

PR40

EIA-TR-17/ Nov 2000

**Impact Assessment of Dahej - Bijaipur Liquefied Natural Gas  
Pipeline (Gas Authority of India Ltd) on the Flora and Fauna**



PA Azeez, S Bhupathy, A Rajasekaran and PR Arun

SACON Library



PR40



**Salim Ali Centre For Ornithology & Natural History  
Coimbatore, Tamil Nadu  
2000**

EIA-TR-17/ Nov 2000

**Impact Assessment of Dahej - Bijaipur Liquefied Natural Gas Pipeline  
(Gas Authority of India Ltd) on the Flora and Fauna**

**PA Azeez, S Bhupathy, A Rajasekaran and PR Arun**



**Salim Ali Centre For Ornithology & Natural History  
Coimbatore, Tamil Nadu  
2000**

## CONTENTS

<b>1 INTRODUCTION</b> .....	1
<b>2 SCOPE</b> .....	1
<b>3 METHODOLOGY</b> .....	1
<b>4 OBSERVATIONS</b> .....	4
<b>4.1 LAND USE ALONG THE ROUTE</b> .....	6
<b>4.2 STATUS OF FOREST</b> .....	12
<b>4.3 FLORA ALONG THE ROUTE</b> .....	12
<b>4.4 AQUATIC PLANTS</b> .....	13
<b>4.5 FLORISTIC COMPOSITION ALONG THE PIPELINE ROUTE</b> .....	13
<b>4.6 MAJOR TREE SPECIES ALONG THE ROUTE</b> .....	24
<b>4.7 FAUNA</b> .....	26
<b>4.7.1 Butterflies</b> .....	26
<b>4.7.2 Amphibians and reptiles</b> .....	27
<b>4.7.3 Birds and mammals</b> .....	28
<b>4.8 ENDANGERED SPECIES</b> .....	31
<b>4.9 IMPACT OF THE PIPELINE</b> .....	32
<b>4.10 SENSITIVE AREAS</b> .....	33
<b>4.11 MITIGATORY MEASURES</b> .....	27
<b>4.11.1 Minimizing the disturbance</b> .....	27
<b>4.11.2 Compensatory afforestation</b> .....	27
<b>4.12 COST VS BENEFIT OF UPROOTING THE TREES ON THE ROW</b> .....	28
<b>5 CONCLUSIONS</b> .....	30
<b>6 ACKNOWLEDGEMENTS</b> .....	31
<b>7 REFERENCES</b> .....	32

## TABLES

Table 1 Sampling locations along the proposed HBJ pipeline route .....	5
Table 2 Land type and use along the pipeline route .....	6
Table 3 Major rivers and wetlands along the pipeline route .....	8
Table 4 Major forest areas close to the HBJ pipeline route.....	9
Table 5 Major road and rail crossings along the HBJ pipeline route .....	9
Table 6 Number of plant species recorded along the pipeline route .....	11
Table 7 Important cultivated plants observed along the pipeline route and environs ....	12
Table 8 Floral species richness and diversity along the pipeline route .....	21
Table 9 GBH and Height class distribution of trees along the pipeline route .....	22
Table 10 Estimated number of trees to be felled for the newly proposed RoU .....	23
Table 11 Butterflies encountered along the pipeline route .....	23
Table 12 Amphibians observed along the pipeline route .....	24
Table 13 Reptiles recorded along the pipeline route.....	24
Table 14 Birds observed along the pipeline route .....	25
Table 15 Mammals observed along the pipeline route.....	27
Table 16 Endangered species present in the environs of the proposed project .....	27

## APPENDICES

Appendix 1 Grading scheme for assessment of ecological sensitivity of an area .....	37
Appendix 2 List of plant species seen along the pipeline route and its environs .....	38
Appendix 3 GBH and Height class distribution of trees along the pipeline route .....	42
Appendix 4 Tree matrices in the existing RoU (Gujarat region) .....	42
Appendix 5 Tree matrices in the existing RoU (Madya Pradesh region) .....	43
Appendix 6. Environmental Impact evaluation matrix (Construction phase) .....	44
Appendix 7 Environmental Impact evaluation matrix (Operation phase).....	44
Appendix 8 Ecological sensitivity of the sectors of the pipeline route .....	45

## FIGURES

Figure 1. Sampling locations along the HBJ pipeline route .....	4
Figure 2. Graph showing the geographical co-ordinates of the sampling plots .....	6

## PLATES

Plate 1. Road kill - Russell's Viper .....	3
Plate 2. Congregation of Whitebacked Vulture .....	3
Plate 3. Major landscapes available along the HBJ pipeline .....	7
Plate 4. Breach of RoU exposing underground pipeline .....	29
Plate 5. Sarus Crane .....	29

## **1 INTRODUCTION**

Gas Authority of India Limited (GAIL) proposes to lay a 610 km long pipeline to transport natural gas from LNG Petronet Dahej, located at Dahej, a coastal township in the Saurashtra region of Gujarat, to Bijaipur in Madhya Pradesh. This project is taken as a part of the enhancement of the existing HBJ project. The pipeline length of 82 km from Dahej to RR station Vemar will be laid in a newly acquired RoU while that from Vemar to Bijaipur (527 km) will be laid in the RoU of the existing pipeline. The pipeline will be laid minimum of 1 m below the surface (1.7m cover at railway crossings and 1.2m at highway and canal crossings) in a 30 m wide RoU. The existing pipeline passes through Bharuch, Vadodara, Godhra and Dahod districts of Gujarat and Jhabua, Dhar, Ujjain, Shajapur, Rajgarh and Guna districts of Madhya Pradesh. It is mandatory to conduct Environmental Impact Assessment of such large scale projects as per the notification of Ministry of Environment and Forests, Government of India (Anonymous 1994). As part of the EIA, the assessment of the impact of the pipeline on the floral and faunal aspects was awarded to Sálím Ali Centre for Ornithology and Natural History (SACON), Coimbatore, an autonomous institute funded by the Ministry of Environment and Forests, Government of India.

## **2 SCOPE**

Scope of the work as per the TOR were to;

- i) examine the pipeline project in light of various forest and wildlife acts and environmental protection act and other relevant regulations and notifications
- ii) assess the baseline status of forest and wildlife of the area including flora, avifauna and aquatic life in LNG Petronet Dahej - Vemar - Bijaipur pipeline corridor (500m on either side) and identify endangered species if any,
- iii) assess the impact on fauna, flora and aquatic ecology due to the proposed pipeline project
- iv) suggest environmental management plan to mitigate the negative impacts of the pipeline, if any, and
- v) carry out cost-benefit analysis of the project with respect to the environment

## **3 METHODOLOGY**

Relevant Survey of India maps (toposheets; scale 1:100000 and 1:50000) with the path of the proposed pipeline marked on it was used for the field survey. Based on preliminary examination of the route of the pipeline, the entire stretch was divided into three sections; the newly proposed part (Vemar to Dahej) forming first section (82 km), the other two sections falling in the range of the

existing pipeline (527 km). The stretch between Vemar and Jabhua forming the second section and Jabhua to Bijaipur, the third. The data were compiled considering each section as one unit. The section I, about 82 km long, extend between Dahej and Vemar located in the west coast of Saurashtra. The remaining stretch (section II and III) is approximately 527 Km long, crossing various industrial townships between Vemar, in Gujarat and Bijaipur in Madhya Pradesh.

The entire stretch (Figure 1) was covered by the team using a four wheel drive vehicle. For intensive study of the flora and fauna, sampling points were marked at an interval of approximately 15 km along the route. These sampling points fall within 500m on both sides of the proposed RoU. The coordinates (latitude and longitude) for these locations were recorded using a Global Positioning System and toposheets. Flora and fauna were studied following standard methods (eg., Greig-Smith 1983, Caustan 1988). Preliminary examination of the pipeline route indicated no thick vegetation and hence, two quadrats of one hectare (100 X 100m) each was laid in each sampling point and i) the species, ii) their number, iii) Girth at Breast Height (GBH) (Chaturvedi and Khanna 1982), and iv) Total height (height of the bole from ground level + height of crown) of the trees were recorded. The total number of trees on the RoU were estimated as  $D \cdot A$  where D is the density of trees per hectare and A, the total area of RoU in hectares ( $A = L \cdot W / 10$  where L is the length of the pipeline in kilometres and W, the width of the RoU in meters). Within the quadrat shrubs and herbs were enumerated by random walk. Specimens of plants whose identity could not be confirmed in the field were collected and preserved following standard methods and identified subsequently using Gamble (1987), Jain and Rao (1983), Nair and Shastry (1988) and Shetty and Singh (1987). Ecologically important / sensitive areas such as National Parks, Wildlife Sanctuaries and Wetlands lying in the environs of the path, which is considered here as up to 5 Km in perpendicular distance, were marked on the map and surveyed laying quadrats as mentioned above.

At each sampling sites animal species encountered and also the signs of others present were recorded. Records of road kills (Plate 1) and congregations of birds (Plate 2) in the close environs were also noted . Those which are likely to be present based on recent literature and information from the local wildlife experts were also recorded. The list of endangered species encountered was prepared based on the Wildlife Protection Act, 1972 (Anonymous 1991, Upadhyay 1995, Chaturvedi and Chaturvedi 1996) and list provided by ZSI (1994). The type and use of land and dominant crop were also recorded at each sampling site. No official / revenue records were consulted to confirm our observations on the type and landuse. All the sites were graded for their ecological sensitivity based on various characteristics (Appendix 1, Usher 1986, Spellerberg 1992), such as number of endangered and endemic species present in the locality and status of the forest; whether the area is a Wildlife Sanctuary, National Park, or an already known ecologically sensitive area.

#### 4 OBSERVATIONS

Altogether forty-two localities selected, at an approximate interval of 15 km, in the entire stretch of the pipeline route were marked on the toposheets (Scale 1:50000) and sampled for flora and fauna (Table 1 and Figure 2).

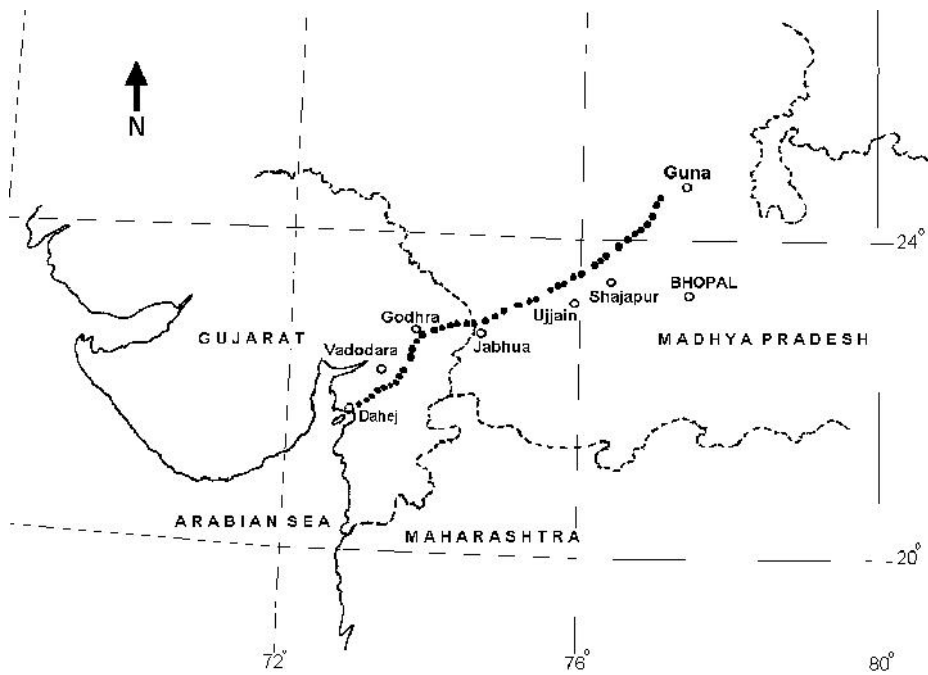
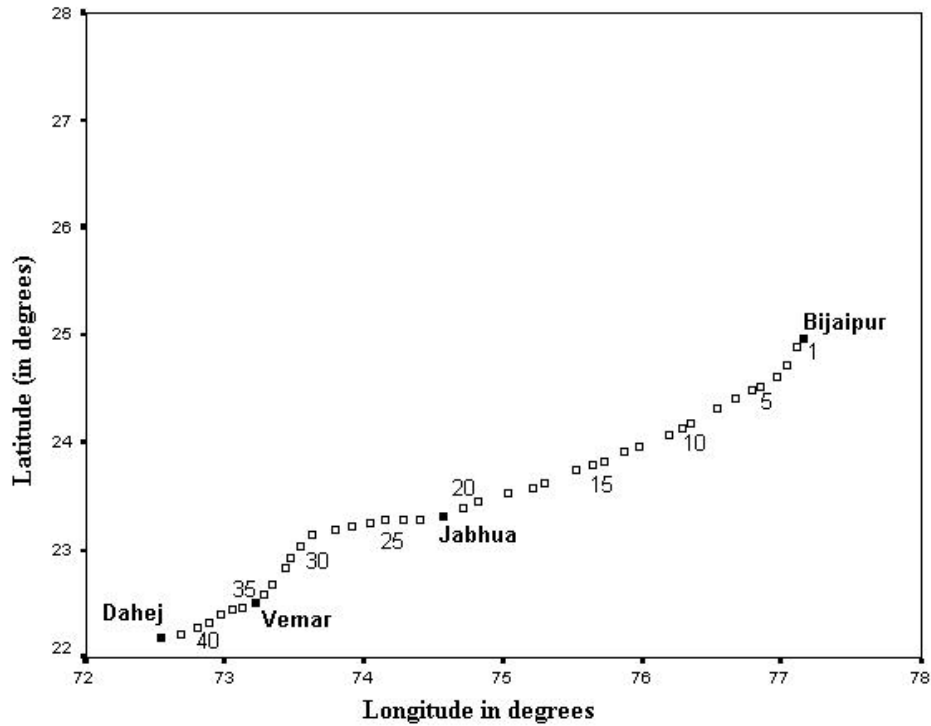




Table 1 Sampling locations along the proposed HBJ pipeline route			
No.	Location	Latitude (In degrees)	Longitude (In degrees)
	<b>Section I</b>		
1	Dahej	21.684	72.532
2	Near Atali	21.716	72.680
3	Kothia	21.784	72.792
4	Ankot	21.818	72.878
5	Wandarsa- Padri	21.904	72.968
6	Makan	21.942	73.050
7	Atali	21.967	73.130
8	Vemar	22.012	73.226
	<b>Section II</b>		
9	Parignaon	22.085	73.282
10	Thuvai	22.176	73.338
11	Bisania	22.347	73.434
12	Tajpura	22.446	73.467
13	Turkanda	22.554	73.542
14	Adadra	22.649	73.625
15	Ichoni	22.700	73.791
16	Devghadhbariya	22.724	73.914
17	Amba	22.768	74.041
18	Dudhmal	22.789	74.142
19	Motikherj	22.791	74.274
20	Wedbara	22.793	74.397
	<b>Section III</b>		
21	Narwaliya (Jabhua)	22.826	74.563
22	Mundot	22.893	74.709
23	Raipuriya	22.967	74.823
24	Doligua	23.037	75.039
25	Multhan	23.081	75.219
26	Sundrabad	23.133	75.301
27	Near Makrawan	23.247	75.521
28	Ruie (near Gambir R)	23.295	75.636
29	Bihariya	23.336	75.719
30	Palwa	23.417	75.871
31	Rupakheri	23.469	75.974
32	Chachakheri	23.577	76.192
33	Dhatrawada	23.641	76.275
34	Malyakeri	23.690	76.337
35	Khaojarpura	23.828	76.546
36	Gorkhpura	23.916	76.669
37	Pipalbelt	23.995	76.792
38	Near Kalipith	24.029	76.855

39	Jherdha	24.116	76.971
40	Charanpura	24.227	77.045
41	Berakheri road	24.393	77.111
42	Bijaipur GAIL Plant	24.463	77.156



#### 4.1 LAND USE ALONG THE ROUTE

Almost 71% of the sampled area was agricultural lands. Plantation was 4.8% while 7.1% was waste-land with neither forest nor agriculture (Table 2). Important landscapes found along the pipeline route are wetlands, grasslands, wastelands, agricultural lands and forest plantations (Plate 3). The major crops, along the route of the pipeline in south Gujarat, where water is sufficiently available, are sugarcane and vegetables. In the Vemar to Bijaipur section, the major crops are soyabean, maize and ladies finger.

The pipeline on its course crosses a number of rivers, wetlands, forests, railway lines and roads (Table 3, 4 & 5). Among the major rivers crossing the pipeline route are Panam, Chambal, Gambhir, Parbati and Goma rivers (Table 3) .

Table 2 Land type and use along the pipeline route		
Land category	No. of sample points	Percentage

Agricultural land	30	71.4
Agriculture + grassland	1	2.4
Barren land	2	4.8
Grassland	1	2.4
Plantation	2	4.8
Wasteland with Prosopis	3	7.1
Others	3	7.1
Total	42	100.0

Table 3 Major rivers and wetlands along the pipeline route and its environs			
No.	River / Wetland	Approximate Chainage	Nearest Village
<b>Dahej - Vemar</b>			
1	Narmada River	6 km	Dahej
<b>Vemar - Jabhua section</b>			
2	Parikha talab	123 km	Parikha
3	Dev River crossing	138 km	Baniya
4	Vessnya talav	159 km	Vessnya
5	Sayaji Sarovar	161km	Gotal
6	Radhanpur talav	177 km	Radhanpur
7	Jhakhariya talab	282 km	Tarkhanda
8	Kharod River crossing	187km	Chanchadiya
9	Chandpuri talav	196km	Chandpuri
10	Sukla River crossing	199km,	Sherpura
11	Goma River	199.5 km	Royari
12	Goma River crossing	208 km	Simolha
13	Panam River crossing	225km	Uehware
14	Hadap River crossing	248km	Timsa
15	Muwaliya talav	265 km	Gadol
16	Nagarala talav	268 km	Modikharaj
17	Khan River crossing	271km	Modikharaj
<b>Jabhua to Bijaipur section</b>			
18	Anas River crossing	3km	Dhebar

19	Gulabi River crossing	11.3 km (TP 159 - 160)	Kalyanpura
20	Negari River crossing	22 km (TP 163 - 164)	Kalapani
21	Negari River tributary crossing	26 km	Mohankot
22	Pampavathy River crossing	34 km (TP 171- 172)	Raipuria
23	Bonkli River crossing	36.7 km (TP 174 - 175)	Rupakheri
24	Mahi River crossing	55.2 km, (TP 187 -188)	Khakhi
25	Bageri River crossing	62 km (TP 191- 192)	Dautriya
26	Chamla River crossing	102.7 km (TP 212 - 213)	Orsinga
27	Chambal River crossing	109.6 km	Murarkheri
28	Suwasa talav	119.5 km	Suwasa
29	Rambaloda talav	121 km	Rambaloda
30	Gambhir River crossing	126.5 km	Jiyajigarh
31	Sipra River crossing	136 km	Pancher
32	Lakhundar River crossing	198.5 km	Aroliya
33	Bhatan River crossing	211 km	Barnawad
34	Kalisindh River crossing	220.3 km	Gunjariya
35	Newaj River crossing	266.5 km	Savankhera
36	Ajnar River crossing	275.2 km	Ghogriya Kalan
37	Ghorapochar River crossing	288.1 km	Jalalpura
38	Khanpura talv	309 km	Khanpura
39	Parbati River crossing	328.2 km	Berakheri
40	Bugalia River crossing	332.6 km	Baya
Source: Route map provided by EIL			

Table 4 Major forest areas close to the HBJ pipeline route			
No.	Forest name	Approximate chainage	Nearest Village
<b>Vemar - Jabhua section</b>			
1	RF crossing	169 -172 km	Tajpura
<b>Jabhua - Bijaipur section</b>			
2	Kararawad RF	0 - 3 km	Narwaliya
3	Bijalpur PF	3rd to 10th km. (north)	Kankradongra
4	Dhebar PF	3rd to 10th km. (south)	Dhebar

5	Kotnai Dhawrapara RF	10 - 16 km	Barkhera
6	Kalyanpura PF	10.5 km	Dhavaripara
7	Dautra PF	55 - 62 km	Wagapara
8	RF	180 km	Bhagawatpura
9	Patan RF crossing	261.5 km	Mohanpura
10	Charanpura RF crossing	309 km	Ramra
11	Charanpura RF	304 - 315 km	Charanpura
12	Barkeri RF	317 km	Barkeri
13	RF crossing	336 to 338 km	Ahirkheri
14	Dongar protected forest	340	Bijapur compressor station
15	RF crossings	190- 267 km	Rupare, Albeta, Gudol ..etc

Table 5 Major road and rail crossings along the HBJ pipeline route			
No	Road / Railway	Chainage	Nearest Village
<b>Dahej - Vemar Section</b>			
1	IPCL - Lakhigam road	2.06 km	Lakhigam
2	Bharuch - Dahej highway	2.9 km	Ambheta
3	Galemnda - Rahiyad road	15.2 km	Rahiyad
4	Dahej - Bharuch SH	16.4 km	Rahiyad
5	Vagra - Bharuch SH	39.7 km	Ankot
6	Bharuch - Amod SH	46.3 km	Samni
7	Railway line	46.4 km	Samni
8	Kamboli - Shrikothi road	56.3 km	Wantarsa
9	Palej - MDR road	62.6 km	Makan
10	Valan - Palej road	64.5 km	Valan
11	Railway line	65.1 km	Valan
12	Bharuch - Baroda NH	65.9 km	Valan
13	Oslam - Choranda road	74.1 km	Oslam
14	Railway line	75.1 km	Choranda
15	Nareshwar - Kurali SH	80.6 km	Kothav
<b>Vemar - Jabhua section</b>			
<b>Road crossings</b>			

16	Vemar - Kurali road crossing	114	Vemar
17	Timbarva to Kayarphan road	119 km	Lingathali
18	Mandala - Nariya road crossing	127.5 km	Sajpur
19	Daboi - Baroda road crossing	134.5 km	Thuvari
20	Vaghodia - Khernadi road crossing	151 km	Vaghodia
21	Halol - Bodell road crossing	174.5 km	Halol
22	Pavagadh - Halol road crossing	185 km	Tarkanda
23	Vejalpur - Pavagadh road crossing	192.5 km	Rinchhi
24	Ghogamba - Demawav road crossing	204 km	Palli
25	Demawav - Devgadhbariya road crossing	216.5 km	Ghollov
26	Piplod - Devgadhbariya road crossing	229 km	Devgadhbariya
27	Dahod - Abhlod road crossing	266 km	Gadol
28	Dahod - Modikharaj road crossing	269km	Modikharaj
<b>Railway crossings</b>			
29	Western railway crossing	122.5 km	Parikha
30	Western railway crossing	329 km	Thuvari
31	Western railway crossing	151 km	Vaghodia
<b>Jabhua - Bijaipur section</b>			
<b>Road crossings</b>			
32	Kararawad - Meghnagar road crossing	1 km	Norwalia
33	Jhabua - Kalyanpura road crossing	10.5 km	Kalyanpura
34	Petlabad - Kalyanpura road crossing	15 km	Mundot
35	Kalyanpura - Petlawad road crossing	30 km	Gularipara
36	Kalyanpura - Petlawad road crossing	33.5 km	-
37	Tilgara - Sindla road crossing	68 km	Sandla
38	Mhow - Ratlam road crossing	77 km	Multan
39	Runija - Bednawar road crossing	83 km	Kachhi Baroda
40	Runija - Barnagar road crossing	88.5 km	Orsinga
41	Indore - Nagda road crossing	114 km	Makrawan
42	Khatiya - Jagoti road crossing	149.5 km	Jagoti
43	Agar - Ujjain road crossing	155.2km	Palwa

44	Tarana - Rupakheri road crossing	167.5 km	Rupakheri
45	Agar - Sarangpur road crossing	204.2 km	Dhatrawada
46	Khujner - Zirapur road crossing	239 km	Kanjarpura
47	Biaora - Bawari road crossing	270.6 km	Pipalbelt
48	Kumbhraj - Khatkia road crossing	323.7 km	Manpura
<b>Railway crossings</b>			
49	Runija - Barnagar W.Railway line crossing	109.6 km	Sunderabad & Runija
50	Nagda - Ujjain W.Railway line crossing	115.3	Makrawan
51	Western Railway (Close to line)	298 - 327 km	Chachaura to Uprikachak
52	Western railway crossing	176 km	Sultanpur

#### 4.2 STATUS OF FOREST

No Sanctuary or National Park exist along the pipeline route. The pipeline route crosses a number of Reserve Forest areas on the Vemar-Bijaipur section, the augmentation part. However, no thickly vegetated area was seen along the route of the pipeline. The route is not known to cross any Sanctuary or National Park. The dominant forest type expected along the tract are tropical dry deciduous forest (Champion and Seth 1968).

#### 4.3 FLORA ALONG THE ROUTE

A total of 155 plant species (Appendix 2) comprising 11 climbers, 42 trees, 23 shrubs, 78 herbs and 1 epiphyte were recorded along the pipeline route (Table 6). No endemic or threatened plant species was observed during the survey. Common crops along the pipeline route and its environs were soyabean (*Glycine max*), maize (*Zea mays*), ladies finger (*Abelmoschus esculentus*), sugarcane (*Saccharum officinarum*), banana (*Musa paradisiaca*), mango (*Mangifera indica*), guava (*Psidium guajava*) and pigeon pea (*Cajanus cajan*; Table 7).

Habit	Section I	Section II	Section III	Entire route
Tree	10	20	20	42
Shrub	8	12	13	23
Herb	24	42	43	78

Climber	7	5	3	11
Epiphyte	-	1	-	1
Total	49	80	79	155

Section I - New RoU (Dahej - Vemar); Section II - Existing RoU (Gujarat region); Section III - Existing RoU (Madhya Pradesh region)

No.	English name	Scientific name
1	Soyabean	<i>Glycine max</i>
2	Maize	<i>Zea mays</i>
3	Groundnut	<i>Arachis hypogea</i>
4	Ladies finger	<i>Abelmoschus esculentus</i>
5	Sugarcane	<i>Saccharum officinarum</i>
6	Banana	<i>Musa paradisiaca</i>
7	Mango	<i>Mangifera indica</i>
8	Guava	<i>Psidium guajava</i>
9	Pigeon pea	<i>Cajanus cajan</i>
10	Coconut	<i>Cocos nucifera</i>

#### 4.4 AQUATIC PLANTS

A number of wetlands occur along the pipeline route and its environs (Table 3). These wetlands had many submerged and floating plant species. *Eichhornia crassipes*, a free floating aquatic herb and *Hydrilla verticillata*, a submerged species were common in most of the wetlands. Rooted aquatic plants such as *Nymphaea nouchali*, *N. pubescens*, *Nelumbo nucifera*, *Ipomoea aquatica* and semi-aquatic species such as *Hygrophila auriculata*, *Cyperus* spp, *Corchorus tridens*, *Eclipta alba*, *Ammania auriculata*, *Ipomoea carnea* and *Alternanthera sessilis* were also common in the wetlands.

#### 4.5 FLORISTIC COMPOSITION ALONG THE PIPELINE ROUTE

##### 4.5.1 Dahej



Thickets of *Prosopis juliflora* dominated the vegetation at Dahej. Since the area is coastal no large trees are seen. Saplings of *Salvadora persica* are common in this area. Common herbs were *Achyranthes aspera*, *Boerhavia diffusa*, *Commelina benghalensis*, *Suaeda maritima*, *Dactyloctenium aegyptium* and *Scirpus* sp. Climbers such as *Coccinia grandis*, *Mukia maderaspatana* and *Cayratia trifolia* were also common in Dahej.

#### **4.5.2 Near Atali**

Common trees near Atali were *Prosopis juliflora*, *Acacia farnesiana* and *Sesbania bispinosa*. Climbers such as *Coccinia grandis* and *Cayratia trifolia* were also common. Common herbs were *Achyranthes aspera*, *Commelina benghalensis*, *Panicum brevifolium*, *Corchorus aestuans*, *Dactyloctenium aegyptium* and *Phyllanthus amarus*.

#### **4.5.3 Kothia**

In Kothia, ten plant species were recorded (Table 8). *Prosopis cinerea* and *Acacia nilotica* were the common trees. Climbers *Coccinia grandis* and *Mukia maderaspatana* were common along the hedges. Common herbs included *Achyranthes aspera*, *Triumfetta rotundifolia*, *Paspalum scrobiculatum*, *Corchorus tridens*, *Panicum brevifolium* and *Euphorbia hypericifolia*.

#### **4.5.4 Ankot**

Common trees in the sampling location were *Prosopis juliflora*, *Acacia farnesiana* and *Salvadora persica*. Shrubs such as *Euphorbia nivulia* and *Capparis sepiaria* were common along the hedges. Common herbs were *Achyranthes aspera*, *Cassia hirsuta*, *Panicum brevifolium*, *Corchorus aestuans*, *Paspalum scrobiculatum*, *Commelina benghalensis*, *Cyperus* sp and *Boerhavia diffusa*. *Coccinia grandis* and *Mukia maderaspatana* were the common climbers in Ankot.

#### **4.5.5 Wandarsa- Padri**

*Acacia nilotica* and *Acacia farnesiana* were common trees in Wantarsa Padri. Common shrubs were *Ipomoea carnea*, *Capparis sepiaria* and *Abutilon indium*. Climbers such as *Coccinia grandis*, *Oxystelma esculentum*, *Cayratia trifolia*, *Mukia maderaspatana* and *Phaseolus trilobus* were also common. Common herbs were *Cassia hirsuta*, *Triumfetta rotundifolia*, *Achyranthes aspera*, *Commelina benghalensis*, *Panicum brevifolium*, *Panicum psilopodium*, *Euphorbia hirta*, *E. hypericifolia*, *Biophytum sensitivum*, *Cenchrus ciliaris*, *Ruellia prostrata* and *Phyllanthus fraternus*.

#### **4.5.6 Makkan**

At Makkan, *Acacia farnesiana*, *Acacia nilotica*, *Albizia lebbek* and *Peltophorum pterocarpum* were the common trees. Common shrubs included *Capparis sepiaria* and *Clerodendrum phlomides*. The

common herbs and grasses were *Achyranthes aspera*, *Panicum brevifolium*, *Trichodesma zeylanica* and *Cassia hirsuta*.

#### 4.5.7 Atali

Thickets of *Prosopis juliflora* dominated the vegetation in Atali. The common trees were *Acacia nilotica* and *Acacia farnesiana*. The common shrubs were *Ipomoea carnea*, *Abutilon indium* and *Lawsonia inermis*. Common herbs and climbers were *Achyranthes aspera*, *Cassia hirsuta*, *Physalis minima*, *Boerhavia diffusa*, *Corchorus aestuans*, *Dactyloctenium aegyptium*, *Panicum brevifolium*, *Echinochloa colona*, *Paspalum scrobiculatum*, *Pergularia daemia* and *Cayratia trifolia*.

#### 4.5.8 Vemar (RR Station)

In Vemar 14 plant species were recorded (Table 8). *Acacia farnesiana*, *Acacia nilotica*, *Prosopis juliflora*, *Cocos nucifera* and *Zizyphus mauritiana* were common trees in Vemar. *Kirganelia reticulata*, *Lawsonia inermis* and *Abutilon indium* were common shrubs. *Clitoria ternatea*, a climber was also common. Ground layer was dominated by *Sida cordata*, *Achyranthes aspera*, *Cassia hirsuta*, *C. occidentalis* and *Panicum brevifolium*.

#### 4.5.9 Parignaon

Thickets of *Prosopis juliflora* dominated the vegetation in Parignaon. *Acacia nilotica* is also common in Parignaon. *Calotropis gigantea* and *Lawsonia inermis* were common shrubs. Common herbs and climbers were *Corchorus aestuans*, *Achyranthes aspera*, *Physalis minima*, *Euphorbia hirta*, *Cassia hirsuta*, *Panicum psilopodium*, *Dactyloctenium aegyptium*, *Amaranthus viridis*, *Eclipta alba*, *Phyllanthus amarus*, *Cayratia trifolia*, *Coccinia grandis* and *Cardiospermum halicacabum*.

#### 4.5.10 Thuvai

Thickets of *Capparis decidua* dominated the vegetation at Thuvai. *Acacia nilotica*, *Acacia farnesiana*, *Peltophorum pterocarpum*, *Salvadora persica* and *Azadirachta indica* were common tree species along the road. Common shrubs were *Lawsonia inermis*, *Capparis sepiaria* and *Euphorbia nivulia*. *Panicum brevifolium*, *Dactyloctenium aegyptium*, *Achyranthes aspera*, *Cyperus* sp, *Triumfetta rotundifolia*, *Tephrosia purpurea*, *Digitaria bicornis*, *Cayratia trifolia* and *Abrus precatorius* were common herbs and climbers in Thuvai.

#### 4.5.11 Bisania

In Bisania *Acacia nilotica*, *A. catechu*, *A. leucophloea*, *Azadirachta indica* and *Zizyphus mauritiana* were the common trees. Thickets of *Bambusa arundinacea* were also seen in Bisania. Common

shrubs were *Ipomoea carnea*, *Euphorbia nivulia* and *Lawsonia inermis*. *Tridax procumbens*, *Sida cordata*, *Indigofera trita*, *Panicum psilopodium*, *Triumfetta rotundifolia* and *Digitaria bicornis* were the common herbs.

#### 4.5.12 Tajpura

Thickets of *Prosopis juliflora* dominated the vegetation at Tajpura. *Cassia siamea* and *Eucalyptus* sp were the other trees common at Tajpura. *Ipomoea carnea* and *Cassia auriculata* were common shrubs. *Sida acuta*, *Cassia occidentalis*, *Malvastrum coromandelianum*, *Panicum brevifolium*, *Sida acuta*, *S. glutinosa*, *Tephrosia purpurea*, *Triumfetta rotundifolia*, *Commelina benghalensis* and *Paspalum scrobiculatum* were common herbs in Tajpura.

#### 4.5.13 Turkanda

The Turkanda was dominated by *Prosopis juliflora* vegetation. *Borassus flabellifer*, *Azadirachta indica*, *Acacia leucophloea*, *Butea monosperma*, *Acacia farnesiana* and *Dichrostachys cinerea* were the other common tree species. *Ipomoea carnea*, *Cassia auriculata* and *Calotropis gigantea* were common shrubs in Turkanda. Common herbs included *Triumfetta rotundifolia*, *Achyranthes aspera*, *Cassia hirsuta* and *Boerhavia diffusa*.

#### 4.5.14 Adadra

*Butea monosperma*, *Azadirachta indica*, *Eucalyptus* sp, *Pithecellobium dulce*, *Mangifera indica*, *Zizyphus mauritiana* and *Euphorbia tirucalli* were common trees in Adadra. The common shrubs were *Ipomoea carnea*, *Calotropis gigantea* and *Kirganelia reticulata*. The common herbs and climbers included *Tephrosia purpurea*, *Boerhavia diffusa*, *Cassia hirsuta*, *Sida acuta*, *Achyranthes aspera*, *Cayratia trifolia* and *Coccinia grandis*.

#### 4.5.15 Ichoni

Common trees included *Tectona grandis*, *Acacia nilotica*, *Madhuca longifolia* and *Azadirachta indica*. *Calotropis gigantea*, *Martynia annua*, *Xanthium strumarium*, *Ipomoea carnea* and *Jatropha glandulifera* were common shrubs. *Cassia hirsuta*, *Dactyloctenium aegyptium*, *Tridax procumbens*, *Euphorbia hirta*, *Alysicarpus vaginalis*, *Panicum brevifolium*, *Evolvulus alsinoides*, *Cassia occidentalis*, *Cassia hirsuta*, *Boerhavia diffusa*, *Indigofera trita*, *Sida acuta*, *Acanthospermum hispidum*, *Cleome pentaphylla*, *Celosia argentea* and *Paspalum scrobiculatum* were common herbs and grasses.

#### 4.5.16 Devgadhbariya

The common trees in the forests of Devgadhbariya were *Madhuca longifolia*, *Tectona grandis*, *Acacia leucophloea*, *A. nilotica* and *Eucalyptus* sp. Thickets of *Prosopis juliflora* were also common in Devgadhbariya. *Holarrhena pubescens*, *Lantana camara* and *Jatropha glandulifera* were common shrubs. *Cassia hirsuta*, *Euphorbia hirta*, *Curculigo orchioides*, *Chlorophytum tuberosum*, *Phyllanthus fraternus*, *Cenchrus ciliaris*, *Sida glutinosa*, *Desmodium triflorum* and *Alysicarpus vaginalis* were common herbs. Epiphytic plant, *Vanda tessellata* was also common in this forest.

#### 4.5.17 Amba

*Madhuca longifolia*, *Acacia nilotica*, *Eucalyptus* sp and *Bambusa arundinacea* were common trees in Amba. *Lantana camara* and *Ipomoea carnea* were common shrubs. Common herbs and grasses included *Cassia hirsuta*, *Euphorbia hirta*, *E. hypericifolia*, *Dactyloctenium aegyptium*, *Panicum brevifolium*, *Cenchrus ciliaris*, *Tephrosia purpurea* and *Indigofera trita*.

#### 4.5.18 Dudhmal (RR Station)

In Dudhmal, 14 plant species were recorded (Table 8). *Ailanthus excelsa*, *Acacia nilotica* and *Parkinsonia aculeata* were common trees. Thickets of *Prosopis juliflora* are also common here. *Ipomoea carnea*, a shrub species, was common in marshy areas. *Glossocardia bosvallia*, *Evolvulus alsinoides*, *Cassia hirsuta*, *Panicum brevifolium*, *Boerhavia diffusa*, *Gomphrena celosioides*, *Alysicarpus vaginalis*, *Digera muricata*, *Tridax procumbens* and *Echinops echinatus* were common herbs.

#### 4.5.19 Motikheraj (Near Dahod)

At Motikheraj, *Ailanthus excelsa*, *Acacia nilotica* and *Prosopis juliflora* were common trees. The common shrubs were *Xanthium strumarium*, *Calotropis gigantea*, *Euphorbia nivulia*, *Datura metal* and *Ipomoea carnea*. *Cassia hirsuta*, *Cyperus* sp, *Panicum brevifolium*, *Malvastrum coromandelianum*, *Echinops echinatus*, *Achyranthes aspera* and *Alternanthera pungens* were common herbs. *Cayratia trifolia*, a climber and *Parthenium hysterophorus*, an exotic weed were also common in Motikheraj.

#### 4.5.20 Wedbara

In Wedbara *Acacia nilotica*, *A.leucophloea*, *Azadirachta indica*, *Syzygium cumini* and *Prosopis juliflora* were common trees. *Lantana camara*, an exotic weed is common in Wedbara. *Martynia annua* and *Ipomoea carnea* were other common shrubs in the area. The common herbs and grasses included *Achyranthes aspera*, *Cassia hirsuta*, *Triumfetta rotundifolia*, *Cynodon dactylon*, *Acanthospermum hispidum*, *Malvastrum coromandelianum*, *Sida acuta*, *S. cordata* and *Panicum brevifolium*.

#### 4.5.21 Narwaliya

In Narwaliya, *Acacia nilotica* was the common tree. *Jatropha glandulifera* and *Ipomoea carnea* were common shrubs. Common herbs were *Cassia hirsuta*, *Echinops echinatus*, *Evolvulus alsinoides*, *Euphorbia hirta*, *E. rosea*, *Justicia simplex*, *Achyranthes aspera*, *Glossocardia bosvallia*, *Tribulus terrestris*, *Indigofera trita*, *Tragus roxburghii* and *Eragrostis viscosa*.

#### 4.5.22 Mundot

*Acacia nilotica*, *Lagerstroemia parviflora*, *Tectona grandis*, *Butea monosperma*, *Terminalia tomentosa*, *Madhuca longifolia*, *Holoptelia integrifolia* and *Azadirachta indica* were common trees. Common shrubs in Mundot were *Ipomoea carnea* and *Holarrhena pubescens*. *Cassia hirsuta*, *Echinops echinatus*, *Triumfetta rotundifolia*, *Cynodon dactylon*, *Euphorbia hirta*, *E. hypericifolia*, *Corchorus* sp, *Paspalum scrobiculatum* and *Cyperus* sp were the common herbs.

#### 4.5.23 Raipuriya

At Raipuriya, *Azadirachta indica*, *Acacia nilotica*, *Zizyphus mauritiana* and *Ficus benghalensis* were common trees. *Jatropha curcas* and *Lantana camara* were common shrubs. Common herbs and climbers were *Achyranthes aspera*, *Bidens pilosa*, *Commelina benghalensis*, *Cenchrus ciliaris*, *Paspalum scrobiculatum*, *Cassia hirsuta*, *Gomphrena celosioides*, *Boerhavia diffusa*, *Amaranthus spinosus*, *Pergularia daemia* and *Euphorbia geniculata*.

#### 4.5.24 Doligua

*Acacia nilotica* and *A.leucophloea* were common trees in Doligua. Common shrubs were *Calotropis gigantea*, *Lantana camara*, *Zizyphus nummularia*, *Ipomoea carnea*, *Xanthium strumarium* and *Securinega leucopyrus*. *Achyranthes aspera*, *Bidens pilosa*, *Cassia hirsuta*, *Gomphrena celosioides*, *Boerhavia diffusa*, *Tridax procumbens*, *Triumfetta rotundifolia*, *Cleome monophylla*, *Eclipta alba*, *Panicum brevifolium*, *Cyperus* sp and *Euphorbia hirta* were common herbs.

#### 4.5.25 Multan

In Multan, 11 plant species were recorded (Table 8), *Acacia nilotica* and *Prosopis juliflora* were common trees. *Parthenium hysterophorus*, an exotic weed was common in Multan. The common shrubs were *Calotropis gigantea*, *Lantana camara*, *Zizyphus nummularia* and *Ipomoea carnea*. *Cassia hirsuta*, *Achyranthes aspera*, *Panicum brevifolium* and *Cynodon dactylon* were common herbs and grasses.

#### 4.5.26 Sundrabad

*Acacia nilotica* and *A.leucophloea* were common trees in Sundrabad. Common shrubs were *Calotropis gigantea*, *Lantana camara*, *Zizyphus nummularia*, *Ipomoea carnea* and *Solanum surattense*. *Achyranthes aspera*, *Panicum brevifolium*, *Euphorbia geniculata* and *Ocimum canum* were common herbs.

#### 4.5.27 Near Makrawan

*Acacia nilotica*, *Ailanthus excelsa* and *Leucaena leucocephala* were common trees near Makrawan. Thickets of *Prosopis juliflora* were also common. *Calotropis gigantea* and *Ipomoea carnea* were common shrubs. The common herbs were *Cassia hirsuta*, *Parthenium hysterophorus*, *Panicum brevifolium*, *Achyranthes aspera* and *Euphorbia hypericifolia*. *Mukia maderaspatana*, a climber, was also common.

#### 4.5.28 Ruie (Near Gambir River)

In Ruie, no large tree species were seen. However, saplings of *Butea monosperma* and *Phoenix sylvestris* were common. Common shrubs were *Ipomoea carnea*, *Lantana camara* and *Carissa carandas*. *Parthenium hysterophorus*, *Panicum brevifolium*, *Alysicarpus vaginalis* and *Cynodon dactylon* were common herbs.

#### 4.5.29 Bihariya

At Bihariya, *Dalbergia sissoo*, *Zizyphus mauritiana*, *Butea monosperma* and *Acacia nilotica* were common trees. Exotic weeds such as *Lantana camara* and *Parthenium hysterophorus* were also common in Bihariya. The common herbs were *Cassia hirsuta*, *Panicum brevifolium*, *Triumfetta rotundifolia*, *Commelina benghalensis*, *Cyperus* sp and *Paspalum scrobiculatum*. Common climbers in the area were *Coccinia grandis* and *Mukia maderaspatana*.

#### 4.5.30 Palwa

In Palwa 10 plant species were recorded (Table 8). *Acacia nilotica*, *A. leucophloea*, *Azadirachta indica* and *Dalbergia sissoo* were common trees along the road. Common shrubs were *Zizyphus nummularia* and *Ipomoea carnea*. *Cassia hirsuta* and *Parthenium hysterophorus*, *Panicum brevifolium* and *Paspalum scrobiculatum* were common herbs.

#### 4.5.31 Rupakheri

At Rupakheri, *Acacia nilotica*, *Mangifera indica*, *Azadirachta indica*, *Butea monosperma* and *Pithecellobium dulce* were common trees. Saplings of *Phoenix sylvestris* were also common.

*Zizyphus nummularia* was common shrub. Common herbs were *Cassia hirsuta*, *Tridax procumbens*, *Euphorbia hirta* and *Panicum brevifolium*.

#### 4.5.32 Chachakeri

In Chachakeri, no large trees were seen. However, saplings of *Butea monosperma* and *Acacia nilotica* were common. Common shrubs were *Zizyphus nummularia*, *Ipomoea carnea*, *Carissa carandas* and *Opuntia dillenii*. *Cassia hirsuta*, *Tridax procumbens*, *Euphorbia hirta*, *Digitaria bicornis*, *Paspalum scrobiculatum*, *Boerhavia diffusa*, *Indigofera trita*, *Glossocardia bosvallia*, *Achyranthes aspera* and *Alysicarpus vaginalis* were common herbs.

#### 4.5.33 Dhatrawada

In Dhatrawada, *Butea monosperma*, *Acacia leucophloea*, *A. nilotica*, *Dalbergia sissoo*, *Eucalyptus* sp, *Phoenix* sp and *Prosopis juliflora* were common trees. *Zizyphus nummularia* and *Calotropis gigantea* were common shrubs. *Cassia hirsuta*, *Glossocardia bosvallia*, *Euphorbia hirta*, *Digitaria bicornis*, *Tridax procumbens*, *Achyranthes aspera*, *Echinops echinatus*, *Evolvulus alsinoides* and *Sida cordata* were common herbs.

#### 4.5.34 Malyakeri

No large tree species were seen in Malyakeri. *Zizyphus nummularia* and *Ipomoea carnea* were common shrubs. Herb and grass species such as *Tridax procumbens*, *Digitaria bicornis*, *Evolvulus alsinoides*, *Cassia hirsuta*, *Panicum brevifolium*, *Paspalum scrobiculatum*, *Echinops echinatus*, *Alternanthera sessilis*, *Apluda mutica* and *Alysicarpus vaginalis* were common along the road.

#### 4.5.35 Khaojarpura

In Khaojarpura 18 plant species were recorded (Table 8). *Mangifera indica*, *Ailanthus excelsa* and *Acacia leucophloea* were the common tree species in Khaojarpura. Saplings of *Anona squamosa* were also common. *Zizyphus nummularia*, *Carissa carandas*, *Jatropha glandulifera*, *Ipomoea carnea* and *Amorphophallus bulbifer* were common shrubs. *Achyranthes aspera*, *Argemone mexicana*, *Cassia hirsuta*, *Euphorbia hirta*, *Sida cordata*, *Boerhavia diffusa*, *Indigofera trita*, *Panicum brevifolium* and *Cyperus* sp were common herbs.

#### 4.5.36 Gorkhpura

*Acacia nilotica*, *A.leucophloea*, *A. catechu*, *Phoenix sylvestris*, *Bauhinia racemosa* and *Zizyphus mauritiana* were common trees. *Lawsonia inermis* is common along the hedges of agricultural fields.

*Cassia hirsuta*, *Panicum brevifolium*, *Cyperus* sp, *Digitaria bicornis*, *Alysicarpus vaginalis*, *Achyranthes aspera* and *Cenchrus ciliaris* were common herbs.

#### **4.5.37 Pipalbelt**

*Acacia nilotica*, *A.leucophloea* and *Butea monosperma* were common trees. *Zizyphus nummularia* was common shrub. Common herbs were *Cassia hirsuta*, *Digitaria bicornis*, *Euphorbia hirta*, *Cynodon dactylon*, *Evolvulus alsinoides* and *Alysicarpus vaginalis*.

#### **4.5.38 Near Kalipith**

*Madhuca longifolia*, *Butea monosperma*, *Acacia nilotica*, *A.leucophloea*, *Azadirachta indica* and *Zizyphus mauritiana* were common trees near Kalipith. Shrub species such as *Ipomoea carnea* and *Lawsonia inermis* are common hedge plants. Common herbs were *Cassia hirsuta*, *Euphorbia hirta*, *Tridax procumbens*, *Panicum brevifolium*, *Cyperus* sp, *Digitaria bicornis*, *Alysicarpus vaginalis*, *Boerhavia diffusa* and *Sida cordata*.

#### **4.5.39 Jherdha**

*Azadirachta indica*, *Acacia nilotica*, *Butea monosperma* and *Phoenix* sp were common trees in Jherdha. No shrub species were seen here. Common herbs were *Triumfetta rotundifolia*, *Cassia hirsuta*, *Borreria hispida*, *Panicum brevifolium*, *Tridax procumbens* and *Euphorbia hirta*.

#### **4.5.40 Charanpura**

*Azadirachta indica*, *Acacia nilotica*, *A.leucophloea*, *Mangifera indica* and *Eucalyptus* sp were common trees in Charanpura. *Ipomoea carnea*, a shrub species was common in marshy area. *Tridax procumbens*, *Parthenium hysterophorus*, *Commelina benghalensis*, *Cassia hirsuta*, *Euphorbia hirta*, *Panicum brevifolium*, *Indigofera trita*, *Cyperus* sp and *Paspalum scrobiculatum* were common herbs in the hedges of agricultural fields.

#### **4.5.41 Berakheri road**

Berakheri road is an agricultural area. *Acacia nilotica*, *Azadirachta indica*, *Mangifera indica*, *Butea monosperma* and *Phoenix sylvestris* were common trees along the road. Common shrubs were *Zizyphus nummularia* and *Calotropis gigantea*. *Corchorus tridens*, *Alysicarpus vaginalis*, *Euphorbia hypericifolia*, *Phyllanthus maderaspatensis* and *Panicum brevifolium* were common herbs.

#### **4.5.42 Bijaipur- GAIL plant**



Most of the trees in the GAIL plant at Bijaipur were planted. Common trees are *Peltophorum pterocarpum*, *Polyalthia longifolia*, *Grevillea robusta*, *Mangifera indica*, *Psidium guajava*, *Delonix regia*, *Callistemon citrinus*, *Azadirachta indica*, *Dalbergia sissoo*, *Leucaena leucocephala*, *Terminalia tomentosa* and *Butea monosperma*. Common herbs were *Phyllanthus maderaspatensis*, *P. fraternus*, *Lagascea mollis*, *Tridax procumbens*, *Alternanthera sessilis*, *Triumfetta rotundifolia*, *Parthenium hysterophorus*, *Alysicarpus vaginalis*, *Cleome viscosa*, *Cenchrus ciliaris*, *Panicum brevifolium* and *Apluda mutica*.

In terms of species richness the area Ichoni was at the top, while in terms of species diversity of trees Adadra and Mundot were at the top of the list. In case of shrubs Doligua occupied the top position while in case of herbs Turkanda and Chachakeri occupied the top of the list (Table 8).

Table 8 Floral species richness and diversity along the pipeline route					
Plot No.	Location	Species richness	Species diversity		
			Trees	Shrubs	Herbs
1	<b>Section I</b> Dahej	11	-	-	0.92
2	Near Atali	12	0.9	0.56	-
3	Kothia	10	0.64	-	0.92
4	Ankot	15	1.16	0.64	1.87
5	Wandarsa - Padri	21	0.35	0.19	1.24
6	Makan	11	1.12	0.55	0.8
7	Atali	17	0.9	0.56	1.76
8	Vemar	14	1.22	0.75	1.04
9	<b>Section II</b> Parignaon	17	0.35	0.35	1.83
10	Thuvai	18	0.96	0.51	1.85
11	Bisania	15	1.55	0.28	1.16
12	Tajpura	15	0.68	0.68	1.93
13	Turkanda	14	1.56	0.49	2.26
14	Adadra	17	1.97	0.87	1.42
15	Ichoni	25	1.2	1.4	2.11
16	Devgadhbariya	19	0.66	0.58	1.94
17	Amba	14	0.67	0.11	1.6
18	Dudhmal	15	1.1	0.11	1.66
19	Motikherj	17	0.85	0.99	1.86
20	Wedbara (Jabhua)	17	1.24	0.93	1.65
21	<b>Section III</b> Narwaliya	14	0.35	0.38	2.12
22	Mundot	18	1.83	0.29	1.85
23	Raipuriya	17	1.33	0.49	1.71
24	Doligua	20	0.67	1.42	2.04
25	Multhan	11	0.56	1.14	1.18
26	Sundrabad	11	0.45	1.36	0.14
27	Near Makrawan	12	1.07	0.11	1.48
28	Ruie (near Gambir R)	9	-	0.98	0.18
29	Bihariya	15	1.1	0.65	1.64
30	Palwa	10	1.17	0.64	0.51
31	Rupakheri	11	1.33	0.11	1.08
32	Chachakheri	16	-	0.51	2.15
33	Dhatrawada	18	1.79	0.53	1.54
34	Malyakeri	12	-	0.67	1.99
35	Khaojarpura	18	1.01	1.14	2.03
36	Gorkhpura	14	1.42	0.47	1.8
37	Pipalbelt	10	0.64	0.11	1.92

38	Near Kalipith	18	1.73	0.64	1.75
39	Jherdha	10	0.45	-	1.44
40	Charanpura	15	1.55	0.68	1.65
41	Berakheri road	12	1.33	0.68	1.13
42	GAIL Plant - Bijaipur	24	1.83	-	1.74

#### 4.6 MAJOR TREE SPECIES ALONG THE ROUTE

Tree density along the pipeline route and its environs was low. Common tree species found were *Prosopis juliflora*, *P. cineraria*, *Acacia nilotica*, *Capparis decidua*, *Salvadora persica*, *Dalbergia sissoo*, *Peltophorum pterocarpum*, *Phoenix sylvestris* and *Borassus flabellifer*. Thickets of *Prosopis juliflora* were frequent along the pipeline. GBH of trees varied between 20 cm and 200 cm, the average being 57 cm. Average height of the trees was 4.7 m, the range being 1 to 13 m. GBH and height class distribution of trees (above 25 cm GBH) are given in Table 9. Section wise GBH and height class distribution is given in appendix 3.

GBH class (cm)	Number	Percentage
25 - 50	184	55
51-75	101	30
76-100	22	7
101-125	18	5
126-150	4	1
151-175	5	1
176-200	2	1
Total	336	100
Height class		
Height class (m)	Numbers	Percentage
<5	185	55.0
6 - 10	146	43.5
11 - 15	5	1.5
Total	336	100.0

It is assumed that in case of the existing RoU (from Vemar to Bijaipur) no further expansion of RoU will be done and hence no further felling of trees. The total number of trees, occurring along the

existing RoU are given in appendix 4 and 5. Considering the width of the RoU as 30 m for the proposed new pipeline route from Vemar to Dahej (82 km), the total area of the RoU for the pipeline is about 246 ha. The total number of trees, occurring along the newly proposed RoU, which will be felled for clearing the RoU will be 2891 (Table 10). Of this 36.2% is *Acacia farnesiana*, 22.3% *A. nilotica*, *Prosopis juliflora* 16% and *Acacia* sp 9.6%. The species of trees that will be felled for RoU in the case of Vemar-Dahej section of the pipeline are common ones. They are also widely distributed elsewhere in the area. Section-wise tree number is given in appendices 3 and 4.

Species	Mean GBH (cm)	Mean Height (m)	No. of trees	Percentage
<i>Acacia farnesiana</i>	52.6	4.7	1046	36.2
<i>Acacia nilotica</i>	64.8	5.5	646	22.3
<i>Acacia sp</i>	44.7	4.1	277	9.6
<i>Albizzia lebbeck</i>	55.0	5.3	92	3.2
<i>Cocos nucifera</i>	55.0	10.0	62	2.1
<i>Peltophorum pterocarpum</i>	55.0	5.0	31	1.1
<i>Prosopis juliflora</i>	38.0	3.9	461	16.0
<i>Salvadora persica</i>	50.7	3.0	215	7.4
<i>Tamarindus indica</i>	150.0	9.5	62	2.1
Total	54.3	4.8	2891	100

## 4.7 FAUNA

### 4.7.1 Butterflies

A total of 13 species of butterflies belonging to five families was recorded from the pipeline route and its surroundings (Table 11). None of them are endangered or endemic.

No.	Common Name	Scientific name	Family
1	Common Crow	<i>Euploea core core</i> Cramer	Danaidae
2	Common Emigrant	<i>Catopsilia pomona</i> Fabricius	Pieridae
3	Common Eveningbrown	<i>Melanitis leda ismene</i> Cramer	Satyridae
4	Common Grass Yellow	<i>Eurema hecabe contubernalis</i> Moore	Pieridae
5	Common Leopard	<i>Phalanta phalantha</i> Drury	Nymphalidae
6	Common Mormon	<i>Priniceps polytes romulus</i> Cramer	Papilionidae
7	Common Rose	<i>Pachliopta aristolochiae aristolochiae</i> Fab.	Papilionidae
8	Danaid Eggfly	<i>Hypolimnas misippus</i> Lin.	Nymphalidae
9	Great Eggfly	<i>Hypolimnas bolina</i> Lin.	Nymphalidae
10	Lemon Pansy	<i>Precis lemonias lemonias</i> Lin.	Nymphalidae
11	Pioneer	<i>Anaphaeis aurota aurota</i> Fabricius	Pieridae

12	Plain Tiger	<i>Danaus chrysippus</i> Lin.	Danaidae
13	Yellow Pansy	<i>Precis hierta magna</i> Evans	Nymphalidae

#### 4.7.2 Amphibians and reptiles

Eight species of amphibians (Table 12) and 16 of reptiles (Table 13) were observed in the vicinity of the proposed pipeline during the study period. Among the reptiles, three species are highly water dependent or aquatic. Most of the reptiles and amphibians found in the project area are highly adaptable and have wider distribution elsewhere in India. Moreover, most of the species are commensals with human habitations.

No.	Scientific name	English name
1	<i>Bufo melanostictus</i>	Common Asian Toad
2	<i>Bufo stomaticus</i>	Marbled Toad
3	<i>Euphlyctis cyanophlyctis</i>	Indian Skipper Frog
4	<i>Limnonectes limnocharis</i>	Cricket Frog
5	<i>Tomopterna breviceps</i>	Short-headed Burrowing Frog
6	<i>Hoplobatrachus tigerinus</i>	Indian Bull Frog
7	<i>Hoplobatrachus crassus</i>	Jerdon's Bull Frog
8	<i>Microhyla ornata</i>	Ornate Narrow-mouthed Frog
Nomenclature following Das and Dutta (1998); all water dependent		

No.	Scientific name	English name
1	<i>Lissemys punctata</i> #	Indian Flapshell Turtle
2	<i>Aspideretes gangeticus</i> #	Indian Softshell Turtle
3	<i>Hemidactylus flaviviridis</i>	Yellow-green House Gecko
4	<i>Sitana ponticeriana</i>	Fanthroated Lizard
5	<i>Calotes versicolor</i>	Indian Garden Lizard
6	<i>Psamophilus blanfordanus</i>	Rock Lizard
7	<i>Mabuya carinata</i>	Keeled Grass Skink
8	<i>Lygosoma punctatus</i>	Spotted Supple Skink
9	<i>Varanus bengalensis</i>	Bengal Monitor
10	<i>Ptyas mucosus</i>	Indian Rat Snake
11	<i>Lycodon aulicus</i>	Common Wolf Snake

12	<i>Amphiesma stolata</i>	Buff-striped Keelback
13	<i>Xenochropis piscator</i> #	Checkered Keelback Water Snake#
14	<i>Naja naja</i>	Spectacled Cobra
15	<i>Bungarus caeruleus</i>	Common Indian Krait
16	<i>Daboia russelli</i>	Russell's Viper
Nomenclature after Das (1997) # Water dependent species		

#### 4.7.3 Birds and mammals

Ninety species of birds (Table 14) and seven of mammals (Table 15) were recorded in the environs of the proposed project. Of the 90 species of birds 36 are highly water dependent. Higher number of waterbirds was due to presence of number of wetlands and major rivers such as Chambal. Several species of water birds including Sarus Crane were sighted in wetlands closer to Adadra village. The fewer number of mammal species was due to the lack of forest cover and the prevailing agricultural and industrial practices along the route.

Table 14 Birds observed along the pipeline route		
No	Scientific name	English name
1	<i>Podiceps ruficollis</i> #	Little Grebe
2	<i>Phalacrocorax niger</i> #	Little Cormorant
3	<i>Ardeola grayii</i> #	Pond Heron or Paddy bird
4	<i>Bubulcus ibis</i> #	Cattle Egret
5	<i>Egretta intermedia</i> #	Smaller (Median) Egret
6	<i>Egretta garzetta</i> #	Little Egret
7	<i>Egretta alba</i> #	Large Egret
8	<i>Anastomus oscitans</i> #	Openbill Stork
9	<i>Mycteria leucocephala</i> #	Painted Stork
10	<i>Threskiornis aethiopica</i> #	White Ibis
11	<i>Nycticorax nycticorax</i> #	Night Heron
12	<i>Platalea leucorodia</i> #	Spoonbill
13	<i>Ardea cinerea</i> #	Gery Heron
14	<i>Ardea purpurea</i> #	Purple Heron
15	<i>Dendrocygna javanica</i> #	Lesser Whistling Teal
16	<i>Anas poecilorhyncha</i> #	Spotbill
17	<i>Nettapus coromandelianus</i> #	Cotton Teal
18	<i>Sarkidiornis melanotus</i> #	Comb Duck
19	<i>Gyps bengalensis</i>	Whitebacked Vulture

20	<i>Neophron percnopterus</i>	Scavenger Vulture
21	<i>Elanus caeruleus</i>	Blackwinged Kite
22	<i>Milvus migrans</i>	Pariah Kite
23	<i>Haliastur indus</i> #	Brahminy Kite
24	<i>Accipiter badius</i>	Indian Shikra
25	<i>Francolinus francolinus</i>	Black Partridge
26	<i>Francolinus pondicerianus</i>	Grey Partridge
27	<i>Coturnix sp.</i>	Quail
28	<i>Pavo cristatus</i>	Common Peafowl
29	<i>Grus antigone</i> #	Sarus Crane
30	<i>Prozana fusca</i> #	Ruddy Crane
31	<i>Amauornis phoenicurus</i> #	Whitebreasted Waterhen
32	<i>Gallinula chloropus</i> #	Indian Moorhen
33	<i>Porphyrio porphyrio</i> #	Purple Moorhen
34	<i>Fulica atra</i> #	Coot
35	<i>Hydrophaasianus chirurgus</i> #	Pheasant- Tailed Jacana
36	<i>Metopidius indicus</i> #	Bronzewinged Jacana
37	<i>Vanellus indicus</i> #	Redwattled Lapwing
38	<i>Tringa hypoleucos</i> #	Common Sandpiper
39	<i>Tringa stagnatilis</i> #	Marsh Sandpiper
40	<i>Tringa nebularia</i>	Green Shank
41	<i>Himantopus himantopus</i> #	Blackwinged Stilt
42	<i>Chlidonias hybrida</i> #	Whiskered Tern
43	<i>Sterna aurantia</i> #	River Tern
44	<i>Columba livia</i>	Blue Rock Pigeon
45	<i>Streptopelia decaocto</i>	Indian Ring Dove
46	<i>Streptopelia senegalensis</i>	Little Brown Dove
47	<i>Streptopelia chinensis</i>	Spotted Dove
48	<i>Psittacula krameri</i>	Rose-ringed Parakeet
49	<i>Clamator coromandus</i>	Pied Crested Cuckoo
50	<i>Cuculus varius</i>	Brainfever Bird
51	<i>Eudynamys scolopacea</i>	Koel
52	<i>Centropus sinensis</i>	Crow-Pheasant
53	<i>Athene brama</i>	Spotted Owlet
54	<i>Caprimulgus sp.</i>	Nightjar
55	<i>Cypsiurus parvus</i>	Palm Swift



56	<i>Apus affinis</i>	House Swift
57	<i>Ceryle rudis</i> #	Lesser Pied Kingfisher
58	<i>Alcedo atthis</i> #	Small Blue Kingfisher
59	<i>Halcyon smyrnensis</i> #	Whitebreasted Kingfisher
60	<i>Merops orientalis</i>	Small Green Bee-eater
61	<i>Coracias benghalensis</i>	Indian Roller
62	<i>Upupa epops</i>	Hoopoe
63	<i>Tockus birostris</i>	Common Grey Hornbill
64	<i>Megalaima haemacephala</i>	Crimsonbreasted Barbet
65	<i>Dinopium benghalense</i>	Lesser Goldenbacked Woodpecker
66	<i>Eremopterix grisea</i>	Ashycrowned Finch Lark
67	<i>Alauda sp.</i>	Sky Lark
68	<i>Hirundo smithii</i>	Wire-tailed Swallow
69	<i>Lanius vittatus</i>	Baybacked Shrike
70	<i>Lanius schach</i>	Rufousbacked Shrike
71	<i>Oriolus oriolus</i>	Golden Oriole
72	<i>Dicrurus adsimilis</i>	Black Drongo
73	<i>Acridotheres ginginianus</i>	Bank Myna
74	<i>Acridotheres tristis</i>	Common Myna
75	<i>Sturnus pagodarum</i>	Brahminy Myna
76	<i>Sturnus contra</i>	Pied Myna
77	<i>Dendrocitta vagabunda</i>	Tree Pie
78	<i>Corvus splendens</i>	House Crow
79	<i>Corvus macrorhynchos</i>	Jungle Crow
80	<i>Pycnonotus cafer</i>	Redvented Bulbul
81	<i>Turdoides affinis</i>	Whiteheaded Babbler
82	<i>Prinia socialis</i>	Ashy Wren-warbler
83	<i>Orthotomus sutorius</i>	Tailor Bird
84	<i>Sylvia curruca</i>	Lesser Whitethroat
85	<i>Copsychus saularis</i>	Magpie Robin
86	<i>Saxicoloides fulicata</i>	Indian Robin
87	<i>Saxicola caprata</i>	Pied Bush Chat
88	<i>Nectarinia asiatica</i>	Purple Sunbird
89	<i>Passer domesticus</i>	House Sparrow
90	<i>Ploceus philippinus</i>	Baya
Nomenclature following Ali and Ripley (1983), # water birds		

Table 15 Mammals observed along the pipeline route		
No.	Scientific name	English name
1	<i>Macaca mulatta</i>	Rhesus Macaque
2	<i>Presbytis entellus</i>	Common Langur
3	<i>Viverricula indica</i>	Small Indian Civet
4	<i>Herpestes edwardsi</i>	Mongoose
5	<i>Pteropus giganteus</i>	Indian Flying Fox
6	<i>Funambulus</i> sp	Palm Squirrel
7	<i>Lepus nigricollis</i>	Indian Hare
Nomenclature following Prater (1993)		

#### 4.8 ENDANGERED SPECIES

No endangered plants were observed during the field survey. However, of the 121 species of vertebrates observed in the vicinity of the proposed project, 13 are listed in the Schedule I and II of the Indian Wildlife Protection Act 1972 (Anonymous 1991; Table 16). This include three species of mammals, three of birds and seven of reptiles. However, only four species are included in the Indian Red Data Book (three vulnerable and one endangered species, ZSI 1994, Table 16). Most of the species found in the project area and its environs are highly adaptable and have wide distribution elsewhere in India. It may be mentioned that none of the vertebrate species observed are endemic to this region.

Table 16 Endangered species present in the environs of the proposed project		
Species	WPA (1972) Schedule*	Red Data Book **
<b>Mammals</b>		
1 Rhesus Macaque	II	No mention
2 Common Langur	II	No Mention
3 Small Indian Civet	II	No mention
<b>Birds</b>		
4 Spoonbill	I	No mention
5 Peafowl	I	Vulnerable
6 Indian Shikra	I	No mention
<b>Reptiles</b>		
7 Indian Flapshell Turtle	I	Vulnerable

8	Indian Softshell Turtle	I	Vulnerable
9	Bengal Monitor	II	Endangered
10	Checkered-Keelback Water Snake	II	No mention
11	Rat Snake	II	No mention
12	Russell's Viper	II	No mention
13	Indian Cobra	II	No mention
*Wildlife Protection Act 1972 (Anonymous 1991), ** ZSI (1994)			

#### 4.9 IMPACT OF THE PIPELINE

The major facilities associated with gas pipeline are the receiving, despatch, control and distribution centres, and the compressor stations. The compressor stations are installed at appropriate intervals along the gas transmission lines to maintain adequate pressure in the pipeline. Installation of underground pipeline mainly involves surveying, right of way clearing, trenching / ditching, pipe stringing, bending, welding, placement of pipe in the trench, backfilling and cleaning. Coating and installing cathodic protection for corrosion control is necessary in most soils, especially in wet or saline areas. The present project proposes laying of 36 inch steel pipes to transport LNG from Dahej in Gujarat to Bijaipur in Madhya Pradesh. The pipeline will be laid minimum of 1 m below the surface (1.7m cover at railway crossings and 1.2m at highway and canal crossings) in a 30 m wide RoU to be acquired by GAIL. The total area of the entire RoU is about 1830 ha, out of which only 246 ha will be newly acquired while the rest is already operational RoU. After laying the pipes the trenches are to be filled and covered and the land returned to the owners. The RoU is demarcated by markers, at short intervals, indicating the path and the boundary of the RoU. Regular use of the land by the owners, except planting of large trees and construction of concrete structures, is allowed on the RoU.

Major impacts, in general, of any underground pipeline project during the construction are; i) felling of trees in the RoU, ii) the movement of labour and machinery, for trench making, welding and laying the pipes in the trench and hydro testing, such as cranes, welding machinery and transport vehicles, iii) creation of RoU can lead to the invasion of exotic plants which may out-compete the natural vegetation, iv) pipeline installation can also result in habitat fragmentation of natural areas resulting in the loss of species and lowering of bio-diversity, and v) long pipelines can open up less accessible natural areas to human activity.

During the rapid ecological assessment, based on sample survey method, we did not encounter any vegetation patches of ecological importance which may get hampered seriously because of construction and operation of the pipeline. The pipeline route passes mainly through agricultural fields and wastelands and does not run through any notable thick vegetation where the density of trees is high. Hence, no drastic alteration in the vegetation, habitat fragmentation or increase in accessibility to wildlands can be expected due to creation of the RoU. Likewise, the chance of invasion of the RoU by exotic plants is negligible. However, it is to be noted that the invasion of *Prosopis juliflora* is rampant, especially in non-agricultural lands, through out the states through

which the pipeline passes. The possibility of this species colonizing the RoUs can not be ruled out, unless measures to clear the species, in case necessary from the point of view of risk, are regularly undertaken. The laying of pipeline is comparatively a fast process and the disturbances, except that due to clear felling of trees and movement of machinery, are limited only for a few days at any specific site. It is estimated that around 2890 trees, mainly *Acacia*, will be uprooted along the RoU during the installation of the pipeline. In the stretch of pipeline from Vemar to Bijapur, the pipeline will be laid in the existing RoU, adjacent to the existing pipeline maintaining a minimum clear distance of 5m, hence no felling of trees is anticipated. All larger trees along the RoU were cleared during the acquiring of RoU for existing HBJ pipeline.

During the operation phase i.e., once the pipeline is laid, the underground pipeline practically does not pose any threat to the local ecological makeup, except in case of accidents like leakage. Breach of the RoU due to heavy rain may expose the underground pipeline (Plate 4). Such incidences can lead to hazardous consequences. Leaks or ruptures of pipelines can have significant impacts beyond the immediate vicinity of the pipelines. The primary cause of pipeline accidents, implicated in more than half of all accidents, is outside forces such as careless operation of mechanical equipments, landslides or earth quakes and also deliberate damages (World Bank 1991b). An attempt was made to develop an impact evaluation matrix. In case of the matrices for both the construction and operation phase, the possible impacts are found very low (Appendix 6 & 7).

#### **4.10 SENSITIVE AREAS**

An attempt to grade the ecological sensitivity / significance of each sector based on the number of schedule I & II animals present in the area, and vegetation status of the area suggest (Appendix 8) that the route is comparatively low in ecological sensitivity.

In pipeline augmentation between Vemar and Bijapur, several wetlands and Reserve Forests were seen in close vicinity (1-2 km). The wetlands support waterfowl species such as Sarus Crane, fish-eating birds and ducks. Some of the important wetlands are; Rambaloda, Parikha, Sultanpur, Vessnya, Jhakhariya, Chandpuri, Muwaliya talavs and Sayaji Sarovar (Table 3). The pipeline near Adadra village passes through wetlands which support waterfowl such as Whistling Teal, Comb Duck, Spotbill and Saras Crane (Plate 5). Important Reserve and Protected Forests found close to the pipeline are; Bijapur PF, Patan RF, Charanpura RF, Barkeri RF, Raipuria, Dudhmal (Grasslands) and Devar Baria RF.

Vemar to Dahej, the new pipeline route does not contain ecologically sensitive areas such as National parks and Sanctuaries. Soon after the take off point near the coastal area, the pipeline enters a *Prosopis juliflora* forest, agricultural and fallow lands.

## **4.11 MITIGATORY MEASURES**

### **4.11.1 Minimizing the disturbance**

The laying of pipeline need to be completed within a short span of time, especially in areas close to the grass beeds of Gujarat and Madhya Pradesh. The pipeline passes through grasslands around Dudmal which may support endangered birds such as Lesser Florican. The main mating season of birds such as Lesser Florican in these areas are during June to October (Sankaran 1996). During these periods disturbance to the species has to be minimum. Summer and pre-monsoon periods (April - May) are advisable for construction in such areas because i) the primary breeding season for most of the resident birds commences with monsoon, ii) winter is the main migratory season for birds and, iii) In this area usually during the monsoon and winter the number of bird species are high.

During the construction the labour force need to be instructed not to cause any damage or disturbance to forest and wildlife. The labour force may be locally recruited. Fuel wood or any feasible fuel for household activities may be supplied to the labour force so as to prevent them from collecting fuel -wood from the nearby forests. The machinery required for construction may be allowed to be stationed at any particular site only for the minimum required duration. Leaks and ruptures of pipeline, eventhough of low probability, can cause explosions and fire which may have grave impact on the fauna and flora. Proper disaster management planning should be done to meet emergencies.

Laying of pipeline in grassland areas of Gujarat and Madya Pradesh may be undertaken during January-May avoiding the breeding season of Lesser Florican (June to October). Fire preventing measures during construction and operation near RF and Grasslands should be strictly implemented. Construction work during November- March near wetlands may be avoided, as during these months maximum concentration of migratory waterfowl could be seen.

### **4.11.2 Compensatory afforestation**

Uprooting of a large number of trees is the major problem with the construction of pipeline. The Forest conservation act, 1980 (Anonymous 1992, Upadhyay 1995), gives specific guidelines for compensatory afforestation, if the uprooting takes place inside forest. However, the proposed pipeline route is mostly through non-forest land and hence, these regulation may not be binding. Nonetheless, as an environmental conservation measure, GAIL should envisage provisions for afforestation programme to compensate the uprooted trees.

Species such as *Acacia catechu*, *Acacia leucophloea*, *Azadirachta indica*, and *Pithecellobium dulce* which are native to the area are recommended for plantation. Native species have long term viability and are adapted to ambient conditions and local climatic extremes than many exotic species. They are better than many exotics to meet the material requirements, such as fodder and fuel wood, of the local public and also many of their cultural requirements. Saplings of the species, approximately

twenty times the number of uprooted trees need to be planted as a compensation for the uprooted trees. The local Forest Department nurseries may be contacted to procure sufficient saplings.

The afforestation scheme may include the following programmes;

- i) Supply of saplings to local villagers and the land owners; Saplings, approximately twenty times the number of uprooted trees, may be supplied to the land owners to plant as a replacement for the uprooted trees.
- ii) Plantation in public / Government land found along the route of the pipeline; A large portion of the RoU is passing through open scrub. Simultaneously with the clearing of the RoU, the GAIL may undertake intensive tree planting programme in government lands along the route.
- iii) Collaborate with the local Social Forestry division of the Forest Department and undertake plantation programme; Many of the Forested areas, which exists within 25 km from the RoU, are fit for implementing afforestation programmes. However, the programme may not be concentrated in any particular location or reserve forest. In each of the districts / taluks, through which the pipeline passes, specific areas may be identified in consultation with the Forest Department for implementing the programme.

#### **4.12 COST VS BENEFIT OF UPROOTING THE TREES ON THE ROW**

An objective cost-benefit analysis of a project from an ecological angle is a highly difficult exercise (World Bank 1991a, 1991b). This is because of i) the difficulty in quantifying the environmental impacts in physical terms and ii) even when impacts are measured in physical terms, valuation in monetary terms are difficult or are liable to subjectivity of the evaluator. The cost - benefit analysis of a project should include the assessment of two different scenarios, namely i) the "with project" and ii) the "without project" situations (World Bank 1991a).

In the case of the present project, in brief, the negative aspects, of the "with project" scenario are acquiring of RoU by the GAIL, clearing of the trees along the RoU, loss of habitat and disturbance to birds and the other fauna, alteration in vegetation and, reduction in the source of fuel wood and fodder to the villagers. The primary positive aspect of the project is that the project is proposed to facilitate transport of a comparatively eco-friendly fuel and raw material for industrial use. In India, as the sources of almost all fuels, except fire wood, are concentrated in certain locations, long range transportation of fuel is inevitable. The transport of LNG by underground pipeline is highly cost effective and comparatively risk free than other modes of surface transport. The operational cost of pipelines is also very low. The pipelines may considerably reduce the pressure on road and rail traffic and also loss of the material being transported to the environment in transit. Subsequent to the installation of the pipeline the land is returned back to the owners and they are free to use the area as they wish with only certain regulations. Except for the markers, which are erected at frequent intervals, the RoU will not stand conspicuous and it will more or less blend with the surroundings. Further the GAIL gives compensation to the land owners for gaining the right of use,

which is an additional income to the villagers. The clearing of trees will have only minor effect on the fauna in terms of habitat loss since, the trees are dispersed more or less uniformly along the entire stretch, similar habitat is available adjacently, and major part of the land through which the pipeline passes are agricultural or waste land with low density of trees. Similarly the loss of fuel and fodder to the villagers due to the uprooting of trees is less, since the number of trees to be felled in each location is low. In a long term perspective the tree plantation programme as discussed in section 4.11.2 can help to compensate for the losses.

In the case of the "without project" scenario the positive aspect is that the trees along the RoU will remain intact, the habitat loss, even though minor with the project will be none without the project. The source of fuel wood and fodder may remain unaltered. These benefits, in contrast to the "with project" scenario, is meagre. The LNG as a source of fuel and industrial raw material relieves pressure from the domestic and industrial users on fuel wood and other sources of fuel. LNG is environment friendly than other commonly used fuels. Relieving the pressure on fuel wood may save vast areas of greenery around human habitations and forests.

## 5 CONCLUSIONS

- 1) The Gas Authority of India Limited (GAIL) proposes to upgrade the existing HBJ pipeline. From Vemar to Bijaipur new pipeline will be laid along the existing RoU. From Vemar upto Dahej for a length of approximately 82 km new RoU will be acquired and new line will be laid. The pipeline is laid to transport Liquefied Natural Gas (LNG). The present study covers the impact of the project on flora and fauna and related ecological aspects.
- 2) The entire route of the pipeline was examined following sample survey method. Quadrats were marked along the route at an interval of approximately 15 km for intensive study of flora and fauna.
- 3) About 71% of the sampled area, along the route, was agricultural lands. 7% of the sampled area was waste-land with neither forest nor agriculture.
- 4) No rare, endangered or threatened species of plants were located along the route. 155 species of flowering plants were recorded along the path of the pipeline and its environs.
- 5) *Acacia nilotica* and *Acacia farnesiana* were the numerically dominant trees along the route. Around 2890 trees is estimated to be uprooted along the route if 30 meter wide RoU is cleared for the new pipeline from Vemar - Dahej.
- 6) As an environmental conservation measure, GAIL should envisage provisions for afforestation programme to compensate the uprooted trees. The afforestation scheme may include the following programmes; i) supply of saplings to local villagers and the land owners, ii) plantation in public / Government land along the route of the pipeline, and iii) collaborate with the local Social Forestry division of the Forest Department and undertake plantation programme
- 7) 121 species of vertebrates were recorded during the survey. A number of species listed in schedule I & II of the wildlife protection act were present along the route and its environs. However, most of these animals are highly mobile and are not very prone to short term disturbances that are likely during the pipeline construction in small stretch of their habitats.
- 8) Ecological sensitivity / significance of each sector based on the number of animals listed in schedule I & II and legal status of the area suggests that the route is comparatively low in ecological sensitivity.
- 9) The major impact of the pipeline project is during the construction. During the operation phase the underground pipeline practically does not pose any threat to the local ecological makeup, except in case of accidents like leakage.
- 10) Summer and pre-monsoon period (April - May) is advisable period for construction of the pipeline because i) the primary breeding season for most of the resident birds commences with monsoon, ii) winter is the main migratory season for birds and, iii) during monsoon and winter the number of bird species will be high in the area.



## **6 ACKNOWLEDGEMENTS**

We highly appreciate the help rendered by the following persons for the successful completion of the project;

Prof. Bony Pilo, MS University, Vadodara

Mr. Fotedar AK, Gas Authority of India limited, Bijaipur, Madhay Pradesh

Mr. Haldar A, Engineers India Limited, New Delhi

Dr. Johnson E, SACON, Coimbatore

Mr Mandal AK, Gas Authority of India limited, Vagodia, Gujarat

Mr. Mohanraj R, SACON, Coimbatore

Mr Pal PK, Gas Authority of India limited, Jabhua

Prof. Panicker RG, MS University, Vadodara

Mr Patel SS, Gas Authority of India limited, Bijaipur, Madhay Pradesh

Mr Ranjan Ray, Engineers India Limited, New Delhi

Mr Saroj GP, Gas Authority of India limited, Bijaipur, Madhay Pradesh

Dr. Sankaran R, Avian Ecology Division, SACON, Coimbatore

Prof. Senan GP, Department of Botany, MS University, Vadodara

Mr Soren, Gas Authority of India limited, Jabhua

Dr. Vijayan VS, SACON, Coimbatore

Dr. Vyas R, Vadodara Zoo, Vadodara

## 7 REFERENCES

- Ali and Ripley (1983) *The Book of Indian Birds (compact edition)*, Oxford University Press, Bombay.
- Anonymous (1991a) *Indian Wildlife Protection Act 1972 as amended upto 1991*. Natraj Publishers, Dehradun.
- Anonymous (1992) *Consolidated Guidelines for diversion of forest land under the Forest (conservation) act, 1980 (revised on October 25,1992)*. Ministry of Environment and Forests, Government of India
- Anonymous (1994) *The environmental impact assessment notification, 1994 (as amended on 4-5-94)*. Ministry of Environment and Forests, Government of India.
- Caustan DR (1988) *An introduction to vegetation analysis*. Unwin Hyman, Boston
- Champion, H G and SK Seth, 1968. *A revised survey of the forest types of India*. Govt. of India, New Delhi.
- Chaturvedi RG and Chaturvedi M M (1996) *Law on protection of environment and prevention of pollution (central and states)*. The Law Book Co., Allahabad.
- Chaturvedi AN and LS Khanna (1982) *Forest mensuration*. International Book Distributors, Dehradun.
- Daniel JC (1985) *Book of Indian Reptiles*. Bombay Natural History Society, Bombay.
- Das, I. (1997): Checklist of the Reptiles of India with English common names. *Hamadryad* 22: 32-45.
- Das, I. and S.K. Dutta (1998) Checklist of the amphibians of India, with English common names. *Hamadryad* 23:63-68.
- Gamble JS (1987) *Flora of the presidency of Madras, Vol. I, II and III*. Bishan Singh Mahendrapal Singh, Dehradun.
- Greig-Smith P (1983) *Quantitative plant ecology, Studies in ecology*. Vol 9. Blackwell Scientific Pub., Oxford.
- Jain SK and RR Rao (1983) *An assessment of threatened plants of India*. Botanical Survey of India, Calcutta

- Nair MP and ARK Shastri (1988) Red data book of Indian plants Vol I & II. Botanical Survey of India, Calcutta
- Prater SH (1993) The book of Indian animals. Oxford University Press, Bombay
- Sankaran R (1996) Background paper for the workshop on Conservation of the Lesser Florican, 28 July 1996, Kota, Rajasthan, p32, Hadothi Naturalists Society Kota, SACON Coimbatore, Dept. of Forests and Wildlife Rajasthan and Centre for Wildlife and Ornithology, Aligarh.
- Shetty BV and V Singh (1987) Flora of Rajasthan, Vol I & II, Botanical Survey of India, Calcutta.
- Upadhyay CB (1995) Forest laws (central and states). Hind Publishing House, Allahabad.
- World Bank (1991a) Environmental Assessment Source book. Vol. I. Policies, procedures, and cross-sectoral issues. World bank technical paper number 139. The World Bank, Washington, DC.
- World Bank (1991b) Environmental Assessment Source book. Vol. III. Guidelines for environmental assessment of energy and industry projects. World bank technical paper number 154. The World Bank, Washington, DC.
- Zoological Survey of India (1994) The red data book on Indian animals, Part I: Vertebrata (Mammalia, Aves, Reptilia and Amphibia), Gosh A K (ed). Zoological Survey of India, Calcutta.

Appendix 1 Grading scheme for assessment of ecological sensitivity of an area		
Parameter		Grade / Weightage
Wildlife importance (Endangered species*)	Number of Schedule I & II species (> 20 numbers)	100
	Number of Schedule I & II species (10 - 20 numbers)	50
	Number of Schedule I & II species (< 10 numbers)	25
Floral endemism	High (>10 species)	100
	Medium (5-10 species)	50
	Low (< 5 species)	25
Faunal endemism	High (>10 species)	100
	Medium (5-10 species)	50
	Low (< 5 species)	25
State of terrestrial vegetation	Relatively undisturbed forest (govt. / private)	100
	Totally managed estate with three tyre vegetation	50
	Totally managed estate such as coffee and cardamom.	25
	Agricultural land with crops such as coconut	0
State of wetland vegetation	Relatively undisturbed wetland visited by migratory waterfowl	100
	Relatively undisturbed wetland not known to be visited by migratory waterfowl	50
	Other wetlands with frequent human activity	25
	Agricultural land with crops such as paddy	10
Legal Status	National Park	100
	Wildlife sanctuary	50
	Reserve forest / Wetland	25
	Agricultural land	0
Conservation importance	Location unique in terms of habitat (such as world heritage site) or species	100
	Habitat although present elsewhere is under threat in those places	75
	Habitat present elsewhere and is not under any serious threat	50
	Habitat is very common elsewhere	25

	Habitat is very common and does not possess any ecological characteristics which need attention	0
Note: * Species included in Schedule I & II of Wildlife Protection Act, 1972		

## Appendix 2 List of plant species seen along the pipeline route and its environs

<b>S.No</b>	<b>Species</b>	<b>Habit</b>
1	<i>Abrus precatorius</i>	Climber
2	<i>Abutilon indicum</i>	Shrub
3	<i>Acacia catechu</i>	Tree
4	<i>Acacia leucophloea</i>	Tree
5	<i>Acacia nilotica</i>	Tree
6	<i>Acacia farnesiana</i>	Tree
7	<i>Acanthospermum hispidum</i>	Herb
8	<i>Achyranthes aspera</i>	Herb
9	<i>Ailanthus excelsa</i>	Tree
10	<i>Albizia lebbeck</i>	Tree
11	<i>Alternanthera pungens</i>	Herb
12	<i>Alternanthera sessilis</i>	Herb
13	<i>Alysicarpus monilifer</i>	Herb
14	<i>Alysicarpus vaginalis</i>	Herb
15	<i>Amaranthus spinosus</i>	Herb
16	<i>Amaranthus viridis</i>	Herb
17	<i>Amorphophallus bulbifer</i>	Shrub
18	<i>Anona squamosa</i>	Tree
19	<i>Anogeissus pendula</i>	Tree
20	<i>Apluda mutica</i>	Herb
21	<i>Argemone mexicana</i>	Herb
22	<i>Azadirachta indica</i>	Tree
23	<i>Bauhinia racemosa</i>	Tree
24	<i>Bidens pilosa</i>	Herb
25	<i>Biophytum sensitivum</i>	Herb
26	<i>Boerhavia diffusa</i>	Herb
27	<i>Boerhavia erecta</i>	Herb
28	<i>Borassus flabellifer</i>	Tree

29	<i>Borreria hispida</i>	Herb
30	<i>Butea monosperma</i>	Tree
31	<i>Callistemon citrinus</i>	Tree
32	<i>Calotropis gigantea</i>	Shrub
33	<i>Capparis decidua</i>	Tree
34	<i>Capparis sepiaria</i>	Shrub
35	<i>Cardiospermum halicacabum</i>	Climber
36	<i>Carica papaya</i>	Tree
37	<i>Carissa carandas</i>	Shrub
38	<i>Cassia auriculata</i>	Shrub
39	<i>Cassia hirsuta</i>	Herb
40	<i>Cassia occidentalis</i>	Herb
41	<i>Cassia siamea</i>	Tree
42	<i>Cayratia trifolia</i>	Climber
43	<i>Celosia argentea</i>	Herb
44	<i>Cenchrus ciliaris</i>	Herb
45	<i>Chlorophytum tuberosum</i>	Herb
46	<i>Cleome pentaphylla</i>	Herb
47	<i>Cleome monophylla</i>	Herb
48	<i>Cleome viscosa</i>	Herb
49	<i>Clerodendrum phlomides</i>	Shrub
50	<i>Clitoria ternatea</i>	Climber
51	<i>Coccinia grandis</i>	Climber
52	<i>Cocos nucifera</i>	Tree
53	<i>Commelina benghalensis</i>	Herb
54	<i>Corchorus aestuans</i>	Herb
55	<i>Corchorus tridens</i>	Herb
56	<i>Crotalaria sp</i>	Herb
57	<i>Curculigo orchioides</i>	Herb
58	<i>Cynodon dactylon</i>	Herb

59	<i>Cyperus sp</i>	Herb
60	<i>Dactyloctenium aegyptium</i>	Herb
61	<i>Dalbergia sissoo</i>	Tree
62	<i>Datura metal</i>	Shrub
63	<i>Delonix regia</i>	Tree
64	<i>Desmodium triflorum</i>	Herb
65	<i>Dichrostachys cinerea</i>	Tree
66	<i>Digera muricata</i>	Herb
67	<i>Digitaria bicornis</i>	Herb
68	<i>Echinochloa colona</i>	Herb
69	<i>Echinops echinatus</i>	Herb
70	<i>Eclipta alba</i>	Herb
71	<i>Eragrostis viscosa</i>	Herb
72	<i>Eriocaulon cinereum</i>	Herb
73	<i>Eucalyptus sp</i>	Tree
74	<i>Euphorbia geniculata</i>	Herb
75	<i>Euphorbia hirta</i>	Herb
76	<i>Euphorbia hypercifolia</i>	Herb
77	<i>Euphorbia nivulia</i>	Shrub
78	<i>Euphorbia rosea</i>	Herb
79	<i>Euphorbia tirucalli</i>	Tree
80	<i>Evolvulus alsinoides</i>	Herb
81	<i>Evolvulus nummularis</i>	Herb
82	<i>Ficus benghalensis</i>	Tree
83	<i>Glossocardia bosvallia</i>	Herb
84	<i>Gomphrena celosioides</i>	Herb
85	<i>Grevillea robusta</i>	Tree
86	<i>Hemidesmus indicus</i>	Climber
87	<i>Holarrhena pubescens</i>	Shrub
88	<i>Holoptelia integrifolia</i>	Tree



89	<i>Indigofera trita</i>	Herb
90	<i>Ipomoea carnea</i>	Shrub
91	<i>Jatropha curcas</i>	Shrub
92	<i>Jatropha glandulifera</i>	Shrub
93	<i>Justicia simplex</i>	Herb
94	<i>Kirganelia reticulata</i>	Shrub
95	<i>Lagascea mollis</i>	Herb
96	<i>Lagerstroemia parviflora</i>	Tree
97	<i>Lantana camara</i>	Shrub
98	<i>Lawsonia inermis</i>	Shrub
99	<i>Leucaena leucocephala</i>	Tree
100	<i>Lindernia ciliata</i>	Herb
101	<i>Madhuca longifolia</i> Var. <i>latifolia</i>	Tree
102	<i>Malvastrum coromandelianum</i>	Herb
103	<i>Mangifera indica</i>	Tree
104	<i>Martynia annua</i>	Shrub
105	<i>Merremia emarginata</i>	Climber
106	<i>Mukia maderaspatana</i>	Climber
107	<i>Ocimum canum</i>	Herb
108	<i>Opuntia dillenii</i>	Shrub
109	<i>Oxystelma esculentum</i>	Climber
3110	<i>Panicum brevifolium</i>	Herb
111	<i>Panicum psilopodium</i>	Herb
112	<i>Parkinsonia aculeata</i>	Tree
113	<i>Parthenium hysterophorus</i>	Herb
114	<i>Paspalum scrobiculatum</i>	Herb
115	<i>Peltophorum pterocarpum</i>	Tree
116	<i>Pergularia daemia</i>	Climber
117	<i>Peristrophe bicalyculata</i>	Herb
118	<i>Phaseolus trilobus</i>	Climber

119	<i>Phoenix sylvestris</i>	Tree
120	<i>Phyllanthus amarus</i>	Herb
121	<i>Phyllanthus fraternus</i>	Herb
122	<i>Phyllanthus maderaspatensis</i>	Herb
123	<i>Physalis minima</i>	Herb
124	<i>Pithecellobium dulce</i>	Tree
125	<i>Polyalthia longifolia</i>	Tree
126	<i>Prosopis cinerea</i>	Tree
127	<i>Prosopis juliflora</i>	Tree
128	<i>Psidium guajava</i>	Tree
129	<i>Ruellia prostrata</i>	Herb
130	<i>Ruellia tuberosa</i>	Herb
131	<i>Salvadora persica</i>	Tree
132	<i>Scirpus sp</i>	Herb
133	<i>Securinega leucopyrus</i>	Shrub
134	<i>Sesbania bispinosa</i>	Shrub
135	<i>Sida acuta</i>	Herb
136	<i>Sida cordata</i>	Herb
137	<i>Sida cordifolia</i>	Herb
138	<i>Sida glutinosa</i>	Herb
139	<i>Solanum surattense</i>	Shrub
140	<i>Suaeda maritima</i>	Herb
141	<i>Tamarindus indica</i>	Tree
142	<i>Tectona grandis</i>	Tree
143	<i>Tephrosia purpurea</i>	Herb
144	<i>Terminalia tomentosa</i>	Tree
145	<i>Tragus roxburghii</i>	Herb
146	<i>Tribulus terrestris</i>	Herb
147	<i>Trichodesma zeylanica</i>	Herb
148	<i>Tridax procumbens</i>	Herb

149	<i>Triumfetta rhomboidea</i>	Herb
150	<i>Triumfetta rotundifolia</i>	Herb
151	<i>Vanda tessellata</i>	Epiphyte
152	<i>Waltheria indica</i>	Herb
153	<i>Xanthium strumarium</i>	Shrub
154	<i>Zizyphus mauritiana</i>	Tree
155	<i>Zizyphus nummularia</i>	Shrub

Appendix 3 GBH and Height class distribution of trees along the pipeline route (Sectionwise)						
GBH class (cm)	Section I		Section II		Section III	
	No.	%	No.	%	No.	%
25 - 50	44	46.8	29	52.6	29	32.2
51-75	40	42.6	45	28.9	45	50.0
76-100	6	6.4	14	9.2	5	5.6
101-125	2	2.1	11	7.2	5	5.6
126-150	1	1.1	1	0.7	2	2.2
151-175	1	1.1	1	0.7	3	3.3
176-200	0	0	1	0.7	1	1.1
Total	94	100	152	100	90	100
Height class						
Height class (m)	52	55.3	97	63.8	36	41.0
<5	37	39.4	55	36.2	46	50.1
6 - 10	5	5.3	-	-	8	8.9
11 - 15	-	-	-	-	-	-
Total	94	100	152	100	90	100

Section I - New RoU (Dahej - Vemar); Section II - Existing RoU (Gujarat region); Section III - Existing RoU (Madya Pradesh region)

Appendix 4 Tree matrices in the existing RoU (Gujarat region)					
Species	Mean GBH (cm)	Mean Height (m)	No. of trees	Percentage	
<i>Acacia catechu</i>	65.0	5.7	141	3.3	
<i>Acacia farnesiana</i>	66.3	4.3	188	4.4	
<i>Acacia leucophloea</i>	59.6	4.6	329	7.8	
<i>Acacia nilotica</i>	55.4	4.4	752	17.8	
<i>Ailanthus excelsa</i>	45.7	4.0	141	3.3	
<i>Anogeissus pendula</i>	70.0	6.0	141	3.3	
<i>Azadirachta indica</i>	57.0	5.7	423	10.0	
<i>Borassus flabellifer</i>	60.0	11.0	47	1.1	
<i>Butea monosperma</i>	65.0	5.5	94	2.2	
<i>Cassia siamea</i>	70.0	4.0	47	1.1	
<i>Eucalyptus sp</i>	63.0	8.8	470	11.1	
<i>Euphorbia tirucalli</i>	25.0	3.0	47	1.1	
<i>Madhuca longifolia</i>	140.0	8.6	423	10.0	
<i>Mangifera indica</i>	55.0	5.0	47	1.1	
<i>Parkinsonia aculeata</i>	30.0	3.0	47	1.1	
<i>Peltophorum pterocarpum</i>	56.3	5.5	188	4.4	
<i>Pithecellobium dulce</i>	56.0	5.0	47	1.1	

<i>Prosopis juliflora</i>	40.7	4.7	141	3.3
<i>Tectona grandis</i>	52.4	7.0	376	8.9
<i>Zizyphus mauritiana</i>	26.7	2.7	141	3.3
Total			4230	100.0

Appendix 5 Tree metrics in the existing RoU (Madya Pradesh region)				
Species	Mean GBH (cm)	Mean Height (m)	No. of trees	Percentage
<i>Acacia catechu</i>	31.0	3.0	232	3.3
<i>Acacia leucophloea</i>	44.4	3.5	1113	15.8
<i>Acacia nilotica</i>	51.3	4.1	2550	36.2
<i>Ailanthus excelsa</i>	45.0	3.0	93	1.3
<i>Azadirachta indica</i>	67.4	4.5	510	7.2
<i>Bauhinia racemosa</i>	35.0	3.0	46	0.7
<i>Butea monosperma</i>	40.2	2.6	742	10.5
<i>Dalbergia sissoo</i>	88.8	5.5	186	2.6
<i>Eucalyptus sp</i>	45.0	4.7	139	2.0
<i>Ficus benghalensis</i>	50.0	4.0	46	0.7
<i>Lagerstroemia parviflora</i>	70.0	5.0	46	0.7
<i>Leucaena leucocephala</i>	40.0	6.0	46	0.7
<i>Madhuca longifolia</i>	78.8	5.5	186	2.6
<i>Mangifera indica</i>	95.4	5.8	556	7.9
<i>Phoenix sylvestris</i>	36.7	4.0	139	2.0
<i>Pithecellobium dulce</i>	90.0	6.0	46	0.7
<i>Prosopis juliflora</i>	30.0	3.3	139	2.0
<i>Tectona grandis</i>	60.0	4.0	46	0.7
<i>Terminalia tomentosa</i>	45.0	4.0	46	0.7
<i>Zizyphus mauritiana</i>	40.0	2.7	139	2.0
Total			7047	100.0

Appendix 6. Environmental Impact evaluation matrix (Construction phase)						
Aspects		Impact on				
		Flora		Fauna		
		Epiphytes	Others	Mammals	Birds	Herpetofauna
Pipeline	Acquisition of RoU	1.00	1.00	1.00	2.00	0.00
	Clearing the RoU	2.00	2.00	2.00	2.00	3.00
	Trenching	0.00	3.00	2.00	2.00	3.00
	Machinery and materials mobilization	0.00	3.00	2.00	1.00	3.00
Intermediate pumping station	Site clearance and levelling	2.00	2.00	1.00	2.00	4.00
	Construction and erection	1.00	1.00	1.00	2.00	3.00
Workforce demands	Transportation	0.00	0.00	0.00	0.00	0.00
	Communication	0.00	0.00	0.00	0.00	0.00
	Power / Fuel	0.00	0.00	0.00	0.00	0.00
	Supportive infrastructure and other facilities such as medical and educational	0.00	0.00	0.00	0.00	0.00

Note: Graded from 0-10 based on the severity of the impact; 0 denotes no impact and 10 very severe impact

Appendix 7 Environmental Impact evaluation matrix (Operation phase)						
Aspects		Impact on				
		Flora		Fauna		
		Epiphytes	Others	Mammals	Birds	Herpetofauna
Pipeline	Inspection and maintenance	0.00	2.00	1.00	1.00	2.00
	Pipeline operation	0.00	0.00	0.00	0.00	0.00
	Work force demands	0.00	0.00	0.00	0.00	0.00
Intermediate pumping station	Terminal operation	0.00	0.00	1.00	1.00	0.00
	Product storage	0.00	0.00	0.00	0.00	0.00
	Product pumping	0.00	0.00	0.00	0.00	0.00
	Workforce requirements	0.00	0.00	0.00	0.00	0.00

Note: Graded from 0-10 based on the severity of the impact; 0 denotes no impact and 10 very severe impact

Appendix 8 Ecological sensitivity of the sectors of the pipeline route			
Parameter	Section 1	Section 2	Section 3
Wildlife importance (endangered species*)	50	50	50
Floral endemism	0	0	0
Faunal endemism	0	0	0
State of terrestrial vegetation	0	0	0
State of wetland vegetation	25	25	25
Legal status	0	25	25
Conservation importance	0	25	25
Total	75	125	125
Note: * Species included in Schedule I & II of Wildlife Protection Act, 1972			



