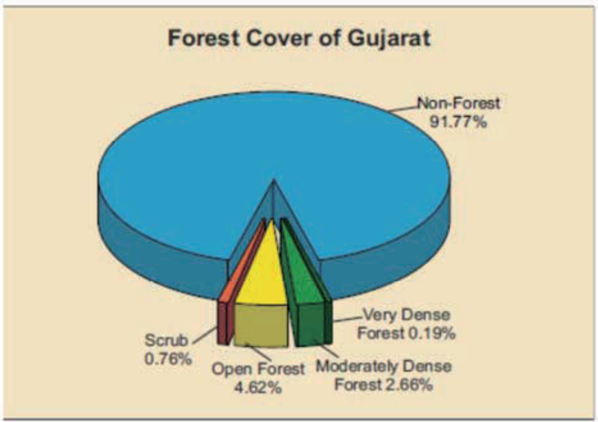
Source: Forest Survey of India 2013

Figure 4.1.40: Forest Cover of Maharashtra



Source: Forest Survey of India 2013

Figure 4.1.41: Forest Cover Map of Gujarat



Source: Forest Survey of India 2013

Figure 4.1.42: Forest Cover of Gujarat

(11) Sanjay Gandhi National Park (SGNP)

The proposed alignment of HSR passes between the SGNP and TWLS at chainage SGNP or Borivali National Park, has unique combinations of rich bio-diversity despite very high anthropogenic and biotic pressures due to its typical location and the almost complete biological fragmentation leading to the “fenced island” type case for its southern block and high values for nature tourism and Eco-tourism. It is notable as one of the major national parks existing within a metropolis limit in Asia and is one of the most visited parks in the world. The Division has immense values for its assimilative capacities and life support services. It is a “Green Oasis or Green Lungs” within the cities of Mumbai and Thane. It protects the catchments of two water reservoirs *i.e.* Tulsi & Vihar that supply water to Mumbai and Thane. Krishnagiri Upvan, well known for tourism in Borivali, is a part of this Division. Leopard, the only big cat of the area, exists with very high density. The forests are mostly moist deciduous type of forests and, in general, they are dense throughout the area. This Division falls between longitude 72^0 51' 49" E to 72^0 58' 32" E and latitude 19^0 08' 20" to 19^0 20' 44" N. SGNP Division is situated partly in Thane District (59.24 Sq.Km.) and in Mumbai Suburban District (44.44 Sq.Km.) of Maharashtra State. Originally, areas of this Division were within Thane Forest Circle. Now this Division is under the administrative control of Additional Principal Chief Conservator of Forest (Wildlife) West Mumbai. The SGNP division is controlled and managed by Chief Conservator of Forests & Director, SGNP. The total area of this Division is 103.68 sq. km, out of which the notified area of SGNP, hereinafter referred to as SGNP, constitutes 86.96 sq. km. SGNP was declared as a National Park vides Maharashtra Government Resolution No. WLP/1094/ OR 177/F-1 dated 16.01.96. Vasai creek passes through this Division from west to east and divides it into north block (Nagla block) with an area of 16.93 sq. km. and south block with an area of 86.75 sq. km. This area is located on the eastern side of Borivali railway station at a distance of roughly 1 km. The nearest Airport is Chatrapati Shivaji-domestic and international airport at a distance of 15 km. Chatrapati Shivaji terminus railway station is about 50 km from the park. The entrance / main gate of this park is on Mumbai-Ahmedabad National Highway. There is another approach from Thane but at present this gate (Bhandup gate) is not open for public since it passes through the high security BMC area & the core zone of SGNP. ESZ is not undefined in the vicinity of SGNP.

Importance

SGNP Division, a green tract amidst the thickly populated metropolis of Mumbai and Thane, is bestowed with immense biological, ecological, archaeological, environmental, recreational & educational values. These values scale from local to International significance. This area represents unique and fragile ecosystem and it belongs to one of the least represented biogeographic zone *i.e.* Malabar Coast of Western Ghats. No other National Park exists within this bio-geographic zone except SGNP, hence, SGNP is unique. Though the major portion of the park *i.e.* south of Vasai Creek is fragmented, it still harbours high density of leopards. As a true representative of the Northern Malabar coast, this area has vast faunal and floral diversity. The park is home to a number of endangered species of flora and fauna. The forest area of the Park houses large number of plant species, 254 species of migratory, land and water birds, about 50,000 species of insects, 40 species of mammals. In addition, the Park also provides shelter to 38 species of reptiles, 9 species of amphibians and about 150 species of butterflies and a large variety of fishes. It protects the catchments of two lakes *i.e* Tulshi & Vihar; which supply water to Mumbai and Thane.

Environmental Value

As mentioned above, the park is surrounded on all sides by one of the most densely urbanized areas of the world, comprising of the cities of Mumbai and Thane. The Vasai-Virar belt is also rapidly expanding in the North West portion of the SGNP and is contributing to the pressures on SGNP, particularly on the Nagla Block. Despite all these immense pressures, the SGNP still survives, due to the various Orders of the Hon'ble Bombay High Court and the Hon'ble Supreme Court of India & with the whole hearted support of the nature loving people. The importance of the SGNP for the survival of the cities of Mumbai and Thane need not be over emphasized. The fact that two lakes which supply water to Mumbai and Thane Vihar Lake and Tulsi Lake are located within SGNP. The catchment areas of both these lakes also lie within SGNP, ensuring that the quality of water supplied by both these lakes is unsurpassed anywhere in the country. The fact that it is supplied nearly free of cost is another great bonus for the citizens of Mumbai and Thane. Besides its role in protecting the water supply of Mumbai and Thane, a fact that is not widely appreciated is that these lakes have never been dried up. In the event of delayed arrival of monsoons, the water of these lakes provide the real security to the survival of the cities of Mumbai and Thane. Another great benefit that has still not been fully appreciated is the vital role played by the forests of SGNP in reducing the atmospheric pollution caused by the anthropogenic activities in Mumbai and Thane. The vegetation in SGNP literally absorbs the pollutants and significantly improves the air quality of the surrounding areas. There is yet one more factor that is under appreciated and that is the role of the forests of SGNP in temperature control. Visitors to the SGNP can immediately notice the drop in temperature when they walk into the SGNP. At most times of the year, the temperature within SGNP is lower by 3-5 degrees Celsius as compared to the temperature outside the SGNP. The forests of SGNP literally act as a natural air conditioner for the cities of Mumbai and Thane, and significantly help in reduction of the electricity consumed by those residents residing along the periphery of the SGNP Division. Finally, in this era of climate change, we cannot but be conscious of the huge amounts of carbon that have been sequestered by these City Forests of SGNP. Four important rivers of Mumbai namely the Mithi River, the Poisar River, the Oshiwara River and the Dahisar River originate from the SGNP.

Biological Value

The vegetation of this area ranges from littoral forests to western sub-tropical hill forests. The park is home to a number of endangered species of flora and fauna. Large numbers of vertebrate and invertebrate species belonging to various classes and orders are indicators of immense biological diversity of this area. Observations and checklists show that there are about 550 faunal species that are found in this area. Besides, this area is a natural home for many endangered faunal species. Recently tail less whip scorpion was seen in the Tulsi tunnel during a jungle trek organized by the Director on 06-10-2011 during Wildlife week celebration in October 2011.While orange breasted green pigean was also seen recently by some bird watchers A large number of species of trees are found within the SGNP Division. Some dominant species are Kadamba, teak, karanj, species of acacia, ziziphus, flame of the forest, red silk cotton. Karvi or Karvy, a flowering plant that flowers once in seven years, is also there in the Park.

Ecological Value

This area acts as a carbon sink for Mumbai and Thane cities and veritably it is known as a "green lungs" of Mumbai and Thane. It protects the catchments of Tulsi and Vihar Lakes that supply potable water to the metropolis of Mumbai and Thane.

Archaeological Value

The Kanheri Caves, located within the park, form a major point of interest. The caves are said to date from the 1^{st} century BC to the 9^{th} century AD and to had been occupied by a well organized Buddhist establishment of monks on an ancient trade route connecting a number of Indian sea-ports.There are total of 109 caves with most of the caves being chiseled in the volcanic basalt rock.; The small chambers are known as *"Vihars"* whereas the larger and deeper chambers are known as *"Chaityas"*.

Recreational and Educational Value

The unique location of this area makes it a paradise amidst thickly populated surroundings. Approximately a million visitors visit this area every year. They encounter rich natural and cultural diversity and are exposed to the need and importance of biodiversity and its conservation. The Nature Interpretation Centre of the SGNP provides invaluable opportunities to create awareness among visitors regarding the importance of nature and biodiversity and also educate them about the importance of forests for their own survival. This NIC has been renewvated recently by adding the information about the bio-diversity of the park. There are three nature trails which are regularly operated by the Nature Interpretation Centre (NIC) *i.e.* Shilonda trail, Kanheri trail and Bamboo Hut trail. The NIC conducts nature trails for different target groups as school children, college students, private groups, corporate groups and under privileged groups during theses trails one is able to see vast variety of flora and fauna. The park harbours approximately 800 species of flowering plants, 45 species of mammals, 43 species of reptiles, 38 species of snakes, 12 species of amphibians, 300 species of birds, 150 species of butterflies and innumerable species of invertebrates. On these trails there are streams too, which attract many naturalists to see birds, reptiles, amphibian and insects. The park has mixed evergreen & deciduous types of forests. Hence, in every season the forest looks different and that adds to the beauty of the nature. Also old forest tracts are being now developed new trails for the benefit of naturalists and nature lovers.

SGNP Division belongs to 5 A - Malabar Plains. The present coverage of Malabar plains by protected areas in India is only 0.4 per cent against the proposed area of 1.1 % by Wildlife Institute of India, Dehradun in 1988. Looking into the forests of SGNP & Tungareshwar there is therefore a need to augment the area of SGNP and Tungareshwar Sanctuary by adding the contiguous forest areas which are with the FDCM and the Thane Territorial Division.

Species of Conservation Importance

- **Trees / Plants**

  1. **Saraca ashoka (Sita ashok)**

     It is rare and endemic species of the national park. A75 hectare patch of Saraca Ashoka, popularly known as 'Ashok Van' is seen near Kanheri Caves. Flowers are seen from March to May. Monkeys, langurs and other herbivores eat the pods.

  2. **Garcinia indica (Kokam)**

     It is an evergreen species seen mostly at the highest point area in the vicinity of Yeur & above Kanheri caves. Monkeys, langurs and some birds eat fruits. Fruits are of medicinal value and are used as an antidote for stomach upset.

  3. **White Orchids**

     Two species of white orchids are found at the highest peak. Orchids are seen in the month of September. They have been identified as species of Platanthera and Habernaria.

(B) Mammals

1. Leopard (or Leopard)

2. Rusty Spotted Cat
3. Sambar

(C) **Avifauna**

1. Brown fish owl
2. Mottled wood owl

(D) **Butterfly / moth**

1. Blue mormon (the largest butterfly)
2. Atlas moth (the largest moth)

(12) Forest Type

According to the revised classification of forest types of India by Champion & Seth, the forests of SGNP Division represent the following forest types.

- 3 B/C1 Southern moist teak bearing forests
- 3 B/C2 Southern moist mixed deciduous forests
- B/TS1 Mangrove scrubs
- 8 A/C2 Western sub-tropical hill forests

3 B/C1 Moist teak bearing forests

The moist teak bearing forests constitutes 3-5 % of the total area of National Park. These forests exist where the soil condition is relatively better. Density is generally above 0.4 and it goes upto 0.7. The forests are mostly concentrated in Yeur and Ghodbander rounds. Earlier Nagla block had vast areas under teak forest but teak has been almost wiped out from this area due to illicit cutting.

Important tree species of this forest type include *Tectona grandis* (Teak), *Garuga pinnata* (Kakad), *Lannea grandis* (Shemat), *Schleichera oleosa* (Koshimb), *Mimusops hexandra* (Rinjan), *Mangifera indica* (Amba), *Adina cordifolia* (Hed), *Pterocarpus marsupium* (Bija), *Bombax malabaricum* (Sawar), and *Syzygium cumini* (Jambul).

Important shrubs include *Carissa carandus* (Karvand), *Helicteres isora* (Murudsheng), *Adhatoda vasica* (Adulsa), and *Thespesia lampas* (Ranbhendi). The climbers are *Abrus precatorius* (Gunj), *Climatis triloba* (Ranjai), *Zizyphus rugosa* (Toria). Bamboo species found in the forests are *Dendrocalamus strictus* (Manvel), *Bambusa arundinacea* (Katas). Important grass species are *Cynodon dactylon* (Harali), *Dicanthium annulatum* (Ranbangdi), *Coix gigantea* (Ranjondhala), *Eragrostis spp*. (Darbha), and *Panicum glabrum* (Varai). Table 4.1.30 shows the checklist of flora found in this area.

3 B/C2 Southern Moist Mixed Deciduous Forest

The Southern moist mixed deciduous forests are profusely found in the area. Teak is occasionally found in low proportions. The density varies from 0.4 to 0.7. Clumps of manvel bamboo (*Dendrocalamus strictus*) and Katas Bamboo (*Bambusa arundinacea*) are found in the area. This forest type covers major part of the Division. The soil is deep, loamy and generally rich in humus content. The semi evergreen species found in this forest type are Mango, Lokhandi, Shendri, Koshimb and Ashok, though Ashok is mostly localised along the stream courses in Kanheri, Chene and Krishnagiri Upvan forests.

4B/TS1 Mangrove Scrubs

The coastal line of Maharashtra is about 720 km. (National Institute of Oceanography - GOA, 1998) and numerous river mouths, creeks, small bays, headlands, cliffs etc indent it. Bassein creek is one of the 37 stations which were surveyed by National Institute of Oceanography for the floral and faunal diversity. Bassein creek is the longest creek with 41 km. length. However only 23% area i.e. approximately 2000 hectares has mangrove coverage (NIO 1998). This creek passes through SGNP. The extent of mangrove forests included within the boundaries of this area is now precisely known. *Avicenna marina* is dominating the vegetation. *Bruguiera gymnorhiza* and *Lumnitzera racemosa* have almost vanished from the estuaries of Bassein Creek, while species like *Sonneratia alba*, *Rhizophora apiculata*, *Acrosticham sureum* are absent from this region. The marine Algae found in Bassein creeks are *Entromorpha clathrata* and *Claloglossal epureurii*. At present SGNP has about 40 ha. of mangrove forests.

8 A/C2 Western Sub-tropical Hill Forests

These are the few remnant patches of natural forests of higher elevations that occur on low lying hills (Bio-diversity of the Western Ghats, 1997). The western sub tropical hill forests are found in very small patches at high altitude. Density is around 0.6. It is semi-evergreen type of forest with many evergreen species present in the crop. The Bamboo is typically absent. The floristic includes, climbers, orchids and ferns. *Mangifera indica* (Mango), *Pongamia pinnata* (Karanj), *Gardcinia indica* (Kokam), *Syzygium cuminii* (Jambul), *Calophyllum inophyllum* (Undi), *Sideroxylon tomentosum* (Kate-Kumbal), *Ixora* (Lokhandi), *Murraya paniculata* (Pandari). *Garcinia* is located on the way to highest point above Kanheri Forests.

(13) Plantation

Some plantations have been taken up in the past in Yeur and Nagla forests. In the period from 1981-82 to 1991-92, over 500 hectare area has been brought under fruit and fodder species plantations. These plantations are successful. *Glyricidia* had been extensively planted on the western side of the area in the past. Since 2008 after removing the encroachment of huts, 17ha. area has been planted with density of 2500 pits/ha. Species like teak, khair, and other indigingous plants have been planted. The exotics species like Subabul and Australian Babul have been planted in the past. *Glyricidia* and the other exotics species give a tinge of artificiality to the area and needs to be removed only after the area is replanted with better indigenous species. In future, only the local species will be planted in the areas made free from encroachments and in the quarries. On experimental basis 1 mt. deep trenches (Continuous contour trenches) will be dug & plants will be planted over mounds to rehabilitate the area.

Table 4.1.30: Floristic Composition of SGNP Area

Sr.No.	Category	Botanical Name	Local Name
1	Trees	*Adansonia digitata*	Gorakh Chinch
2		*Azadirachta indica*	Kaduneem
3		*Adina cordifolia*	Haldu
4		*Alstonia scholaris*	Satwin, Saptaparni
5		*Annona squamosa*	Sitaphal

6		*Anona reticulata*	Ramphal
7		*Anacardium occidentale*	Kaju
8		*Acacia arabica*	Babul
9		*Acacia catechu*	Khair
10		*Aegle marmelos*	Bel
11		*Anogeissus latifolia*	Dhawda
12		*Albizzia procera*	Kinhai
13		*Albizzia lebbek*	Siris, Sankesar
14		*Albizzia odoratissima*	Chinchona
15		*Albizzia chinensis*	Pharadi
16		*Acacia suma*	Shenkhair
17		*Atlantia racemosa*	Ranilimbu
18		*Acacia Ferruginea*	Pandhara Khair
19		*Bombax malabaricum*	Sawar, Kate Sawar
20		*Borassus flabellifer*	Tad
21		*Bauhinia racemosa*	Apta
22		*Bauhinia variegata*	Kanchan
23		*Bridelia retusa*	Asana
24		*Bauhinia vahlii*	Mahul
25	**Trees**	*Bauhanania lanzam*	Charoli
26		*Bauhinia malabarica*	Ambotha
27		*Barringtonia acutangula*	Nivar (Samudra-phal)
28		*Butea monosperma*	Palas
29		*Cocos nucifera*	Naral
30		*Cassia fistula*	Arnaltas, Bahawa
31		*Cordia myxa*	Bhokar
32		*Cyperus Spp.*	Motha
33		*Cordia macleodii*	Daiwas (Dahivel)
34		*Careya arborea*	Kumbh
35		*Casuarina equisetifolia*	Suru
36		*Calophyllum inophyllum*	Undi
37		*Dalbergia latifolia*	Shisam
38		*Delonix regia*	Gulmohar
39		*Diospyros melanoxylon*	Tendu
40		*Dalbergia paniculata*	Dhobin
41		*Dalbergia Sisoo*	Shisoo
42		*Dillenia pentagyna*	Karambel
43		*Dolichandrone falcata*	Medsingi
44		*Erythrina indica*	Pangara
45		*Ehretia laevis*	Daterang
46		*Euphorbia parviflora*	Newali, Thor
47		*Excoecaria agallocha*	Phungali
48		*Emblica officinalis*	Awala
49		*Elaeodendron glaucum*	Jamrasi
50		*Ficus tsiela*	Pipar

51		*Ficus arnottiana*	Payar
52		*Ficus bengalensis*	Wad
53		*Ficus mysorensis*	Bhurwad
54		*Ficus religiosa*	PimpaI
55		*Ficus elastica*	Indian Caoutchuc Tree
56		*Ficus hispida*	Kala Umbar
57		*Ficus glornerata*	Umbar
58		*Ficus asperrima*	Kharwat
59		*Ficus retusa*	Nandruk
59		*Ficus retusa*	Nandruk
60		*Ficus heterophylla*	Datir
61		*Flacourtia montana*	Attak, Champer
62		*Feronia elephantum*	Kawath
63		*Garcinia indica*	Kokarn
64		*Garuga pinnata*	Kakad
65	Trees	*Grewia colimnaria columnaris*	Kala Dhaman
66		*Grewia tiliaefolia*	Dhaman
67		*Gardenia latifolia*	Ghogari
68		*Gmelina arborea*	Shivan
69		*Glycosmis pentaphylla*	Kirmira
70		*Holoptelea integrifolia*	Vavla, Papra
71		*Hymenodictyon excelsum*	Potur
72		*Holarrhena an-tidysenterica*	Kuda
73		*Heterophragma quadriculata*	Warus, Panlag
74		*Ixora arborea*	Kuda
75		*lxora parviflora*	Lokhandi
76		*Ixora nigricans*	Lokhandi
77		*Jatropha curcus curcas*	Mogli, Erandi
78		*Kydia calycina*	Aranga
79		*Lannea grandis*	Shemat
80		*Lagerstroemia parviflora*	Bondara
81		*Lagerstroemia lanceolata*	Lendi
82		*Mangifera indica*	Amba
83		*Madhuca indica*	Mohwa
84		*Manilkara hexandra*	Ahmadabadi hewa
85		*Mimnusops elengi*	Bakul
86		*Morinda tinctoria*	Shevga
87		*Macaranga peltata*	Chandoda
88		*Mitragyna parviflora parvifolia*	Kalamb
89		*Memecylon edule*	Anjani
90		*Murraya koenigii*	Kadulimb
91		*Melia dubia*	Bakan
92		*Murraya exotica*	Pandhari
93		*Mimusops hexandra*	Bakul
94		*Mallotus phillipensis*	Kamela, Kunku

95		*Nyctanthes arbortristis*	Parijatak
96		*Ochrocarpus longifolius*	Surangi
97		*Oroxylum indicum*	Tetav
98		*Olea dioica*	Par-Jambhul
99		*Ougenia oojeinensis dalbergioides*	Tiwas
100		*Ptrocarpus marsupium*	Bibla
101		*Phoenix sylvestris*	Shindi
102	Trees	*Pterospermum suberifolium*	Konak Champa
103		*Parkinsonia acutangula aculeata*	Vedi -Babul
104		*Pongamia pinnata*	Karanj
105		*Randia dumetorum*	Gela
106		*Ricinus communis*	Erandi
107		*Sterculia colorata*	Khavas
108		*Sterculia urens ureus*	Kadhai
109		*Saccopetalum tomentosum*	Humb
110		*Syzygium cumini*	Jambhul
111		*Stereospermum personatum*	Padal
112		*Sapindus trifoliatus*	Ritha
113		*Semecarpus anacardiurn*	Biba
114		*Sesbania grandiflora*	Agasta
115		*Salvadora persica*	Khakan
116		*Streblus asper*	Kharota
117		*Schleichera oleosa*	Kusum
118		*Spondias magnifera*	Ambada
119		*Sideroxylon tomentosum*	Katekumbhal
120		*Sterculia guttata*	Kukeri
121		*Tamarindus indica*	Chinch
122		*Terminalia bellerica*	Behada
123		*Terminalia tomentosa*	Ain, Sadada
124		*Terminalia arjuna*	Arjun
125		*Terminalia chebula*	Hirda
126		*Tectona grandix grandis*	Sagwan
127		*Trewia polycarpa*	Petari
128		*Trema orientalis*	Ran-Ambada, Kargol
129		*Thespesia populnea*	Ranbhendi
130		*Vengueria spinosa*	Alu
131		*Wrightia tinctoria*	Dudhi
132		*Xylia xylocarpa dolabriformis*	Jambu
133		*Zizyphus jujuba*	Bor
134		*Zizyphus xylopyra*	Ghatbor
135	Shrubs	*Acacia pinnata pennate*	Shembati
136		*Adhatoda vasica*	Adulsa
137		*Asparagus racemosus*	Shatawari

138		*Acacia concinna*	Shikekai
139		*Amorphophallas campanulatus*	
140		*Bambusa arundinacea*	Bamboo (Katas)
141		*Barleria prionitis*	Koranti
142		*Capparis spinosa*	Waghata
143		*Capparis zeylanica*	Waghati
144		*Calycopteris floribunda*	Ukshi
145		*Carissa carandas*	Karwand
146		*Calotropis gigantea*	Rui
147		*Clerodendron inerne inerme*	Koyanel
148		*Crotolaria retusa*	Ghogali
149		*Euphorbia neriifolia*	Nivdung
150		*Erythropsis calorata*	Khavas
151		*Helicteres isora*	Murudsheng
152		*Ixora parviflora*	Bakors
153		*Jasminum pubescens*	Ranmogra, Ranjai
154		*Jatropha curcas*	Chandrajyot
155		*Kirganolis reticulata*	Pavan
156		*Leea edgeworthii*	Dina
157		*Lawsonia inermis*	Mendi
158		*Lepidagathis cristata*	Kumbhi
159		*Lantana camera camara*	Ghaneri
160		*Lantana alba*	Gultora
161		*Microcos paniculata*	Shetali
162		*Mayenia arecta*	Alu
163		*Moghania strobelifera*	Kanfuti
164		*Nerium indicum*	Ran Kanher
165		*Opuntia dillenii*	Nivdung
166		*Oci mum canum*	Ran-TuIas
167		*Pogostemon purpuria caulis*	Pangal i
168		*Strobilanthes callosus*	Karvi
169		*Solanum indicum*	Bhui, Ringani
170		*Vitex negundo*	Nirgudi
171		*Woodfordia floribunda*	Dhayati
172		*Zizyphus cenoplia*	Makor
173	**Herbs**	*Agave americana*	Ghaypat
174		*Argemone mexicana*	Pivla Dhotra
175		*Abutilon indicum*	Mudra
176		*Aeschynomene indica*	Silar-
177		*Alysi carpus rugosus*	Baker
178		*Ammania baccifera*	Bhar jambhul
179		*Ammania multiflora*	--
180		*Anisomeles Anisomelis indica*	--
181		*Achyranthes aspera*	Aghada

182		*Alternanthera sessilis*	kanchari
183		*Amaranthus Amairanthus spinosus*	Kate-Math
184		*Biophytum sensitivum*	--
185		*Begonia crenota crenata*	--
186		*Bidens biternata*	--
187		*Blumea laciniata*	Burada
188		*Blepharis asperrima*	--
189		*Corchorus capsularis*	--
190		*Corchorus aestuans*	--
191		*Corchorus olitorius*	Jute
192		*Cardiospermum helicacabum*	Kapsihodi
193		*Cassia tora*	Takla
194		*Crotalaria juncea*	Taag
195		*Centalla asiatica*	--
196		*Caesulia axillaris*	Maka
197		*Centratherum anthelminticum*	--
198		*Centarium centaurioides*	--
199		*Coldenia procumbens*	--
200		*Commelina benghalensis*	Kena
201		*Commelina obliqua*	Kena
202		*Curcuma aromatica*	Jungli Halad
203		*Desmodium triflorum*	Ran Methi
204		*Dinebra retroflexa*	Kardi
205		*Datura kutal*	Dhotra
206		*Digera muricata*	Tanduliira
207		*Dioscorea bulbifera*	--
208		*Dioscorea pentaphyla pentaphylla*	Babra
209		*Eclipta alba*	Maka
210		*Elephantopus scaber*	--
211		*Evolvulus alsinoides*	Shankavali
212		*Euphorbia Euphoirbia hirta*	Dudhi
213		*Grangea maderaspatana*	--
214		*Hemidesmus indicus*	Anant-Mul
215		*Helianthus Spp*	Suryaphul
216		*Hoppea dichotoma*	--
217		*Holiotropium indicum*	Bhurundi
218		*Haplanthus tentaculatus*	--
219		*Hemigraphis latebrosa*	--
220		*Hygrophila serpyllum*	--
221		*Indigofera astragalina*	--
222		*Impatiens balsamina*	Terdi
223		*Jussiaea suffruticosa*	Ban Lavang
224		*Justicia simplex*	Sokamble Zara

225		*Leea macrophylla*	Dindi
226		*Limnophila indica*	--
227		*Lindernia ciliata*	--
228		*Leucas aspera*	--
229		*Malachra rotundifolia*	Ran Bhendi
230		*Melochia corchorifolia*	Methuri
231		*Mollugo pentaphylla*	--
232		*Musa superba*	Jungli-K
233		*Oxalis latifolia*	Khatta Zara
234		*Oldenlandia corymbosa*	Bit Papda
235		*Portulaca oleracea*	Ghola
236		*Phaseolus radiatus*	Mug, Moong
237		*Phaseolus trilobus*	--
238		*Plumbago zeylanica*	Shitrak
239		*Physalis Physalia minima*	Ran Popti
240		*Peristrophe Peristiophe bicalyculata*	--
241		*Phyla nodiflora*	--
242		*Polygonum glabrurn*	Dongra
243		*Phyllanthus niruri*	Ran-Aol i
244		*Pavetta indica*	Papadi
245		*Sida acuta*	Jungli Methi
246		*Sida retusa*	Atibala
247		*Smithia Smithea hirsuta*	--
248		*Smithia Smithea sensitiva*	--
249		*Sphaeranthus indicus*	Gorkmundi
250		*Solanum xanthocarpum*	Bhuivangani
251		*Sesamum indicum*	Til
252		*Stachytarpheta indica*	Tuisi Zara
253		*Strychnos nuxvomica nux-vomica*	Kuchla
254		*Scilla indica*	--
255		*Triumfetta annua angulata*	--
256		*Triumfetta pilosa*	--
257		*Tephrosia purpurea*	Sai-p Mukhc
258		*Tridax procumbens*	Degadipala
259		*Trichodesma indicum*	Ghotakalpa
260		*Urena lobata*	Jal -Jaltang
261		*Vernonia cineria cinerea*	Sahadevi
262		*Waltheria indica*	--
263		*Woodfordia floribunda*	Dhaiti
264		*Xanthium strumarium*	Gokharu
265	**Grasses**	*Apluda mutica*	Pochati, Fuli-Zara
266		*Arundinella ciliata*	--
267		*Arundinella intricata*	--

268		*Arundinella minila mutica*	--
269		*Andropogon triticus triticeus*	Bhale Kusa
270		*Andropogon monticola*	Dongari Gavat
271		*Andropogon pertusus*	Ghanya Marvel
272		*Andropogon pumilus pumilis*	Gondval
273		*Andropogon halepensis*	Boru
274		*Andropogon contortus*	Kusali
275		*Andropogon annulatus*	Marvel
276		*Andropogon schoenanthus*	Rosha
277		*Anthistiria ciliata*	Bhongrut
278		*Aristida paniculata funicalata*	Bhuri
279		*Brachiaria eruciformis*	Sheprut
280		*Coix aquatica*	Ran Jondhala
281		*Cynodon dactylon*	Hariali, Durwa
282		*Eleusine coracana*	Nachni, Nagli
283		*Eragrostis Spp*	Darbha, Kusha
284		*Imperata cylindrica aryndinaca*	--
285		*Ischaemum indicum*	Ber
286		*Ophismenus Ophismanus compositus*	Hirvi Bangadi
287		*Panicum Paspalidium flavidum*	--
288		*Panicurn glabrum*	Varai
289		*Paspalum disticum*	--
290		*Spodiopogon rhizophorus*	Math-Zara
291		*Sporobolus indicus*	--
292		*Themeda trianndra*	Gondel
293	**Bamboos**	*Bambusa arundinacea*	Katas
294		*Dendrocalarnus strictus strietus*	Manvel
295	**Climbers**	*Ampelocissus latifolia*	Kandvel, Rudrakshi
296		*Abrus precatorius*	Gunj
297		*Argyreia nervosa*	Samudra-Ashok
298		*Argyreia sericea*	Sambarvali
299		*Butea superba*	Palasvel
300		*Capparis horrida*	Tarati
301		*Clematis Clematius triloba*	Ranjai
302		*Cocculus Cocclus villosus*	Parval
303		*Cissus repanda*	Arbatvel
304		*Cissus auriculata*	Kalivel
305		*Cylista Cyclista scariosa*	Ran Ghewada
306		*Coccinia indica*	Tondli
307		*Caesalpinia sepiaria*	Chillari
308		*Celastrus paniculata*	Malkangni, Pingvel
309		*Capparis sepiaria*	--
310		*Combretum ovalifolium*	Madhel
311		*Derris trifolia*	Kajarvel

312		*Entada scandens*	--
313		*Gloriosa superba*	Bachmag
314		*Hemidesmus indicus*	Anantvel
315		*lpomea digitata*	Bhuikohala
316		*Jasminum malbaricum*	Jai
317		*Luffa acutangula*	Shirali
318		*Mucuna prurita pruriens*	Khajkoyli
319		*Momordica dioica*	Kartoli
320		*Marsdenia volubilis*	--
321		*Parsonsia Parsonia spiralis*	NagaIkuda
322		*Smilax zeylanica*	Ghotvel
323		*Tinospora cordidolia cordifolia*	Gulvel
324		*Teramnus labialis*	Ranudid
325		*Trichosanthes palmata*	Padval
326		*Zizyphus rugosa*	Torai
327	**Epiphytes**	*Cuscuta reflexa*	Amarvel
328		*Dendrophthoe falcata*	Bandgul
329		*Viscum nepalensis*	Banda
330		*Vanda tessellata*	Aitkel
331	**Aquatic plants**	*Asteracantha longifolia*	Kolshinda, Talimkhan
332		*Cariops tagal*	Chauri
333		*lpomoea aquatica*	--
334		*Limnanthemum Limnanthemus indicum*	Kumud
335		*Murdannia nudiflora*	--
336		*Pistia Pistacia stratiotes*	Gondal
337		*Utricularia orbiculata*	--
338	**Halophytes**	*Aegiceras corniculata*	Kunjala
339		*Acanthus ilicifolius*	Marandi (Seaholly)
340		*Avicennia officinalis*	Ti var
341		*Avicennia marina*	Tivar
342		*Pandanus tectorius*	Kewada
343		*Sonneratia apetala*	Tivar
344	**Orchids**	*Platanthera spp*	
345		*Habenaria Habernaria spp.*	

Source: SGNP Working Plan

(14) Wild Animals

The forests in this area were bestowed with rich faunal density in the past. However this rich heritage of wildlife had dwindled due to the problems caused by the huge encroachments. However, removal of some of the encroachments and implementation of conservation practices over a period of 40 years, this area has becoming rich in wildlife as shown in Table 4.1.31. The tiger which had become extinct from this area in the early forties, made a surprising but unconfirmed reappearance in 2004 as per the existing records the origin and destination of the tiger that lived in the Nagla block for around 6 weeks in 2004 still remains a mystery and no photographic confirmation was made.

Table 4.1.31: Faunal Density & Diversity

	Mammal	Reptile	Amphibian	Bird
Order	7	3	1	18
Family	17	14	4	46
Species	43	38	9	250

Source: SGNP Working Plan

Innumerable species of grasshoppers, spiders, bugs, mosquitoes, beetles, termites, mantises, bees, hornets, wasps, cockroaches, cicadas, aphids, moths and butterflies, dragonflies and damselflies are found in SGNP. Leaf insects and stick insects are seen in the area. This area boasts to harbour almost 150 butterfly species. September to January is the best time for their observation. The Atlas moth was seen in September 1999, which is regarded as a valuable discovery. The vertebrate fauna of the area includes 43 species of Mammals, 250 species of birds, including the migratory land and water birds, 38 species of reptiles and 9 species of amphibians.

Mammals

Wildlife habitats in SGNP Division supports are number of species of herbivores, carnivores and omnivores. Nearly 43 species of mammals belonging to 8 natural orders and 17 families are seen in the national park. Out of these 8 species are “Endangered” and have been included in the Schedule - I and Part-II of Schedule-II of the Wildlife (Protection) Act, 1972. The details are given in Table 4.1.32.

Table 4.1.32: Endangered Faunal Species

Sl.No.	Common Name	Scientific Name
1	Leopard or Leopard	*Leoparda pardus*
2	Rusty-Spotted Cat	*Felis rubiginosa*
3	Jungle Cat	*Felis chaus*
4	Small Indian Civet	*Viverricula indica*
5	Common Palm Civet	*Pardoxurus hermaphroditus*
6	Jackal	*Canis aureus*
7	Four-horned Antelope	*Tetracerus quadricornis*
8	Mouse Deer	*Tragulus meminna*

Source: SGNP Working Plan

Leopard or Leopard is the only big cat found in this area. In total, eight Leopard lairs have been seen in this area. Jungle cat, small Indian civet, common palm civet or Toddy cat, rusty-spotted cat, jackal, stripped hyena are quite rare. The jackals are seen in the scrub forest around Vihar and also near the MAFCO factory, in the Krishnagiri Upvan. The hyenas are seen particularly around the Yeur village and were earlier found near the MAFCO factory, which has now been demolished.

Leopard or Leopard

Leopards of this area have some unique features. The spatial distribution of Leopard in this area has been studied in light of census data of Leopard conducted in this Division in the past. The scat analysis shows that leopards mainly feed on domestic dogs, chital, *etc.* The scat analysis showed that 77% scats contained only one prey species, 21% scats contained two species and 2% contained three species. After demolition of the MAFCO factory the artificial feeding ground has been disappeared and that had resulted in the better distribution of leopards within SGNP. Recently a study was undertaken by the park administration to assess the distribution of leopards and to focus on measures to be taken to mitigate the man-animal (mainly leopard) conflict; the study is called as "Mumbaikars for SGNP".

Large Herbivores

Large herbivores of this area represent four families of Artiodactyla as shown in the Table 4.1.33.

Table 4.1.33: Large Herbovores Species

Large Herbivores Order: Artiodactyla (even-toed ungulates)		
Family	**Group Name**	**Common Name**
Suidae	Pig	Wild boar
Tragulidae	Chevrotains	Mouse deer
Cervidae	Deer	Spotted deer
		Sambar
		Barking deer
Bovidae	Cattle	chousinga

Source: SGNP Working Plan

The spotted deer are seen mostly around the Tulsi and Vihar lake area and also around Tumnipada area. Sambars are mostly seen in the Shilondha forests, around Tulsi and Vihar lakes, Yeur and Chene forests. The population of the Mouse Deer is concentrated mainly around Tulsi and Vihar lakes and Kanheri caves. Wild boars/pigs are mostly seen around Tulsi & Vihar lakes and Shilondha forests.

Small Herbivores

Small herbivores in this area have not been studied. The black-naped hare is common in all valleys. The crested porcupine is commonly seen around Kanheri Caves area. A detailed study of small herbivores shall be taken in near future.

Primates

Three species of monkeys *viz.* the Bonnet macaque, the Rhesus macaque and the common or Hanuman langur occur in the area. The Bonnet monkey is common in many parts. It is also reported that there is also a hybrid species of macaques due to the inter-breeding of the Bonnet and Rhesus macaques.

Bats

Seven species of bats have been recorded in the area. Brosset (1962) had studied extensively all the seven species of bats from this area and had published his findings in his book – "The Bats of Central and Western India" (published by the B.N.H.S.) His records include all three species of fruit-eating bats (Megachiroptera).

Avifauna

The avifauna of this area is an attractive wildlife feature of this park About two hundred and fifty bird species, both resident and migrant, belonging to eighteen different orders and forty-seven families have been recorded here. The period between December and February is ideal for bird watching. This area is a home of five endangered birds, namely the **Peafowl (*Pavo cristatus*), Osprey or fish-eating eagle**

(*Pandion haliaetus*), white-bellied sea eagle (*Haliaetus leucoquaster*), Hawks (*Accitridae*) and large Falcons (*Falco peregrinus, Falco biarmicus and Falco chicuera*). The cormorant is a common bird of the area. Migratory ducks such as common teal, garganey and the redheaded poachard are seen in small numbers in Vihar and Tulsi Lakes. Two species of Jacanas namely the Pheasant tailed jacana and the Bronzed winged jacana have also been recorded in the area. Mangrove swamps attract a variety of plovers, sandpipers, gulls and terns. The nocturnal birds include the Barn Owl, the Great Horned Owl, the barred Jungle Owlet and the Spotted Owlet. The Rose-ringed parakeet and the Blossom headed parakeet are common and breed within the park. The white-breasted kingfisher and the common kingfisher are common. Several types of woodpeckers including the rare heart-spotted woodpeckers occur in the park.

Reptiles

The reptiles found in the park are covered under three orders and fourteen families. In the park there are thirty-eight species of reptiles of which seven are "Endangered" and are included in Schedule I and Part II of Schedule II of Wildlife (Protection) Act.1972. Details are given in Table 4.1.34.

Table 4.1.34: Endangered Reptiles

Sr.No.	Common Name	Scientific Name
1	Indian Marsh Crocodile (Mugger)	*Crocodilus palustris*
2	Indian Rock Python	*Python molurus*
3	Dhaman or Rat snake	*Ptyas mucosus*
4	Indian Cobra	*Naja naja*
5	Russel's Viper	*Vipera russelli*
6	Checkered keelback	*Natrix piscatar*
7	Common monitor	*Varanus monitor*

Source: SGNP Working Plan

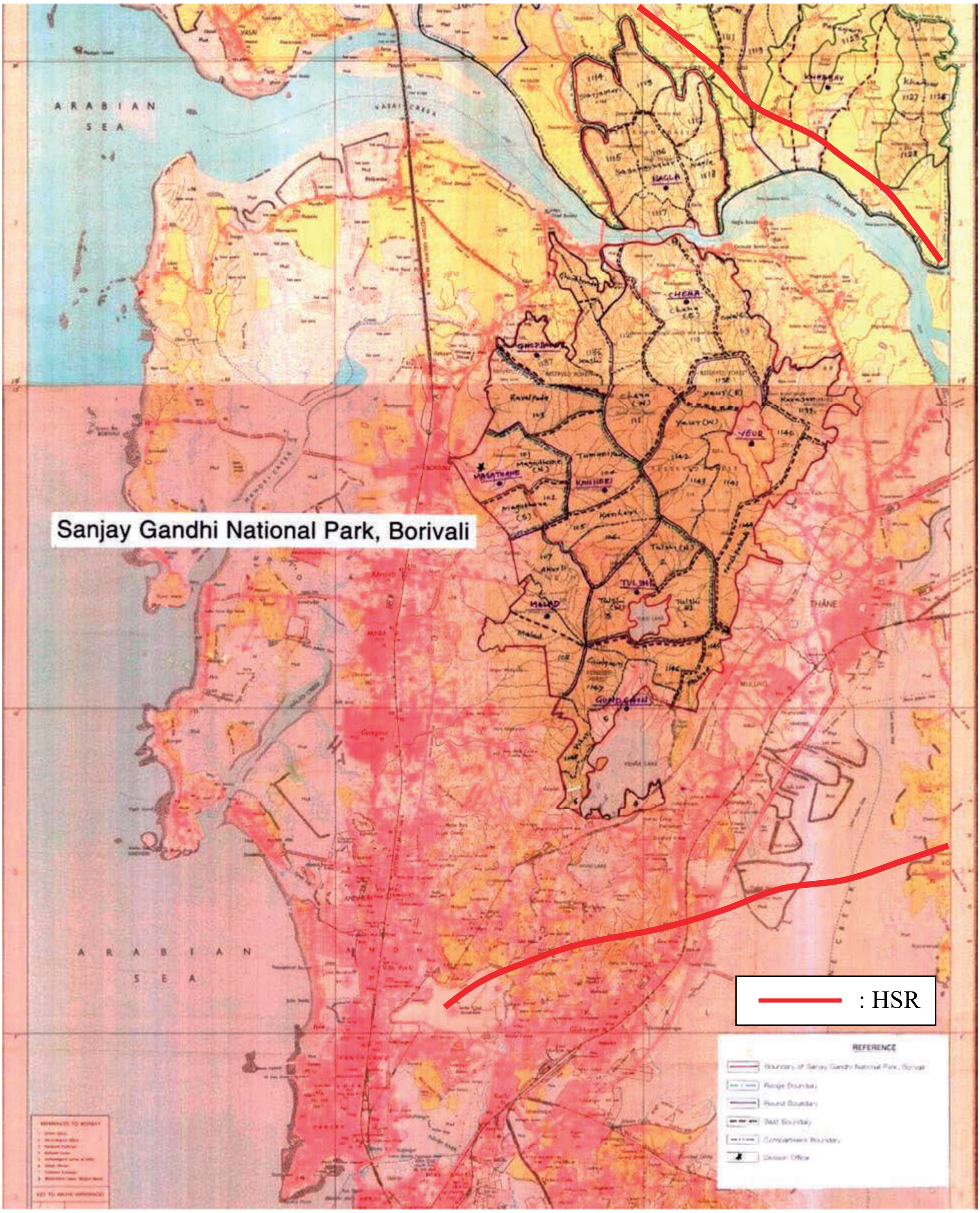
The eleven species of lizards found in this area which includes the chameleon and the monitor lizard. There are twenty-three species of serpents in the park, of which seven species are "Endangered" and are included in the Schedule-I and Part-II of Schedule-II of Wildlife (Protection) Act, 1972.

Amphibia

The Kanheri Caves with its perennial pools of water have a variety of frogs and toads. Besides the common ones such as the tree frogs, the bullfrog and common toad, the uncommon toad (*Ramanella montana*) has been recorded in the area. Fungoid frogs are seen in Tulsi tunnel. In the cisterns in the rocks around Kanheri caves, a few interesting species of frogs have been recorded including the six-toed frog and the skipper frog. Common during the rains are the extraordinary tadpoles of *Rana loith* capable of swimming upstream. In all, nine species of amphibia belonging to four different families are seen in the area.

Ichthyofauna

The Bassein Creek and the other watercourses in and around the area abound in fishes. During the monsoons when deep-sea fishing is suspended many sea fishes migrate to the shore. 25 species of the marine fishes and 18 species of the freshwater fishes are seen within the park.



Source: Office of the Chief Conservator Forest (Wildlife), SGNP

Figure 4.1.43: SGNP

Table 4.1.35: Faunal Species Reported in the SGNP

Order	Family	Scientific Name	Common English Name
Insectivora	Pterodidae	*Suncus murinus*	House Shrew or Grey Musk Shrew
Chiroptera		*Rousettus leschenaulti*	Fulvous Fruit Bat
		Pteropus giganteus	Indian Flying Fox
		Cynopterus sphix	Shortnosed Fruit Bat
	Emballonuridae	*Taphozous melanopogon*	Black-beared Tomb Bat
		Taphozous soccolaimus	Pounch Bearing Bat
	Megadermatidae	*Megaderma spasma*	Malay False Vampire
		Megaderma iyra	Indian False Vampire
		Rhinolophus rouxi	Roux's Horseshoe Bat
		Hiposideros sperosis	Schenider's Leaf-nosed Bat
		Hipposideros bicolox	Bicoloured Leaf-nosed Bat
		Hipposiderous galeritus	Cantor's Leaf-nosed Bat
	Vespertilionidae	*Pipistrellus coromandra*	Indian Pipistrelle
		Pipistrellus minus	Indian Pigmy Pipistrelle
		Pipistrellus dormeri	Dormer's Bat
		Hesperoptenus tickelli	Indian Tickell's Bat
		Scotophilus heathi	Coomon Yellow Bat
		Kerivoula picta	Painted Bat
Primates	Cercopithecidae	*Macaca radiata*	Bonnet Macaque
		Macaca mulata	Rhesus Macaque
		Presbytis entellus	Common Langur
Carnivora	Canidae	*Canis aureus*	Jackal
	Viverridae	*Viverricula indica*	Small India Civet
		Paradoxurus hermaphroditus	Toddy Cat or Small India Civet
		Herpestes edwardsi	Indian Grey Mongoose
	Hyaenidae	*Hyaena hyaena*	Striped Hyaena
	Felidae	*Felis chaus*	Jungle cat
		Panthera pardus	Leopard
		Felis rubiginosa	Rusty Spotted Cat
Artiodactyla	Suidae	*Sus scrofa*	Wild Boar
	Tragulidae	*Tragulus meminna*	Mouse Deer or Indian Spotted Chevrotain
	Cervidae	*Axix axis*	Spotted Deer
		Cervus unicolor	Sambar
		Muntiacus muntjac	Barking Deer or Muntjac
	Boridae	*Tetracerus quadricornis*	Fourhorned Antelope or Chausinga
Lagomorphia	Leoporidae	*Lepus nigricollis*	Indian Black Naped Hare
Rodentia	Sciuridae	*Funambulus palmarum*	Three Stripped Palm Squirrel
		Funambulus pennanti	Five striped Palm Squirrel
		Hystrix indica	Indian Crested Porcupine
	Muridae	*Rattus blanfordi*	Whitetailed Wood Rat or Blanford's Rat

		Rattus rattus	House Rat
		Mus musculus	House Mouse
		Bandicota bengalensis	Indian Mouse, Rat or Lesser Bandicoot

Table 4.1.36: Avifauna Reported in the SGNP

Order	Family	Scientific Name	Common English Name	Move-ment	Abun-dance
Podicipediformes	Podicipitidae - Grebes	*Podiceps ruficolIis capensis*	Little Grebe or Dabchick	R	O
Peiecaniforms	Phalacrocoracidae	*PhaIaerocorax niger*	Little of Pigmy cormorant	R	C.F.
		Anhinga rufa Melanogaster	Dartar	R	O
Cicomipormes	Ardeidae	*Ardeola - gray*	Pond Heron or paddy bird	R	C
		Bubulcus ibis, Coromandus	Cattle Egret	R	C.F.
		Egretta alub modesta	Large Egret	R	U
		Elgrettca interrmedia intermedia	Median or Smaller Egret	R	O
		Egretta gazzetta gazzetta	Little Egret	R	C
		Nicticorax nicticarax nicticorex	Night Heron	R	U
		Ixobrychus cinnamomeus	Chestnut Bitters	R	U
	Ciconidae	*Anastomus ositanas*	Openbill stork	R	UF
		Ciconia episcopus episcopus	White Necked Stork	R	OF
Anserjformes	Anatidae	*Dendrocygna javanica*	Lesser Whistling Teal	R	C.F.
		Anas acuta	Pintail	M	C.F.
		Anas creca creca	Common Teal	M	OF
		Anas poeciIorhyncha poecilor hyneha	Spotbill Duck	R	OF
		Anas quercquedula	Gazganey or Blue Winged Teal	M	C.F.
		Aythaya ferina	Comman or Redneded Pochard	M	OF
		Aythya nyroca	White Eyed Pochard	M	C.F.
		Aythya fuligula	Tuffed Duck	M	C.F.
		Nettapus coromandelianus coromandelianus	Cotton Teal	R	C.F.
Falconifor-ces	Accipitridae	*Elanus caeruleus vociferus*	Black winged kite	RLM	O
		Pernis ptiIorhyncus ruficollis	Crested Honey Buzzard	R	O
		Milvus migrans govinda	Pariah Kite	R	C

		HaIiastur indus indus	Brahminy Kite	R	O
		Accipiter badius dussumieri	Indian Shikra	R	C
		Accipiter trivirgatus	Crested Goshawk	R	U
		Accipter nisus meIaschistos	Sparrow Hawk	M	U
		Butastur teesa	White Eyed Buzzard	R	U
		AquiIa rapax vindhina	Ta Wny Eagle	LM	O
		Ictinactus Malayensis Perniger	Black Eagle	R	U
		Haliaeetus leucogaster	White Bellied Sea Eagle	R	O
		Gyps indicus indicus	Indian Longbilled Vulture	R	OF
		Gyps bengalensis	Indian Whitebacked Vulture	R	C.F.
		Neophron Perenopterus	Indian Scavenger Vulture	R	OF
		Circus macrourus	Pale Harrier	M	O
		Circus pygarus	Montagus Harrier	M	O
		SpiIornis cheeIa meIanotis	Crested Serpent Eagle	R	O
		Pandion hatiaetus haliaetus	Osprey	M	U
		Falco tinnunculus tinnunculus	European Kestrel	M	O
	Falconidae	*francolinus pictus*	Painted patridge	R	C
Galliformes	Phastanidae	*Coturnix coturnix coturnix*	Common Grey Quail	M	C.F.
		Coturnix coromandelica	Blackbreasted or Rain Quail	M	C.F.
		Perdicula asiatica asiatica	Jungle Bush Quail	R	C.F.
		GalIoperdix spadicea spadicea	Red Spurfoud	R	C.F.
		GalIus galIus	Red Jungle Fowl	R	U
		GalIus sonneratti	Grey Jungle Fowl	R	O
		Pavo cristatus	Common Peafowl	R	C.F.
		Turnix sylvatica dussumier	Liggle Bustard Quail	R	U
		Turnix suscitator taigoor	Common Bustard Quail	R	C
		Rallus stviatus albiventer	Blue Brested Banded Rail	R	U
	Rallidae	*porxana pusiIIa pusiIIa*	BailIon's Grake	M	U
		Porzane porzane	Spottd Crake	M	O

		Amaurarnis phoenicurus phoenicurus	White Brested Waterhen	R	C
		Amaurornis fuscus zelonicus	Ruddy Crake	M	O
		Gallicrex chinerea cinerea	Water Gock or Kora	R	O
		Gallinula chloropus indica	Moorhen	R	O
		Porphyrio porphyrio poliocephalus	PurpIe Moorhen	R	O
		Fulica atra atra	Coot	R	OF
		Hydropha sianus chirurgus	Pheasant Tailed Jacana	R	C
Charadriiformes	Jacanidae	*Metopidicus*	Bronzewinged Jacana	R	C
		Haematopus ostralegus	Dyster catcher	R	C
		Venellus indicus indicus	Red watted lapwing	R	C
		VaneIlus malbaricus	YeIIow wattIed Iapwing	R	O
Charadriiformes	Jacanidae	*Numeniua phaeopus*	WhimbreI	R	O
		Numenius orquata	CurIew	R	O
		Tringa totanus eurhinus	Common Redshank	M	C.F.
		Tringa stagnatills	Marsh sandpiper	M	U
		Tringa nebuiaria	Green shank	M	O
		Tringa ochropus	Green sand piper	M	C
		Tringa hupoleucos hypoleuccos	Common sand piper	M	C
		Gappela stenura	Pintail Snipe	M	C.F.
		GapeIla gallinago	Fantail shipe	M	C.F.
		GapeIla mihima	Jack shipe	M	C.F.
		CaIdris minutus	Little stint	M	C.F.
		CaIdris temminickii	Temminck's Stint	M	C.F.
		Phiomachus pugnax	Ruft and Reeve	M	C.F.
		Rostratula benghalensis benghalensis	Painted shipe	R	OF
	Rostratulidae	*Himantopus himantopus himantopus*	Blackwinged stilt	MR	C.F.
	Recurvirostridae	*Burhinus ocdicnemus*	Stone curlew	M	O
	Burhinidae	*Cursorius coromandelicus*	Indian courser	M	O
	Glareolidae	*Larus brunnicephalus*	Brounheaded Gull	M	C.F.

	Lardiae	*Larus brunnicephalus*	Brounheaded GullIa	M	C.F.
		Childonias bybrida indica	Whiskered Tern	LM	OF
		Gelochelidon nilotica nilotica	Gullbilled Tern	LM	OF
		Sterna aurantia	Indian River Tern	LM	OF
		Sterna acuticauda	Blackbellied Tern	LM	OF
		Sterna albifvons	Little Tern	M	OF
		Petrocles exustus	Indian sandgrouse	M	O
Columbiforms	Ptercolidae	*Treron pompadora affinis*	Grey fronted Gveon	LM	OF
	Columbidae	*Treron pheonicoptera chlorigaster*	Pigeon Yellow legged green pigeon	LM	OF
		Columba livia intermedia	Blue Rock Pigeon	R	C.F.
		Streptopelia decaocto	Indian Ring Dove	R	O
Columbiforms	Columbidae	*Streptopelia tranque baraca*	Red Turtile Dove	R	O
		Stveptopelia chinensis surantemsis	Spotted Dove	R	C
		Streptopila Senegalensis Cambayensis	Little Brown Dove	R	C
		Chalcophas indica indica	Emeraldd Dnv«o	C	O
		Psittacula eupatria eupatria	Large Alexandrine Parakeet	LM	U
Psittaciformes	Psittacidae	*Psittacula krameri Manillensis*	Roseringed Parakeet	R	C.F.
		Psittacula Cyanocephala Cyanocephala	Blossomheaded Parakeet	R	OF
		Loriculuc vernalis	Indian Lorikeet	R	U
		Clamator Coromandus	Redwinged Crested	B.M.	C
Cuculiformes	Cuculidae	*Clamator jacobinus serratus*	Pied Crested Cuckoo	B.M.	C
		Cuculus varius varius	Common Hawk, Cuckoo or Brain Fever Bird	M	O
		Cuculus Micropterus Micropterus	Indian Cuckoo	M	O
		Cuculus canorus	Cuckoo	M	O
		Cacomantis sonneratti sonneratti	Indian Baybanded Cuckoo	B.M.	O
		Cacomantis Merulinus passezinus	Indian Plaintive Cuckoo	B.M.	O

		Surniculus lugubris dicruroides	Drongo Cuckoo	B.N.	O
		Eudynamys scolopacea scolopacea	Koel	R	C
		Taccocua leschenaultii	Sipkeer Cuckoo	R	C
		Centropus sinensis parroti	Gow Pheasant or Coucal	R	C
		Tyto alba stertens	Barn Owl	R	O
Strigiforms	Strigidae	*Otus scops*	Scops Owl	R	O
		Bubo bub	Great Horned Owl or Eagle Owl	R	O
		Bubo zeyionensis	Brown Fish Owl	R	U
		Glaucidium radiatum radiatum	Barred Jungle Owlet	R	C
		Athene brama brama	Spotted Owlet	R	C
		Asio flammeus flammeus	Shorteared Owl	M	O
		Caprimulgus indicus indicus	Indian Jungle Nightjar	R	O
Carrimulgiporns	Carrimulgidae	*Caprimulgus asiaticus*	Common Indian Nightjar	R	O
		Apus affinis affinis	House awiff	R	C.F.
Apodiformes	Apodidae	*Cypsiurus parvus batasiensis*	Palm swift	R	C.F.
		Harpactes fasciatus legerli	Central Indian Trogon or Malabar Trogon	R	U
Trogoniformes	Trogonidae	*Ceryle rudis*	Lesser Pied Kingfisher	R	C
Coractiformes	Alcedinidae	*Alcedo atthis taprobana*	Small Blue or Common Kingfisher	R	C
		Ceyx erithacus	Three Toed Kingfisher	R	C
		Halcyon smyrnesis fusca	White Breasted Kingfisher	R	C
		Halcyon Pileata	Black Capped Kingfisher	L.M.	C
		Merops Philippinus Phillippinus	Blue Tailed Bee-eater	P.M.	OF
	Meropidae	*Merops Orientails Orientails*	Green Bee-eater	MR	C.F.
		Coracias benghalensis indica	Indian Roller or Blue Jay	LM	C
	Coracudae	*Upupa-Epops*	Hoopoe	M	C
	Upupidae	*Tockus griseus*	Malabar Indian Grey Hornbill	R	O
	Bucrotidae	*Megalaima Zeylanica inornata*	Large Green Barbet	R	C
Pictformes	Capitonidae	*Megalaima huemacephala indica*	Crimsonbreasted Barbet or Copper smith	R	C
	Picidae	*Jynx torquilla torquilla*	Wryeck	M	O

		Micropternus brachyurus jerdonil	Rufous Wood Pecked	R	C
		Dinopun benghalense tehminae	Lesser Gold Backed Wood Pecker	R	C
		Dinopium Javanense	Indian Goldenbacker Three Toed Wood Pecker	R	C
		Dryocopus Javensis	Indian Great Black Wood Pecker	R	O
		Picoides mahraltensis mahraltensis	Yellow Fronted Pied or Maratha Wood Pecker	R	O
		Picoides hunus hardwickil	Brownarouned Pygmy Wood Pecker	R	O
		Hemicirecus canente	Heart Spotted Wood Pecker	R	U
		Chrysocolaptes lucidus	Larget Golden Backed Wood Pecker	M	U
		Chrysccolaptes fistivus festivus	Black Backed Wood Pecker	R	U
		Pitta brachyura brachyura	Indian Pitta	PM	RO
Passerofpres	Pittidae	*Mirafra erythroptera*	Redewinged Bush lark	R	O
		Eremopterix grisea	Ashycrowned finch-larK	R	C
		Ammomanes phoenicurus phoenicurus	Rufoustailed finch lark	R	C
		Galerida malabarica	Malbar Gested lark	R	C
		Aluuda gulgula gulgula	Small or Eastern Skylark	R	O
		Hirundo concolar	Dusky Carg martin	M	C
	Harundinidae	*Hirundo rustica*	Swallow	M	C.F.
		Hirundo srnithii filifera	Wiretailed swallow	R	OF
		Hirundo dawrica nipalensis	Straited swallow	M	C.F.
		Hirundo dawrica erythropygia	Redrumped swallow	R	O
		Lanius schach erythronotus	Rufous backed shrika	M	C
	Lanidae	*Oriolus oriolus*	Golden Oriode	LMR	C
	Oriolidae	*Oriolus xanthornus*	Blackheaded onde	R	C
		Dicrurus adsimilies macrocercus	Black Drongo or king Crow	R	C
	Dicruridae	*Dicrurus leucophaeus longicaudatus*	Grey or Ashy Drongo	M	C
		Dicrurus aeneus aeneus	Bronzed Drongo	LM	U

		Dicrurus hottentottus hottentottus	Haircrested Drongo	RS	U
		Dicrurus paradiseus paradiseus	Large Racket tailed Drongo	R	O
		Artamus fascus	Ashy Swallow shrike	R	OF
Passerofpres	Artamidae	*Sturnus malabaricus malabaricus*	Grey headed Myna	MR	OF
	Sturnidae	*Stunus pogodurum*	Black headed or Byahmnya Myna	MR	OF
		Sturnus roseus	Rosy pastor, or rosy starling	M	C.F.
		Sturnus contra contra	Pied Myna	R	O
		Acridotheres tristis tristis	Common Myna	R	C.F.
		Acridotheres fuscus maharattensis	Jungle Myna	R	OF
		Gracula religiosa indica	Grackle or Hill Myna	S	U
		Dendrocitta vagabunda vagabunda	Indian Tree Pie	R	O
	Corvidae	*Corvus splendens splendens*	House Crow	R	C.F.
		Corvus macrorhynahos culminatus	Jungle Crow	R	C
		Tephrodornis pondicerianus pondicerians	Common wood shrike	R	C
	Campehagidae	*Coracina novachollandiae mecei*	Large cuchooshrike	R	O
		Coracina melanoptera sykesi	Blackheaded cuckooshrike	R	C
		Pericrocotus flammeus	Scarlet minivet	R	O
		Pericrocotus cinnamomeus	Small Minivet	R	C.F.
		Aegithina tipha multiculor	Common lora	R	C
	Trenidae	*Chloropsis aurifrons frontalis*	Gold fronted choropsis	R	O
		Chloropsis cochinchinensi jerdoni	Jerdons or Goldmantled chlopasis	R	O
	Trenidae	*Pycononofus jocosus fuscicaudatus*	Redwhiskered Bulbul	R	C
Passerofpres	Pycononotidae	*Pycononotus leucogenys leucotis*	White eared Bulbul	R	U
		Pycononotus cafer cafer	Redvented Bulbul	R	C
		Pycononotus luteolus luteolus	White browed Bulbul	R	O
		Pellorneum ruficeps ruficeps	Spotted Babbler	R	C.F.
	Muscicapidae	*Pomatarhinus schisticeps horsfieldii*	Slaty headed Scimitar Babbler	R	O

	Sub-family - Timalinae	*Dumetia hypezythra*	Rufous bellied babbler	R	C
		Chrysomma sinense siense	Yelloweyed Babbler	R	C.F.
		Turdoides caudatus	Common babbler	R	C
		Turdoides rnalcolmi	Large Grey Babbler	R	C
		Turdoies strlatus	Jungle Blabbler	R	C
		Alcippe poioicephala brucei	Quaker Babbler	R	C.F.
		Musciacapa pazva parva	Western Redbreasted flycatcher	M	O
	Sub-family - Musciapinae	*Muscicapa tickelliae thickialliae*	Tickell's Blue flycatcher	LM	O
		Muscicapa thalassina thalassina	Verditer flycatcher	M	O
		Muscicapa latirostvs	Brown flycatcher	LM	O
		Culicicapa ceylonensis calochrysea	Grey headed flycatcher	M	O
		Rhipidura albicollis albogularis	White spotted fantail	R	C
		Terpsiphorie paradisi paradisi	Paradise flycatcher	MR	O
		Monarcha azurea styani	Blacknaped flycacher	R	O
		Cisticola juncidis cursitans	Stveaked fantail warbler	BM	O
	Sub-family - Sylviinae	*Prinia hodgsonii hodgsonni*	Franklin's wren warbler	R	C
		Prinia subflava inarnata	Plain wren warbler	R	C
		Prinia socialis socialis	Ashy wren warbler	R	C
		Prinia sylvatica	Jungle wren warbler	R	C
Passerofpres		*Orthotornus sutorius gusuratus*	Tailor Bird	R	C
		Acrocephalus stentoreus brunnescens	Indian Great Reed warbler	MR	O
		Acrocephalus dumetorum	Blyth's Reed warbler	M	C
		Acrocephalus aqricola	Paddyfield warbler	M	O
		Hippolais caligata caligata	Booted Treewarbler	M	O
		Syivia curruca blythi	Lasser whitethroat	M	O
		Phylloscopus collybita	Brown leafwarbler or chiffchaff	M	O
		Phylloscopus tytleri	Tytler's leas warbler	M	O
		Phyllascopus inornatus	Yellow browed leaf warbler	M	O

		Phylloscopus biochiloides viridanus	Dull Green Leaf Warbler	M	O
		Erithacus avecicuc	Blue throat	M	C
	Sub-family - Turdinae	*Copsychus saularis saularis*	Magpie Robin	R	C
		Copsychus Malabaricus Malabaricus	Shama	R	O
		Saxicoloides fulicata intermedia	Indian Robin	R	C
		Monticola Cinclothynchus	Blue headed Rock Thrush	M	O
		Monticola Solitarius pandoo	Blue Rock Thrush	M	O
		Myiophonus horsfieldil horsfieldii	Malabar whisting Thrush	R	C
		Zoothera Citrina cyanotus	White throated Ground Thrush	R	O
		Turdus herula Nigropileus	Blackbird or Black caped	LM	O
		Anthus trivialis trivialis	Tree Pipit	M	C.F.
	Family - Motacillidae	*Anthus godlewskii*	Blythe pipit	M	OF
		Motacilla citreola citreola	Yellow headed wagtail	M	C.F.
		Motacilla alba dukhunensis	White or pide Wagtail	M	C.F.
		Dicaeum ezythrorhynchos ezythrorhynchos	Tickell's flower	R	C
		Dicaeum agile agile	Thickbilled flower pecker	R	O
	Family - Nectarinida	*Nectarinia Zeylonica sola*	Purplerumped sunbird	R	C
		Nectarinia lotenia hindustanica	Lotn's sunbird	R	O
Passerofpres		*Nectarinia asiatica asiatica*	Purple sunbird	R	C
		Aethopyga siparaja vigorsii	Yellow backed Sunbird	R	U
		Passer domesticus indicus	House Sparrow	R	C.F.
	Family - Ploceidae	*Petonia xanthocllis zanthocllis*	Yellow throated Sparrow	R	C.F.
	Sub-family - Passerinae	*Ploceus philippinus philippinus*	Baya or weaver Bird	BM	C.F.
	Sub-family - Ploceinae	*Estrilda amandava amandava*	Red Munid or Avadavat	R	OF
		Lonchura malabarica malabarica	White throated Munia	R	C.F.
		Lonchura striata striata	White backed Munia	R	C
		Lonchura Punetulata punctulata	Spotted Munia	R	C.F.
		Lonchura malacca malacca	Blackheaded Munia	R	OF

		Carpodacus erythrinus roseatus	Common Rosefinch or Scarlet Grosbeak	M	C.F.
	Family - Fringllidae	*Emberiza melanoc eahala*	Blackeaded Bunting	M	C.F.

Note: Abbreviations Used Are
R* Resident, M Winter Migrant
MR Migrant But Some Breed Here
LM Local Migrant
BM Breeding Migrant
PM Passage Migrant
S Stray or vagrant
RS Stray Record(s) But Resident In Neighbouring Areas
C Common
O Occasional
U Uncommon
F In Parties or Flocks

(15) Tungareshwar Wildlife Sanctuary (TWLS)

There is another ESA through which the proposed MAHSRC passes is TWLS. The TWLS falls between longitude $72^0$52' E to 73^0 E and latitude 17^0 00' N to $19^0$28' N. It is situated in Thane district of Maharashtra State and under the administrative control of Conservator of Forest and Director SGNP Division, Borivali (Mumbai). The total Notified area of Sanctuary is 85.70 sq. km. has been declared by Maharashtra Government Resolution No.WLP 10-02lCR-47/F-1 dated 24^{th} October 2003.The protected forest 917.305 ha. and unclassified forest 37.140 ha. In small patches around TWLS was handed over to Sanctuary staff for protection and management as per C.C.F. order dated 1.11.2003. Total area under management of TWLS is 95.24sq.km. ESZ is not undefined in the vicinity of TWLS.

Approach and Access

Large area is located on the eastern side of Mumbai-Ahemadabad National highway no. 8. The nearest Airport is Chatrapati Shivaji Airport-domestic and international at a distance of 45 km. Chatrapati Shivaji railway station terminus is roughly at a distance of 65 km. from this area. Vasai Road is nearest railway station of western railway which is approximately 10 km.

Significance

TWLS is a tiny green tract amid thickly populated near Mumbai and situated in Thane district. The area protects the catchments of Pelahar dam, Juchandra M.I.Tank which supplies water to Vasai and Nallasopara Municipal orporation.

Biological Values

The vegetation of this area ranges form semi evergreen forests to western sub-tropical hill forests. A large numbers of vertebrate and invertebrate species belonging to various classes and orders are only indicators of immense biological diversity of this area. This area is a natural home for many endangered faunal species.

Ecological Values

This area represents unique and fragile ecosystem and it belongs to one of the least represented biogeographic zone *i.e.* Malabar Coast of Western Ghats. This area acts as a carbon sink for Vasai, Nallasopara, Virar and Bhivandi Corporation.

Archeological and Religious Values

The ancient Tungareshwar Mahadev temple, Parashuram kund, Ishwarpuri Mahadev Mandir are located within the sanctuary. Lakhs of pilgrims visit Tungrashwer Mahedev Temple during Mahashivratri and auspicious Shravsn month. Small caves like structure chiseled in volcanic rocks are popularly known as Parashuram kund. Ishwarpuri Mahadev temple is situated in northern part of-sanctuary, near Chandip village.

Recreational and Educational Values

The unique location of this area makes it a center of attraction to thickly populated surrounding urban areas. A large numbers of visitors come to this area every year for religious reasons and hilly terrain covering up with thick forest and variety of fauna attracting researchers, and students. It is paradise for nature lovers. Visitors receive the message of wildlife conservation.

Biogeographical Zone

Biogeography is the study of the distribution of living organisms, and the natural processes that affect these distributions. It forms a basis to classify the biosphere into distinct physical and biological entities that contain distinct biotic communities. As every living species is an integral component of some ecosystem or ecosystems, it follows that its conservation is dependent on the survival of those ecosystems or biotic communities. Within the context of the World Conservation Strategy (lUCN, 1980), a system of selecting protected areas on the basis of well-founded bio-geographic principles is an important tool in evaLuating conservation efforts and for determining priorities for future action. The bio-geographic classification developed at the WII Dehradun has recognized 10 broad bio-geographical zones of India. Within these zones are 25 biotic provinces. TWLS belongs to 5 A - Malabar Plains. The present coverage of Malabar plains by protected areas in India is only 0.4 per cent against the proposed area of 1.1 % by Wildlife Institute of India, Dehradun in 1988.

Species of Conservation Importance

Dalbergia latifolia (Shisam) - It is sparsely found species of the TWLS. It is an evergreen species

Panthera pardus (Leopard or Panther)
Muntiaeus muntyale (Barking Deer or muntyle or Bhakar)
Bubo zeylonenisis.
Garcinia indica (Kokam)
Leopard
Barking Deer (Bhekar)
Brown fish owl
Mottled wood owl
Blue Mormon
Atlas Moth- The breeding site for atlas moth needs effective conservation.

Forest Types

According to the revised classification of forest types of India by Champion and

Seth, the forests of TWLS represent the following forest types:
3 B/C1 Southern moist teak bearing forests
3 B/C2 Southern moist mixed deciduous forests
8 A/C2 Western sub-tropical hill forests.

3 B/C1 Southern Moist Teak Bearing Forests

The moist teak bearing forests exists where the soil condition is relatively better. Density of the crop is generally above 0.4 and it goes upto 0.7. The forests are mostly concentrated in Chinchoti and Majivali rounds.

Important tree species of this forest type include *Tectona grandis* (Teak), *Lannes grandis* (Shemat), *Schleichera oleosa* (Koshimb), *Mimusops hexandra* (Ranjan), *Mangifera indica* (Amba), *Adina cordifolia* (Hed), *Pterocarpus marsupium* (Bija), *Bombax malabaricum* (Sawar), and *Syzygium cumini* (Jambul).

Important shrubs include *Carissa carandus* (Karvand), *Helicteres isora* (Murudsheng), *Adhatoda vasica* (Adulsa), and *Thespesia lampas* (Ranbhendl). The climbers are *Abrus precatorius* (Gum), *Climatis triloba* (Ranjai). *Zizyphus rugosa* (Toria). Bamboo species found in the forests are *Dendrocalamus strictus* (Man vef), *Bambusa arundinacea* (Katas). Important grass species are *Cynodon dactylon* (Harall), *Dicanthium anulatum* (Ranbangdl), *Coix gigantean* (Ranjondhala), *Eragrostis spp.* (Darbha), and *Panicum glabrum* (Varai).

3 B/C2 Southern Moist Mixed Deciduous Forest

The Southern moist mixed deciduous forests are profusely found in the area. Teak is occasionally found in low proportions. The density varies from 0.4 to 0.7. Clumps of manvel bamboo (Dendrocalamus strictus) and Katas Bamboo (Bambusa arundinacea) are found in the area. This forest type covers major part of the TWLS. The soil is deep, loamy, and generally rich in humus content. The semi evergreen species found in this forest type are mango, lokhandi, shendri, Khair, koshimb Bamboo is mostly localized along the nalla courses in Sativali and Majivali forests.

8 *AlC2* Western Sub-tropical Hill Forests

These are supposed to be few of the remnant patches of natural forests of higher elevations that occur on low lying hills.The western sub tropical hill forests are found in small patches at high altitude. Density is around 0.6. It is semi-evergreen type of forest with many evergreen species present in the crop. The Bamboo is typically absent. The floristic include, besides climbers. orchids and ferns .: Mangifera indica (Mango), Pongamia pinnata (Karanj), Gardenia indicia (Kokomo), Syzygium cuminii (Jarnbul), Calophyllum inophyllum (Undi), Sideroxyton tomentosum (Kate Kumbal). Ixora (Lokhandi). Murraya paniculata (Pandari), MelKo cylieu dactylon, Pisa sporadic patdus dosex are noticed at higher elevation. Innumerable species of grasshoppers, bugs, mosquitoes, beetles, termites', mantises. bees. hornets. wasps, cockroaches, cicadas, aphids, moths and butterflies. dragonflies and damselflies, leaf insects and stick insects are seen in the area. This area boasts to harbour almost 150 butterfly species. September to January is the best time to observe them. The vertebrate fauna of the area includes 43 species of Mammals, 250 species of birds, including the migratory land and water birds, 38 species of reptiles and 9 species of amphibian.

Mammals

Wildlife Habitats in TWLS supports a number of species of herbivores, carnivores and omnivores. Nearly 43 species of mammals belonging to 7 natural orders and 17 families are seen in the Sanctuary. Out of these 8 species are of "Endangered Status" and are included in the Schedule-1 and Part-II of Schedule-II of the Wildlife Protection Act, 1972. The status of endangered species reported in the TWLS is presented in Table 4.1.37.

Table 4.1.37: Endangered Faunal Species

Sr. No.	Common Name	Scientific Name
1	Panther or Leopard	Panthera pardus
2	Rusty-Spotted Cat	Felis rubiginosa
3	Jungle Cat	Felis chaus
4	Small Indian Civet	Viverricula indica
5	Common Palm Civet	Pardoxurus hermaphroditus
6	Mouse Deer	Tragulus meminna

Source: Management Plan of TGWLS

Small Herbivores

Small herbivores have not been studied in this area. The common is black-napped hare and crested porcupine.

Primates

Three species of monkeys *viz.* the Bonnet macaque, the Rhesus macaque and the common or Hanuman langur occur in the area. The Bonnet monkey is common in many parts.

Bats

This area has seven species of bat. Brosset (1962) studied extensively all the seven species of bats from this area and published his findings in his book - "The Bats of Central and Western India" (Published by the B.N.H.S.) His records **include all three species of fruit-eating bats (Megachiroptera).**

Avifauna

This area attracts summer and winter migratory birds. Two water bodies and Bazarmal plateu are ideal for bird watching. Black headed gulls, stilt, harriers etc. are commenly seen.In Compartment No. 1080, there is rocky place which is known as "Gidda kadak". Accouding to Shri Zanje, Round Officer, who is serving in this area for decades, "Gidda Kadak" rocks were nesting and perching site area of "Vultures" before 1995. Now hardly any vulture is seen in this area. This is subject matter of research.

Reptiles

The reptiles of the Sanctuary are covered under three orders and fourteen families. In the Sanctuary there are thirty-eight species of reptiles of which seven are of "Endangered Status" and are included in Schedule I and Part II of Schedule \I of Wildlife Protection Act.1972. These are given in Table 4.1.38.

Table 4.1.38: Endangered Reptiles

Common English Name	Scientific Name
Indian Rock Python	*Python molurus*
Dhaman or Rat snake	*Ptyas mucosus*
Indian Cobra	*Naja Naja*
Russel's Viper	*Vipera russelli*
Checkered keel back	*Natrix piscatar*
Common monitor	*Varanus monitor*

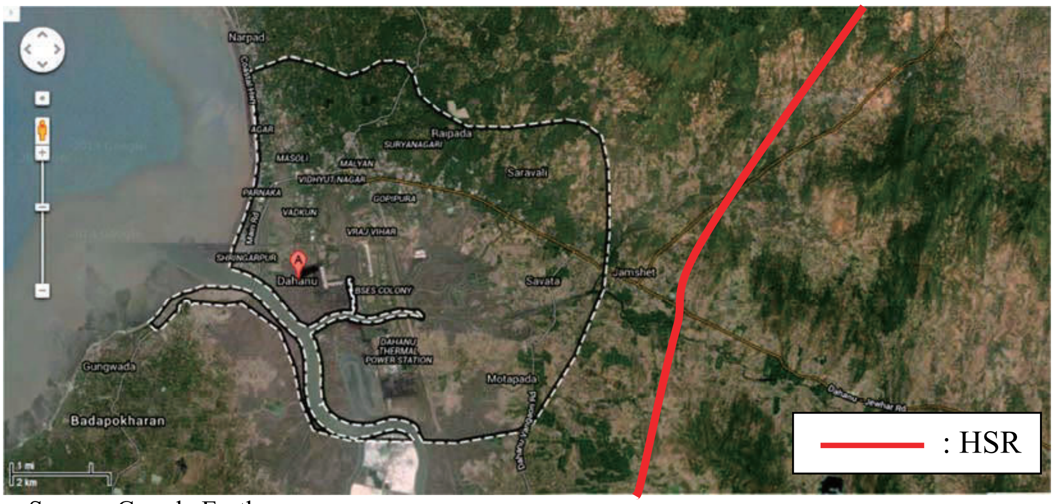
Source: Management Plan of TGWLS

Amphibian

The Tungar hill with its perennial pools of water have a variety of frogs and toads. Besides the common ones such as the tree frogs, the bullfrog and common toad, the uncommon toad (*Ramanella montana*) has been recorded in the area. In the cisterns in the rocks around the parshuram kund a few interesting species of frogs have been recorded including the six-toed frog and the skipper frog. Common during the rains are the extraordinary tadpoles of Rana loithi capable of swimming upstream. In all, nine species of amphibia belonging to four different families are seen in the area. Three species of tortoise occur in the Sanctuary. The eleven species of lizards found in this area includes the chameleon and the monitor lizard. There are twenty-three species of serpents seen in the Sanctuary. Out of which seven species are of "Endangered Status" and are included in t'1e Schedule-I and Part-II of Schedule-II of Wildlife Protection Act, 1972.

(16) Dahanu Taluka-ESA

Dahanu is a coastal city and a municipal council in Thane District on the western coast of Maharashtra State. It is located 120 km north of Mumbai. Topographically, Dahanu Taluka can be divided into a 10-12 km wide bandarpatti i.e a coastal belt of lowlands and flats extending from the coast to foot of the Sahyadari Range. The entire coastal belt with its rich natural resources, wetlands, mangroves and river deltas, forms a lucrative fishing area. The junglepatti or the forest belt, to the east of the foothills consists of tropical deciduous forests. The forest cover in Dahanu is still fairly high at 45%. Dahanu Taluka is one of the last green areas remaining in western Maharashtra and Gujarat. 32% of the total land of Dahanu Taluka is used for agriculture and horticulture, 24% is used for grazing cattle, 2.5% of the lands are wetlands and mangroves and 38% of the land comprises protected and reserved forests. These harbour a rich variety of wildlife including endangered species such as leopards, spotted deer, barking deer, and mouse deer. The coastal creeks and inlets at Dahanu are the feeding grounds for various species of fish. Dahanu, with its 35 km coastline acts like an oasis on the western coast of Maharashtra, sandwiched between Bombay and its sprawling suburbs to the south and the industrial cities of Vapi and Surat to its north. The Dahanu Taluka was declared as Ecologically Fragile Area vide its Notification S.O. 416 (E) dated 20th June 1991. In exercise of powers conferred by clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986, the Central Government, in consultation with the Government of Maharashtra, after considering the need for protecting the ecologically sensitive Dahanu Taluka, and to ensure that the development activities are consistent with principles of environmental protection and conservation, hereby declare Dahanu Taluka, District Thane (Maharashtra) as an ecologically fragile area and to impose restrictions on the setting up of industries which have detrimental effect on the environment. With the local groups in Dahanu seeking legal redress for consistent flouting of environmental laws, the Supreme Court in a landmark order, in 1996 recommended the setting up of a special Authority in "order to address the complex issues of planning and management of ecologically fragile areas".With the mandate to protect the ecologically fragile area of Dahanu taluka, specifically control pollution, consider and implement the 'Precautionary Principle' and the 'Polluter Pays' principle, the Authority was set up, headed by Justice Chandrashekhar Dharmadhikari (Read Notification setting up of the special Dahanu Taluka Environment Protection Authority, 1996). The Authority also has as its members, experts from the areas of hydrology, environmental engineering, urban planning, government representatives, *etc.* The map of Dahanu Eclogically Sensitive Area is shown in Figure 4.1.44.



Source: Google Earth

Figure 4.1.44: ESA of Dahanu

A unique prototype of a democratic institution set up to protect the ecology, natural resources and livelihoods of a region, the Dahanu Taluka Environment Protection Authority (DTEPA) has for a period of twelve years been more than just a watchdog institution. Recognising the ecological politics of control over natural resources, the Authority has unwaveringly stood by the principles of social justice and equitable rights for local communities. With its landmark orders and judgements, the DTEPA has contributed to the environmental discourse and debate in India. The Dahanu Authority continues to play an important role in ensuring that Dahanu Taluka becomes a model taluka of environmental protection and conservation. All projects to be located in Dahanu have to becleared by the DTEPA before obtaining a No Objection Certification from MPCB and other State departments to operate in Dahanu. Usually the Authority asks the Project proponents to undertake compensatory afforestation or provide basic amenities for the people of Dahanu for example a Trauma Centre. The Authority oversees the compensatory afforestation while the Forest Department implements it. While the project proponents provide the financial compensation, different government departments (such as the Forest Department, Revenue Department, Urban Development Department and Maharashtra Pollution Control Board) assist with implementing the compensatory tasks.

Source: Google Map

Figure 4.1.45: ESA of Dahanu-Map

Through various orders from January 1995 to October 1996, the Supreme Court directed the state government to indicate the number of industries that have been set up with the latter's permission along with information on safety and pollution control measures they employed from the date of the notification in Dahanu Taluka. It also directed the state government not to grant further permission or consent for setting up or the operation of any industry in the Dahanu area. Even industries that were given consent but hadn't started operating were asked not to operate till further orders. It asked the Central Pollution Control Board to inspect the 315 industries operating in Dahanu (including rubber balloon units and stone crushers) and submit a report within four weeks. As the CRZ Notification also applies to Dahanu, no construction of any kind was permitted within 500 meters of the high tide line by the Court.

(17) Mangrove Ecosystems

Mangrove ecosystems are highly productive but extremely sensitive and fragile. Mangrove forests are undergoing constant seasonal, short term, long term changes due to their dynamic nature and, to a greater extent, through various natural and biotic influences. Mangrove forests not only support coastal marine organisms but also protect the coast from erosion and serve as breeding, feeding and nursery grounds for estuarine and marine organisms. Additionally they are important for capture and culture fisheries. Therefore, monitoring mangrove habitat from time to time is an essential component in coastal marine ecological studies and coastal management. Traditional field surveys inside mangrove swamps are quite cumbersome. Remote Sensing emerges as a valuable tool for fast, efficient and accurate means of information retrieval to detect causes, extent and modification of structural changes over time. The information gained can be utilised for effective planning and management of mangrove forests. Mangroves, admittedly, are not only important but crucial for the coastal areas. Since estuarine areas are highly populated areas, the slightest ecological imbalance will take a heavy toll. They play a vital role in stabilizing these areas. No engineering and technological solutions can be sought for stabilizing these areas. Even if we negate all benefits of mangroves as forests, their value as "protector of shore-line" is enough to convince us for conserving them.
Mangroves are buffers between the land and the sea. Coastlines throughout the world are facing serious problems of coastal erosion and threat of rising sea levels due to

climate change, have increased the threats by several folds. To control such assault of the sea on land the nature has provided what is called as Mangroves, a tropical littoral ecosystem which is more dynamic than the sea itself.

Mangroves not only help in preventing soil erosion but also act as a catalyst in reclaiming land from seas. This is a very unique phenomenon, since there is a general tendency of water to engulf land. Mangrove forests and estuaries are the breeding and nursery grounds for a number of marine organisms including the commercially important shrimp, crab and fish species. Hence, loss of mangroves not only affects us indirectly but there are direct economic repercussions through loss of fishing industry.

Mangrove trees are also used for house building, furniture, transmission as well as telephone poles and certain household items. When these activities are managed appropriately it is possible to derive timber products from mangrove forests without significant environmental degradation, and while maintaining their value as a nursery and a source of food for commercial capture fisheries.

In many coastal areas including Gulf of Kutch, mangroves are a substitute for fodder. Thus mangroves reduce pressures from the scarce pasturelands.

Tannin is extracted from the bark of some mangrove species like Rhizophora mucronata, Bruguiera gymnorrhiza and Ceriops tagal. Indian mangrove trees have 35% tannin in their bark, which is higher compared to other countries. Extracts from mangrove bark are used by Indian fishermen to dye their fishing net and enhance its durability.

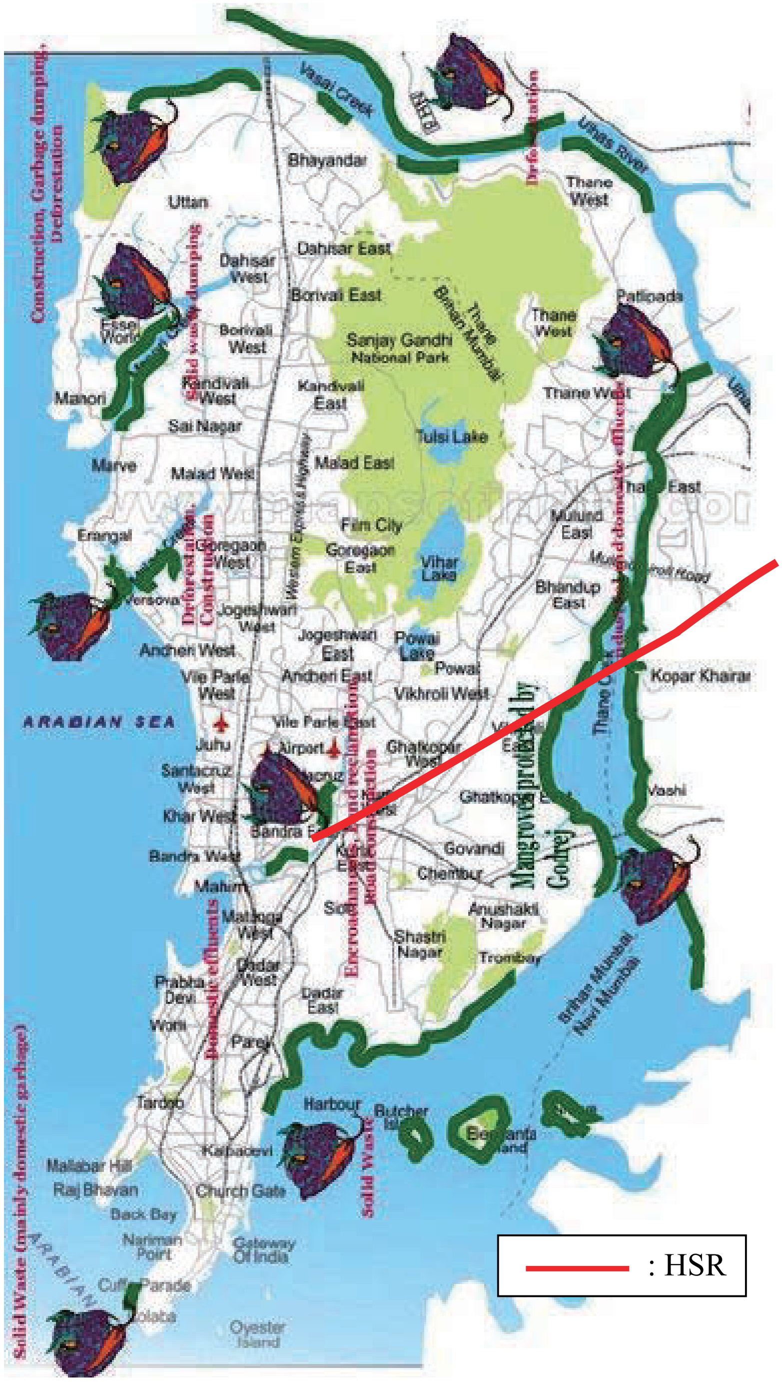
Mangrove trees have been the source of firewood in India since ancient time. Because of the high specific gravity of rhizophoraceous wood, the species of *Rhizophora*, *Kandelia*, *Ceriops* and *Bruguiera* are preferred for firewood. *Heritiera agallocha* is used for boat building, while *Avicennia spp*. and *Rhizophora spp*. are used for brick-burning. *Bruguiera spp.* are used to make poles. Honey collection from the mangrove forest is a promising business in India. It has been estimated that Sundarbans mangrove alone produce 111 tons of honey annually. Honey collected from Cynometra ramiflora and Aegialitis rotundifolia has a good market value and is in demand. *Avicennia spp.*, *Phoenix paludosa* and *Sonneratia caseolaris* are used for human consumption and as cattle feed. *Nypa fruticans* is tapped for an alcoholic drink. Leaves of *Nypa palm* are used for thatching of roofs, *Suaeda* and *Acrostichum* leaves are used as green vegetable. Above all, Mangroves are now looked after by scientists as saviors in the today's scenario of climate change. We all know that most of the coastal areas throughout the world are going to be affected by sea level rise due to global warming.The effects of which are already visible. Therefore, when most of the coastal areas will be flooded, mangroves can possibly provide a gene bank for cultivating salt tolerant species of crops which could be our future resource.

Importance of Mangroves

a. Buffer Zone between the land and sea;
b. Protect the land from erosion;
c. Play an invaluable role as nature's shield against cyclones, ecological disasters and as protector of shorelines;
d. Breeding and nursery grounds for a variety of marine animals;
e. Harbour a variety of lifeforms like invertebrates, fish, amphibians, reptiles, birds and even mammals like tigers;
f. Good source of timber, fuel and fodder;
g. Main source of income generation for shoreline communities like fisherfolk;
h. Save the marine diversity, which is fast diminishing;

i. Purify the water by absorbing impurities and harmful heavy metals and help us to breathe a clean air by absorbing pollutants in the air; and
j. Potential source for recreation and tourism.

In the present study, the proposed alighment passes through three-four patches of mangroves in Mumbai area. The mangrove map of Maumbai is illustrated in Figure 4.1.46. The status of mangroves in Mumbai region is described in the subsequent sections.



Source: www.mahaforest.nic.in

Figure 4.1.46: Mangrove Map of Mumbai

(18) Mangrove Status in Mumbai

Mumbai Historical records indicate that there were several islands around Mumbai during 1670. However, the Britishers, who were ruling the country, identified the importance of these islands for commercial purpose. They deforested the fringing mangroves and reclaimed these islands into one continuous landmass, which later came to be known as "Greater Bombay". Since then the developmental and subsequently population pressure rapidly increased and being the coastal area, it took the toll of mangrove land. During the process of deforestation and reclamation, a few mangrove patches are still left in the heart of the city, which proves that today's megacity had a luxuriant past of mangrove forests. Major mangroves are seen today in Mumbai along the Vasai Creek, Thane Creek, Manori and Malad, Mahim - Bandra, Versova, Siwari, Mumbra - Diva and few more places.

Mangroves represent the spirit of Mumbai – they are plucky survivors. But each day, millions of citizens in Mumbai pass these hardy plants imagining they are little more than dirty, muddy weeds growing pointlessly along the shoreline. How little people understand just how important mangroves are to the quality of life of the citizens of Mumbai. By trapping silt, mangroves maintain the integrity of Mumbai’s shoreline. This is a vital service to the city of Mumbai as it is very prone to erosion, having been built on reclaimed land that is battered by the sea on all three sides. The recent rains in Mumbai and the disaster that followed demonstrated the consequence of tampering with the ecology of fragile ecosystems like mangroves. Had Mumbai’s Mithi river and Mahim creek mangroves not been destroyed by builders, fewer people would have died and the property damage would have been dramatically less.

The Koli community in Mumbai worships mangroves because they know that these are breeding and nursery grounds for the marine organisms on which their sustenance depends. In the early nineties, perhaps over 37 sq. km. of mangroves existed in Mumbai, largely in the Thane creek, Mahim, Versova, Gorai and Ghodbunder, with sporadic patches in places such as Bandra, Malabar Hill and Colaba. Mumbai has probably lost 40 per cent of all its mangroves in the past decade or so, largely because of reclamation for housing, slums, sewage treatment and garbage dumps. Fortunately, thanks to the Godrej family, we still have excellent mangrove forests in Vikhroli (Link). Around 20 out of the 35 species of true mangroves found in India have been identified along the Maharashtra coast and 15 species of these are found in Mumbai.Because of the high salinity of the soil, something like 60 per cent of Mumbai mangroves comprise *Avicennia marina*. Nor surprisingly this species also tolerates pollution including heavy metals such as lead, mercury and chromium, all found in significant concentrations in the Mithi river.

Mangrove Destruction in Mumbai

Rapid developments like housing, industrialization, pollution and increasing population of Mumbai has resulted into degradation of mangroves. There are two important creeks, Vasai Creek towards north and Thane Creek toward south where luxuriant mangrove patches are still left. Otherwise the State Govt. agencies have failed to protect this important, productive mangrove ecosystem from building mafias. The worst affected area in Mumbai is the entire western front excepting Carter Road where the mangroves have grown and have also registered an increase in height in the last 10 years. This has been possible due to the participation of citizen’s forums fighting individually. In India, a legal protection is afforded to this ecosystem by way of legislation in the form of CRZ Notification. Recently Mumbai High Court has

ordered freeze on destruction of mangrove forests in Maharashtra and has banned construction within 50 metres of them. The court has also directed to notify mangrove areas as protected forests. Thus, there is already a mechanism provided for management of this ecosystem. Unfortunately, however many a times the legal provisions are not being enforced to curb the illegal activities. In such a situation, protection of the mangrove ecosystem is possible only through the participation of the local community and by building up pressure groups for ensuring management of this ecosystem and strict implementation of the legal provisions by the Government. Thereby, integrity of habitats critical for spawning, juveniles and feeding and for biodiversity, apart from ecological sustainability and community-sustainability could be maintained. In the past few years there has been an increase in the awareness of the people in Mumbai. Residents associations are coming together to spread this awareness. They realize that the rapid destruction of mangroves along the coast of Mumbai will have far-reaching effects on the city. The NGOs in Mumbai are making efforts to highlight the issues like land reclamation, CRZ notification and illegal destruction of the mangrove areas through the interventions of the local state government and a local bodies.
Figure 4.1.47 shows the mangrove ecosystem near Thane Creek and also the scenario of destruction.

Mangrove of Thane Creek

Land Reclamation

Source: Journal of Experimental Sciences 2011, 2(10): 73-77, ISSN: 2218-1768, Available Online:

Figure 4.1.47: Mangrove of Mumbai

<u>Mangroves Species in Mumbai</u>
The composition and Ecological Status of Mangroves in Mumbai Suburban Region, based on the visual interpretation and data collected from the various sources, like Mangrove Cell, Maharashtra Forest Department of Mumbai are presented in Table 4.1.39.

Table 4.1.39: Composition and Ecological Status of Mangroves

Mangroves Species	Gorai	Madh Island	Versova	Bandra	Mahul	Thane	Kopar Khairane
Rhizophora mucronata	A	LC	LC	A	A	A	A
Ceriops tagal	A	A	LC	A	A	A	A
Bruguiera cylindrica	A	A	C	A	A	A	A
Sonneratia apetala	A	R	R	C	A	VC	C
Avicennia marina	VC	VC	VC	VC	C	VC	VC
Aegiceras corniculatum	A	LC	LC	A	A	A	A
Acanthus ilicifolius	A	C	C	C	A	A	A
Avicennia officinalis	A	LC	LC	A	A	A	A
Rhizophora apiculata	A	A	LC	A	A	A	A
Bruguiera gymnorhiza	A	A	C	A	A	A	A
Kandelia candel	A	R	R	C	A	VC	C
Sonneratia alba	VC	VC	VC	VC	C	VC	VC
Sonneratia caseolaris	A	LC	LC	A	A	A	A
Lumnitzera racemosa	A	C	C	C	A	A	A
Excoecaria agallocha	A	C	C	C	A	A	A
Cynometra iripa	A	LC	LC	A	A	A	A
Heritiera littoralis	A	A	LC	A	A	A	A
Dolichandrone spathacea	A	A	C	A	A	A	A
Acrostichum aureum	A	R	R	C	A	VC	C
Xylocarpus granatum	VC	VC	VC	VC	C	VC	VC
Key: A-Absent, VC-Very Common, LC-Less Common, C-Common, R-Rare							

Source: Journal of Experimental Sciences 2011, 2(10): 73-77, ISSN: 2218-1768, Available Online

It is evident from the table, that the mangroves in Mumbai follow the same pattern of distribution as that of the common Indo-Pacific region in many of the isolated creeks. They were dominated by *Avicennia marina* near to the tidal waves, followed by *Rhizophora mucronata.* Progressing landward, the next zone was that of *Bruguiera cylindrica*, whereas *Acanthus ilicifolius* formed the fringe layer near to the land. Shrubs of *Ceriops tagal* and *Aegiceras corniculatum* were scattered intermittently among the other mangroves species. However, in the Thane region, an *Avicennia – Sonneratia* association was evident. The density of mangroves found in the Mumbai suburban region based on field studies is summarised in Table 4.1.40. Approximate overall density of mangroves around Mumbai is 23 individuals/25 m^2. Gorai region had the lowest density, while Thane region had the highest density.

Table 4.1.40: Density of Mangroves in Mumbai Sub-urban Region

Region	Gorai	Madh Island	Versova	Bandra	Mahul	Thane	Kopar Khairane
Density (trees/25 m^2)	9.50	25.00	21.80	27.50	17.50	30.00	28.50

Source: Journal of Experimental Sciences 2011, 2(10): 73-77, ISSN: 2218-1768, Available Online

Dozens of other species live in close proximity to mangroves. As their distribution is not confined to the saline zone and they are not blessed with the special adaptations characteristic of true mangroves, it is customary to classify them as Mangrove Associates. Examples are *Cerbera odollam*, *Salavdora persica* (meswalk), *Calophyllum inophyllum, Barringtonia racemosa, Thespesia populnea, Derris heterophylla, Pongamia pinnata, Caesalpinia crista, Clerodendrum inerme etc.* Mangroves are also a haven for a lot of living organisms including birds like Kingfishers, Herons, Flamingos, Painted Storks, Egrets, Rosy Starling, Brahminy Kite, Marsh Harrier and many more. They also attracts insects like ants, moths and butterflies, apart from Spiders, Amphibians (Frogs, toads *etc.*), Reptiles (Lizards, snakes, turtles, crocodile *etc.*) and aquatic fauna like Earthworms, Shells, Crabs, Mudskipper fish *etc.* Some of the mammalian diversity that mangrove forests support includes bats, mongoose, jackals, monkeys *etc.*

(19) Aquatic Ecology

There are nineteen rivers/nallahs/estuaries; small *nallahs* (rivulets) and ponds which cross the proposed alignment of Mumbai-Ahmedabad High Speed Railway Corridor represent the natural water aquatic ecosystems in the study area. Aquatic ecosystems provide home to many species including phyto-planktons, zooplanktons, aquatic plants, insects, molluscs, *etc.* They are organized at many levels from smallest building blocks of life to complete ecosystems, encompassing communities, populations, species and genetic levels. All aquatic ecosystems are generally colonized by the representatives of Arthropoda and Mollusca. Benthic invertebrates occupy the bottom of the water body. The functional role of benthic communities in the trophic dynamics of river ecosystem is well-acknowledged. The composition and distribution of benthic organisms over a period of time provide index of an ecosystem. In recent years, there has been greater emphasis worldover for better understanding of benthic environment. Clarke (1979) attempted to show the utility of molluscs in primary classification of the rivers in their various trophic status stages. Choubisa (1992) collected 32 species of molluscs from various freshwater habitats of southern Rajasthan. Harman (1974) has also pointed out that molluscs are bio-indicators of freshwater pollution. Molluscs are, thus, of great significance because they serve as food for fishes. Benthic organisms are detrivores and form an important link in the food chain. On account of their ability to convert low quality and low energy detritus into better quality food for higher organisms in the food web with the unfolding of importance of benthos in food chain, benthic productivity has been correlated with fish resources. Mollusc communities are good indicators of localized conditions, indicating the water quality.

1) The Objectives

The biological species are the best indicators of environmental quality. These include different species, such as, phytoplanktons, zooplanktons, benthos, fishes, *etc.* Studies on biological aspects of aquatic ecosystems are important part of any EIA in view of the need for conservation of environmental quality and safety of aquatic life. The study was carried out with a view to:

- inventorise different aquatic species [plankton (phyto-and- zoo), benthos and fishes];
- study of population density of the macro-invertebrates and ichthyofauna in the river;
- identify the feeding and breeding grounds of economically -important fishes; and
- assess the existing status of endangered species.

2) Planktons

<u>Importance and Roles</u>

Plankton is a term used to designate any organism that lives in water column and incapable to swim against water current. However, the use of term has been confined to designate only the microscopic and free floating organisms (Adoni 1985). Though many planktonic species are microscopic in size, planktons include organisms covering wide range of size. Plankton abundance and distribution are strongly dependent on factors, such as, ambient nutrient concentration, the physical state of water column, and the abundance of other plankton. Planktons are the basis of freshwater and saltwater ecosystem, meaning that the entire aquatic life is dependent on the energy and oxygen they provide. Phytoplanktons are the initial food source for every food chain and food web. Phytoplanktons respond immediately to the changes that take place in the surroundings and, hence, indicate the water quality. Fish production and composition are not only affected by primary production, but also by phytoplankton community structure (Cury *et al*. 2008). The maintenance of a healthy aquatic ecosystem depends on the abiotic properties of water and biological properties of the ecosystem (Harikrishnan et al. 1999). Plankton are primarily divided into the following broad groups:

i) <u>Phytoplanktons</u>

Phytoplanktons are chlorophyll-bearing suspended microscopic organisms, consisting of algae with representatives from all major taxonomic phyla; the majority of members belong to Chlorophyceae, Cyanophyceae and Bacillariophyceae (Adoni 1985). Phytoplanktons are, thus, photosynthesizing microscopic organisms that inhabit the upper sunlight-rich layer of almost all water bodies. Their unique ability to fix inorganic carbon to build up organic matter through primary production makes their study a subject of prime importance (Adoni 1985). The growth of phytoplankton population is dependent on light levels and nutrient availability.Phytoplanktons play an important role as food for herbivorous animals (primary production) and also acts as biological indicators of water quality in pollution studies (Bhoyar and Tamloorkar 2012).

ii) <u>Zooplanktons</u>

Zooplanktons are microscopic free-swimming animal component of aquatic ecosystems that feed on other planktons. They belong to wide array of taxonomic groups like protozoa, rotifera, cladocera, copepod, molluscs and chordate, *etc.* They constitute an important link between primary producers and consumers of higher order in aquatic food chain and web. Zooplanktons occupy central position between the autotrophs and heterotrophs, and form an important link in food web of the fresh water ecosystem (Joshi 2011).

3) Selection of Sampling Locations for Study

The aquatic ecology study was carried out by selecting nineteen sampling locations in the different surface water sources of the study area (ZOI) crossing the proposed alignment. Sampling depths ranged from 0.5 to 20 cm below the surface. Samples collected were then preserved in 4.0 per cent formaldehyde solution. The sampling locations are same as for the water quality.

4) Methodology

<u>Zooplanktons Study</u>

For zooplankton analysis, 20 litre of sub-surface water was strained through 53μ Nytex plankton net, and the concentrate was transferred to labelled plankton bottle after rinsing the net with distilled water. The planktons were immediately preserved in 4.0 per cent neutral formaldehyde solution for subsequent examination and quantification.

Zooplankton samples were observed in a sedimentation chamber under an inverted plankton microscope. Planktons were identified with the help of standard keys and references. For quantification, an aliquot of the concentrate was suitably diluted. After thorough mixing, 1.0 ml of the sample was transferred to a clean Sedgwick-Rafter cell and examined under the inverted microscope. Planktons were counted genera-wise. Three replicates were taken and averaged. The number of organisms per litre under each genus was calculated by the following formula:

No. of organism per litre = Vol. of Conc. (ml) x No. of organism/Vol. of Conc. examined (ml) x Vol. of water filtered (l)

Phytoplanktons Study

Similarly, for phytoplankton analysis, sub-surface water samples were taken directly from the sites in 100 ml sampling bottles, and preserved with Lugol's solution immediately. The samples were then centrifuged in the laboratory, followed by removal of desired amount of supernatant from the centrifuge tube to make the required concentration. Phytoplanktons were then analyzed using a compound microscope and haemocytometer in the concentrates. The number of organisms per litre was calculated as follows:

No. of organisms per litre = No. of organism x 107 / Concentration factor x No. of slides examined

Benthos Study

Sediment samples were taken from the bottom of river Yamuna for benthic organism study manually and brought to laboratory for analysis. The samples were washed through sieves to harvest the organisms and then preserved in sampling vials using formaldehyde as preservative. Benthic organisms were enumerated using a simple microscope/ hand lens.

Ichthyofauna Study

Information about the local fishes was collected through consultation with the local fishermen. Fish occurrence was determined by collecting samples using different fishing gears like cast net, scoop net, hand net, hook-line, pot and open local devices methods. Also, visual observations in different habitats were made. Fishes were identified upto the species level following Jayaram (1981), Menon (1987) and Talwar and Jhingran (1997). IUCN Red Data list (2006) was used to assess threatened, endangered and vulnerable species in the study area.

Macrophytes Study

Macrophytes were studied visually in the field. The diversity was noted following 1-5 grade point scale.

Phytoplanktons Productivity Study

It was measured using Light and Dark bottle method of Gaarder and Grann. The dissolve oxygen measurement for this purpose was done by Winkler's Iodometric method.

5) Plankton Population Analysis: Results

Phytoplankton

The phytoplankton population recorded in fresh water, seawater and estuarine water in the post-monsoon season is presented in Table 4.1.41 and the species identified for phytoplankton are presented in Table 4.1.42.The population dynamics of fresh water were estimated by phytoplankton count in no/ml which was observed as 180. The percentage composition of groups revealed highest amount of Bacillariophyceae (clean water indicator) (38.75%) followed by Chlorophyceae (polluted water indicator) (35.50%). The dominance of Bacillariophyceae in the fresh water samples and low phytoplankton count and low value of Palmer's Pollution Index (5) indicate oligotropic water quality. But the presence of Chlorophyceae (35.50 %) in small amount, indicate poor productivity due to limited enrichment with Shannon Winer Index as 2.750. The estuarine water showed low algal count (64-165/ml), low PPI values (6-7), showing oligotropic nature of water. However, sub-dominance of Chlorophyceae and Cyanophyceae and medium value of SWDI (2.250-3.250) indicated presence of some amount of nutrients in sea water.

Table 4.1.41: Phytoplanktons recorded at sampling locations

Sampling Locations	Phytoplan-kton no./m l.	Percentage Composition of Algal Group				Shannon Weiner Diversity Index*	Palmer's Pollution Index (PPI)*
		Bacillari o-phyceae	Cyano-phyceae	Chloro-phyceae	Eugleno-phyceae		
Estuary Water							
SW1	64	50.00	20.00	30.00	-	2.250	18
SW2	106	45.00	35.00	20.00	-	3.250	16
SW3	165	48.50	21.50	30.00	-	2.500	10
Fresh Water							
SW4	180	38.75	25.75	35.50	-	2.750	5
SW5	165	37.50	22.50	40.00	-	2.850	2
SW6	174	36.50	25.60	37.90	-	2.540	4
SW7	172	28.50	22.70	48.8	-	2.150	1
SW8	168	35.00	38.50	26.5	-	2.350	4
SW9	150	24.00	22.60	53.4	-	2.150	2
SW10	166	38.00	37.50	24.5	-	2.225	3
SW11	150	37.25	25.55	37.2	-	2.110	4
SW12	145	38.24	22.90	38.86	-	1.550	5
SW13	142	29.80	28.50	41.7	-	1.250	5
SW14	144	28.90	29.10	42.0	-	1.345	4
SW15	156	34.55	26.50	38.95	-	2.115	5
SW16	164	35.00	27.60	37.4	-	1.550	6
SW17	168	37.44	25.40	37.16	-	2.110	4
SW18	170	38.22	25.30	36.48	-	2.500	5
SW19	179	37.85	25.45	36.7	-	2.250	5

Source: EIA Study team-GPSTPL

*** Ranges of Palmer's Pollution Index**

< 15 Indicate absence of organic pollution
15-20 Indicate presence of organic pollution
<20 Indicate presence of high organic pollution

*** Ranges of Shannon Wiener Diversity Index**

<1 Highest level of impact

1-3 Medium level of impact

>3 Indicates absence of any impact

Table 4.1.42: Phytoplankton Species

Bacillariophyceae	Cyanophyceae	Chlorophyceae
Consinodiscus sp.	*Anabaena* sp.	*Actinastrum* sp.
Cyclotella sp.	*Gleocapsa* sp.	*Chlorococcum* sp.
Cymbella sp.	*Lyngbya* sp.	*Cosmarium* sp.
Diatoma sp.	*Nocticuluca* sp.	*Gyrosigma* sp.
Leptocylindrus sp.	*Phormidium* sp.	*Penium* sp.
Melosira sp.	*Tribonema* sp.	*Selenastrum* sp.
Navicula sp.		*Spirulina* sp.
Nizschia sp.		*Spirogyra* sp.
Pinnularia sp.		*Staurastrum* sp.
Rhizosolenia sp.		*Triceratum* sp.
Synedra sp.		*Volvox* sp.
Surirella sp.		
Thalassiosira sp.		

Source: EIA Study team-GPSTPL

Zooplankton

Among the zooplanktons, Rotifera, Copepoda, Cladocera and Nematoda were observed. The zooplankton population recorded in the post-monsoon season is presented in Table 4.1.43 and the species identified are presented in Table 4.1.44. The density of zooplankton ranges between 58-78 cells /l. The SWDI and zooplankton count varies between 0.00-1.55 and 90-2500 nos/m^3 respectively. The percentage composition reveals dominance of Copepoda and Rotifera.

Table 4.1.43: Zooplanktons recorded at sampling locations

Sampling Locations	Zooplank-ton no./m^3	Percentage Organism in Group				Shannon Weiner Diversity Index*
		Copepoda	Rotifera	Cladocera	Nematoda	
Estuary Water						
SW1	1200	50	30	10	10	1.15
SW2	1100	45	35	20	-	1.55
SW3	2500	75	15	10	-	0.85
Fresh Water						
SW4	90	-	100	-	-	0.00
SW5	80	-	85	-	2	0.00
SW6	75	-	95	-	4	0.00
SW7	78	35	53	12	6	0.38
SW8	72	30	65	5	-	0.34
SW9	70	25	67	8	-	0.00
SW10	71	34	55	11	-	0.02
SW11	76	-	94	6	-	0.00
SW12	78	-	96	4	8	0.00
SW13	85	-	92	8	-	0.08
SW14	88	20	70	10	5	0.12
SW15	82	10	84	6	4	0.18
SW16	80	15	80	5	6	0.65
SW17	86	10	86	4	-	0.20

SW18	84	14	84	2	-	0.18
SW19	81	19	81	-	-	0.00

Source: EIA Study team-GPSTPL

*** Ranges of Shannon Wiener Diversity Index**
<1 Highest level of impact
1-2 Medium level of impact
>2 Indicates absence of any impact

Table 4.1.44: Zooplankton Species Identified

Phylum	Copepoda	Rotifera	Cladocera	Nematoda
Species	*Cyclops sp.*	*Keratella* sp.	*Daphnia* sp.	*Rabditiform larva*
	Cypris	*Brachionus* sp.		
	Herpactocoid	*Monostyla* sp.		
	Nauplius larva	*Lepadella* sp.		
	Ostracod	*Euchlanis* sp.		
		Filinia sp.		
		Aspelta sp.		

Source: EIA Study team-GPSTPL

6) Primary Productivity

Primary production is the basis of the entire biogenous cycle in aquatic environment, the organic substance produced by photoautotrophic organisms (plants, algae *etc.*). The Gross Primary Productivity represents the amount of plant substance produced per unit of time and space. *In situ* measurement was performed by measuring the oxygen production in light and dark bottles exposed in the water during a known period of time. Gross primary production rate was measured for all nineteen sites in mg C/m^2/day. The intensity of the primary production reflects the trophic level of water. The primary productivity examined at all the statiosn during post-monsoon season is given in Table 4.1.45

Table 4.1.45: Primary Productivity

Stations	Gross Primary Productivity (mg C/m^2/day)
	Post-Monsoon Season
SW1	85.4
SW2	82.6
SW3	98.7
SW4	78.6
SW5	72.5
SW6	70.5
SW7	68.5
SW8	72.5
SW9	74.6
SW10	72.8
SW11	68.9
SW12	71.2
SW13	72.6
SW14	74.5
SW15	70.6
SW16	72.9
SW17	75.8

SW18	77.8
SW19	78.6
Average	**76.3**

Source: EIA Study team-GPSTPL

7) Benthic Macro-Invertebrates

The benthic macro-invertebrate communities or mud-dwelling invertebrate communities have proved useful in the biological surveillance of water quality in streams reservoirs. These are sufficiently large (> 0.5mm) to make them clearly observable without the aid of microscope. They dwell at least part of their life-cycle in association with the substratum of aquatic habitat. Benthic macro-invertebrates are recognized as very important group in water quality surveillance as these organisms which move from the site of pollution and show considerable sensitivity to pollution (Mason, 1987). The Benthic macro-invertebrates recorded in the sediment sample are given in Table 4.1.46.

Table 4.1.46: Benthic Micro-Invertibrates

Sea Anemones	Crustaceans	Bivalves	Gastropodes
Cribrnopsis sp.	*Aceteus* sp.	*Perna viridis.*	*Bullia lineolata*
Anemonis sp.	*Emerita ulthusia*	*Meretrix* casta	*Trochus radiatus*
Neoaiptasis sp.	*Squilla* sp.	*paphia* sp.	*Umbonium vestiarum*
	Eurydice sp.	*Donax scortium*	*Turbo intercostalis*
Polychaeta	*Cirolona* sp.	*Gifrarium* sp.	*Babylonia spirata*
Glycera alba	*Mysidopsis* sp.	*Sunetta* sp.	*Terebra* sp.
Nereis costae	*Dotilla* sp.	*Modiolus* sp.	
Cirratula sp.	*Ocypode* sp.	*Gelonia* sp.	**Pisces**
Dioptera sp.	*Portunis* sp.	*Crassostrea cucullata*	*Therapon jatbua*
Prionospio sp.	*Charybdilis* sp.	*Solen truncata*	*Batrachus* sp.
Terebella sp.	*Thalamita* sp.	*Triceratum* sp.	
Onuphis sp.	*Uca* sp.	*Volvox* sp.	
Syllis sp.	*Scylla serrata*		**Echinderma**
Thalassiosira sp.	*Penaeus* sp.		*Ophiactis* sp.
	Thallasina sp.		

Source: EIA Study team-GPSTPL

8) Ichthyofauna

The study area represents the amalgamation of coastal part of Maharashtra and mainland of Gujarat one. It has sea fishing as prominent activity. Fishing season commences from September and lasts till the end of May. There is practically no fishing in monsoon except in the creek, estuary and rivers. The important fishes found in the coastal stretch of the study area are presented in Table 4.1.47

Table 4.1.47: Fishes Found in the Coastal Stretch

Scientific Name	Common Name	Scientific Name	Common Name
Family : Orectolobidae		***Family : Dussumieridae***	
Chiloscyllium indicum	Sunera	*Dussumieria acuta*	Toak
Chiloscyllium griseum	Sunera	*Dussumieria hasselti*	Toak
Family : Carcharinidae		***Family : Engraulidae***	
Galeocerda cuvieri	Waghbeer	*Coillia dussmieri*	Mandeli
Scoliodon sorrakowah	Sonmushi	*Thrissocles malabarica*	Kati

Eulamia melanoptera	Balda	*Thrissocles mystax*	Dandetar
Eulamia limbatus	Mushi	*Thrissocles setirostris*	Dandetar
Family : Sphyrnidae		*Thrissocles dussmieri*	Kati
Sphyrna blochii	Kanmushi	*Thrissocles purava*	Kaval
Sphyrna tudes	Kanmushi	*Anchoviella tri*	Dindas
Sphyrna zygaena	Kanmushi	***Family : Chirocentridae***	
Family : Rhinobatidae		*Chrocentrus dorab*	Karli
Rhynchobatus djiddensis	Lanj	***Family : Synodontidae***	
Rhinobatos granulatus	Ranja	*Trachinocephalus myops*	Chor-Bombil
Family : Pristidae		***Family : Plotosidae***	
Pristis cuspidatus	Nali	*Plotosus anguillaris*	Nar Shingali
Family : Trygonidae		*Plotosus canius*	Nar Singali
Gymnura poesilura	Pakat	***Family : Tachysuridae***	
Pastinachus sephen	Pakat	*Osteogeneiosus militaris*	Shingala
Amphotistius zugel	Pakat	*Tachysurus sumatranus*	Shingala
Himantura uarnak	Waghya pakat	*Tachysurus caelatus*	Shingala
Family : Myllobatidae		*Tachysurus nenga*	Shingala
Aetobatus narinari	Bolad	*Netuma thalassinus*	Shingala
Aetomylaeus nichofii	Bolad	*Ariodes dussumieri*	Shingala
Aetomylaeus maculates	Waghali	*Pseudarius jella*	Shingala
Family : Mobulidae		*Hexanematichthys sona*	Shingala
Mobula diabolus	Bolad	***Family : Muraenidae***	
Family : Torpedinidae		*Muraenosox talabonoides*	Wam
Narke dipterygala	Bijali	*Family : Ophichtyidae*	
Family : Elopidae		*Ophichthys bora*	Mundri
Elops machnata	---	*Family : Belonidae*	
Megalops cyprinoids	Chiral	*Tylosurus strongylurus*	Tali
Family : Clupeidae		*Tylosurus choram*	Tali
Kowala coval	Bhiljee	*Family : Hemirhamphidae*	
Tenuahsa	Bhing	*Hyporhamphus xanthopterus*	Sumb
Tenualosa ilisha	Palla	*Hyporchmphus gaimardi*	Sumb
Saurida tumbli	Chor-Bombil	*Hemiramphus cantori*	Sumb
Harpodon nehereus	Bombil	*Hemirhamphus leucopterus*	Sumb
Sardinella longiceps	Tarli, Haid	*Family : Exocoetidae*	
Sardinella fimbriata	Pedwa	*Cypselurus poecilopterus*	Pakharu
Euplatygaster indica	Gubar		
Family : Ggaddidae		*Family : Carangidae*	
Asthenurus atripinnis	---	*Caranx carangus*	Shitap
Family : Fistularidae		*Decaterus russelli*	Shitap
Fistularia villosa	---	*Chrinemus lysan*	Dogal
Family : Syngnathidae		*Chorinemus tol*	Dogal
Hippocampus trimaculatus	Ghoda Masa	*Chorinemus tala*	Dogal
Hippocampus kuda	Ghoda Masa	*Trachinotus blochi*	Ladgoo
Family : Cyprinodontidae		*Trachinotus bailloni*	Lodgoo
Panchax lineatus dayi	Piku	*Family : Rachycentridae*	
Family : Sphyraenidae		*Rachycentron canadus*	Modusa
Sphyraena jello	Badvi	*Family : Menidae*	
Family : Mugilidae		*Mene maculate*	Chand
Mugil kelaartii	Boi	*Family : Lutianidae*	
Liza waigiensis	Boi	*Lutianus johni*	Chavri Tamb
Mugil carinatus	Boi	*Lutianus arentimaculatus*	Tamb
Mugil cunnesius	Boi	*Lutianus rivulatus*	Tamb
Mugil cephalus	Boi	*Lutianus chrysotaenia*	Tamb
Family : Latidae		*Lutianus quinquillneatus*	Tamb
Lates calcarifer	Jitada	*Family : Nemipteridae*	
Ambassidae		*Nemipterus japonicus*	Bamnl.

Ambassis commersoni	Kachki	*Family : Gerridae*	
Family : Serranidae		*Gerremorpha setifer*	Charbat.
Promicrops lanceolatus	Gobra	*Pertica filamentosa*	Charbat.
Epinephelus dicanthus	Gobra	*Genes abbreviatus*	Charbat.
Epinephelus malabaricus	Gobra	*Family : Leiogmathidae*	
Epinephelus maculates	Gobra	*Secutor insidiator*	Kap.
Epinephelus undulosus	Gobra	*Leiognathus brevirostris*	Kap.
Epinephelus tauvina	Gobra	*Leiognathus bindus*	Kap.
Family : Theraponidae		*Leiognathus fasciatus*	Kap.
Therapon jarbua	Naveri	*Family : Plectorhynchidae*	
Autisthes puta	Naveri	*Pseudopristipoma nigra*	Harvil.
Eutherapon theraps	Daddada	*Spilotichthys puctus*	Harvil.
Family : Apogonidae		*Family : Sciaenidae*	
Apogon fasciatus	Kombada	*Johnius dussumieri*	Dhoma
Apogon frenatus	Kombada	*Johnius diacanthus*	Ghal.
Archamia macropterus	Kombada	*Johnius sina*	Ghal.
Apogon kalasoma	Kombada	*Otolithus argenteus*	Dhoma, Dhodi
Family : Sillaginidae		*Otolithus rubber*	Dhoma
Sillago sihama	Renvi	*Otolithoides brunneus*	Koth.
Family : Lactariidae		*Family : Mullidae*	
Lactarius lactarius	Sundala	*Upeneus sulphureus*	Chiri.
Family : Carangidae		*Family : Pempheridae*	
Magalaspis cordyla	Katkata Bangada	*Pempheris moluca*	Kombada.
Atropus atropus	Kat Bangada	*Family : Ephippidae*	
Selar kalla	Kat Bangada	*Ephippus orbis*	Chand.
Selar mate	Kat Bangada	*Family : Scorpaenidae*	
Selar djeddaba	Shitap	*Pterois russelli*	Kombada.
Caranx melampygus	Shitap	*Scorpaenopsis*	Kombada.
Carangoides malabaricus	Shitap	*Scorpaenopsis cirhosus*	Kombada.
Family : Platacidae		*Family : Platycephalidae*	
Platax teira	Kawala	*Suggrudus macracanthus*	Mench.
Family : Drepanidae		*Thysanophrys crocodiles*	Mench.
Drepane punctata	Chand	*Family : Psettodidae*	
Family : Scatophagidae		*Psettodes erumei*	Bhakas.
Scientific Name	Common Name	*Scientific Name*	Common Name
Scatophagus argus	Wada	*Family : Bothidae*	
Family : Pomacanthidae		*Pseudorhombus triocellatus*	Lep.
Pomacanthodes annularis	Chand.	*Pseudorhombus arsius*	Lep.
Pomacanthodes nicobariensis	Chand.	*Family : Soleidae*	
Family : Chaetodontidae		*Zabrias quagga*	Lep.
Heniochus acuminatus	---	*Solea ovata*	Lep.
Linophora auriga	Chandwa	*Family : Cynoglossidae*	
Linophora vagabunda	Chandwa.	*Paraplagusia bilineata*	Lep.
Chaetodontops collaris	Chandwa.	*Cynoglossus brachycephalus*	Lep.
Family : Cichlidae		*Cynoglossus brevis*	Lep.
Etoplus suratensis	Kalundar	*Cynoglossus semifasciatus*	Lep.
Family : Pomacentridae		*Cynoglossus lingua*	Lep.
Abudefduf saxatilis vaigiensis	Kavandal.	*Family : Mastacembelidas*	
Abudefduf leucopleura	Kavandal.	*Mastacembelus armatus*	Ahir.
Family : Labridae		*Family : Echeneidae*	
Platyglossus dussumier	Popat.	*Echeneis naucrates*	Lachuk
Family : Acanthuridae		*Family : Triacanthidae*	
Acanthurus gahm	Suraiya.	*Triacanthus brevirostris*	Bail.
Family : Trichicuridae		*Family : Ostraciontidae*	

Thichiurus savala	Wagti.	*Lactoria cornuta*	Gai.
Trichiurus haumela	Bala.	*Family : Lagocephalidae*	
Family : Scombridae		*Torquigener oblongus*	Kend.
Rastrelliger kanagurta	Bangda.		
Family : Kalsuwonidae			
Auxis thazard	Gedri.		
Euthynnus affinis	Bibbya Gedar.		
Family : Thunnidae			
Neothunnus macropterus	Khavlya Gedar.		

Source: Department of Fisheries, Thane

9) Spawning and Breeding Areas

Being the coastal stretch, fishing activity is prominent in the region. There is commercial fishing ground near Thane and Vasai creeks. There are spawning and breeding areas of fishes along the coastal stretch.

(20) Conclusions

The main findings of the study can be outlined as follows:

- In general the area around the proposed alignment in the Mumbai region harbours moderate diversity of marine organisms including the phyto and zooplankton, algae, higher plants, mangroves and faunal groups such as benthic organisms, macrofauna with the avian richness.
- The water is mesotrophic and shows sign of pollution especially in the Ulhas river.
- The fish catch is low near the shore, which increases towards mouth of the sea with increase in depth.
- In the Gujarat mailnad region, the water is free from any pollution except the river Sabarmati in Ahmedabad.

4.1.12 Water Use

The surface water resources within the study area primarily consist of the rivers, estuaries, sea and various small nallahs and distributaries. A large number of confined water bodies such as open well, ponds also form a part of the surface water resources. The main source of drinking water in the study area are open well and tube well. The ground water sources comprise of a number of open dug wells, tube wells and bore wells.

Increased irrigation activities and growth of population have made a noticeable impact on the demand for fresh water in the study area. Presently, there are a number of industries in the study area which consume lion's share of the water. The primary water use in the study area is for irrigation, domestic purposes, industries and livestock.

Water of open water bodies (rivers and channels) throughout Maharashtra and Gujarat is used extensively for navigation, fisheries, and agriculture, domestic and for industrial uses. The people settled on river sides usually depend on water for domestic uses that include potable water collection, bathing and washing and cattle washing. Though at present most of the rural people collect their drinking water from shallow and deep tube wells sunk on homesteads or at agriculture land. Fishermen and boatmen communities living along the river banks adopted fishing and boat plying as professions. Presently many industries that developed on river adjacent sites and banks make industrial use of river water. Unfortunately wastes and effluents from many of these industries are discharged in the rivers. Part of the solid wastes from these industries and from urban/rural residences are also discharged untreated in open water bodies that pollute the river water. Water in pond, lake, and harbor are used for stocking capture fish and for captive fisheries by a section of people. Water in closed water bodies like the open water bodies are used for domestic and limited agricultural uses. The closed water bodies are extensively used for fish culture. Fish culture has presently turned as a sustainable source for supply of fish to the local markets and generated work for a large number of poor. The seasonally flooded croplands though shallowly flooded are also used for short rotation fresh water fishes culture while shrimps and white fish species are cultured in brackish water zones. Cat fish culture in transplanted paddy fields as alley generates additional income to the farmers and play roles in biological control of insects. The rivers are used for navigation, fisheries, industrial uses and irrigation purposes. The boatmen, fishermen and poor people use river water for domestic purposes.

4.1.13 Protected Areas

The entire stretch of the proposed alignment can be divided into two segments in accordance with the ecological characteristics of the region. The first stretch falling in the Maharashtra region shows rich diversity comprising of SGNP, ESA like Dahanu, TWLS, forests, creek, mangroves whereas, the stretch falling in Gujarat region comprises of mainly agricultural land with flat topography.The study area is delineated 250 m either side from centerline of the proposed alignment. Mangroves are found scattered along the friges of the Ulhas and Vaitarni rivers and mouth of the estuary. Mangroves are the evergreen forests having restricted distribution to coasts only –rather endemic to coastal areas. Their plant species accumulates the toxic air pollutants where as animal population consumes organic waste. They are particularly valuable as repositories of many unique varieties of floral and fauna. The mangroves are transitional ecosystem between land and sea. The represent combine status of adjoining ecosystems. Most of the land in the study area (Zone of Influence) is used for agriculture and horticultural practices. The list of the ESAs notified in both the provinces-Maharashtra and Gujarat are depicted in Table 4.1.48. The list of forests (Reserved, Protected and Unscheduled) through which the proposed MAHSRC alignment passes is presented in Table 4.1.49. Some protected areas shown in following table are covered in the world heritage “Western Ghats.” It is no impacts because “Western Ghats” are away from planned HSR route and outside this project area.

Table 4.1.48: List of Protected Areas

Sl. No.	Status	Name	Concerned District
MAHARASHTRA			
1	National Park	Chandoli NP	Sangli
2		Gugamal NP	Amravati
3		Nawegaon NP	Bhandara, Gondia
4		Pench NP	Nagpur
5		Sanjay Gandhi（Borivilli）NP	Mumbai, Thane
6		Tadoba NP	Chandrapur

1	Wildlife Sanctuary	Amba BarwaWLS	Buldhana
2		Andhari WLS	Chandrapur
3		Aner Dam WLS	Dhule
4		Bhamragarh WLS	Gadchiroli
5		Bhimashankar WLS	Pune, Thane, Raigad
6		Bor WLS	Wardha, Nagpur
7		Chaprala WLS	Gadchiroli
8		DeolgaonRehkuri WLS	Ahmednagar
9		Dhyanganga WLS	Buldhana
10		Gautala WLS	Aurangabad, Jalgaon
11		Great Indian Bustard WLS	Solapur, Ahmednagar
12		Jaikwadi WLS	Ahmednagar, Aurangabad
13		KalsubaiHarishchandragad WLS	Ahmednagar
14		Karnala WLS	Raigad
15		Karanjasohol WLS	Akola
16		Katepurna WLS	Akola, Washim
17		Koyana WLS	Satara
18		Lonar WLS	Buldhana
19		Malvan Marine WLS	Sindhudurg
20		MayureswarSupe WLS	Pune
21		Melghat WLS	Amravati
22		Nagzira WLS	Bhandara
23		NaigaonMayur WLS	Beed
24		NandurMadhameshwar WLS	Nashik
25		Narnala WLS	Akola
26		Painganga WLS	Yeotmal, Nanded
27		Phansad WLS	Raigad
28		Radhanagari WLS	Kolhapur
29		Sagareshwar WLS	Sangli
30		Tansa WLS	Thane
31		Tipeshwar WLS	Yeotmal
32		Tungareshwar WLS	Thane
33		Yawal WLS	Jalgaon
34		YedsiRamlinGhat WLS	Osmanabad
35		Wan WLS	Amravati
36	Conservation Reserve	Bhorkada	Nashik
37	ESA	Dahanu Taluka ESA	Thane
GUJARAT			
1	National Park	Vansda NP	Navasari、Valsad
2		Blackbuck NP	Bhavnagar
3		Gir NP	Junagadh
4		Marine (Gulf of Kachchh) NP	Jamnagar
1	Wildlife Sanctuary	BalaramAmbaji WLS	Banaskantha
2		Barda WLS	Rajkot,Jamnagar, Porbandar
3		Gaga Great Indian Bustard WLS	Jamnagar
4		Gir WLS	Junagadh、Amreli
5		Girnar WLS	Junagadh
6		Hingolgadh Nature Reserve WLS	Rajkot
7		Jambugodha WLS	Panchmahal
8		Jessore WLS	Banaskantha
9		Lala Great Indian Bustard WLS	Kachchh
10		Kachchh Desert WLS	Kachchh

11		Khijadiya WLS	Jamnagar
12		Marine (Gulf of Kachchh) WLS	Jamnagar
13		Mitiyala WLS	Amreli
14		Nal Sarovar Bird WLS	Ahmedabad, Surendranagar
15	Wildlife Sanctuary	Narayan Sarovar (Chinkara) WLS	Kachchh
16		Paniya WLS	Amreli
17		Porbandar Lake WLS	Porbandar
18		Purna WLS	Dangs
19		RamparaVidi WLS	Rajkot
20		Ratanmahal WLS	Dahod
21		Shoolpaneswar (Dhumkhal) WLS	Narmada、Bharuch
22		Thol Lake WLS	Mahesana
23		Wild Ass WLS	Kachc, Rajkot, Mahesana, Patan, Banaskantha, Surendranagar
24	Conservation Reserve	Chharidhand	Kachchh

Source: Protected Area Network India
Maharashtra Environment Department homepage
Maharashtra Forest Department homepage
Gujarat Forests & Environment Department homepage
Gujarat Forest Department homepage

Table 4.1.49: List of Forests (RF, PF & Unscheduled) in HSR Alignment

Sl. No.	Name of the Forest	Province/District	Chainage (in km)
1	Vadghar Reserved (Forest & Open Jungle)	Maharashtra/ Thane	35.433-45.359
2	Sarjmori Reseved (Forest & Open Jungle) Thane	Maharashtra/ Thane	50,671-54.612
3	Sativli (Reserve Forest)	Maharashtra/ Thane	55.203-59.000
4	Khairpada (Forest & Open Jungle)	Maharashtra/ Thane	65.536-67.262
5	Kasarali (Forest & Open Jungle)	Maharashtra/ Thane	69.642-71.315

(1) Important Bird Area (IBA)

A program of Important Bird Areas is the project that BirdLife International i.e. international bird protection organization jointly implements with member organizations of more than 100 countries. The purpose of this program is that "important natural environment considered the birds as an indicator" is selected based on Universal criteria (IBA criteria) and not only individual habitat but also all habitat are conserved throughout the world as a network. IBA in Maharashtra and Gujarat are shown in Table 4.1.50 and Table 4.1.51 in the vicinity of the planned HSR route is fill. In the vicinity of the planned HSR route there are four IBAs, however, there is no possibility of modification by this project because they are away from the planned HSR route.

Table 4.1.50: IBA list in Maharashtra

No	Name of the Place	Area
1	Bhimashankar Wildlife Sanctuary	13,078 ha
2	Burnt Island (Bandra) Vengurla Rocks	6 ha
3	Gangapur Dam and grasslands	4,000 ha
4	INS - Shivaji and adjoining areas, Lonavla	1,000 ha
5	Jaikwadi Wildlife Sanctuary	34,105 ha
6	Jawaharlal Nehru Bustard Sanctuary	849,644 ha
7	Koyna Wildlife Sanctuary	42,652 ha
8	Mahul - Sewree Creek	1,000 ha
9	Melghat Tiger Reserve	115,003 ha
10	Nagzira Wildlife Sanctuary	15,281 ha
11	Nandur Madhmeshwar Wildlife Sanctuary	10,012 ha
12	Navegaon National Park	13,388 ha
13	Ozar and adjoining grassland	20,000 ha
14	Radhanagari Wildlife Sanctuary	35,116 ha
15	Sanjay Gandhi National Park	10,308 ha
16	Tadoba National Park and Andhari Tiger Reserve	11,655 ha
17	Taloda Reserve Forest	33,400 ha
18	Tansa Wildlife Sanctuary	30,481 ha
19	Thane Creek	12,200 ha
20	Toranmal Reserve Forest	26,000 ha

Source: Bird Life International

Table 4.1.51: IBA list in Gujarat

No	Name of the Place	Area
1	Banni Grassland and Chhari Dhand	384,700 ha
2	Bhal area	259,000 ha
3	Charakla Saltworks	8,200 ha
4	Flamingo City	750,722 ha
5	Gir National Park and Wildlife Sanctuary	141,213 ha
6	Kaj Lake	720 ha
7	Khijadiya Lake and Bird Sanctuary	1,650 ha
8	Marine National Park and Wildlife Sanctuary	45,792 ha
9	Nalsarovar Wildlife Sanctuary	12,082 ha
10	Naliya Grassland	50,000 ha
11	Rampura Grassland	2,000 ha
12	Saltpans of Bhavnagar	357,540 ha
13	Thol Lake Wildlife Sanctuary	700 ha
14	Velavadar National Park	3,408 ha
15	Wetlands of Kheda	8,700 ha
16	Wild Ass Wildlife Sanctuary	495,371 ha

Source: Bird Life International

4.2 Social and Cultural Characteristics

4.2.1 Current Land Use

Land is the most vital resource for sustenance of life and degradations of land due to industrialization; urbanization and population growth is a matter of concern. Therefore, it is necessary to establish the existing land use pattern to optimize the land use as well as minimize degradation due to the developmental activities. The basic idea of land use classification for the purpose of EIA study is to define the distribution of the existing land according to its actual use. The land use pattern indicates the manner in which different parts of land in the study area is being utilized or un-utilized. It is an important indicator of environmental health and human activity and a degree of inter-play between these two. Even though the soil quality, water availability and climatic conditions have strong influence on agriculture and vegetation, the human activity may alter the natural environment to a large extent to suit human needs. Unsuitable land use often triggers rapid environmental deterioration and disturbs ecological balance. The objectives of the present study are:

- To map the study area (250 m both sides from the centre line of the proposed alignment of High Speed Railway Corridor) with respect to various land use/land cover categories; and
- To identify the sensitive area within the Zone of Influence (ZOI).

The land use pattern of the ZOI as deciphered from satellite imageries listed in Table 3.2.1.3 with limited ground truth verifications has been established. Ground and ancillary information have been used to identify the sensitive places within ZOI around the proposed alignment with the help of toposheets of Survey of India of the respective area. The land use/land cover map has been developed based on the satellite imagery.

Land Use/Land Cover Classification Based on Remote Sensing Data

Method of Data Preparation

Remote Sensing technology has emerged as a powerful tool in providing reliable information on various natural resources at different levels of details in a spatial format. It has played an important role in effective mapping and periodic monitoring of natural resources environment. With the availability of high resolution remote sensing data, newer areas of remote sensing applications have been identified, techniques of data processing have been improved and computer based image processing systems have become more effective.

Data Used

Maps in order to strengthen the baseline information on existing land use pattern, the following data between the latitude 23° 5'39.87"N longitude 72°34'33.56"E and latitude 19° 3'58.52"N longitude 72°51'47.59"E has been interpreted. (The grid size is 7.4 km x 7.4 km) were used.

A. Remote Sensing Data

Details of the LANDSAT 7 ETM+ imagery used for delineation of the land use pattern of the ZOI is presented in Table 4.2.1.

Table 4.2.1: Details of the Satellite Imagery Acquired for Data Interpretation

Sl. No.	Path	Row	Date
1.	514	309	Dec. 2013
2.	510	292	Jan. 2014
3.	508	290	Jan. 2014
4.	208	291	Jan. 2014
5.	514	307	Dec. 2013
6.	514	308	Jan. 2014
7.	514	310	Dec. 2013
8.	512	300	Jan. 2014
9.	515	309	Jan. 2014
10.	509	291	Jan. 2014
11.	509	292	Jan. 2014
12.	511	293	Jan. 2014
13.	511	294	Dec. 2013
14.	511	295	Jan. 2014
15.	511	296	Jan. 2014
16.	511	297	Jan. 2014
17.	511	298	Jan. 2014
18.	511	299	Jan. 2014
19.	511	300	Dec. 2013
20.	512	299	Jan. 2014
21.	512	301	Jan. 2014
22.	512	302	Dec. 2013
23.	513	301	Jan. 2014
24.	513	302	Jan. 2014
25.	513	303	Dec. 2013
26.	513	304	Jan. 2014
27.	513	305	Jan. 2014
28.	513	306	Jan. 2014
29.	513	307	Jan. 2014
30.	513	308	Jan. 2014
31.	515	308	Jan. 2014
32.	515	310	Dec. 2013

B. Collateral data

Toposheet No. of Survey of India used for verification of the land use pattern data derived from the processing of satellite imagery is presented in Table 4.2.2.

Table 4.2.2: Details of the Toposheet of Survey of India

Sl. No.	Survey of India Toposheet No.
1.	46-A-12
2.	46-B-9
3.	46-B-13
4.	46-B-14
5.	46-F-2
6.	46-F-3
7.	46-F-4
8.	46-F-7
9.	46-F-8
10.	46-G-1
11.	47-A-14
12.	47-A-15
13.	47-A-16
14.	47-B-13

15.	46-G-2
16.	46-G-3
17.	46-C-15
18.	46-C-16
19.	46-D-13
20.	46-D-14
21.	46-D-15
22.	46-D-16
23.	46-H-2
24.	47-A-9
25.	47-A-10
26.	47-A-11
27	47-A-13

Methodology

Salient features of Methodology are given below:

- Acquisition of Satellite data;
- Data loading;
- Data processing;
- Geo-referencing Image;
- Rectification;
- Classification;
- Ground Truthing / field checks using Global Positioning System; and
- Masking.

The spatial resolution and the spectral bands in which the sensor collects the remotely sensed data are two important parameters for any land use survey. LANDSAT 7 ETM+ data offers spatial resolution of 23.5 m with the swath width of 141 x 141km. The data is collected in four visible bands namely green (Band 20) (0.52-0.59µ), red (Band 30) (0.62-0.69µ), near Infrared (NIR) (Band 40) (0.77-0.89µ), Short wave infrared band (Band 60) (1.55-1.75µ) with orbit repeat period of 24 days (three days revisit). The shapes, sizes, colours, tone and texture of several geomorphic features are visible in LANDSAT 7 ETM^+ data. Four spectral bands provide high degree of measurability through band combination including FCC generation, bands rationing, classification etc. These features of the LANDSAT 7 ETM^+ data are particularly important for better comprehension and delineation of the landuse classes. Hence, LANDSAT 7 ETM^+ data has been used for land use mapping. The digital image processing was performed on EARDAS IMAGINE 9.1 System on high-configured computer. This software package is a collection of image processing functions necessary for pre-processing, rectification, band combination, filtering, statistics, classification *etc.* Apart from contrast stretching, there are large numbers of image processing functions that can be performed on this station. The satellite data from the compact disc is loaded on the hard disk and by studying quick looks (the sampled image of the appropriate area), the sub-scene of the study area is extracted. Supervised classification using all the spectral bands can separate fairly accurately, the different land use classes at level II on the basis of the spectral responses, which involve the following three steps:

- Acquisition of ground truth;
- Calculation of the statistics of training area; and
- Classification using maximum likelihood algorithm.

The training areas for classification were homogeneous, well spread throughout the scene with bordering pixels excluded in processing. Several training sets have been used through the scene for similar land use classes. After evaluating the statistical parameters of training sets, the training areas were rectified by deleting no congruous training sets and creating new ones.

Results and Discussions

Land use refers to man's activities on land, utilitarian in nature whereas land cover denotes the vegetation cover, water body cover and artificial constructions *etc.* The land use/land cover classification system standardized by Department of Space, Government of India, for mapping different agro-climatic zones has been adopted. This classification system has six major land use classes at Level I (Table 4.2.3). The six major classes at Level I was further enunciated in the following six categories:

Built up land/Settlements: This comprises areas of land covered by man made structures and habitations.

Agricultural land: Land used for production of food, fiber, crop and plantation.

Forest/ Vegetation: This includes land such as dense or sparse evergreen forests, deciduous Forests and degraded forests.

Wastelands: Land having potential for development of vegetation cover but not being used due to constraint includes salt affected land, eroded land and water logged areas.

Water bodies: Area persistently covered by water such as rivers/streams, reservoirs / tanks, lakes / ponds and canals.

Others/Miscellaneous: Grassland and snow covered land are included in this category.

Land use / land cover distribution in the study area has been estimated as given below using the above classification system and digital analysis techniques. It is the colour-coded output (Figure 4.2.1) of supervised classification with colours assigned to various classes for the ZOI of MAHSRC covering Gujarat and Maharashtra. In this image, colours are assigned to various classes as given in legend .The land use / land cover classification indicates that about 94.86 % of the ZOI is covered by agricultural land followed by water bodies 2.92 %.

Areas under Different Land Use

The land use classes with the areas falling under the respective classification are presented in Table 4.2.3.

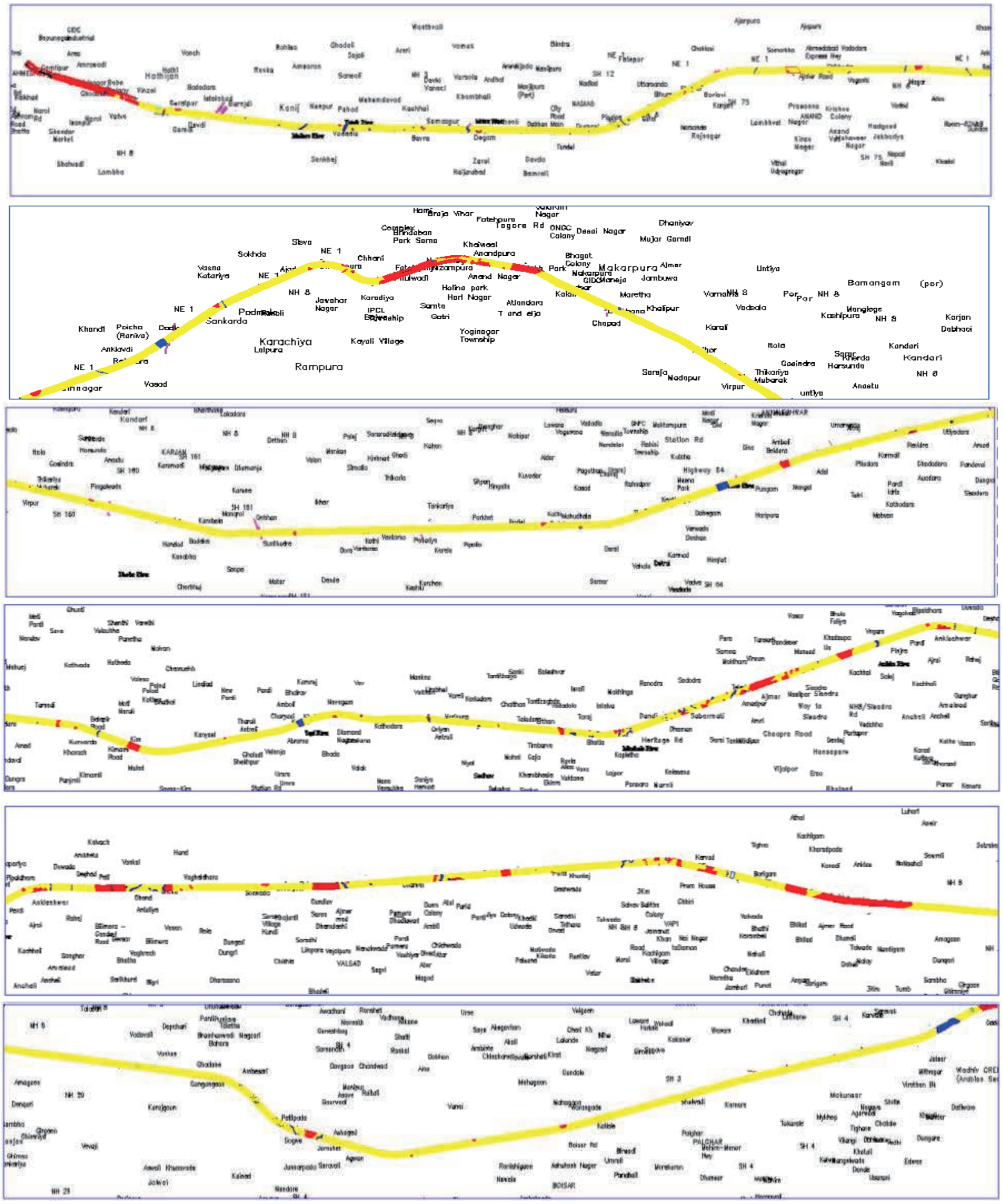
Table 4.2.3: Land Use/Land Cover of the Study Area Based on Satellite Imagery

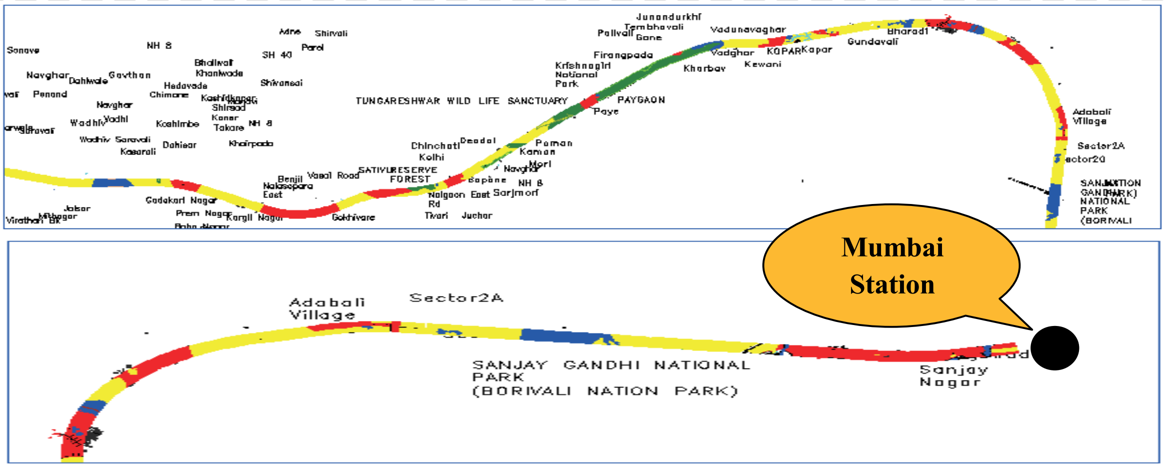
Land Use Class	Area in Ha	%
Agriculture	23644.94	94.86
Water bodies	726.81	2.92
Settlements	225.12	0.90
Vegetation	137.72	0.55

Waste Land	166.68	0.67
Miscellaneous	25.64	0.10
Total	**24926.91**	**100**

Source: EIA Study Team GPSTPL based on Satellite Imagery

It can be inferred from the Table that the ZOI of the proposed alignment in most of the stretches passes through the barren land or arable land. At few places of the entire alignment it crosses through sparse settlement and also eco-sensitive zones like TWLS and SGNP. The proposed alignment does not involve eviction of habitation throughout its stretches (Mumbai to Ahmedabad).





Source: EIA Study Team GPSTPL based on Satellite Imagery

Figure 4.2.1: Land Use/Land Cover Map of ZOI

4.2.2 Cultural Heritage

India is one of the oldest civilizations in the world, spanning a period of more than 4000 years, and witnessing the fusion of several customs and traditions, which are reflective of the rich culture and heritage of the Country. The History of India begins with the birth of the Indus Valley Civilization, more precisely known as Harappan Civilization. It flourished around 2,500 BC, in the western part of South Asia, what today is Pakistan and Western India. The Indus Valley was home to the largest of the four ancient urban civilizations of Egypt, Mesopotamia, India and China. Nothing was known about this civilization till 1920s when the Archaeological Department of India carried out excavations in the Indus valley wherein the ruins of the two old cities, viz. Mohenjodaro and Harappa were unearthed. The ruins of buildings and other things like household articles, weapons of war, gold and silver ornaments, seals, toys, pottery wares, etc., show that some four to five thousand years ago a highly developed Civilization flourished in this region. India colourful and vibrant, a land as diverse as its people. A mosaic of faiths, cultures, customs and languages that blend harmoniously to form a composite whole. One of the world's oldest living civilizations - which gave to the world - the concept of zero, the primordial sound *Aum*…Yoga, and Buddhism. Today - the India of the 21st century is carving a niche for itself as an economic superpower. The *Maharajas* of yore have yielded place to some of the wealthiest tycoons of the world. Our country has achieved remarkable breakthroughs in missile, aeronautical and space technologies. India has become the hub of Information technology in south Asia, owing to its vast pool of English-knowing technical manpower. Enchanting India…a treasury of art, architecture; philosophy, classical dances and music; the mesmerising Taj, the eternal Ganges, the Thar desert, the mighty Himalayas, tropical rainforests, the Cape where the waters of three seas mingle…the rich fauna-snakes, peacocks, Royal Bengal Tiger, lions…India is all of these and more. India-perennial, yet young and dynamic; come discover its myriad moods- in the pages of **India Heritage**-a website whole-heartedly devoted to providing a kaleidoscopic view of this wonderland to the world. Although there is no such historical and cultural heritage protected by law with direct impact to the planned route, several heritages are found in its vicinity. The major temples, ruins and cultural heritages between Mumbai and Ahmedabad are listed in the Table 4.2.4.

Table 4.2.4: Cultural Heritage of Maharashtra and Gujarat

Sl. No.	Type	Name	Disrict
MAHARASHTRA			
1	Fort	Bandra Fort	Mumbai Suburban
2		Dharavi Fort	Mumbai Suburban
3		Mahim Fort	Mumbai City
4		Shivadi Fort	Mumbai City
5		St. George fort	Mumbai City
6	Historical Monument	August KrantiMaidan	Mumbai City
7		Gateway of India	Mumbai City
8	Temple/Shrine	BangangaTalav	Mumbai City
9	Station	**Chhatrapati Shivaji Terminus (formerly Victoria Terminus)**	**Mumbai City**
GUJARAT			
1	Fort	Dabhoi	Vadodara
2		Surat Castle	Surat
3	Grave Site	Badshah no Hajiro	Ahmedabad
4		Dutch Tomb	Ahmedabad
5		European tombs	Surat
6		Heritage Walk	Ahmedabad
7		QutbuddinHajira	Vadodara
8		Rani no Hajiro	Ahmedabad
9		Tomb KoriatMakbaro	Surat
10	Haveli	Heritage Walk	Ahmedabad
11		Tambekar Wada	Vadodara
12	Historical Monument	AmrutvarshniVav	Ahmedabad
13		Ancient Step Well	Ahmedabad
14		Ancient Talav	Vadodara
15		Bhadrakali Mata Stepwell	Kheda
16		Kabirvad	Bharuch
17		KadiaDungar Caves	Bharuch
18		Khan Talav Having Water Let out	Ahmedabad
19		MotaTodavaliVav	Kheda
20		Vav (Step Well)	Kheda
21		VidyadharVav	Vadodara
22		VoriVav	Kheda
23	Palace	Palaces	Vadodara
24		Utelia Palace	Ahmedabad
25	Pilgrim Place	Ancient Masjid (Mosque)	Ahmedabad
26		Dakor	Kheda
27		Kayavarohan	Vadodara
28		Malsar	Vadodara
29	Pilgrim Place	Shuklatirth	Bharuch
30		Udwada	Valsad
31	Temple / Shrine	KirtiMandir	Vadodara
32		Kund&Toran	Kheda
33		Nyaya Mandir	Vadodara
34		Radhakrishna Temple	Valsad
35		Ranmukteshwar Temple	Vadodara
36		Surya Narayan Temple	Vadodara

*Note: World heritage is shown in **bold**.*

Description of the selection criteria of the World Heritage

Criterion (ii): ChhatrapatiShivaji Terminus (formerly Victoria Terminus) of Mumbai (formerly Bombay) exhibits an important interchange of influences from Victorian Italianate Gothic Revival architecture, and from Indian Traditional buildings. It became a symbol for Mumbai as a major mercantile port city on the Indian subcontinent within the British Commonwealth.

Criterion(iv): Chhatrapati Shivaji Terminus (formerly Victoria Terminus) is an outstanding example of late 19th century railway architecture in the British Commonwealth, characterized by Victorian Gothic Revival and traditional Indian Features, as well as its advanced structural and technical solutions.

Source: Archaeological Survey of India
UNESCO World Heritage Centre
The Official Website of Gujarat Tourism, Govt. of Gujarat
The Official Website of Maharashtra Tourism, Govt. of Maharashtra

4.2.3 Indigenous/Ethnic Minority

Maharshtra

According to the provisional results of the 2011 national census, Maharashtra is the second most populous state in India with a population of 112,374,333 (9.28% of India's population) of which male and female are 58,243,056 and 54,131,277 respectively. The total population growth in 2011 was 15.99 percent while in the previous decade it was 22.57 percent. Since independence, the decadal growth rate of population has remained higher (except in the year 1971) than the national average. For the first time, in the year 2011, it was found to be lower than the national average. The 2011 census for the state found 55% of the population to be rural with 45% being urban based. The state has a large number of Uttar Pradesh diaspora. Marathis comprise the majority of the population. Bihari, Gujarati, Punjabis, Parsis, Marwari, Kannada and Tamil minorities are scattered throughout the state. The 2011 census found scheduled castes and scheduled tribes to account for 11.8 and 8.9% of the population respectively. The scheduled tribes include *adivasis* such as Thakar, Warli, Konkana and Halba. At the 2001 census (Religious Composition data of 2011 Census has not been declared yet), Hinduism was the principal religion at 80.34% of the total population, while Muslims accounted for 10.6% of the total population, being the second-largest community and the largest minority group. Buddhism accounts 6% in Maharashtra's total population. 5,838,710 people are followers of Buddhism in Maharashtra as per 2001 census. Sikhism, Christianity and Jainism constituted 0.22%, 1.09%, 1.34% respectively. Maharashtra had the largest concentration of Buddhists at 58.3% – 73.4% of the total Buddhists in India reside in Maharashtra. The state contributed 9.28% to India's population. The list of the ethnic minority present in Maharashtra is given in Table 4.2.5.

Table 4.2.5: List of Castes & Tribes in Maharashtra

Other Backward Class		
No. & Name of the Caste	**No. & Name of the Caste**	**No. & Name of the Caste**
1. Alitkar	130. Bandi	234. Chintala
2. Bagdi	131. Rachbandhiya	235. Dakaleru
3. Deleted	132. Rangari	236. Darji
4. Badia	133. Ragrez	237. Deleted
5. Bajania	134. Raot, Ravat, Rautiya	238. Kurba, Kurubar
6. Bajigar	135. Rangrez (Bhavsar, Rangari)	239. Harkantra,Mangeli, Mangele, Page, Sanduri
7. Buttal	136. Deleted	240. Wats, Bhadwal, Rajak
8. Bhand, Chappar Bhand	137. Deleted	241. Dommara
9. Bavaiya or Targal	138. Deleted	242. Gaadaaba or Godaba
10. Bhavin	139. Deleted	243. Gangani
11. Bhisti or Pakhali, Sakka	140. Sanjogi	244. Garodi

12. Deleted	141. Saraaniya	245. Goller
13. Bari or Barai	142. Deleted	246. Godala
14. Beriya	143. Deleted	247. Habura
15. Besdeva	144. Deleted	248. Harani
16. Bhadbhunja, Bhujaya, Bhunjva, Bhurji, Bharadbhunja, Bhuranji, Bhunj	145. Suppaling	249. Hil- Redidas
17. Bhanta	146. Sutharia (In Sindh)	250. Deveri
18. Bhat Bhaat	147. Sahis,Saes,Shis	251. Winkar, Wanya, Bankar
19. Chamatha	148. Sapera	252. Kachiya
20. Chandalgada	149. Shilavat	253. Korach, Padlor
21. Charan or Gadhavi	150. Singiwala	254. Kalal, Kalar, Lad, Ladwak, Goud Kalal, Shivhare - excluding Lad Barahman * (comment added in June 2008)
22. Charodi	151. Deleted	255. Kandel
23. Chippa, Chhipa	152. Deleted	256. Kasera
24.Das or Dangadidas	153. Shimpi, Idrisi/Darji,Sai Sutar, Jain Shimpi, Shravak Shimpi, Shetwal, Shetval, Saitwal, Saitval, Meru Shimpi / Meru Kshatriya Shimpi *	257. Kasai, Kasab, Kureshi
25. Davgar	154. Sonar	258. Katipamula
26. Depala	155. Tandel	259. Kirar
27. Devali	156. Deleted	260. Christian Koli
28. Devdig, Devadiga *	157. Targala	261. Korachar or Korave
29. Deleted	158. Thetwar	262. Kodaku with Korava
30. Dholi, Hashmi/ Dafali	159. Thoria	263. Komakapu
31. Deleted	160. Tambat,Twashta Kasar, Kasar	264. Kondu
32. Deleted	161. Thogati	265. Lakhari
33. Deleted	162. Wadi	266. Lohar-Gada, Dodi, Panchal, Khatawali
34. Deleted	163. Deleted	267. Chunari
35. Gandharap	164. Wansphod, Hindu Dharkar	268. Deleted
36. Gujrath Bori	165. Wadhai (Sutar) (deleted * in June 2008)	269. Mahil
37. Deleted	166. Warthi	270. Maidasi
38. Deleted	167. Deleted	271. Mazwar
39. Gadhavi	168. Yerkula	272. Matiyara, Matihara
40. Deleted	169. Agari, Agale or Kalan	273. Mankar khalu
41. Deleted	170. Bhavsar	274. Mondiwar, Mondiwara
42. Gochaki	171. Kurhin,Shetti	275. Munda
43. Gurav	172. Nilgar, Nili, Nirali	276. Hajam, Kalseru, Navliga, Kanshi, Nabhik, Nai, Waland
44. Deleted, Gavlan (Gawalvansh) (deleted * in June 2008)	173. Koskanti Devang (No.CBC-1468/ 83475/j, dt.19.01.1968)	277. Pachbhotala, Pachbotala
45. Gavandi, Gurjar - Kadia	174. Sutar, Sudhar, Vaadhhai *, Baadhhi *, Badhhai *, Baadhhai *, Wadhhi *, Wadi *, Wadhai * and Sub-Castes- Jhade Sutar *,	278. Padampari

	Panchal Sutar *	
46. Halepaik	175. Phutgudi	279. Bhisti
47. Deleted	176. Deleted	280. Pamula
48. Deleted	177. Pinjara, Pinjari, Mansuri	281. Panchama
49. Jagiyasi	178. Deleted	282. Panda
50. Jajak	179. Bhilala	283. Phar
51. Jatiya	180. Deleted	284. Pinjari
52. Jatigar	181. Teli, Tilwan-teli, Maratha-teli, Tarane-teli, Deshkar-teli, Erandel -teli, Lingayat-teli,Ekbail- teli, Donbail-teli, Ekbahiya-teli, Savteli	285. Purwali
53. Javheri, Parjiya Soni	182. Mali (Sub castes- Phulmali, Phule, Halade, Kacha, Kadu, Bawane Adhprabhu, Adhsheti, Jire,Unde, Lingayat Mali, etc), Bagwan (Muslim), Bharat Bagwan, Marar, Maral, Kosare, Gase Wanmali, Savatamali, Pachkalasi,Waadwal, Chowkalashi, Raen (Bagwan), Pachkalsi similar sub castes- Somvanshiya Pathare Kshatriya *, Pathare Kshatriya Pachkalsi * Pathare Kshatriya *, Sutar *, Sartikar *, Ghodekhau *, S.K.P. *	286. Rachbhoya
54. Deleted	183. Lonari	287. Rautiya
55. Jogin	184. Deleted	288. Sangari
56. Johari	185. Talwar-Kanade/Kanadi *(rectified in 2008)	289. Santal
57. Julaha - Ansari	186. Raghvi (Dist-Vidarbh)	290. Saunta or Sonta
58. Jangam	187. Bhandari,Bawarchi/ Bhatiyara (Muslim)	291. Savteli
59. Deleted	188. Ganali or Gandali	292. Sare
60. Jadi	189. Powar or Pawar, (Powar or Pawar surnames), Bhoyar, Bhoir, Bhovir	293. Bhavgar, Shiv shimpi, Namdev
61. Deleted	190. Kathar, Kathar-wani, Kanthhar wani, Vaishya wani, Kulwant wani, Nevi (excluding Lingayat wani or Ladwani) - added:- Dhakad *, Mitkari Wani *, Wani *, Boral *, Borul *, Boraal *, Borad *, Tamboli *	294. Shingdav or Shingadya
62. Kammi	191. Momin, Ansari	295. Sindhur
63. Kapadi	192. Fakir Bandarwala	296. Sore
64. Deleted	193. Deleted	297. Sunna
65. Khati	194. Ghadashi	298. Sunnai
66. Deleted	195. Tamboli, Muslim religious Pan pharosh * (rectified in June 2008)	299. Bhadai
67. Deleted	196. Christians - Converted from Schedule caste.	300. Ganninga, ganchi
68. Deleted	197. Lanzad, Lazad *	301. Thotewadu
69. Kongadi	198. Yadav	302. Timali
70. Korchar	199. Ladsi	303. Walwai
71. Deleted	200. Deleted	304. Wadder (Kalawader or Pathroad)
72. Kachora	201. Gabit	305. Wanadi

73. Kadaira	202. Atar	306. Yenadiwadas
74. Kamati	203. Aundhiya	307. Yergolawad or Thella pamalwadas
75. Kasabi	204. Baadak, Baarav	308. Odewar
76. Deleted	205. Bagaloo	309. Manyar (Bangalwala), Maniyar, Maneri
77. Deleted	206. Marwar Bawori, Marbar Waghri	310. Jaatgaar
78. Deleted	207. Udasi, Deleted	311. Karadi
79. Deleted	208. Balsanthanam	312. Kunkuwale
80. Kuchbandh	209. Mathura Banjara	313. Wadhai (deleted * in June 2008), Deleted, Khat-wadhai
81. Kuchharia	210. Shingade Banjara	314. Deleted
82. Kumbhar or Kumhar	211. Lambade	315. Kohali
83. Kunbi (Leva, Kunbi, Leva Patidar), Maratha Kunbi, Kunbi Maratha	212. Phanade Banjara	316. Khatik, Kureshi Khatik, Kasai
84. Deleted	213. Sunar Banjara	317. Daangari
85. Kachi	214. Ghaliya Banjara	318. Wedu (Waghari)
86. Kathi	215. Shigadya Banjara	319. Dhawad
87. Kasar (sub-castes - Kachar, Kachari)	216. Baoriya	320. Nirhali (Nirali)
88. Labha	217. Koli Bariya	321. Chitrakathi - Hardas
89. Ladiya, Ladhiya, Lariya	218. Bathini	322.Besta, Besti. Bestallu
90. Ladhaf or Lai-daf (Naddaf), Mansuri	219. Begari	323. Parivar
91. Lakheria	220. Bhampta / Ghantichore / Pardeshi	324. Sawakalar
92. Deleted, Hadad/ Mistri, (Luhar, Luwar)	221. Pong	325. Hanbar
93. Machhi	222. Daasar	326. Dode Gujar, Gujar, Leve Gujar, Reve Gujar, Reva Gujar, Suryavanshi Gujar, Badgujar similar castes- Londhari */Pendhari *
94. Manbhav	223. Uchila	327. Pahad / Pahadi
95. Deleted	224. Bhandura,Billawar, Thiya *, Belchheda *	328. Gadriya
96. Marwar bori	225. Kharavi, Dhivar Bhoi	329. Machhimar (Daldi)
97. May	226. Bhoyar	330. Bhaldar
98. Mina	227. Bindali	331. Alkari
99. Mahali	228. Burbuk	332. Pendhari
100. Mehadar	229. Chadar	333. Yalam / Yelam / Yallam
101. Mhali	230. Chakravaday -Daasar	334. Mahat / Mahut, Mahawat
102. Mitha	231. Chandal	335. Fakir
103. Deleted	232. Chenwu or Chenwwar	336. Loth, Lotha, Lothi
104. Mathura	233. Chimur	337. Nalband
105. Namdhari	130. Bandi	338. Kulekadgi, Kullekadgi, Kulakadgi, Kullakadgi
106. Namdharipek	131. Rachbandhiya	339. Mujavar
107. Nirshikari	132. Rangari	340. Mulana, Mulani, Mulane
108. Naavi-Nhavi, (Salmani,	133. Ragrez	341. East Indian, East Indian

Hajam), Warik, Nabhik, Napit, Mhali, Waland, Hadpad, Hajjam, Naavisen, Salmaniya		Christian, East Indian Katholic
109. Nethura	134. Raot, Ravat, Rautiya	342.
110. Noniya, Loniya, Luniya, Nuniya	135. Rangrez (Bhavsar, Rangari)	343. Lad Shakhiya Wani *
111. Nakkashi	136. Deleted	344. Muslim - Kakar *
112. Nili	137. Deleted	345. Dorik *
113. Nilkanti	138. Deleted	346. Patwa *
114. Nekar jada	139. Deleted	
115. Padharia	140. Sanjogi	
116.Padiyar	141. Saraaniya	
117. Paatradavru	142. Deleted	
118. Phasechari	143. Deleted	
119. Phudagi	144. Deleted	
120. Pakhali, Sakka	145. Suppaling	
121. Panchal	146. Sutharia (In Sindh)	
122. Paanka	147. Sahis,Saes,Shis	
123. Peraki, Perakewad, Perike, Peraka	148. Sapera	
124. Putligar	149. Shilavat	
125. Parit or Dhobi,Telgu Madelwar (Parit)	150. Singiwala	
126. Patkar, Patavekari, Patavegar, Pategar, Pattegar, Patvi, Kshatriya Patkar, Somvanshiya Sahastrarjun Kshatriya, Khatri *,Kshatriya *	151. Deleted	
127. Phulari	152. Deleted	
128. Rachevar	153. Shimpi, Idrisi/Darji,Sai Sutar, Jain Shimpi, Shravak Shimpi, Shetwal, Shetval, Saitwal, Saitval, Meru Shimpi / Meru Kshatriya Shimpi *	
129. Raikari, Rayikar	154. Sonar	

SN	Name of Caste - SBC	Remarks
1	Gowaari, Gawaari	
2	Deleted	(Maana)
3	(1)Koshti (2) Halaba Koshti (3) deleted (4) Sali, Swakul Sali (5) Lad Koshti (6) Gadhhewal Koshti (7) Deshkar (8) Salewar (deleted *) (9) Padma Shali, Chenewar, Channewar, Salewar * (10) Dewang (11) Kachi Bandhhe (12) Patvis (13) Satasaale (14) Saade (15) Jainkoshti	* Deleted Salewar at Sr No.3/8 & added Salewar at Sr No. 3/9 in 2008 June
4	(1)Koli and similar castes (2) Machhimar Koli (3) Ahir Koli (4) Khandeshi Koli (5) Paankoli (6) Christian Koli (7) Chumbale Koli (8) Paanbhare Koli (9) Koli Suryavanshi (10) Mangela (11) Sonkoli (12) Vaiti (13) Khaarava or Khaaravi (14) Those Kolis who are not included in SC	
5	(1) Munnerwar (2) Munnurwar (3) Munnur (4) Telagu Munnur (5)	*Deleted in 2008 June

	Munnurwar Telagu (6) Munnurkapu (deleted*) (7) Kaapewar (deleted *) (8) Telagu Kaapewar (9) Munnurwaad (10) Telagu Phulmaali.	
6	Muslim Religious Bhangi */Mehetar */ Lalbeg */ Halalkhor */Khakrob *	* Included at Sr No.7 in 2008 June
N.B.	**SBC Caste Status Updated till March 31, 2006.** This refers to **Maharashtra Govt Letter No.CBC-10/2006/P.No.94/MVC-5** of Dept of Social Justice, Cultural Affairs & Special Assistance, Mantralaya Extension Building, Mumbai-32 **dated 25.5.2006** addressed to various Ministerial Depts, Divisional Commissioners, DMs, ZP CEOs, Tahsildars etc	
	* **In June 2008, some New Castes were added, some Castes were deleted or rectified in OBC, NT and SBC categories** on the basis of 3 reports No.18 to 21 of the State Backward Class Commission submitted to the Govt during 2006 and 2007 and published vide **Maharashtra Govt Letter No.CBC-10/2006/P.No.94/MVC-5** of Dept of Social Justice, Cultural Affairs & Special Assistance, Mantralaya Extension Building, Mumbai-32 **dated 25.6.2008**	

SCHEDULED CASTES

SN	Name of Caste - SC	Remarks
1	Ager	
2	Anamook	
3	Aaremala	
4	Aarwa Mala	
5	Bahna, Bahana	
6	Bakad, Bant	
7	Balahi, Balaai	
8	Basor, Burud, Baansor, Baansodi	
9	Bedajangam, Budagaa Jangam	
10	Bedar	
11	Bhaambi, Bhaambhi, Asodi, Chamdiya, Chamaar, Chamaari, Chambhar, Chamgaar, Haralayya, Harali, Khalpa, Machigaar, Mochigaar, Maadar, Maadig, Mochi, Telagu Mochi, Kamati Mochi,Ranigaar, Rohidas, Nona, Ramnami, Rohit, Samgaar, Surajyabanshi, Surajyaramnami	
12	Bhangi, Mehatar, Olagaana, Rukhi, Malkana, Halalkhor, Lalbegi, Balmiki, Karor, Zadgalli	
13	Bindala	
14	Byagara	
15	Chalwaadi, Channaya	
16	Chennadaasar, Holaya Daasar, Holeya Dasaari	
17	Dakkal, Dokkalwar	
18	**Dhor, Kakkayya,** Kankayya, Dohor	
19	Dom, Dumar	
20	Yallamwar, Yellamalvandalu	

21	Ganda, Gandi	
22	Garoda, Gaaro	
23	Ghassi, Ghassiya	
24	Hallir	
25	Halsaar, Hasalaar, Hulsawar	
26	Holar, Vhalar	
27	Holaya, Holer, Holeyaa, Holiyaa	
28	Kaikadi	Akola, Amaravati, Bhandara, Buldhana, Nagpur, Vardha and Yavatmal Districts. And Chadrapur dist except Rajura Taluka.
29	Katiya, Pathariya	
30	Khangar, Kanera, Mirdha	
31	**Khatik,** Chikwa, Chikvi	
32	Kolupool-Wandalu	
33	Kori	
34	Lingader	
35	Maadagi	
36	Maadiga	
37	**Mahar,** Meharaa,Taral, Dhegu-Megu	
38	Maahayaavanshi, Dhed, Vankar, Maru-Vankar	
39	Mala	
40	Mala Daasari	
41	Mala Hannai	
42	Mala Jangam	
43	Mala Masti	
44	Mala Saale, Netkanee	
45	Mala Sanyasi	
46	**Mang, Matang,** Minimaadig, Dakhani-Mang, Mang-Mhashi, Madaari, Gaarudi,Radhemang	
47	Mang-Garodi, Mang-Garudi	
48	Manne	
49	Masti	
50	Menghwal, Menghwar	
51	Mitha, Ayalwar	
52	Mukri	
53	Nadiya, Haadi	

54	Paasi	
55	Saansi	
56	Shenwa, Chenwa, Sedamaa, Ravat	
57	Sindhollu, Chindollu	
58	Tirgaar, Tirbanda	
59	Toori	
N.B.	**SC Caste Status Updated till March 31,2006.** This refers to **Maharashtra Govt Letter No.CBC-10/2006/P.No.94/MVC-5** of Dept of Social Justice, Cultural Affairs & Special Assistance, Mantralaya Extension Building, Mumbai-32 **dated 25.5.2006** addressed to various Ministerial Depts, Divisional Commissioners, DMs, ZP CEOs, Tahsildars *etc.*	

SCHEDULED TRIBES

S.N.	Name of Tribe	Remarks
1.	Andh	
2.	Baiga	
3.	Barda	
4.	Bavacha, Bamcha	
5.	Bhaina	
6.	Bharia Bhumia, Bhuinhar Bhumia, Pando	
7.	Bhattra	
8.	Bhil, Bhil garasia, Dholi, Bhil, Dangri Bhil, Dungri, Garasia, Mewsi Bhil, Rawal Bhil, Tadvi Bhil, Bhagalia, Bhilala Pawra, Vasava, Vasave	
9.	Bhunjia	
10.	Binjhwar	
11.	Birhul, Birhor	
12.	Chodhara (excluding Akola, Amravati, Bhandara, Buldana, Chandrapur, Nagpur, Wardha, Yavatmal, Aurangabad, Bhir, Nanded, Osmanabad and Parbhani districts)	
13.	Dhanka, Tadvi, Tetaria, Valvi	
14.	Dhanwar	
15.	Dhodia	
16.	Dubla Talavia, Halpati	
17.	Gamit, Gamta, Gavit, Mavchi, Padvi	
18.	Gond, Rajgond, Arakh, Arrakh, Agaria, Asur, Bedi Maria, Bada Maria, Bhatola, Bhimma, Bhuta, Koilabhuta, Koilabhuti, Bhar, Bisonhorn Maria, Chota Maria, Dandami Maria, Dhuru, Dhurwa, Dhoba, Dhulia, Dorla, Kaiki, Gatta, Gatti, Gaita, Gond Gowari, Hill Maria, Kandara Kalanga, Khatola, Koitar, Koya, Khirwar, Khirwara, Kucha Maria, Kuchaki Maria, Media, Maria, Mana, Meannewar, Moghya, Mogia Moghya, Mudia, Muria, Nagarchi, Naikpod, Nagwanshi, Ojha, Raj Sonjhari Jhareka, Thatia, Thotya, Wade Maria, Vade Maria.	

19.	Halba, Balbi	
20.	Kamar	
21.	Kathodi, Katkari, Dhor Kathodi, Dhor Kathkari, Son Kathodi, Son Katkari	
22.	Kawar, Kanwar, Kaur, Cherwa, Rathia, Tanwar, Chattri	
23.	Khairwar	
24.	Kharia	
25.	Kokna, Kokni, Kukna	
26.	Kol	
27.	Kolam, Mannervarlu	
28.	Koli dhor, Tokre Koli, Kolcha, Kolgha	
29.	Koli Mahadev, Dongar Koli	
30.	Koli Malhar	
31.	Kondh, Khond, Kandh	
32.	Korku, Bopchi, Mouasi, Nihal, Nahul, Bondhi, Bondeya	
33.	Koya, Bhine Koya, Rajkoya	
34.	Nagesia, Nagasia	
35.	Naikda, Nayaka, Cholivala Nayaka, Kapadia Nayaka,, Mota Nayaka, Nana Nayaka	
36.	Oraon, Dhangad	
37.	Pardhan, Pathari, Saroti	
38.	Pardhi, Advichincher, Phans Pardhi, Phanse Pardhi, Langoli Pardhi, Behelia, Behellia, Chita Pardhi, Shikari, Takankar, Takia	
39.	Parja	
40.	Patelia	
41.	Pomla	
42.	Rathwa	
43.	Sawar, Sawara	
44.	Thakur, Thakar, Ka Thakar, Ma Thakur, Ma Thakar	
45.	Thoti (in Aurangabad, Bhir Nanded, Osmanabed and Parbhani districts and Rajura tahsil of Chandrapur district)	
46.	Varli	
47.	Vitolia, Kotwalia, Barodia	

VIMUKTA JATI (VJ) -DENOTIFIED TRIBES (DTS) - 3%

SN	Name of VJ Tribe	SN	Akin Tribe	Remarks
1	Berad	1.A	-	
		1.B	Naikwadi	
		1.C	Talwar	

		1.D	Walmiki	
2	Bestar	2	Sanchalu Vaddar	
3	Bhamata	3.A	Bhamati	
		3.B	Girni Vaddar	
		3.C	Kamati	
		3.D	Patharut	
		3.E	Takari (incl Muslims)	
		3.F	Uchale	
		3.G	Ghantichor	
4	Kaikadi	4.A	Dhontale	
		4.B	Korva	
		4.C	Makadwale or Kunchi Korva	
		4.D	Pamlor	
		4.E	Korvi	
5	Kanjarbhat	5.A	Chhara	
		5.B	Kanjar	
		5.C	Nat	
6	Katabu	-	-	
7	Banjara	7.A	Gor Banjara	
		7.B	Lambada / Lambara	
		7.C	Lambhani	
		7.D	Charan Banjara	
		7.E	Labhan	
		7.F	Madhura Labhan	
		7.G	Kachakiwale Banjara	
		7.H	Laman Banjara	
		7.I	Laman/Lamani	
		7.J	Laban	
		7.K	-	
		7.L	Dhali /Dhalia	
		7.M	Dhadi /Dhari	
		7.N	Singari	
		7.O	Navi Banjara	
		7.P	Jogi Banjara	
		7.Q	-	
		7.R	-	

		7.S	Banjari	
8	***	-	Pal Pardhi	
9	Raj Pardhi	9.A	****	
		9.B	Gaon Pardhi	
		9.C	Haran Shikari	
		9.D	****	
10	Rajput Bhamta	10.A	Pardeshi Bhaamta	
		10.B	Pardeshi Bhamti	
11	Ramoshi	-	-	
12	Vadar	12.A	Gadi Vaddar	
		12.B	Jaati Vaddar	
		12.C	Mati Vaddar	
		12.D	Patharwat	
		12.E	Sangtarash / Dagadfodu	
		12.F	Vaddar	
13	Waghari	13.A	Salaat	
		13.	Salaat Waghari	
14	Chhapparband (incl Muslims)	-	-	
VJ Status Updated till March 31, 2006. This refers to **Maharashtra Govt Letter No.CBC-10/2006/P.No.94/MVC-5** of Dept of Social Justice, Cultural Affairs & Special Assistance, Mantralaya Extension Building, Mumbai-32 **dated 25.5.2006** addressed to various Ministerial Depts, Divisional Commissioners, DMs, ZP CEOs, Tahsildars *etc.*				

Gujarat

This is the land of Gujarat where a very small community "Parsis" in the world came in the middle of 7th centuary and landed at Sanjan in Gujarat and adopted Gujarati language. In the middle of the 17th centuary, the Africans called Siddis migrated to Gujarat and carved out a small State of Jafrabad in the State. In adddition, there are number of dominant castes in the State. The people of Gujarat comprises several different ethnic groups and tribes, including the nomadic Ahirs, shepherd community of the Garasia Jats, the craftsmen of the Meghwal tribe and the vibrant colourful Rabadis who trace their roots to Afghanistan and Sind. There are 290 distinct communities in Gujarat. And interestingly, as many as 206 of these are immigrants from neighbouring Rajasthan, Madhya Pradesh & Maharashtra - and even overseas! The Siddis who live in coastal Saurashtra have Negroid features typical of the people of Africa. They are descendants of the African sailors and traders who found their way to Indian shores in the early centuries of the millennium. The majority of the population lives in small, rustic villages, although about one-third lives in urban areas. The peace-loving Jains form a sizable and influential part of the population of the state (12%). Their foremost religious vow is ‘ahimsa’ (non-violence) - the simple, but unique weapon that Mahatma Gandhi used against the British! The people of Gujarat are so courteous that in conversation they add the suffix ‘Bhai’ (brother) or ‘Ben’ (sister) to the name of the person addressed hence 'Vallabh-bhai' or 'Meera-ben'. They are mostly vegetarian as befitting their religious vows not to harm any living being. Incidentally, Gujarat boasts of a number of Jain pilgrim centres, including Shatrunjaya near Palitana, one of the holiest. The crest of 'Shatrunjaya' hill- Shatrunjaya means 'the Place of Victory', over hatred and worldly things - is dotted with as many as 863 beautifully carved marble temples built over a period of 900 years. The constant chanting in the vicinity of the temples makes for a truly spiritual experience. The people of Gujarat are essentially business minded, though agriculture continues to remain the primary occupation of a large majority of its people. Business acumen, industry and thrist and adventure are the principal characteristics, which distinguish Gujaratis from the people of other parts of the country. Trade and commerce have flourished in Gujarat because of its long coastline and have enabled it to carry on brisk maritime trade with foreign countries since ancient times. Among Indians settled in foreign countries, Gujaratis are in considerable strength even today in the countries of east and South Africa, Aden, New Zealand, England and the United States of America. Association with the people of other countries has made Gujaratis cosmopolitan and liberal in their outlook. The Varnashram are, however, gradually disappearing. The words for castes in Gujarat are two-Jati and Gnati, which have special significance. Jati emphasises birth, while Gnati emphasises connections, relationship and community. The caste is an instution, an ordering of life and a special system in this land. The Hindus are divided into a number of castes. The four main castes in the past in order were: Brahman, Kshatriya, Vaishya and Shudra. The caste, formed under many circumstances, represented a religion, a craft, a profession, a religious system, a social belief, language, often split due to some innovations in the mode of life *etc.* It was based upon occupation and was sub-divided according to the original place of its members, religious beliefs and modes of life. On account of industrial development, a concept of hereditary profession has lost its relevance to diversification of professions under economic compulsion. A general review of the class structure that exists today in Gujarat is briefly described below. The Brahmins were the custodians and interpreters of the Hindu religion and traditions. Their presence was essential at all rituals and ceremonies. The Brahmins in the State belong to Panch Dravid and are said to be of 84 groups. Almost all of the Brahmin sub-castes are found in the State. The Gujarat Kayasthas appear to be of the same stock as the Kayasthas of Bengal. Of the twelve branches of Bengal Kayasthays, only three Valmiki, Mathur and Bhat Nagars are found in Gujarat. Generally they are agriculturists, traders and are also engaged in various economic pursuits. Meshri Vanias, Gujarati Shravaks or Jain Vanias and Marvadi Shravaks constitute the folk of trading community in Gujarat. The Meshri Vanias have many sub-castes in the State. The Shravak Vanias have two major divisions, *viz.* the Shwetamber and the Digamber. Among traders, the Lohanas.also stand as a separate caste by them. They are said to have derived their name from Lohanpur or Lohokat in Multan, now in Pakistan. Generally they are Vaishnavas.

Among cultivators, there are Patidars, Kachhias, Malis and Kolis. The Patidars are divided into Anjana, Kadava and Leva. The Anjana are more like Rajputs than Patidars. Like Rajputs, some of their names end in "sing" such as Dansing, Harising etc. The Patidars are mostly cultivators, but the Kadava and Leva Patidars, some are engaged in business and service. The Leva Patels form a very enterprising community in the State. The Rajput is a Kshatriya caste found everywhere in the State. There are two classses among them *viz.* the Thakors and the Garasias. The Kachhias grow and sell vegetables, flowers and fruits. they are divided into sub-castes such as Ajvalias, Andharias and Khambhatis. The Malis are gardeners and florists. The koli is a term applied to social groups which differ widely from each other**.** Among the castes, generally engage in manufacturing as well as in allied professions are Khatris, Ghanchis, Bhavsars and Chhipas. The Khatris are weavers and cloth-silk and cotton. They follow Vaishnavism. The Ghanchis are oil-processers, vegetable sellers, weavers and labourers. They have many sub castes. Widow remarriage is permissible in their caste. They are followers of Kabir, Ramanand, Swaminarayan and Vallabhacharya. The bhavsars are generally calico-printers, many of whom have given up this profession and have become confectioners, tailor, washermen and cloth and pretty brassware merchants. The chhipas are calenderers, printers, labourers and brick layers. Among artisans, Sonis, Suthars, Kansaras, Kadiyas, Salats, Luhar, Khumbhars and Darjis are the main castes. the Sonis are gold and silversmiths and are divided into eight sub castes. The Suthar have six sub castes. The Kansaras or copper smiths are divided into sub castes. The Kadias and Bricklayers are also called Chunaras or lime-men whose main profession is brick laying, though a few among them work as masons. Among the Salats or stone cutters, the leading class is that of Sompuras. Other calling themselves Salats are Kumbhars or Talpada Kolis. The Luhars are Blacksmiths. They are divided into many sub castes, the Khumbhar or Potters are found in such sub castes as Gujjar Lad, Maru, Ajmeri, Banda, Khambhati, Sami, Varia and Vatalia. Darji's (Tailors) are also called Merai or Sai. They have many sub-castes. Among bards and actors, the Bhats and Barots and Charans and Gandhraps are the main castes which have settled in this State. A Bhat is the geneologist bard and historian of his patrons' family. His book called Vahi is a record of authority by which question of consanguinity are determined, when a marriage or right to ancenstral property is in dispute. Among personal servants there are the Barbers (Hajamas) and Washermen (dhobis). The general profession of barbers is shaving. Among the hardmen and shephered there are Bharvads, Rabaris, and Ahirs. They keep and rear cows and buffaloes , as well as sheep and goats and are sturdy and very active. Among fishermen, there are Bhois and Kharvas. Besides, their employment as fresh water fishers, the Bhois are cultivators, far labouers and work as domestic servants also. Among labourers and miscellaneous classes, there are Gola, Ravalia or Raval, Bhadbhuja, Bajania, Ode, Vaghri, Maratha, Purabia, Marvadi, Bhavcha and Pomla, Kalal, Vadi, Vanjara etc. Among the devotees and religious medicants, the Brahmachari, Vairagi, Gosain, Sadhu and Jogi are the main group in the State. According to the last census, the population of Scheduled Castes in Gujarat is 30,60,000 which 7.4 per cent of the total population. Most of the Scheduled Castes are local, but some of them like Maru, Vankar have migrated from south India e.g. Mahar. They generally follow their hereditary professions but some of them serve in different cadres. The total population of Scheduled Tribes is 14.9 per cent of the total population of the State. In the country as a whole, the population of the tribals is about 8.1 per cent. Gujarat thus has a larger concentration of the tribal population than the national average. The seven districts in which most of the tribal people live are - Valsad, Dangs, Surat, Bharuch, Vadodara, Panchmahals and Sabarkantha. Bhils are the largest tribal group.

Siddis are notified as a Scheduled Tribe under the Constitution. The Africans in Gujarat are called Siddis who are supposed to have migrated to Gujarat in the middle of the 17th centuary. They had carved out a small State of Jafrabad in Gujarat. They are the decendants of African Negrows, chiefly from Somalia coast and brought to India as slaves. It was customary with the rulers to employ Arabs, Makranis and Sidis as guards and watchmen at their palaces. They are Muslim by religion.

The Parsis are a very small community in the world. They are mainly concentrated in India but some have settled in U.K., U.S.A., Australia, Japan *etc.* They are the decendants of the ancient Iranian people who belonged to the Zorostrian religion and flourished in Iran. After the downfall of the last empire of the Sasanians on account of religious persecution, about the middle of the7th centuary, some of the Parsis left Iran for ever. They came to India and landed at Sanjan in Gujarat and have adopted Gujarati language. The Parsis are scattered over in several towns in Gujarat.
After Independence, due to partition of the country, there was steady flow of Hindu population from Pakistan to India. The Hindus from Sindh migratedto all parts of India, including Gujarat area of the then Bombay Province. Kachchh being in close proximityto Sind (Pakistan) the influx was naturally large there. This is the way the refugees were settled in different parts of Gujarat and are now concentrated in cities like Ahmedabad, Vadodara *etc.* Jews who came and settled in Gujarat in the 19th centuary came from Maharashtra for trade. The Gujarati Muslims may be divided into two main sections, those who have a foreign origin and those who are almost entirely of local Hindu discent. From the middle of the 7th to the end of the 18th centuary, foreign Muslims continued to find their way into Gujarat. Of the local converts, some were persuaded while others were forced to adopt Islam. Gujarat Sultans as well as some of Mughal emperors too forced the Hindus to accept Islam as their religion. Among the Muslims of foreign origin, there are Saiyads, Shaikhs, Pathans and Mughals. The Vohras, Siphais, Ghanchis, Pinjaras, Momnas, Khojas, Molesalams, Memons and Chhipas are Muslims converted from Hindu.

Scheduled Caste and Scheduled Tribes-Zone of Influence (Study Area)
Table 4.2.6 illustrates the status of Scheduled Caste and Scheduled Tribes in the Study Area as per the Census Records of 2011. The total Schedule Cast (SC) population in the study area stood at 3129030 (5.98 per cent of the total population of the study area) comprising 1620602 males and 1508428 females. The highest SC population was recorded as 645107 in Thane urban area followed by 640981 in Ahmedabad urban area as per the Census Records of 2011. The Schedule Tribe (ST) contributes to 12.58 per cent (6585506) of the total population of the study area comprising 3326853 males and 3258653 females. The highest ST population was reported as 1265162 in Thane rural area followed by 1040599 in Vadodara rural area. It can be concluded that the ST population are on higher side in the rural area as compared to urban conglomerate. The lowest SC population was reported as 17348 in Navsari rural area whereas the ST population was lowest in Anand urban area as 9884.

Table 4.2.6: Status of Schedule Cast & Schedule Tribe for the Zone of Influence

District	No. of Households	Total Population	Male	Female	Schedule Cast Population	Male Schedule Cast	Female Schedule Cast	Schedule Tribe Population	Male Schedule Tribe	Female Schedule Tribe
GUJARAT										
Ahmedabad-Rural	228482	1151178	595583	555595	118502	61988	56514	16749	8656	8093
Ahmedabad-Urban	1281652	6063047	3192468	2870579	640981	337087	303894	72389	38450	33939
Anand-Rural	297658	1457758	758499	699259	74755	39026	35729	9884	5129	4755
Anand-Urban	129947	634987	328725	306262	29710	15450	14260	14940	7632	7308
Kheda-Rural	359691	1776276	915197	861079	86794	44935	41859	27275	14255	13020
Kheda-Urban	107165	523609	270530	253079	28837	14799	14038	13061	6802	6259
Panch Mahals-R	378648	2055949	1053376	1002573	83082	42398	40684	697576	356032	341544
Panch Mahals-U	67963	334827	173585	161242	17364	8880	8484	24028	12316	11712
Vadodara-Rural	417600	2099855	1077943	1021912	83102	42935	40167	1040599	529305	511294
Vadodara-Urban	459506	2065771	1075793	989978	138527	71667	66860	109302	57360	51942
Bharuch-Rural	217298	1026060	529393	496667	35364	18086	17278	431980	221464	210516
Bharuch-Urban	116185	524959	276314	248645	26871	13893	12978	56214	28934	27280
Navsari-Rural	203297	920535	464749	455786	17348	8712	8636	571812	285999	285813
Navsari-Urban	91834	409137	213416	195721	18116	9247	8869	67847	33741	34106
Valsad-Rural	216948	1070177	542644	527533	20777	10537	10240	785002	392473	392529
Valsad-Urban	147455	635501	344578	290923	17460	9020	8440	117792	58503	59289
Surat-Rural	269680	1232109	640060	592049	38640	19559	19081	683413	342580	340833
Surat-Urban	1063520	4849213	2762164	2087049	119475	62643	56832	173539	89509	84030
MAHARASHTRA										
Mumbai Suburban	2105604	9356962	5031323	4325639	583302	300291	283011	104560	55033	49527
Mumbai-Urban	674339	3085411	1684608	1400803	219934	111564	108370	25093	13488	11605
Thane-Rural	541599	2545470	1300136	1245334	84982	43891	41091	1265162	627288	637874
Thane-Urban	1987566	8514678	4564942	3949736	645107	333994	311113	277289	141904	135385
Total	**11363637**	**52333469**	**27796026**	**24537443**	**3129030**	**1620602**	**1508428**	**6585506**	**3326853**	**3258653**

Source: Directorate General Office, Census of India, 2011

4.2.4 Social Infrastructure and Decision Making Institutions

(1) Social Infrastructure

Social infrastructure and amenities are crucial to creating sustainable communities. Experience from the post-war New Towns to more recent new housing settlements has repeatedly shown that local services like schools, shops and public transport, are needed at an early stage in the life of new communities. Social Infrastructure is a subset of the infrastructure sector and typically includes assets that accommodate social services. Examples of Social Infrastructure Assets include schools, universities, hospitals, prisons, public transport and community housing. Social Infrastructure does not typically extend to the provision of social services, such as the provision of teachers at a school or custodial services at a prison. In India the Social Infrastructure includesthe following:

- The health care system, including hospitals, the financing of health care, including health insurance, the systems for regulation and testing of medications and medical procedures, the system for training, inspection and professional discipline of doctors and other medical professionals, public health monitoring and regulations, as well as coordination of measures taken during public health emergencies such as epidemics.
- The educational and research system, including elementary and secondary schools, universities, specialised colleges, research institutions, the systems for financing and accrediting educational institutions.
- Social welfare systems, including both government support and private charity for the poor, for people in distress or victims of abuse.

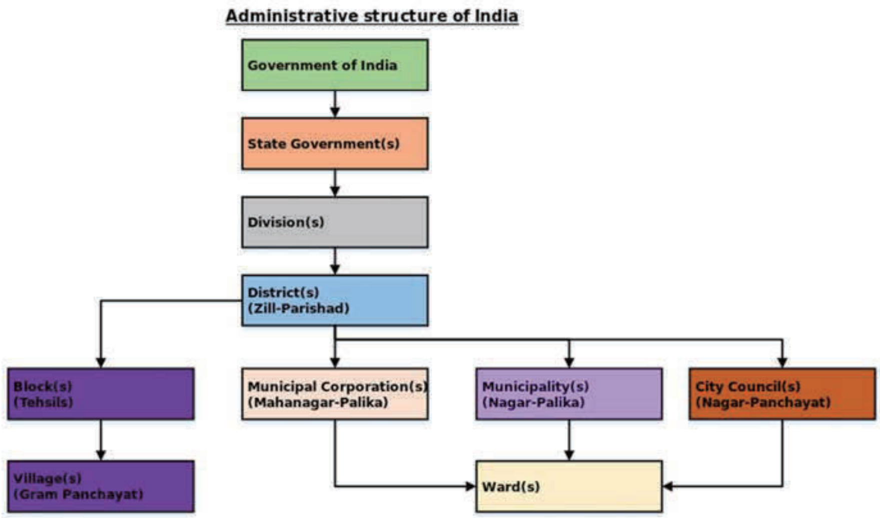
Infrastructure can be broadly divided into two types:- 1) Physical, 2) Social. The former consists of transport, communication, energy, banking and insurance. The positive contribution of physical infrastructure comes through increase investment, employment, output and income in a chain of cumulative causation. On the other hand, social infrastructure broadly includes education, health, housing, water, sanitation, and childcare. The contribution to productive activity although indirect is some occasions is no less important.

The economic prosperity, increase in per capita income alone, doest not always ensure enrichment in quality of life. Against the backdrop of the increasing importance being attached to human development both at national and international levels, therefore, an attempt should be made to examine the development of social sector and to examine the effectiveness of public spending on social sector viz. education, health, housing, water supply in terms of select human development indicators. When the question of funding social infrastructure development arises, the burden falls squarely on the government. Since these sectors don't enjoy the glamour associated with the construction of flyovers and international airports, they perhaps get low priority. As Dr. Amartya Sen is emphasized, the development of education especially private education and health especially public health is an improvement in the quality of life. According to experts, at least 6 percent of the union budget outlay should be set apart for human resource development.

In over sixty years since independence, India has developed an extensive public delivery system for the provision of health care. This was preceded in 1946 by the Bhore Commission that recommended basic health services be provided for all through Primary Health Centres (PHCs). In line with the recommendations, PHCs were set up all across the country, each serving about 30,000 inhabitants in its vicinity. At the time, the urban population of India was less than 18 per cent. Since then, the urban population has grown over fourfold to 285 million of over the 1 billion people living in India. 22.6 per cent of this 285 million live in slums (GOI 2001). As in the case of health services, provision of education for all in India has also largely been envisaged within the public delivery system even though this sector has a significant presence of private providers. Since independence the government has launched various schemes and programmes for increasing literacy among all sections of the population, the ***Sarva Shiksha Abhiyan*** and the Right to Education Bill are the two seminal steps in this direction. Recently there has been a growing demand for privatization and growth in the number of private institutions. This phenomenon is more strongly visible in the urban areas where there is a greater proportion of literate population as well. As per the latest Census of India (2011), 80 per cent of the urban population is literate as opposed to 59 per cent in the rural areas.

(2) Decision Making

The administrative setup of India is shown in Figure 4.2.2.



Source:http://en.wikipedia.org/wiki/Municipal_governance_in_India#/media/File:Administrative

Figure 4.2.2: Administrative Structure in India

Maharashtra

The state has a long tradition of highly powerful planning bodies at district and local levels. Local self governance institutions in rural areas include 33 zilla parishads, 355 Taluka Panchayat samitis and 27,993 Gram panchayats. Urban areas in the state are governed by 23 Municipal Corporations, 222 Municipal Councils, four Nagar Panchayats and seven Cantonment Boards. The administration in each district is headed by a Deputy Commissioner, who belongs to the Indian Administrative Service and is assisted by a number of officers belonging to Maharashtra state services. The Deputy Commissioner of Police, an officer belonging to the Indian

Police Service and assisted by the officers of the Maharashtra Police Service, maintains law and order in addition to other related issues in each district. The Deputy Conservator of Forests, an officer belonging to the Indian Forest Service, manages the forests, environment and wildlife of the district, assisted by the officers of Maharashtra Forest Service and Maharashtra Forest Subordinate Service. Sectoral development in the districts is looked after by the district head of each development department, such as Public Works, Health, Education, Agriculture and Animal Husbandry. The judiciary in the state consists of the Maharashtra High Court (The High Court of Bombay), district and session courts in each district and lower courts and judges at the taluka level. The President of India appoints the chief justice of the High Court of the Maharashtra judiciary on the advice of the chief justice of the Supreme Court of India as well as the Governor of Maharashtra. Other judges are appointed by the chief justice of the high court of the judiciary on the advice of the Chief Justice. Subordinate Judicial Service is another vital part of the judiciary of Maharashtra. The subordinate judiciary or the district courts are categorised into two divisions: the Maharashtra civil judicial services and higher judicial service. While the Maharashtra civil judicial services comprises the Civil Judges (Junior Division)/Judicial Magistrates and civil judges (Senior Division)/Chief Judicial Magistrate, the higher judicial service comprises civil and sessions judges. The Subordinate judicial service of the judiciary is controlled by the District Judge.

Gujarat

Gujarat is governed by a Legislative Assembly of 182 members. Members of the Legislative Assembly are elected on the basis of adult suffrage from one of 182 constituencies, of which 13 are reserved for scheduled castes and 27 for scheduled tribes. The term of office for a member of the Legislative Assembly is five years. The Legislative Assembly elects a speaker who presides over the meetings of the legislature. A governor is appointed by the President of India, and is to address the state legislature after every general election and the commencement of each year's first session of the Legislative Assembly. The leader of the majority party or coalition in the legislature (Chief Minister) or his or her designee acts as the Leader of the Legislative Assembly. Gujarat is a large state with major cities that represent the vibrant Gujarati culture on one hand and its impending growth on the other. The state has 8 municipal corporations to look after civic administration of this state. These municipal corporations are the executive bodies working for the development of their respective cities in all spheres. As a law enforcement unit, Gujarat Police is entrusted with maintenance of law and order in the state. It has its head quarters at Gandhinagar, the state capital. Gujarat Police was formed in 1960, when this state was separated from The Great Bombay state. The force is headed by Director General of Police. In four cities of state, there are Police Commissionerate, viz, Ahmedabad, Vadodara, Surat, and Rajkot. For better functioning of police, Gujarat has 26 police districts. It has seven police ranges in Gandhinagar, Surat, Rajkot, Ahmedabad, Vadodara, Border Range, and Junagadh. It is committed to maintain internal security, prevention of crimes, public orders, and sustaining legal system in the state. For special tasks, the department has several branches that include Anti Terror Squad (ATS), Intelligence Wing, Crime Wing, Human Rights Wing, Armed Unit, Railways Wing, and Training Wing. Mr. PC Thakur (IPS) is the present DGP of Gujarat. Judicial administration of Gujarat is well managed by the courts established in the state. The apex court is the Hon'ble High Court of Gujarat having its seat at Ahmedabad. The state has 25 district courts in all the districts excluding the newly formed district of Tapi. The High Court of Gujarat was formed on 1st May, 1960 when Gujarat was separated from State of Bombay. The court was started in a building near Akashvani in Ahmedabad. Later on, it was shifted to a new building in Sola area of this city in 1999. It has sanctioned strength of 42 judges, appointed by Presidential composition method. Justice V.M. Sahai is the current Acting Chief Justice of Gujarat.

4.2.5 Health Care Facilities

Importance of Health

Health is defined by the World Health Organization (WHO) as "a state of complete physical, mental, and social well-being and not merely absence of disease or infirmity." This definition was accepted by all the signatories to the Alma Ata Declaration on health adopted by the Thirty-first World Health Assembly in 1978. This declaration gave the call of 'Health for All by 2000 AD and accepted that primary health care was a key to attaining this goal. The purpose of this definition was to bring the positive concept of general well-being into focus rather than a negative definition of absence of disease. The human development concept of UNDP is based on the ethics of life claims. Good health is towards universalization of life claims (UNDP 1995). 'Health is wealth' goes the old saying in India. The public health system in India comprises a set of state-owned health care facilities funded and controlled by the Government of India. Some of these are controlled by agencies of the central government while some are controlled by the governments of the states of India. The governmental ministry which controls the central government interests in these institutions is the *Ministry of Health & Family Welfare*. Governmental spending on health care in India is exclusively this system, hence most of the treatments in these institutions are either fully or partially subsidised. Since the Alma-Ata Conference of 1978, which declared health as a fundamental human right, health and nutrition have been accepted as important national concerns in the developing countries. In the Indian federal system, health is the concern of state governments, though some of the important health programmes are funded by the central government.

National Health Policy

The general consensus is that the government's involvement in the health sector is important. However, there are differences regarding the nature and extent of government's involvement. Debate about public versus private involvement in the health sector is ongoing. The Alma Ata Declaration of 1978, which accepted comprehensive primary health care system as a means to achieve Health for All by 2000, entrusted governments with this responsibility. Much before the Alma Ata conference, the Bhore Committee (1946) in India had emphasised the importance of government’s role in primary health care. Experiences have, however, shown that this approach was too expensive for governments to succeed. Instead, these have found selective or targeted primary health care approach more acceptable. WHO, which organized the Alma Ata conference, and UNICEF have all along been supporting the comprehensive approach. They too, over time, have accepted this partial approach because of practical exigencies (Werner 1995). Health is a state government subject in India. However, the central and state governments jointly share the responsibility. The state governments, while following the policies laid down by the central government, pursue some autonomous goals and objectives. Hence there are wide variations in the health sector programmes across states. Each state government has varying levels of involvement in the health sector, depending on its ideology and political pressure from the people.

Maharashtra

Maharashtra has been in the forefront of healthcare development in the country. It was among the first states to decentralize primary healthcare administration through Zilla Parishads as early as1961. Further, under the Minimum Needs Program Maharashtra was again one of the first states to achieve the norms mandated for primary health centres, subcentres and Rural Hospitals. The state also has the largest private health sector in India whose reach is quite extensive. While Maharashtra is today also the most affluent state in the country with the highest per capita income, and contributes over 15% of the country's national income and 40% of the tax revenues, it continues to have high levels of poverty and inequalities which get reflected in health outcomes which are not the best in the country. Thus Maharashtra has to still struggle with malnutrition deaths, child mortality and maternal mortality levels not commensurate with its economic position in the country, declining child sex-ratios, low and declining levels of public health spending and investments, high levels of vacant positions of doctors at PHCs and CHCs, and low levels of access to various health services like antenatal care, complete child immunization, institutional deliveries *etc.* Further given the fact that Maharashtra is also one of the largest states intra-state differences are very sharp. The Mumbai-Pune region is highly developed and skews favourably the averages of health outcomes for the state but there are large pockets of underdevelopment across the state which also skew averages to bring down Maharashtra's health status nationally. Thus it is becoming apparent that if Maharashtra wants to retain its position of lead, the government must address the needs of other parts of the State too. In 2011, the health care system in Maharashtra consisted of 363 rural government hospitals, 23 district hospitals (with 7,561 beds), 4 general hospitals (with 714 beds) mostly under the Maharashtra Ministry of Health and Family Welfare, and 380 private medical establishments; these establishments provide the state with more than 30,000 hospital beds. It is the first state in India to have nine women's hospitals serving 1,365 beds. The state also has significant number of medical practitioners who hold the Bachelor of Ayurveda, Medicine and Surgery qualifications. These practitioners primarily use the traditional Indian therapy of Ayurveda but can use modern western medicine as well. Maharashtra has a life expectancy at birth of 67.2 years in 2011, ranking it third among 29 Indian states. The total fertility rate of the state is 1.9. The Infant mortality rate is 28 and the maternal mortality ratio is 104 (2012–2013), which are lower than the national averages. Public health services are governed by the Ministry of Health and Family Welfare (MoHFW), through various departments. The Ministry is divided into two departments: the Public Health Department, which includes family welfare and medical relief, and the Department of Medical Education and Drugs. In Maharashtra, health insurance includes any program that helps pay for medical expenses, whether through privately purchased insurance, social insurance or a social welfare program funded by the government. In a more technical sense, the term is used to describe any form of insurance that provides protection against the costs of medical services. This usage includes private insurance and social insurance programs such as National Health Mission, which pools resources and spreads the financial risk associated with major medical expenses across the entire population to protect everyone, as well as social welfare programs such as National Rural Health Mission (NRHM) and the Health Insurance Program, which provide assistance to people who cannot afford health coverage. A special feature of Maharashtra's health organisation system has been the early devolution of primary health care implementation to the Zilla Parishads. As early as 1961 primary health care, school education and other social sector programmes/schemes have been given to the Zilla Parishads to implement. The Zilla Parishads get grant-inaid as establishment and purposive grants under Section 183 and 182, respectively, of the Maharashtra Zilla Parishad and Panchayat Samiti Act, 1961 for carrying out the following activities:

- Vaccinations
- School health clinics
- Primary health centres
- Primary health units
- Mobile health units
- Allopathic dispensaries
- Mobile launch units in Panshet/Mulshi dam areas
- Construction and upgradation of PHCs and sub-centres (plan grants under Section 187)
- Health checkup of ashramschool children
- District local board schemes under Section 183

Availability of health care infrastructure facilities in Maharashtra by districts is presented in Table 4.2.7.

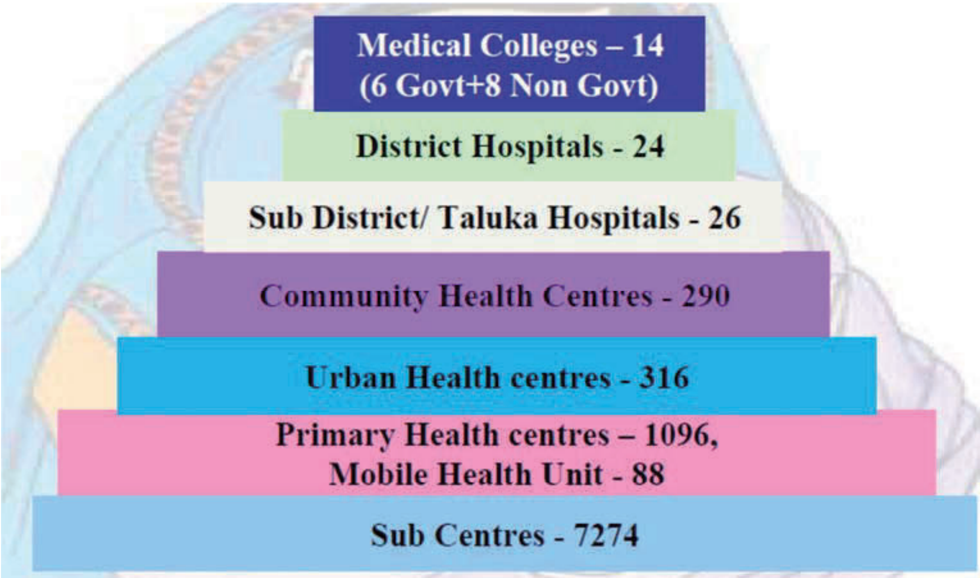
Table 4.2.7: Availability of health care infrastructure facilities in Maharashtra by Districts

	Population served per					% in Public sector		% in Urban areas		
	Hospi-tals@	Dispen-saries@	ISM #	All Medical Inst.	Beds	Hospi-tals@	Dispen-saries@	Hospi-tals@	Dispen-saries@	Beds
Ahmednagar	25691	12892	31940	6766	838	7.8	7.8	87.7	99.6	60.7
Akola	22815	8619	47492	5528	833	11.7	2.4	92.2	92.2	76.8
Amravati	11064	7557	7812	2851	418	16.8	10.3	94.7	87.9	71.9
Aurangabad	21350	2502	179009	2212	757	27.7	100	72.5	26.5	73.1
Beed	26973	36134	23355	9297	1469	18.6	11.4	88.7	100	56.7
Bhandara	52755	79132	29154	15176	1458	22.5	5.5	61.9	47.2	51.4
Buldhana	27533	12957	17089	5813	1124	16.1	7.8	93.1	94.8	76.3
Chandrapur	20027	9701	16630	4692	856	7.6	4.2	81.7	67.2	64.7
Dhule	14809	12227	63466	6058	1385	15.9	2.9	95.0	100	69.0
Gadhchiroli	48659	22357	22357	9090	1020	11.3	23.1	47.1	56.8	14.8
Greater Mumbai	13764	5251	65617	3593	355	8.0	100	100	100	100
Jalgaon	6742	17453	63224	4516	665	7.9	6.3	71.7	95.3	76.8
Jalna	25152	477897	89606	18864	1086	19.7	13.8	82.5	66.7	75.3
Kolhapur	36544	14755	42470	8426	1155	24.4	3.8	84.9	3.8	39.7
Latur	28896	440670	62953	18954	1157	12.8	2.5	93.4	100	73.5
Nagpur	9624	41130	29279	6159	471	22.8	100	44.7	84.3	69.9
Nanded	27212	17876	44528	8685	1058	16.0	5.7	98.1	61.9	93.4
Nashik	21192	8144	44975	5203	837	18.3	13.2	87.8	100	69.3
Osmanabad	38320	47900	41912	14118	1316	17.8	12.4	92.1	99.4	76.8
Parbhani	23672	21192	42792	8865	1284	25.7	10.7	80.0	100	55.3
Pune	11163	17257	306089	6631	373	19.7	100	90.4	100	67.9
Raigad	20192	12296	213138	7378	1062	18.1	5.9	96.5	96.4	99.2
Ratnagiri	34529	324577	324577	28472	1234	15.7	10.7	88.4	95.5	66.0
Sangli	11438	12093	22542	4662	618	10.0	17.6	74.5	100	68.5
Satara	13703	184016	143124	11710	615	33.7	11.6	95.1	99.5	83.4
Sindhudurg	20337	7110	9016	3325	694	22.0	47.5	79.3	100	81.8
Solapur	19631	26124	169804	10514	575	8.6	100	14.0	3.3	35.8
Thane	21468	3720	73562	3040	662	42.9	47.2	97.1	50.8	90.9
Wardha	27354	19009	86270	9925	438	19.4	7.3	96.9	99.5	91.8
Yavatmal	26303	19492	41191	8803	1011	64.7	43.2	85.4	52.5	53.4
Maharashtra	**16891**	**9972**	**40811**	**5435**	**642**	**13.4**	**8.9**	**86.7**	**90.2**	**61.7**

Source: Computed on the basis of information in Statistical Abstract of Maharashtra State 1993-94 & 1994-95, Mumbai: Directorate of Economics and Statistics, Government of Maharashtra.
@ includes only allopathic medical institutions, excludes private GP Clinics.
# includes Ayurvedic, Unani and Homeopathic institutions.

Gujarat

Gujarat's performance is better than all India aggregates with regard to all vital statistics The crude birth rate (CBR) is 25.2 in Gujarat against 25.8 in India (2000), crude death rate (CDR) is 7.5 against 8.5 in India, the infant mortality rate (IMR) is 62 against 68 in India, and the child mortality rate (CMR) is 85.1 as against 94.9 in India. The neo-natal mortality (NNM), post neo-natal mortality (PNNM) and peri natal mortality rates are also lower in Gujarat than in India according to the National Family Health Survey (NFHS)-2 conducted in 1998-99. The gap between the NNM in Gujarat and that for the country, however, is of just one point. The estimated maternal mortality rate (MMR) in Gujarat was far lower (3.89) than in India (4.58) in 1992-93. According to the SRS data MMR for Gujarat has reduced to 2.9 in 1997. The total fertility rate (TFR) in Gujarat is lower (3.0) compared to that for the country (3.2) in 1998. The only vital statistics where Gujarat falls behind all-India aggregates is the life expectancy at birth (LEB). Status of health care infrastructure in Gujarat is illustrated in Figure 4.2.3.



Source: Health and Family Welfare Department, Government of Gujarat.

Figure 4.2.3: Healthcare Facilities Status of Gujarat

Gujarat Health Policy

The state government targets are mostly at par with the central government targets, though in some areas the Gujarat targets are higher. The state government is in the process of formulating a State Health Policy. The proposed health policy appears to be well designed. It is hoped that it will soon be adopted officially.

Health Care Facilities

Though per capita healthcare expenditure in the state is much lower than that for the country, the state has much higher level of health facilities. The number of hospitals and dispensaries per lakh population is more than three times that in India. But the difference between Gujarat and India is not high when the health sub-centres, beds per lakh population and doctors and nurses per lakh population are considered. With respect to primary health centres (PHCs), Gujarat's performance is lower. Thus Gujarat's performance is better in high order health facilities, which are generally located in urban areas.

Health Care Delivery System in Gujarat

The health care delivery in Gujarat is organized in a three tier system:

(i) At the primary level, there are primary health centres (PHCs) and sub-centres.

(ii) At the intermediate level, there are community health centres (CHCs), taluka hospitals, and district hospitals. About 3-4 PHCs are affiliated to a CHC. It has been planned to develop CHC as a first referral unit (FRU), because they are scattered all over the state and can provide hospital services at the doorstep of the patient. Almost all CHCs are located in taluka headquarters or other important towns of a taluka. There is at least one operational hospital in each district headquarters.

ii) The tertiary or referral level facilities are affiliated to medical colleges and specialized hospitals.

Norms for health facilities are:

- PHC all areas one per 30,000 population

- PHC tribal, hilly & inaccessible areas one per 20,000 population
- Sub-Centre all areas one per 5,000 population
- Sub-Centre tribal, hilly & inaccessible areas one per 3,000 population
- CHC all areas one per 100,000 population

The good spread of high order health facilities in Gujarat is supported by public expenditure. However, the private, voluntary sector, and charity institutions also are playing an important role. A number of hospitals and dispensaries have been set up in the past by princely states, especially the Vadodara state and the states of the Saurashtra region. Many of these are either run by charity trusts or have been handed over to the public sector. Presence of charity established and even run health facilities in urban areas is quite noticeable.

Health Care Delivery System –Vision of Gujarat

- State Government's healthcare outlay has risen to Rs. 1900 crores in the current year, which is a rise of 58% over the last year.
- In the field of medical education, the present capacity of producing 2055 doctors annually is being planned to be raised to over 3500 in the next few years.
- Focused attention on institutional capacity building – A state of art 2800 bed multi- specialty hospital is also being planned in the Civil Hospital Campus, Ahmedabad, which will also bring in those medical technologies and services in the complex which are not there at present.
- The State Government has also set up the Gujarat Medical Education and Research Society which has commenced setting up institutions of excellence in medical education and research in various parts of the State, thus ensuring spread of services and knowledge all over the State.
- Providing state-of-art facilities.
- Providing seamless healthcare through computerization of health system & moving towards an ERP in health.
- Visioning a health card for every individual of Gujarat.

4.2.6 Educational Institutions

The essence of Human Resource Development is education, which plays a significant and remedial role in balancing the socio-economic fabric of the Country. Since citizens of India are its most valuable resource, our billion-strong nation needs the nurture and care in the form of basic education to achieve a better quality of life. This warrants an all-round development of our citizens, which can be achieved by building strong foundations in education. Indian leaders have long realised that a literate population is an asset to the country not only because of the contribution that the educated make to productivity but also because of the social benefits that accrue in terms of lowering of fertility and infant and child mortality and the improvements in the education levels and skills of the coming generations. At the individual level, literacy is an important tool for empowerment. In the ensuing almost 60 years since Independence, a number of policy statements have been made and programmes conceived and implemented to provide education to all. Article 45 of the Indian Constitution, framed in 1950, declared, "the State shall endeavour to provide, within a period of 10 years from the commencement of the Constitution, free and compulsory education to all children until they complete the age of 14 years".

The Constitution also guarantees educational rights for minorities and calls for the educational development of weaker sections of society such as Scheduled Castes and Scheduled Tribes. Admittedly, at the time of the framing of the Constitution, the country had a long way to go to ensure that all children received schooling. However, despite several schemes and programmes, the goal of providing education to even the new entrants to the population has continued to elude us. More recently in 2002, an Amendment, known as 86th Amendment to the Indian Constitution, was introduced that calls for free and compulsory elementary education (up to class 7) as a fundamental right for all children in the age group of 6-14 years. Towards this goal, the latest programme launched is ***Sarva Shiksha Abhiyan*** (SSA) that aims to universalize primary education (up to class 4) by 2007 and elementary education (up to class 7) by 2010 by focusing on the disadvantaged sections – girls and those belonging to Scheduled Castes and Tribes among whom the number of out of school children is quite high.

Maharashtra

Maharashtra schools are run by the state government or by private organizations, including religious institutions. Instruction is mainly in Marathi, English or Hindi, though Urdu is also used. The secondary schools are affiliated with the Council for the Indian School Certificate Examinations (CISCE), the Central Board for Secondary Education (CBSE), the National Institute of Open School (NIOS) or the Maharashtra State Board of Secondary and Higher Secondary Education. Under the 10+2+3 plan, after completing secondary school, students typically enroll for two years in a junior college, also known as pre-university, or in schools with a higher secondary facility affiliated with the Maharashtra State Board of Secondary and Higher Secondary Education or any central board. Students choose from one of three streams, namely liberal arts, commerce or science. Upon completing the required coursework, students may enroll in general or professional degree programs. Maharashtra has 24 universities with a turnout of 160,000 Graduates every year. Maharashtra has played a pioneering role in the development of the modern education system in India. The University of Mumbai is the largest university in the world in terms of the number of graduates and has 141 affiliated colleges. People like, Jyotirao Phule, Scottish missionary John Wilson, Bal Gangadhar Tilak, Dhondo Keshav Karve and Bhaurao Patil played a leading role in the setting up of modern schools and colleges in the state. The Deccan College Post-Graduate and Research Institute was established in 1821. The Shreemati Nathibai Damodar Thackersey Women's University, the oldest women's liberal arts college in South Asia, started its journey in 1916. College of Engineering Pune, established in 1854, is the third oldest college in Asia. According to prominent national rankings, 5 to 7 Maharashtra colleges and universities are ranked among the top 20 in India. Maharashtra is also home to such notable autonomous institutes as Indian Institute of Technology Bombay, Dr. Babasaheb Ambedkar Technological University, Institute of Chemical Technology, Homi Bhabha National Institute, Walchand College of Engineering, Visvesvaraya National Institute of Technology Nagpur (VNIT) and Veermata Jijabai Technological Institute (VJTI).[153] These autonomous institutes are ranked as the most difficult colleges in Maharashtra to gain admission to. At the undergraduate level admission to autonomous institutes is extremely competitive. The University of Pune, the National Defence Academy, Film and Television Institute of India, National Film Archives, Armed Forces Medical College and National Chemical Laboratory were established in Pune after the Indian independence movement. Maharashtra has hundreds of other private colleges and universities, including many religious and special-purpose institutions. Most of these were set up in the last thirty years after the State Government of Vasantdada Patil liberalized the Education Sector in 1982. [154]. There are also local community colleges with generally more open admission policies, shorter academic programs, and lower tuition. Besides these, the state also has Dr. Babasaheb Ambedkar Marathwada University, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, North Maharashtra University, Shivaji University, Swami Ramanand Teerth Marathwada University and Rashtrasant Tukadoji Maharaj Nagpur University, all well established and nationally renowned, to cover the educational needs at the district levels of the state. Apart from this, there are a number of deemed universities in Maharashtra: the Symbiosis International University, Tata Institute of Social Sciences, Tilak Maharashtra University and Tata Institute of Social Sciences. Notable scholars who were born, worked or studied in the geographic area of the state include prominent Varkari saint and spiritual poet Tukaram, Dalit Leader and Father of Indian Constitution Dr. B. R. Ambedkar, Indian Nationalist leader Bal Gangadhar Tilak, the father of Indian cinema Dadasaheb Phalke and Social reformer Jyotirao Phule.

Gujarat

On the basis of available data, it is evident that improvements in literacy have been quite impressive especially among girls in the decade of 1991-2001 and one can surmise optimistically that at long last a corner has been turned. The achievement is both because the demand for education has increased and the supply has also improved in most parts of the state. With the decline in fertility, and increase in the exposure to mass media, couples who have fewer children aspire to provide better life, including more and better quality education, to their children compared to what they had when they were children. The perceptions of the returns to education, especially lower levels of education, may be conflicting in the minds of parents given the fact that secure salaried jobs are not easy to get with only very few years of schooling and acquisition of limited skills. There is also a perception in the minds of the poor parents that children with few years of exposure to schooling are unwilling to undertake manual labour work. However, the hope that at least one or two children would break away from the poverty trap after acquiring education is fairly widely pervasive. Gujarat has both private and public universities, many of which are supported by the Government of India and the state government - Government of Gujarat. Apart from these there are private universities supported by various bodies and societies. There are total 30 universities in Gujarat as of 4th February 2012. In Gujarat there is one central university, eighteen state universities, two deemed universities and nine private universities and a number of institutions imparting higher education in the field of Management, Medical, Engineering, Research Organizations *etc.* Fresh data released by the Ministry of Human Resources Development (MHRD), Government of India, suggest that Gujarat is one of the poorest performers in ensuring the enrollment of children in secondary and higher secondary schools. Found reflected in the report, "Secondary Education in India, Thematic Maps: 2012-13", published by the National University of Educational Planning and Administration (NUEPA), which operates under the MHRD, the data suggest that out of 20 major states, as many as 13 of them enrolled a higher proportion of students than Gujarat at the higher secondary level. At the secondary level, things are not very different – here, too, as many as 13 major states enrolled higher proportion of students than Gujarat.

At the higher secondary level, Gujarat could enroll just 38.04 per cent of children, the data show. This was better than only Odisha, Bihar, Assam, Jharkhand, Madhya Pradesh and Karnataka. The best performer was Himachal Pradesh with a gross enrollment ratio of 94.57 per cent. At least three states known for poor scores in social sector performed better than Gujarat Rajasthan was found to have a gross enrollment ratio of 41.58 per cent, Chhattisgarh had a gross enrollment ratio of 41.49 per cent, and Uttar Pradesh had a gross enrollment ratio of 42.80 per cent.

The Gujarat Secondary and Higher Secondary Education Board (GSHSEB) are in charge of the schools run by the Government of Gujarat. However, most of the private schools in Gujarat are affiliated to the Central Board of Secondary Education (CBSE) and Council for the Indian School Certificate Examinations (CISCE) board. Gujarat has 13 state universities and four agricultural universities. The premier management institute Indian Institute of Management in Ahmedabad ranks the best in India and among the best management Universities in the world. The top-notch institutes for Engineering and Research include IIT Gandhinagar, Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT) also in Gandhinagar, Sardar Vallabhbhai National Institute of Technology (SVNIT) in Surat, Pandit Deendayal Petroleum University (PDPU) in Gandhinagar and Nirma University in Ahmedabad. Mudra Institute of Communications Ahmedabad (MICA) is one of the most famous institutes for mass communication and is well-renowned across India. In addition, Institute of Rural Management Anand (IRMA) is one of the leading sectoral institution in rural management. IRMA is a unique institution in the sense that it provides professional education to train managers for rural management. It is the only one of its kind in all Asia. The National Institute of Design (NID) in Ahmedabad and Gandhinagar is internationally acclaimed as one of the foremost multi-disciplinary institutions in the field of design education and research. Centre for Environmental Planning & Technology University, popularly known as (CEPT) is one of the best planning and architectural school not in India, but across the world; providing various technical and professional courses. Lalbhai Dalpatbhai College of Engineering (LDCE) is also one of the top engineering college of the state. The Maharaja Sayajirao University of Baroda, Vadodara, is a premier university of Gujarat. It is one of the oldest universities of Gujarat and provides education in Faculty of Fine Arts, Engineering, Arts, Journalism, Education, Law, Social Work, Medicine, Science and Performing Arts. Originally known as the Baroda College of Science (established 1881), it became a university in 1949 after the independence of the country and later renamed after its benefactor Maharaja Sayajirao Gaekwad III, the former ruler of Baroda State. Gujarat University, Sardar Patel University, Ahmedabad University, Saurashtra University, Veer Narmad South Gujarat University, Dharmsinh Desai University and Hemchandracharya North Gujarat University are also amongst reputed universities. The Space Applications Centre (SAC) is an institution for space research and satellite communication in Ahmedabad, India, under the aegis of the Indian Space Research Organisation (ISRO). Dr. Vikram Sarabhai, a renowned scientist, industrialist, and visionary Gujarati, played an important role in it. He also founded Physical Research Laboratory, a research institute encompasses Astrophysics, Solar System, and cosmic radiation. He also envisioned Indian Institute of Management Ahmedabad, one of the internationally reputed management research institute that is located in Gujarat's commercial capital Ahmedabad and is the top ranked management institutes in the country. Central Salt and Marine Chemicals Research Institute has been established under Council of Scientific and Industrial Research Government of India at Bhavnagar. It was inaugurated by Late Pandit Jawaharlal Nehru, the first Prime Minister of India on 10 April 1954, with a view to carry out research on marine salt, and salt from inland lakes and sub-soil brine. It is working on reverse osmosis, electro membrane process, salt and marine chemicals, analytical science, marine biotechnology, and other related fields. The Gujarat National Law

University situated at Gandhinagar is the 5th Best Law School currently in India. Gujarat Science City, is a government initiative to draw more students towards education in science, which hosts India's first IMAX 3D theatre, an energy park, a hall of science, an amphitheatre, and dancing musical fountains amongst others. Institute of Management under Nirma University is constantly ranked amongst the top MBA colleges in India. International Institute of Management and Technical Studies affiliated with Gujarat Knowledge Society, European Association for Distance Learning, Association of Indian Management Schools and Ahmedabad Textiles Industry's Research Association has performed globally for its Higher Education Certification courses for working professionals. IIMT STUDIES also launched GET SET GO programme in 2013 in Affiliation with Gujarat Technological University and Gujarat Knowledge Society, Department of Technical Education- Government of Gujarat. B.K. School of Business Management is ranked 6th in terms of financial Management. K. S. School of Business Management is also an MBA College in Gujarat University providing a unique five year's integrated MBA Cource. Shanti Business School in Ahmedabad is one of the emerging business schools offering Post Graduate Diploma in Management through corporate citizenship initiative. The Institute of Seismological Research (ISR) has been established by the Science and Technology Department, Government of Gujarat in 2003 and is registered as a Society. ISR campus is at Raisan, Gandhinagar in a sprawling and picturesque area on the banks of Sabarmati river. Aims and objectives include assigning optimum seismic factors for buildings in different regions and long-term assessment of earthquake potential. The ISR is the only institute in India fully dedicated to seismological research and is planned to be developed into a premier International institute in few years time.

(1) Literacy Rate

Table 4.2.8 illustrates the status of literacy rate in the ZOI. It is evident from the Table 4.2.8. that there has been phenomenal growth in the literacy rate both in urban and rural areas of the study area during the last decade 2001-2011.In Gujarat region, the highest literacy rate was recorded in Ahmedabad and Surat (86.65 %) in all followed by Anand (85.79 %). The male literacy rate was the highest in Kheda (93.40 %) followed by Anand (93.23 %), where as the literacy rate amongst female was highest in Surat (81.02 %) followed by Ahmedabad (80.29 %). In the Maharashtra region, the highest literacy rate was recorded in Mumbai suburban areas as 90.9 % as per the Census Records of 2011 compared to 86.89 % as per the Census Records of 2001. The male literacy rate was highest in Mumbai, where it stood at 94.28 per cent as per Census Records 2011 against 91.56 per cent as per Census Records of 2001. Amongst the female, the highest literacy rate was recorded in Mumbai suburban as 86.93 per cent as per Census Records 2011 against 81.12 per cent as per Census Records 2001. It can be concluded that the literacy rate in the study area is excellent in the urban areas whereas same in rural area is moderate. However, trend in literacy rate shows upward surge over the decade.

Table 4.2.8: Literacy Rates by Sex for the Zone of Influence

District	Literacy Rate*					
	Persons		Males		Females	
	2001	2011	2001	2011	2001	2011

GUJARAT						
Ahmadabad	79.62	86.65	87.4	92.44	70.98	80.29
Anand	74.51	85.79	86.09	93.23	61.94	77.76
Kheda	71.9	84.31	85.97	93.40	56.8	74.67
Panch Mahals	60.92	72.32	75.91	84.07	44.94	59.95
Vadodara	70.76	81.21	80.04	87.59	60.73	74.40
Bharuch	74.41	83.03	82.98	88.80	65.11	76.79
Navsari	75.83	84.78	82.77	90.06	68.61	79.30
Valsad	69.15	80.94	77.9	86.48	59.62	74.96
Surat	77.62	86.65	83.83	91.05	69.87	81.02
MAHARASHTRA						
Thane	80.66	86.18	87.06	90.9	73.10	80.78
Mumbai (Suburban)	86.89	90.9	91.56	94.28	81.12	86.93
Mumbai	86.40	88.48	90.23	90.54	81.38	86.03

Note-* Literacy rate is the percentage of literates to population aged 7 years and above
Source: Directorate General Office, Census of India, 2011

4.2.7 Human Immunodeficiency Virus (HIV)/Acquired Immune Deficiency Syndrome (AIDS)

India has a population of 1.2 billion people, around half of whom are adults in the sexually active age group. The first AIDS case in India was detected in 1986 and since then HIV infection has been reported in all states and union territories.

Health and Socio economic developments are so closely intertwined that it would be impossible to achieve one without the other. It is therefore necessary to improve the health outcomes in India so as to support India's economic developments over the last decade. HIV/AIDS is not merely a public health challenge; it is also a political, social and economic challenge. AIDS is hindering decades of health, economic and social progress. Indicators of human development-such as child mortality, literacy, and food production are slipping as the disease ravages families, communities, economies, and health systems in heavily affected countries. AIDS reduces life expectancy by years, erodes productivity, consumes savings, increases expenditure and reduces income. AIDS creates a stigma and leads to unfair discrimination of HIV infected people in the society. It causes significant obstacles to children coming from AIDS infected families in achieving universal access to primary education and health. Poor countries become poorer as AIDS intensifies chronic food shortages by reducing agricultural workforce in developing countries, it is estimated that AIDS will have claimed the lives of one-fifth or more of agricultural workers in southern Africa by 2020. The epidemic has created a need for robust, flexible health systems at a time when many affected countries are facing severe financial constraints for public service spending. Although global spending on AIDS has increased from US$ 300 million in 1996 to US$ 8 billion in 2005, it is less than what is needed by 2010 in order to address all the socio-economic and health issues of HIV/AIDS in developing countries. According to the Joint United Nations Program on AIDS (UNAIDS, 2006), more than 20 million people have already died of AIDS, and the number of people living with HIV/AIDS continues to grow. It is estimated that 38.6 million people are living with HIV/AIDS in 2005, 4.1 million newly infected with HIV, and 2.8 million lost their lives to HIV. The number of children orphaned by the disease rose from 11.5 million in 2001 to 15 million in 2003. About 95 percent of those living with HIV/AIDS are in developing countries. Sub-Saharan Africa is the hardest hit region in the world, accounting for almost two-thirds of people (approximately 25 million) infected with HIV worldwide.

India with 5.1 millioncases of HIV has the largest number of people living with HIV outside South Africa. As per UNAIDS estimate, India has the largest number of people living with HIV outside South Africa. Out of 6.5 million HIV/AIDS victims in South and South East Asia, 5.1 million live in India alone.

While the epidemic is still spreading in the country (up from 3.5 million in 1998 to 5.1 million in 2003), there is no significant upsurge in the number of new infections, and therefore India continues to be a low prevalence country. However, six Indian states (Andhra Pradesh, Karnataka, Maharashtra, Manipur, Nagaland, and Tamil Nadu) have a high prevalence rate of more than 1 percent among the general population. The predominant route of transmission of HIV/AIDS in India is through the heterosexual route (86%). Some of the key factors fueling the spread of HIV/AIDS in India are commercial sex, high prevalence of STI, large scale migration of workers from rural to urban areas and low levels of female literacy. According to the Annual Round of HIV Sentinel Surveillance 2003, the estimated number of 5.1 million HIV infections consists of 3.48 million general population, 1.49 million STI patients, 70000 Female sex workers, 10000 intravenous drug users, and 55000 children. The rates of HIV among sex workers, intravenous drug users, and STI patients remain unacceptably high in many parts of the country. Rural India accounts for 60 percent and male infected persons account for 62 percent of the total number of infections. It has been reported that young people in India are among the most vulnerable to HIV. Over 35 percent of all reported HIV/AIDS cases in India occur among young people in the age group of 15-24 years. Knowledge about the virus and its transmission is still scant and incomplete.

Even though HIV prevalence is less than 1% in India, a mere 0.1% increase in the prevalence rate would increase the numbers living with HIV/AIDS by over half a million. Significantly, the epidemic is moving from high risk group and urban areas to the general population and hinterland (NACO 2005).

The spread of HIV in India has been uneven. Although much of India has a low rate of infection, certain places have been more affected than others. HIV epidemics are more severe in the southern half of the country and the far north-east. The highest estimated adult HIV prevalence is found in Manipur (0.78%), followed by Andhra Pradesh (0.76%), Karnataka (0.69%) and Nagaland (0.66%). However for the first time, in 2010 no states reported HIV prevalence among ANC antendees of 1.0% or more. In the southern states, HIV is primarily spread through heterosexual contact. Infections in the north-east are mainly found amongst injecting drug users (IDUs) and sex workers. Unless otherwise stated, the data in this report has been taken from a 2012 report by the Indian government's AIDS organisation – NACO (National AIDS Control Organisation).

People living with HIV/AIDS	2.39 million
Adult (15 years or above) HIV prevalence	0.31%

Previously it was thought that around 5 million people were living with HIV in India - more than in any other country. Better data, including the results of a national household survey conducted in 2005-2006, led to a major revision of the prevalence estimate in July 2007. It is now thought that around 2.39 million people in India are living with HIV. Of these, an estimated 39.0% are female and 4.0% are children.

Back-calculation suggests that HIV prevalence in India may have declined slightly in recent years, though the epidemic is still growing in some regions and population groups.

Across India HIV prevalence appears to be low among the general population, but disproportionately high among high-risk groups, such as IDUs, female sex workers, men who have sex with men (MSM) and STD clinic attendees. The average HIV prevalence among women attending antenatal clinics in India is 0.40%. Much higher percentages are found among people attending STD clinics (3.6%), female sex workers (2.67%), injecting drug users (7.14%) and men who have sex with men (4.43%). As the table below shows, the figures among different groups vary widely between states. Table 4.2.9 shows the different type of prevalence of HIV/AIDS infected population. The status of Gujarat and Maharashtra is shown in coloured.

Following measures will be taken in the construction stage by the expert to prevent HIV/AIDS.

- What is the AIDS
- Infection route of HIV
- Progress from HIV infection to AIDS
- Infection prevention against HIV
- When you have worry about the infection
- When the infection becomes clear
- When infected person is around you

Table 4.2.9: Status of HIV/AIDS in India in Different States

State/Union Territory	Antenatal clinic HIV prevalence 2010-11 (%)	STD clinic HIV prevalence 2007 (most recent data) (%)	IDU HIV prevalence 2010-11 (%)	MSM HIV prevalence 2010-11 (%)	Female sex worker HIV prevalence 2010-11 (%)
A & N Islands	0.13	1.33	...	...	...
Andhra Pradesh	0.76	17.20	3.05	10.14	6.86
Arunachal Pradesh	0.21	0.00	0.24	...	0.28
Assam	0.09	0.50	1.46	1.40	0.46
Bihar	0.17	0.40	4.54	4.20	2.30
Chandigarh	0.00	0.42	7.20	0.40	0.00
Chhattisgarh	0.43	3.33	0.42	14.98	2.73
D & N Haveli	0.00	...	...	...	...
Daman & Diu	0.13	...	...	...	...
Delhi	0.30	5.20	18.27	5.34	0.70
Goa	0.33	5.60	...	4.53	2.70
Gujarat	0.46	2.40	1.60	3.00	1.62
Haryana	0.19	0.00	0.80	3.05	0.48
Himachal Pradesh	0.04	0.00	4.89	1.23	0.53
Jammu & Kashmir	0.06	0.20	0.00	...	0.00
Jharkhand	0.25	0.40	2.02	0.40	0.82
Karnataka	0.69	8.40	0.00	5.36	5.10
Kerala	0.13	1.60	4.95	0.36	0.73
Lakshadweep	0.00	0.00	...	...	...
Madhya Pradesh	0.32	1.72	5.13	7.94	0.93

Maharashtra	0.42	11.62	14.17	9.91	6.89
Manipur	0.78	4.08	12.89	10.53	2.80
Meghalya	0.05	2.21	6.44	...	...
Mizoram	0.40	7.13	12.01	...	...
Nagaland	0.66	3.42	2.21	13.58	3.21
Odisha (formerly Orissa)	0.43	1.60	7.16	3.79	2.07
Puducherry (formerly Pondicherry)	0.13	3.22	...	1.21	1.21
Punjab	0.26	1.60	21.10	2.18	0.85
Rajasthan	0.38	2.00	...	...	1.28
Sikkim	0.09	0.00	0.00	...	0.00
Tamil Nadu	0.38	8.00	...	2.41	2.69
Tripura	0.00	0.40	0.45	...	0.21
Uttar Pradesh	0.21	0.48	2.03	1.56	0.62
Uttarakhand (formerly Uttaranchal)	0.25	0.00	4.33	...	...
West Bengal	0.13	0.80	2.72	5.09	2.04

Source: National AIDS Control Organization (NACO)

(1) National Aids Control Program

The Government of India launched a National AIDS Control Program in 1987, which concentrated on surveillance, blood safety, and IEC. A comprehensive five-year strategic plan was launched in 1992-99 with World Bank credit as the National AIDS control program (NCAP-I). NACP-I was a start-up investment to launch interventions for HIV prevention, so as to slow the spread of HIV, and mitigate the impact of AIDS. During this period, the National AIDS Control Organization (NACO) was established. NACO was entrusted with the responsibilities to strengthen the systems for HIV sentinel surveillance, install Voluntary Counseling and Testing Centres (VCTC), step up awareness generation activities, modernize blood banks, and so on. NACO created AIDS cells in all the states for effective implementation of the NACP I program. While some progress was achieved at the state levels, there were significant limitations in implementation: vulnerable groups were not identified, IEC remained somewhat limited, and community involvement was inadequate.

4.2.8 Socio-Economic Profile of the Study Area-Zone of Influence

This section describes the regulatory setting and the affected environment for socioeconomics, communities, and environmental justice; the impacts that would result from the project; and the mitigation measures that would reduce these impacts. The EIA Study for the proposed MAHSRC provides a demographic analysis with complete race, income, and housing characteristics for socioeconomics, communities, and environmental justice. Environmental justice is a requirement that the Project Proponent address, to the extent practicable and permitted by law, the potential disproportionately high adverse human health and environmental impacts of their programs, policies, and activities on minority and low-income populations. Related topics are discussed in the different sections of this Chapter. This section presents the socioeconomic topics of population trends, demographic characteristics, housing, household income, fiscal resources, and agricultural industry characteristics. The socioeconomic data used in the analysis are derived from various sources, including the published data of Census of India, District Census Handbook and various agencies and websites. The analysis included a review of the Draft Feasibility Report for the proposed MAHSRC, which include early community involvement in the project (including outreach to minority and low-income populations, in compliance with the prevailing law of the land), station design workshops, and the maintained connectivity of pedestrian, bicycle, and vehicle crossings of the rail corridor to maintain neighborhood and community integrity.

(1) Study Area

For population and household characteristics, including minority populations, census data were collected for the area within 250 m on both sides of the centerline of the proposed alignment. Because of the sparse population in rural portions of the study area, especially in the State of Gujarat region, some villages encompass very large areas of land that often extend for miles beyond the study area. Because the majority of the residents are close to urban areas, census block groups with limited populations in the study area boundaries were not included in the demographic analysis. This more accurately reflects the demographics within the study area boundaries. This was done by reviewing Google imagery, satellite imagery and toposheet of Survey of India to determine the presence of residential buildings within the study area and by site visits to the study areas in September 2014, October 2014 and November 2014. The analysts also collected population and household characteristics for the surrounding region, including the cities of the proposed station. There are twelve proposed stations in the entire alignment of HSR. All the stations are located in the urban conglomerate. The list of the villages and cities falling in the Zone of Influence is illustrated in Table 4.2.10.

Table 4.2.10: Villages and Cities in the Zone of Influence

S.No	District	Sub-district	Villages
STATE: GUJARAT			
1	Ahmadabad	Ahmadabad City	Urban Area of Ahemdabad and Sabarmati
2	Ahmadabad	Daskroi	Vinzol, Ropda, Geratpur, Gamdi & Barejdi
3	Anand	Anand	Bhumel, Chaklasi, Boriavi, Kanjari, Rajnagar, Ajarpur, Lambhvel, Samarkha, Ajupura, Mangal nagar, Prasanna Nagar, Nav Bhavan Colony, Ganesh Colony, Anand, Mahaveer Nagar,
4	Kheda	Mehmedabad	Raska, Rohlsa, Amsaran, Nenpur
5	Kheda	Kheda	Devdi
6	Kheda	Nadiad	Khambhali,Degam,Zarol,Andhai,Arera,Hathnoli, Alijada, Manjipura,Dabhan,Davda,Bamroli, Tundel, Dumral, Pipalag, Gutal, Narsanda
7	Vadodara	Vadodara	Rajupura,Vasad,Dodka,Fajalpur,Sankarda,Nandesari,Lalpura,Vasana Kotariya,Padmala,Ranoli,Dhanora, Ajod, Sisva, Omkarpura, Jawahar Nagar, Kayali Village, Karadiya, Chhani, Laxmi Nagar, Phulwadi, Fatehganj, Saraswati Nagar, Alembic Nagar, Gorwa, Swami Narayan Nagar,Murji Nagar, Nizampura,Sri Krishna Nagar,Badi Gaon,Balaji Nagar, Lajpat Nagar, Vadiwadi, Anand Nagar, Anandpura,

			Fatehpura, Babajipura, Navapura, Manjalpur, Manjeet Nagar, Bhagat Colony, Kololi
8	Vadodara	Padra	Chapad,Gavkhana,Shihor,Virpur,Madapur,Sareja Colony
9	Vadodara	Karjan	Pingalwada,Harsunda,Sarar,Bamangam,Kherda,Anastu,Khandha, Kanabha,Chorbhuj,Karjan,Karanmadi Bodka,Khambola,Manqrol, Sanpa
10	Bharuch	Amod	Sunthodra,Telod,Ochhan,Matar,Ajamnagar,Vasna, Vantarsa,Keshlu
11	Bharuch	Bharuch	Padariya,Kurchan,Karela,Tankariya,Kahan,Seqva, Pipalia, Parkhet,Sitpon,Hingalla,Jhanghar,Pariej,Tralsa Kothi,Mahudhala, Aldar, Luwara, Vagusana, Derol, Samar, Vahalu, Vansi, Vilayat, Tham,Kanthariya,Manubar
12	Bharuch	Anklesvar	Dehegam,Park Safari,Hinqlot,Shishu Vihar Dham, Borbhatha, Modi Nagar, Haripura, Pungam, Diva,Surwadi,Andada,Boldara,Nangal, Kosamadi, Kathodara, Ghodadara, Panoli, Utiyadara, Dhamdod, Hath, Amod, Dungra, Pandavai, Kosamba,Kharach,Kumvarda
13	Navsari	Navsari	Padgha,Vejalpor,Kasbapar,Sarai,Ahmadpur,Telada,Amadpor,Pinsad,Navsari,Nasilpur,Dharagin,Siaodra,Adada,Khadsupa,Kachhol,Vegam
14	Navsari	Jalalpore	Kapletha,Dabhel,Asana,Asunder,Kolasana,Dhaman,Sadodra
15	Navsari	Gandevi	Pinjra,Pathari,Pardi,Manekpor,Dhanori,Pipaldhara,Surat,Khergam,Ankleshwar,Vadsangal,Kesali,Deshad,Nandarkha,Pati,Antaliya,Bilimora
16	Navsari	Chikhli	Ghekti
17	Valsad	Valsad	Gorgam,Panchlai,Dungari,Sonwada,Tighara,Saron Village, Endergota,Khajurdi,Palan,Gundlav,Kewada,Muli,Abrama,Jujwa,Pathri,Chanvai,Binwada,Balda
18	Valsad	Pardi	Sukhlav,Jiyu Colony,Kumbhariya,Kutchihie Society, Pardi, Palsana,Borlai,Udwada,Amli,Khadki,Dungri,Velparva,Motiwada,Kikarla,Sarodhi,Tidhara,Paria,Khuntej,Bagwada,Tarmaliya,Dumalav,Tukwada,Ambach,Pandor,Balitha,Kocharva, Vankachh,Karvad,Aarti Colony, Dungra,Borigam,Valwada
19	Valsad	Umbergaon	Achchhari,Boralai,Bhilad,Anklas,Achad,Nandigam
20	Surat	Olpad	Kudsad,Bharundi,Kareli,Madhar,Khalipor
21	Surat	Kamrej	Shekhpur,Ghaludi,Antroli,tharoli,Velanja,Umra,Choryasi,Amboli,Abrama,Kathor,Bhairav,Kholvad,Diomand nagar,Navagam,Laskana,Pasodara,Kathodara,Kosmada,Oviyan,Antroli,Umbhel
22	Surat	Surat City	Khambhsla,Saniya Kanade,Eklera,Bonand,Ravla Allas Vaktana,,Kapletha,Lajpor
23	Surat	Palsana	Haripura,Kadodara,Tantlthalya,Kharbhasi,Chalthan,Sanki,Talodara,Timbarva,Erthan,Vadadala,Baleshvar,Lingad,Taraj,Intalva,Makhinga
DADRA & NAGAR HAVELI			
24	Dadra & Nagar Haveli	Dadra & Nagar Haveli	Dadra,Demani,Nani Tambadi, Dhapsa, Kachigam, Athal, Kharadpada, Kanadi,Naroli
STATE: MAHARSHTRA			
25	Thane	Talasari	Achchhad,Kajali,Bormal,Kochai,Sawroli,Amagaon, Donqari, Girgaon, Vasa,Kawada,Sawane,Vadavali, Dhamanagaon,Karajgaon,Vankas
26	Thane	Dahanu	Dahanu,Gangangaon,Ghadane,Bramhanwadl,Pardi,Bahare,Talothe,Punjave,Sasvand,Nagzari,Ambesari,Patilpada,Sogwe, Junnarpada,Ashagad,Jamshet,Saravali,Gaurwadi,Agwan,Motapada,Pale,Sakhare, Motgaon,Gowane,Vadade,Palghar,Ambiste

27	Thane	Palghar	Ranishigaon,Shigaon,Police Colony,Pamali,Swarup Nagar,Ashutosh Nagar,Boisar,Mahagaon,Friends Colony, Warangade, Betegaon, Kambalgaon,Umroli,Birwadi,Panchali,Agawan,Morekuran, Kolgaon,Devkhope,Shelwadi,Palghar,Varkhunti,Wasare,Kamare,Mykhop,Umbar Pada, Nandade, Agarwadi, Nagave, Vatthalwadi, Saravali, Manjurli,Mande,Shilte,Saratodi,Virathan, Khardi, Bandar, Dongare, Mithagar,Jalsar,Kandre Bhure,Wadhiv, Saravali, Navghar, Vadhi, Datiware
28	Thane	Vasai	Kasarali,Palghar,Dahisar,Koshimbe,Gadakari Nagar,Baba Nagar,Tokare,Khairpada,Prem Nagar,Virar,Kargil Nagar,Nalaso East,Benjil,Nagrik Colony,Ostwal Nagari,Umvaola,Pelhar,Dube State,Bilalpada,Vasai,Agarwa,Gokhivare,Waliv, Gokul Nagar, Rajavali,Kolhi,Chinchoti,Juchar,Sarjmori,Kaman,Navghar Mori, Poman, Nagll Dongar,Nagal
29	Thane	Bhiwandi	Nagli,Bhivandi,PayeGaon,Firangpada,Kharbav,Tembhavali, Junandurkhi,Vadghar,Dunge,Vadunavaghar,Kewani,Heera Nagar, Kewani,Kopar,Kalher Village,Pume,Val Village,Kasheli Village, Thane, Mankoli Village,Dapode, Dive Anjur, Gundavali, Surai, Anjur,Bharodi,Alimghar
30	Thane	Navi Mumbai	Adabali Village,Mahape Village,Sector-2,Sector-3,Sector-4, Kopar, Sector-20,Sector-9,Sector-19,Sector-22, Khairane
31	Thane	Thane	Diva, Mumbara,
32	Mumbai (Suburban)	Mumbai (Suburban)	Vikhroli,Ghatkopar-West, Amrut Nagar, Vidya Vihar, Sanjay Nagar, Rajawadi,Wadia Colony,Kranti Nagar,Jari Mari Govind Nagar,Premier Colony,Kole, Kalyan,Sundar Nagar,Kallna,Nagpada

Source: Study Team-GPSTPL compiled from Census India 2011

(2) Demography and Socio-Economic Features

Demography and socio-economic features include population, number of houses and households, literacy, population density *etc.* In order to assess the demographic and socio-economic features of the study area, census records of Maharashtra and Gujarat State for the year 2001 and 2011 have been compiled and analyzed. The list of the villages and cities falling within the ZOI of the proposed alignment has been illustrated in Table 4.2.10 above. As the village level data of Census 2011 is not available, only district level data of Census 2011 has been compiled, analyzed and discussed in the subsequent sections.

(3) Population, Gender and Population Density

Table 4.2.11 illustrates the status of population and its growth, sex ratio and population density. It is evident from the Table 4.2.11, that there has been phenomenal growth in the population and its density. The highest population density is recorded in Mumbai suburban area which stands at 20925 per sq. km. showing upward trend as compared to that of 2001 (19373.1 per sq. km.). However, the rural area of Mumbai district shows downward trend with 20038 per sq. km. in 2011, compared to that of 2001 (21261.3 per sq. km.).This is because of the migration of the rural population towards suburban area in search of livelihood. The lowest population density was recorded in Bharuch district of Gujarat with figure at 238 per sq. km in

2011 as compared to 210 per sq. km. The sex ratio in general shows positive trend except the Surat. Surat shows declining trend in sex ratio. As per the Census Records of 2001, it stood at 810 females per 1000 males which came down to 788 females per 1000 males as per Census Records of 2011. Mumbai has recorded phenomenal growth in sex ratio having 857 females per 1000 males as per Census Records of 2011 as compared to 822 females per 1000 males as per Census Records of 2001which shows 4.26 percentage increase in the sex ratio. As per the Census Records of 2011, the total population of the ZOI stood at 45,131,455. The population growth shows downward trend during the last decade of 2001-2011 as compared to 1991-2001. The Mumbai District shows negative trend which is good for the development. The population growth in the Mumbai district stood at 5.13851 per cen during 1991-2001 and the same has been recorded as -5.75 per cent during 2001-2011 decade. Similarly the Mumbai city has shown remarkable control over population outburst, having 27.9872 per cent during 1991-2001 drastically came down to 8.01 per cent during 2001-2011.

Table 4.2.11: Population, Sex Ratio and Population Density in the Zone of Influence

District	Population 2011			Percentage decadal growth rate of population		Sex- Ratio (Number of Females per 1000 Males)		Population Density per sq. km.	
	Persons	Males	Females	1991-01	2001-11	2001	2011	2001	2011
GUJARAT									
Ahmadabad	7,208,200	3,787,050	3,421,150	27.25	22.31	892	903	727	890
Anand	2,090,276	1,088,253	1,002,023	13.04	12.57	910	921	631	711
Kheda	2,298,934	1,187,098	1,111,836	13.32	12.81	923	937	479	541
Panch Mahals	2,388,267	1,227,805	1,160,462	20.39	17.92	938	945	389	458
Vadodara	4,157,568	2,150,229	2,007,339	19.87	14.16	919	934	482	551
Bharuch	1,550,822	805,945	744,877	19.37	13.14	921	924	210	238
Navsari	1,330,711	678,423	652,288	13.24	8.24	955	961	557	602
Valsad	1,703,068	884,064	819,004	29.65	20.74	920	926	465	561
Surat	6,079,231	3,399,742	2,679,489	54.30	42.19	810	788	968	1376
MAHARSHTRA									
Thane	11,054,131	5,879,387	5,174,744	54.92	35.94	858	880	850.79	1157
Mumbai (Suburban)	9,332,481	5,025,165	4,307,316	27.9872	8.01	822	857	19373.1	20925
Mumbai	3,145,966	1,711,650	1,434,316	5.13851	-5.75	777	838	21261.3	20038
Total	45,131,455	27,824,811	24,514844						

Source: Directorate General Office, Census of India, 2011

(4) Occupational Pattern of the Study Area

Table 4.2.12 illustrates the occupational pattern of the ZOI based on the Census Records of 2011. The population of main workers in the ZOI stands at 18465302 (35.29 per cent of the total population) comprising of male-15024665 and female-3440637 respectively. On perusal of the table, it is evident that the population of the main workers is highest in Mumbai suburban which stands at 93515922 followed by Thane urban-3045058 whereas, the lowest population of main workers recorded in Navsari-144902. The population of the marginal workers (which work for 3 to 6 months in a year) stood at 2412238 (4.61 per cent of the total population). The population of the marginal workers recorded highest in Panch Mahals which stands at 379808 (0.73 per cent of the total population). This is because of the rural character of the district. The population of non-workers in the study area stands at 31140831(59.50 per cent of the total population) comprising male-11595194 and female-19545637. The number of female non-workers are on higher side, which indicate that even now most of the female are house wives. They prefer to be at home to take care of the children and old aged family members. It is surprising to note that the population of non-workers in Mumbai suburban is the highest in the study area which stands at 5621941 (10.74 per cent of the total population of the ZOI) comprising male-2087001 and female-3534940 followed by Thane where it stands at 5191640 (9.92 per cent of the total population of the ZOI) comprising male-1931237 and female-3260403.

Table 4.2.12: Occupational Pattern of the Study Area

District	Population			Main Workers			Marginal Workers			Non-Workers		
MAHARASHTRA												
	Persons	Males	Females	Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
Thane -Rural	2545470	1300136	1245334	885453	595115	290338	237976	113980	123996	1375741	570718	805023
Thane -Urban	8514678	4564942	3949736	3045058	2464388	580670	244438	149082	95356	5191640	1931237	3260403
Mumbai Suburban	9356962	5031323	4325639	3515922	2811481	704441	183283	109677	73606	5621941	2087001	3534940
Mumbai	3085411	1684608	1400803	1209334	975508	233826	63664	38123	25541	1801015	663599	1137416
GUJARAT												
Ahmedabad-Rural	1151178	595583	555595	374763	311753	63010	87848	26721	61127	677954	254049	423905
Ahmedabad-Urban	6063047	3192468	2870579	1957646	1693961	263685	145434	80976	64458	3941319	1406455	2534864
Anand-Rural	1457758	758499	699259	495207	403545	91662	113832	37047	76785	836746	313254	523492
Anand-Urban	634987	328725	306262	194824	166681	28143	26122	14191	11931	411205	146409	264796
Kheda-Rural	1776276	915197	861079	568726	461277	107449	174935	60833	114102	1018196	386662	631534
Kheda-Urban	523609	270530	253079	153408	132291	21117	19814	12130	7684	347706	124479	223227
Panch Mahals	2390776	1226961	1163815	685141	561301	123840	379808	98657	281151	1293269	553396	739873
Vadodara-Rural	2099855	1077943	1021912	712860	567617	145243	253760	68557	185203	1107415	433027	674388
Vadodara-Urban	2065771	1075793	989978	647800	554174	93626	46534	29580	16954	1364738	487397	877341
Bharuch-Rural	1026060	529393	496667	363649	281479	82170	73534	29063	44471	578875	214202	364673
Bharuch-Urban	524959	276314	248645	162892	142405	20487	14469	9577	4892	345020	122586	222434
Navsari-Rural	920535	464749	455786	365102	256694	108408	64473	23882	40591	483631	181124	302507
Navsari-Urban	409137	213416	195721	144902	118681	26221	8515	4793	3722	254207	89160	165047
Valsad-Rural	1070177	542644	527533	350874	259041	91833	121648	44417	77231	576743	230795	345948
Valsad-Urban	635501	344578	290923	226453	191353	35100	20394	11294	9100	385690	140239	245451
Surat-Rural	1232109	640060	592049	522191	375267	146924	66490	22311	44179	636710	239610	397100
Surat-Urban	4849213	2762164	2087049	1883097	1700653	182444	65267	36395	28872	2891070	1019795	1871275
TOTAL	**52333469**	**27796026**	**24537443**	**18465302**	**15024665**	**3440637**	**2412238**	**1021286**	**1390952**	**31140831**	**11595194**	**19545637**

Source: Directorate General Office, Census of India, 2011

4.2.9 Children's Right

The Indian constitution accords rights to children as citizens of the country, and in keeping with their special status the State has even enacted special laws. The Constitution, promulgated in 1950, encompasses most rights included in the UN Convention on the Rights of the Child as Fundamental Rights and Directive Principles of State Policy. Over the years, many individuals and public interest groups have approached the apex court for restitution of fundamental rights, including child rights. The Directive Principles of State Policy articulate social and economic rights that have been declared to be "fundamental in the governance of the country and … the duty of the state to apply … in making laws" (Article 37). The government has the flexibility to undertake appropriate legislative and administrative measures to ensure children's rights; no court can make the government ensure them, as these are essentially directives. These directives have enabled the judiciary to give some landmark judgements promoting children's rights, leading to Constitutional Amendments as is in the case of the 86th Amendment to the Constitution that made Right to Education a fundamental right. Constitutional Guarantees that are meant specifically for children include:

- Right to free and compulsory elementary education for all children in the 6-14 year age group (Article 21 A)
- Right to be protected from any hazardous employment till the age of 14 years (Article 24)
- Right to be protected from being abused and forced by economic necessity to enter occupations unsuited to their age or strength (Article 39(e))
- Right to equal opportunities and facilities to develop in a healthy manner and in conditions of freedom and dignity and guaranteed protection of childhood and youth against exploitation and against moral and material abandonment (Article 39 (f)).
- Right to early childhood care and education to all children until they complete the age of six years (Article 45).

Besides, Children also have rights as equal citizens of India, just as any other adult male or female:

- Right to equality (Article 14)
- Right against discrimination (Article 15)
- Right to personal liberty and due process of law (Article 21)
- Right to being protected from being trafficked and forced into bonded labour (Article 23)
- Right of minorities for protection of their interests (Article 29)
- Right of weaker sections of the people to be protected from social injustice and all forms of exploitation (Article 46)
- Right to nutrition and standard of living and improved public health (Article 47).

While all children have equal rights, their situations are not uniform. At the same time, childhood and the range of children's needs and rights are one whole, and must be addressed holistically. A life-cycle approach must be maintained. Keeping this in mind, there are several national laws and policies that address the different age-groups and categories of children. Table 4.2.13 presents the list of acts of Children's Right formulated in the Constitution of India.

Table 4.2.13: Acts of Children's Right in the Constitution of India

Year	Description
2012	The Child Labour (Prohibition and Regulation) Amendment Bill, 2012
2012	Protection of Children from Sexual Offences Notified Rules - 2012
2012	Protection of Children from Sexual Offences Act-2012
2009	The Right of Children to Free and Compulsory Education Act, 2009
2006	Juvenile Justice (Care and Protection of Children) Act (Amendment, 2006)
2006	Prohibition of Child Marriage Act
2002	The Pre-Natal Diagnostic Techniques (Regulation and Prevention of Misuse) Amendment Act
2000	The Pre-Natal Diagnostic Techniques (Regulation and Prevention of Misuse) Amendment Act
2000	Juvenile Justice (Care and Protection of Children) Act (2000)
2000	Information Technology Act
1996	Persons with Disabilities (Equal Protection of Rights and Full articipation) Act
1994	Transplantation of Human Organ Act
1992	Infant Milk Substitutes, Feeding Bottles and Infant Foods (Regulation of Production, Supply and Distribution) Act
1989	Schedule Caste and Schedule Tribes (Prevention of Atrocities) Act
1987	Prevention of Illicit Traffic in Narcotic Drugs and Psychotropic Substances Act
1986	Child Labour (Prohibition and Regulation) Act
1976	Bonded Labour System (Abolition) Act
1974	National Policy for Children
1960	Orphanages and Other Charitable Homes (Supervision and Control) Act
1956	Probation of Offenders Act
1956	Immoral Traffic (Prevention) Act (amended in 1986)
1956	Hindu Adoption and Maintenance Act
1948	Factories Act (Amended in 1949, 1950 and 1954)
1890	Guardians and Wards Act

Source: http://www.haqcrc.org/indian-laws-policies

RIGHT TO EDUCATION (RTE) ACT: Right of access and free elementary education (Classes 1-8) The most significant provision in the RTE Act is the one that addresses this basic right of access to free elementary education for all children: 'Every child of the age of six to fourteen years shall have a right to free and compulsory education in a neighbourhood school till completion of elementary education. In other words, this right to free elementary education (Classes1-8) in a neighbourhood government school extends to all children irrespective of gender, religion, class, caste and includes those with physical and other disabilities. The State will ensure this right of access to free elementary education. 'Free'means that that in a local government school or Zilla Parishad school, all children are entitled to be admitted, and no fees or payments of any kind can be charged. They are entitled to free textbooks, writing materials and uniforms. Children with disabilities are also entitled to these and other special facilities. What will be provided free in schools will be determined by each Indian state, and could also include free transport. In other words, the State will ensure that no child will be prevented by any financial barriers from completing elementary education (Classes 1-8) in a government school. In other types of schools, not all children will be provided 'free' education.
Compulsory education'means that the State/Local Education Authorities are legally compelled to:

- Provide a neighbourhood school.
- Ensure compulsory admission, attendance and completion of 8 years of elementary education.
- Guarantee that economically and socially disadvantaged children are not discriminated against.
- Provide remedial training for students in need.
- Take measures so that all schools have facilities and an adequate number of teachers as required in the Schedule to the Act by 2013.
- Some facilities are to improve the access of sub-groups of children like separate toilets for girls, and barrier-free access (ramps) for children with disabilities.

In other words, the law now compels the government to ensure that all children have a right of access to good quality elementary schooling of 8 years, and its completion.

4.2.10 Climate Change

(1) Country

The effects of **global warming on the Indian subcontinent** vary from the submergence of low-lying islands and coastal lands to the melting of glaciers in the Indian Himalayas, threatening the volumetric flow rate of many of the most important rivers of India and South Asia. In India, such effects are projected to impact millions of lives. As a result of ongoing climate change, the climate of India has become increasingly volatile over the past several decades; this trend is expected to continue. Elevated carbon dioxide emissions from industries, factories, vehicles etc. have contributed to the greenhouse effect, causing warmer weather that lasted long after the atmospheric shroud of dust and aerosols had cleared. Further climatic changes 20 million years ago, long after India had crashed into the Laurasian landmass, were severe enough to cause the extinction of many endemic Indian forms.[1] The formation of the Himalayas resulted in blockage of frigid Central Asian air, preventing it from reaching India; this made its climate significantly warmer and more tropical in character than it would otherwise have been. According to data from 2009 India is the world's third biggest emitter of CO_2 after China and the United States - pushing Russia into fourth place.

<u>Past Climate Change</u>
However, such shifts are not new: for example, earlier in the current Holocene epoch (4,800–6,300 years ago), parts of what is now the Thar Desert were wet enough to support perennial lakes; researchers have proposed that this was due to much higher winter precipitation, which coincided with stronger monsoons. Similarly, Kashmir, which once had a warm subtropical climate, shifted to a substantially colder temperate climate 2.6–3.7 mya; it was then repeatedly subjected to extended cold spells starting 1 million years ago.

<u>Rise in Sea Level</u>
The corresponding sea level rise at the end of the 21st Century relative to the end of the 20th Century ranges from 0.18 to 0.59 m (excluding any rapid dynamical changes in ice flows in the future). Ongoing sea level rises have already submerged several low-lying islands in the Sundarbans, displacing thousands of people. Temperature

rises on the Tibetan Plateau, which are causing Himalayan glaciers to retreat. It has been predicted that the historical city of Thatta and Badin, in Sindh, Pakistan would have been swallowed by the sea by 2025, as the sea is already encroaching 80 acres of land here, every day.

Environmental

Increased landslides and flooding are projected to have an impact upon states such as Assam. Ecological disasters, such as a 1998 coral bleaching event that killed off more than 70% of corals in the reef ecosystems off Lakshadweep and the Andamans, and was brought on by elevated ocean temperatures tied to global warming, are also projected to become increasingly common. The first among the countries to be affected by severe climate change is Bangladesh. Its sea level, temperature and evaporation are increasing, and the changes in precipitation and cross boundary river flows are already beginning to cause drainage congestion. There is a reduction in fresh water availability, disturbance of morphologic processes and a higher intensity of flooding and other such disasters. Bangladesh only contributes 0.1% of the world's emissions yet it has 2.4% of the world's population. In contrast, the United States makes up about 5 percent of the world's population, yet they produce approximately 25 percent of the pollution that causes global warming.

Economic

The Indira Gandhi Institute of Development Research has reported that, if the predictions relating to global warming made by the Intergovernmental Panel on Climate Change come to fruition, climate-related factors could cause India's GDP to decline by up to 9%; contributing to this would be shifting growing seasons for major crops such as rice, production of which could fall by 40%. Around seven million people are projected to be displaced due to, among other factors, submersion of parts of Mumbai and Chennai, if global temperatures were to rise by a mere 2 °C (3.6 °F).

Villagers in India's North Eastern state of Meghalaya are also concerned that rising sea levels will submerge neighbouring low-lying Bangladesh, resulting in an influx of refugees into Meghalaya—which has few resources to handle such a situation.

If severe climate changes occur, Bangladesh will lose land along the coast line. This will be highly damaging to Bangladeshis especially because nearly two-thirds of Bangladeshis are employed in the agriculture sector, with rice as the single most important product. The economy has grown 5-6% over the past few years despite inefficient state-owned enterprises, delays in exploiting natural gas resources insufficient power supplies, and slow implementation of economic reforms. However, Bangladesh remains a poor, overpopulated, and inefficiently governed nation. If no further steps are taken to improve the current conditions global warming will affect the economy severely worsening the present issues further. The climate change would increase expenditure towards health care, cool drinks, alcoholic beverages, air conditioners, ice cream, cosmetics, agro chemicals *etc.*

Social

Climate Change in India will have a disproportionate impact on the more than 400 million that make up India's poor. This is because so many depend on natural resources for their food, shelter and income. More than 56% of people in India work in agriculture, while many others earn their living in coastal areas.

Pollution

Thick haze and smoke, originating from burning biomass in northeastern India and air pollution from large industrial cities in northern India, often concentrate inside the Ganges Basin. Prevailing westerlies carry aerosols along the southern margins of the steep-faced Tibetan Plateau to eastern India and the Bay of Bengal. Dust and black carbon, which are blown towards higher altitudes by winds at the southern faces of the Himalayas, can absorb shortwave radiation and heat the air over the Tibetan Plateau. The net atmospheric heating due to aerosol absorption causes the air to warm and convect upwards, increasing the concentration of moisture in the mid-troposphere and providing positive feedback that stimulates further heating of aerosols.

(2) Maharashtra

Maharashtra, one of India's largest states and home to the commercial hub of Mumbai, is facing up to the serious threat posed by climate change. Although Maharashtra is a relatively industrialised state, the majority of its population continues to work in agriculture. This high level of dependency on the land, combined with a vulnerable coastline of more than 840 km, leaves the state particularly susceptible to changing weather patterns. As well as fluctuations in temperature and precipitation, there is the potential for climate change to affect the frequency and intensity of extreme events such as droughts, floods, cyclones, storm surges and heatwaves. Of course, Maharashtra is not alone. Many other areas of India, and other parts of the world, face a similar challenge. But what's particularly interesting about Maharashtra is what is being done now to tackle that challenge and how others may be able to learn from the project. It's likely that the strongest impact of climate change will be felt by the world's least developed countries. Without detailed climate change information at a local level, regional authorities and governments will not be able to plan adequately for the future — yet few developing countries currently have the capacity to perform the necessary climate research on their own.

Key Changes and Impacts

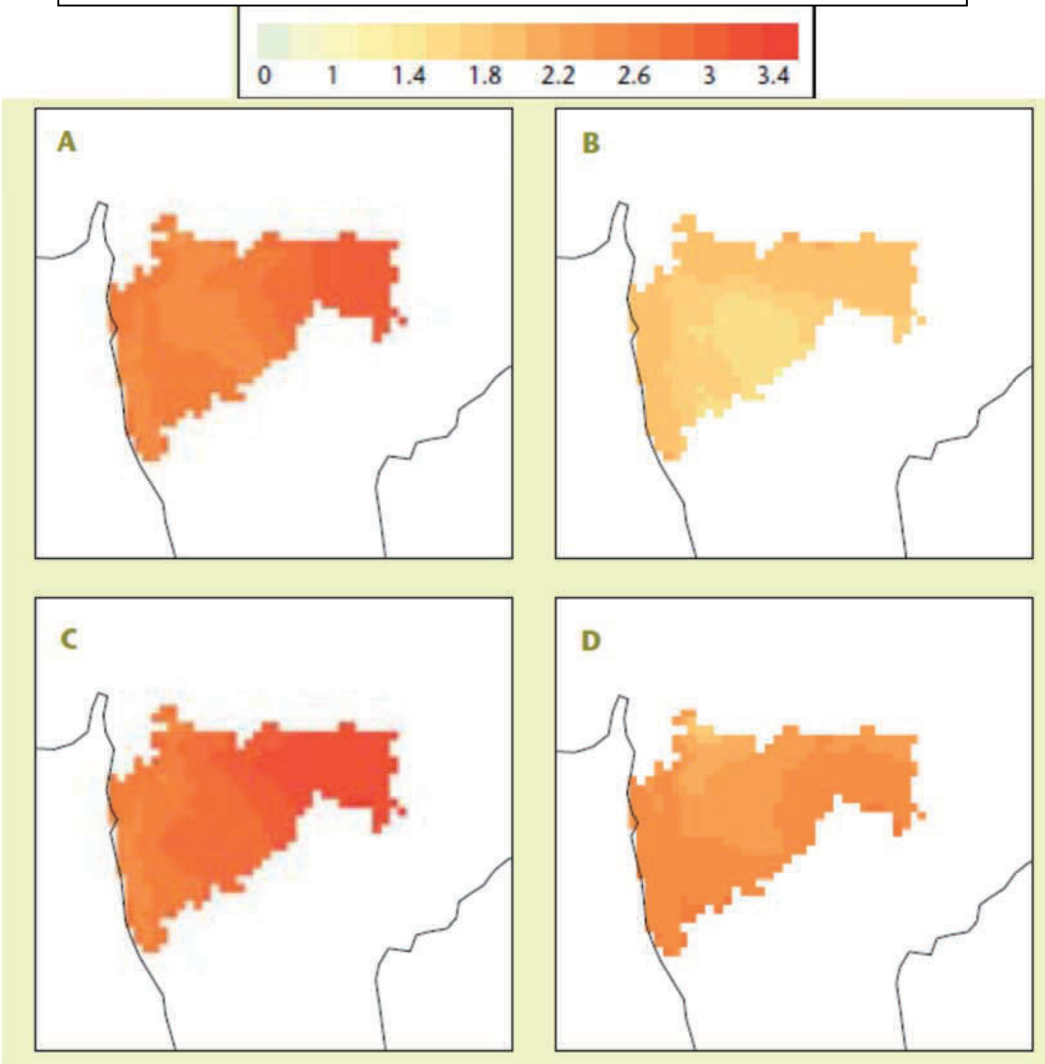
The main climate changes and potential impacts expected in Maharashtra are as follows:

- Increased temperatures and altered seasonal precipitation patterns (both in amount and timing) could affect the hydrological systems and agricultural productivity.
- Increased risk of severe weather events may have a devastating impact on agriculture, water resources, forestry and the well-being of the population.
- Coastal communities face a serious threat from rising sea levels. A one-metre rise in sea level would put more than 1.3 million people at risk.
- If no action is taken, the associated costs of climate change-related damages in Mumbai alone could be upwards of Rs. 2 trillion.

Temperature

With rising concentrations of carbon dioxide, it is understood that globally averaged temperatures are expected to increase. However, regional climate change could exhibit different behaviour to this global average, and hence regional climate modelling techniques are used in order to identify the effect of climate change on a local scale. For the region of Maharashtra, the climate studies performed in this project consistently project an increase in temperature over the entire region for the monsoon season, with a range between 1.5 °C and 3 °C for the four models used (herein denoted projection A, B, C and D, see Figure 4.2.4). The threat of increasing temperatures for the region of Maharashtra could lead to severe drought, water scarcity, and reduced crop yield, all of which could have a devastating impact on people.

Changes in temperature (°C) during 2070-2099 with respect to 1971-2000



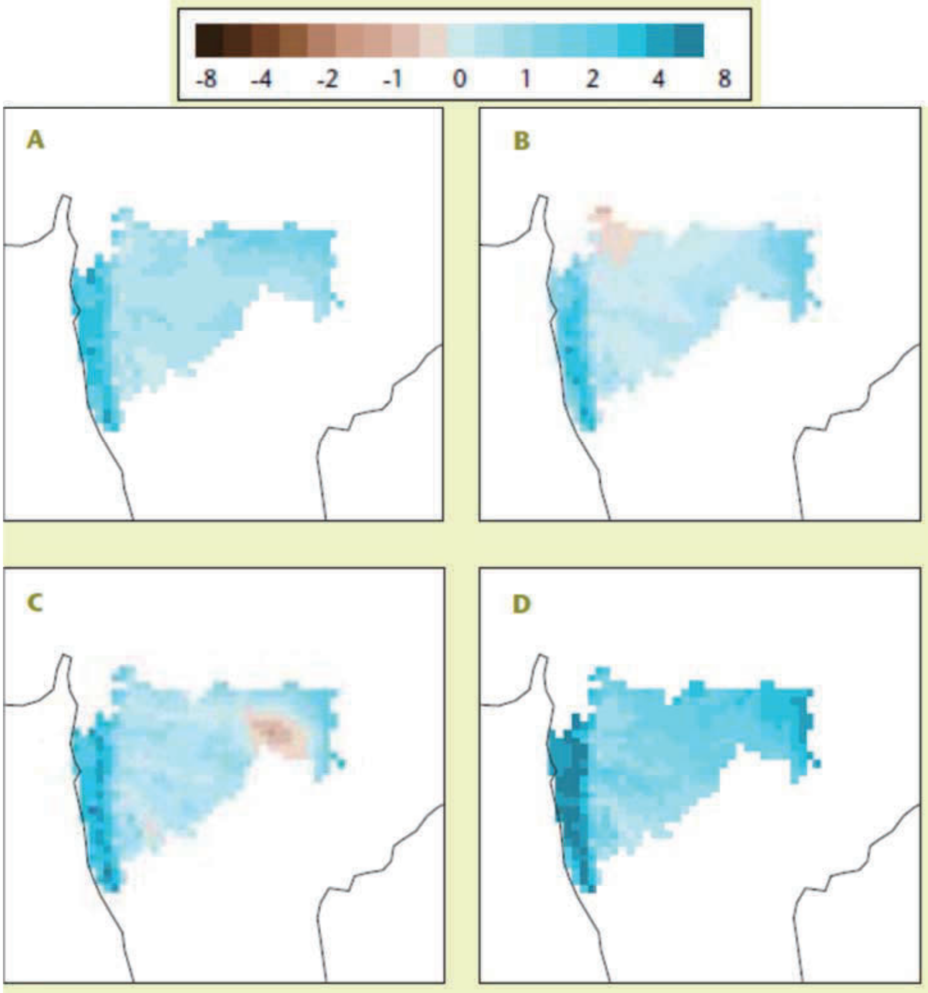
Source:Climate Change Threat to Maharashtra-TERI

Figure 4.2.4: Future Temperature Projections

<u>Rainfall</u>

In addition to increasing temperatures, climate change is expected to alter the magnitude and shape of global precipitation patterns. For Maharashtra, all four projections in this study suggest an increase in monsoon rainfall, particularly along the state's coastlines and the Western Ghats, with only slight decreases in rainfall seen further inland by projections B and C (see Figure 4.2.5). Strong increases in rainfall, such as those seen along the Maharashtra coast, could result in extreme flooding events, which could drastically reduce the productivity of the state's agricultural industry, and promote the presence of waterborne diseases such as cholera.

Changes in rainfall (mm/day) during 2070-2099 with respect to 1971-2000



Source: Climate Change Threat to Maharashtra-TERI

Figure 4.2.5: Future Rainfall Projections

(3) Gujarat

Managing Climate Change is a major challenge to humanity. To tackle it, Gujarat has established a separate **Department for Climate Change**. This Initiative by Gujarat Government is a trendsetter not only for India but for the whole of Asia as it is the "**First in Asia**" with a Department for Climate Change. It is the only **4th State/Province in the World** to have a Department for Climate Change. Set up in February 2009, the Department is headed by Shri Narendra Modi to handle issues of Climate Change. The Initiative is to give a human face to environmental issues; empower people to become active agents of sustainable development; promote an understanding that communities are pivotal to changing attitudes towards environmental issues; and advocate partnership, which will ensure all citizens and people in Gujarat to enjoy a safer and more prosperous future. The vulnerability to climate change is greater in developing countries like India- which are mostly located in lower, warmer latitudes. Climatic data of different stations of Gujarat have been analyzed to ascertain the climatic change/variability in the state and its likely impact on crop production using crop models. The long period rainfall analysis showed slight increase in annual rainfall by 2.86 mm per year. The rainfall intensity in terms of daily maximum rainfall also showed increasing trend. The rate of maximum temperature increase was between 0.2 to 0.5°C per decade, maximum being in summer season. Similarly, the minimum temperature was found to increase but with slightly lower rate of 0.2 to 0.3°C per decade in different seasons. The calibrated DSSAT-3.5 models were used to simulate the wheat and maize yield under hypothetical weather condition that may be arising due to climate change. The climate scenario simulated for temperatures (± 1 to ± 3°C), radiation (± 1 to ± 3 MJm-2 day-1) and CO_2 (440, 550 and 660 ppm against present concentration of 330 ppm) were well within the range of projected climate scenario by IPCC.

Results revealed that increase in temperature significantly reduced the wheat yield (-8 to -31 %) while decrease in temperature increased the yield (10 to 26%). The effect of maximum temperature on maize yield had similar effect but the magnitude is marginal (- 4 to 6%) over whole range of temperature (±3°C) change. The minimum temperature had similar effect on wheat yield with less magnitude of variation (-14 to +19 %), however on maize yield increasing trend was observed with increase in minimum temperature. The effect was higher in wheat crop (-50 to 40%) than maize (-18 to 8%). Increase in CO_2 had beneficial effect on both the crops. Large Scale Infrastructure changes have transformed the economy and environment to a Green Gujarat. Gujarat is the only state in India with a Gas Grid, using India's natural gas to replace coal use and reduce pollution. Gujarat has committed to reach gas to hundreds of thousands of households and industries to lower carbon emissions. Already industries, transport vehicles and households are using gas, giving much less pollution in our cities.

It has been estimated that Gujarat's Gas Grid has reduced seventeen million tonnes of carbon emissions. While groundwater levels are falling in other States, in Gujarat the levels are increasing. Data from the Central Ground Water Board (CGWB) shows Gujarat has increased groundwater levels over the last eight years. Over four hundred thousand water- harvesting structures have been constructed: checkdams, bori-bandh and khet talavadi (farm ponds). Climate Change requires change on a mass scale. The Government has increased micro irrigation by offering a subsidy and loan as well as a fast-track application system. Jyotigram Scheme has regulated groundwater use by controlling power supply for agriculture areas. We have successfully controlled the wasteful use of agriculture electricity in Gujarat. International studies have shown that water management reforms have led to a huge increase in output of crops and milk Gujarat, while taking care of the environment. Bus Rapid Transport System is now operational in Ahmedabad, a city of over 4.5 million people. The impact of BRTS has been estimated at a reduction of thirty-seven thousand tonnes of carbon emissions. We are planning to build BRTS in other large cities next for even greater benefits. Gujarat is already committed to using Green Energy for the future. We have created the most attractive policies for Solar, Wind and Biomass Energy production. Gujarat is an ideal place for solar power generation because of large open space for solar panels and high-intensity solar radiation. Gujarat Government has already approved thirty-four solar power projects that will produce seven hundred and sixteen mega watts of electricity, and a reduction of one point two five million tonnes of carbon emissions. Recently the Clinton Climate Initiative announced setting up the world's largest solar power plant in Gujarat, giving an additional capacity of 3000 mega watts. Gujarat Government plans to make Gujarat an international solar hub for manufacturing solar power equipment, research and development and for generating solar energy.

Gujarat has the longest coastline in India of over 1600 km where wind speeds are good for harnessing wind energy. Private wind power plants have been set up along the coast and Gujarat's total wind power capacity is now over one thousand six hundred mega watts. Gujarat plans to add more than four thousand mega watts of wind power capacity by 2012. The United Nations Clean Development Mechanism (CDM) is encouraging carbon emission reductions. Gujarat has over onehundred CDM projects registered with the highest amount of carbon dioxide reduction in India, of twenty-two million tonnes of carbon dioxide. Gujarat is transforming polluting cities to green cities. In 2003 Ahmedabad was named as the mostpolluted city in India. In 2009 Ahmedabad topped the list of United Nations 'Green Cities'. We must transform how cities prepare for climate change. Surat City in Gujarat has been selected by the Rockefeller Foundation - for the Asian Cities Climate Change Resilience Network (ACCCRN) project to prepare an action plan to withstand and recover from impacts of climate change. This will be an international model for other cities to make climate change action plans. The initiative taken by the Government of India to implement MAHSRC will certainly reduce the CO_2 emissions at greater level and will be helpful in combating the challenge of Climate Change at large scale.

Proposal for Ten Carbon Neutral Municipal Towns

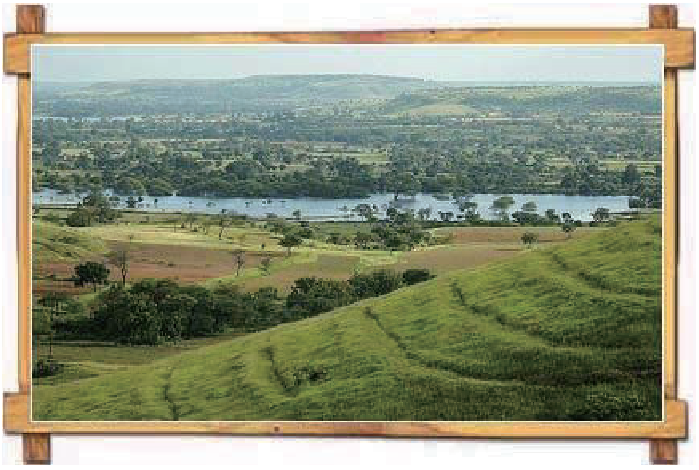
Initially ten towns are suggested to be developed as Carbon Neutral towns by using Wind Energy and Solar Energy. The potential of Wind and Solar Energy is high in Gujarat as Gujarat is the coastal state with high wind velocities and it is the State with such latitudes which experiences one of the best exploitable solar radiations. Baseline data of electricity consumption by these Municipalities are found from Municipal Energy Efficiency Programme (MEEP). Further development of town and extension of water supply and sewerage network will increase the electricity consumption, by keeping this scenario in consideration the size of renewable energy system is proposed at higher side.

4.2.11 Landscape

The landscape of the proposed alignment can be bifurcated into two different regions. The first part towards Mumbai, having undulated and coastal area while the second one, falling in the Gujarat region having plain with minor undulation.

(1) Mumbai & Thane Region

If you want to see the specimen of heaven, you don't need to leave this world. Come to Maharashtra and you will find every thing a human mind can imagine about. According to geological terms the state of Maharashtra can be divided into three different regions Konkan Coastal Line, Deccan plateau and Western Ghats. Variant topography of the state offers you the best it has - deciduous forests, arid deserts, coastal regions, lofty hills and lush green forests. The moderate summers and mild winters of the state make your holidays most pleasant experience. The landscape of Maharashtra is shown in Figure 4.2.6.



Source: Wikipedia

Figure 4.2.6: Landscape of Maharashtra

The physiographic feature of the Mumbai region is broad and flat terrain flanked by north-south trending hill ranges. The hill ranges form almost parallel ridges in the eastern and western part of the area. The Powai-Kanheri hill ranges are the other hill extending in the eastern and central part running NNE-SSW. The maximum elevation of the area is 450 m above mean sea level (m msl) at some of the peaks of hill ranges. Trombay island has north-south running hills with maximum elevation of 300 metre above mean sea level. Malbar, Colaba, Worli and Pali hills are the small isolated ridges trending north-south in the western part of the area. Geographically, the Mumbai is an island outside the mainland of Konkan in Mahrashtra separated from the mainland by narrow Thane Creek and a somewhat wider Harbor Bay. At present, it covers the original island group of Mumbai, and most of the island of Salsette, with the former eTrombay island appended to it in its Southeast. A small part in the north, the Salsette Island however, lies in Thane District. The Salsette-Mumbai island creek and the Thane creek together separate it from the mainland. The relief features of the region presents the steep scarps of the Sahyadri in the east, the land of the district falls through a succession of plateaus in the north and centre of the district to the Ulhas valley in the south centre. These lowlands are separated from the coastal flats by a fairly well defined narrow ridge of hills that runs north-south to the east of the Thane creek, maintaining a remarkable parallelism to the shore at a distance of about six to ten kilometers from the shores. A number of isolated hills and spurs dot the entire district area, so much so that the district as a whole in its aspects is hilly.

The Sahyadri

The western steep slope of the Sahyadri, falling from the crestal plateaus and high peaks, as well as the foothills lie within the limits of the district.

Passes

From the northern limits, adjoining the Gujrat border, till reaching the Thal Ghat, the Sahyadri is subdued in relief, and nowhere, elevations exceed 600 meters. There is no well marked physical barrier between Nasik and Mokhada taluka of this district and a number of ghat passes have been traditionally used as routes between villages in the plateau and this district.

Off-shoots

A number of spurs shoot off from the Sahyadri westwards into Thane lowlands and plateau. Most of them are narrow, rarely more than two kilometers wide, with steep slopes on either side and often rising to considerable levels, rather abruptly, above the floor level of the plateau. Many of them carry on their crests, small plateaus, often forest clad and of difficult access. This type of a hill, range country, with intervening deep gorges of stream valleys, is at its best seen in the central part of Wada and Jawhar talukas it presents a memorable picturesque landscape clothed in green soon after the monsoon.

Coastal Ranges

The most rugged terrain of the district is a belt about 15-25 kilometers broad that runs parallel to the coast at a distance of 15-20 kilometers from the shore. In the south of these tracts are the hills of the Salsette Island that form the core and rise to the highest elevation of 462 kilometers at Kanheri and Avaghad and further north in Kamandurg and Tungar hills of Bassein.

Interior Hills

Further inland to the north east of the Manor is the semi-circular hill of Pola with its peaks Adkilla and Asheri. About thirteen kilometers south of Manor, across the Vaitarna from Keltan and Takmak stands the solitary fortified hill of Kohoj rising abruptly from the plains and visible over considerable distances from all around. Between this rugged terrain and the Sahyadri in the east, the country is comparatively level, broken by few hills. Of these, the western-most hill in Wada is Davja with its two spurs. Smaller hills in Wada are Kapri in the east, Indagaon hills in the north-west, and Ikna and Domkavla hills in the south-east border. About seven kilometers north-east of Shahapur the long flat-topped mass of Mahuli (849 meters) rises like a great block of masonry. The sides of the hills are richly wooded but the laterite-capped top has only a poor stunted vegetation mostly of hirda (Terminalia chebula). North of this, Bhopatgad is crowned with a fort which overlooks Kurlod on the north of the Pinjal River and rises about 170 meters above the general level of the neighboring high country. From the east, the ascent is about 170 meters from the west; it is about 500 meters for its slopes form the face of the Mokhada tableland.

The Southern Hills

In the south, the country is far from level. On the west, the Parsik range runs from Panvel creek northwards and ends abruptly with a cliff face overlooking the Ulhas near Mumbra. Its highest elevation is Dophora peak (405 meters). The curved range of Chanderi stretches from the long level back of Matheran, west to the quaintly cut peaks Tavli and Bava Malang (791 meters) along southern limits of the district. About every twenty kilometers to the north-east, near Bablapur is Muldongri hills.

The Plateaus

Between the coastal range, the hills and Sahyadri scarp the whole country is a succession of plateaus descending from the sahyadri, step by step and separated from the next lower down with a well-defined scarp face. In the north-east at an elevation of about 300-400 meters is the Jawahar-Mokhada plateau that descends down further west to the Wada plateau at an elevation of about 150-300 meters. The Wada plateau is separated from the coastal lowlands of Palghar and Dahanu by the double range of hills that runs about 15-25 kilometers from the coast, enclosing within it the Surya and the Vaitarna valleys. South-east of the Wada plateau is the Shahapur upland at an average elevation of 300 meters which in the west falls to the Bhiwandi lowland and in the south to the narrowly entrenched Bhatsai-Kalu valleys. In the south-east of the district is the Murbad plateau at an elevation of less than100 meters. The plateau country locally is dotted with low mounds and ladges that are best seen along the railway line from Kalyan to Kasara.

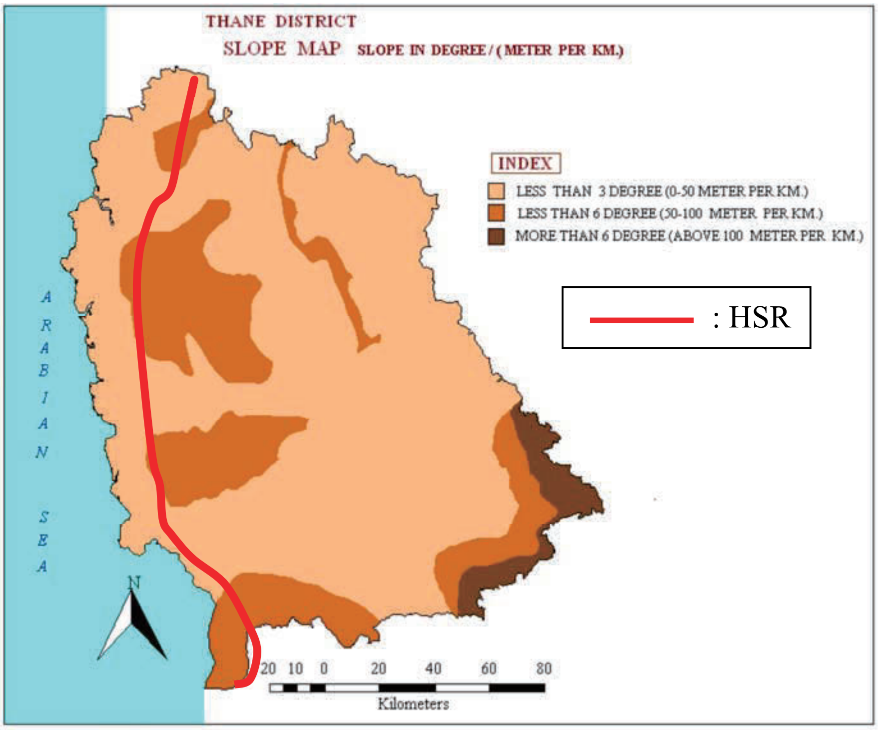
The Coast

To the west, the district of Thane has a fair coast-line, about 100 kilometers long. The coast naturally falls into two sections to the north and south of Vaitarna estuary. Then the south, the great gulf that runs from the north of Kolaba to Bassein, must in recent time have stretched far further inland than it now stretches. Idrisi description of Thane (1153 A.D.) that it stands on a great gulf where vessels anchor and from which they set sail, may have been adequately deep when sea filled the marsh through which the Thane creek now runs towards Bhivandi and Kalyan and where the wide tracts are now half dry. As late as the beginning of the 19th century, Salsette comprised a number of islands. Within three to five kilometers of the Vaitarana estuary formed the islands of Basssein. The backwater that separated this strip of coast from the mainland opened south-westward into the Bassein creek forming the Sopari creek on which stood the celebrated fort of Sopara Ptolemy. In-between the Vaitarana and Ulhas mouths, island were formed once by the branches of the Bassein creek that ran up to Bhivandi. In the south, the Thane creek was once a broad belt of sea with a number of islands like the Gharapuri, Butcher islands and Karanja, dotting it. Many of these islands have now become a continuous mass of land extending as peninsulas from the mainlands. On the whole, the coast here presents the appearance of considerable submergence. However, geologically the coast is not without its variety. The present coast from Bandra to Dahanu is a constant alternation of bays and rocky headlands with sand spits, dunes and bars in protected reaches behind headlands. Along the coast, in the neighbourhood of Manori and further north, as far as Dahanu, raised beaches made of littoral concrete have been recognized, running north-south close to the present shores and not very high above the present sea level.

North of the Vaitarana estuary, the shores are flat, with long sandy beaches and spits running into muddy shallows; the creeks and streams are at best small inlets divided by wide wastes of salt marshes tracts of slightly rising ground in-between covered by palms, fruit orchards and casurina. This landscape stretches to the foot of the hills that live a few kilometers away and rise abruptly to sufficiently high elevations to mask off the flatness of the low ground. All along the coast, the dreary salt marshes are being steadily reclaimed as salt pans and rice flats.

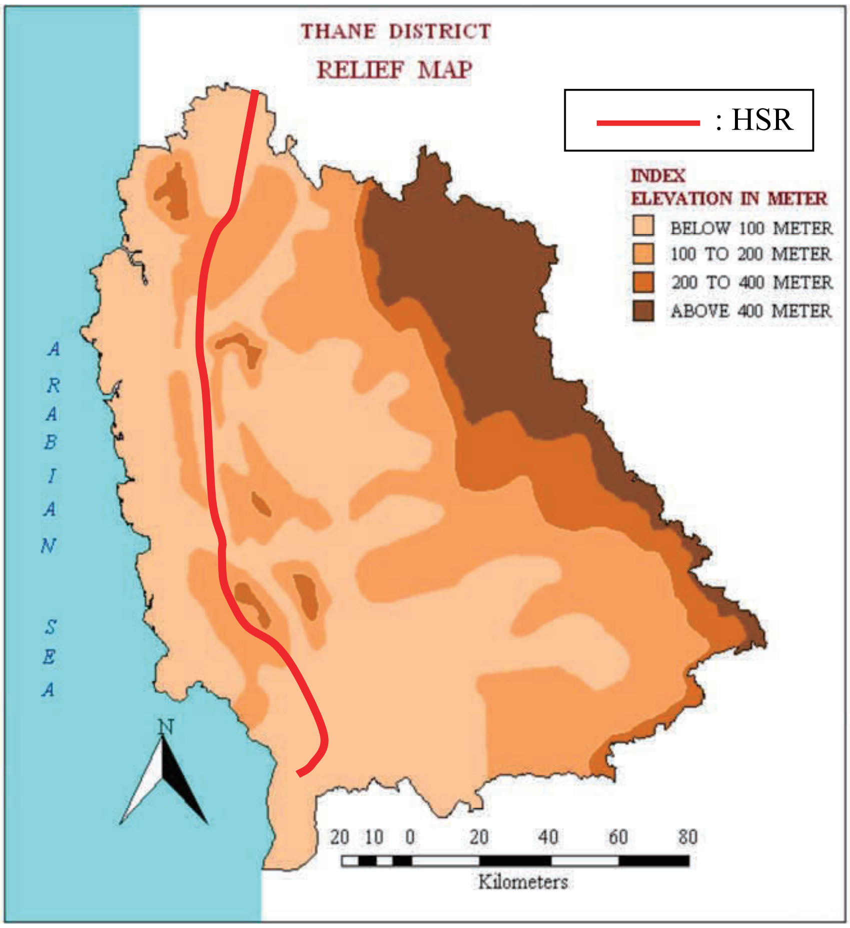
Islands

There are number of islands along the sea-margins of the district. The most important of these is the group of Mumbai islands, overlooking Uran and Panvel of Kolaba district on the mainland. In the Bassein tahsil, at the entrance to the Vaitarana estuary lies the island of the Arnala containing a well preserved fort. The slope map of Thane showing the change in grade is shown in Figure 4.2.7 and the relief feature of Thane is illustrated in Figure 4.2.8.



Source: District profile of Thane, District Gazetter

Figure 4.2.7: Slope Map of Thane

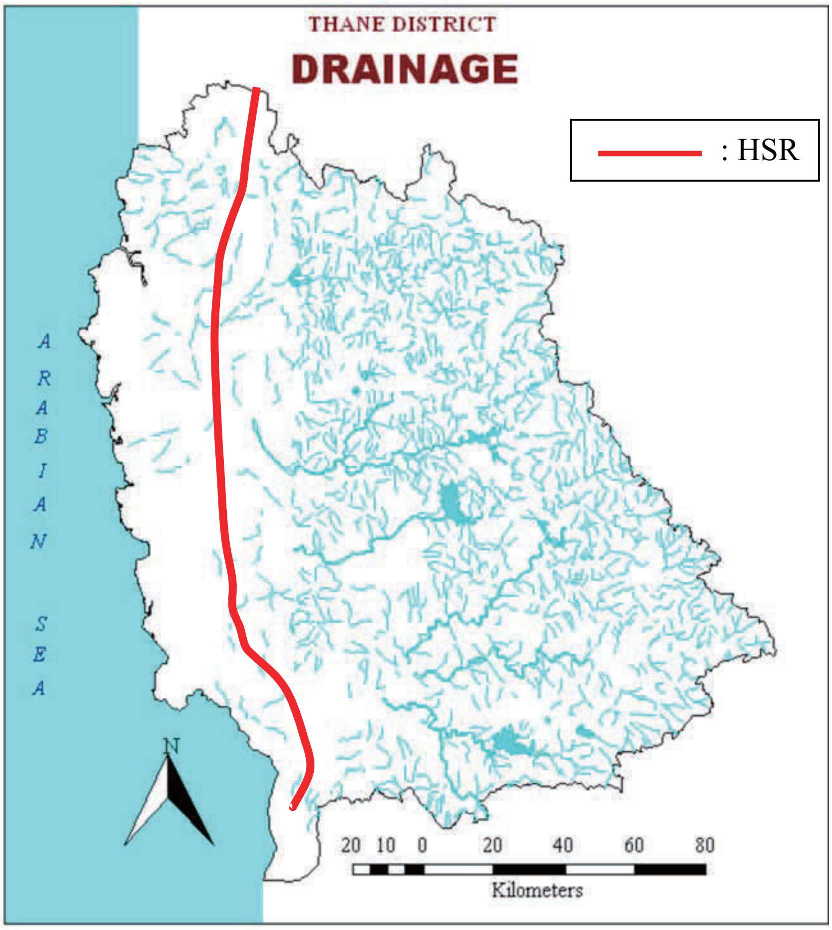


Source: District profile of Thane, District Gazetteer

Figure 4.2.8: Relief Map of Thane

Drainage System

The drainage of this region is controlled by mainly two rivers streams of North Konkan, namely the Ulhas and the Vaitrana, both draining the rainy western slopes of Sahyadri that lie between the Bhor and the Thal Ghats. There is much similarity in their courses. Dashing over the black scarp of the Sahyadri. The drainage pattern of Thane is shown in Figure 4.2.9.



Source: District profile of Thane, District Gazetteer

Figure 4.2.9: Drainage Map of Thane

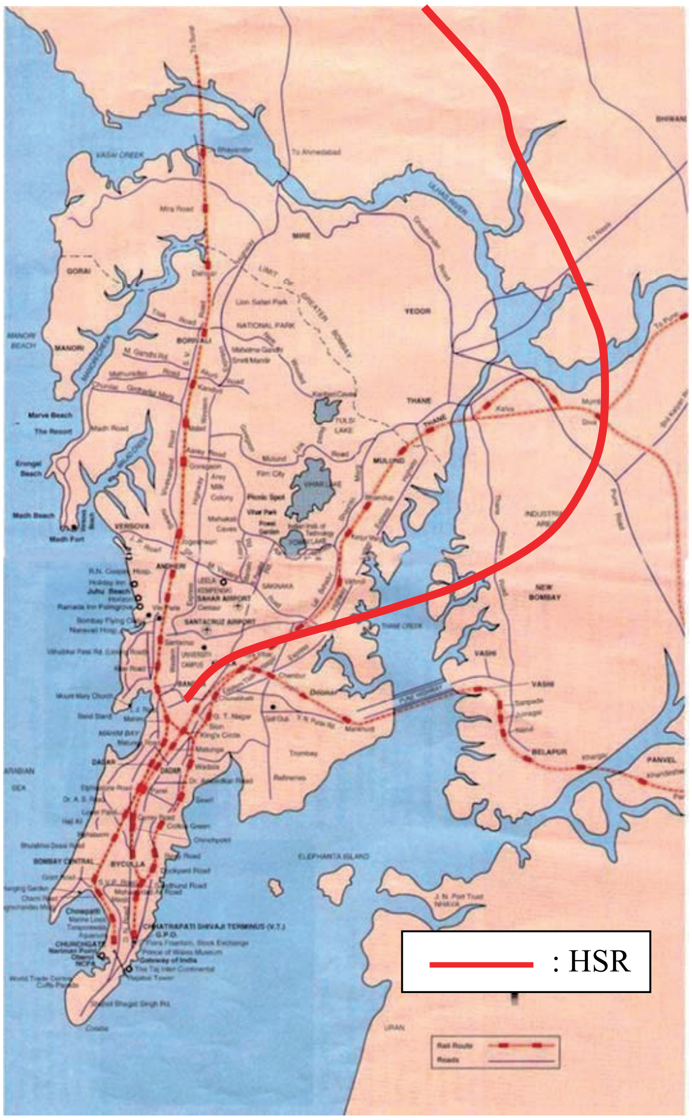
Creeks

All along the coast are found many small creeks, in which tidal water flood upstream and inundate much low ground; human interference in many cases has helped in converting them into mud flats. Of these, mention can be made of the Bhivandi, Chinchani, and Dahanu creeks. The Sopara creek in the bygone days was an important artery of sea-traffic bringing Arab dhows and Greek sailing vessels to the now forgotten Sopara that was a celebrated port. The Thane creek is not a creek in the true sense, but a depression engulfed by the sea. Its shallowest point is just south of Thane where a ridge of rocks affords the foundation for the railway bridge.

The Mumbai

Geographically, Mumbai is an island outside the mainland of Konkan in Maharashtra separated from the mainland by narrow Thane Creek and a somewhat wider Harbor Bay. At present, it covers the original island group of Mumbai, and most of the island of Salsette, with the former Trombay island appended to it in its Southeast. A small part in the north the Salsette island however, lies in Thane District. The Salsette-

Mumbai island creek and the Thane Creek together separate it from the mainland. Thus the area of Greater Mumbai is surrounded on three sides by the seas; by the Arabian Sea to the west and the south, the Harbor Bay and the Thane Creek in the east-but the north, the district of Thane stretches along its boundary across the northern parts of Salsette. Its height is hardly 10 to 15 meters above sea level. At some places the height is just above the sea level. Part of Mumbai City district (Backbay and Bandra reclamation) is the major reclamation areas of Mumbai in the Arabian sea. The drainage pattern of Mumbai region is illustrated in Figure 4.2.10.



Source: District profile of Mumbai, District Gazetteer

Figure 4.2.10: Drainage Map of Mumbai

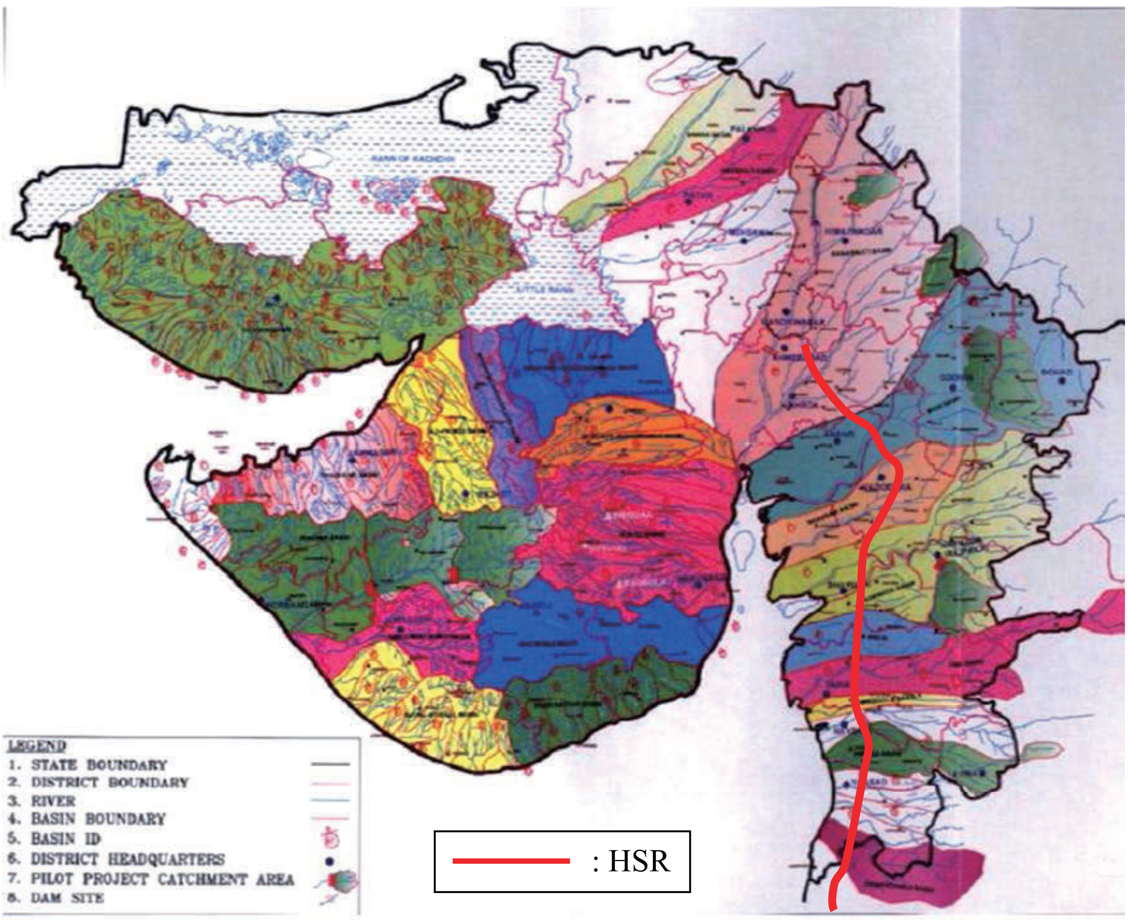
(2) Gujarat Region

Gujarat is situated on the west coast of India. It is bounded in the west by the Arabian sea, in the north-west by Pakistan, in the north by Rajasthan, in the east by Madhya Pradesh and in the south and south-east by Maharashtra. The state of Gujarat occupies the northern extremity of the western sea-board of India. It has the longest coast line of 1290 kms. The state comprises of three geographical regions. The peninsula, traditionally known as Saurashtra, is essentially a hilly tract sprinkled with low mountains. Kutch on the north-east is barren and rocky and contains the famous Rann (desert) of Kutch, the big Rann in the north and the little Rann in the east. The mainland extending from the Rann of Kutch and the Aravalli Hills to the river Damanganga is on the whole a level plain of alluvial soil. Gujarat's mountains are rich in scenic beauty and have been closely associated with religious and historical aspects of the people. The northern and eastern borders are made up of mountains which are the tails or offshoots of outside ranges like the Aravallis, Vindhyas, Satpuras and Sahyadris. Saurashtra contains two parallel ranges, one stretching from east to west and the other from north-east to south-west. The tracts of saline land of Kutch have three mountain ranges. The Aravalli which is the most ancient mountain range in Gujarat lies largely in Rajasthan and enters Gujarat at Abu and zigzagging up to the Pavagadh merges into the Vindhyas. The Taranga lies on the line from Mehsana to Visnagar. The Arasur branch of the Aravalli goes in the direction of Danta, Khedbrahma, Idar and Shamlaji and joins the Vindhyas. The Satpura tail lies between the Narmada and Tapi with Rajpipla hills. The ranges of the Sahyadri lie across the Tapi with the highest rainfall and the densest forest in the state. The Saler Muler and the Parner form part of the Sahyadri range. The rocky region of Saurashtra has only two regular mountain ranges, the northern one having about a 357 metre peak in the Panchal region. The Girnar which is the highest mountain in the state (1,145 metres) forms a part of the range south of the Bardo and is about 160 km in length. The highest peak is named after Guru Dattatreya. Garakhnath, Amba Mata, Kalika Mata are the names of the other peaks of Girnar. The small hill beside the Girnar, called the Jamial Shah Pir is a Muslim holy place. The Shatrunjaya hill near Palitana is one of the five sacred hills of Jains. The hills of Talaja, Lor and Sana are known for their Buddhist caves. Kutch is a saline tract with three mountain ranges. The hills of Kutch are devoid of plant life. Among the three main ranges in Kutch, the northern one goes by Pachham, Khadir and Pranjal. The Kala Parvat forming a part of the ranges lies between Kutch and Sind. The southern range begins at Madh and goes up to Roha. A wide range of physiographic features are displayed within relief variations from sea level to 1000 m elevation. It has a 1600 km long coast line characterized by two gulfs (Gulf of Khambhat and Gulf of Kachchh) and several estuaries. The state astrides the Tropic of Cancer in its northwestern part and forms a subtropical high pressure region. As a result, the atmospheric conditions are influenced dominantly by the monsoon and to some extent by physiography, insularity and the Thar Desert. Thus climatically, the region experiences extremes of arid to humid conditions. The proposed MAHSRC alignment passes through five different physiographic divisions of the Gujarat as given below:

- North Rocky Highland- Panch Mahals
- Central Alluvial Plain-Vadodara, Kheda and Bharuch
- Northern Alluvial Plain-Ahmedabad
- Southern Rocky Highland-Valsad
- Coastal Zone of Gujarat- Surat

Drainage System

Drainage of all five physiographical regions of Gujarat State is distinct with the prevailing topographical and physical characteristics of the rock formations. The flow direction of some of the major rivers is controlled by major tectonic activity. The drainage system of Gujarat is shown in Figure 4.2.11. Drainage of the Mainland Gujarat has been controlled by the factors of physiography, geology (tectonics) and climate (past as well as present). It shows two distinct sets of rivers. Rivers occurring in the northwestern part (Rupen, Saraswati and Banas) arise from Aravalli hills and flow into the Ranns of Kachchh. These rivers have courses of about 150 km lengths at the maximum and are more or less seasonal carrying water only during the monsoons. Interestingly, these rivers though shallow, have wide sandy channels in their lower reaches. The rivers draining the central and southern parts fall into the Gulf of Khambhat and the Arabian Sea. Major rivers are Sabarmati, Mahi, Narmada and Tapi. The Sabarmati river originates in the southwestern spurs of the Aravalli hills and traverses a distance of 416 km through the districts of Sabarkantha, Ahmedabad and Kheda before meeting the Gulf of Khambhat. Interestingly, the river has, in its upper reaches cliffy banks rising upto 50m. In its lower reaches, the river is seen to have frequently changed its course. The plains of Central Gujarat lying between Sabarmati and Mahi are drained by a number of tributaries of Sabarmati, *viz.,* Khari, Shedhi, Mejan, Andheri, Meshwo and Vatrak, of these, Meshwo and Vatrak are the major ones. Meshwo originates in Dungarpur district of Rajasthan and meets the Vatrak river. The Vatrak also rises from the Dungarpur hills and meets Sabarmati at Vautha. The river Shedhi which forms the chief drainage of the alluvial plains between Sabarmati and Mahi originates from the eastern hills of Panchmahals district and meets Vatrak at Kheda.



Source: www.gujarat.gov.in

Figure 4.2.11: Drainage Map of Gujarat

The river Mahi, the third largest river of Gujarat after Narmada and Tapi, rise from about 556 m above sea-level in the Malwa region around Sardarpur in Madhya Pradesh. It flows for about 180 km in Gujarat before emptying into the Gulf of Khambhat. The lower course of the river for about 70 km is characterized by heavily gullied cliffy sand-banks and ravines. Further south, the river Dhadhar rising from the Shivrajpur hills also flows into the Gulf of Khambhat. This river is met by a major tributary Visvamitri, 25 km SW of Vadodara. The river Narmada originating in the hills of Amarkantak in Madhya Pradesh, 1150 m above the sea-level, cuts through the hill' range of Satpura and Vindhya before entering Gujarat, and. as is well known, this river flows along a major geofracture zorre. Within the Gujarat State it has a 150 km l.ong. cours~ and, finally falls into the Gulf of Khambhat near Bharuch. The Orsang nver is a major tributary of Narmada, meets it on its right bank at Chandod; on the left bank, the river Karjan flows into Narmada at Rundh. Lower down its course between Shuklatirth and Bharuch, three more smaller tributaries namely *viz.*, Kaveri, Amravati and Bhukhi, join the main river. For almost 100km, the Narmada flows across the most fertile plains of Gujarat. Other rivers to the south of Narmada (Damanganga, Kolak, Par, Puma, Auranga, Ambica and Mindhola) of South Gujarat are comparatively smaller and rise within the boundaries of the state from the eastern trappean highlands. Tapi river, after flowing through Madhya Pradesh and Maharashtra, enters the. trappe an highlands of Gujarat and runs for about 100km before meeting the sea, 10 km west of Surat. As compared to Narmada, Tapi is a smaller river but the area drained by it in Gujarat is quite large. The lower Tapi valley is very fertile and covered with black cotton soil. The Kim river rises in the Rajpipla hills and flows into the Gulf of Khambhat. The river Mahi, the third largest river of Gujarat after Narmada and Tapi, rise from about 556 m above sea-level in the Malwa region around Sardarpur in Madhya Pradesh. It flows for about 180 km in Gujarat before emptying into the Gulf of Khambhat. The lower course of the river for about 70 km is characterized by heavily gullied cliffy sand-banks and ravines. Further south, the river Dhadhar rising from the Shivrajpur hills also flows into the Gulf of Khambhat. This river is met by a major tributary Visvamitri, 25 km SW of Vadodara. The river Narmada originating in the hills of Amarkantak in Madhya Pradesh, 1150 m above the sea-level, cuts through the hill' range of Satpura and Vindhya.

4.2.12 Accident

Many of the railway accidents occurred in India are due to level crossing and human error involved in train operation. Moreover, traffic accident mortality rate in India is 10.9 (traffic fatalities per 100,000 population) and a relatively high number of the same extent as the United State. The list of train accidents in India is mentioned below:

1890s

- 5 November 1891 - A mail train derailed near Nagpar, killing 10 people and injuring another 35.

1900s

- 24 October 1907 - A passenger train collided with a freight train at Kot Lakhanat station, killing 11 people, and injuring 27 others.
- 2 December 1908 - 18 people were killed and 20 others injured when two mail trains collided at Barana station.

1920s

- April 1920 - 50 people killed, 50 others injured in a rail collision.

1930s

- 17 July 1937 - An express train from Calcutta plunged down an embankment near Bihta station, about 15 miles from Patna. At least 119 people were killed, and 180 others injured.
- 28 June 1939 - 10 people were killed and 21 injured in a train accident.]

1940s

- 4 October 1942 - 12 people were killed and 40 others injured in a railway accident 40 miles northeast of Bombay.
- 22 September 1947 - A train carrying more than 4500 Muslim refugees was attacked by armed Sikhs at the Amritsar station and fired upon for three hours. 3418 people were either killed or missing, and 1328 others were wounded.

1950s

- April 1950 - 32 people were killed when a train derailed and crashed into a river.
- 7 May 1950 - At least 81 people were killed and 100 others injured when a train plunged off a bridge in Bihar state.
- 3 September 1951 - Ten persons were killed and thirty others injured when the Sharanpur Express derailed about 11 miles from Delhi.
- June 1953 - Five people were killed and fifty others injured in the collision of a passenger train with a freight train between Semapore and Kalihar.
- 4 January 1954 - A passenger train derailed while crossing a bridge near Bhatinda, killing at least 15 people and injuring another 40.
- 31 March 1954 - 31 people were killed, and 32 others injured near Gorakhpur when explosives transported on a passenger train detonated.
- 15 September 1954 - A train crashed into a truck carrying students at a crossing 80 miles north of New Delhi, killing 10 and injuring 18 others.
- 28 September 1954 - A train crashed into the Yasanti river, about 75 km south of Hyderabad, when the bridge collapsed. 139 people were killed and more than 100 injured.
- 2 September 1956 - A bridge collapsed under a train between Jadcherla and Mahbubnager, about 100 km from Hyderabad. At least 125 dead, 22 injured.
- 23 November 1956 - 104 people were killed and 100 others injured 175 miles south of Madras when a train plunged into a river from an embankment weakened by flood.
- 2 June 1957 - 18 people died and 53 others were injured when a passenger train crashed into a stationary train in Bombay.
- November 1957 - At least 50 people were killed and more than 50 others injured in a rail accident.
- 21 May 1958 - An express train derailed near Chamaraj, killing 31 people and injuring 41 others.

1960s

- 4 January 1961 - Head-on collision of two passenger trains near Umeshnagar. 35 dead, 61 injured.

- 8 March 1961 - 11 people were killed and 37 others injured in the collision of a passenger train with a freight train between Kalihar and Bihar.
- October 1961 - 40 people were killed and many others injured when a train derailed 200 km from Kolkata.
- 22 July 1962 - 48 people were killed in a train crash in northwest India.
- 12 November 1962 - 25 passengers riding on the roof of a train were killed when they were hit by a bridge girder.
- 19 June 1965 - 15 people were killed when a freight train collided with a train carrying railway workers. The accident occurred about 500 miles from Bombay.
- 16 February 1966 - The bombing of a mail express in Assam by Naga separatists killed 38.
- 20 April 1966 - The bombing of a train at the Lumding railway station by Naga separatists killed 55 and wounded 127.
- 23 April 1966 - The bombing of a train at the Diphu railway station by Naga separatists killed 40 and wounded 60.
- 13 June 1966 - At least 57 people were killed and 100 others injured when two passenger trains collided near the Matunga railway station.
- May 1968 - 25 people were killed, and 38 others injured when a train crashed into a bus.
- 4 February 1969 - Passengers riding on top of a train were swept off by the girders of a bridge, near Madras. 32 dead, 50 injured.
- June 1969 - An express train derailed. 75 dead, 38 injured.
- 14 July 1969 - 85 people were killed and 130 others injured when a freight train crashed into a standing passenger train at Jaipur.

1970s

- 26 April 1972 - 21 people were killed and 37 injured when a train derailed in Mysore state.
- 21 February 1974 - A passenger train crashed into a freight train at Morabad, killing 41 and injuring 63 others.
- 30 May 1977 - A bridge across the Beki river near Gauhati collapsed under a train, killing at least 45 people and injuring 100 others.
- 23 November 1977 - A passenger train derailed near Rewari, probably due to sabotage of the rail tracks. 20 people were killed and 21 others seriously injured.
- 18 April 1978 - 30 people were killed and 60 others injured when an express train crashed into the rear of a passenger train at Bassain Road station in Bombay.
- 14 November 1979 - Five people were killed and fifty others injured when two trains collided near Matunga.
- 23 December 1979 - An express train crashed into the rear of a standing passenger train near Sarupeta, killing 18, and injuring 25.

1981

- 6 June 1981 – Bihar train disaster, India: Hundreds are killed (300-800) when a train falls into a river.
- 17 July 1981 – A freight train slams into the back of a NARMADA EXPRESS train in Madhya Pradesh, India, killing 700 people and injuring 43.
- 19 July 1981 – In an incident blamed on sabotage, a train traveling to Ahmedabad from New Delhi, India, derailed in Gujarat, killing 30 people and injuring 70.
- 31 July 1981 – Six coaches of a train derail near Bahawalpur, India, killing 43 and injuring 50.

- Early morning of 11 Feb 1981 three trains travelled on same track collide with each other in VANIYAMBADI 199 KM from CHENNAI killing many people.

1982
- 27 January 1982 – A freight train and an express passenger train collided head-on in heavy fog near Agra, India, killing 50 and injuring 50.
- 20 March 1982 – A Mangalore-to-New Delhi train slammed into a tourist bus at a level crossing in Andhra Pradesh, snapping the bus in two, killing at least 59 people on the bus and injuring 25 others.

1985
- 23 February 1985 – Rajnandgaon train fire, Madhya Pradesh, India: Over 50 people were killed when an express train catches fire.
- 13 June 1985 – Agra rail disaster, Argra, India: 38 people were killed in a collision.

1986
- 10 March 1986 – Khagaria rail disaster, over 50 people are killed in a collision in Bihar.

1987
- 8 July 1987 – Machieral rail disaster, 53 people killed in the derailment of a train in Andhra Pradesh.

1988
- 8 July 1988 – Ashtamudi Lake rail disaster, passenger train falls in the lake after derailing, 107 people drowned.

1989
- 18 April 1989 –Lalitpur rail disaster, near Lalitpur, Uttar Pradesh, India: 75 killed when train derails.
- 1 November 1989 – Sakaldiha, Uttar Pradesh: Udyan Abha Toofan Express derailed; 48 people died.

1990
- 16 April 1990 – Patna rail disaster, near Patna, India: 70 killed as shuttle train is gutted by fire.
- 6 June 1990: Thirty-five killed in a train accident at Gollaguda in Andhra Pradesh.
- 25 June 1990: Sixty killed as a goods train rams into a passenger train at Mangra in Daltongunj in Bihar.
- Oct 10, 1990: Forty killed in a fire in a train near Cherlapalli in Andhra Pradesh.

1991
- Oct 31, 1991: Thirty killed as Karnataka Express derails near Makalidurga ghats in Karnataka, about 60 km from Bangalore on a rainy evening.

1992
- Sept 5, 1992: Forty-one killed in a train accident near Raigarh in Madhya Pradesh.

1993

- 16 July 1993: Sixty killed in an accident in Darbhanga district of Bihar.
- Sept 21, 1993: Seventy-one killed as Kota-Bina passenger train collides with a goods train near Chhabra in Rajasthan.

1994

- 3 May 1994: Thirty-five people killed as Narayanadri Express rams into a tractor in Nalgonda district of Andhra Pradesh.
- 26 Oct 1994: Twenty-seven killed as 8001 DN Mumbai – Hawrah mail caught fire on its S5 Sleeper class coach between Lotapahar and Chakradharpur stations (SE Railway) at 02.51 AM.

1995

- 14 May 1995: Fifty-two people killed as Madras-Kanyakumari Express collides with a goods train near Salem.
- 1 June 1995: Seventy-three killed in two accidents in West Bengal and Orissa.
- Aug 20, 1995: Three hundred and two killed as Delhi-bound Purushottam Express rams into the stationary Kalindi Express near Firozabad in Uttar Pradesh.

1996

- 18 April 1996: Sixty killed as Gorakhpur-Gonda passenger train rams into a stationary goods train at Domingarh near Gorakhpur in Uttar Pradesh.
- 14 May 1996: Thirty-five of a marriage party killed as bus carrying them collides with the Ernakulam-Kayamkulam train at an unmanned level-crossing near Alappuzha in Kerala.
- 25 May 1996: Twenty-five killed as an Allahabad-bound passenger train rams into a tractor-trolley at an unmanned level crossing near Varanasi.
- Dec 30, 1996: Thirty-three people killed in a bomb blast on the Brahmaputra mail between Kokrajahar and Fakiragram stations in lower Assam.

1997

- 8 July 1997: Thirty-three people killed in bomb blast on a passenger train at Lehra Khanna railway station in Bhatinda district in Punjab.
- 28 July 1997: Twelve people killed in a collision involving Karnataka Express and Himsagar Express near Faridabad on the outskirts of Delhi.
- Sept 14, 1997: Eight-one killed as five bogies of the Ahmedabad-Howrah Express plunge into a river in Bilaspur district of Madhya Pradesh.

1998

- 4 April 1998: Eleven people killed near Fatuha station on Howrah-Delhi main line as Howrah-Danapur Express derails between Fatuha and Bankaghat stations.
- 24 April 1998: Twenty-four killed and 32 injured at Parali Vaijanath railway station in Maharashtra as 15 wagons of a goods train Ram into the Manmad-Kachiguda Express.
- Aug 13, 1998: Nineteen killed and 27 injured as a bus rams into the Chennai-Madurai Express train at an unmanned level-crossing on the new Karur-Salem bypass road on the outskirts of Karur town.
- Sept 24, 1998: Twenty people, including 14 school children, killed and 33 injured when a train engine rams into a bus at an unmanned level-crossing near Bottalaapalem village in Andhra Pradesh.

- Nov 26, 1998: Over 200 people die as Jammu Tawi-Sealdah Express rams into three derailed bogies of Amritsar-bound Frontier Golden Temple Mail near Ludhiana.

1999
- 16 July 1999: Seventeen killed and over 200 injured as the new Delhi-bound Grand Trunk Express from Chennai collides with derailed wagons of a goods train near Mathura.
- Aug 2, 1999: 268 killed and 359 injured in a collision involving Awadh-Assam Express and Brahmaputra Mail at Gaisal in North Frontier Railway's Katihar division.

2003
- On 15 May, 2003, fire breaks out in Golden Temple Mail at 3.55 hrs between Ludhiana and Ladhowal stations, resulting in 36 deaths and 15 injuries
- On 22 June, 2003, the train engine and first four coaches of Karwar-Mumbai central Holiday Special derailed and capsized at about 21.15 hrs.52 persons lost their lives and 26 others were injured.
- On 2 July, 2003, Golconda Express derailed at Warangal station at 10.25 hrs. 21 persons were dead and 24 injured.

2004
- 16 June 2004 matsyagandha express mangalore to mumbai derails when stiking with a huge boulder on konkan railway line. 14 dead

2006
- 11 July 2006 – A series of bomb attacks strikes commuter trains in Mumbai, India, killing at least 200.
- 18 August 2006 two carriages catch fire on the Chennai-Hyderabad Express near Secundrabad station
- 9 November 2006 – India- 40 die and 15 injured in a West Bengal rail accident.
- 20 November 2006 – India- A bomb explodes on a train near Belacoba station in West Bengal, India, killing 7 and injuring 53. See 2006 West Bengal train disaster.
- 1 December 2006 – Bihar, India – Bhágalpur in the Ganges a portion of the 150-year-old 'Ulta Pul' bridge being dismantled collapsed over a passing train of India's Eastern Railways, killing 35 and injuring 17.

2009
- 13 February 2009 – India- Twelve carriages of the Coromandel Express derails soon after the train left Jajpur Road station near the city of Jajpur in the state of Orissa.[7]Interestingly, the accident occurred on the day of Railway Budget presentation when Railway Minister Mr Lalu Prasad Yadav boasted about increased safety measures at Indian Railways.
- 21 October 2009 – India- 21 people died and several others injured when locomotive of Goa Express rammed the rearmost carriage of stationary Mewar Express near Mathura, Uttar Pradesh. Initially the railways officials held driver responsible for overlooking the signal but in the investigation it was proved that the signal was given green even though Mewar express was held up ahead due to chain pulling by passenger. Railways.[8]

- 11th November 2009: 10 coaches of 6210 Mysore-Ajmer express derails 80kms bfore Pune;No casualities reported.

2010

- 02 January 2010 – India- Three accidents involving five trains took place in Uttar Pradesh due to dense fog conditions.
- The first accident took place near the town of Etawah, about 170 miles (270 kilometers) southwest of Lucknow, the capital of Uttar Pradesh state, when the Lichchavi Expressentering the station rammed into the stationery Magadh Express train stopped there. Ten people, including the driver of one of the trains, were injured.
- In a second similar Gorakhdham Express and Prayagraj Express collided near the Panki railway station in Kanpur, about 60 miles (100 kilometers) southwest of Lucknow, and left five people dead and about 40 others injured.
- Another accident has been reported from Pratapgarh, 61 kms from Allahabad. The Sarayu Express broke into a tractor trolley at an unmanned railway crossing leading to the accident. Though nobody is injured following the incident, the engine of the train is severely destroyed.
- 03 January 2010 – India- All seven coaches of the Arunachal Pradesh Express, running between Murkongselek and Rangiya, derailed at a place between Helem and Nij Bogaon inAssam in the early hours of today, but none of the passengers was hurt.
- 16 January 2010 – India- Three people died and around a dozen were injured when two express trains (The Kalindi Express and Shram Shakti Express) collided in thick fog in India’s northern state of Uttar Pradesh on Saturday, 16 January 2010. The accident happened near Tundla, 25 kilometres from Agra, when the driver of one of the trains apparently did not react to a signal, slamming his train into another on the same track.
- 17 January 2010 – India- Two persons were killed and four others injured when their car was hit by a train at an unmanned crossing on Sunday afternoon in Barabanki district. The accident happened when the Lucknow-Sultanpur Harihar Nath Express hit the car at Barha railway crossing under Haidergarh police station area. Two persons traveling in the car died on the spot while the four others who sustained serious injuries have been referred to Trauma Centre in Lucknow. Train traffic on this route was disrupted for nearly two hours after the accident. This is the fifth accident in series of similar train accidents.
- 22 January 2010 – India- A goods train derailed near Azamgarh in Uttar Pradesh on Friday, disrupting rail traffic in the region, officials said. No one was injured. The accident took place at Sathiyaon station near Azamgarh, some 300 km from here, when three bogeys of the goods train derailed, an official said. Traffic was disrupted on the busyVaranasi-Azamgarh-Gorakhpur route.

2011

- 1 January 2011 – Amritsar-Sealdah Akaltakth Express rammed into two trucks in Uttar Pradesh's Jaunpur district when its driver failed to notice the red signal at a level crossing at Babura railway crossing, killing a man (a truck driver) and leaving two people (another truck driver and a helper) injured. No passengers were injured in the collision.
- 3 January 2011 – Four wagons of a goods train got derailed in the Dadri area of Ghaziabad district of Uttar Pradesh on 3 January 2011. The goods train was going

towards Aligarh from Delhi when the mishap occurred. No one was injured in the accident but the running of trains on the busy section was disrupted. Train traffic on the Ghaziabad-Aligarh section on the Delhi-Howrah trunk route was disrupted following the derailment.

- 18 April 2011 – Three coaches of the Mumbai - Delhi Rajdhani Express caught fire near Ratlam district in Madhya Pradesh. The train, carrying nearly 900 passengers caught fire while running between Bikramgarh Alot and Phuria stations in Kota division. The coaches were removed from the train and the fire was put out quickly. No passenger was harmed.
- 16 May 2011 – Just after midnight 15 May, a truck on the rail cum road bridge of Rajahmundry fell onto the railway lines. An incoming high speed goods train powered by a WAG 9 smashed into the truck destroying it and the railway tracks there. Due to it, several trains between Vijayawada Junction and Visakhapatnam Junction were delayed for more than 05:30 hours. Trains were held up at Nidadavole, Samalkot and Kaikaluru.
- 7 July 2011 – A Mathura Chhapra Express train rams into a bus carrying wedding guests around 2 a.m. at an unmanned railway crossing in Thanagaon, Kanshiram Nagar district, Uttar Pradesh, killing 38 and injuring 30.
- 10 July 2011 – Kalka Mail derails near Fatehpur, Uttar Pradesh killing 70 people and injuring more than 300.
- 10 July 2011 – The engine along with 4 coaches of Guwahati Puri Express derails between Rangiya and Ghagrapar, Nalbari district, Assam at 8:10 PM, & capsized in a rivulet. The Cause of the disaster presumed to a sabotage to the track with explosives by local millitants. IED wires were found near the accident spot.
- 12 July 2011 - New Delhi-Patna Rajdhani Express's coach caught fire near outskirts in New Delhi. No casualties.
- 22 July 2011 - Two wagons of a goods train carrying cement bags derailed near Rambagh railway station under NER zone on Friday morning, no casualties reported.
- 23 July 2011 - Less than 24 hours after a goods train derailed in Uttar Pradesh's Allahabad district, eight wagons of another goods train on Saturday jumped tracks at almost the same place where the first incident took place.
- 31 July 2011 – The engine and some coaches of the Guwahati Bangalore Express derail and are hit by another train in Malda district, West Bengal. At least three people are killed and 200 injured.
- 2 September 2011 - Two bogies of a goods train were damaged and three others derailed after it was hit by a rail engine near the depot in Whitefield railway station in Bangalore on Friday.
- 13 September 2011 - A Chennai suburban MEMU train rammed into a stationary Arakonam-Katpadi passenger train at around 9.30 PM. Ten people were killed and many injured. It happened between Melpakkam and Chitheri Station in Vellore district. The passenger train was waiting for the signal. In the impact eight coaches were derailed and 3 were completely damaged.
- 22 November 2011 - Howrah-Dehradun express train caught fire- 7 burnt to death. It was around 2.30am when coach number B1 of the Dehradun-bound train caught fire. Later, the fire spread to coach B2. Both coaches were badly burnt, but all the casualties were from B1.

2012

- 11 January 2012 - Five persons were killed and nine others, including a child, injured in a collision between the Delhi-bound Brahmaputra Mail and a stationary goods train.
- 5 February 2012 - Nearly 1,000 passengers of a Gwalior-bound narrow-gauge train escaped unhurt when its engine derailed after hitting a tractor and the coaches got stuck over a canal bridge.
- 26 February 2012 - Three people died and one man was injured, when Kozhikode-bound Jan Satabdi Express ran into a crowd of people who were watching Uthralikkavu pooram sample fireworks standing on the railway track.
- 19 March 2012 - Seven persons were injured when the locomotive of 73261 Islampur-Patna MEMU passenger train dashed against a truck at a manned level crossing gate near Daniyawan on Fatuha-Islampur section under the Danapur division of East Central Railway (ECR).
- 20 March 2012 - 15 people were killed when a train collided with an overcrowded taxi minivan at an unmanned railroad crossing in northern Uttar Pradesh state, Mahamaya Nagar district, 296 kilometres from state capital Lucknow.
- 26 March 2012 - A loco pilot of a Mainline Electric Multiple Unit (MEMU) train and a truck driver were killed when the speeding passenger train rammed into a boulder-ferrying truck at the Kannamangala gate on the outskirts of Bangalore.
- 6 May 2012 - Coaches of Mumbai Bound 12138 Firozpur Mumbai Punjab Mail Derailed in Haryana. Coaches from S5 to S11 and even general coaches had derailed. No deaths are reported.
- 22 May 2012 - The Hubli-Bangalore, Hampi Express collided with a goods train near Penukonda in Andhra Pradesh early on Tuesday morning on its way from Hubli to Bangalore. 14 people were dead and 35 were injured in the collision. The accident happened at around 3:45 am on Tuesday.
- 31 May 2012 - Howrah-Dehradun-Doon Express,derailed near Jaunpur(U.P.).At least 7 people killed and 15 sevearly injured.
- 19 July 2012 - One person was killed, four were injured seriously, and nine sustained minor injuries in a collision between a local train and Vidarbha Express near Khardi station near Nashik on Mumbai-Kasara route.
- 30 July 2012 - One of the coaches of the Chennai-bound Tamil Nadu Express (New Delhi - Chennai) caught fire early on 30 July morning, near Nellore in Andhra Pradesh. 47 people have died and 25 others have been injured.
- 16 October 2012 - A bogie of the Solapur-bound passenger train from Hyderabad caught fire during its halt at the station in Gulbarga. There were over 15 passengers in the bogie of the Falaknuma Passenger after it arrived at the station at 12:30 PM and caught fire, but six jumped to safety. Some of the passengers were headed for Tuljapur in Maharashtra to attend the Bhavani festival which takes place during Navaratri. Immolation by couple led to fire in train at Gulbarga station, says Railway police.
- 30 Nov 2012 - At least two AC coaches of GT Express caught fire near Gwalior on Friday, claiming several lives
- 19 December 2012-Indore Yeshwantpur Exp Met an Accident at Medak District near Sankhapur. Accident occurred by hitting a lorry to 300mts. Many were injured.
- 20 December 2012 - The Loco of Pune Ernakulam Superfast Express slipped from tracks at Lanja village near Nivsar. No one was Injured.

2013

- February 2013 - 12618 Hazrat Nizamuddin-Ernakulam South Mangala Lakshadweep SF Express derailed at Pen Railway station which is situated on Panvel-Roha section of Central Railway.Nobody was injured.
- 10 April 2013 - Seven compartments of the 15228 Muzaffarpur-Yeshvantpur Weekly Express derailed near Arakkonam, 40 km from Chennai killing one passenger and leaving another seriously injured.
- 19 August 2013 - Dhamara Ghat train accident, at least 35 people died when 12567 Saharsa-Patna Rajya Rani SF Express ran over people at the Dhamara station near Saharsa in Bihar.
- 2 November 2013 - 10 people were ran over by 13352 Alapuzha-Dhanbad express, near Gotlam in Vizianagaram district on Saturday evening at around 6:30PM .It started after passengers of the 57271 Vijayawada-Rayagada passenger pulled the chain at the railway yard at Gotlam railway station when they heard a rumour that a compartment of the train was on fire. They then alighted the train and jumped onto the tracks at around 6.50pm .It was dark and the passengers didn't see the express train coming on the adjacent rack. The express train ran over them, killing 10 people, and injuring at least 20.
- 13 November 2013 - A herd of 40 elephants was struck by a passenger train in Chapramari Wildlife Sanctuary.
- 15 November 2013 - 13 Coaches of Ernakulam Bound 12618 Down Nizamuddin Ernakulam Mangala Lakshadweep Superfast Express were derailed near Ghoti village, at 6.25 am at Kms 145/15 about 30 km from Nashik district. 3 to 4 people died and dozens injured. Out of thirteen coaches,most affected coaches were S11,B1,B2,B3,A1 and Pantry Car. The cause is stated to be possibility of Rail fracture. Injured were shifted to various hospitals in Nashik.
- 28 December 2013 - An AC coach of the 16594 Bangalore City-Hazur Sahib Nanded express caught fire near Kothacheruvu in Anantapur district of Andhra Pradesh resulting in the death of at least 26 people and injuring 12 others. The incident took place early in the morning around 3:15 am. 54 passengers are expected to be on board in the B1 compartment of the train which was completely gutted in the fire.

2014

- A Number of minor mishaps took place in the Mumbai Suburban section of Indian Railways in March and early April.
- 20 March 2014 An 18-year-old student was killed while nine persons, including two women and a railway guard, were injured when six coaches of a local train derailed after getting uncoupled from the rest of the train at Titwala, 61 km from Chhatrapati Shivaji Terminus.
- 18 April 2014 - 11068 Faizabad Junction-Lokmanya Tilak Terminus Express derailed near Asangaon in the evening, holding up services on the Central Railway. The engine and one coach of the Faizabad-LTT Express derailed around 8pm. The CR spokesperson said, "There were no injuries and cause of derailment was not known."
- May 4, 2014 - 50105 Diva Junction-Sawantvadi Passenger train derailed between Nagothane and Roha stations at 9-30 AM. About 20 are dead while about 100 are injured. Several other trains were delayed, cancelled or diverted in the Konkan Railways.

- 26 May 2014 - 12556 Gorakhpur bound Gorakhdham Express rammed into an stationary goods train near Khalilabad station in Sant Kabir Nagar district of Uttar Pradesh killing at least 25 and injuring over 50.
- 25 June 2014 - 12236- Dibrugarh Rajdhani Express Derailed near Bihar's Chapra town, Four Killed and Eight injured.

Scenario-High Speed Train Accidents

Accidents

High-speed rail is one of the safest modes of transportation. The first high-speed rail network, the Japanese Shinkansen has not had any fatal accidents involving passengers since it began operating in 1964.

Notable major accidents involving high-speed trains include the following.

The 1998 Eschede Accident

Main article: Eschede train disaster

In 1998, after over thirty years of high-speed rail operations worldwide without fatal accidents, the Eschede accident occurred in Germany: a poorly designed ICE 1 wheel broke at 200 km/h (124 mph) near Eschede, resulting in the derailment and destruction of almost the entire full set of 16 cars and the subsequent death toll of 101 people.

The 2011 Wenzhou Accident

On 23 July 2011, 13 years after the Eschede train accident, a Chinese CRH2 traveling at 100 km/h (62 mph) collided with a CRH1 which was stopped on a viaduct in the suburbs of Wenzhou, Zhejiang province, China. The two trains derailed, and four cars fell off the viaduct. 40 people were killed, at least 192 were injured, 12 of which were severe injuries.

The disaster led to a number of changes in management and exploitation of high-speed rail in China. Despite the fact that high speed was not a factor in the accident, one of the major changes was the lowering by 50 km/h (31 mph) of all maximum speeds in China HST, 350 km/h (217 mph) becoming 300, 250 km/h (155 mph) becoming 200, and 200 km/h (124 mph) becoming 160.

The 2013 Santiago de Compostela accident

On 23 July 2011, two high-speed trains travelling on the Yongtaiwen railway line collided on a viaduct in the suburbs of Wenzhou, Zhejiang province, China. The two trains derailed each other, and four cars fell off the viaduct. 40 people were killed, at least 192 were injured, 12 of which were severe injuries.Officials responded to the accident by hastily concluding rescue operations and ordering the burial of the derailed cars. These actions elicited strong criticism from Chinese media and online communities. In response, the government issued directives to restrict media coverage, which was met with limited compliance, even on state-owned networks.

The collision was the first fatal crash involving HSR in China, and is the third-deadliest HSR accident in history, after the 1998 Eschede train disaster in Germany and 2013 Santiago de Compostela rail disaster in Spain. High speed was not a factor in the accident, however, since neither train was moving faster than 99 km/h (62 mph), a moderate speed for a passenger train. The accident, the first of its kind, had a profound impact on the development of high-speed rail in China. Public confidence in high-speed rail eroded, leading to lower ridership. Construction of high-speed rail lines in China was temporarily suspended as the accident was under investigation. Speeds on other major high-speed rail lines in China were reduced. China's reputation in high technology was scrutinized internationally. Two days after the accident, the driver was provisionally charged with homicide by negligence. This is the first accident that occurred with a Spanish high-speed train, but it occurred in a section that was not high speed. In response to the accident, Railways Minister Sheng Guangzu announced a comprehensive two-month railway safety review. The official investigation completed in December 2011 blamed faulty signal systems which failed to warn the second train of the stationary first train on the same track, as well as a series of management failures on the part of railway officials in carrying out due procedure.

4.2.13 Social Consideration and Resettlement and Rehabilitation Action Plan

(1) Preamble

The prime objective of the Mumbai-Ahmedabad High Speed Railway Corridor Projects is to promote further economic development in India as well as to be a symbol of the successful growth of the country. Based on several previous studies, Mumbai-Ahmedabad section has been recommended as initial development sections, (hereafter referred to as the projects). In the case of a transportation development project, land acquisition and resettlement is generally inevitable but it can be minimized. As for the projects, an optimal route was selected for each section through the comparison exercise of alternatives as explained in previous chapters. In addition, the minimum distance between two track centerlines was adopted in order to minimize land acquisition area and the number of project affected persons (PAPs). Although the optimal route carries less environmental and social impacts as compared to other options, acquiring privately used land (*i.e.,* agriculture land, residential land, and commercial land) is necessary in order to make the route technically viable and financially feasible as well as convenient for users. Thus, resettlement is inevitable and necessary measures to compensate loss caused by land acquisition/resettlement and to secure livelihood after land acquisition/resettlement are necessary. In the light of above, Taru Leading Edge Pvt Limited (hereafter referred to as Taru) was appointed by Japan International Consultants for Transportation Co. Ltd., Oriental Consultants Co., Ltd. and Nippon Koei Co., Ltd (hereafter referred to as Client) to prepare a Resettlement Action Plan (RAP) for the affected area/people in the MAHRC. The RAP is a part of the Joint FS. The RAP has been developed in accordance with the requirement of JICA. Environmental & Social Consideration Guidelines (April 2010)" and World Bank OP.4.12 guidelines (together referred to as the reference framework). The RAP provides a framework and a plan within which the resettlement, livelihood and other impacts linked/associated with the project will be addressed. Census and socio-economic survey was conducted with an objective of identifying the affected population by residence, business base and their locality, information on associated socio-economic parameters such as gender, literacy, occupation and livelihoods, ownership status (of affected structure) and type, household consumption and expenditure patterns, and thus a broad socio-economic baseline status of affected population. The survey output (which is presented in this chapter) is primarily based on field data collected during social survey and juxtaposed against secondary data (as appropriate) such as census handbooks / gazetteers / other relevant texts. This chapter on Census and Socio-Economic Survey begins with brief description on methodology followed to collect relevant data and subsequent data analysis and reporting. It is followed with sections describing data findings pertaining to various parameters as described in paragraph above. In the context of this RAP document, and this chapter in particular, it may be noted the findings presented are based on the data collected from only those households who were identified as stakeholders associated with structures likely to be affected due project related constructions. It must be recognized, as also emphasized as study limitations that the survey does not include 'land loser' households. Such information can be included only upon finalization of the alignment and subsequent sharing with the state and local administration that in turn would identify the affected land owners.

(2) Data Collection

Survey assignments for projects such as MAHSRC pre-determine the required data and associated primary stakeholder categories. Further literature review and client interactions were the basis of finalization of data collection tools and the approach. Secondary data already available by means of feasibility studies conducted by RITES India, Systra of France and others in 2009, Study report (August 2014) by MAHSRC Advisory Board on Social and Environmental Considerations, existing guidelines of world bank and JICA, reference to existing RAPs of similar JICA and WB supported projects, reports and other unpublished document were referred to and reflect in survey data collection design and the tools used. The following methods were applied for ensuring authentic data collection from the stakeholders and Affected People:

A. **Collection of information through questionnaires** and marking affected structures/assets on field survey maps (satellite imageries)

B. **Observations/ physical verifications and capturing video/still images** of the structures likely to be affected.

C. **Stakeholders Consultations/Meeting and Individual Interview/Discussions** (with line department officials and for the Purpose of Replacement Cost Estimations)

Survey for data collection was carried out by team of experienced surveyors; divided into smaller teams of 4 surveyors and directly monitored by field supervisors.

<u>**Type of Data Collected for the Survey**</u>
As mentioned above, broadly four types of tools were used to collect primary survey data. Key information captured under these are briefly discussed here:

A. **Field Survey Maps and other Maps:** Various maps were developed both for the purpose of data collection aid tools and for estimation and recording (through direct observation) of number of affected fruit bearing trees and identification of structures on maps. Maps were particularly useful in locating land corridors, identification of impacted (likely) structures/assets and validation of data collected.

B. **Survey Questionnaire and Observation Tools:** The survey purpose was to identify all impacted structures and assets and associated households likely to be affected on account of these. *It may be noted (as mentioned earlier), that the survey did not include those households likely to affected due to loss of land only.*

For the purpose, the tools deployed included those for i) Inventory of Loss (both for private and Public/community structures/assets), ii) Census of Affected Household and iii) Socio Economic Survey. Key information aspects collected and approach adopted for administration of these tools are mentioned below in Table 4.2.14.

Table 4.2.14: Key Informations Collected and Approach Adopetd

Inventory of Loss (IOL)	
Key Information Items	**Approach**
➢ Identification and location of Structures and assets (GPS coordinates *etc.* ➢ Basic Information (Village, district name *etc.*) ➢ Structure details (type of structure, type of construction, structure dimensions such as no. of floors, area/size, type construction material, extent of likely impact, no. of affected PAPs)	Direct observation and recording the same on the IOL tool for all structure identified along the alignment land corridor, interaction with affected households/PAPs to identify them. A separate tool used for identification and recording of information (similar to those for private structures) were used.
Census of Affected Households	
➢ Identification and of affected households *vis-à-vis* affected structures/assets ➢ Basic Information about affected households (Village, district name etc), head of household identification-name, age, gender, socio-economic background ➢ Ownership details of affected structure, tenure, type *etc.*, identification of owner ➢ Use of structures, availability of alternate land for relocation *etc.*	Only such households were approached and data collected for who were affected by way of loss of structures. Only land losers were not covered as their identification will be possible only after alignment is finalized and shared with the state administration/land revenue department. Stakeholders included those owners, tenants and others whose livelihood
Key Information Items	**Approach**
➢ Household members details (age, gender, education, income and occupation *etc.*), vulnerability status ➢ Access to basic facilities such as sanitation and drinking water ➢ Household income and expenditure ➢ Impact on business/income, details of business establishment ➢ Perception about project and its impacts, R&R expectations and preferences	is linked to the structures being impacted. However, in case of business establishments it is likely that workers/staff may not have been covered in few instances due to non-cooperation by unit owners/ managers. Further in few cases, due to non cooperation or refusal or absence of affected household members, the census information could not be completed. In such cases, information collected is limited to those covered through 'Inventory of Loss' tool.
Socio-Economic Survey	
➢ Identification and of affected households *vis-à-vis* affected structures/assets ➢ Basic Information about affected households (Village,	Socio Economic Survey was limited to 20 percent of the sample covered under Census Survey and chosen randomly.

district name etc), head of household identification-name, age, gender, socio-economic background ➢ Details of household assets such as livestock, agriculture implements, household items and other assets ➢ Land ownership- type and area ➢ Agriculture- type and production ➢ Household income and expenditure- itemized details ➢ Accessibility to various government welfare schemes ➢ Accessibility to basic infrastructure facilities such as school, market, bus stop, hospital and project impact on these Saving and indebtedness status and practices	

C. **Stakeholders Consultations and Interviews: Stakeholders Consultation** was done for multiple purposes. Stakeholder consultation was particularly important for initiation of primary data in each of the affected settlements. This primarily related to briefing about nature of survey and the purpose and getting consent of the stakeholders prior to data collection. The findings of the Stakeholders Meeting (SHM) has been detailed in Chapter-6.0 of the report.

Stakeholder Meetings/ Consultations (SHMs) on a larger scale were held in each of the districts. First round of such meetings were held at each district head quarter during December 2014. In each such meeting, PAPs were invited from across villages to participate in the meeting and were briefed about the MAHSRC project, its key features, proposed alignment, current status, broad policy frameworks that may apply. Occasion was also used to collect PAPs feedback on the project, their perceptions, concerns and suggestions about land acquisition and the governing R&R policies and the project overall. District administration and officials from the line department constitute another important segment of project stakeholders. Every opportunity was used to engage and interact with the line department particularly those from land and revenue (and land acquisition cell, if existing), agriculture, tribal welfare and forest department. Such interactions have helped in developing better perspective about existing land acquisition and R&R practices and policies in the state, specifically in the context of similar project such as Dedicated Freight Corridor, challenges and suggestions on the same. The **Replacement Cost Survey (RCS)** was done in parallel with Census and IOL activities by collecting information from both secondary sources and primary sources (direct interviews with people in the affected areas, material suppliers, house contractors, line governments and real estate agents of the area), and from both those affected and those not affected. Key to the approach was triangulating quoted market rate from one source with multiple other sources in the area for arriving at most approximate rate prevailing in the market.

(3) Project Affected Persons (PAPs)

This section discusses the findings of the census and socio economic survey carried out for MAHSRC project affected households and its members. The families were identified as stakeholder families associated with assets likely to be affected by the project. Data information was collected from all such families, who agreed to share information.[1] Major questions of the Census questionnaire were on occupation, family members, education level, religion and social categories, Income source, assets including livestock, agricultural equipment's, household goods and access to public facilities such as school, markets, workplace, and religious buildings andthe impact of the project during its construction and operation phases on the PAHs .Based on findings of the Census and Socio-Economic Survey, the social profile of the PAHs/PAPs such as social category, religion, income level and other socio-economic characteristics are presented in the Tables 4.2.15. Census Survey information was collected from 1082 Project Affected Households (PAHs) with 5404 Project Affected Persons (PAPs) through the Socio-Economic and Census Survey. The table below provides distribution of PAHs and PAPs spread across 11 districts of Gujarat and Maharashtra.

Table 4.2.15: Distribution Details of PAHs and PAPs

State/Districts	PAHs	PAPs
Maharashtra		
Thane	48	199
Palghar	195	951
Dadra Nagar Haveli **(UT)**	4	18
Gujarat		
Valsad	95	431
Navsari	54	273
Surat	86	410
Bharuch	64	324
Vadodara	105	470
Anand	65	349
Kheda	147	783
Ahmedabad	219	1196
Grand Total	**1082**	**5404**

Source: Census Survey Data, Sep-Dec 2014

In the context of Palghar, it may be noted that one of the talukas (and the habitations) *i.e.* Vasai is situated in the suburban Mumbai and thus has high urban characteristics.

(4) Duration of Living in the Project Area

Table 4.2.16 shows the time duration of the PAHs living in the project area. 82 PAHs out of 1082 PAHs have been living in the project area since last one year. 185 PAHs have been living in the project areas for a period 31 to 50 years. 343 PAHs has been living in the project area for more than 50 years. All the PAHs (4) in Dadra and Nagar Haveli location have been living in the project area for the last 50 years or more

[1] It may be noted that not all families, identified on the basis of Inventory of Loss survey agreed to provide information for Census Survey; one of the prime reasons being that there has been no formal notification from the government with regards to MAHSRC project.

Table 4.2.16: Duration of PAHs Living in the Project Area

District	Last 1 Year	1-3	4-10	11-30	31-50	More than 50 Years	Grand Total
Thane	5	-	19	26	-	-	50
Palghar	43	-	55	34	14	47	193
Dadra Nagar Haveli	-	-	-	-	-	4	4
Valsad	8	-	7	24	10	46	95
Navsari	2	2	5	14	4	27	54
Surat	6	4	10	30	22	14	86
Bharuch	2	-	-	8	5	49	64
Vadodara	1	6	34	35	14	15	105
Anand	1	3	10	22	12	17	65
Kheda	11	3	13	50	27	43	147
Ahmedabad	3	7	12	39	77	81	219
Grand Total	**82**	**25**	**165**	**282**	**185**	**343**	**1082**
Percent	**7.6%**	**2.3%**	**15.2%**	**26.1%**	**17.1%**	**31.7%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

(5) PAHs and Population by Sex, Age Group and Religion

This section classifies PAHs and PAPs on parameters of sex, age and religion. Additional information has been provided on distribution these based on ownership (number of structures and ownership type) pattern.

Family Size

Affected Households covered under census survey may be classified in four categories based on number of family members, as presented in Table 4.2.17. Out of 1082 PAHs in total, 704 PAHs (65.1%) classify assmall sized family, 355 PAHs (32.8%) asmid-size family, 20 PAHs (1.8%) as big family and only 3 PAHs (0.27 %) categorize as a large family.

Table 4.2.17: Family Size of the PAHs and PAPs

District	Small	Mid-Sized	Big	Large	Grand Total
Thane	41	8	1	-	50
Palghar	131	62	-	-	193
Dadra Nagar Haveli	4	-	-	-	4
Valsad	67	26	2	-	95
Navsari	32	19	1	2	54
Surat	58	24	4	-	86

Bharuch	43	19	1	1	64
Vadodara	84	20	1	-	105
Anand	43	21	1	-	65
Kheda	85	56	6	-	147
Ahmedabad	116	100	3	-	219
Grand Total	**704**	**355**	**20**	**3**	**1082**
Percent	**65.1%**	**32.8%**	**1.8%**	**0.3%**	**100.0%**
Source: Census Survey Data, Sep-Dec 2014					

Note: Small family: 1-5 members; Mid-Sized Family: 6-10 members; Big Family: 11-20 members; Large Family: more than 20 members.

Religion

District wise distribution of PAHs along religious faiths practised is presented in Table 4.2.18.Out of 1082 PAHs, 969 (89.6%) PAHs are Hindus, 96 (48.9%) PAHs are Muslim, 14 PAHs are Christian, and 1PAH is a Buddhist. Most of the Muslim families are found to be located in Ahmedabad (60 out of total 96 Muslim PAHs). Such high concentration is expected as the alignment in the Ahmedabad passes along existing track, that witnesses growth of low/poor income settlements, with significant presence of Muslim population.

Table 4.2.18: Distribution of the PAHs and PAPs by Religion

District	Hindu	Christian	Islam	Buddhist	Others	Grand Total
Thane	48		1	-	1	50
Palghar	177	3	11	1	1	193
Dadra Nagar Haveli	4	-	-	-	-	4
Valsad	88	1	6	-	-	95
Navsari	47	1	6	-	-	54
Surat	84	-	2	-	-	86
Bharuch	63	-	1	-	-	64
Vadodara	99	2	4	-	-	105
Anand	63	1	1	-	-	65
Kheda	142	1	4	-	-	147
Ahmedabad	154	5	60	-	-	219
Grand Total	**969**	**14**	**96**	**1**	**2**	**1082**
Percent	**89.6%**	**1.3%**	**8.9%**	**0.1%**	**0.2%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

Age Sex Composition

Total of 1082 affected families (PAHs) is constituted of 5404 family members, out of which 2814 (52.07%) are male and 2590 (47.93%) are female. It may be noticed from Table 4.2.19 that the overall sex ratio among PAPs is 920. 111 PAPs come in the age group of less than 1 year whereas 172 PAPs come in the age group of more than 65 years. A large number of PAPs (1133) fall in the age group of 21-30 years. In the village Telod of Bharuch District, the females (111) outnumber the male which is (96).

Table 4.2.19: Distribution of the PAHs and PAPs by Religion

District	0-1		1-5		6-10		11-20		21-30		31-40		41-50		51-65		65+		Grand Total	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Thane	2	1	6	7	9	13	28	25	17	21	20	22	11	9	5	5	5	2	103	105
Palghar	7	13	41	45	47	59	135	87	100	108	88	80	41	31	28	19	6	7	493	449
Dadra Nagar Haveli	-	-	-	-	2	-	1	3	-	2	1	2	2	1	2	2	-	-	8	10
Valsad	3	5	9	15	14	11	45	38	47	48	28	34	30	25	29	28	12	10	217	214
Navsari	5		12	2	7	5	20	18	24	28	21	18	22	24	20	22	16	9	147	126
Surat	5	4	21	13	19	15	39	34	47	41	40	29	16	28	26	24	2	7	215	195
Bharuch	3	8	11	5	3	8	24	21	24	31	31	30	22	22	26	36	10	9	154	170
Vadodara	2	6	16	12	19	17	52	35	52	47	38	38	25	25	39	34	8	5	251	219
Anand	2		3	6	20	13	52	43	30	33	28	27	31	26	13	13	3	6	182	167
Kheda	4	7	31	22	47	18	87	75	80	62	68	63	45	57	50	39	13	15	425	358
Ahmedabad	11	13	37	42	58	43	128	129	157	134	81	75	67	63	68	63	12	15	619	577
Grand Total	**44**	**57**	**187**	**169**	**245**	**202**	**611**	**508**	**578**	**555**	**444**	**418**	**312**	**311**	**306**	**285**	**87**	**85**	**2814**	**2590**

Source: Census Survey Data, Sep-Dec 2014

PAHs With Structures

It is evident from the Table 4.2.20, that out of the 1082 Project Affected Households (PAHs), a majority of PAHs *i.e.* 95.3% has 1 structure falling in the alignment. About 35 PAHs (3.23%) have 2 structures and only 4 PAHs (0.4%) of PAHs have got more than 3 structures in the designated corridor of HSPR survey.

Table 4.2.20: No. of PAHs With Structures

District	With 1 Structure	With 2 Structures	With 3 Structures	More than 3 Structures	No. of PAHs
Thane	50	-	-	-	50
Palghar	180	9	3	1	193
Dadra Nagar Haveli	3	1	-	-	4
Valsad	87	5	3	-	95
Navsari	48	3	2	1	54
Surat	77	7	1	1	86
Bharuch	61	3	-	-	64
Vadodara	104	1	-	-	105
Anand	62	1	1	1	65
Kheda	143	4	-	-	147
Ahmedabad	217	1	1	-	219
Grand Total	**1032**	**35**	**11**	**4**	**1082**
Percent	**95.4%**	**3.2%**	**1.0%**	**0.4%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

Ownership Type

Based on the number of families affected, 930 (86%) PAHs out of 1082 PAHs are the owners of the structures as shown in Table 4.2.21. Only 142 (13%) PAHs are living as tenants whereas only 10 (0.9%) PAHs are identified as encroachers/squatters/illegal occupiers [2]. It is to be noted that PAHs belonging to the category of Encroacher/Squatter/Illegal Occupier has been identified in the Project Areas on the basis of respondents view and not been as per the Records of Revenue (RoR).

Table 4.2.21: Ownership Type of PAHs

District	Owner	Tenant	Encroacher/Squatter/ Illegal Occupier	Grand Total
Thane	44	6	-	50
Palghar	162	31	-	193
Dadra Nagar Haveli	4	-	-	4
Valsad	81	13	1	95
Navsari	48	6	-	54
Surat	69	17	-	86

[2] The number of PAHs under this category may be much higher which can be ascertained only upon formal project notification and official land ownership data provided by district administration.

Bharuch	62	2	-	64
Vadodara	67	38	-	105
Anand	57	8	-	65
Kheda	141	5	1	147
Ahmedabad	195	16	8	219
Grand Total	**930**	**142**	**10**	**1082**
Percent	**86.0%**	**13.1%**	**0.9%**	**100.0%**
Source: Census Survey Data, Sep-Dec 2014				

(6) Social Category and Socio-Econimic Dimensions of PAHs

Assessment of PAHs social background shows that the majority among them belong to General Caste (414 PAHs, 38.3%) and Backward Caste (BC/OBC) category (407 PAHs, 37.6%) followed by Scheduled Tribe (202 PAHs, 18.7%). The presence of Schedule Caste (SC) family in the project area is 59 PAHs as shown in Table 4.2.22. Scheduled Tribe families are found to be mostly in Palghar (72 PAHs, Talasari and Dahanu taluka), Valsad (32 PAHs) and Ahmedabad District (51 PAHs, Ahmedabad city area).

Table 4.2.22: Social Category of PAHs

District	Gen	BC/OBC	SC	ST	Grand Total
Thane	26	8	1	15	50
Palghar	54	61	6	72	193
Dadra Nagar Haveli	4	-	-	-	4
Valsad	21	37	5	32	95
Navsari	8	31	10	5	54
Surat	22	29	24	11	86
Bharuch	31	23	1	9	64
Vadodara	69	22	7	7	105
Anand	43	22	-	-	65
Kheda	81	66	-	-	147
Ahmedabad	55	108	5	51	219
Grand Total	414	407	59	202	1082
Percent	38.3%	37.6%	5.5%	18.7%	100.0%

Source: Census Survey Data, Sep-Dec 2014

<u>Economic Status of PAHs</u>

The Table 4.2.23 highlights the state recognized economic status of the PAHs. 359 (33%) PAHs in the project areas are below the poverty line whereas 505 (47%) PAHs are above the poverty line. Rest of the families 218 (20%) couldn't give a clear answer regarding their economic status.

Table 4.2.23: Economic Status of PAHs

District	BPL	APL	Don't know	Grand Total
Thane	3	24	23	50
Palghar	71	40	82	193
Dadra Nagar Haveli	1	3	-	4
Valsad	32	61	2	95
Navsari	25	19	10	54
Surat	36	27	23	86
Bharuch	27	37	-	64
Vadodara	14	63	28	105
Anand	25	30	10	65
Kheda	64	70	13	147
Ahmedabad	61	131	27	219
Grand Total	**359**	**505**	**218**	**1082**
Percent	**33.2%**	**46.7%**	**20.1%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

PAHs as Beneficiary of Antyodaya and Annapurna Schemes[3]
Survey also attempted to identify such families who are vulnerable and recognized by the state through food security schemes support. Information given in Table 4.2.24 identifies the status of PAHs in the project areas regarding their beneficiary status vis-à-vis Antyodaya and Annapurna shcemes. Only 60 (5.5%) PAHs have Antyodaya and 30 (2.7%) PAHs have Annapurna Card.Highest concentration of Antyodaya beneficiaries (among PAHs) was reported in Palghar (20 PAHs); a district having high tribal population in two of the project affected talukas.

Table 4.2.24: PAHs having Antyodaya and Annapurna Card

District	Antyodaya Beneficiary PAHs		Annapurna Beneficiary PAH		Grand Total
	Yes	No	Yes	No	
Thane	1	49	1	49	50
Palghar	20	173	4	189	193
Dadra Nagar Haveli	-	4	-	4	4
Valsad	4	91	1	94	95
Navsari	5	49	6	48	54
Surat	2	84		86	86
Bharuch	2	62	-	64	64
Vadodara	8	97	13	92	105
Anand	5	60	1	64	65
Kheda	5	142	3	144	147

[3] Antyodaya is food security scheme for poorest of poor category families by the government while Annapurna is another food security scheme for old and infirm elderly people with no family support.

Ahmedabad	8	211	1	218	219
Grand Total	**60**	**1022**	**30**	**1052**	**1082**
Percent	**5.5%**	**94.5%**	**2.8%**	**97.2%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

(7) Ethnicity, Mrital Status, Literacy Levels & Occupations of PAPs

Marital Status

Information collected about 5404 PAPs in the survey as presented in Table 4.2.25 suggests that 2234 (41.3%) persons are single and 2939 (54.4%) persons are married. A small number (5, 0.09%) is divorced. 226 PAPs are widow/widower. In Vadodara district, 274 persons are married whereas 190 persons are single whereas one can find 58 numbers of widow/widowers in district Ahmedabad.

Table 4.2.25: Marital Status of PAPs

District	Single	Married	Divorced	Widow/Widower	Grand Total
Thane	96	106	-	6	208
Palghar	482	442	-	18	942
Dadra Nagar Haveli	7	10	-	1	18
Valsad	163	242	-	26	431
Navsari	94	166	-	13	273
Surat	162	224	-	24	410
Bharuch	101	207	-	16	324
Vadodara	190	274	-	6	470
Anand	148	182	-	19	349
Kheda	258	484	2	39	783
Ahmedabad	533	602	3	58	1196
Grand Total	**2234**	**2939**	**5**	**226**	**5404**
Percent	**41.3%**	**54.4%**	**0.1%**	**4.2%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

Educational Status

Education level of the affected population is presented in the Table 4.2.26. Among the PAPs, 1183 (21.9%) are illeterate, 1311 (24.3%) have not completed elementary school, 712 (13.2%) of PAPs have completed elementary school, 729 (13.5%) have completed Class 10th level, and 289 (5.2%) has completed graduation. In District Valsad, 71 persons don't have formal education whereas 55 persons have finished college in district Vadodara. Districts like Palghar (29.65) and Ahmedabad (27.6%) have relatively higher percentage of persons in the category of no education in comparison to other districts.

Primary Occupation of PAPs

Occupation-wise distribution of affected persons in the project area is presented in Table 4.2.27, 527 (9.7%) out of the 5404 PAPs are dependent upon Agriculture, whereas 420 PAPs (7.8%) are Unskilled Labour, 203 (3.75%) are engaged in Business/Trade and 36 PAPs (0.7%) are from Household/Cottage Industry. Only 195

PAPs (3.6%) are from Private Sector and a meagre 31 PAPs (0.6%) are Govt. Servants.

Table 4.2.26: Literacy Levels of PAPs

District	Too young for school		No Education		Below Elementary		Completed Elementary		Below High School		Completed High School		Not completed college		Finished College		Grand Total
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	
Thane	16	7.7	45	21.6	51	24.5	10	4.8	13	6.3	27	13.0	10	4.8	36	17.3	208
Palghar	106	11.3	279	29.6	196	20.8	63	6.7	81	8.6	171	18.2	21	2.2	25	2.7	942
Dadra Nagar Haveli	-	-	-	-	5	27.8		0.0	1	5.6	4	22.2	2	11.1	6	33.3	18
Valsad	32	7.4	71	16.5	104	24.1	40	9.3	45	10.4	94	21.8	20	4.6	25	5.8	431
Navsari	19	7.0	38	13.9	79	28.9	35	12.8	31	11.4	39	14.3	12	4.4	20	7.3	273
Surat	43	10.5	59	14.4	111	27.1	50	12.2	51	12.4	54	13.2	19	4.6	23	5.6	410
Bharuch	27	8.3	43	13.3	40	12.3	38	11.7	59	18.2	69	21.3	14	4.3	34	10.5	324
Vadodara	36	7.7	81	17.2	82	17.4	76	16.2	57	12.1	68	14.5	15	3.2	55	11.7	470
Anand	11	3.2	73	20.9	92	26.4	60	17.2	34	9.7	54	15.5	12	3.4	13	3.7	349
Kheda	64	8.2	164	20.9	218	27.8	138	17.6	89	11.4	64	8.2	13	1.7	33	4.2	783
Ahmedabad	103	8.6	330	27.6	333	27.8	202	16.9	111	9.3	85	7.1	13	1.1	19	1.6	1196
Grand Total	**457**	**8.5**	**1183**	**21.9**	**1311**	**24.3**	**712**	**13.2**	**572**	**10.6**	**729**	**13.5**	**151**	**2.8**	**289**	**5.2**	**5404**

Source: Census Survey Data, Sep-Dec 2014

Table 4.2.27: Occupational Pattern of PAPs

District	Agriculture	Allied Agriculture	Dairy	Forestry	Household/ Cottage Industry	Business/ Trade	Skilled Profession	Unskilled Labour	Pvt. Service	Govt. Service	Retired/ Pensioner	Unemployed but capable to work	Too Young/ Disabled	Others	Grand Total
Thane	2	-	-	1	-	27		6	5	-	-	4	84	79	208
Palghar	122	8	1	15	8	42	43	38	33	2	-	-	403	227	942
Dadra Nagar Haveli	2	-	-	-	-	3	-	-	-	-	-	-	7	6	18
Valsad	56	1	-	2	4	27	26	9	16	1	8	6	142	133	431
Navsari	28	12	-	-	1	12	12	31	7	1	3	4	76	86	273
Surat	4	12	-	-	15	19	10	31	32	4	10	-	150	123	410
Bharuch	53	30	-	1	2	2	3	17	15	2	-	3	94	102	324
Vadodara	17	3	-	3	1	30	20	35	35	12	6	84	143	81	470
Anand	61	7	9	-	2		4	16	3	1	5	8	137	96	349
Kheda	175	22	4	1	3	22	9	16	6	2	4	49	257	213	783
Ahmedabad	7			1		19	50	221	43	6	10	11	504	324	1196
Grand Total	**527**	**95**	**14**	**24**	**36**	**203**	**177**	**420**	**195**	**31**	**46**	**169**	**1997**	**1470**	**5404**
Percent	**9.8%**	**1.8%**	**0.3%**	**0.4%**	**0.7%**	**3.8%**	**3.3%**	**7.8%**	**3.6%**	**0.6%**	**0.9%**	**3.1%**	**37.0%**	**27.2%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

(8) Income and Poverty Dimensions of PAHs

Information collected during Census survey on income level of each PAH indicates of mixed income category households. It can be seen from Table 4.2.28 that out of total 1082 PAHs, about 225 (21%) PAHs of total PAHs are earning less than Rs. 5,000 per month, whereas only 120 (11.1%) PAHs are earning more than Rs. 20000 per month. Nearly two fifth of the PAHs have monthly income in Rs. 5000-10,000 range

Table 4.2.28: Monthly Income of PAHs (INR)

District	Less than 5000 INR	5000-10000	10000-20000	20000-50000	50000-1 Lakh	More than 1 Lakh	Grand Total
Thane	8	13	8	6	12	3	50
Palghar	34	120	31	8	-	-	193
Dadra Nagar Haveli	-		1	1	1	1	4
Valsad	20	34	32	5	3	1	95
Navsari	14	29	9		2	-	54
Surat	23	31	26	4	2	-	86
Bharuch	17	17	19	10	1	-	64
Vadodara	17	22	45	9	9	3	105
Anand	19	22	16	4	1	3	65
Kheda	37	43	48	12	5	2	147
Ahmedabad	36	112	59	11	-	1	219
Grand Total	**225**	**443**	**294**	**70**	**36**	**14**	**1082**
Percent	**20.8%**	**40.9%**	**27.2%**	**6.5%**	**3.3%**	**1.3%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014
1 lakh: 100,000

(9) Monthly Expenditures of PAHs

Information collected during Census survey on expenditure pattern among PAHs as presented in Table 4.2.29, indicates that out of total 1082 PAHs, around 380 (35%) of PAHs of total PAHs are spending than less than Rs. 5,000 per month, whereas only 7 (0.7%) PAHs are spending more than Rs. 1 Lakh per month.

Table 4.2.29: Monthly Expenditure of PAHs (INR)

District	Less than 5000 INR	5000-10000	10000-20000	20000-50000	50000-1 Lakh	More than 1 Lakh	Grand Total
Thane	17	10	6	12	5	-	50
Palghar	71	96	22	3	-	1	193
Dadra Nagar Haveli	-	-	1	2	1	-	4
Valsad	26	45	18	2	3	1	95
Navsari	22	22	8	-	2	-	54
Surat	36	30	17	2	1	-	86
Bharuch	26	15	14	9		-	64
Vadodara	23	37	27	11	6	1	105
Anand	31	24	6		1	3	65
Kheda	53	46	33	10	4	1	147
Ahmedabad	75	103	35	5	1	-	219
Grand Total	**380**	**428**	**187**	**56**	**24**	**7**	**1082**
Percent	**35.1%**	**39.6%**	**17.3%**	**5.2%**	**2.2%**	**0.6%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014
1 lakh: 100,000

(10) Access to Basic Amenities by the PAHs

Socio-Economic Household Survey was conducted for about one fifth of project affected households covered under Census Survey. The following tables are based on the information collected from 224 PAHs. This section primarily highlights the physical accessibility of PAHs to major social infrastructure like School, Market, Religious Centre, Hospitals, Local Government Office, Work Place of the local Population and access to Drinking Water. This section will also discuss on the opinion of PAHs on whether or not they will be disturbed during the construction and operation of the proposed project.

Accessibility to School and Project Impact

The Table 4.2.30 presents information on accessibility aspect of Schools among 224 PAHs (covered under socio-economic survey) and the project impact. In 77 (34%) PAHs, children have to cover less than 1 km. to reach their respective schools whereas in 142 (63%) PAHs, children travel between 1 to 5km. to reach their schools. 41 (18%) PAHs felt that the accessibility to the schools will be affected during the construction of the project whereas 101 (45%) PAHs said that the accessibility to the schools will be affected during the operation of the project.

Table 4.2.30: Distance of the Schools and Impact of the Project

District	Distance to School (in KM)			Disturbed during Construction			Disturbed during Operation			Grand Total
	Less than 1 Km	1-5	6-10	Yes	No	Can't Say	Yes	No	Can't Say	
Thane	1	11				12	6	3	3	12

Palghar	13	24		1	2	34	15	14	8	37
Dadra Nagar Haveli		1	1			2	2			2
Valsad		16	3	1	1	17	11	5	3	19
Navsari	5	6		2	1	8	1	2	8	11
Surat	7	19		1	2	23	5	1	20	26
Bharuch	8	10		3	3	12	14		4	18
Vadodara	7	13		6	6	8	8	3	9	20
Anand	4	8		5	3	4	4	7	1	12
Kheda	10	12	1	8	8	7	10	11	2	23
Ahmedabad	22	22		14	15	15	25	10	9	44
Grand Total	**77**	**142**	**5**	**41**	**41**	**142**	**101**	**56**	**67**	**224**
Percent	**34.4%**	**63.4%**	**2.2%**	**18.3%**	**18.3%**	**63.4%**	**45.1%**	**25 %**	**30 %**	**100%**

Source: Census Survey Data, Sep-Dec 2014

<u>Accessibility to Market and Project Impact</u>

The Table 4.2.31 presents information on accessibility to market and perceived project impact among 224 PAHs. Among the, 72 (32%) PAHs have to cover less than 1 km. to visit market place whereas 125 (56%) PAHs travel between 1 to 5 km. to visit the market. 136 (61%) PAHs felt that the accessibility to the market place will be affected during the construction of the project whereas 111 (49.5%) PAHs said that the accessibility to the market place will be affected during the operation of the project.

Table 4.2.31: Distance to Market and Impact of the Project

District	Distance to Market (in KM)				Disturbed during Construction			Disturbed during Operation			Grand Total
	Less than 1 Km	1-5	6-10	>10	Yes	No	Can't Say	Yes	No	Can't Say	
Thane	3	8	1		6	5	1	6	5	1	12
Palghar	6	24		7	15	15	7	15	14	8	37
Dadra Nagar Haveli	-	1	1	-	2	-	-	2	-	-	2
Valsad	4	13	2		19	-	-	14	5	-	19
Navsari	1	8		2	4	2	5	4	2	5	11
Surat	4	15		7	13	3	10	11	1	14	26
Bharuch	8	8	1	1	14	3	1	15	1	2	18
Vadodara	9	9		2	10	5	5	8	4	8	20
Anand	3	9			6	5	1	3	8	1	12
Kheda	8	14	1		21		2	10	8	5	23
Ahmedabad	26	16		2	26	9	9	23	13	8	44

Total	**72**	**125**	**6**	**21**	**136**	**47**	**41**	**111**	**61**	**52**	**224**
Percent	**32.1%**	**55.8%**	**2.7%**	**9 %**	**61%**	**21%**	**18%**	**50%**	**27%**	**23%**	**100%**

Source: Census Survey Data, Sep-Dec 2014

Accessibility to Religious Centre and Project Impact

Accessibility details in relation to religious centres/places are presented in the Table 4.2.32. Out of 224 PAHs, 88 (3.6%) PAHs shared that they have to cover less than 1 km. to visit their respective religious centre whereas 81 (36%) PAHs travel between 1 to 5km. to visit the religious centre. 112 (50%) PAHs felt that the accessibility to the religious centre will be affected during the construction of the project whereas 90 (40.1%) PAHs said that the accessibility to the religious centre will be affected during the operation of the project.

Table 4.2.32: Distance to Religious Places and Impact of the Project

District	Distance to Religious Centre (in KM)				Disturbed during Construction			Disturbed during Operation			Grand Total
	Less than 1 km	1-5	6-10	>10	Yes	No	Can't Say	Yes	No	Can't Say	
Thane	-	11	1		4	7	1	8	2	2	12
Palghar	5	22	1	9	12	16	9	12	14	11	37
Dadra Nagar Haveli	-	1	1		2	-	-	2	-	-	2
Valsad	3	12	1	3	16		3	10	6	3	19
Navsari	2	2	-	7		2	9		2	9	11
Surat	2	4	-	20	3	1	22	6	1	19	26
Bharuch	10	3	-	5	10	2	6	11	1	6	18
Vadodara	14	4	-	2	14	1	5	10	2	8	20
Anand	10	2	-	-	8	-	4	4	3	5	12
Kheda	17	5	-	1	19	2	2	8	9	6	23
Ahmedabad	25	15	-	4	24	11	9	19	11	14	44
Total	**88**	**81**	**4**	**51**	**112**	**42**	**70**	**90**	**51**	**83**	**224**
Percent	**39%**	**36.2%**	**1.8%**	**22.8%**	**50%**	**19%**	**31%**	**40%**	**23%**	**37%**	**100%**

Source: Census Survey Data, Sep-Dec 2014

Accessibility to Hospitals and Project Impact

In relation to accessibility to hospital, 116 (52% of 224) PAHs need to cover between 1 km. to 5 km to visit nearest hospitals whereas 56 (25%) PAHs travel more than 10 km. for availing these facilities. 94 (42%) PAHs felt that the accessibility to the hospital will be affected during the construction of the project whereas 69 (31%) PAHs said that the accessibility to the hospital will be affected during the operation of the project as presented in the Table 4.2.33.

Table 4.2.33: Distance to Hospitals and Impact of the Project

District	Distance to Hospitals (in KM)				Disturbed during Construction			Disturbed during Operation			Grand Total
	Less than 1 km	1-5	6-10	>10	Yes	No	Can't Say	Yes	No	Can't Say	
Thane	-	10	2		4	6	2	1	9	2	12
Palghar	-	20	10	7	11	18	8	12	13	12	37
Dadra Nagar Haveli	-		1	1	2			2			2
Valsad	-	5	12	2	18		1	13	5	1	19
Navsari	-	3	1	7		1	10		2	9	11
Surat	-	7		19	3	1	22	3	1	22	26
Bharuch	-	11	1	6	5	7	6	5	6	7	18
Vadodara	-	16	2	2	9	5	6	6	3	11	20
Anand	-	6	6		8		4	4	3	5	12
Kheda	-	5	11	7	18	2	3	7	5	11	23
Ahmedabad	-	33	6	5	16	18	10	16	15	13	44
Grand Total	-	**116**	**52**	**56**	**94**	**58**	**72**	**69**	**62**	**93**	**224**
Percent	**-**	**52%**	**23%**	**25.0%**	**42%**	**26%**	**32%**	**31%**	**28%**	**41%**	**100%**

Source: Census Survey Data, Sep-Dec 2014

<u>Accessibility to Govt. Offices and Project Impact</u>

Information collected on accessibility to government offices as presented in Table 4.2.34, suggests that 108 (48% of 224) PAHs have to cover less than 5 km. to visit the Govt. offices whereas 58 (26%) PAHs travel more than 20 km. 82 (37%) PAHs believe that the accessibility to the Govt. offices will be affected during the construction of the project whereas 57 (25.4%) PAHs said that the accessibility to the Govt. offices will be affected during the operation of the project.

Table 4.2.34: Distance to Govt. Offices and Impact of the Project

District	Distance to Govt. Office (in km)				Disturbed during Construction			Disturbed during Operation			Grand Total
	Less than 5 km	6-10	11-20	>20	Yes	No	Can't Say	Yes	No	Can't Say	
Thane	4	1	7		3	8	1	4	3	5	12
Palghar	20	1	9	7	9	19	9	8	14	15	37
Dadra Nagar Haveli	-	-	1	1	2	-	-	2	-	-	2
Valsad	7	-	8	4	14	1	4	8	7	4	19
Navsari	4	-	-	7	-	1	10	-	2	9	11
Surat	6	-	-	20	6	1	19	5	1	20	26
Bharuch	1	6	-	11	1	6	11	1	6	11	18

Vadodara	14	-	3	3	11	2	7	8	2	10	20
Anand	9	-	3	-	5	3	4	1	6	5	12
Kheda	10	1	11	1	17	1	5	6	8	9	23
Ahmedabad	33	-	7	4	14	18	12	14	18	12	44
Grand Total	**108**	**9**	**49**	**58**	**82**	**60**	**82**	**57**	**67**	**100**	**224**
Percent	**48%**	**4%**	**22%**	**26%**	**37%**	**27%**	**37%**	**25%**	**30%**	**45%**	**100%**

Source: Census Survey Data, Sep-Dec 2014

Accessibility to Work Place and Project Impact

The Table 4.2.35 suggests that 190 (85% of 224) PAHs cover less than 5 km. to visit their work place whereas only 3 (1.3%) PAHs travel more than 20 km. 96 (43%) PAHs perceive that project will impact their accessibility to the work place during the construction phase while 72 (32%) PAHs felt that the accessibility to the work place will be affected during the operation of the project.

Table 4.2.35: Distance to Work Place and Impact of the Project

District	Distance to Work Place (in km)				Disturbed during Construction			Disturbed during Operation			Grand Total
	Less than 5 Km	6-10	11-20	>20	Yes	No	Can't Say	Yes	No	Can't Say	
Thane	10	1	1	-	3	4	5	4	2	6	12
Palghar	31	5	1	-	8	18	11	8	13	16	37
Dadra Nagar Haveli	1	-	-	1	2	-	-	2	-	-	2
Valsad	15	3	1	-	11	2	6	6	7	6	19
Navsari	10	1		-	1	1	9	1	2	8	11
Surat	20	3	3	-	10	2	14	9	1	16	26
Bharuch	15	2	-	1	11	5	2	10	3	5	18
Vadodara	16	3	-	1	10	3	7	7	3	10	20
Anand	11	1	-	-	8	-	4	5	3	4	12
Kheda	21	2	-	-	19	1	3	8	9	6	23
Ahmedabad	40	3	1	-	13	15	16	12	13	19	44
Grand Total	**190**	**24**	**7**	**3**	**96**	**51**	**77**	**72**	**56**	**96**	**224**
Percent	**85%**	**11%**	**3%**	**1%**	**43%**	**23%**	**34%**	**32%**	**25%**	**43%**	**100%**

Source: Census Survey Data, Sep-Dec 2014

Distance to access Drinking Water and affect by the Project

As per socio economic survey data presented in Table 4.2.36, 117 (52.2% of 224) PAHs have drinking water sources within a kilometre of their homes/project affected structures. However, 69 (31%) PAHs travel more than 8 km to get drinking water. 93 (41.5%) PAHs felt that the accessibility to get drinking water will be affected during the construction of the project whereas 66 (29%) PAHs said that the accessibility to get drinking water will be affected during the operation of the project.

Table 4.2.36: Distance to Drinking Water and Impact of the Project

District	Distance to Access Drinking Water (in km)				Disturbed during Construction			Disturbed during Operation			Grand Total
	Less than 1 km	2-4	5-7	>8	Yes	No	Can't Say	Yes	No	Can't Say	
Thane	11	-	1		7	-	5	8	-	4	12
Palghar	20	4	2	11	7	8	22	7	9	21	37
Dadra Nagar Haveli	-	-	-	2	-	-	2	-	-	2	2
Valsad	7	1	-	11	8	2	9	3	7	9	19
Navsari	5	1	-	5	2	1	8	2	2	7	11
Surat	5	-	7	14	5	1	20	4	1	21	26
Bharuch	11	-	2	5	15	1	2	14	1	3	18
Vadodara	13	2	5	-	10	3	7	7	2	11	20
Anand	11	-	1	-	8	1	3	5	2	5	12
Kheda	16	2	1	4	13	3	7	3	8	12	23
Ahmedabad	18	8	1	17	18	5	21	13	10	21	44
Grand Total	**117**	**18**	**20**	**69**	**93**	**25**	**106**	**66**	**42**	**116**	**224**
Percent	**52.2%**	**8.0%**	**8.9%**	**30.8%**	**41.5%**	**11.2%**	**47.3 %**	**29. %**	**18.8 %**	**51.8 %**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

Water and Sanitation

Detailed information was collected with respect to access to water and sanitation facilities through census survey and has been presented in Table 4.2.37. As per information collected from 1082 PAHs, 125 (11.6%) PAHs are dependent on Hand Pumps for getting drinking water. A large number of 534 (49.3%) PAHs are dependent upon Piped Water Supply Govt. corporations, whereas only 5 (0.4%) PAHs get drinking water from Open well and Canal.

Table 4.2.37: Distance to Sources of Water

District	Hand Pump	Bore well	Piped Water from Govt.	Private Water Tanker	Govt. Water Tanker	Bottled Water	Open well/ Canal	Other	Grand Total
Thane	11	6	27			3	2	1	50
Palghar	56	74	28	7	21	6		1	193
Dadra Nagar Haveli		2						2	4
Valsad	19	37	9			22		8	95
Navsari	10	13	20		6	1		4	54

Surat	2	38	38	1	7				86
Bharuch		56	5	1	2				64
Vadodara	5	9	88	1	1	1			105
Anand	5	32	28						65
Kheda	12	48	84				3		147
Ahmedabad	5	6	207		1				219
Grand Total	**125**	**321**	**534**	**10**	**38**	**33**	**5**	**16**	**1082**
Percent	**11.6%**	**29.7%**	**49.4%**	**0.9%**	**3.5%**	**3.0%**	**0.5%**	**1.5%**	**100%**

Source: Census Survey Data, Sep-Dec 2014

PAHs Source of Water for Washing/Bathing

Information collected on water source for washing and bathing purposes is presented in Table 4.2.38. As per the table, 122 (11.3%) PAHs are dependent on Hand Pumps to get water for washing and bathing. A large number of 562 (51.9%) PAHs receive this facility from Piped Water Supply by Govt. corporations/private suppliers whereas 19 (1.8%) PAHs source water from Open well and Canal for these purposes.

Table 4.2.38: Distance to Sources of Water for Washing/Bathing

District	Hand Pump	Bore Well	Piped Water from Govt.	Private Water Tanker	Govt. Water Tanker	Bottled Water	Open well/ Canal	Other	Grand Total
Thane	11	6	32	-	-	-	-	1	50
Palghar	46	80	27	8	19	2	11	-	193
Dadra Nagar Haveli	-	2	-	-	-	-	-	2	4
Valsad	29	39	14		1	-		12	95
Navsari	11	10	22	1	6	-	1	3	54
Surat	4	31	50	1		-	-	-	86
Bharuch	-	55	7	-	2	-	-	-	64
Vadodara	4	9	88	1	1	1	1	-	105
Anand	6	30	27	-	-	-	2	-	65
Kheda	10	49	84	-	-	-	4	-	147
Ahmedabad	1	6	211	-	1	-	-	-	219
Grand Total	**122**	**317**	**562**	**11**	**30**	**3**	**19**	**18**	**1082**
Percent	**11.3%**	**29.3%**	**51.9%**	**1.0%**	**2.8%**	**0.3%**	**1.8%**	**1.7%**	**100%**

Source: Census Survey Data, Sep-Dec 2014

Toilet Facility for PAHs

The table 4.2.39 indicates that 569 (52.6%) PAHs have got their own toilet within the house. A high number of 363 (33.6%) PAHs still defecate in the open whereas 129 (11.9%) PAHs use the public toilet.

Table 4.2.39: Toilet Facilities for PAHs

District	Own Toilet within house	Public Toilet	In the field/open space	Near canal/ River	Other	Grand Total

Thane	28	6	15	1		50
Palghar	77	62	51	1	2	193
Dadra Nagar Haveli	4	-	-	-	-	4
Valsad	46	14	34	-	1	95
Navsari	36	6	12	-	-	54
Surat	59	3	24	-	-	86
Bharuch	48	1	10	5		64
Vadodara	76	7	20	-	2	105
Anand	34	3	28	-	-	65
Kheda	58	1	79	9	-	147
Ahmedabad	103	26	90	-	-	219
Grand Total	**569**	**129**	**363**	**16**	**5**	**1082**
Percent	**52.6%**	**11.9%**	**33.5%**	**1.5%**	**0.5%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

Discharge of used water by PAHs

Information collected on practices/facilities relating to discharge of used water is presented in Table 4.2.40 which identifies that 249 (23%) PAHs use soak pit to discharge used water. A large number of 348 (32%) PAHs have access to covered drainage, whereas 258 (23.9%) PAHs discharge used water in the open.

Table 4.2.40: Discharge of Used Water by PAHs

District	Soak Pit	Covered Drainage	Open Drainage	Just Outside house in open	Others	Grand Total
Thane	4	23	7	15	1	50
Palghar	77	19	60	37	-	193
Dadra Nagar Haveli	-	3	1	-	-	4
Valsad	60	15	7	12	1	95
Navsari	8	21	6	19	-	54
Surat	10	46	15	14	1	86
Bharuch	27	31	5	1	-	64
Vadodara	11	65	16	13	-	105
Anand	13	17	9	26	-	65
Kheda	21	21	21	84	-	147
Ahmedabad	18	123	41	37	-	219
Grand Total	**249**	**384**	**188**	**258**	**3**	**1082**
Percent	**23.0%**	**35.5%**	**17.4%**	**23.8%**	**0.3%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

Disposal of Garbage by PAHs

In relation to disposal of garbage, census survey data as depicted in Table 4.2.41, suggests that 140 (52.6%) PAHs dispose their garbage through the Government/community garbage collector. 191 (33.6%) PAHs dump their garbage at designated garbage place whereas 530 (11.9%) PAHs dump and burn the garbage outside their home.

Table 4.2.41: Disposal of Garbage by PAHs

District	Through the Govt. Collectors	Dump at Garbage place	Dump and Burn	Throw Anywhere	Throw in the Canal	Grand Total
Thane	22	4	18	5	1	50
Palghar	19	22	97	52	3	193
Dadra Nagar Haveli	-	-	4	-	-	4
Valsad	5	3	80	5	2	95
Navsari	3	4	42	5	-	54
Surat	8	6	54	11	7	86
Bharuch	-	28	35	1	-	64
Vadodara	36	31	22	16	-	105
Anand	4	17	19	25	-	65
Kheda	3	12	75	57	-	147
Ahmedabad	40	64	84	31	-	219
Grand Total	**140**	**191**	**530**	**208**	**13**	**1082**
Percent	**12.9%**	**17.7%**	**49.0%**	**19.2%**	**1.2%**	**100.0%**

Source: Census Survey Data, Sep-Dec 2014

(11) Household Assets

Additional detailed information was collected on household assets among PAHs through socio-economic survey. This survey was conducted for about one fifth of project affected households covered under Census Survey. The following tables are based on the information collected from 224 PAHs. This section primarily presents information on movable assets owned by sample PAHs such as livestock, agricultural implements, household items and other assets.

Livestock

The district wise ownership patterns of livestock among the PAHs is presented in Table 4.2.42. The Livestock owned by PAHs generally include cows, buffalos, sheep, oxen, goats *etc.* As evident from the table below, livestock ownership is not high among the PAHs. Maximum reporting among PAHs is related to buffaloes (33 families in total, 14 PAHs from Kheda alone).

Table 4.2.42: Livestock Holdings of PAHs

District	PAHs	Cow	Ox	Buffalo	Sheep	Goat	Camel	Donkey	Horse	Pig	Chicken	Duck
Thane	12	-	-	-	-	-	-	-	-			1
Palghar	37	7	6	5	2	2		2	-	4	1	1
Dadra Haveli	2	-	-	-	-	-	-	-	-		-	-
Valsad	19	-	-	-	1			-	-		-	-

Navsari	11	1		2		2	1	-	-	2	-	1
Surat	26	1		1				-	-		-	-
Bharuch	18		5	2		2		-	-		-	-
Vadodara	20	1		2	-	-	-	-	-	1	-	-
Anand	12	4		7	-	-	-	-	-		-	-
Kheda	23	1	1	14	-	-	-	-	-		-	-
Ahmedabad	44				-	-	-	-	-		-	-
Total	**224**	**15**	**12**	**33**	**3**	**6**	**1**	**2**	-	**7**	**1**	**3**
Percent		**7%**	**5%**	**15%**	**1%**	**3%**	**0.5%**	**0.9%**	-	**3%**	**0.5%**	**1%**

Source: Census Survey Data, Sep-Dec 2014

Agricultural Implements

The district wise number of PAHs reporting ownership of various agricultural implements is presented in Table 4.2.43. Only 8 PAHs use Tractor for agriculture purpose whereas 11 PAHs use Pump set for irrigation purpose in the agricultural field.

Table 4.2.43: Agriculture Implements Owned by the PAHs

District	PAHs	Tractor	Power Trailer	Thresher	Harvester	Genset Sprayer	Pump Set	Electric Pump
Thane	12	-	-	-	-	-	-	-
Palghar	37	-	-	-	-	-	1	1
Dadra Nagar Haveli	2	-	-	-	-	-		
Valsad	19	1	-	-	1	-	-	1
Navsari	11	2	1	-	-	-	1	2
Surat	26	-	-	-	-	-	1	1
Bharuch	18	2	-	-	-	7	4	5
Vadodara	20	-	-	-	-	-	-	-
Anand	12	1	-	-	-	1	1	1
Kheda	23	1	1	1	1		3	1
Ahmedabad	44	1	-	-	-	-	-	-
Grand Total	**224**	**8**	**2**	**1**	**2**	**8**	**11**	**12**
Percent		**4%**	**1%**	**0.4%**	**1%**	**4%**	**5%**	**5%**

Source: Census Survey Data, Sep-Dec 2014

Household Items

Information collected on reported ownership of various household items among PAHs is presented in Table 4.2.44. Most commonly owned household item is television (193 PAHs) and electric fan (179 PAHs); followed by Gas Chullah (121 PAHs) and fridge (104 PAHs).

Table 4.2.44: Households Items Owned by the PAHs

District	PAHs	TV	Fridge	Mixer	Electric Cooker	Geyser	Electric Fan	OTG	Toaster	Microwave	Radio	Gas Chullah/ Burner	Kerosene Chullah/ Burner	Grain storing facilities
Thane	12	12	7	6	4	4	9		2	1	7	6	3	-
Palghar	37	34	25	25	14	14	29	2	-	1	23	20	15	-
Dadra Nagar Haveli	2	2	2	1	1	1	2		-	-		2	-	-
Valsad	19	17	11	7	1	4	15	1	-	-	6	15	2	1
Navsari	11	6	4	3	1	-	9	1	-	-		5	5	3
Surat	26	17	11	14	2	-	23	1	-	-	3	15	5	6
Bharuch	18	16	9	9	-	-	14		-	-	4	14	5	6
Vadodara	20	18	8	11	6	4	11	1	-	2	7	13	8	15
Anand	12	10	5	3	-	-	10		-	-	2	4	7	5
Kheda	23	20	3	6	3	-	21	1	-	-	1	6	16	14
Ahmedabad	44	41	19	18	16	2	36	1	-	1	16	21	24	17
Grand Total	**224**	**193**	**104**	**103**	**48**	**29**	**179**	**8**	**2**	**5**	**69**	**121**	**90**	**67**
Percent		**86%**	**46%**	**46%**	**21%**	**13%**	**80%**	**4%**	**1%**	**2%**	**31%**	**54%**	**40%**	**30%**

Source: Census Survey Data, Sep-Dec 2014

Other Assets Owned

Reported ownership of other assets (vehicles in particular) among PAHs in project affected districts is presented in the Table 4.2.45. As per the information collected, cycle (137 PAHs, 61% of the PAHs) is most commonly owned followed by scooter/motorcycle (106 PAHs) and car/jeep (8 PAHs).

Table 4.2.45: Other Assets Owned by the PAHs

District	AHs	Cycle	Scooter/Motorcycle	Three wheeler	Jeep/Car	Truck	Bus	Bullock/Camel Cart
Thane	12	11	7	-	1	-	-	
Palghar	37	26	7	1	1	-	-	-
Dadra Nagar Haveli	2	2	2	-	1	-	-	-
Valsad	19	6	13	-	-	-	-	-
Navsari	11	3	4	1	-	-	-	-
Surat	26	11	16	-	-	-	-	-
Bharuch	18	10	13	-	-	-	-	-
Vadodara	20	14	14	-	2	-	-	-
Anand	12	7	7	1	1	-	-	-
Kheda	23	17	9	-	2	-	-	-
Ahmedabad	44	30	14	-		-	-	-
Grand Total	**224**	**137**	**106**	**3**	**8**	-	-	-
Percent		**61%**	**47%**	**1%**	**4%**	-	-	-

Source: Census Survey Data, Sep-Dec 2014