

Impact Assessment  
Of Hazira / Okha / Kandla / Pyala LPG Pipeline  
On The Flora And Fauna



Salim Ali Centre  
For  
Ornithology & Natural history  
Coimbatore, Tamil Nadu

May 1996

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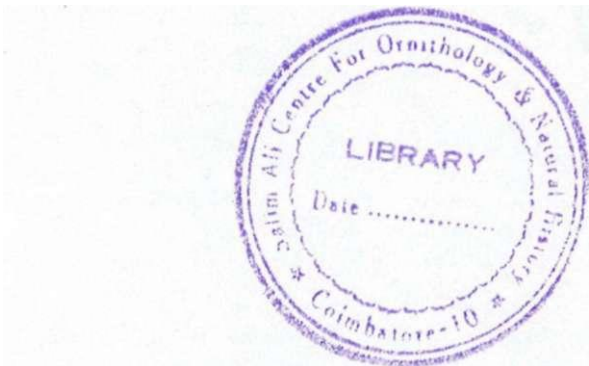
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## 1.0 INTRODUCTION

Gas Authority of India Limited (GAIL) proposes to lay a 1600 Km long pipeline, traversing three states, namely Gujarat, Rajasthan and Haryana, to transport Liquefied Petroleum Gas (LPG). The proposed pipeline originates from three different places namely, Hazira, Okha and Kandla in Gujarat. The lines starting from Okha and Kandla join at Samakhiali and later at Patan join with the line starting from Hazira. The line further travels through Rajasthan to terminate at Pyala in Haryana. 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 a part of the EIA, the assessment of the impact of the pipeline on the floral and faunal diversity was awarded to Salim Ali Centre for Ornithology and Natural History (SACON), Coimbatore, an autonomous institute funded by the Ministry of Environment and Forests, Government of India.

## 2.0 OBJECTIVES

The objectives of the study were to;

- i) assess the baseline status of forests and associated wildlife of the area,
- ii) evaluate the impact of the proposed project on forest and wildlife,
- iii) review the project in the light of various Forest and Wildlife Protection Acts,
- iv) cost benefit analysis of the project related to uprooting of trees on the Right Of Way (ROW),
- v) propose Environmental Management Plan (EMP) for the protection of forest and wildlife during construction and operation phases of the project and
- vi) propose scheme for afforestation.

## 3.0 METHODS

Relevant Survey of India maps (toposheets; scale 1:100000 and 1:50000) were provided by GAIL showing the path of the proposed pipeline. Based on our preliminary examination of the route of the pipeline, the entire stretch was divided into four zones. Each zone was further divided into shorter sectors to facilitate data analysis. The sectors were numbered continuously, irrespective of the zones. The data were compiled considering each sector as a unit. The zone I is approximately 375 Km long passing through various industrial towns between Hazira and Patan in Gujarat. This zone has two sectors i.e.,



sector I which is more than 200 Km long running through south Gujarat, and sector ii 175 km long running through the central parts of Gujarat. While the former has abundant water from a number of rivers such as Narmada and Mahi (Plate 1 a & b), the latter is comparatively dry. The Zone II, about 400 Km long, extending between Okha and Kandla is largely coastal (Plate 2a). This zone is divided into two sectors i.e., sector iii and sector iv, almost 200 Km each. The zone III which includes Samakhiali to Jessor region in Gujarat is about 275 Km in length and is mostly semi arid (Plate 2b). The entire zone III, where the Great and Little Rann joins together, was considered as one sector (sector v). Zone IV, which is also semi-arid as zone III, comprises rest of the route in Rajasthan and Haryana. It is about 675 Km in length and is divided into 4 sectors (sectors vi - ix), of which the shortest, the sector ix, falls in Haryana.

The entire stretch (Figure 1) was covered by the team using a four wheel vehicle. For intensive study of the flora and fauna, sampling points were marked, at an interval of approximately 25 Km, all along the route. 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, a quadrat of one hectare (100 X 100m) 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 ROW were estimated as  $D \times A$  where D is the density of trees per hectare and A, the total area of ROW in hectares ( $A = L \times W / 10$  where L is the length of the pipeline in kilometers and W, the width of the ROW in meters). Within the quadrat shrubs and herbs were enumerated by a random walk. Specimens of plants whose identity can not be confirmed were collected and preserved following standard methods and identified subsequently using Gamble (1987), Jain and Rao (1983), Nair and Shastri (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 10 Km in perpendicular distance, were marked on the map and surveyed laying quadrats as in the above.

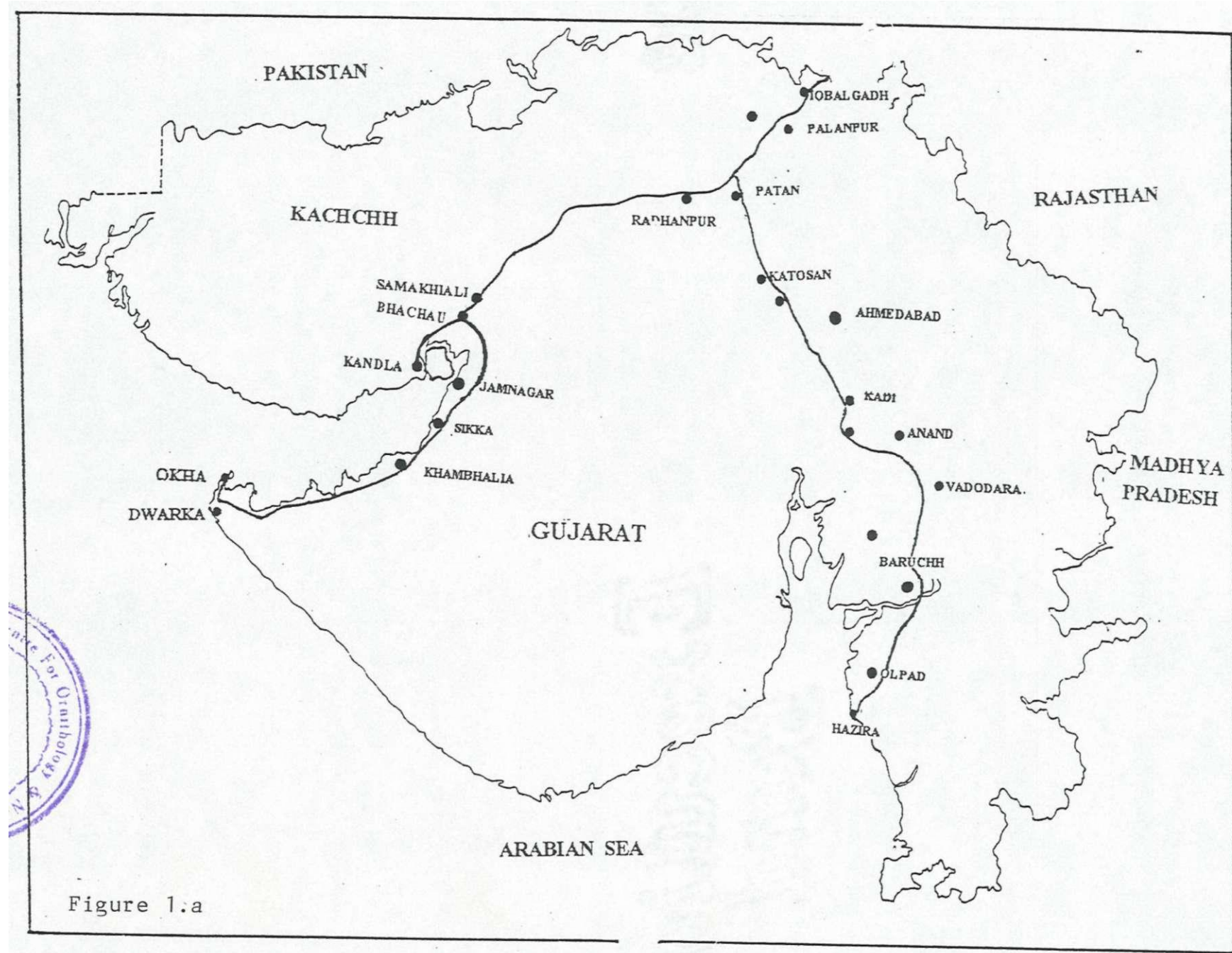


Figure 1.a

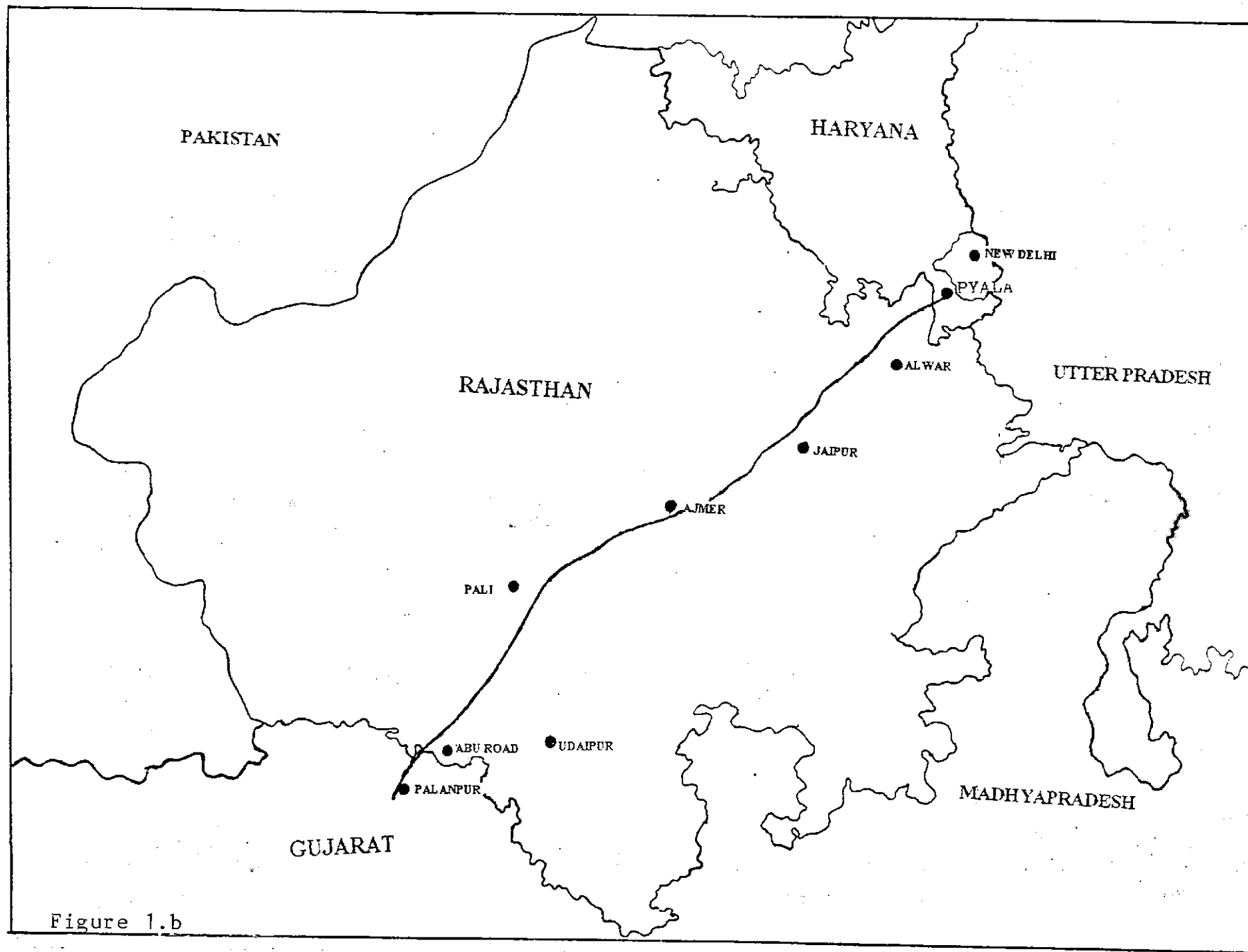


Figure 1.b

At each sampling sites all animal species encountered and also the signs of others present were recorded. Those which are likely to be present based on recent literature and information from the local wildlife experts and Forest Department officials were also recorded. In coastal areas and backwaters, along the environs of the pipeline route, all the marine organisms including algae were identified and in cases where identification was doubtful specimens were collected, preserved and confirmed later. The list of endangered species encountered was prepared based on the Wildlife Protection Act, 1972 (Anonymous 1991, Upadhyay 1995, Chaturvedi and Chaturvedi 1996). 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 use of land. All the sites were graded for their ecological sensitivity based on various characteristics (Table 1, Usher 1986, Spellerberg 1992), such as number of endangered species present in the locality and legal status; whether the area is a Wildlife Sanctuary, National Park, or an already known ecologically sensitive area.

| Table 1. Grading pattern for assessment of ecological sensitivity of an area |   |                   |
|--|---|-------------------|
| Parameter  |   | Grade / Weightage |
| Wildlife importance  | Number of endangered* species (1)           | 1                 |
|  | Number of endangered species (2-5)          | 2                 |
|  | Number of endangered species (6 -10)        | 3                 |
|  | Number of endangered species (more than 10) | 4                 |
| Legal Status   | Agricultural land                           | 1                 |
|  | Reserve Forest / Wetland                    | 2                 |
|  | Wildlife Sanctuary                          | 3                 |
|  | National Park                               | 4                 |
| Note: * Species included in Schedule I & II of Wildlife Protection Act, 1972 |   |                   |

#### 4.0 OBSERVATIONS

Altogether seventy localities, at an approximate interval of 25 Km, in the entire stretch of the pipeline route were marked on the toposheets (Scale 1:50000) and sampled for fauna and flora (Appendix I). In addition to these, certain locations in Marine National



Park, Khijadia Bird Sanctuary, Wild Ass Sanctuary near Adesar, Jessor Sloth Bear Sanctuary (Plate 3 a & b and 4 a & b) and Sumer Wildlife Sanctuary, were visited and examined for flora and fauna.

#### 4.1 LAND USE ALONG THE ROUTE

Almost 86 % of the sampled area was agricultural lands (Plate 5 a & b). Coastal area and human habitations were only 3 and 4% respectively. 7 % was waste-land with neither forest nor agriculture (Table 2). The major crops, along the route of the pipeline in south Gujarat where water is sufficiently available, are sugar cane, vegetables and wheat. In the Okha - Kandla sector, the major crops are groundnut, cotton and fodder grass. In Samakhiali - Jessor sector it is cotton, castor oil, fodder grass, wheat and groundnut. In the Rajasthan and Haryana sectors of the pipeline route wheat, mustard, cotton, maize and gram are the dominant crops (Appendix I).

| Table 2. Land type and use along the route of the pipeline |               |            |
|--|---------------|------------|
| Land category  | Sample points | Percentage |
| Agricultural land  | 40            | 57.1       |
| Agriculture + Wasteland                                    | 16            | 22.8       |
| Agriculture + Scrub Forest                                 | 4             | 5.7        |
| Wasteland  | 5             | 7.1        |
| Human settlement   | 3             | 4.3        |
| Mudflats (marine)  | 2             | 2.9        |
| Total  | 70*           |            |
| Note: * Gujarat 44, Rajasthan 24 and Haryana 2             |               |            |

#### 4.2 FLORA

Two hundred and thirty one species of flowering plants comprising 66 species of trees, 36 of shrubs, 14 of climbers and 115 of herbs were recorded along the path of the pipeline and its environs (Appendix II - V). While in Gujarat part of the route 207 species were seen, in Rajasthan part it was 173 (Table 3) and in Haryana, only 38. The low number in Haryana is mainly because the length of the pipeline running

through the state is only about 50 km. The above numbers of floral species do not suffice for any comparison with the overall floral composition of the respective states, because of the difference in the length of the pipeline and number of sampling sites among the states. No rare or endangered or threatened species of plants were located along the route.

| Table 3. Number of plants recorded along the route of the pipeline |         |           |         |
|--|---------|-----------|---------|
| Plant category   | Gujarat | Rajasthan | Haryana |
| Trees  | 56      | 56        | 15      |
| Shrubs   | 31      | 26        | 5       |
| Climbers   | 13      | 7         | 2       |
| Herbs  | 107     | 84        | 16      |
| Total  | 207     | 173       | 38      |

A large proportion of the total plant species reported to be present in these states and regions was not encountered during the survey along the route. For example, Gujarat is reported to have 12.9 % of the flora of the country; 2198 species of plants belonging to 902 genera (Gujarat Ecology Commission 1996). Although the south Gujarat region is richer in flora than the other regions of the state, the low number of species spotted along the route of pipeline is low because; i) the pipeline mostly traverses agricultural areas, and ii) many of the herbs which are annuals would have completed their annual cycle and were not present during the period of the survey. The richness in floral species in South Gujarat reported elsewhere (Gujarat Ecology Commission 1996) is mainly because of the Dangs, northern most extension of western ghats. The proposed route does not cross the Dangs and hence, the area has a low floral species diversity.

#### 4.3 STATUS OF FOREST

No Wildlife Sanctuary or National Park, is present along the route of the pipeline. However, at about 5 - 10 km distance from the route Marine National Park (Okha), Khijadia Bird Sanctuary (Jamnagar), Wild Ass Sanctuary (Adesar), Jessor Sloth Bear Sanctuary (Iqbalgadh, Palanpur) and Sumer Wildlife Sanctuary are situated (Table 4).

A number of reserve forests are also situated at a distance of less than 25 km from the route. The major forest type in these areas are open or dense scrubs.

| Table 4. National Parks / Sanctuaries in the environs of the pipeline |                                |  |
|---|--------------------------------|--|
| Route of the pipeline   |                                | National Parks / Sanctuaries   |
| Zone I: Hazira - Patan  |                                |  |
|   | Sector i: Hazira - Sojitra     | None   |
|   | Sector ii: Sojitra - Patan     | None   |
| Zone II: Okha - Kandla  |                                |  |
|   | Sector iii: Okha - Balachadi   | Marine National Park (Okha),<br>Khijadia Bird Sanctuary (5-10 Km )     |
|   | Sector iv: Balachadi - Kandla  | Wild Ass area (5-10 Km)  |
| Zone III: Samakhiali - Jessor   |                                |  |
|   | Sector v: Samakhiali- Jessor   | Wild Ass Sanctuary (5-10 Km),<br>Jessor Sloth Bear Sanctuary (5-10 Km) |
| Zone IV: Abu Road - Pyala   |                                |  |
|   | Sector vi: Abu Road - Haripur  | Sumer Wildlife Sanctuary (5-10 Km)                                     |
|   | Sector vii: Haripur- Naiwala   | None   |
|   | Sector viii: Naiwala - Tapukda | None   |
|   | Sector ix: Tapukda - Pyala     | None   |

The route also crosses a few perennial and seasonal streams and rivers of which Narmada and Mahi are the major ones. The other rivers across the pipeline route are Dhabhar, Vatrak, Sabarmati, Pushpavati, Saraswati, Khari nadi, Banas, Sukri and Machu, of which many get dry in summer. Wetlands such as Traj near Kheda, Thol near Ahmedabad, Santalpur wetland, Sihan reservoir, Mudflats and coastal areas near Okha and Chhaparwara tank in Jaipur district also lie within a few kilometers of the route. Apart from these, several village ponds of more than one hectare in size are present in the vicinity of the route.

#### 4.4 MAJOR TREES ALONG THE RIGHT OF WAY

*Acacia nilotica*, *Acacia leucophloea*, *Azadirachta indica*, *Acacia catechu* and *Prosopis*



were the numerically dominant trees on the route (Table 5). 2  
 encountered were *Acacia nilotica*, while 23.4 % were *Prosopis juliflora*.  
*Prosopis* were large thickets unlike the other species. The mean  
 varied between 1.4 and 17 (Table 6). The tree density, as  
 erably lower than that in certain protected forests in the enviro  
 ndix VI a & b, VII). The sector viii (zone IV, Rajasthan) has t  
 y and sector iv (zone II) in Gujarat has the lowest. The second  
 n sector II.

Table 5. Dominance of tree species along the pipeline route

|   | Species                   | Perce |
|---|---------------------------|-------|
| 1 | <i>Acacia nilotica</i>    | 2     |
| 2 | <i>Prosopis juliflora</i> | 23    |
| 3 | <i>Acacia leucophloea</i> | 1     |
| 4 | <i>Azadirachta indica</i> | 7     |
| 5 | <i>Acacia catechu</i>     | 7     |

te: \* mostly large thickets

Table 6. Metrics of trees in various sectors along the pipeline ro

|                           | Sector |       |       |     |       |       |       |   |
|---------------------------|--------|-------|-------|-----|-------|-------|-------|---|
|                           | i      | ii    | iii   | iv  | v     | vi    | vii   |   |
| Mean number of trees / ha | 5.4    | 16    | 2.1   | 1.4 | 11.2  | 8     | 15.2  |   |
| Mean GBH (cm)             | 82     | 65    | 60    | 50  | 53    | 92    | 67    |   |
| Mean DBH (cm)*            | 26     | 20    | 20    | 16  | 18    | 30    | 21    |   |
| Mean total height (m)     | 7.5    | 6.5   | 3.8   | 3.4 | 4.1   | 9.3   | 6.8   |   |
| Total number of trees     | 3,240  | 8,400 | 1,260 | 840 | 9,240 | 5,400 | 9,120 | 1 |

\*following the relation  $DBH/GBH = 0.3182$ . Hence, the values are overestimate beca  
 are never perfectly cylindrical and  $DBH/GBH$  is mostly  $< 0.3182$  (Chaturvedi and Kha

Not many large trees were encountered along the route. The average G  
 in various sectors varied between 50-112 cm. The overall average GBH  
 route was only 72 cm and the total height 6 m. More than 70% of the tre  
 <100 cm GBH class (Table 7) and 50 - 96 % were in <7.5 m height cl



Altogether around 49000 trees, of which 23 % (around 11000) are large thickets of *Prosopis juliflora*, are estimated to be uprooted along the route if 30 meter wide ROW is to be cleared. Number of trees to be uprooted is highest in sector viii and lowest in sector iv. Among the trees to be uprooted the number of commercially valuable trees is very less, since the average GBH is 72 cm only. The wood / timber generated from the uprooted trees will be mostly fuel wood / miscellaneous timber because of the low GBH. Hence, the commercial value of the uprooted trees is comparatively low.

| Table 7. GBH class of select species of trees along the pipeline route |                     |           |            |         |
|--|---------------------|-----------|------------|---------|
| Species  | GBH class (Percent) |           |            |         |
|  | < 50 cm             | 51-100 cm | 101-150 cm | >150 cm |
| <i>Azadirachta indica</i>  | 17                  | 63        | 20         | 0       |
| <i>Acacia nilotica</i>   | 17                  | 54        | 21         | 8       |
| <i>Acacia leucophloea</i>  | 33                  | 59        | 7          | 0       |
| <i>Acacia catachu</i>  | 36                  | 51        | 12         | 1       |

| Table 8. Height class of select species of trees along the pipeline route |                        |          |       |
|---|------------------------|----------|-------|
| Species   | Height Class (Percent) |          |       |
|   | < 5 m                  | 5 - 10 m | >10 m |
| <i>Azadirachta indica</i>   | 29                     | 59       | 12    |
| <i>Acacia nilotica</i>  | 49                     | 36       | 13    |
| <i>Acacia leucophloea</i>   | 35                     | 52       | 12    |
| <i>Acacia catachu</i>   | 70                     | 30       | 0     |

#### 4.5 STATUS OF THE WILDLIFE

Altogether 248 species of vertebrates (excluding fish) comprising several species of birds (210), mammals (16), reptiles (17) and amphibians (5) were recorded during the survey (Table 9, Appendix VIII - XI). As the present survey was conducted at a rapid pace, many species reported to be present in the area could not be encountered in the field. A perusal of recent literature (Ali and Ripley 1983, Daniel 1983, Prater 1993, Shah *et al* 1995, Vyas and Patel 1991, Vyas 1996) and discussion with local experts suggests that at least another 51 species should be present in and around the route.

| Table 9. Number of vertebrate taxa recorded along the pipeline route and its environs |                 |                              |       |
|---|-----------------|------------------------------|-------|
| Taxa  | Species sighted | Species likely to be present | Total |
| Amphibians  | 5               | 2                            | 7     |
| Reptiles  | 17              | 14                           | 31    |
| Birds   | 210             | 24                           | 234   |
| Mammals   | 16              | 11                           | 27    |
| Total   | 248             | 51                           | 299   |

#### 4.6 COASTAL AND MARINE FLORA AND FAUNA

Marine flora and fauna were observed mainly near Okha (Okha, Mithapur and Chandri reef - Appendix XII). Besides this, in Surajbarii and Kandla a few intertidal forms were observed in the back waters. 12 species of marine algae, belonging to Rhodophyceae, Chlorophyceae, Florideophyceae and Pheophyceae were seen in these areas. The coast around Kandla port is sandy and abundant with bivalves and gastropods which are unique to sandy substratum. In this area bivalves such as *Katelysia opima*, *Donex cunniatus* and *Cardium sp.* and gastropods such as *Turritella sp.*, *Babylonia spirata* and *Rapana bulbosa* are predominant, whereas at the Surajbarii coast which is muddy, intertidal organisms such as crabs (*Uca* and Ghost Crab *Ocypode sp.*) outnumber gastropods such as *Cerithidea sp.* and *Telescopium sp.* The crab species are known to prefer muddy substratum. Certain parts of Surajbarii area which experience periodical tidal flushing are characterized by forms such as mud skippers (*Periopthalmus sp* and *Boliopthalmus sp*) and intertidal crab *Uca annulipus*. Only one species of gastropod, *Telescopium sp.* was seen in this area. The large expanse of salt pans may be one of the major reasons for the poor species richness.

The Chandri reef which is located close to Okha exhibits high diversity of marine fauna. This island is characterized by sandy coast intermixed with hard substratum of coral rocks. The common organisms here are gastropods, bivalves, cephalopods, crustaceans and echinoderms. Five species of marine corals, 31 species of

gastropods, 13 species of bivalves, four species of crustaceans, six species of cephalopods, three species of echinoderms and 11 species of marine algae were observed in this area. The area is also abundant with many species of coral fishes. The crustaceans, especially crabs were low in number. Certain gastropods (*Thais lapellus*, *Turbo sp.*) and bivalves (*Crossostrea sp.*) which are unique to rocky substratum were also observed in the coral rocks. In the Marine National Park, endangered species such as Dugong and Dolphin are present (Nambiar *et al* 1995).

#### 4.7 SCHEDULE I & II SPECIES

Schedule I & II of the Wild Life Protection Act (1972) list a number of wildlife species in the country which deserves total protection. 15 species of reptiles, 9 species of birds and 15 species of mammals (Table 10), which are present in the environs of the proposed pipeline are included in the schedules I & II of Wildlife Protection Act 1972 (Anonymous 1991). The distribution of schedule I & II animals along the route and the environs of various sectors was more or less similar (15 to 22 numbers). Of the various species listed in the table 10, the Dugong and Dolphin are seen only in the Marine National Park, and hence, the laying of pipeline does not pose any threat to them. Great Indian Bustard and Lesser Floricorn are occasionally sighted approximately 15-20 km south of Khambaliya in Gujarat. Great Indian Bustard is a resident species while the Lesser Floricorn visits the area with the advent of Monsoon and is present upto October. Houbara Bustard is reported in the Little Rann of Kutch during 1991-92. The species arrives towards the end of October and leaves in March. The pipeline route does not pose any threat to these species. However, minor mitigatory measures, as discussed in section 4.10, if enforced will further reduce any disturbances. Most of the other species, especially birds and mammals, are highly mobile and common elsewhere. They are also not observed to be prone to short term minor disturbances, such as movement of people, cutting a common species of tree which is not a traditional roosting or nesting site and digging a shallow and narrow trench in small stretch of the habitats.

| Table 10. WPA Schedule I & II species found in various sectors along the pipeline route and its environs |                                       |              |        |    |     |    |   |    |     |      |    |
|--|---------------------------------------|--------------|--------|----|-----|----|---|----|-----|------|----|
| Species*   |                                       | WPA Schedule | Sector |    |     |    |   |    |     |      |    |
|  |                                       |              | i      | ii | iii | iv | v | vi | vii | viii | ix |
| Reptiles   | Olive Ridley <sup>#</sup>             | I            | -      | -  | ?   | -  | - | -  | -   | -    | -  |
|  | Green Turtle <sup>#</sup>             | I            | -      | -  | +   | -  | - | -  | -   | -    | -  |
|  | Hawksbill <sup>#</sup>                | I            | -      | -  | ?   | -  | - | -  | -   | -    | -  |
|  | Indian Flapshell Turtle <sup>\$</sup> | I            | +      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Indian Roof Turtle <sup>\$</sup>      | I            | +      | -  | -   | -  | - | -  | -   | -    | -  |
|  | Common Monitor <sup>#</sup>           | II           | +      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Desert Monitor <sup>#</sup>           | II           | -      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Spiny Tailed Lizard                   | II           | -      | -  | +   | +  | + | -  | -   | -    | -  |
|  | Indian Chameleon                      | II           | +      | ?  | ?   | -  | - | -  | -   | -    | -  |
|  | Mugger                                | I            | +      | ?  | -   | -  | - | -  | -   | -    | -  |
|  | Indian Python <sup>#</sup>            | I            | +      | -  | -   | -  | - | +  | +   | +    | +  |
|  | Common Rat Snake                      | II           | +      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Checkered keelback                    | II           | +      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Indian Cobra                          | II           | +      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Russell's Viper                       | II           | +      | +  | +   | +  | + | +  | +   | +    | +  |
| Birds  | White Stork                           | I            | +      | +  | +   | +  | + | -  | -   | -    | -  |
|  | Spoonbill                             | I            | +      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Indian Shikra                         | I            | +      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Sparrow-hawk                          | I            | +      | +  | -   | -  | - | +  | -   | -    | -  |
|  | Osprey <sup>\$</sup>                  | I            | +      | +  | +   | ?  | - | +  | -   | -    | -  |
|  | Peafowl <sup>\$</sup>                 | I            | +      | +  | +   | +  | + | +  | +   | +    | +  |
|  | Great Indian Bustard <sup>#</sup>     | I            | -      | -  | +   | -  | + | -  | -   | -    | -  |
|  | Houbara Bustard <sup>#</sup>          | I            | -      | -  | +   | +  | + | -  | -   | -    | -  |
|  | Lesser Florican <sup>\$</sup>         | I            | -      | -  | +   | -  | + | -  | -   | -    | -  |



|   |                               |    |    |    |    |    |    |    |    |    |    |
|---|-------------------------------|----|----|----|----|----|----|----|----|----|----|
| Mammals   | Rhesus Macaque                | II | -  | -  | -  | -  | -  | -  | +  | +  | +  |
|   | Common Langur                 | II | +  | +  | +  | +  | +  | +  | +  | +  | +  |
|   | Leopard <sup>\$</sup>         | I  | -  | -  | -  | -  | -  | +  | -  | -  | -  |
|   | Jungle Cat                    | II | ?  | +  | +  | +  | +  | +  | +  | +  | +  |
|   | Caracal <sup>#</sup>          | I  | -  | -  | -  | ?  | -  | ?  | -  | -  | -  |
|   | Small Indian Civet            | II | +  | ?  | ?  | ?  | -  | +  | +  | +  | +  |
|   | Wolf <sup>\$</sup>            | I  | -  | ?  | ?  | ?  | ?  | ?  | -  | -  | -  |
|   | Jackal                        | II | +  | +  | +  | +  | +  | +  | ?  | ?  | ?  |
|   | Indian Fox                    | II | -  | ?  | ?  | ?  | ?  | ?  | -  | -  | -  |
|   | Smooth Indian Otter           | I  | +  | -  | -  | -  | -  | -  | -  | -  | -  |
|   | Asiatic Wild Ass <sup>#</sup> | I  | -  | -  | -  | +  | +  | -  | -  | -  | -  |
|   | Chinkara <sup>\$</sup>        | I  | -  | -  | -  | +  | +  | -  | -  | -  | -  |
|   | Blackbuck <sup>\$</sup>       | I  | -  | -  | -  | +  | +  | -  | -  | -  | -  |
|   | Sea Dolphin                   | I  | -  | -  | +  | -  | -  | -  | -  | -  | -  |
|   | Dugong <sup>\$</sup>          | I  | -  | -  | +  | -  | -  | -  | -  | -  | -  |
| Total   |                               |    | 20 | 16 | 22 | 20 | 21 | 18 | 15 | 15 | 15 |
| Note: WPA = Wild life protection act, 1972, * Inclusive of probable species, + Present, - Absent, ? Doubtful, # Endangered according to Zoological Survey of India (1994), \$ Vulnerable according to Zoological Survey of India (1994) |                               |    |    |    |    |    |    |    |    |    |    |

#### 4.8 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 legal status of the area suggests that all the sectors on the route are comparatively low in ecological sensitivity (Table 11). Only sector III has a National Park (Marine) in its environs (Table 12). The boundary of the National Park is loosely defined (Nambiar *et al* 1995) and hence, actual distance from the route of pipeline could not be ascertained. The closest locality of the National Park may be the Chandri reef located at a perpendicular distance of around 5 Km from the path. Sectors iv, v and vi have reserve forests in their environs. All the sectors have wetlands or village ponds (Plate 6a). However, none of them are in such a close proximity to the route to have any impact during or after laying the pipeline.



Plate 6a. A small wetland (approximately 1 ha) in the environs of the pipeline.



Plate 6b. Stone marker demarcating the ROW of an existing pipeline near Hazira.

| Table 11. Ecological Sensitivity of the various sectors along the pipeline route |                   |    |     |    |   |    |     |      |    |
|--|-------------------|----|-----|----|---|----|-----|------|----|
| Parameter  | Sector            |    |     |    |   |    |     |      |    |
|  | i                 | ii | iii | iv | v | vi | vii | viii | ix |
|  | Grade / weightage |    |     |    |   |    |     |      |    |
| Presence of Schedule I & II species  | 4                 | 4  | 4   | 4  | 4 | 4  | 4   | 3    | 3  |
| Agricultural Land  | 1                 | 1  | 1   | 1  | 1 | 1  | 1   | 1    | 1  |
| Wetland  | 2                 | 2  | 2   | 2  | 2 | 2  | 2   | 0    | 0  |
| Reserve Forest   | 0                 | 0  | 2   | 2  | 2 | 2  | 0   | 0    | 0  |
| Wildlife Sanctuary   | 0                 | 0  | 0   | 0  | 0 | 0  | 0   | 0    | 0  |
| National Park  | 0                 | 0  | 0   | 0  | 0 | 0  | 0   | 0    | 0  |
| Total grade / weightage  | 7                 | 7  | 9   | 9  | 9 | 9  | 7   | 4    | 4  |

| Table 12. Locations of ecological importance in the environs of the pipeline route |                                 |                 |
|--|---------------------------------|-----------------|
| Description  | Area of ecological significance |                 |
|  | on the route                    | in the environs |
| Sector i: Hazira - Sojitra   | -                               | -               |
| Sector ii: Sojitra - Patan   | -                               | -               |
| Sector iii: Okha - Balachadi   | -                               | +               |
| Sector iv: Balachadi - Kandla  | -                               | +               |
| Sector v: Samakhiali - Jessor  | -                               | +               |
| Sector vi: Abu Road - Haripur  | -                               | +               |
| Sector vii: Haripur - Naiwala  | -                               | -               |
| Sector viii: Naiwala - Tapukda   | -                               | -               |
| Sector ix: Tapukda - Pyala   | -                               | -               |
| Note: + Present, - Absent  |                                 |                 |

#### 4.9 IMPACT OF THE PIPELINE

The major facilities associated with gas pipeline are the receiving, despatch, control 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 16 inch steel pipes to transport LPG from Hazira, Okha and Kandla, in Gujarat to Pyala in Haryana. The pipeline is to be laid in 1 meter deep trenches in the middle of a 30 meter wide ROW to be acquired by GAIL. The total area of the entire ROW is about 4800 ha. After laying the pipes the trenches are to be filled and covered and the land given back to the owners. The ROW is demarcated by markers, at short intervals, indicating the path and the boundary of the ROW (Cover and Plate 6b). Regular use of the land by the owners, except planting of large trees and construction of concrete structures, is allowed on the ROW.

Generally the major impacts of any underground pipeline project during the construction are; i) felling of trees in the ROW, 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 ROW 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 such as wildlands 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 ROW. Likewise, the chance of invasion of the ROW 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 ROWs 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 about 38000 trees (about 24 trees per kilometer stretch of the ROW), mainly *Acacia* and *Azadirachta* will be uprooted along the ROW during the installation of the pipeline. Nearly 11000 large thickets and trees of *Prosopis juliflora*, present along the route, also are likely to be uprooted. 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. 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).

The proposed pipeline passes close to the coast at Okha and Kandla (approximately 500 m distance). At Salaya it is almost 2 km away from the coast and at Nana Asota, 4 km. The coast of Okha is rich with marine fauna such as gastropods, bivalves, crustaceans, cephalopods, echinoderms and marine algae. The coast in this region is mostly sandy with sporadic coral rock outcropping and a predominant distribution of sandy shore animals. All these marine fauna are intertidal and do not move beyond 10 to 15 meters from the High Tide Level (HTL). However, certain marine crabs like Ghost Crab (*Ocypode sp.*) are capable of moving up to a distance of 200 meters. Marine turtles which come to the shore during night hours for egg laying are also known to move a few hundred meters from the HTL. The pipeline passes well beyond the HTL and the Coastal Regulation Zone (CRZ - the land between HTL and low tide level and the stretch influenced by tidal action up to 500m in the landward side from the HTL - Anonymous 1991b) in this stretch of coast. Hence, the intertidal organisms are unlikely

to get affected. In certain areas in Okha and Kandla the pipeline although passes nearby tidal marshes which are inhabited by highly adaptable organisms such as mud skippers, fiddler crabs, and gastropods such as *Cerithidea sp.* minor disturbance in the physical habitat may not have notable impact on these species.

#### **4.10 MITIGATORY MEASURES**

##### **Minimizing the disturbance**

The laying of pipeline need to be completed within a short span of time, especially in areas such as Rann and places close to forests. The main mating period of Wild Ass is during June to January and foaling during July to August. During these periods disturbance to the species has to be minimum. Summer and pre-monsoon periods (April - June) are advisable for construction 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. The construction can be continued in the stretch between Ajmir and Pyala during anytime of the year.

During the construction the labour force need to be instructed not to cause any damage or disturbance to forest and wildlife. 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 planning should be done to meet emergencies.

##### **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*, *Syzygium sp.* 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 ten 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 raise sufficient saplings.

The afforestation scheme may include the following programmes;

i) Supply of saplings to local villagers and the land owners; Saplings, approximately ten 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 along the route of the pipeline; A large portion of the ROW is passing through open scrub. Simultaneously with the clearing of the ROW, 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 distance of 25 km from the ROW, are fit for implementing an afforestation programme. However, the programme should 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.

#### **4.11 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 1991). 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, further to the discussion in Section 4.9, of the "with project" scenario are acquiring of ROW by the GAIL, clearing of the trees along the ROW, 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. 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 LPG 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 gas 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 minor regulations. Except for the markers, which are erected at frequent intervals, the ROW 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 way, 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 a stretch of 1600 km, similar habitat is available adjacently, and 86 % 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 cut in each location is low. In a long term perspective the tree plantation programme as discussed in section 4.10 can help to compensate for these losses.

In the case of the "without project" scenario the positive aspect is that the trees along the ROW will remain intact, the habitat loss, even though minor, will be nil and the source of fuel wood and fodder may remain unaltered. These benefits, in contrast to the "with project" scenario, is meagre. The LPG as fuel relieves pressure from the domestic and industrial users on fuel wood and other sources of fuel. LPG is more environment friendly than other commonly used fuels. Relieving the pressure on fuel wood may save vast areas of greenery around the human habitations and forests.

## **5.0 CONCLUSIONS**

- 1) Gas Authority of India Limited (GAIL) proposes to lay a 1600 Km long pipeline, traversing three states, namely Gujarat, Rajasthan and Haryana, to transport Liquefied Petroleum Gas (LPG). The present study covers the impact of the project on flora and fauna.
- 2) The entire route of the pipeline was examined following sample survey method. Quadrat of one hectare was marked along the route at an interval of approximately 25 Km for intensive studies of flora and fauna.
- 3) About 86 % of the sampled area, along the route, was agricultural lands. Coastal area and human habitations were only 3 and 4% respectively of the surveyed area. 7 % of the sampled area was waste-land with neither forest nor agriculture.

- 4) 231 species of flowering plants were recorded along the path of the pipeline or in its immediate surroundings. No rare, endangered or threatened species of plants were located along the route.
- 5) No notified Sanctuary or National Park, is present along the pipeline route.
- 6) *Acacia nilotica*, *Acacia leucophloea*, *Azadirachta indica*, *Acacia catechu* and *Prosopis juliflora* were the numerically dominant trees along the route. About 38000 trees (excluding *Prosopis juliflora*) is estimated to be uprooted along the route if 30 meter wide ROW is cleared.
- 7) As an environmental conservation measure, GAIL should envisage provisions for afforestation programme to compensate for 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
- 8) 248 species of vertebrates (excluding fish) 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 in 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.
- 9) An attempt to grade the 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 all the sectors on the route are comparatively low in ecological sensitivity. However, the comparatively low grade of ecological sensitivity / significance assigned to the various sectors of the route has to be judged from



the perspective of the low ecological impact from the installation of an underground pipeline of small diameter.

10) 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 which have low probability.

11) In the stretch along the coastal area the pipeline passes well beyond the high tide level and the coastal regulation zone and hence, the marine and intertidal organisms are unlikely to be affected.

12) Resident population of Wild Ass is reported to be present in Rann near Surajbarii and Adesar. Hence, in this sector the construction has to be completed as fast as possible to minimize disturbance to these endangered animals. Similarly, construction work should be completed at a faster pace in sectors of Jessor Sloth Bear Sanctuary and Sumer Wildlife Sanctuary although these sanctuaries are situated few kilometers away from the pipeline.

13) Summer and pre-monsoon period (April - June) 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 the monsoon and winter the number of bird species will be high in the area.

14) The forest types of the Jessor Sloth Bear Sanctuary and Sumer Wildlife Sanctuary are Dry deciduous and Scrub which are prone to fire during dry season and hence, precautionary measures should be taken during construction.

## **ACKNOWLEDGEMENTS**

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

Prof. Bony Pilo, M. S. University, Vadodara

Dr. Balsubramanian, P., Terrestrial Ecology Division, SACON, Coimbatore

Dr. Das, H. S., Wetland Division, SACON, Coimbatore

Director, Marine National Park, Jamnagar

Divisional Forest Officer, Palanpur

Mr. Fotedar, A. K., Gas Authority of India limited, Hazira, Gujarat

Mr. Hemu Bhai, Okha, Gujarat

Dr. Jayaraj, R S C., IFS, Institute of Forest Genetics and Tree Breeding, Coimbatore.

Dr. Johnson, E., SACON, Coimbatore

Mr. Khalsi, G. K., Gas Authority of India limited, New Delhi

Mr. Khan, J. A., Engineers India Limited, New Delhi

Mr. Krishnan, K. S., Engineers India Limited, New Delhi

Mr. Lavkumar Kachhar, Kuchch, Gujarat

Dr. Muralidharan, S., Ecotoxicology Division, SACON, Coimbatore

Dr. Nair, V. J., Botanical Survey of India, Coimbatore

Dr. Nita Shah, M.S. University, Vadodara

Prof. Panicker, R. G., MS University, Vadodara

Dr. Pimparkar, P. M., Engineers India Limited, New Delhi

Mr. Pratap Singh, Gas Authority of India, New Delhi

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

Dr. Siddiqui, T. A., Engineers India Limited, New Delhi

Dr. Sivakumar, R., Environmental Impact Assessment Division, SACON, Coimbatore

Dr. Stephen, D., SACON, Coimbatore

Dr. Vijayan, V. S., SACON, Coimbatore

Dr. Urfi, A. J., Sundervan, Ahmedabad

Dr. Vyas R, Vadodara Zoo, Vadodara

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| Appendix I. Sampling locations along the pipeline route and its environs for survey of fauna and flora |              |                 |                        |   |                  |
|--|--------------|-----------------|------------------------|---|------------------|
| No.  | Nearest Town | Nearest Village | Land use               | Major Crops                                   | Map*             |
| Zone I: Hazira- Patan (Gujarat) - approximately 375 km   |              |                 |                        |   |                  |
| Sector i - approximately 200 km  |              |                 |                        |   |                  |
| G1   | Hazira       | Olpad           | Agriculture            | Sugar Cane                                    | 46C/12           |
| G2   | Hazira       | Syan            | Agriculture            | Sugar Cane                                    | 46C/16           |
| G3   | Ankleshwar   | Kosampa         | Agriculture, wasteland |   | 46C/15           |
| G4   | Ankleshwar   | Dhamroad        | Agriculture            | Cotton, vegetables                            | 46C/14           |
| G5   | Baruch       | Narmada river   | Agriculture            | Sugar Cane                                    | 46C/14           |
| G6   | Rajapardi    | Matter          | Agriculture            |   | 46B/16           |
| G7   | Padra        | Anklav          | Agriculture            | Tobacco, Vegetables, Orchard                  | 46B/16           |
| G8   | Borsad       | Borsad          | Agriculture            | Wheat, Tobbaco, Vegetables, Fodder            | 46B/15           |
| G9   | Anand        | Sojitra         | Agriculture            | Wheat, Tobbaco, Vegetables, Fodder            | 46B/14           |
| Sector ii - approximately 175 km   |              |                 |                        |   |                  |
| G10  | Kheda        | Naika           | Agriculture            | Wheat, Tobbaco, Vegetables                    | 46B/10           |
| G11  | Amdavad      | Sarkhej         | Wasteland              | -   | 46B/9            |
| G12  | Amdavad      | Thol            | Agriculture            | Wheat   | 46B/5            |
| G13  | Kadi         | Detroj          | Agriculture, Wastland  | Cotton, Castor                                | 46A/8            |
| G14  | Mehsana      | Jotana          | Agriculture            | Castor, cotton, Wheat, Chilli                 |                  |
| G15  | Mehsana      | Palaj           | Wastland               | -   | 46A/3            |
| G16  | Patan        | Chansma         | Agriculture            | Castor, Cotton, Wheat, Barlie, Chilli, Fodder | 46A/2            |
| Zone II: Okha - Kandla (Gujarat) - approximately 400 km  |              |                 |                        |   |                  |
| Sector iii - approximately 200 km  |              |                 |                        |   |                  |
| G17  | Okha         | Okha            | Wastland               | -   | 41F/3            |
| G18  | Mithapur     |                 | Dry scrub              | -   | 41F/3            |
| G19  | Dwarka       | Vasai           | Dry scrub              | -   | 41F/3            |
| G20  | Dwarka       | Shrinagar       | Wastland, Agriculture  | Groundnut, Corn                               | 41F/4&<br>41B/16 |
| G21  | Khambhalia   | Nana Asota      | Agriculture            | Chilli, Ground nut, Wheat                     | 41F/7&<br>41F/8  |
| G22  | Salaya       | Timbdi          | Agriculture            | Corn, Fodder                                  | 41F/11           |
| G23  | Sikka        | -               | Wastland, Agriculture  | Fodder, Castor                                | 41F/15           |
| G24  | Jamnagar     | -               | Agriculture            | Cotton  | 41J/3            |
| G25  | Jodiya       | Balachadi       | Agriculture            | Cotton, Castor                                | 41J/2            |

|   |            |              |                         |                                  |        |
|---|------------|--------------|-------------------------|----------------------------------|--------|
| Sector iv - approximatly 200 km   |            |              |                         |                                  |        |
| G26   | Jodiya     | Balambha     | Wasteland               | -                                | 41J/6  |
| G27   | Morbi      | Virpada      | Agriculture             | Cotton, Castor                   | 41J/9  |
| G28   | Morbi      | Machu bridge | Agriculture             | Cotton, Castor                   | 41I/16 |
| G29   | Surajbari  | -            | Tidal Mudflat           | Salt pans                        | 41I/12 |
| G30   | Samkhiyali | Adhoi        | Agriculture             | Cotton, Castor, Fodder           | 41I/11 |
| G31   | Bhachau    | Vanda        | Agriculture             | Cotton, Castor, Fodder           | 41I/7  |
| G32   | Gandhidam  |              | Wastland                | Human habitation                 | 41/4   |
| G33   | Kandla     |              | Wastland, Tidal Mudflat | Human habitation                 | 41I/4  |
| Zone III. Samkhiali - Jessor (Gujarat) - approximatly 275 km            |            |              |                         |                                  |        |
| Sector v - approximatly 275 km  |            |              |                         |                                  |        |
| G34   | Adesar     | Padeempur    | Agriculture             | Cotton, Fodder                   | 41I/14 |
| G35   | Adesar     | Chanwa       | Wasteland, Agriculture  | Cotton, Castor                   | 41M/2  |
| G36   | Sanalpur   | Madhutra     | Scrub, Agriculture      | Cotton, Castor, Corn             | 41M/1  |
| G37   | Varahi     | Daladi       | Scrub, Agriculture      | Cotton, Fodder                   | 41M/5  |
| G38   | Radhanpur  | Premnagar    | Agriculture, Wasteland  | Cotton, Castor, Fodder           | 41M/9  |
| G39   | Patan      | Roda         | Agriculture             | Cotton, Wheat                    | 41M/13 |
| G40   | Patan      | Charup       | Agriculture             | Castor, Fodder                   | 46A/1  |
| G41   | Palanpur   | Sasam        | Agriculture             | Wheat, Castor, Fodder            | 45D/8  |
| G42   | Palanpur   | Chadotar     | Agriculture, Wastland   | Castor                           | 45D/8  |
| G43   | Palanpur   | Iqbalgadh    | Agriculture             | Wheat, Castor, Cotton, Groundnut | 45D/11 |
| G44   | Palanpur   | Jessor       | Agriculture             | Wheat, Tomato, Castor            | 45D/11 |
| Zone IV. Abu Road - Pyala (Rajasthan and Haryana) - approximatly 675 km |            |              |                         |                                  |        |
| Sector vi - approximatly 225 km   |            |              |                         |                                  |        |
| R1  | Abu Road   | Abu Road     | Sparse habitation       | -                                | 45D/15 |
| R2  | Watera     | Watera       | Agriculture             | Castor, Cotton                   | 45D/14 |
| R3  | Pindwada   | Pindwada     | Agriculture             | Wheat                            | 45H/1  |
| R4  | Pindwada   | Nana         | Agriculture             | Wheat, Cotton, Grams             | 45H/1  |
| R5  | Kot        | Kot          | Agriculture             | Cotton, Wheat                    | 45G/8  |
| R6  | Desuri     | Ganthi       | Agriculture, Wastland   | Cotton                           | 45G/11 |
| R7  | Fulad      | Fulad Rd     | Wastland                | -                                | 45G/10 |
| R8  | Barr       | Haripur      | Agriculture             | Cotton, Mustard, Wheat           | 45J/4  |
| Sector vii - approximatly 200 km  |            |              |                         |                                  |        |
| R9  | Barr       | Barr         | Agriculture             | Cotton, Mustard, Wheat           | 45J/4  |
| R10   | Fatehpur   | -            | Agriculture, Wastland   | Wheat, Cotton                    | 45J/7  |
| R11   | Nasirabad  | -            | Agriculture, Wastland   | Wheat, Cotton                    | 45J/11 |

|                                   |                     |                 |                            |                                   |        |
|-----------------------------------|---------------------|-----------------|----------------------------|-----------------------------------|--------|
| R12                               | Shrinagar           | -               | Agriculture, Wastland      | Wheat, Cotton                     | 45J/15 |
| R13                               | Arain               | Arain           | Agriculture, Wastland      | Maize, Barlie, Fodder             | 45N/3  |
| R14                               | Dudu                | Kudiyala        | Agriculture, Wastland      | Wheat, Fodder                     | 45N/6  |
| R15                               | Dudu                | Kadwaka         | Agriculture, Wastland      | Wheat, Fodder                     | 45N/6  |
| R16                               | Naiwala             | Pruthrisinhpara | Agriculture, Wastland      |                                   | 45M/9  |
| Sector viii - approximatly 200 km |                     |                 |                            |                                   |        |
| R17                               | Jaipur              | Harmada         | Human habitation, Wastland |                                   | 45M/16 |
| R18                               | Manpura-m<br>acheri |                 | Agriculture, Wastland      | Wheat, Gram                       | 45M/16 |
| R19                               | Bairath Rd          | Shahpura        | Agriculture                | Wheat, Mustard, Fodder            | 45M/15 |
| R20                               | Mandha              |                 | Agriculture                | Wheat, Mustard, Fodder            | 54A/2  |
| R21                               | Bansur              |                 | Agriculture                | Wheat, Mustard, Fodder            | 54A/6  |
| R22                               | Sukhmeri            | Pehal           | Agriculture                | Wheat, Mustard, Fodder            | 54A/9  |
| R23                               | Karwar Rd           | -               | Agriculture                | Wheat, Mustard, Fodder, Gram      | 54A/9  |
| R24                               | Tapukda             | Guwalda         | Agriculture                | Wheat, Mustard, Fodder, Vegetable | 53D/16 |
| Sector ix - approximatly 50 km    |                     |                 |                            |                                   |        |
| H1                                | Sohana              | Sohana          | Agriculture, Wastland      | Orchard, Wheat                    | 53H/4  |
| H2                                | Piyala              | Piyala          | Agriculture                | Wheat                             | 53H/7  |
| Note: Map scale 1:50000           |                     |                 |                            |                                   |        |

| Appendix - II. Trees recorded along the pipeline route and environs |                                |         |           |         |
|---|--------------------------------|---------|-----------|---------|
| S.No  | Species                        | Gujarat | Rajasthan | Haryana |
| 1   | <i>Acacia catechu</i>          | +       | +         | +       |
| 2   | <i>Acacia leucophloea</i>      | +       | +         | +       |
| 3   | <i>Acacia nilotica</i>         | +       | +         | +       |
| 4   | <i>Acacia senegal</i>          | -       | +         | -       |
| 5   | <i>Aegle marmelos</i>          | -       | +         | -       |
| 6   | <i>Ailanthus excelsa</i>       | +       | +         | -       |
| 7   | <i>Albizia lebbeck</i>         | +       | +         | -       |
| 8   | <i>Anogeissus latifolia</i>    | -       | +         | -       |
| 9   | <i>Anona squamosa</i>          | +       | -         | -       |
| 10  | <i>Azadirachta indica</i>      | +       | +         | +       |
| 11  | <i>Bauhinia variegata*</i>     | +       | +         | -       |
| 12  | <i>Balanites roxburghii</i>    | +       | +         | -       |
| 13  | <i>Bambusa arundinacea</i>     | -       | +         | -       |
| 14  | <i>Borassus flabellifer</i>    | +       | -         | -       |
| 15  | <i>Butea monosperma</i>        | +       | +         | +       |
| 16  | <i>Capparis decidua</i>        | +       | +         | +       |
| 17  | <i>Capparis sepiaria</i>       | +       | +         | +       |
| 18  | <i>Callistemon viminalis</i>   | +       | +         | -       |
| 19  | <i>Carica papaya</i>           | -       | +         | -       |
| 20  | <i>Cordia wallichii</i>        | +       | +         | -       |
| 21  | <i>Cassia siamiae</i>          | +       | +         | -       |
| 22  | <i>Cassia fistula</i>          | +       | -         | -       |
| 23  | <i>Casuarina equisetifolia</i> | +       | +         | -       |
| 24  | <i>Cocos nucifera</i>          | +       | +         | -       |
| 25  | <i>Citrus aurantifolia</i>     | +       | -         | -       |
| 26  | <i>Dalbergia sissoo</i>        | +       | +         | +       |
| 27  | <i>Delonix elata</i>           | +       | +         | -       |
| 28  | <i>Diospyros montana</i>       | +       | -         | -       |
| 29  | <i>Erythrina indica</i>        | +       | +         | -       |
| 30  | <i>Eucalyptus globulus</i>     | +       | +         | +       |
| 31  | <i>Ficus aronottiana</i>       | +       | +         | -       |
| 32  | <i>Ficus benghalensis</i>      | +       | +         | -       |
| 33  | <i>Ficus infectoria</i>        | +       | +         | -       |
| 34  | <i>Ficus virens</i>            | +       | -         | -       |



|    |  |   |   |   |
|----|--|---|---|---|
| 35 | <i>Ficus religiosa</i>                 | + | + | + |
| 36 | <i>Holoptelea integrifolia</i>         | - | + | - |
| 37 | <i>Lagerstroemia parviflora</i>        | - | + | - |
| 38 | <i>Madhuca indica</i>                  | - | + | - |
| 39 | <i>Mangifera indica</i>                | + | + | - |
| 40 | <i>Melia azadirachta</i>               | + | + | - |
| 41 | <i>Melilaka sapota</i>                 | + | + | - |
| 42 | <i>Millingtonia hortensis</i>          | - | + | + |
| 43 | <i>Moringa oleifera</i>                | + | + | - |
| 44 | <i>Morinda tinctoria</i>               | + | - | - |
| 45 | <i>Parkinsonia aculeata</i>            | + | + | - |
| 46 | <i>Peltophorum pterocarpum</i>         | + | + | - |
| 47 | <i>Phyllanthus acidus</i>              | + | + | - |
| 48 | <i>Phyllanthus emblica</i>             | + | - | - |
| 49 | <i>Phoenix sylvestris</i>              | + | + | + |
| 50 | <i>Pithecellobium dulce</i>            | + | + | - |
| 51 | <i>Polyalthia longifolia</i>           | + | + | + |
| 52 | <i>Pongamia pinnata</i>                | + | + | - |
| 53 | <i>Prosopis cineraria</i>              | - | + | - |
| 54 | <i>Prosopis juliflora</i>              | + | + | + |
| 55 | <i>Psidium guajava</i>                 | + | - | - |
| 56 | <i>Salvadora oleoides</i>              | + | + | - |
| 57 | <i>Salvadora persica</i>               | + | + | - |
| 58 | <i>Syzygium cumini</i>                 | + | + | - |
| 59 | <i>Syzygium jambus</i>                 | + | + | - |
| 60 | <i>Sterculia uirens</i>                | + | + | - |
| 61 | <i>Tamarindus indica</i>               | + | + | - |
| 62 | <i>Tectona grandis</i>                 | + | + | - |
| 63 | <i>Thevetia peruviana</i>              | + | + | - |
| 64 | <i>Thespesia populina</i>              | + | - | - |
| 65 | <i>Zizyphus mauritiana / hysudrica</i> | + | + | - |
| 66 | <i>Zizyphus oenoplia</i>               | + | + | + |

| Appendix - III. Shrubs recorded along the pipeline route and its environs |                                  |         |           |         |
|---|----------------------------------|---------|-----------|---------|
| S.No  | Species                          | Gujarat | Rajasthan | Haryana |
| 1   | <i>Adhatoda vasica</i>           | +       | +         | -       |
| 2   | <i>Agave americana</i>           | +       | +         | -       |
| 3   | <i>Agave sisulana</i>            | +       | +         | -       |
| 4   | <i>Aeschynomene indica</i>       | +       | -         | -       |
| 5   | <i>Avicennia marina</i>          | +       | -         | -       |
| 6   | <i>Bougainvillea glabra</i>      | +       | +         | -       |
| 7   | <i>Caesalpinia bonduc</i>        | +       | -         | -       |
| 8   | <i>Calotropis gigantea</i>       | +       | +         | +       |
| 9   | <i>Cassia auriculata</i>         | +       | +         | -       |
| 10  | <i>Clerodendron siphonanthus</i> | +       | -         | -       |
| 11  | <i>Crossandra undulaefolia</i>   | -       | +         | -       |
| 12  | <i>Dichrostachys cinerea</i>     | +       | +         | -       |
| 13  | <i>Euphorbia caducifolia</i>     | +       | +         | -       |
| 14  | <i>Euphorbia tirucalli</i>       | +       | +         | -       |
| 15  | <i>Hibiscus caesius</i>          | +       | -         | -       |
| 16  | <i>Hibiscus rosasinensis</i>     | +       | +         | +       |
| 17  | <i>Ipomoea carnea</i>            | +       | +         | +       |
| 18  | <i>Ixora arborea</i>             | +       | -         | -       |
| 19  | <i>Jatropha curcas</i>           | +       | +         | -       |
| 20  | <i>Jatropha glandulifera</i>     | +       | +         | -       |
| 21  | <i>Kriganelia reticulata</i>     | +       | +         | +       |
| 22  | <i>Lantana camara</i>            | +       | +         | -       |
| 23  | <i>Lawsonia inermis</i>          | +       | +         | +       |
| 24  | <i>Malvastrum tricuspidatum</i>  | +       | -         | -       |
| 25  | <i>Mimosa hamata</i>             | -       | +         | -       |
| 26  | <i>Melhaniania futeyporensis</i> | -       | +         | -       |
| 27  | <i>Musa paradisiaca</i>          | +       | -         | -       |
| 28  | <i>Nerium oleander</i>           | +       | +         | -       |
| 29  | <i>Opuntia dillenii</i>          | +       | +         | -       |
| 30  | <i>Oxyceros fasciculata</i>      | -       | +         | -       |
| 31  | <i>Pupalia lappacea</i>          | +       | -         | -       |
| 32  | <i>Ricinus communis</i>          | +       | +         | -       |
| 33  | <i>Thunbergia alata</i>          | +       | +         | -       |
| 34  | <i>Urena lobata</i>              | +       | -         | -       |
| 35  | <i>Vitex negundo</i>             | +       | +         | -       |
| 36  | <i>Xeromphis spinosa</i>         | -       | +         | -       |

| Appendix - IV. Climbers recorded along the pipeline route and its environs |                              |         |           |         |
|--|------------------------------|---------|-----------|---------|
| S.No   | Species                      | Gujarat | Rajasthan | Haryana |
| 1  | <i>Abrus precatorius</i>     | +       | -         | -       |
| 2  | <i>Aristolochia indica</i>   | +       | -         | -       |
| 3  | <i>Cissus heyneana</i>       | +       | -         | -       |
| 4  | <i>Cissus quadrangularis</i> | +       | -         | -       |
| 5  | <i>Citrulus colocynthis</i>  | +       | +         | -       |
| 6  | <i>Clitoria ternatea</i>     | +       | +         | -       |
| 7  | <i>Coccinia grandis</i>      | +       | -         | +       |
| 8  | <i>Cocculus hirsutus</i>     | +       | +         | -       |
| 9  | <i>Daemia extensa</i>        | +       | +         | -       |
| 10   | <i>Gloriosa superba</i>      | -       | +         | -       |
| 11   | <i>Ipomoea hispida</i>       | +       | -         | -       |
| 12   | <i>Ipomoea pes-caprae</i>    | +       | -         | -       |
| 13   | <i>Ipomoea aquatica</i>      | +       | +         | +       |
| 14   | <i>Maerua arenaria</i>       | +       | +         | -       |



| Appendix -V. Herbs recorded along the pipeline route and its environs |                                  |         |           |         |
|---|----------------------------------|---------|-----------|---------|
| S.No  | Species                          | Gujarat | Rajasthan | Haryana |
| 1   | <i>Abelmoschus manihot</i>       | +       | -         | -       |
| 2   | <i>Abutilon indicum</i>          | +       | +         | -       |
| 3   | <i>Achyranthes aspera</i>        | +       | +         | +       |
| 4   | <i>Aerva javanica</i>            | +       | +         | -       |
| 5   | <i>Alhagi maurorum</i>           | +       | +         | -       |
| 6   | <i>Alternanthera sessilis</i>    | +       | +         | +       |
| 7   | <i>Alysicarpus vaginalis</i>     | +       | +         | -       |
| 8   | <i>Amberboa ramosa</i>           | +       | +         | -       |
| 9   | <i>Amaranthus spinosus</i>       | +       | +         | -       |
| 10  | <i>Amaranthus viridis</i>        | +       | +         | -       |
| 11  | <i>Apluda mutica</i>             | +       | +         | +       |
| 12  | <i>Argemone mexicana</i>         | +       | +         | +       |
| 13  | <i>Arachis hypogaea</i>          | +       | -         | -       |
| 14  | <i>Aristida adscenionis</i>      | +       | +         | -       |
| 15  | <i>Aristida setacea</i>          | +       | +         | -       |
| 16  | <i>Asphodelus tenuifolius</i>    | +       | +         | -       |
| 17  | <i>Asteracantha longifolia</i>   | +       | -         | -       |
| 18  | <i>Avena sativa</i>              | -       | +         | -       |
| 19  | <i>Blepharis molliuginifolia</i> | +       | +         | +       |
| 20  | <i>Boerhaavia diffusa</i>        | +       | +         | +       |
| 21  | <i>Borreria hispida</i>          | +       | +         | -       |
| 22  | <i>Brassica junctia</i>          | +       | +         | -       |
| 23  | <i>Blumea laciniata</i>          | -       | +         | -       |
| 24  | <i>Cassia occidentalis</i>       | +       | +         | -       |
| 25  | <i>Cassia tora</i>               | +       | +         | +       |
| 26  | <i>Carthamus oxycantha</i>       | +       | +         | -       |
| 27  | <i>Capsicum annuum</i>           | +       | +         | -       |
| 28  | <i>Cenchrus ciliaris</i>         | +       | +         | -       |
| 29  | <i>Chenopodium album</i>         | +       | +         | -       |
| 30  | <i>Chloris inflata</i>           | +       | -         | -       |
| 31  | <i>Chrozophora rottleri</i>      | +       | -         | -       |
| 32  | <i>Corchorus tridens</i>         | +       | +         | -       |



|    |                                  |   |   |   |
|----|----------------------------------|---|---|---|
| 33 | <i>Commelina benghalensis</i>    | + | - | - |
| 34 | <i>Coriandrum sativum</i>        | + | + | - |
| 35 | <i>Crotalaria junctia</i>        | + | + | - |
| 36 | <i>Croton bonplandianus</i>      | + | + | + |
| 37 | <i>Cynodon dactylon</i>          | + | + | + |
| 38 | <i>Cyperus rotundus</i>          | + | + | - |
| 39 | <i>Cyperus articulatus</i>       | + | - | - |
| 40 | <i>Cyperus corymbosus</i>        | + | - | - |
| 41 | <i>Dactyloctenium aegypticum</i> | + | + | - |
| 42 | <i>Datura metel</i>              | + | + | - |
| 43 | <i>Digera muricata</i>           | + | + | - |
| 44 | <i>Desmodium triflorum</i>       | + | + | - |
| 45 | <i>Eclipta alba</i>              | + | + | - |
| 46 | <i>Eichhornia crassipes</i>      | + | - | - |
| 47 | <i>Euphorbia hirta</i>           | + | + | + |
| 48 | <i>Evolvulus alsinoides</i>      | + | + | - |
| 49 | <i>Foeniculum vulgare</i>        | + | + | - |
| 50 | <i>Gisekia pharnaceoides</i>     | + | + | - |
| 51 | <i>Glinus lotoides</i>           | + | - | - |
| 52 | <i>Glycine max</i>               | + | + | - |
| 53 | <i>Gomphrena decumbens</i>       | + | + | - |
| 54 | <i>Gossipium arboreum</i>        | + | + | - |
| 55 | <i>Heteropogon contortus</i>     | + | + | + |
| 56 | <i>Heliotropium ovalifolium</i>  | + | - | - |
| 57 | <i>Heliotropium indicum</i>      | + | - | - |
| 58 | <i>Hydrilla verticillata</i>     | + | - | - |
| 59 | <i>Hydrocotyle asiatica</i>      | + | - | - |
| 60 | <i>Imperata cylindrica</i>       | + | + | + |
| 61 | <i>Indigofera angulosa</i>       | + | + | - |
| 62 | <i>Indigofera cassioides</i>     | + | + | - |
| 63 | <i>Justicia glauca</i>           | + | - | - |
| 64 | <i>Justicia simplex</i>          | - | + | - |
| 65 | <i>Lasiurus hirstutus</i>        | + | - | - |
| 66 | <i>Launaea procumbans</i>        | + | - | - |
| 67 | <i>Leersia hexandra</i>          | + | - | - |
| 68 | <i>Leucas aspera</i>             | + | + | - |

|     |                                    |   |   |   |
|-----|------------------------------------|---|---|---|
| 69  | <i>Lepidacathis cristata</i>       | + | + | - |
| 70  | <i>Leptadenia pyrotechnica</i>     | + | + | - |
| 71  | <i>Lycopersicum esculentum</i>     | - | + | - |
| 72  | <i>Marsilea quadrifolia</i>        | + | - | - |
| 73  | <i>Merremia tridentata</i>         | + | - | - |
| 74  | <i>Mollugo oppositifolia</i>       | + | + | + |
| 75  | <i>Ocimum canum</i>                | + | + | - |
| 76  | <i>Oldenlandia umbellata</i>       | - | + | + |
| 77  | <i>Ophiuros exaltatus</i>          | + | - | - |
| 78  | <i>Parthenium hysterophorus</i>    | + | + | - |
| 79  | <i>Paspalidium germinatum</i>      | + | + | - |
| 80  | <i>Paspalum longiflorum</i>        | + | - | - |
| 81  | <i>Pavonia procumbens</i>          | + | - | - |
| 82  | <i>Phyla nodiflora</i>             | + | + | - |
| 83  | <i>Phyllanthus niruri</i>          | + | + | - |
| 84  | <i>Phyllanthus maderaspatensis</i> | + | - | - |
| 85  | <i>Physalis minima</i>             | - | + | - |
| 86  | <i>Portulaca oleracea</i>          | - | + | - |
| 87  | <i>Rhynchosia minima</i>           | + | + | - |
| 88  | <i>Rotala mexicana</i>             | + | - | - |
| 89  | <i>Ruellia tuberosa</i>            | + | + | - |
| 90  | <i>Saccharum officinarum</i>       | + | + | - |
| 91  | <i>Sagittaria sagittifolia</i>     | + | - | - |
| 92  | <i>Sesuvium portulacastrum</i>     | + | - | - |
| 93  | <i>Sida acuta</i>                  | + | + | - |
| 94  | <i>Sida spinosa</i>                | + | + | - |
| 95  | <i>Solanum indicum</i>             | + | + | - |
| 96  | <i>Solanum melongena</i>           | + | + | - |
| 97  | <i>Solanum nigrum</i>              | + | + | - |
| 98  | <i>Solanum surattense</i>          | + | + | - |
| 99  | <i>Solanum trilobatum</i>          | + | - | - |
| 100 | <i>Sorghum vulgare</i>             | + | + | - |
| 101 | <i>Sphaeranthus indicus</i>        | + | - | - |
| 102 | <i>Tephrosia hirta</i>             | - | + | - |
| 103 | <i>Tephrosia purpurea</i>          | + | + | + |
| 104 | <i>Torenia aerinea</i>             | + | - | - |



|     |                               |   |   |   |
|-----|-------------------------------|---|---|---|
| 105 | <i>Tragia involucrata</i>     | + | + | - |
| 106 | <i>Triticum aestivum</i>      | + | + | + |
| 107 | <i>Tridax procumbens</i>      | + | + | - |
| 108 | <i>Trigonella hamosa</i>      | + | + | - |
| 109 | <i>Trigonella corniculata</i> | + | + | - |
| 110 | <i>Typha angustata</i>        | + | + | - |
| 111 | <i>Verbesina encelioides</i>  | + | + | - |
| 112 | <i>Vernonia albicans</i>      | + | + | - |
| 113 | <i>Vernonia cinerea</i>       | + | - | - |
| 114 | <i>Vetiveria zizanioides</i>  | + | + | - |
| 115 | <i>Xanthium strumarium</i>    | + | + | - |

| Appendix - VIa. Metrics of the trees along the pipeline route (Gujarat)         |          |     |    |           |     |    |            |     |    |           |     |    |          |     |    |
|---|----------|-----|----|-----------|-----|----|------------|-----|----|-----------|-----|----|----------|-----|----|
| Species   | Sector i |     |    | Sector ii |     |    | Sector iii |     |    | Sector iv |     |    | Sector v |     |    |
|   | No       | GBH | Ht | No        | GBH | Ht | No         | GBH | Ht | No        | GBH | Ht | No       | GBH | Ht |
| <i>Acacia catechu</i>   | -        | -   | -  | -         | -   | -  | 4          | 38  | 4  | 1         | 31  | 3  | 7        | 59  | 4  |
| <i>Acacia leucophloea</i>   | 8        | 94  | 7  | 20        | 84  | 9  | 1          | 162 | 9  | -         | -   | -  | 5        | 83  | 5  |
| <i>Acacia nilotica</i>  | 9        | 54  | 6  | 16        | 97  | 10 | 11         | 52  | 3  | 8         | 39  | 3  | 30       | 55  | 6  |
| <i>Albizia lebbeck</i>  | -        | -   | -  | -         | -   | -  | -          | -   | -  | -         | -   | -  | 1        | 50  | 8  |
| <i>Azadirachta indica</i>   | 4        | 110 | 10 | 28        | 50  | 6  | -          | -   | -  | 2         | 103 | 5  | 14       | 119 | 8  |
| <i>Balanites roxburghii</i>   | -        | -   | -  | -         | -   | -  | 2          | 62  | 5  | -         | -   | -  | 9        | -   | -  |
| <i>Butea monosperma</i>   | -        | -   | -  | -         | -   | -  | -          | -   | -  | -         | -   | -  | 16       | 98  | 9  |
| <i>Cordia wallichii</i>   | 2        | 65  | 6  | -         | -   | -  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Cassia siamia</i>  | 1        | 38  | 5  | -         | -   | -  | -          | -   | -  | -         | -   | -  | 2        | 72  | 10 |
| <i>Diospyros montana</i>  | 2        | 57  | 6  | -         | -   | -  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Eucalyptus globulus</i>  | 7        | 33  | 6  | 2         | 72  | 11 | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Ficus aronottiana</i>  | 1        | 480 | 12 | 1         | 175 | 12 | -          | -   | -  | -         | -   | -  | 1        | 250 | 15 |
| <i>Ficus benghalensis</i>   | 1        | 125 | 7  | -         | -   | -  | 1          | 115 | 5  | -         | -   | -  | -        | -   | -  |
| <i>Ficus religiosa</i>  | 1        | 175 | 12 | -         | -   | -  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Mangifera indica</i>   | 5        | 58  | 10 | 4         | 26  | 4  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Morinda tinctoria</i>  | -        | -   | -  | 1         | 35  | 4  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Peltophorum pterocarpum</i>  | -        | -   | -  | 1         | 63  | 10 | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Phyllanthus emblica</i>  | 2        | 75  | 9  | -         | -   | -  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Pithecellobium dulce</i>   | 2        | 70  | 7  | 5         | -   | -  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Pongamia pinnata</i>   | 2        | 115 | 5  | 2         | 66  | 8  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Prosopis juliflora</i>   | -        | -   | -  | 27        | 46  | 4  | -          | -   | -  | 59        | -   | -  | 36       | 7   | 1  |
| <i>Salvadora oleoides</i>   | -        | -   | -  | -         | -   | -  | -          | -   | -  | -         | -   | -  | 5        | -   | -  |
| <i>Salvadora persica</i>  | 1        | 75  | 7  | 9         | 77  | 3  | -          | -   | -  | -         | -   | -  | 2        | 35  | 4  |
| <i>Tamarindus indica</i>  | 1        | 85  | 7  | 1         | 55  | 8  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| <i>Zizyphus mauritiana /<br/>hysudrica</i>                                      | 1        | 78  | 8  | -         | -   | -  | -          | -   | -  | -         | -   | -  | -        | -   | -  |
| Note: Number of trees per hectare, GBH in centimeters and height (Ht) in meters |          |     |    |           |     |    |            |     |    |           |     |    |          |     |    |

| Appendix - VIb. Metrics of the trees along the pipeline route (Rajasthan and Haryana) |           |     |    |            |     |    |             |     |    |           |     |    |
|---|-----------|-----|----|------------|-----|----|-------------|-----|----|-----------|-----|----|
| Species   | Sector vi |     |    | Sector vii |     |    | Sector viii |     |    | Sector ix |     |    |
|   | No        | GBH | Ht | No         | GBH | Ht | No          | GBH | Ht | No        | GBH | Ht |
| <i>Acacia catechu</i>   | 9         | 78  | 4  | 23         | 71  | 6  | 7           | 64  | 5  | 2         | 78  | 5  |
| <i>Acacia leucophloea</i>   | 3         | 76  | 7  | 34         | 78  | 7  | 39          | 80  | 6  | 1         | 80  | 6  |
| <i>Acacia nilotica</i>  | 18        | 91  | 11 | 34         | 69  | 6  | 73          | 65  | 6  | 11        | 111 | 7  |
| <i>Aegle marmelos</i>   | 1         | 130 | 20 | -          | -   | -  | -           | -   | -  | -         | -   | -  |
| <i>Ailanthus excelsa</i>  | -         | -   | -  | 1          | 150 | 15 | 2           | 51  | 6  | 1         | 45  | 4  |
| <i>Albizia lebbeck</i>  | 1         | 60  | 11 | -          | -   | -  | 6           | 65  | 7  | -         | -   | -  |
| <i>Azadirachta indica</i>   | 6         | 111 | 13 | 2          | 53  | 6  | 1           | 68  | 9  | -         | -   | -  |
| <i>Balanites roxburghii</i>   | 2         | 79  | 7  | -          | -   | -  | 1           | 32  | 3  | -         | -   | -  |
| <i>Butea monosperma</i>   | 4         | 127 | 10 | -          | -   | -  | -           | -   | -  | 1         | 110 | 9  |
| <i>Dalbergia sissoo</i>   | -         | -   | -  | -          | -   | -  | 4           | 140 | 21 | 2         | 175 | 22 |
| <i>Ficus benghalensis</i>   | 1         | 263 | 11 | -          | -   | -  | -           | -   | -  | -         | -   | -  |
| <i>Holoptelia integrifolia</i>  | 1         | 116 | 8  | -          | -   | -  | 1           | 78  | 8  | -         | -   | -  |
| <i>Mangifera indica</i>   | -         | -   | -  | -          | -   | -  | 1           | 100 | 10 | -         | -   | -  |
| <i>Phoenix sylvestris</i>   | 2         | 105 | 13 | -          | -   | -  | 1           | 55  | 8  | 1         | 65  | 7  |
| <i>Pithecellobium dulce</i>   | 3         | 111 | 11 | -          | -   | -  | -           | -   | -  | -         | -   | -  |
| <i>Pongamia pinnata</i>   | 1         | 65  | 8  | -          | -   | -  | -           | -   | -  | -         | -   | -  |
| <i>Prosopis juliflora</i>   | 24        | 71  | 8  | 28         | 46  | 8  | -           | -   | -  | 1         | 150 | 10 |
| <i>Salvadora persica</i>  | 1         | 120 | 12 | -          | -   | -  | -           | -   | -  | -         | -   | -  |
| <i>Tamarindus indica</i>  | 1         | 350 | 25 | -          | -   | -  | -           | -   | -  | -         | -   | -  |
| <i>Zizyphus mauritiana / hysudrica</i>  | 2         | 66  | 5  | -          | -   | -  | 3           | 42  | 4  | 3         | 42  | 4  |
| Note: Number of trees per hectare, GBH in centimeters and height (Ht) in meters       |           |     |    |            |     |    |             |     |    |           |     |    |

| Appendix - VII. Metrics of the trees in protected area in the environs of the pipeline<br>(Gujarat and Rajasthan) |         |     |    |           |     |    |
|---|---------|-----|----|-----------|-----|----|
| Species   | Gujarat |     |    | Rajasthan |     |    |
|   | No      | GBH | Ht | No        | GBH | Ht |
| <i>Acacia catechu</i>   | 25      | 40  | 4  | 200       | 70  | 5  |
| <i>Acacia nilotica</i>  | 25      | 36  | 3  | 50        | 46  | 6  |
| <i>Bauhinia variegata</i>   | -       | -   | -  | 50        | 55  | 5  |
| <i>Butea monosperma</i>   | 225     | 77  | 8  | -         | -   | -  |
| <i>Cordia wallichii</i>   | 75      | 90  | 7  | -         | -   | -  |
| <i>Cassia siamia</i>  | 125     | 43  | 6  | -         | -   | -  |
| <i>Diospyros montana</i>  | 100     | 95  | 6  | -         | -   | -  |
| <i>Lagerstroemia parviflora</i>   | -       | -   | -  | 550       | 61  | 6  |
| <i>Prosopis juliflora</i>   | 100     | -   | -  | -         | -   | -  |
| <i>Zizyphus oenoplia</i>  | 75      | -   | -  | -         | -   | -  |
| Total   | 750     | -   | -  | 850       | -   | -  |
| Note: Number of trees per hectare, GBH in centimeters and Ht height in meters                                     |         |     |    |           |     |    |

**Appendix - VIII. Avifauna along the pipeline route and its environs**

|                                      |                          |
|--------------------------------------|--------------------------|
| 1 <i>Podiceps cristatus</i>          | Great Crested Grebe      |
| 2 <i>Podiceps nigricollis</i>        | Blacknecked Grebe        |
| 3 <i>Podiceps ruficollis</i>         | Little Grebe             |
| 4 <i>Pelecanus crispus</i> *         | Dalmatian Pelican        |
| 5 <i>Pelecanus onocrotalus</i>       | White or Rosy Pelican    |
| 6 <i>Phalacrocorax carbo</i>         | Large Cormorant          |
| 7 <i>Phalacrocorax fuscicollis</i>   | Indian Shag              |
| 8 <i>Phalacrocorax niger</i>         | Little Cormorant         |
| 9 <i>Anhinga rufa</i>                | Darter or Snake-bird     |
| 10 <i>Ardea cinerea</i>              | Grey Heron               |
| 11 <i>Ardea purpurea</i>             | Purple Heron             |
| 12 <i>Ardea alba</i>                 | Large Egret              |
| 13 <i>Ardeola grayii</i>             | Pond Heron or Paddy bird |
| 14 <i>Bubulcus ibis</i>              | Cattle Egret             |
| 15 <i>Egretta intermedia</i>         | Smaller (Median) Egret   |
| 16 <i>Egretta garzetta</i>           | Little Egret             |
| 17 <i>Egretta gularis</i>            | Reef Heron               |
| 18 <i>Nycticorax nycticorax</i>      | Night Heron              |
| 19 <i>Ixobrychus cinnamomeus</i>     | Chestnut Bittern         |
| 20 <i>Botaurus stellaris</i>         | Bittern                  |
| 21 <i>Mycteria leucocephala</i>      | Painted Stork            |
| 22 <i>Anastomus oscitans</i>         | Openbill Stork           |
| 23 <i>Ciconia episcopus</i>          | Whitenecked Stork        |
| 24 <i>Ciconia ciconia</i>            | White Stork              |
| 25 <i>Ephippiorhynchus asiaticus</i> | Blacknecked Stork        |
| 26 <i>Threskiornis aethiopica</i>    | White Ibis               |
| 27 <i>Pseudibis papillosa</i>        | Black Ibis               |
| 28 <i>Plegadis falcinellus</i>       | Glossy Ibis              |
| 29 <i>Platalea leucorodia</i>        | Spoonbill                |
| 30 <i>Phoenicopterus roseus</i>      | Flamingo                 |
| 31 <i>Phoeniconaias minor</i>        | Lesser Flamingo          |
| 32 <i>Anser anser</i> *              | Greylag Goose            |
| 33 <i>Anser indicus</i> *            | Barheaded Goose          |
| 34 <i>Dendrocygna javanica</i>       | Lesser Whistling Teal    |
| 35 <i>Tadorna ferruginea</i> *       | Ruddy Shelduck           |

|                                     |                           |
|-------------------------------------|---------------------------|
| 36 <i>Anas acuta</i>                | Pintail                   |
| 37 <i>Anas crecca</i>               | Common Teal               |
| 38 <i>Anas poecilorhyncha</i>       | Spotbill                  |
| 39 <i>Anas platyrhynchos*</i>       | Mallard                   |
| 40 <i>Anas strepera</i>             | Gadwall                   |
| 41 <i>Anas penelope</i>             | Wigeon                    |
| 42 <i>Anas querquedula</i>          | Garganey Teal             |
| 43 <i>Anas clypeata</i>             | Shoveller                 |
| 44 <i>Netta rufina*</i>             | Redcrested Pochard        |
| 45 <i>Aythya ferina</i>             | Common Pochard            |
| 46 <i>Aythya nyroca</i>             | White-eyed Pochard        |
| 47 <i>Aythya fuligula</i>           | Tufted Duck               |
| 48 <i>Nettapus coromandelianus</i>  | Cotton Teal               |
| 49 <i>Sarkidiornis melanotos</i>    | Comb Duck                 |
| 50 <i>Elanus caeruleus</i>          | Blackwinged Kite          |
| 51 <i>Pernis ptilorhyncus</i>       | Honey Buzzard             |
| 52 <i>Milvus migrans</i>            | Pariah Kite               |
| 53 <i>Haliastur indus</i>           | Brahminy Kite             |
| 54 <i>Accipiter badius</i>          | Indian Shikra             |
| 55 <i>Accipiter nisus</i>           | Sparrow-hawk              |
| 56 <i>Aquila spp.</i>               | Eagle                     |
| 57 <i>Sarcogyps calvus</i>          | King Vulture              |
| 58 <i>Gyps indicus</i>              | Indian Longbilled Vulture |
| 59 <i>Gyps bengalensis</i>          | Whitebacked Vulture       |
| 60 <i>Neophron percnopterus</i>     | Scavenger Vulture         |
| 61 <i>Circus macrourus</i>          | Pale Harrier              |
| 62 <i>Circus aeruginosus</i>        | Marsh Harrier             |
| 63 <i>Circaetus gallicus</i>        | Short-toed Eagle          |
| 64 <i>Spilornis cheela *</i>        | Crested Serpent Eagle     |
| 65 <i>Falco tinnunculus</i>         | Kestrel                   |
| 66 <i>Pandion haliaetus</i>         | Osprey                    |
| 67 <i>Francolinus pondicerianus</i> | Grey Partridge            |
| 68 <i>Coturnix coturnix</i>         | Common quail              |
| 69 <i>Pavo cristatus</i>            | Common Peafowl            |
| 70 <i>Grus grus</i>                 | Common Crane              |
| 71 <i>Grus antigone</i>             | Sarus Crane               |



|                                    |                        |
|------------------------------------|------------------------|
| 72 <i>Anthropoides virgo</i>       | Demoiselle Crane       |
| 73 <i>Amaurornis akool</i>         | Brown Crake            |
| 74 <i>Amaurornis phoenicurus</i>   | Whitebreasted Waterhen |
| 75 <i>Gallinula chloropus</i>      | Indian Moorhen         |
| 76 <i>Porphyrio porphyrio</i>      | Purple Moorhen         |
| 77 <i>Fulica atra</i>              | Coot                   |
| 78 <i>Hydrophasianus chirurgus</i> | Pheasant-tailed Jacana |
| 79 <i>Ardeotis nigriceps</i> *     | Great Indian Bustard   |
| 80 <i>Chlamydotis undulata</i> *   | Houbara Bustard        |
| 81 <i>Sypheotides indica</i> *     | Lesser Florican        |
| 82 <i>Metopidius indicus</i>       | Bronzewinged Jacana    |
| 83 <i>Haematopus ostralegus</i>    | Oystercatcher          |
| 84 <i>Rostratula benghalensis</i>  | Painted Snipe          |
| 85 <i>Himantopus himantopus</i>    | Blackwinged Stilt      |
| 86 <i>Recurvirostra avosetta</i>   | Avocet                 |
| 87 <i>Burhinus oediconemus</i>     | Stone Curlew           |
| 88 <i>Dromas ardeola</i>           | Crab Plover            |
| 89 <i>Esacus magnirostris</i>      | Great Stone Plover     |
| 90 <i>Vanellus leucurus</i> *      | Whitetailed Lapwing    |
| 91 <i>Vanellus indicus</i>         | Redwattled Lapwing     |
| 92 <i>Vanellus spinosus</i> *      | Spurwinged Lapwing     |
| 93 <i>Vanellus malabaricus</i>     | Yellowwattled Lapwing  |
| 94 <i>Pluvialis apricaria</i>      | Golden Plover          |
| 95 <i>Charadrius dubius</i>        | Little Ringed Plover   |
| 96 <i>Charadrius alexandrinus</i>  | Kentish Plover         |
| 97 <i>Charadrius leschenaultii</i> | Large Sand Plover      |
| 98 <i>Charadrius mongolus</i>      | Little Sand Plover     |
| 99 <i>Numenius phaeopus</i>        | Whimbrel               |
| 100 <i>Numenius arquata</i>        | Curlew                 |
| 101 <i>Limosa limosa</i>           | Blacktailed Godwit     |
| 102 <i>Limosa lapponica</i>        | Bartailed Godwit       |
| 103 <i>Tringa erythropus</i>       | Spotted Red Shank      |
| 104 <i>Tringa totanus</i>          | Common Sandpiper       |
| 105 <i>Tringa stagnatilis</i>      | Marsh Sandpiper        |
| 106 <i>Tringa nebularia</i>        | Greenshank             |
| 107 <i>Tringa ochropus</i>         | Green Sandpiper        |

108 *Tringa glareola*  
 109 *Tringa hypoleucos*  
 110 *Arenaria interpres*  
 111 *Gallinago gallinago*  
 112 *Calidris minuta*  
 113 *Calidris temminckii*  
 114 *Philomachus pugnax*  
 115 *Larus argentatus*  
 116 *Larus fuscus*  
 117 *Larus brunnicephalus*  
 118 *Larus ridibundus*  
 119 *Larus genei*  
 120 *Chlidonias hybrida*  
 121 *Gelochelidon nilotica*  
 122 *Hydroprogne caspica*  
 123 *Sterna aurantia*  
 124 *Sterna acuticauda*  
 125 *Sterna albifrons*  
 126 *Rhynchops albicollis* \*  
 127 *Pterocles exustus*  
 128 *Treron phoenicoptera* \*  
 129 *Columba livia*  
 130 *Streptopelia decaocto*  
 131 *Streptopelia tranquebarica*  
 132 *Streptopelia chinensis*  
 133 *Streptopelia senegalensis*  
 134 *Psittacula eupatria*  
 135 *Psittacula krameri*  
 136 *Psittacula cyanocephala*  
 137 *Clamator jacobinus*  
 138 *Cuculus varius*  
 139 *Cuculus canorus*  
 140 *Eudynamys scolopacea*  
 141 *Taccocua leschenaultii*  
 142 *Centropus sinensis*  
 143 *Tyto alba*

Wood Sandpiper  
 Common Sandpiper  
 Turnstone  
 Fantail Snipe  
 Little Stint  
 Temminck Stint  
 Ruff  
 Herring Gull  
 Lesser Blackbacked Gull  
 Brownhead Gull  
 Blackhead Gull  
 Slenderbilled Gull  
 Whiskered Tern  
 Gullbilled Tern  
 Caspian Tern  
 Indian River Tern  
 Blackbellied Tern  
 Little Tern  
 Indian Skimmer  
 Indian Sandgrouse  
 Green Pigeon  
 Blue Rock Pigeon  
 Indian Ring Dove  
 Red Turtle Dove  
 Spotted Dove  
 Little Brown Dove  
 Alexandrine Parakeet  
 Rose-ringed Parakeet  
 Blossomheaded Parakeet  
 Pied Crested Cuckoo  
 Common Hawk Cuckoo  
 Cuckoo  
 Koel  
 Sirkeer Cuckoo  
 Crow-Pheasant  
 Barn Owl

|                                    |                               |
|------------------------------------|-------------------------------|
| 144 <i>Otus bakkamoena</i> *       | Collared Scops Owl            |
| 145 <i>Athene brama</i>            | Spotted Owlet                 |
| 146 <i>Caprimulgus indicus</i>     | Indian Night Jar              |
| 147 <i>Apus affinis</i>            | House Swift                   |
| 148 <i>Cypsiurus parvus</i>        | Palm Swift                    |
| 149 <i>Ceryle rudis</i>            | Lesser Pied Kingfisher        |
| 150 <i>Alcedo atthis</i>           | Small Blue Kingfisher         |
| 151 <i>Halcyon smyrnensis</i>      | Whitebreasted Kingfisher      |
| 152 <i>Merops superciliosus</i> *  | Bluecheeked Bee-eater         |
| 153 <i>Merops philippinus</i> *    | Bluetailed Bee-eater          |
| 154 <i>Merops orientalis</i>       | Small Green Bee-eater         |
| 155 <i>Coracias benghalensis</i>   | Indian Roller                 |
| 156 <i>Upupa epops</i>             | Hoopoe                        |
| 157 <i>Tockus birostris</i> *      | Grey Hornbill                 |
| 158 <i>Megalaima haemacephala</i>  | Crimsonbreasted Barbet        |
| 159 <i>Jynx torquilla</i> *        | Wryneck                       |
| 160 <i>Dinopium benghalense</i>    | Goldenbacked Woodpecker       |
| 161 <i>Picoides mahrattensis</i>   | Yellowfronted Pied Woodpecker |
| 162 <i>Picoides nanus</i> *        | Pigmy Woodpecker              |
| 163 <i>Mirafr erythroptera</i>     | Redwinged Bush Lark           |
| 164 <i>Eremopterix grisea</i>      | Ashycrowned Finch Lark        |
| 165 <i>Ammomanes phoenicurus</i>   | Rufoustailed Finchlark        |
| 166 <i>Galerida cristata</i>       | Crested Lark                  |
| 167 <i>Alauda gulgula</i>          | Skylark                       |
| 168 <i>Calandrella cinerea</i>     | Short-toed Lark               |
| 169 <i>Calandrella raytal</i>      | Sand Lark                     |
| 170 <i>Hirundo concolor</i>        | Dusky Crag Martin             |
| 171 <i>Hirundo rustica</i>         | Swallow                       |
| 172 <i>Hirundo smithii</i>         | Wire-tailed Swallow           |
| 173 <i>Hirundo daurica</i>         | Redrumped Swallow             |
| 174 <i>Lanius excubitor</i>        | Grey Shrike                   |
| 175 <i>Lanius vittatus</i>         | Baybacked Shrike              |
| 176 <i>Lanius schach</i>           | Rufousbacked Shrike           |
| 177 <i>Oriolus oriolus</i>         | Golden Oriole                 |
| 178 <i>Dicrurus adsimilis</i>      | Black Drongo                  |
| 179 <i>Dicrurus caerulescens</i> * | Whitebellied Drongo           |

|  |                                |
|--|--------------------------------|
| 180 <i>Sturnus pagodarum</i>           | Blackheaded Myna               |
| 181 <i>Sturnus roseus</i>              | Rosy Pastor                    |
| 182 <i>Sturnus vulgaris</i>            | Starling                       |
| 183 <i>Sturnus contra</i>              | Pied Myna                      |
| 184 <i>Acridotheres tristis</i>        | Common Myna                    |
| 185 <i>Acridotheres ginginianus</i>    | Bank Myna                      |
| 186 <i>Dendrocitta vagabunda</i>       | Tree Pie                       |
| 187 <i>Corvus splendens</i>            | House Crow                     |
| 188 <i>Corvus macrorhynchos</i>        | Jungle Crow                    |
| 189 <i>Tephrodornis pondicerianus*</i> | Common Wood Shrike             |
| 190 <i>Coracina novaehollandiae</i>    | Large Cuckoo Shrike            |
| 191 <i>Aegithina tiphia</i>            | Common Iora                    |
| 192 <i>Pycnonotus jocosus</i>          | Redwhiskered Bulbul            |
| 193 <i>Pycnonotus leucogenys</i>       | Whitecheeked Bulbul            |
| 194 <i>Pycnonotus cafer</i>            | Redvented Bulbul               |
| 195 <i>Pycnonotus luteolus</i>         | Whitebrowed Bulbul             |
| 196 <i>Chrysomma sinense</i>           | Yelloweyed Babbler             |
| 197 <i>Turdoides caudatus</i>          | Common Babbler                 |
| 198 <i>Turdoides malcolmi</i>          | Large Grey Babbler             |
| 199 <i>Turdoides striatus</i>          | Jungle Babbler                 |
| 200 <i>Muscicapa parva</i>             | Redbreasted Flycatcher         |
| 201 <i>Muscicapa thalassina*</i>       | Verditer Flycatcher            |
| 202 <i>Rhipidura aureola</i>           | Whitebrowed Fantail Flycatcher |
| 203 <i>Terpsiphone paradisi</i>        | Paradise Flycatcher            |
| 204 <i>Prinia hodgsonii</i>            | Franklin's Wren-warbler        |
| 205 <i>Prinia socialis</i>             | Ashy Wren-warbler              |
| 206 <i>Orthotomus sutorius</i>         | Tailor Bird                    |
| 207 <i>Acrocephalus stentoreus</i>     | Indian Great Reed Warbler      |
| 208 <i>Sylvia curruca</i>              | Lesser Whitethroat             |
| 209 <i>Phylloscopus collybita</i>      | Chiffchaff                     |
| 210 <i>Erithacus svecicus</i>          | Blue Throat                    |
| 211 <i>Copsychus saularis</i>          | Magpie Robin                   |
| 212 <i>Phoenicurus ochruros</i>        | Black Redstart                 |
| 213 <i>Cercomela fusca</i>             | Brown Rock Chat                |
| 214 <i>Saxicola torquata</i>           | Stone Chat                     |
| 215 <i>Saxicola caprata</i>            | Pied Bush Chat                 |

|                                    |                          |
|------------------------------------|--------------------------|
| 216 <i>Saxicoloides fulicata</i>   | Indian Robin             |
| 217 <i>Monticola solitarius</i>    | Blue Rock thrush         |
| 218 <i>Parus major</i>             | Grey Tit                 |
| 219 <i>Sitta castanea</i> *        | Chestnutbellied Nuthatch |
| 220 <i>Motacilla caspica</i>       | Grey Wagtail             |
| 221 <i>Salpornis spilonotus</i>    | Spotted Grey Creeper     |
| 222 <i>Anthus novaeseelandiae</i>  | Paddyfield Pipit         |
| 223 <i>Motacilla flava</i>         | Yellow Wagtail           |
| 224 <i>Motacilla cinerea</i>       | Grey Wagtail             |
| 225 <i>Motacilla alba</i>          | Pied or White Wagtail    |
| 226 <i>Dicaeum erythrorhynchos</i> | Tickell's Flowerpecker   |
| 227 <i>Nectarinia zeylonica</i>    | Purplerumped Sunbird     |
| 228 <i>Nectarinia asiatica</i>     | Purple Sunbird           |
| 229 <i>Zosterops palpebrosa</i>    | Indian White-eye         |
| 230 <i>Passer domesticus</i>       | House Sparrow            |
| 231 <i>Petronia xanthocollis</i>   | Yellowthroated Sparrow   |
| 232 <i>Ploceus philippinus</i>     | Baya                     |
| 233 <i>Lonchura malabarica</i>     | Whitethroated Munia      |
| 234 <i>Lonchura striata</i>        | Whitebacked Munia        |

**Note:** \* Recorded in the same general locality in recent past, # Birds preferring aquatic areas

#### Appendix - IX. Amphibians present along the route of the pipeline

|                               |                       |
|-------------------------------|-----------------------|
| 1 <i>Bufo melanostictus</i> * | Indian Toad           |
| 2 <i>Bufo stomaticus</i>      | Marbled Toad          |
| 3 <i>Rana cyanophlyctis</i>   | Common Indian Frog    |
| 4 <i>Rana limnocharis</i>     | Indian Skipper Frog   |
| 5 <i>Rana breviceps</i>       | Indian Burrowing Frog |
| 6 <i>Rana tigerina</i>        | Indian Bull Frog      |
| 7 <i>Microhyla ornata</i> *   | Ornate Microhyla      |

**Note:** \* Recorded in the same general locality in recent past



**Appendix X. Reptiles found along the pipeline route and its environs**

|                                    |                          |
|------------------------------------|--------------------------|
| 1 <i>Lepidochelys olivacea</i> *#  | Olive Ridley             |
| 2 <i>Chelonia mydas</i> #          | Green Turtle             |
| 3 <i>Eretmochelys imbricata</i> *# | Hawksbill                |
| 4 <i>Aspideretes leithi</i> #      | Leith's Softshell Turtle |
| 5 <i>Lissemys punctata</i> #       | Indian Flapshell Turtle  |
| 6 <i>Kachuga tecta</i> *#          | Indian Roof Turtle       |
| 7 <i>Geochelone elegans</i> *      | Starred Tortoise         |
| 8 <i>Hemidactylus</i> sp.          | House Gecko              |
| 9 <i>Sitana ponticeriana</i>       | Fanthroated Lizard       |
| 10 <i>Calotes versicolor</i>       | Garden Lizard            |
| 11 <i>Acanthodactylus cantoris</i> | Sand Lizard              |
| 12 <i>Riopa punctata</i>           | Snake Skink              |
| 13 <i>Mabuya</i> sp.               | Skink                    |
| 14 <i>Varanus bengalensis</i>      | Common Monitor           |
| 15 <i>Varanus griseus</i>          | Desert Monitor           |
| 16 <i>Uromastyx hardwickii</i> *   | Spiny Tailed Lizard      |
| 17 <i>Chamaeleon zeylanicus</i>    | Indian Chameleon         |
| 18 <i>Crocodylus palustris</i> #   | Mugger                   |
| 19 <i>Eryx conicus</i>             | Russell's Sand Boa       |
| 20 <i>Eryx johni</i> *             | Red Sand Boa             |
| 21 <i>Python molurus</i> *         | Indian Python            |
| 22 <i>Psammophis leithi</i>        | Sand Snake               |
| 23 <i>Ptyas mucosus</i>            | Common Rat Snake         |
| 24 <i>Spalerosophis diadema</i> *  | Royal or Diadem Snake    |
| 25 <i>Lycodon aulicus</i> *        | Wolf Snake               |
| 26 <i>Amphiesma stolata</i> *      | Striped Keelback         |
| 27 <i>Xenochropis piscator</i> #   | Checkered keelback       |
| 28 <i>Naja naja</i> *              | Indian Cobra             |
| 29 <i>Bungarus caeruleus</i> *     | Common Indian Krait      |
| 30 <i>Vipera russelli</i> *        | Russell's Viper          |
| 31 <i>Echis carinata</i> *         | Saw Scaled Viper         |

**Note:** \* Likely species in the environs, # aquatic species

| Appendix XII. Marine fauna and algae recorded in Okha and environs   |  |   |
|--|--|---|
| Algae  | Corals   | Echinoderms   |
| <i>Amphiroa</i> sp.<br><i>Caulerpa fastigiata</i><br><i>Caulerpa racemosa</i><br><i>Chetomorpha antennina</i><br><i>Dictyota divaricata</i><br><i>Gracilaria foliifera</i><br><i>Gracilaria corticata</i><br><i>Pedina</i> sp.<br><i>Sargassum carpophyllum</i><br><i>Turbinaria</i> sp.<br><i>Ulva lactuca</i><br><i>Ulva fasciata</i>  | <i>Favia</i> sp<br><i>Goniophora stokesi</i><br><i>Pocillopora</i> sp<br><i>Porites</i> sp<br><i>Siderastrea</i> sp<br><i>Symphyllia</i> sp  | Brittle star<br>Sand dollar<br>Star fish  |
| Gastropodes  | Bivalves   | Crustaceans   |
| <i>Acanthina granulosa</i><br><i>Architectonica indica</i><br><i>Babylonia</i> sp<br><i>Bursa spinosa</i><br><i>Cerithidea fluviatilis</i><br><i>Conus virginicus</i><br><i>Cyprea cyprea</i><br><i>Drupa</i><br><i>Murex brunneus</i><br><i>Natica</i> sp<br><i>Neorapana</i> sp<br><i>Neptunea</i><br><i>Nerita</i> sp<br><i>Nucella lapillis</i><br><i>Oliva oliva</i><br><i>Polinices</i> sp<br><i>Purpura</i> sp<br><i>Rapana rapiformis</i><br><i>Rapana bulbosa</i><br><i>Sinum</i> sp<br><i>Tectone grandis</i><br><i>Thyas</i> sp<br><i>Turbo versicolor</i><br><i>Turritella</i> sp<br><i>Volena</i> sp<br><i>Volvo</i> sp | <i>Anadara rhombea</i><br><i>Crossostrea crista-galli</i><br><i>Cardium</i> sp<br><i>Crossostrea madrasensis</i><br><i>Diodora</i> sp<br><i>Donex cunneatus</i><br><i>Katelsysia opima</i><br><i>Pecten</i> sp<br><i>Pinna pectata</i><br><i>Placenta placenta</i><br><i>Siliqua radiata</i><br><i>Solen kemp</i><br><i>Tellina</i> sp | <i>Balanus amphitrite</i><br><i>Balanus balan</i><br><i>Calappa</i> sp.<br>Coral crab<br><i>Portunus pelagicus</i><br><i>Scylla serrata</i><br><i>Uca annulipus</i> |