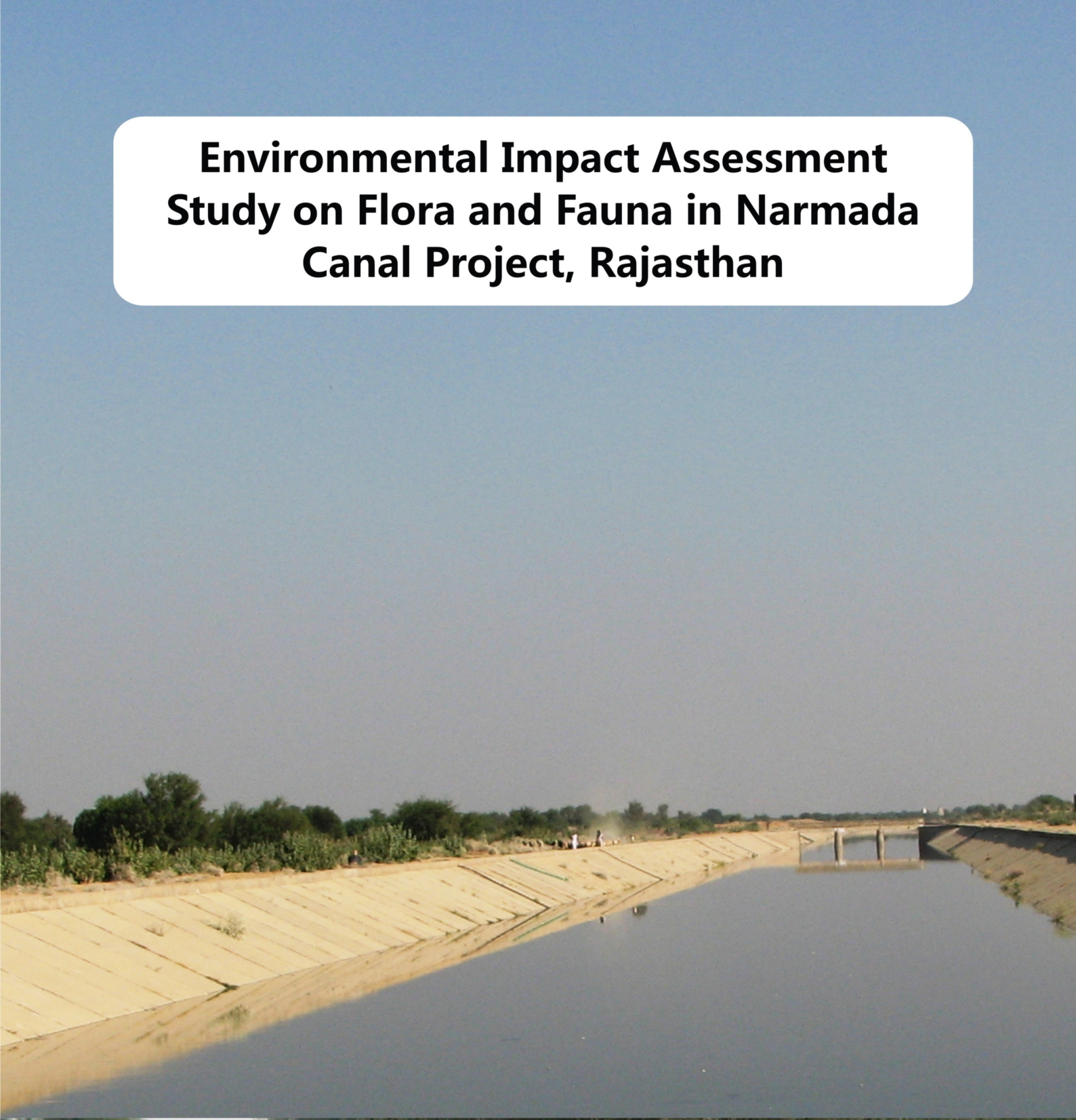
Environmental Impact Assessment Study on Flora and Fauna in Narmada Canal Project, Rajasthan



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Environmental Impact Assessment Study on Flora and Fauna in Narmada Canal Project, Rajasthan

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Project Team

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1. INTRODUCTION

About 70 percent of the human population living in rural areas, particularly in Asia and Africa, are targeted to benefit from the Millennium Development Goals (MDGs'). For most of the rural poor, agriculture is a critical component in the successful attainment of the MDGs. Even though infrastructural transformations are important for the longer term economic security, enhanced agricultural productivity to ensure food security, has been considered as a fundamental requirement for meeting the challenges of achieving the MDGs by 2015. While the link between agriculture and human development is particularly strong for MDG 1(halving by 2015 the proportion of those suffering from extreme poverty and hunger), all other MDGs also have direct or indirect linkages with agriculture. Agriculture contributes directly to MDG 1 through agriculture dependent economic growth and to MDGs 4-6 through contributions in improved nutrition, for improving maternal health, reducing child mortality and combating diseases.

Like in most developing countries in Asia, in India too, a great deal of importance has been on promoting developments in agricultural sector as a strategy for reducing poverty and hunger. Agriculture can be stated as one of the strongholds of the country's economy as it currently (2009-10 estimates) accounts for 14.6 percent of India's gross domestic product (GDP). Out of the 328.7 million ha geographical area of the country, 140.3 million hectares is net sown area, while 193.7 million hectares is the gross cropped area (Ministry of Agriculture, Annual Report, 2010).

Water is a major limiting factor in raising agricultural productivity. Much of the success of the Green Revolution came from improved productivity in areas of assured irrigation provided through canals or through ground water utilization. The scope for expanding irrigation through large and medium scale projects has yet to be fully exploited. Out of the total of 59 million hectares that could be irrigated through such projects, only 40 million hectares have been irrigated (Ahluwalia, 2005). The largest increase in area under irrigation across the world is expected to be in India in next few years (Thakkar, 1999).

The importance of building canal infrastructure for promoting irrigation in India is aptly captured in the views of Sengupta, (1993) - "There is a reason why only canals among the indigenous techniques were adopted by modern engineers while others were not. Canal irrigation allows centralized management, which goes well with bureaucratic control." Since agriculture is the primary source of livelihood in rural areas, for approx. 75% of India's population and 80% of its poor, irrigation inputs influence up to 56%, or possibly more of total agricultural output (Persaud *et al.,* 2003). Given the increasing trend in population, policy makers find it imperative for India to achieve higher agriculture production to meet the food security objective of the country. Hence, there is an emergent need to emphasise on large scale developments of canals and their distributary systems across the country.

1.1 Environmental Implications of Canal Development

India's irrigated area expanded at a steady rate during the last few decades. The net irrigated area has increased by 24% during 1980-81 to 1990-91 and by 18% from 1990-91 to 2000-01. This increment can be attributed to increase in surface water irrigation which includes irrigation by canals. In terms of relative share of India's utilised irrigation potential, surface water in canals accounts for 35.5%, groundwater for 50.5% and other water sources for 14% (Thakkar, 1998). Several important irrigation projects have been initiated in various regions in India including those in arid/semi-arid areas. Indira Gandhi Canal Project (IGNP), one of the biggest canal projects in the world, is one such example. It runs mainly through Rajasthan providing irrigation facilities to Jaisalmer and Barmer districts and aims to improve the agricultural productivity and thereby the living standards and conditions of the people living in the desert region. One of the key lessons learnt was that despite short run gains, the long-run problems of external diseconomies have originated from the complex phenomenon of environmental and socio-economic problems in the Indira Gandhi canal command area in Rajasthan (Agnihotri *et al.,* 1985).

It is of vital importance that India achieves all of its Millennium Development goals by 2015, which also includes ensuring environmental sustainability (MDG 7). Environmental sustainability is the process of ensuring that current processes of interactions with the environment (social, physical and ecological) are pursued with the idea of keeping the environment as pristine as naturally possible (www.wikipedia.org).

Advances in developmental sectors benefit the country's economy and people's living standards greatly but they also pose significant environmental challenges and threats. Hence, the emergent need is to ensure that developments in all sectors specially those of canals and roads and those that involve land take in long linear stretches of ecologically sensitive areas must incorporate necessary safeguards in the planning, design and implementation of projects to not only avoid any direct conflict with biodiversity conservation goals but to also harmonise developments with conservation priorities.

Various studies have indicated that most linear development projects pose serious implications for environment and wildlife conservation (Ledec, 1987; McNeeley, 1987; FAO, 1995; Stockle, 2001). Some of the following impacts that can be most commonly recognized are:

- Fragmentation of land or forests, disturbing or destroying wildlife habitat, migration corridors and other environmentally sensitive areas;
- Damage to streams where the linear development cross waterways;
- Disruption to natural drainage systems;
- Potential for soil erosion, stream sedimentation and slope stability issues
- Introduction of weeds and non-native species
- Intrusion into wild previously untouched tracts of land, including increased public access for recreation and hunting; and
- Site clean-up and reclamation issues.

The British Columbia Guide (www.wcel.org/issues/water/bcgwlp/l7.shtml) provides a ready reckoner for visualising the canal related impacts.

More specifically, irrigation projects do modify the environment by reshaping the land surface and by changing its hydrological regime-sometimes with harmful side effects. The construction of dams and irrigation channel networks, while providing water for irrigation and power, affects soil moisture, changes the depth of groundwater and alters water quality (Guy, 1991).

In addition, the two most common problems related with irrigation canals are water-logging and salinity of soils. This "twin menace" of water-logging and salinity can be attributed to mismanaged construction operations and maintenance of canals (Guy, 1991).

There is no denial about the importance of irrigated agriculture. Society has for long time supported the development and improvement of irrigation systems but has not taken into account the varied dimensions of environment impacts of canals. Improving the environmental performance of irrigation agriculture is also important for reaping the long-term benefits of its economic, environmental and social sustainability (Stockle, 2001) of developments in irrigation sector.

This obviously justifies the need for environmental impact assessment of the irrigation canals. Biodiversity, being an inseparable and a vital component of the environment, should be mainstreamed in all development initiatives. Environmental impact assessment is one of the most valuable planning and decision-support tool that evaluates the impacts of development projects and helps to visualize mitigation options that can blend conservation and development objectives thereby paving the road to sustainable development. It is only recently that the planners and decision makers have attempted to incorporate biodiversity considerations in all development projects through the process of encouraging biodiversity inclusive environment impact assessment studies, policy reforms and best practices.

1.2 Need for Irrigation in Rajasthan

The state of Rajasthan occupies the largest area in the country and lies in the most arid and semi-arid regions of the country with a short and erratic monsoon making it the most water deficient state. Even so, its economy is predominantly agrarian and rural in nature. Agriculture provides livelihood to almost two thirds of the population and contributes about 30 per cent to the Net State Domestic Product (NSDP).

Nearly 60% of the region is arid, crop yields are generally low, and yield is also constrained by lack of water and access to it. Even outside the arid region, agriculture depends on rainfall, which in most parts of Rajasthan is minimal and irregular. Only 24% of the cropped area is under irrigation, and only half of the irrigation potential is being used (CMIE 1994). The state has a low population density, at 128 persons/km2 (in 1991), with 267 persons/$km^{2.}$ Thirty-four percent of this population lives below the poverty line (Hashim, 1995). Although this is below the national average (39%), it poses a significant development challenge to Rajasthan, given the low productivity of land and limited availability of water. Despite having low population density, average size of agricultural holdings, 4.34 ha, is much larger than the national average of 1.68 ha. A much larger proportion of the cultivators in Rajasthan are owner–operators.

The extent of poverty in the region, the heavy reliance of people on agriculture, compounded by water scarcity leads to low extent of prosperity in the state. The state government has realised the need for increasing the inputs of irrigation for increasing agricultural productivity of arid and semi-arid lands, by improving inputs in already irrigable areas and by roping in new areas under irrigated areas. Narmada Canal project is one such initiative aimed to fulfil water needs in the south western region of Rajasthan.

2. ENVIRONMENTAL CLEARANCE AND TECHNICAL CONSIDERATIONS

2.1 Project Background

The Government of India (GoI) constituted a Narmada Water Disputes Tribunal (NWDT) for adjudication of the dispute on utilisation of Narmada water. NWDT gave its award in 1979 according to which utilizable flow of Narmada water at Navagaon village in Gujarat is to be shared by 4 co-basin states namely-Madhya Pradesh, Gujarat, Maharashtra and Rajasthan.

The share of Rajasthan shall be drawn from Sardar Sarovar dam in Gujarat through Narmada main canal reaching Gujarat-Rajasthan border at 458.318 km at Silu village, District Jalore, Rajasthan. The project aims to provide irrigation as well as drinking water facilities to many villages in Barmer and Jalore districts of Rajasthan. The increase in irrigation, water availability and consequent improvement in soil quality is likely to bring about a change in the cropping pattern from single season cropping to double season cropping.

The State had earlier prepared a detailed project feasibility report for utilisation of the allocated Narmada Water to Rajasthan through a canal and distribution network and had submitted the same to the Central Water Commission (CWC), New Delhi in October 1984. The project remained as a proposal under correspondence since then and could not be finalised in absence of observations and comments from various Directorates of CWC. Subsequently, a revised project proposal was submitted to the CWC in July 1990. The Project was finally appraised and cleared techno-economically by the Technical Advisory Committee (TAC) for irrigation, flood control and multipurpose projects of the Ministry of Water Resources, GoI in 1990. The Planning Commission awarded the clearance to investment in 1996 vide letter no. 2 (307) / 92 – I&CAD dated 23rd January 1996.

While according the approval to the Narmada Canal project, Planning Commission stipulated the condition that ‘environmental action plan for the project will be prepared and implemented *pari passu* with the engineering works under the overall guidance of NCA".

In accordance with the directives of the Environment Sub-Group (ESG) of NCA, a study relating to flora and fauna of the command area was necessitated to

identify/quantify likely impacts of the project with a view to suggest preventive/restorative/ameliorative measures that can be implemented to meet the requirement of environmental controls, as specified by the NCA/ESG of MoEF. Following the discussions held on 16/3/2007 at Jaipur, the Government of Rajasthan (GoR) was directed to prepare and present an EIA report on biological component of command area. It was also suggested that, it would be desirable that Wildlife Institute of India, Dehradun may be engaged for preparation of EIA report on biological resources in the command area in Rajasthan.

2.2 WII's Role in Preparation of Environmental Management Plan (Floral and Faunal Aspect) of Narmada Canal Command Area

In pursuance of the directives of the Environment Sub group (ESG)of NCA, chaired by the Secretary, (Environment and Forests), Govt. of India, the Govt. of Rajasthan vide office letter no. CE NCP/NCA/T-13F/07-08/52 dated 1 Jan 2008 (***Annexure – I***) invited WII to conduct the required study. Subsequent to this, the Memorandum of Understanding (MoU) between the Water Resources Department, Govt. of Rajasthan and WII was signed vide letter no. 1387 dated 24 July 2009 (***Annexure – II)***.

2.2.1 Scope of work

As a follow up of the MoU jointly signed by WII and Govt of Rajasthan, WII formulated the techno-commercial proposal for addressing the following scope of work that essentially involved -

i. Assessment of key floral and faunal attributes of the proposed command area of NCP Rajasthan.

ii. Inventorying the floral resources and valuation of their medicinal and forage values.

iii. Identification of the impacts on key flora and fauna on account of construction of canals, water flows in canal system and drains, including those due to practicing irrigated agriculture.

iv. Mitigation/management options including monitoring plan to minimize adverse impacts on key floral and faunal attributes

v. Recommendations on the management of the flora and fauna in the command area, falling in Jalore (ca 1600 km^2) and Barmer districts of Rajasthan (ca 800 km^2).

3. PROJECT PROFILE AND STUDY AREA

3.1 Project Profile

As per the water resources development planned for the Narmada basin, 30 major dams, 135 medium dams and more than 3,000 minor dams are to be constructed. Out of the 30 Major dams, the terminal project- Sardar Sarovar Dam is located in Gujarat while the remaining 29 are in the state of Madhya Pradesh. Down the main course of Narmada River, the three major dams - Indira Sagar (earlier known as Narmada Sagar), Omkareshwar and Maheshwar are all located in Madhya Pradesh and while Sardar Sarovar is located in Gujarat. Rajasthan will receive its share of water from Sardar Sarovar Dam through the Narmada Main Canal (NMC) of Sardar Sarovar Project (SSP).

The Project envisages providing irrigation water to part of Sanchore tehsil of Jalore district and part of Gudhamalani and Chauhtan tehsils of Barmer district through 74 km long main Narmada Canal and 1,403 km long distribution system network **(Fig.3.1)**. The project was designed entirely on flow irrigation, by following natural contours throughout the canal alignment that restricted the total command area under the project. The total number of villages to be benefited through canal development is 233, out of which 129 are located in Sanchore tehsil of Jalore district and 104 villages are located in Gudhamalani and Chauhtan tehsils of Barmer district. Of these, 87 villages will be served by flow distributaries from the main canal and 146 by lift distributaries **(Fig. 3.2)**.

Narmada canal project will also provide drinking water facility to 1336 villages and 3 towns within the command area. The break- up of beneficiary villages and towns in different districts is as under:

(i) 697 villages and Jalore, Sanchore and Bhimal town in District Jalore

(ii) 639 villages District Barmer

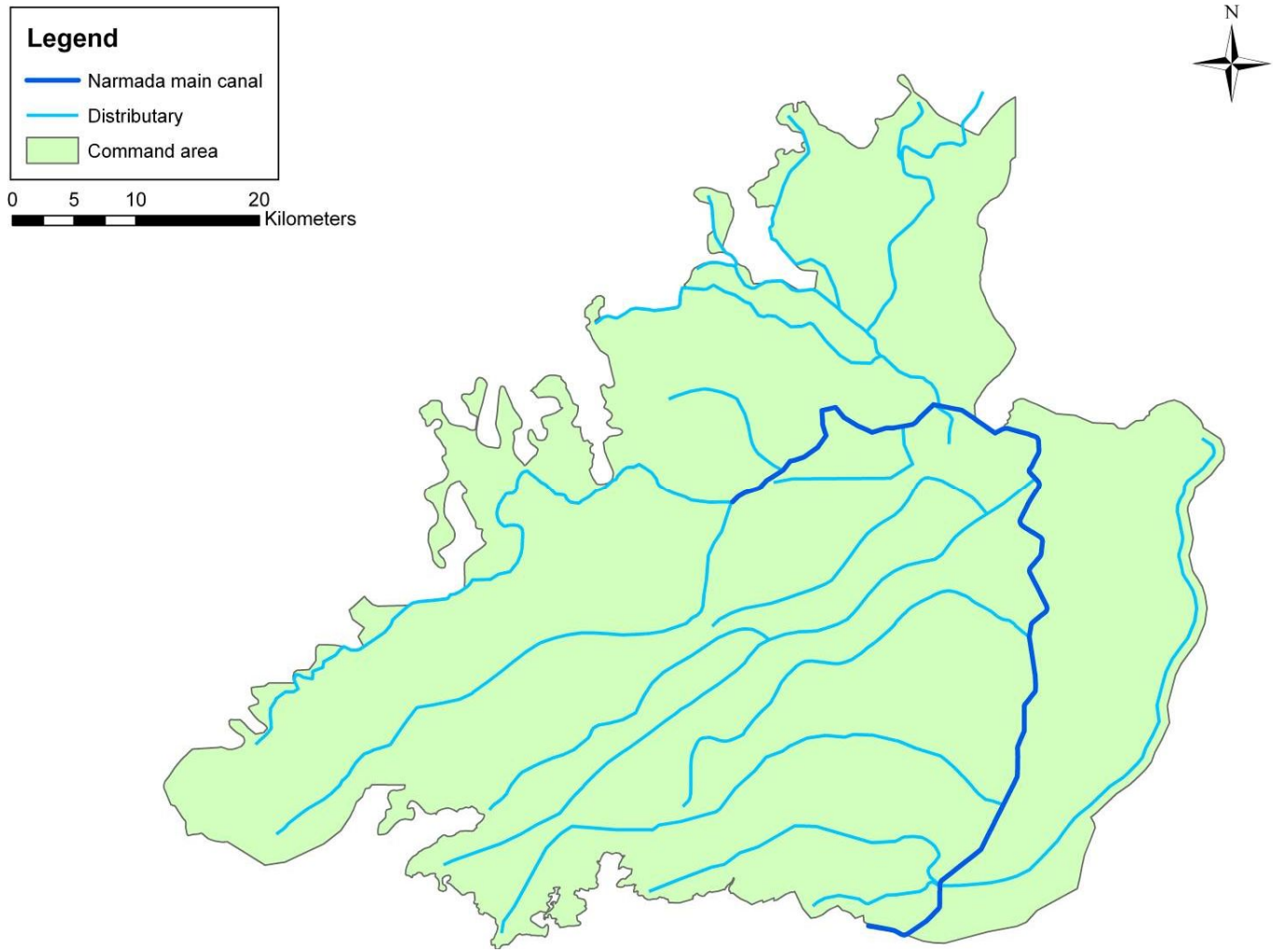

Fig. 3.1 The main canal and network of its distributaries envisaged under the Narmada Canal Project.

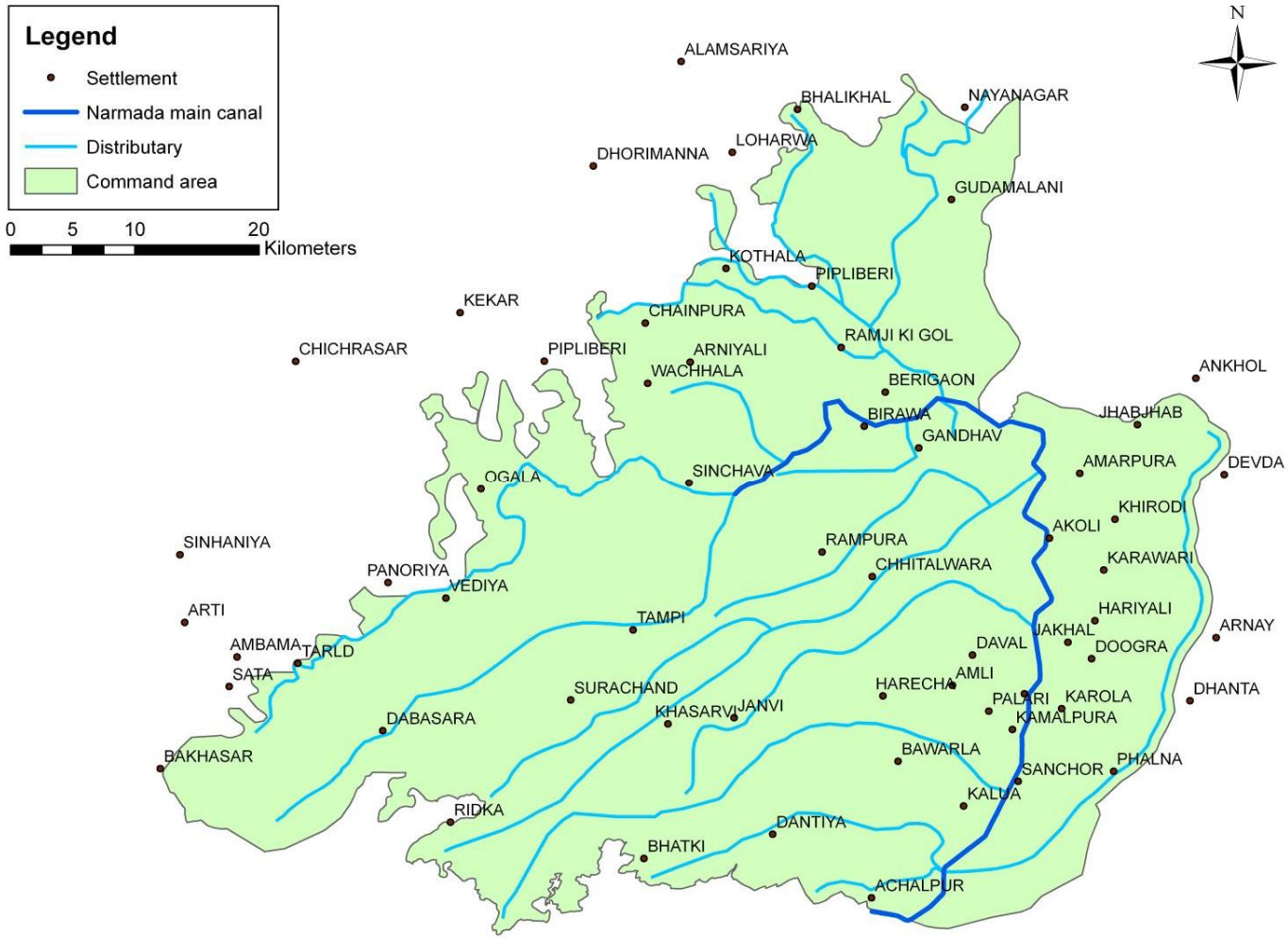

Fig. 3.2 Location of beneficiary villages falling within the command area of the Narmada Canal and in adjoining area.

3.2 Project Design

The initial project proposal contemplated accrual of benefits to a Gross Command Area of 1.42 lakh ha, Culturable Command Area (CCA) of 1.35 lakh ha and Irrigable Command Area (ICA) of 0.73 lakh ha with 54% of irrigation intensity in Jalore and Barmer districts of Rajasthan. Out of the total CCA, 0.38 lakh ha located in the “Flood Prone Area” (locally known as ‘Ned’) area in Jalore district. This is the tail drainage basin of the Luni and Sukri rivers that experience flooding nearly once in every three years in the last two decades.

The project proposal was revised to include additional areas upto a lift of about 20 m in the command. The CCA has now been increased to 2.46 lakh ha. This includes a CCA of 1.26 lakh ha to be irrigated by flow and 1.20 lakh ha to be irrigated by lift.

This is likely to reduce the water allowance of the canal so that the water logging problem is reduced. In addition to this conjunctive use of ground and surface water is being proposed to restrict the rise in groundwater level. Salinity resistant and low water requiring crops are being proposed.

Narmada Main Canal (NMC) of Rajasthan takes off from the tail of NMC of Gujarat near village Shilu of Sanchor tehsil of Jalore district (**Plate 3.1 and 3.2**). The total length of the canal in Rajasthan is 74 km with a head discharge of 73.5 cumec. The canal initially runs in the north direction for a length of about 51 km where it crosses river Sukri and then river Luni. Both these rivers form the main drainage of the area. Syphons are provided on these rivers for canal crossing. The canal then turns in a westerly direction and tails near Aleti village .

The salient features of the approved Narmada Canal project are presented in **Table 3.1.**

Table 3.1 Salient features of the Narmada Canal Project.

Type of Project	**Irrigation and Drinking Water**		
Irrigation from the project			
(i) Gross Command Area	2.86 lakh ha		
(ii) Culturable Command Area	2.46 lakh ha		
(a) Ned area (Delta region of Luni) (b) Normal flow area (c) Lift area (with lift upto about 20 m **Total**	0.30 lakh ha 0.96 lakh ha 1.20 lakh ha **2.46 lakh ha**		
Intensity of irrigation			
	Kharif	**Rabi**	**Total**
(A) Flow			
(i) Ned area	15%	25%	40%
(ii) Flow area	20%	50%	70%
(B) Lift area	20%	40%	60%
No of villages to be served for irrigation A) Flow area including 'Ned' B) Lift Area Total	 87 146 233		
Drinking water from the project No. of villages and Towns served (i) Within the command area of irrigation project (ii) Outside the command area of the project **Total** No. of Towns	 233 883 **1116** 2		
Rajasthan share in Narmada Water	616.74 MCM (0.50 MAF)		
Mode of conveyance of water to Rajasthan border	Narmada Main Canal taking off from Sardar Sarovar Dam in Gujarat		
Water available for Rajasthan (i) Share at Sardar Sarovar Dam (ii) At Rajasthan border (iii) Drinking water requirement (iv) Water available for irrigation (a) From Rajasthan share in Narmada Water (b) From groundwater **Total**	 616.74 MCM (0.50 MAF) 597.10 MCM (0.48408 MAF) 131.25 MCM (0.1064 MAF) 465.85 MCM (0.37768 MAF) 107.41 MCM (0.08708 MAF) **573.25 MCM (0.46475 MAF)**		
Water allowance for irrigation at canal	cumec/100 ha cusec/1,000 ha		

Type of Project	Irrigation and Drinking Water	
head		
(A) Flow	0.0091	1.3064
(i) *Ned* Area	0.0176	2.5124
(ii) Normal Area	0.0142	2.0366
(B) Lift Area		
Per capita drinking water requirements (litres per capita per day)		
(i) Rural villages	40	
(ii) Rural villages including cattle requirements	70	
(iii) Urban towns	100	

Salient Features of the Narmada Canal

Narmada Main Canal details	Rajasthan	Gujarat
(i) Main canal length	74 Km.	458 Km
(ii) FSL at head	44.97 m	91.44 m
(iii) Bed width at head	10.3 m	73.1 m
(iv) FSD at head	4.4 m	7.6 m
(v) Bed slope at Head	1 in 15,500	1 in 12,500
(vi) Side slope	2:1	2:1
(vii) Canal Section	Trapezoidal	Trapezoidal
(viii) Head discharge	73.5 Cumec	1133 Cumec
Distributaries		
(i) Number of distributaries for flow area (including Ned)	10	
(ii) Number of distributaries for lift area	3	
(iii) Approximate length of distributaries	390 km	
(iv) Approximate length of minors and sub-minors	1340 km	
Water distribution system		
(i) Method of application	Sprinkler / drip	
(ii) Number of chaks	2500	
(iii) Average area of each chak	100 ha	

Plate 3.1 The Narmada Main Canal (NMC) of Rajasthan taking off from the tail of NMC of Gujarat near village Shilu of Sanchor tehsil of Jalor district(a) and the already constructed section of main Narmada Canal(b).

Plate 3.2 The canal is already becoming a source of water for local people.

3.2.1 Irrigation techniques adopted

Special irrigation techniques have been proposed in the project so that most of the land can benefit optimally from economic gains from irrigated agriculture. These can be summarised as:

(i) Compulsory pressure irrigation is being adopted in the entire commanded area by using sprinklers or drip. No flood irrigation has been proposed in the command area. This will regulate the quantity of water to be used in irrigation and limit the seepage to ground thus preventing significant fluctuations in groundwater table.

(ii) Drainage of low lying areas is proposed by conjunctive use of surface and groundwater. By suitable mixing of surface and groundwater, the quality of mixed water will remain suitable for irrigation.

(iii) It is proposed to plant trees along canal system and on the boundaries of the fields of farmers. This will serve as bio-drainage for excessive groundwater.

(iv) The crops that are generally salinity resistant are proposed in most areas and more specifically in flood prone areas that are at greater risk of salinity ingression. In *Ned* area, date palms are proposed which are salinity resistant and draw substantial amount of groundwater.

3.2.2 Water delivery system

In order to regulate the water utilisation and to ensure optimised regulation of water the application of irrigation water by drip or sprinklers has been made mandatory in the project command (**Plate 3.3**). The water from the minors will be drawn into 'diggies' (shallow tanks) from where the cultivators will draw their share of water by using pumps (**Plate 3.4 & 3.5**). As the cultivators in the area are presently using sprinklers for irrigation; this method of irrigation will easily be adopted by all the cultivators in the project command. Water User Associations (WUAs) will also be constituted at the distributary level as per the provisions under the Rajasthan Farmers Participation in Management of Irrigation Act and Rules. The operation and maintenance of the distribution system will be vested with WUAs.

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Plate 3.3 Use of drip irrigation through sprinklers within the command area.

Plate 3.4 A typical lift and distribution system for serving the lift command area of the project.

Plate 3.5 Pump house (a) A typical diggi that draws water from the minor canal from where the cultivators draw water through pumping system (b)

3.3 Study Area

The area undertaken for this study is the command area of Narmada canal in Rajasthan which is located between 24^{o}-37' to 25^{o}-18' N and 71^{o}3' to 71^{o}52' E **(Fig. 3.3)**. The project area falls in Jalore and Barmer districts of South-West Rajasthan, bordering Gujarat

The Western region in which the command area of Narmada Canal Project (NCP) lies is generally sandy and water scarce and supports xerophytic vegetation in general. Luni basin tract, with better rainfall and shallow ground water supports xeromorphic woodland vegetation comprising of Khejri (*Prosopis cineraria*), Jal (*Salvadora oleoides*) in combination of other associated species forming various plant communities.

The command area can be divided into three distinct physiographic units viz, alluvial plains, aeolian plains and duney complex. The region is characterized by arid landscape features such as levelled rocky structural plains, rock-cut pediments, gravelly pavements, shallow colluvial plains, other sandy plains with alluvial underneath, sandy hummocks and low sand streaks, sand dunes of various kinds and inter-dunal plains. Transverse, longitudinal and compound parabolic dunes are the major types of dunes in the region. The rainfall in the Western arid region varies between 400 mm to 100 mm.

The command area of the project covers a total area of 2.46 lakh ha. It has been broadly divided in three categories depending on the method of irrigation (lift or flow), ground water depth and salinity namely **(Fig. 3.4)**.

(a) 'Ned' area (0.30 lakh ha)

This is the tail drainage basin of the Luni and Sukri rivers and classified as "Flood Prone Area" and experiences flooding nearly once in three years since the last two decades. The soils in this area are saline and the groundwater is also highly saline. Water table is about 10 m below ground. Indiscriminate application of irrigation water can cause rise in water table and further increase in salinity.

(b) Normal flow area (0.96 lakh ha)

These soils are generally coarse textured, very deep, somewhat excessively drained. The land is gently sloping with moderate erosion. The water table in the area is more than 10 m deep and on account of drainage of surface and groundwater towards the 'Ned' area, the salinity is also less.

(c) Lift area (1.20 lakh ha)

This area has nearly level to gentle slopes with severe to moderate problems of erosion. There are duney complexes in the lift area in West and North-West. The soils are very deep, fine sand, excessively drained having wind erosion activities. The groundwater is 10 to 20 m below ground level.

The command area has also been classified into 4 categories of land according to their suitability and intensity of irrigation **(Fig.3.5)**. The intensity for irrigation was determined based on productivity potential and suitability of soil for irrigation.

Irrigable Lands

- **Moderately Good Irrigable Land**

  Lands in this class are suitable for irrigation inputs but are approaching marginal qualifications for irrigated lands. They have restricted suitability, because of deficiencies in soil, topography or drainage more than Class II lands. The soils are droughty, have hammocky or low dune topography, or restricted drainage. Most of these deficiencies are manageable or correctable.

  Marginal Irrigable Land

  Lands in this class have very severe limitation in soils, topography low lying areas and /or drainage that may further reduce the choice of crops and require more special management and/or higher development expenditure than class III lands.

Non-Irrigable Lands

- **Tentatively Non-irrigable Lands**

  These lands require further investigation. They are not irrigable under existing conditions but have a potential value sufficient to warrant tentative delineation prior to additional studies to ascertain whether these lands should be classed economically irrigable or non-irrigable.

- **Economically non-irrigable Land**

  These lands are not economically suitable for irrigation development. They generally are high dunes, salt waste lands and marshy lands, or in other ways below the minimum requirements for any of the irrigable classes. Map

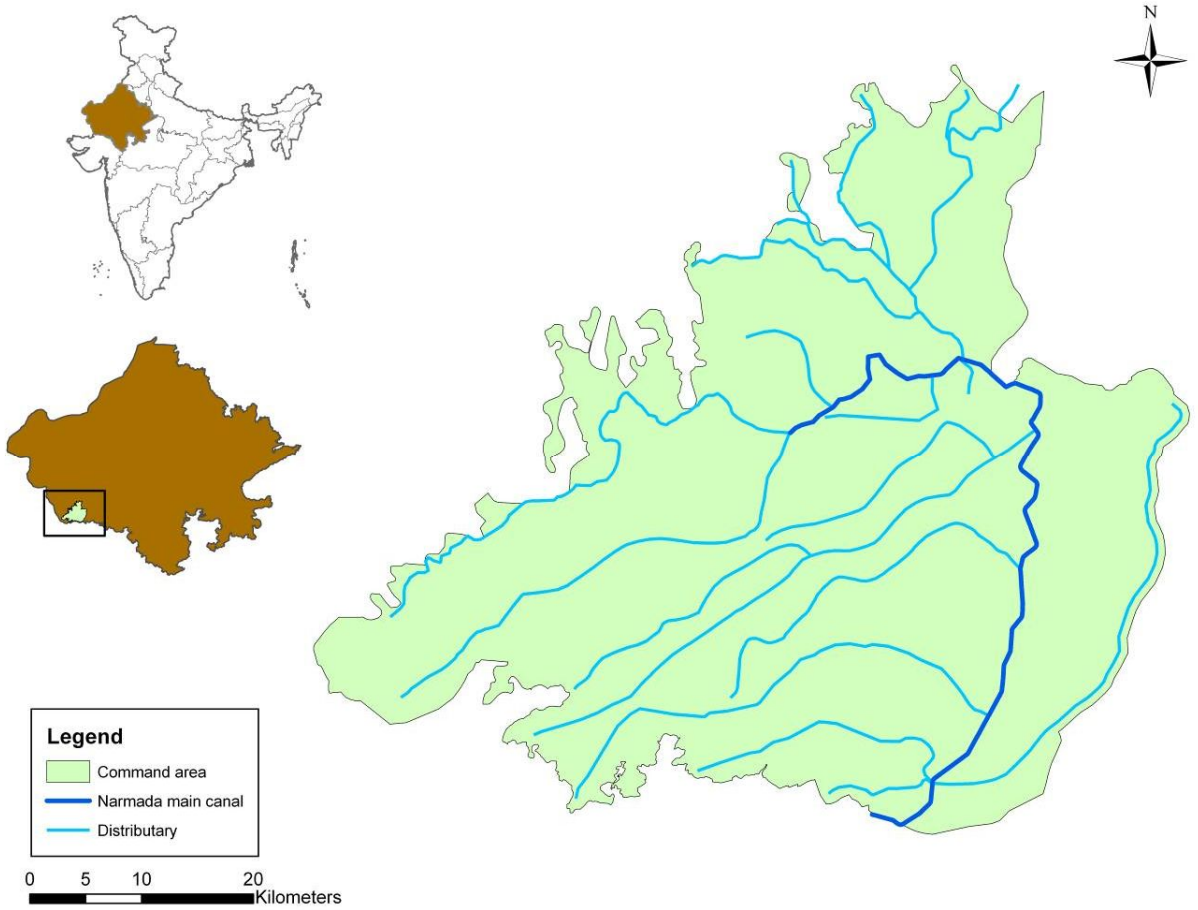


Fig. 3.3 Map showing location of project area.

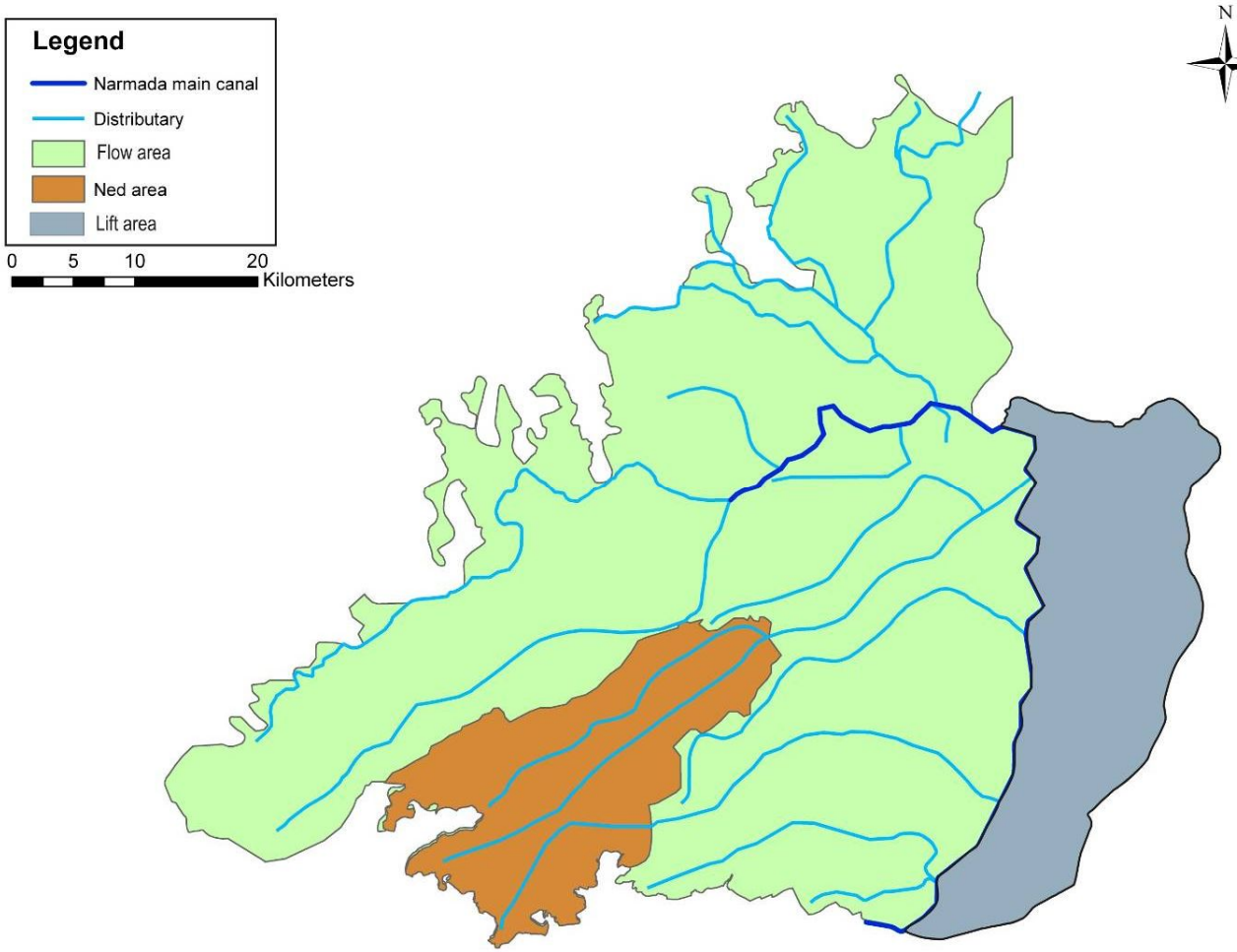


Fig. 3.4 Map showing areas under different type of irrigation inputs.

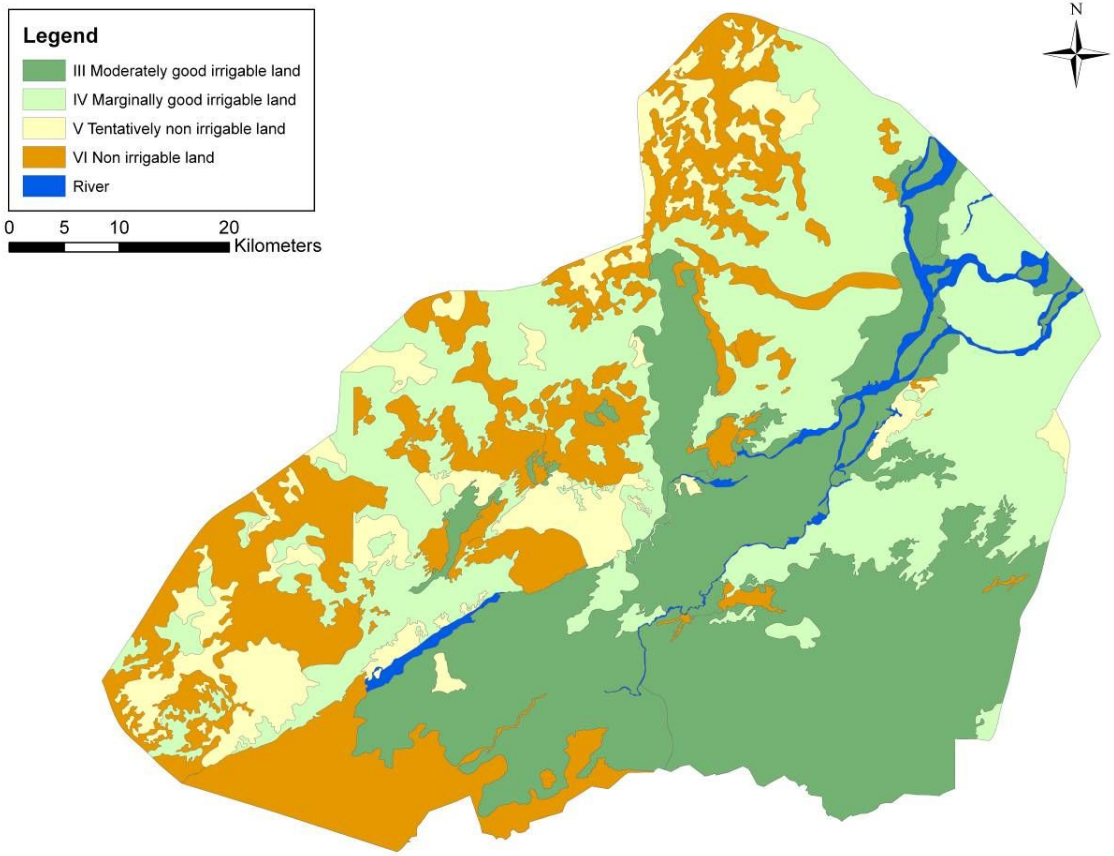


Fig. 3.5 Land categories identified in the command area based on soil suitability and irrigation intensity.

4. AN OVERVIEW OF IMPACTS OF IRRIGATION CANALS ON WILDLIFE

4.1 Introduction

Irrigation and drainage projects invariably result in many far reaching changes in ecology of the area. Some of these changes benefit human population while others threaten the long-term productivity of the irrigation and drainage projects themselves as well as the natural resource base. The undesirable changes are not solely restricted to increasing pollution or loss of habitat for native plants and animals but cover the entire range of environmental components, such as air, water, soil, energy, and the socio-economic system. The most pervasive impacts in the context of canals are presented in **Fig. 4.1.**

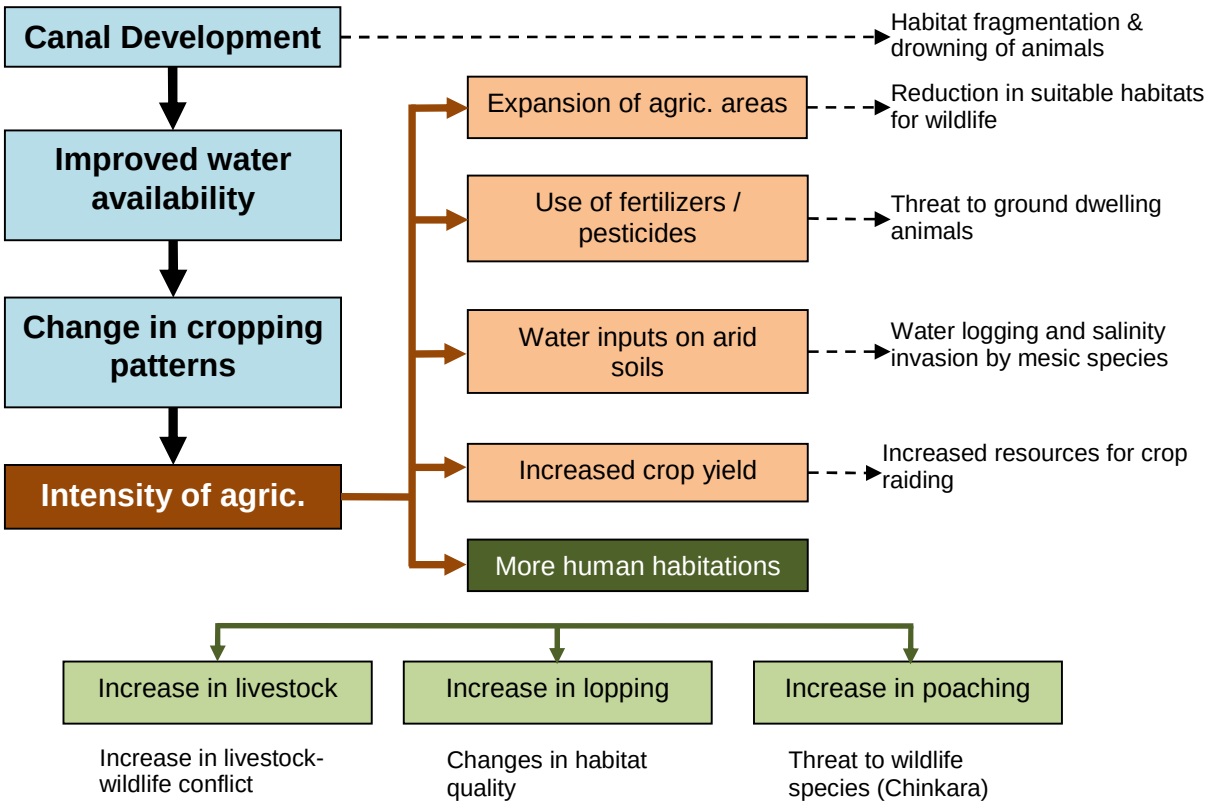


Fig. 4.1 Key impacts associated with a typical irrigation canal.

These impacts are further discussed here:

4.1.1 Primary impacts

These are the direct impacts caused due changes in physico-chemical and natural environmental characteristics and parameters due to construction/operation related activities associated with the canal. The following are some of the more recognisable direct impact of the canal:

- **Habitat loss or avoidance**

  The linear stretch of land diverted for construction of canal infrastructure itself may involve clearing of vegetation that may be a part of the habitat for several wildlife species which will subsequently become unavailable for use leading to loss in extent of available habitat. Once the canal is constructed, it will also have a visual impact that may result in animals avoiding the use of alongside habitats (Jalkotzy *et al.,* 1997).

- **Disruption of animal movements**

  Canals serve as significant barriers to movement. There is growing evidence that linear developments such as canals can affect the distribution, movements, and overall populations of wildlife species (Jakotzy *et al*., 1997). Although all linear developments can cause problems, roads and canals probably have been reported to induce the greatest impact on wildlife populations (Forman *et al*., 2003; Johnsingh *et al*., 2002; Ledec, 1987). In deserts, some species may use canals as a water source, but canals have more negative than positive impacts on wildlife. In the Anamalai hills of Kerala and Tamil Nadu, a series of dams and associated canal and pipes have affected the movement of elephants (Sukumar, 1993).

- **Direct or indirect mortality**

  Drowning or entrapment in canals has been reported to be one of the cause of direct mortality of animals. Desert mule deer, bighorn sheep, and Sonoran pronghorn have been reported to be drowned in canals (Rautenstrauch and Krausman, 1989; Rautenstrauch and Krausman, 1986; Busch *et al.,* 1984). Atleast 10 elephants have been reported to have died in the canals associated with the Parambikulam-Aliyar Project in South India and another 15 having been rescued since 1970. Many

animals including elephant, gaur spotted deer, sambar and even a tiger are reported to have been washed away by the swift currents when they attempted to cross the canal leading from Tunacadavu reservoir to the Sirkarapathy power house in the Parambikulam-Aliyar Project (Sukumar,1993). Direct mortality can also result due to animal collisions on the roads along canals (Rajvanshi *et al.,* 2001).

- **Social disruption**

  This refers to changes to the social structure of a population which may result from barrier effects of a canal. Changes can include displacement into habitat areas already occupied by other animals of the same species, changes in group structure, or mortality in different age classes as a result of the linear feature (Foreman, 1997).

- **Habitat fragmentation**

  By far, the largest single threat to biological diversity worldwide from linear structure such as canals is the alteration, destruction and fragmentation of large habitats into smaller patches (Meffe *et al*., 1997).

  Adverse effects of habitat fragmentation to both wildlife populations and species may include increased isolation of populations or species, which ultimately may lead to adverse genetic effects such as inbreeding depression (depressed fertility and fecundity, increased natal mortality) and decreased genetic diversity from genetic drift and bottlenecks (Watson, 2005).

  Construction of Ramganga reservoir and the Kunaun–Chilla power channel, both constructed in early 70s represent examples of fragmentation of the elephant habitat (Johnsingh and Joshua, 1994).

4.1.2 Secondary impacts

These impacts are a result of changes brought about in environmental quality and natural characteristics of the project area as a consequence of indirect changes associated with the canal construction and operation (such as expansion of agricultural areas, use of pesticides/insecticides, increased water inputs to soil, increased crop yield).

- **Increased salinity of soils**

  Water logging and consequent increase in salinity of soils are the two most commonly associated problems with canal development. Water seeping from canals down to the soil below may, at times, raise the ground water very close to the ground level. This may result in blocking of all the voids in the soil and obstructing the plant roots to breathe.

  Water logging for prolonged durations may also lead to salinity (IIT Kharagpur undated). Salinity is often linked with the rise of groundwater tables resulting from excess irrigation and poor drainage in large-scale, perennial irrigation systems. The resulting shallow water tables bring salts to the upper layers of the soil profile. Saline soils contain sufficient soluble salts to adversely affect the growth of most plants. With a predominance of sodium on the exchange complex and a low concentration of salts in the infiltrating water, the infiltration rate and permeability can be severely, and in some cases, irreversibly reduced (Stockle, 2001).

  In India, 2,189,400 ha have been reported to suffer from water-logging in irrigation canal commands. Also 3,469,100 ha were reported to be seriously salt affected (Tyagi, 1996). One of the technical problems that have led to irrigation-induced salinity include poor construction, operation and maintenance of irrigation canals causing excessive seepage losses, and inadequate or lack of drainage infrastructure or, if drainage facilities are present, their poor quality of construction, operation, and maintenance (Stockle, 2001). All these effects have a direct impact on the surrounding flora thereby causing an indirect impact on the wildlife populations living in or nearby such areas.

- **Habitat disruption or replacement**

  Canal developments can disrupt habitat use by introducing exotic plants, pesticide and fertlisers application. Habitat can also be altered when vegetation is removed for construction or when new plants or grasses are planted in canal right-of-ways. The effects of habitat disruption on wildlife are probably small when compared with the effects of habitat avoidance (Jalkotzy *et al.,* 1997).

Introduction of weeds and other invasive species –

Any change to a more uniform environment on the project lands is likely to favour vigorous species adapted to a wide variety of conditions. For example, population of insects and rodents, are often regarded as pests may increase. The preferred habitats of natural predators, such as snakes, birds and spiders, may be reduced by land use changes and by the increased use of pesticides. Local or colonising varieties of weeds may thrive in the irrigated environment and reduce agricultural productivity (Dougherty *et al.,* 1995).

Habitat degradation due to pollution –

Extensive use of chemicals such as pesticides, herbicides (common by-products of irrigated agriculture), may lead to decline in functions of wetlands habitats due to contamination of the water supplies from agricultural pesticides and herbicides in surface runoff from irrigated fields (Roe *et al.,* 1980; Nell, 1987; Moore *et al.,*1990). Moreover, food chains could also get modified by the use of insecticides and pesticides, thus have detrimental impacts upon wildlife.

- **Habitat alteration and fragmentation**

  Landscape structure can be altered by changes in agriculture in terms of the composition and relative availability of habitat elements (*e.g.* patches, corridors), and/or their spatial configuration (Freemark, 1995). When particular habitat elements become rare or absent as a result of agricultural activities, species that depend on them also become rare or absent (Erhardt, 1985; Herkert, 1991; Delphey and Dinsmore, 1993). Many of these stated impacts can also be related to canal induces changes in agriculture patterns and productivity.

4.1.3 Tertiary impacts

These are long term indirect impacts associated with changes brought about in the environmental characteristics by development projects. Increased crop yield as an after effect of improved irrigation inputs to agricuture, may result in consequent increase in human habitations near more productive lands that may further induce impacts on wildlife. Some of the probable secondary impacts of canal development are:

- **Increase in human-wildlife conflicts**

  As human populations rapidly increase and settled agriculture spreads to more marginal rangelands, conflict between wildlife and people inevitably

increases (Muruthi, 2005). This may result from increased pressure on the natural resource for consumptive uses which in turn may have a bearing on resource availability for wildlife and decline in the quality of habitats from where the resource needs are met for people and wildlife.

- **Increase in livestock-wildlife conflicts**

  Increase in livestock population due to the rise in number of farmer communities is likely to lead to greater incidences of livestock-wildlife conflicts. Livestock are often considered a threat to ungulates and other large mammals which share the same habitats with livestock species. According to a study (FAO, undated), in East Africa, grazing lands/pastures are under greater pressure as human populations increases. In addition, pastoral land and wildlife dispersal areas are under threat from external actors who are allocated larger tracts of land for commercial cropping. The spontaneous spread of agriculture throughout this semi-arid ecosystem, by both pastoralists and external agents, has resulted in habitat change and truncation of important ecosystems.

4.2 Lessons Learnt from Indira Gandhi Canal Project in Rajasthan

Considering that the Narmada Canal project is also located in the state of Rajasthan, it became relevant to review the impacts of earlier constructed canal projects such as the Indira Gandhi Canal for better visualisation of the scope of the present study and for a holistic and meaningful evaluation of impacts on desert flora and fauna. The following are some of the significant impacts of the Indira Gandhi Canal project that have been reported by different workers:

i. According to the Task Force report (GOI undated) tremendous changes in the avifaunal structure of the Thar desert are taking place due to the Indira Gandhi Nahar Project (IGNP) and species never seen earlier are now regularly found near the canal (Rahmani, 1997a, 1997b; Rahmani and Soni, 1997)

ii. According to Prakash (2001), desert and semi arid regions have a number of highly specialized insects and reptiles. The canal poses most imminent danger for the reptile species which inhabit extremely loose soil since the water consolidates the soil. Lizard species such as *Phyrocephalus laungwalensis, Rig mahi, Ophimorus tridactylus, Eumeces teaniolatus, Acanthodactylus cantoris, Cyrtodactylus kachhensis, Ablepharus grayanus,*

Stenodactylus orientalis, Ophisops jerdoni and the snake species *Leptotyphlops macrorhynchus* and *Lytorhyncus paradoxus* are likely to be severely impacted due to transformation of desert grassland to irrigated crop fields.

iii. Prakash (2001), also reported that before the establishment of irrigation in the northwestern desert, *gerbils Gerbillus gleadowi*, *Tatera indica* and *Meriones hurrianae* constituted 80 percent of the rodent fauna of the desert. After the advent of canal, the bandicoot *Bandicota bengalensis* and the *metad Millardia meltada* have invaded the crop fields almost totally replacing the gerbil population because of the enhancement of mesic conditions by expanding irrigated agriculture (Prakash, 2001).

iv. According to Prakash (2001), the preferred habitat of the porcupine *Hystrix indica*, is rocky formations, especially in the foothill slopes. But in the recent years, it inhabits slopes of tall sand dunes along the IG canal and causes considerable damage to crops at night.

v. According to Rana (1991), large mammals, such as Nilgai and wild pig which are not typically the desert species are increasingly inhabiting the areas along the canal because of increased availability of water, vegetation cover and abundant food resources.

vi. A number of shrubs such as *Calligonum polygonoides, Haloxylon salicornicum, Dipterygium glaucum, Tribulus alatus* and the sedge *Cyperus conglomerates*, which are adapted to survive only in extreme xeric conditions, were feared to disappear by the time about 15 percent of the desert is irrigated by IG canal tributaries (Prakash, 2001).

5. METHODOLOGY

5.1 Introduction

Assessment of ecological impacts of development activities essentially need to be based on reliable information about the profile of the proposed project and the baseline conditions along with attendant human aspects characterizing the environment of the project area. Recognition and identification of the ecological areas of significance within the study area for establishing biological baseline, comprehensive understanding of the location and design features of the project and visualization of the activities in the operation phase are the important prerequisites for determining the ecological impact potential of the proposed project. It is therefore extremely important to collate information both on the ecological environment, human aspects and the proposed project profile prior to attempting an assessment of nature and the magnitude of impacts. The methodological approach adopted for this study was aimed to incorporate the above aspects. The framework for conducting ecological assessment of the proposed project is presented in **Fig. 5.1** and conforms to the standard practices followed worldwide in the evaluation of development projects (Davy, 1998; Petts, 1999; Treweek, 1999; Slootweg and Kolhoff, 2003). The scope of work and the approaches adopted to accomplish some of the steps outlined in the traditional EIA framework are discussed in subsequent subsections of this chapter.

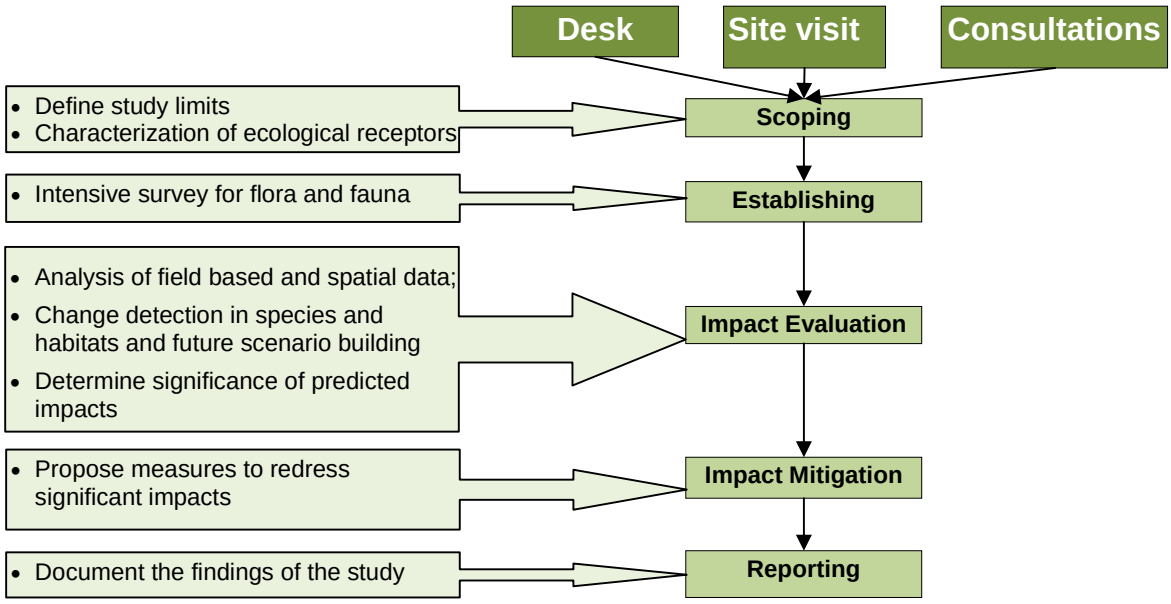


Fig. 5.1 The sequence of steps in ecological assessment of the Narmada Canal project.

5.2 Study Area

The entire culturable command area of the Narmada Canal, spread over 2.46 lakh ha represented the study area. The study further recognized the delineation of 4 land categories within the command area for intensive studies.

5.3 Desk Studies

The project feasibility reports formed an important source of information for understanding the profile of the project and the activities envisaged to visualise the nature and extent of the impacts. The project report (Narmada Canal Division of the Irrigation department) provided information on the extent of area included under the command area, classification of the area on the basis of soil suitability, details about the distribution system of the Narmada canal, irrigation techniques to be adopted in the project area, proposed crops to be grown within the project area and the construction schedule. This information was vital for detecting changes in cropping pattern, intensity, area and their bearing on changes in wildlife habitats and their use patterns in the operational phase of the project.

An extensive literature survey was undertaken for gaining insight into nature of the ecological impacts associated with canal development projects. Additional information on regional ecology and wildlife distribution and abundance was acquired through discussions with the local people (**Plate 5.1**).

5.4 Scoping of Issues

The purpose of scoping is to prioritize relevant and the most important issues that should merit consideration in the EIA. This helps in identifying areas of ecological interest, species and habitats of conservation importance and biodiversity resources that have significant economic importance for placing greater focus on evaluation of impacts in the impact assessment studies. The preceding chapter (Chapter 4) presented an overview of canal related impacts to facilitate the scoping step. Public consultations and reconnaissance surveys provided additional means to facilitate the scoping of issues relevant for the study.

Plate 5.1 Consultations with local people.

5.4.1 Reconnaissance study

A reconnaissance survey was carried out in the command area during 23rd November to 28th November 2009. Effort was made to eyeball the command area with an objective to identify prominent landscape features; land uses types, land categories delineated on the basis of proposed intensity of irrigation; broad vegetation types and key wildlife values within the command area. On the basis of this information, an intensive survey was planned to develop an ecological baseline with a special focus on key faunal elements such as chinkara and ethnobotanical values of desert flora. The reconnaissance survey also helped in appreciating the ecological importance of several grazing lands (*gochar bhoomi)* interspersed with agriculture areas. Grazing lands are village lands meant for livestock grazing. These lands, devoid of any agricultural activities and human settlements, were observed to be of significant value as refuges for chinkara and other desert species. Any impacts of land uses changes on account of increasing intensity of irrigation in these areas could influence their habitat suitability. Keeping in view, the need to include all representative land categories in the ecological assessment of the Narmada canal, transects were laid in all the four land categories identified by the project authorities within the command area and also in the fifth land category recognised based on importance of grazing lands (**Table.5.1; Fig. 5.2 and Plate 5.2, 5.3 & 5.4**)

Table 5.1 Different land categories within the command area.

CLASS TYPE		*% AREA of CA*	*CODE*
Irrigable lands (Low cost effort)	*Moderately Good Irrigable Land*	*33.58*	*A*
	Marginally Irrigable Land	*32.96*	*B*
Non Irrigable Lands (High cost effort)	*Tentatively Non-irrigable Land*	*8.47*	*C*
	Economically Non-irrigable Land	*23.4*	*D*
GRAZING LAND (NOT INCLUDED UNDER IRRIGATION)		*Interspersed with other land classes*	*E*

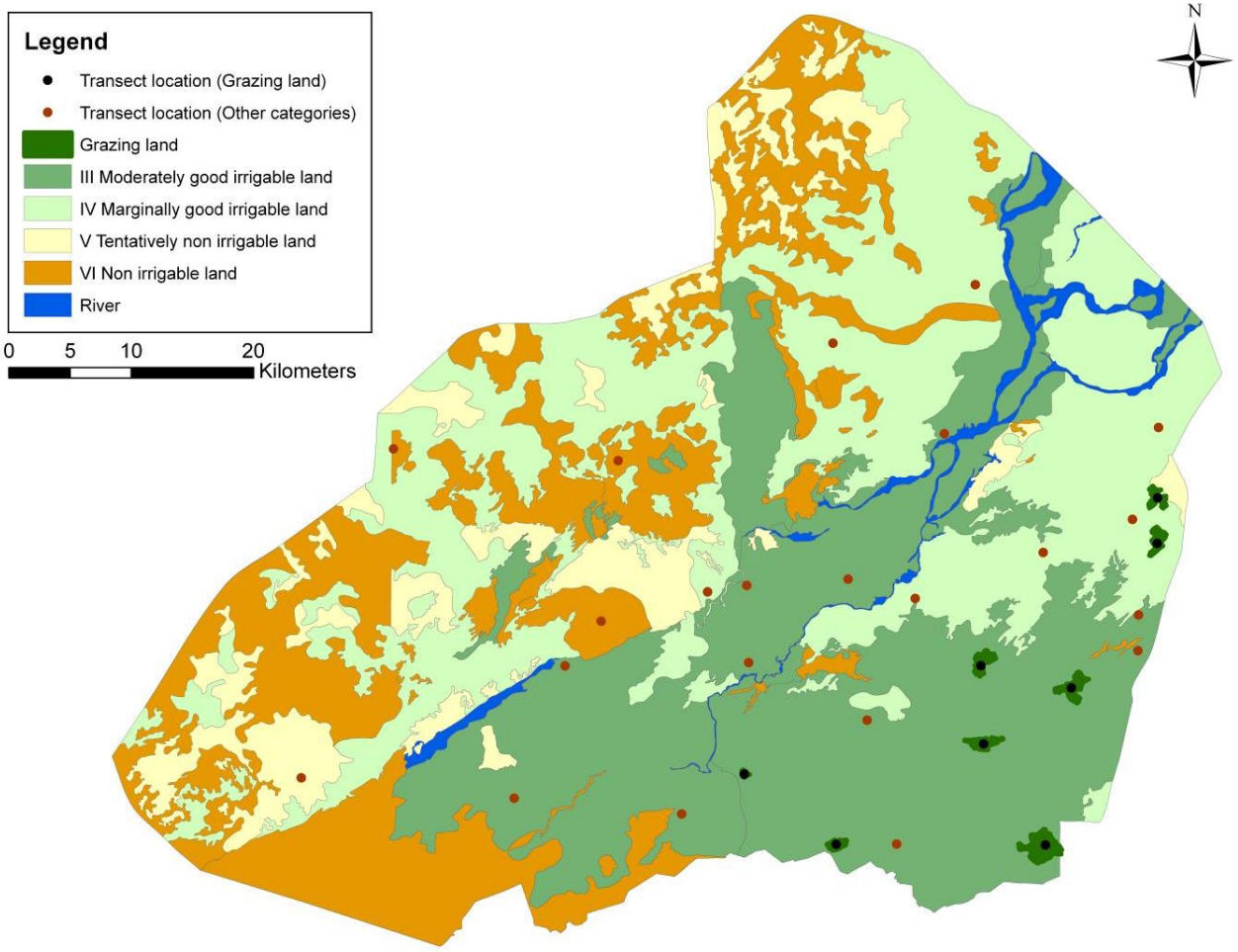
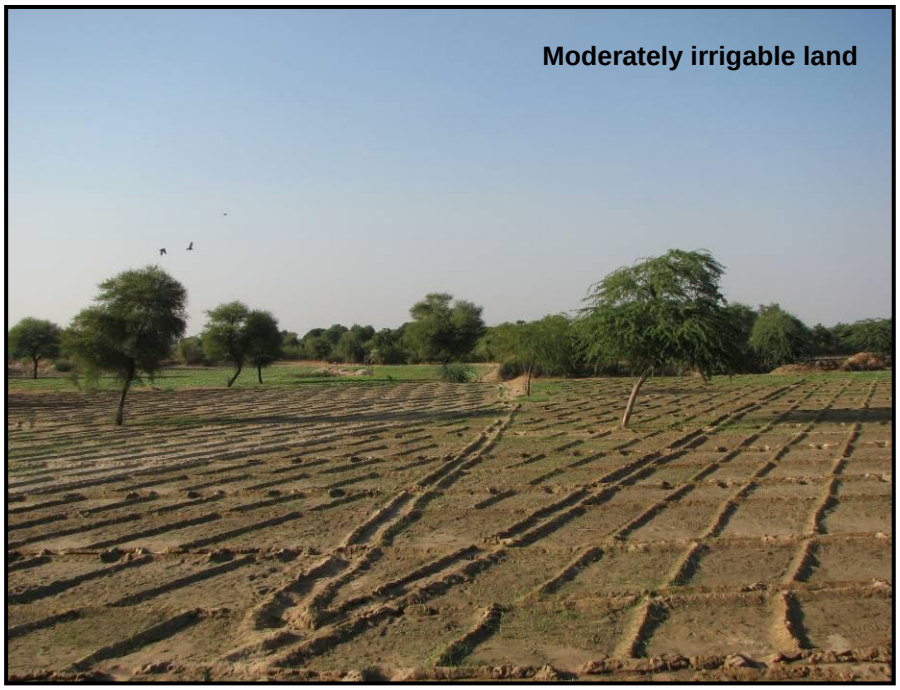


Fig. 5.2 Map showing transect points.



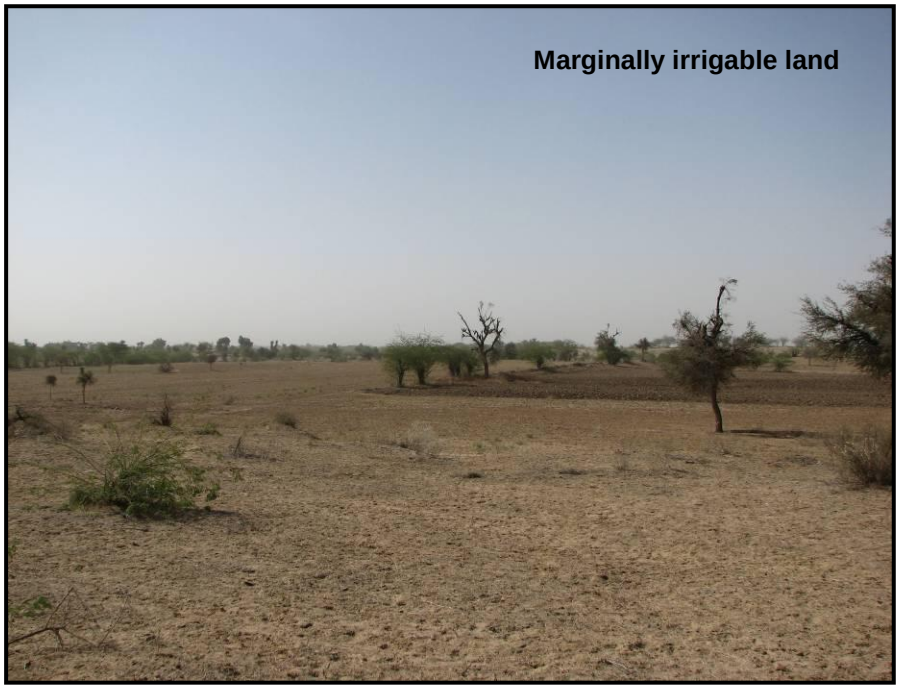
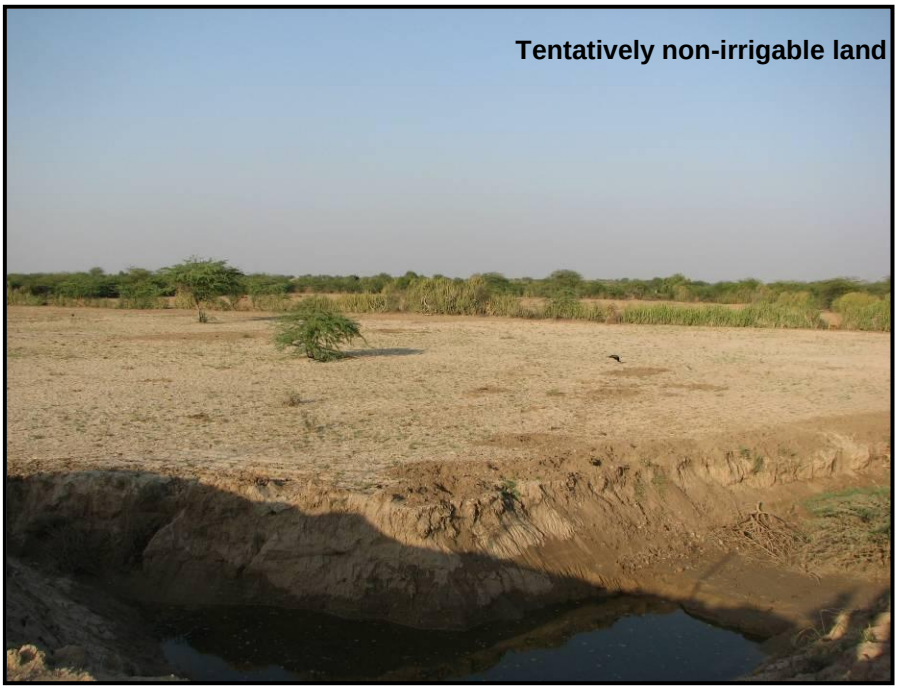


Plate 5.2 Irrigable lands.



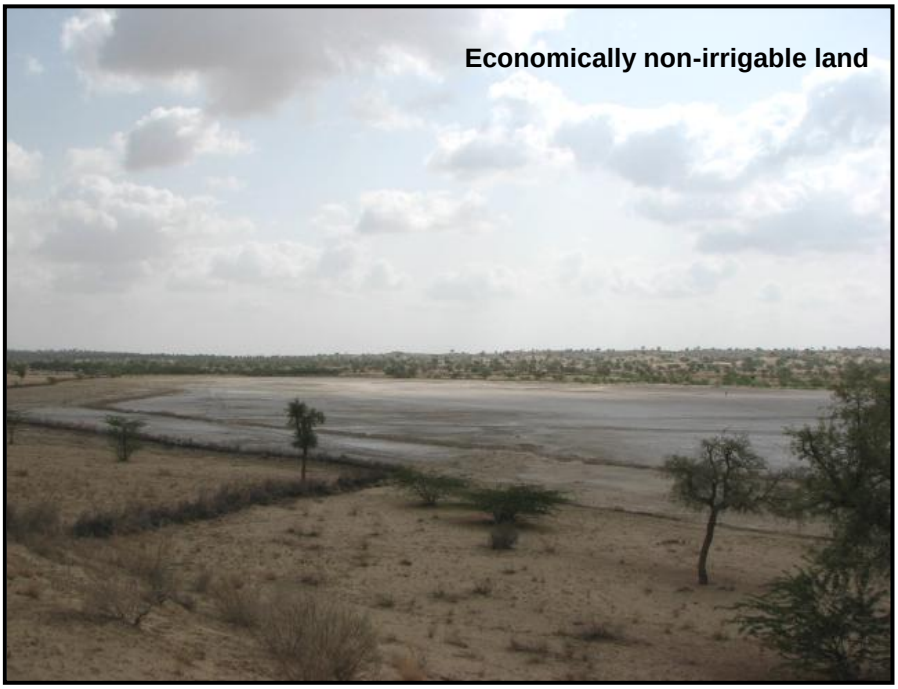


Plate 5.3 Non-Irrigable lands.

Plate 5.4 Grazing lands.

5.5 Establishing Baseline

Line transects of average length 3 km were laid in each of the five categories of land during different seasons.

MONTHS	SEASON	TRANSECTS	No
November-December 2009	WINTER	Moderately Irrigable land Marginally Irrigable land Tentatively Non Irrigable land Non Irrigable Land Grazing Land	8 8 3 3 11
February 2010			33
June 2010	SUMMER	All categories of land as above	13

Data was collected on the following parameters:

5.5.1 Faunal attributes

a) *Mammals:* The occurrence of major faunal species of mammals especially chinkara and nilgai along the transects was determined based on sign surveys to record direct and indirect evidences (pellets, droppings, scats, animal tracks and signs) (Rodgers, 1991; Sutherland, 2006).

b) *Avifauna:* For birds, point counts (open radius) were made at every 250 m (Bibby *et al.,* 2000) along the transect with the aim of inventorying of species.

For both, mammal and bird species, opportunistic sightings were also recorded. These observations were made both in terrestrial areas (crop fields, grazing lands, and village commons) and in aquatic bodies (canal, distributaries, and temporary wetlands created by changes in water regimes).

5.5.2 Floral attributes

a) *Trees:* Point Centered Quadrat (PCQ) method was followed for quantifying tree species in the study area. PCQ is a plot-less method which involves measuring distances for a random sample of trees, typically along transect and recording the characteristics of interest for this sample. In this case, observations were recorded at every 250 m along the 3 km transect. At

each sampling point, the quarter number (I, II, III, or IV), the distance from the sampling point to the nearest tree and the tree species was recorded.

b) *Shrubs/Herbs:* Circular plots of radius 5m were laid at every 250 m of the transect for recording herb and shrub species in different category of lands.

5.5.3 People's response

Informal consultations were organized with local people to understand their perceptions about the benefits of development of canal in the region and their associated impacts on their socio-economic well being. Information about their values and beliefs associated with wildlife was also collected to predict the changing dimensions of anthropogenic threats and human wildlife conflicts in the operational phase of the project.

5.5.4 Generation of spatial information for impact prediction

One of the major constraints in undertaking this study was the non-availability of topographical maps on account of the fact that the study area corresponded with the '*Restricted Area*' designated by Survey of India. This greatly limited the ability to follow map features and record information systematically to correspond to different topographical and other land use features. To overcome this limitation, conversion of autocad drawing files to shape files was initially attempted. This was followed by vector geo-referencing and finally the extraction of different layers of information including roads, settlements, river line, canal network command area, Ned area, soil, and land irrigability classes.

The information generated during intensive studies was superimposed on these spatial layers to represent the spatial dimensions of likely impacts on wildlife habitats, grazing lands and species distribution in altered scenario after the advent of the canals in the area.

6. BASELINE INFORMATION

6.1 Ecology of the Area

The study area represents the elements of the Thar Desert ecosystem. Among the desert ecosystems of the world, this desert is one of the smallest yet most populated with an average density of 83 persons per km^2, when compared to other deserts, with an average density of seven persons per km^2 (Baqri and Kankane 2001). Due to its geographical configuration, the Thar Desert is a conglomeration of Palaearctic, Oriental and Saharan biological taxa. About 4 percent of its vertebrate fauna is macro-endemic and 14 percent micro-endemic to the Great Indian Desert (Prakash, 2001).

The vegetation in Thar Desert has been classed as Northern Desert Thorn Forest (Champion 1936) and exhibits 682 plant species (Bhandari, 1991). The density of vegetation in this desert increases from West to East following the increase in rainfall. A major portion of the Thar is occupied either by dry open grassland or by grassland interspersed with trees and thorny shrubs and herbs (Gupta, 1975) such *as Acacia jacquemontii, Acacia nilotica, Calligonum polygonoides, Capparis decidua, Commiphora wightii, Leptadenia phytotechnica, Lycium barbarum, Prosopis cineraria, Salvadora oleoides, Salvadora persica, Tamarix aphylla, Zizyphus nummularia, Aerva persica, Blepharis scindica, Calotropis procera, Crotalaria burhia, Cymbopogon javarancusa, Euphorbia caducifolia, Grewia tenax* and *Tephrosia purpurea*,. Most of the grasslands Dichanthium-Lasiurus-Cenchrus type (Dabadghao and Shankarnarayan, 1973). The plant taxa endemic to the Thar Desert includes 23 species and 14 sub-species, forming 6.4 percent of the total recorded flora (Khan and Frost, 2001).

Despite its comparatively small area, the Thar Desert has high avian diversity with low endemicity, owing to its location on the confluence of Palaearctic and Oriental biogeographic regions. To the west, it is connected through the Sind plains to the Persian and the Arabian deserts; to the northeast with the Gangetic plains, and to the east, it joins the Semi-Arid biogeographic zone. In the south, it merges with the Rann of Kutch. Therefore most species of birds of the Thar are widely distributed (GOI, undated). Nearly 300 species of birds have been recorded from the Thar desert (Adam, 1873, 1874; Barnes, 1886; Ticehurst, 1922; Whistler, 1938; Rahmani, in press).

In terms of mammalian diversity, Thar Desert has altogether 68 species belonging to nine orders dwelling in the area (Alfred and Agarwal, 1995). These constitute about 18% of the total mammalian fauna of the country. They range widely in size from as big as nilgai to as small as shrew (Kankane, 2009). The Indian Gazelle or chinkara is a very widely distributed mammal in the Thar Desert with the highest concentrations being found here. The chinkara is a very adaptable animal and is present in all the habitat types seen in Rajasthan (Rahmani, 1990). The distribution of the chinkara is closely associated with settlements of Bishnoi and Jain communities which do not permit the killing of animals, as chinkara and blackbuck as they are considered sacred (Rahmani, 1990)

While Protected Areas (PAs) of Thar Desert constitute only 4.3% of its total geographical area, the habitats suitable for wildlife outside such protected areas still hold viable populations of wild animals. The factors such as low human population density, non-availability of surface water for irrigation, geological features and other socio-cultural aspects have influenced high diversity of wildlife in areas outside PAs (Kankane, 2009).

6.2 Wildlife Values of the Narmada Canal Command Area

6.2.1 Flora

The vegetation of the command area representing the Northern Desert Thorn Forest (Champion, 1936) is characterised by low diversity of trees, shrubs and herbs occurring in small clumps scattered more or less openly.

As part of this study, a total of 42 floral species belonging to 26 families were recorded from the command area (***Annexure - III***).

The highest numbers of species belong to the family Fabaceae. The major tree species in this area are *Prosopis cineraria*, *Tecomella undulata*, *Salvadora persica*, *Azadirachta indica* with *Prosopis cineraria* being the most dominant. Among the herb/shrub species, *Salvadora oleoides*, *Aerva persica, Calotropis procera, Capparis decidua* and *Crotalaria burhia* are dominant. Out of the 40 species recorded, 1 species, *Tecomella undulata*, belongs to the 'threatened' category.

Some of the endemic plant species recorded in the study area are: *Calligonum polygonoides* (Polygonaceae), *Prosopis cineraria* (Fabaceae), *Lasiurus sindicus* (Poaceae), *Cenchrus biflorus* (Poaceae), *Tecomella undulata* (Bignoniaceae), *Citrullus colocynthis* (Cucurbitaceae), *Tamarix aphylla* (Tamaricaceae), *Salvadora oleoides* (Salvadoraceae), *Capparis decidua*

(Capparaceae), *Sueda fructicosa* (Chenopodiaceae), *Aerva pseudotomentosa* (Amaranthaceae), *Crotolaria burhia* (Fabaceae), *Leptadenia pyrotechnica* (Ascelpiadaceae) (**Plate 6.1 A to E**).

Most of the species have medicinal or forage values or both. Species such as *Convolvulus microphyllous, Cressa cretica, Leptadenia pyrotechnica, Salvadora sp. Tephrosia purpure, Solanum surattense, Citrullus colosynthis* have high medicinal values. *Prosopis cineraria, Zizyphus nummularia, Capparis decidua, Acacia leucophlea* are some species known for their high fodder values. Some species such as *Tecomella undulata, Balanites aegyptica* have high medicinal as well as fodder values.

The relative variation in absolute frequency of the dominant species is presented in **Table 6.1**.

Table. 6.1 Absolute frequency(%) of the dominant tree species in different land categories of the command area.

Sl.No	Land Categories / Dominant Tree Species	A *(Moderately good irrigable land)*	B *(Marginally irrigable land)*	C *(Tentatively non-irrigable land)*	D *(Economically non-irrigable land)*	E *(Grazing land)*
1.	*Prosopis cineraria*	68.3	89.58	65.26	97.23	31.7
2.	*Tecomella indica*	27.48	44.9	55.56	30.56	43.44
3.	*Azadirachta indica*	15.61	19.36	23.6	0	0

Prosopis cineraria is the state tree of Rajasthan. It is evergreen or nearly so. It inhabits dry, arid areas where annual rainfall averages less than 500 mm. The tree grows on a variety of soils, but grows best on alluvial soils consisting of various mixtures of sand and clay. It is common on moderately saline soils, but quickly dries out where the soil is very saline. It is much valued as a fodder tree and its wood is also used for construction purposes. Rural communities encourage the growth of *Prosopis cineraria* in agricultural fields, pastures and village community lands as it stabilizes shifting sand dunes because of its extensive root system and is also useful as a windbreak.

Plate 6.1A *Prosopis cineraria*(a) and *Tecomella undulata*(b) are both important plant species of the Thar desert ecosystem.

Plate 6.1B ***Capparis decidua*****(a) and** ***Salvadora oleoides*****(b).**

Plate 6.1C ***Aerva javanica*****(a) and** ***Fagonia cretica*****(b).**

Plate 6.1D *Crotalaria burhia*(a) and *Calligonum polygonoides*(b).

Plate 6.1E ***Tamarix aphylla*****(a) and** ***Solanum surattense*****(b).**

Tecomella undulata is a deciduous or nearly evergreen tree of arid and semi arid regions. It grows in areas of scanty rainfall (annual 150-500mm) and high temperature. It is mainly used as a source of timber. It also has an important role to play in ecology. It acts as a soil-binding tree by spreading a network of lateral roots on the top surface of the soil. It acts as a windbreak and helps in stabilizing shifting sand dunes. It is considered as the home of birds and provides shelter for other desert wildlife.

Salvadora oleiodes is a small bushy evergreen shrub. It is a very common plant in arid tracts but becomes scarce where rainfall conditions are better. It has good medicinal, forage and cover values.

Capparis decidua is a bushy shrub and grows in dense tufts. It is one of the important multipurpose tree species of desert and arid regions of India. It provides vegetative cover in dry, hot, sandy desert areas where little else grows and is an extremely hardy species. It is used for preparing vegetables, and has fodder and medicinal values.

Crotalaria burhia is a low under shrub found in the arid regions of Rajasthan. It forms a major component of chinkara's diet.

6.2.2 Fauna

Avifauna: A total of 55 bird species were recorded from this area (**Table 6.2 & Plate 6.2A to E**). Out of these 55, 22 species belong to the order Passeriformes; 5 species to the order Charadriiformes; 4 species to the order Ciconiformes; 4 species to the order Pelecaniformes; 3 species to orders Columbiformes, Coraciiformes, Falconiformes; 2 species each to orders Anseriformes, Galliformes, Gruiiformes; and 1 species each to orders Acciptriformes, Cuculiformes, Psittaciformes and Piciformes. Based on their preferred habitat types (desert, forest, miscellaneous, wetland, grassland), more than half (24) of the bird species recorded from the study area, belong to the miscellaneous habitat category followed by 16 species which are commonly found in wetlands. There are only 6 true desert species while 5 species, 2 species and 1 species belong to the forest, desert/grassland and grassland habitat types respectively.

Table. 6.2 Birds recorded from different habitat types within command area.

Sl.no	Name of the species	Scientific name	Order	Habitat
1.	**Black Ibis**	**P*seudibis papillosa***	**Pelecaniformes**	
2.	Common babbler	*Turdoides caudatus*	Passeriformes	
3.	**Egyptian vulture**	***Neophron percnopterus***	**(Falconiformes)**	***DESERTS***
4.	Green Bee-eater	*Merops orientalis*	(Coraciiformes)	
5.	Steppe Eagle		(Acciptriformes)	
6.	Variable Wheatear	*Oenanthe picata*	(Passeriformes)	
7.	Common Kestrel	*Falco tinnunculus*	(Falconiformes)	***DESERT/ GRASSLAND***
8.	Grey Francolin	*Francolinus pondicerianus*	(Galliformes)	
9.	Black-rumped Flameback	*Dinpopium benghalense*	(Piciformes)	
10.	Rosy Starling	*Sturnus roseus*	(Passeriformes)	***FOREST / PLANTATIONS***
11.	Shikra	*Accipiter badius*	Falconiformes	
12.	White browed Fantail	*Rhipidura aureola*	(Passeriformes)	
13.	White cheeked Bulbul	*Pycnonotus leucotis*	(Passeriformes)	
14.	Greater Short toed Lark	*Calandrella brachydactyla*	(Passeriformes)	***GRASSLAND***
15.	Ashy Prinia	*Prinia socialis*	Passeriformes	
16.	Bank myna	*Acridotheres ginginianus*	Passeriformes	
17.	Black Drongo	*Dicrurus macrocercus*	(Passeriformes)	
18.	Black Red start (?)	*Phoenicurus ochruros*	(Passeriformes)	
19.	Brahminy Starling	*Sturnus pagodarum*	Passeriformes	
20.	Chesnut shouldered Petronia	*Petronia xanthocollis*	(Passeriformes)	
21.	Common Myna	*Acridotheres tristis*	(Passeriformes)	
22.	Common Tailor bird	*Ortthotomus sutorius*	(Passeriformes)	
23.	Eurasian Collared Dove	*Streptopelia decaocto*	(Columbiformes)	
24.	Greater Coucal	*Centropus sinensis*	(Cuculiformes)	***MISCELLANEOUS*** (habitats including crop fields, urban areas, scrub land, hedgerows)
25.	House Crow	*Corvus splendens*	(Passeriformes)	
26.	House Sparrow	*Passer domesticus*	(Passeriformes)	
27.	Indian Peafowl	*Pavo cristatus*	(Galliformes)	
28.	Indian Robin	*Saxicoloides fulicata*	(Passeriformes)	
29.	Indian Roller	*Coracias benghalensis*	(Coraciiformes)	
30.	Large Babbler	*Turdoides malcolmi*	(Passeriformes)	
31.	Laughing dove	*Streptopelia senegalensis*	(Columbiformes)	
32.	Purple Sunbird	*Nectarinia asiatica*	(Passeriformes)	
33.	Red Vented Bulbul	*Pycnonotus cafer*	(Passeriformes)	
34.	Rock Pigeon	*Columba livia*	(Columbiformes)	
35.	Rose Ringed Parakeet	*Psittacula krameri*	(Psittaciformes)	
36.	Rufous tailed Shrike	*Lanius collurio*	(Passeriformes)	
37.	Southern Grey Shrike	*Lanius meridionalis*	(Passeriformes)	
38.	White Breasted	*Halcyon smyrnensis*	(Coraciiformes)	

Sl.no	Name of the species	Scientific name	Order	Habitat
	Kingfisher			
39.	Black winged stilt	*Himantopus himantopus*	(Charadriiformes)	
40.	Common Coot	*Fulica atra*	(Gruiformes)	
41.	Common Pochard	*Aythya ferina*	(Anseriformes)	
42.	Common Sandpiper	*Tringa hypoleucos*	(Charadriiformes)	
43.	Eurasian Spoonbill	*Platelea leucorodia*	(Pelecaniformes)	
44.	Gadwall	*Anas strepera*	(Anseriformes)	
45.	Great Cormorant	*Phalacrocorax carbo*	(Pelecaniformes)	
46.	Great Egret	*Ardea alba*	(Ciconiiformes)	
47.	Great White Pelican	*Pelecanus onocrotalus*	(Pelecaniformes)	
48.	Grey Heron	*Ardea cinerea*	(Ciconiiformes)	***WETLAND***
49.	**Painted Stork**	***Mycteria leucocephala***	**(Ciconiiformes)**	
50.	Pied Avocet	*Recurverostra avosetta*	(Charadriiformes)	
51.	Pond Heron	*Ardeola grayii*	(Ciconiiformes)	
52.	Red Wattled Lapwing	*Vanellus indicus*	(Charadriiformes)	
53.	River tern	*Sterna aurantia*	(Charadriiformes)	
54.	Sarus Crane	*Grus antigone*	(Gruiformes)	
55.	Eurasian Thicknee (?)			

W = wetland; **F** = forest or plantation; **D** = desert; **M** = miscellaneous habitat including crop fields, urban areas, scrub land, hedgerows, etc.; **G** = grassland

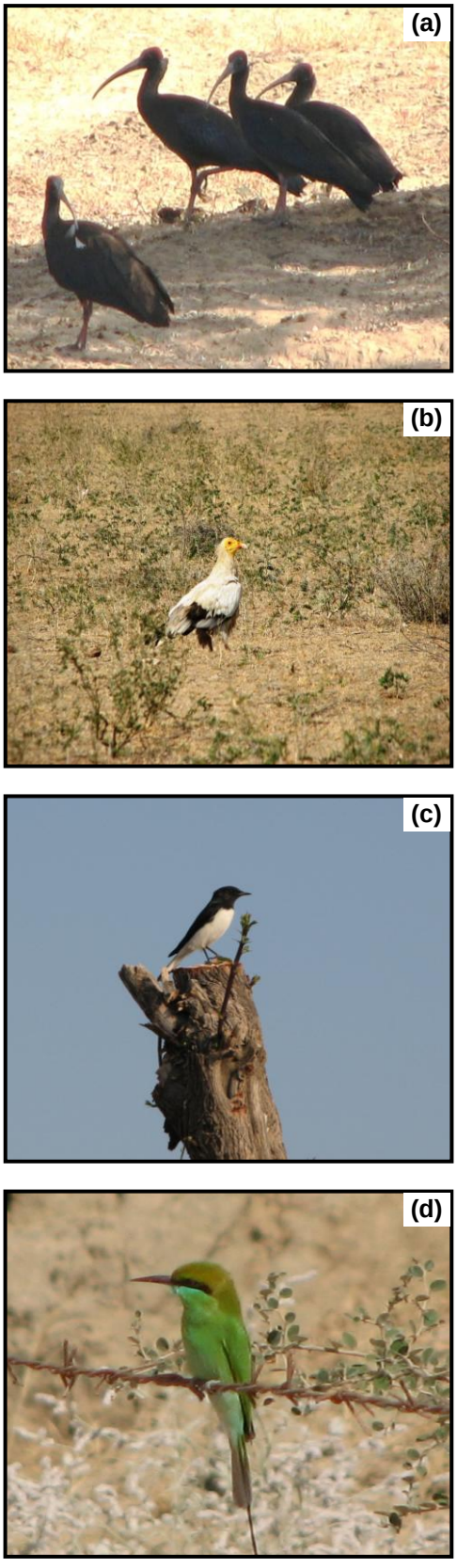


Plate 6.2A Desert birds(a), Black ibis(b), Egyptian vulture(c) and Variable Wheatear(d).

Plate 6.2B Birds belonging to miscellaneous habitat : Purple sunbird(a), Indian roller(b), Indian robin(c) and White breasted kingfisher(d).

Plate 6.2C Forest birds - White cheeked bulbul(a) and Shikra(b).

Plate 6.2D Desert/grassland birds - Grey francolin(a) and Common kestrel(b).

Plate 6.2E Wetland birds - Sarus crane(a) and Common coot(b).

Among the 55 species, Indian black Ibis and Painted stork belong to the near threatened (NT) category and Egyptian vulture belongs to the endangered category (EN) (IUCN, 2010a). Indian Black Ibis *Pseudibis papillosa*, is found in lakes, in marshes, in riverbeds and on irrigated farmland – it is not as aquatic as many other species of Ibis. It is gregarious and generally forages on margins of wetlands in small numbers. It nests in trees and breeds from March to October in North India. *Prosopis cineraria and Azadirachta indica* are the principal roosting trees for this bird.

6.2.3 Wetland values

During the survey, a temporary wetland was identified in the command area during the months of November-December (**Fig. 6.1**). This wetland was created as a result of water accumulation in low lying agriculture areas that received excessive amount of water abstracted by the land holders from the canal section routed nearby. This wetland located along the Highway (NH-15) near Gandhav village and falling within Moderately Irrigable Land Category, retains the standing water during post monsoon to winter months (August to January). During the visit to this site, many winter migratory bird species and water birds were observed in huge numbers. These included Great White Pelican, Painted Stork, Eurasian Spoonbill, Pied Avocet, River Tern, Great Cormorant, Grey heron, Common Coot, and Gadwall.

The wetland had dried up when revisited during the months of February and June and hence none of these species were sighted at this site during that time.

Some other area along the NH-15 also received excess water from canals leading to heavily drained soils that had become saline patches over the period. These areas therefore had little value as a wetland habitat for birds.

Reptiles: Among reptiles, direct sighting of Indian fringe toed lizard *Acanthodactylus cantoris cantoris,* Northern House gecko *Hemidactylus flaviviridis* and Glossy bellied racer (*Platyceps ventromaculatus)* were recorded in sand dunes area that represent the Non Irrigable Land Category within the command area. Indirect evidence of *Ophiomorus* sp. and an unidentified snake was also recorded. People reported possible presence of Indian sand boa *Eryx johnii* (**Plate 6.3a & b**).

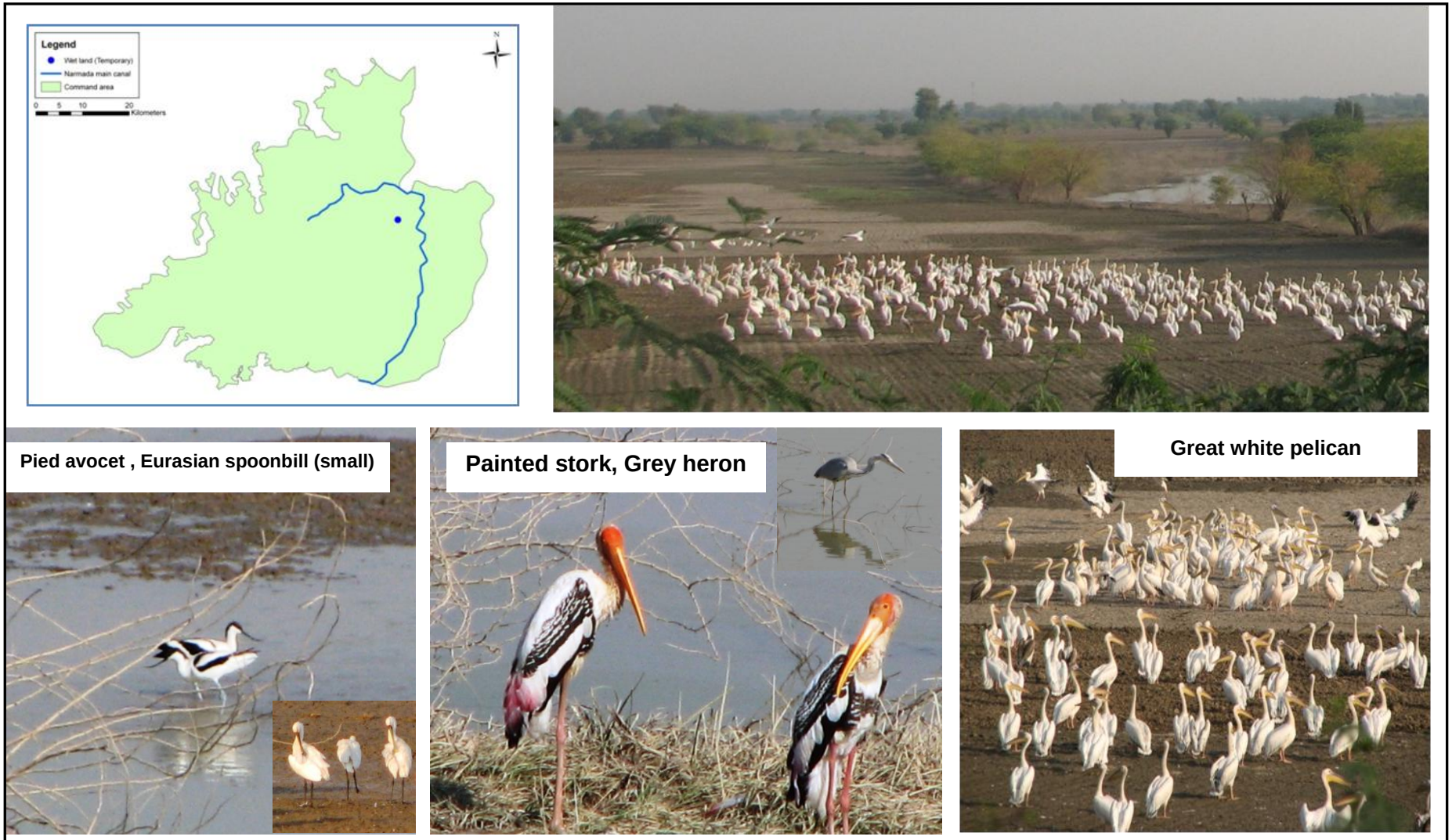


Fig. 6.1 A temporary wetland located along the Highway (NH-15) near Gandhav village within the command area.

Plate 6.3a Direct sightings of Indian fringe toed lizard(a) and glossy bellied racer(b).

Plate 6.3b Indirect evidences of Ophiomorus sp.(a) and of unidentified snake(b).

Mammals: Out of the 68 species that reside in the Thar Desert ecoregion, 12 species of mammals were recorded in the command area. List of mammalian species recorded from the command area is presented in **Table 6.3**. These include species belonging to Schedule I (Indian Gazelle), Schedule II (Hanuman Langur, Golden Jackal) and Schedule III (Striped Hyena, Wild pig, Blue bull) of the Indian Wildlife (Protection) Act (1972) (**Plate 6.4 A to E**).

Table 6.3 List of mammalian species recorded from the command area.

Sl.No.	Common Name	Scientific Name	Order
1.	Indian Gazelle	*Gazella benetti*	Artiodactyla
2.	Blue Bull	*Boselaphus tragocamelus*	Artiodactyla
3.	Wild Pig	*Sus scrofa*	Artiodactyla
4.	Indian Fox	*Vulpes bengalensis*	Carnivora
5.	Golden Jackal	*Canis aureus*	Carnivora
6.	Striped Hyena	*Hyaena hyaena*	Carnivora
7.	Indian Gerbil	*Tatera indica*	Rodentia
8.	Indian desert Gerbil (Jird)	*Meriones hurrianae*	Rodentia
9.	Five striped Palm Squirrel	*Funambulus pennantii*	Rodentia
10.	Hanuman Langur	*Semnopithecus dussumieri*	Primates
11.	Long-eared Hedgehog	*Hemiechinus auritus*	Erinaceomorpha
12.	Black naped Hare	*Lepus nigricollis*	Lagomorpha

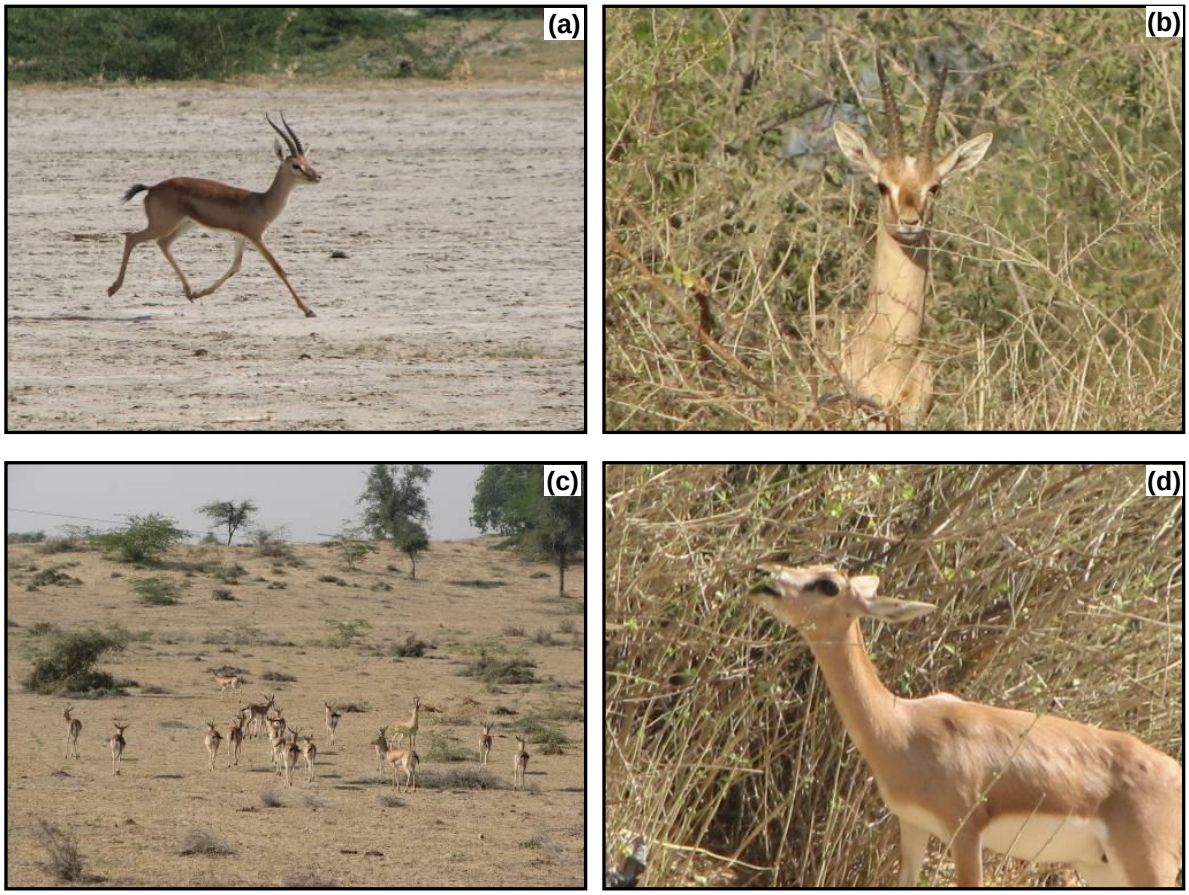


Plate 6.4A Chinkara uses a variety of habitats interspersed within the project command and ranging from saline patches to crop fields to grazing lands.

Plate 6.4B Indian desert Gerbil (a) and an active colony of gerbils(b).

Plate 6.4C Indirect evidences of wildlife animals in the command area - Indian fox(a), Striped hyena(b) and Chinkara (c&d).

Plate 6.4D Jackal kill(a) and wild pig(b) sighted in the canal command area.

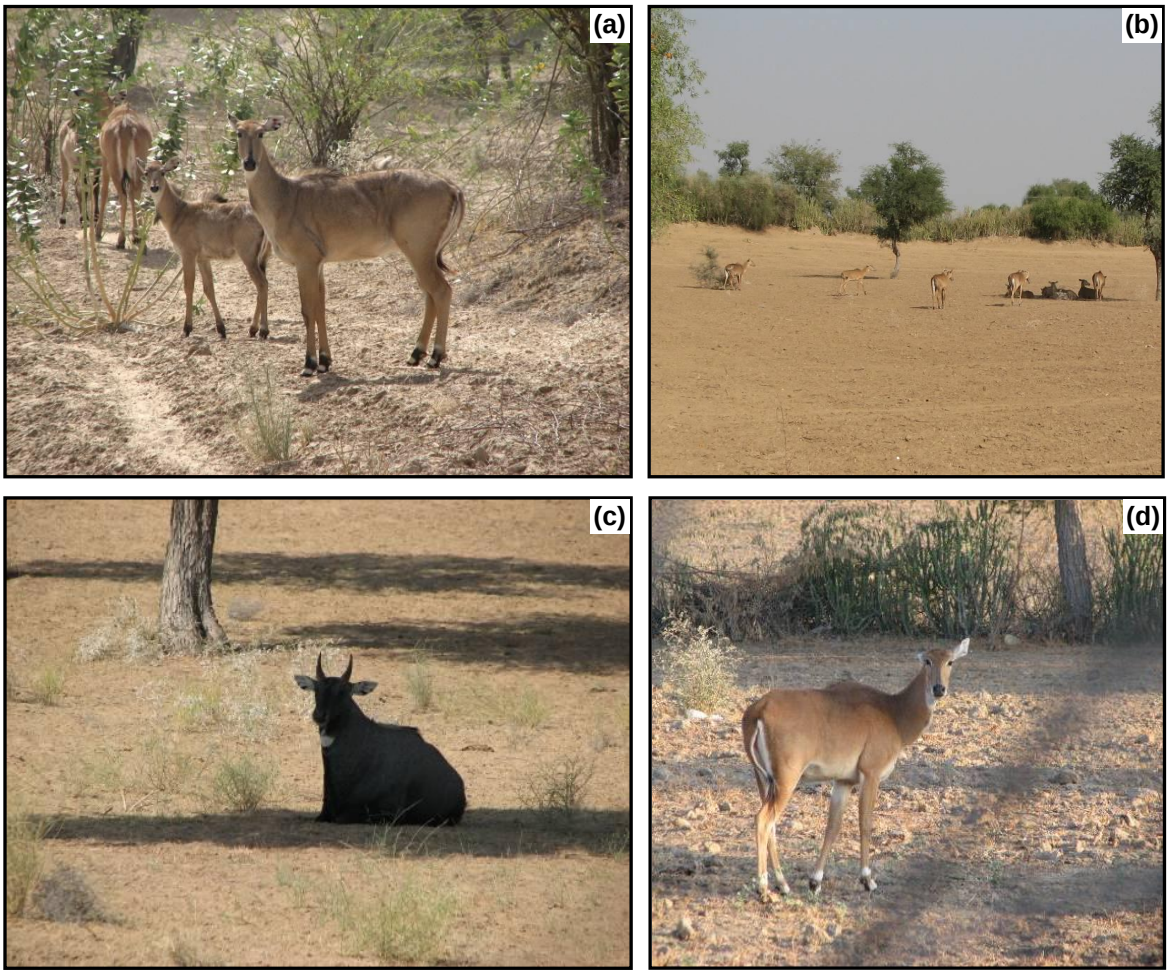


Plate 6.4E Chinkara and Nilgai are the two predominant species of herbivores that were frequently encountered in crop fields and fallow lands within the project command.

The transect wise details about the landuse, dominant vegetation and wildlife evidence are presented in **Table 6.4**.

Table 6.4 Wildlife evidences recorded on transects laid in different land categories within the command area.

Sl.No	Transect Name	Land Category	Dominant land type	Dominant vegetation	Faunal evidences	
					Direct	Indirect
1.	Bhichchavadi to Bakasadi	Moderately Irrigable lands	Agricultural Lands	*Prosopis cineraria, Tecomella undulta, Salvadora oleoides, Calotropis procera*	Chinkara, Nilgai, Indian fox, Indian desert gerbil	Indian gerbil
2.	Shivpura to Ratoda		Agricultural lands interspersed with *Prosopis juliflora* dominated areas	*Tecomella undulata, Salvadora persica, Prosopis juliflora*	---	Nilgai
3.	Karola to Dangra		Agricultural lands interspersed with fallow lands	*Prosopis cineraria, Calotropis procera, Crotolaria burhia, Tephrosia purpurea*	Nilgai	---
4.	Bhawatra to Ridka		Agricultural lands interspersed with *Prosopis juliflora* dominated areas	*Prosopis cineraria, Prosopis juliflora*	Nilgai, Indian fox	Chinkara
5.	Bhatki to Balera		Agricultural lands interspersed with fallow lands	*Prosopis cineraria, Tecomella undulata, Azadirachta indica, Prosopis juliflora*	Chinkara, Nilgai	Indian desert gerbil
6.	Goliya to		Agricultural lands	*Salvadora oleoides*	Chinkara	---

Sl.No	Transect Name	Land Category	Dominant land type	Dominant vegetation	Faunal evidences	
					Direct	Indirect
	Achalpur		interspersed with fallow lands			
7.	Keriya to Gandhav		Agricultural lands	*Prosopis cineraria, Prosopis juliflora*	Chinkara, Nilgai	---
8.	Bhadrun to Bheda		Agricultural lands	*Prosopis cineraria, Salvadora oleoides*	Chinkara, Nilgai	---
9.	Roli to Gadevi	Marginally Irrigable lands	Agricultural lands	*Prosopis cineraria, Azadirachta indica, Prosopis juliflora*	Chinkara, Black naped Hare	Indian fox
10.	Karawadi to Akoli		Agricultural lands interspersed with fallow lands	*Prosopis cineraria, Azadirachta indica, Tecomella undulate, Aerva persica*	Black naped Hare	Chinkara, Nilgai
11.	Daboi to Dholinaadi		Agricultural lands	*Prosopis cineraria*	Chinkara	Nilgai, Striped Hyena, Jackal
12.	Raipura to Surechand		Agricultural lands interspersed with fallow lands. Small saline areas present in between	*Tecomella undulata, Prosopis juliflora*	Wild pig	---
13.	Sewada to Jhotra		Agricultural lands interspersed with fallow lands	*Prosopis cineraria, Prosopis juliflora, Aerva persica, Crotolaria burhia*	Chinkara, Nilgai	
14.	Amarpura to		Agricultural lands	*Prosopis cineraria,*	Chinkara, Nilgai	

Sl.No	Transect Name	Land Category	Dominant land type	Dominant vegetation	Faunal evidences	
					Direct	Indirect
	Jhab		interspersed with fallow lands	*Tecomella undulata, Crotolaria burhia*		
15.	Jakhal to Hariyali		Agricultural lands	*Prosopis cineraria, Azadirachta indica*	---	---
16.	Gomi to Ratanpura		Agricultural lands interspersed with fallow lands	*Prosopis cineraria, Salvadora oleoides*	Chinkara	Nilgai
17.	Tembi to Padardi	Tentatively Non Irrigable lands	Agricultural lands with interspersed fallow lands	*Prosopis cineraria, Prosopis juliflora*	---	Nilgai, Wild pig
18.	Tonpi to Doothwa		Agricultural lands with interspersed fallow lands	*Prosopis cineraria, Prosopis juliflora, Calotropis procera, Crotolaria burhia*	---	Nilgai, Chinkara, Wild pig
19.	Babarwal towards Bhakasar		Most of the area under fallow land. Presence of sand dunes.	*Tecomella undulata, Aerva persica*	Chinkara	---
20.	Nimbaj to Bhimgira	Economically Non Irrigable lands	Agricultural lands with interspersed fallow lands. Undulating terrain.	*Prosopis cineraria, Tecomella undulata, Calotropis procera, Crotolaria burhia, Aerva persica*	Chinkara, Black naped Hare	---
21.	Jaalberi to Vavtalai		Fallow agricultural lands. Two big salt pans present. Presence of sand dunes.	*Prosopis cineraria, Aerva persica, Crotolaria burhia*	Chinkara	---

Sl.No	Transect Name	Land Category	Dominant land type	Dominant vegetation	Faunal evidences	
					Direct	Indirect
22.	Somewhere to Gangasariya		Agricultural lands interspersed with fallow lands	*Prosopis cineraria, Salvadora oleoides*	---	Chinkara
23.	Dhabal	Grazing lands	Grazing lands	*Capparis deciduas, Tecomella undulata*	Chinkara, Nilgai, Indian fox	---
24.	Karawadi			*Prosopis cineraria, Tecomella undulata, Tephrosia purpurea*	Chinkara, NIlgai	---
25.	Palari			*Prosopis cineraria, Tecomella undulata, Tephrosia purpurea*	Chinkara, Nilgai	Striped Hyena
26.	Sarvana			*Prosopis juliflora*	Wild pig	Chinkara, Nilgai
27.	Arna			*Tecomella undulata, Acacia tortilis*	Chinkara	Nilgai
28.	Hadecha			*Tecomella undulata*	Chinkara, Nilgai	
29.	Golasan			*Salvadora oleoides*	---	
30.	Jhajhusan			*Prosopis cineraria, Salvadora oleoides*	Nilgai	
31.	Badsam			*Salvadora oleoides, Leptadenia pyrotechnica*	Nilgai	
32.	Jaisla			*Salvadora oleoides*	Nilgai	
33.	Kiraudi			*Prosopis cineraria*	---	---

6.3 Habitat values of Command Area for Ungulate Species

The study specially focussed on the use of command area by the Indian gazelle and Blue bull owing to their ecological significance and abundance in the study area.

Indian gazelle is an important desert species which is found in almost every type of ecosystem in western Rajasthan (Dookia and Goyal, undated). Habitat loss through overgrazing and conversion to agriculture is a major threat to this species (IUCN, 2010b). Blue Bull or Nilgai is an antelope species which is rapidly spreading through the Thar Desert ecosystem with the increase in agricultural activities.

6.3.1 Habitat value for Indian Gazelle

Indian gazelle or Chinkara (*Gazella bennettii*), a globally threatened ungulate, once widely distributed antelope in India, is now facing threat due to increasing human population and mechanised/irrigated agriculture. It is a small, slender and beautiful common antelope, found in a variety of habitats from plains to scrub desert sandy areas. This animal is characterised by its sandy or tawny colour, poorly expressed flank stripes and pygal stripes, hairy build and horns. The horns in males are straight with tips slightly out turned with prominent rings whereas in female the horns are comparatively shorter (Groves, 1985). Its preferred habitat is open bare plains or low rocky hills or sandy hills or a barren country to richly cultivated and alluvial plains. It mainly consumes four plants, namely *Crotalaria burhia* (42%), *Zizipus nummularia* (15%), *Maytenus emerginata* (11%) and *Prosopis cineraria* (9%), all these constitute about 77% of its total dietary requirements (Dookia 2009).

Habitat use in the command area

On the basis of the data collected during the study in 5 land categories, the encounter rates (number of individuals of species sighted per km walk of transect) of the chinkara were calculated for each land category (**Table 6.5; Fig. 6.2**).

Table 6.5 Encounter rates of chinkara in different land classes within the Command Areas (CA).

Land classes within CA	Area (% of the CA)	Chinkara (No. of individuals per km)
Moderately Good Irrigable Land	33.58	1.6 ± 0.88(SE)
Marginally Irrigable Land	32.96	2.2 ± 0.87(SE)
Tentatively Non-irrigable Land	8.47	0
Economically Non-irrigable Land	23.4	6.1 ± 2.4(SE)
Grazing Land	--	3.8 ± 1.3(SE)

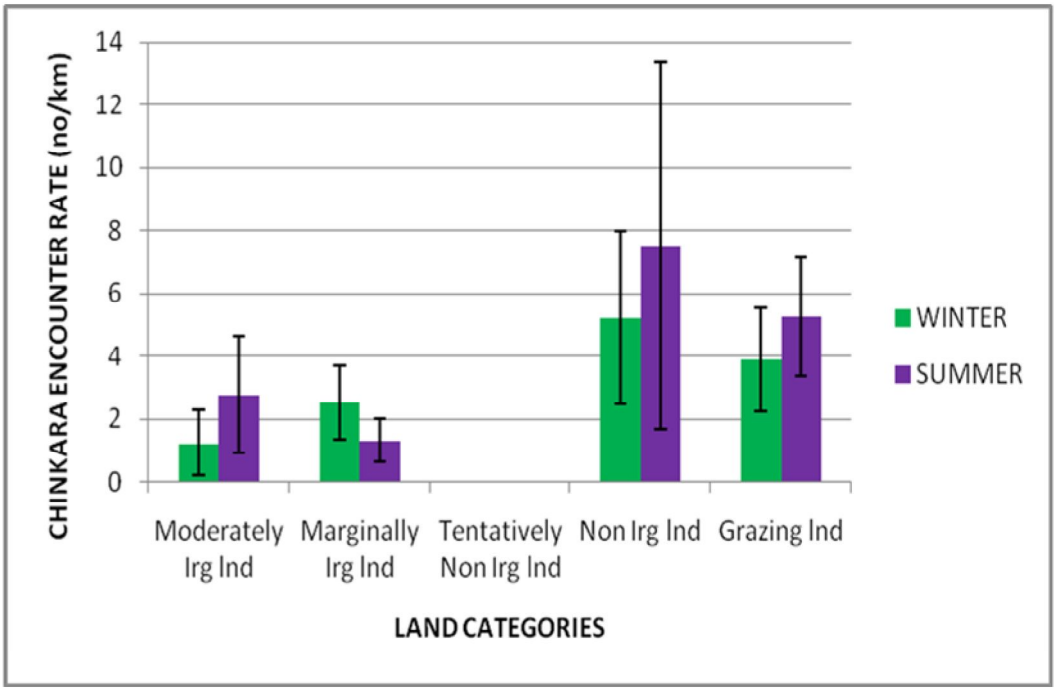


Fig. 6.2 Encounter rates for chinkara observed in various land categories in the command area.

Table and figure 6.2 shows that the encounter rates observed in summer are higher than the encounter rates observed during winter. Also, the highest encounter rates were observed in 'Economically Non-Irrigable lands' (=5 to 8 individuals/km) and grazing lands (=4 to 5 individuals/km) for both summer and winter.

Kruskal-Wallis test was carried out to test for any significant difference between encounter rates across the categories (irrespective of seasons). According to the test, there was no significant difference [$\chi 2$ (4, N=46)= 8.63, p= 0.071].

Map showing transect locations and encounter rates (denoted by numbers) gives an understanding of relative use of the command area by chinkara (**Fig. 6.3**). Chinkara presence based on direct sightings confirm their preference for use of habitats in grazing lands (indicated as green dots on the map) falling within Moderately Irrigable Land Category. Most of the areas under Marginally Irrigable, Tentatively Non Irrigable and Economically Non Irrigable lands have low intensity of chinkara (< 1/km) except in few areas under Non Irrigable lands having chinkara presence of 6-9.5 animals/km. Areas under Moderately Irrigable lands and some of the adjoining Irrigable lands have even presence of chinkara > 4 animals/km.

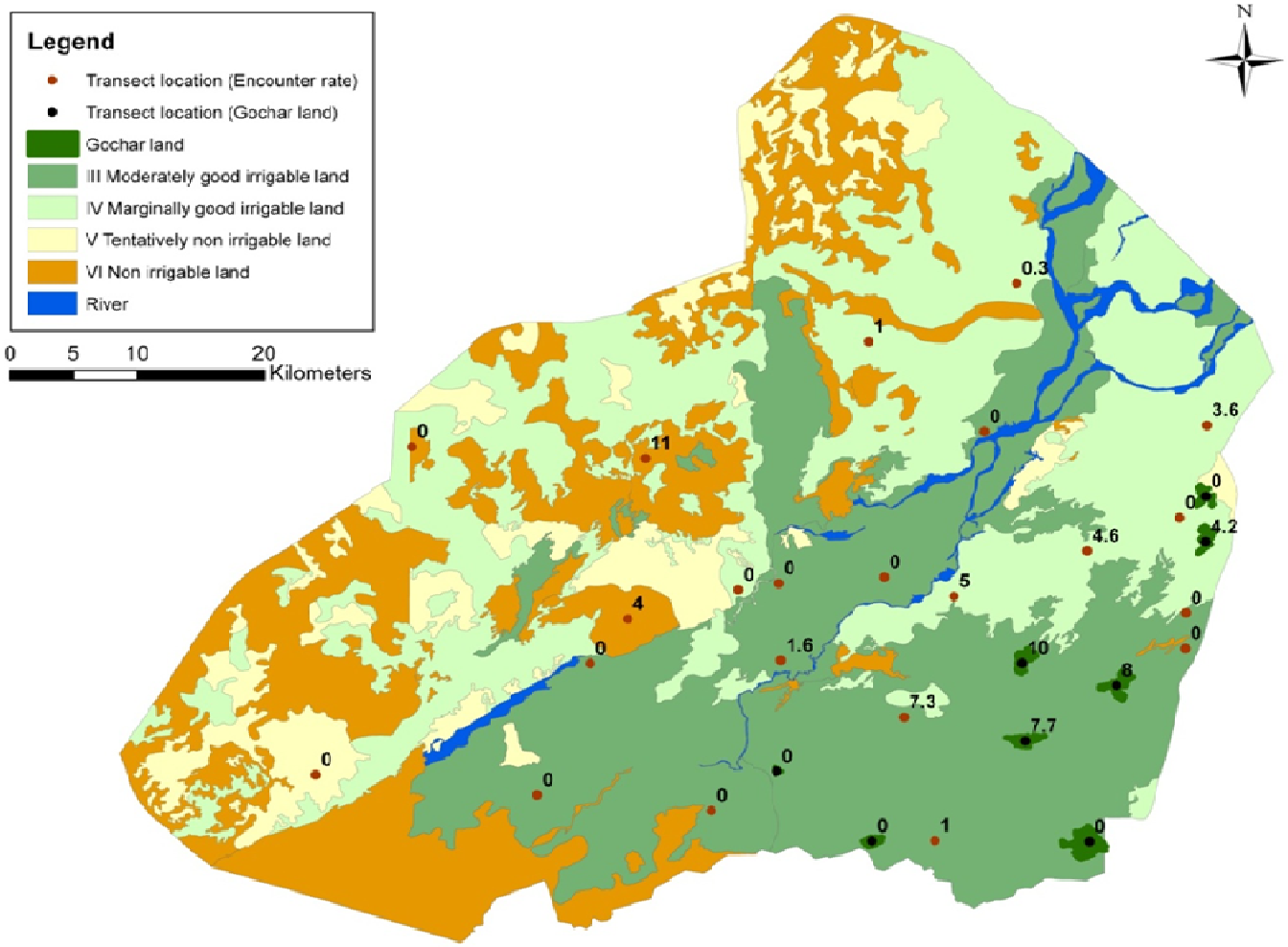


Fig. 6.3 Encounter rates (No. of individuals per km walk) of chinkara recorded in various transects in the command area.

Observations were also made for chinkara group sizes in the various land categories (**Fig. 6.4**).

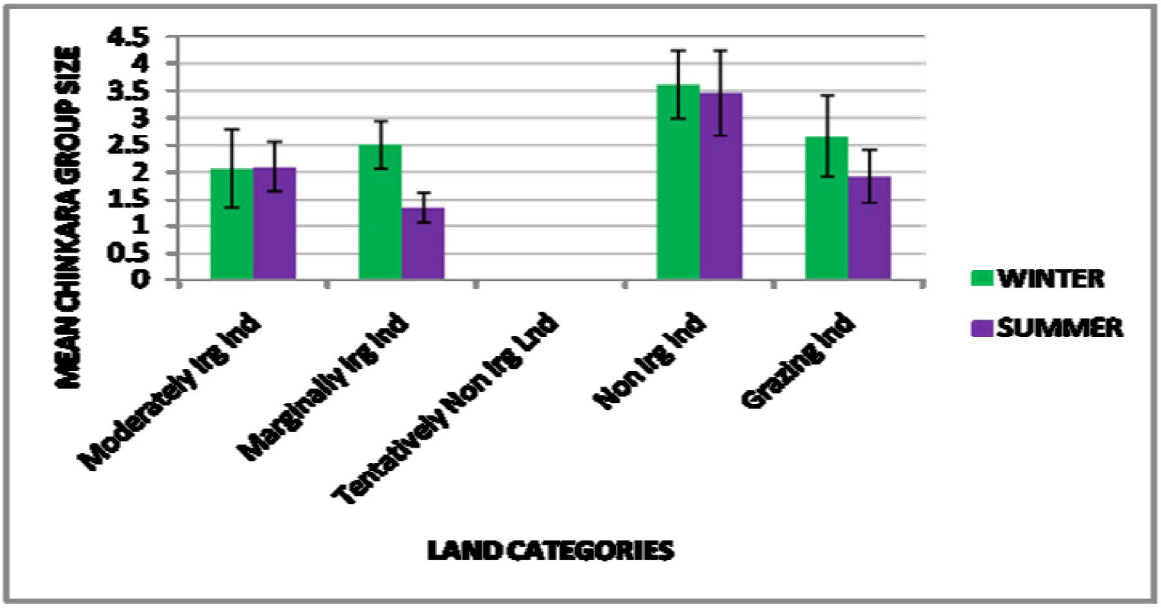


Fig. 6.4 Group sizes for chinkara observed in various land categories in the command area.

The figure shows that smaller group sizes were observed in summer as compared to those observed in winter. Also, the largest group sizes (=3.5 individuals/group) were observed in Economically Non-irrigable Lands and Grazing Lands (= 2 to 2.5 individuals/group) in both the seasons.

To conclude, economically non-irrigable lands and grazing lands are the most preferred land types by chinkara as these areas are not inhabited as much as other areas. Chinkara being a shy animal tends to avoid human habitations. Moreover, most of the areas covered within the economically non-irrigable lands were *Bishnoi* dominated who have been traditionally protecting wildlife in the state of Rajasthan.

6.3.2 Nilgai or Blue bull

Blue bull (*Boselaphus tragocamelus)* , commonly known as nilgai, is a species of antelope. They have thin legs and a robust body that slopes down from the shoulder. Their long, narrow heads are topped by two small conical horns which are straight and tilted slightly forward. Female nilgai have a short yellow-brown coat. Males' coats gradually darken to a grey-blue as they reach maturity. They have white

spots on the cheeks and white coloring on the edges of the lips. They also have a white throat bib and a narrow white stripe along the underside of the body that widens at the rear. Blue bulls mostly live in herds. They avoid dense forest and prefer the plains and low hills with shrubs. The deserts earlier limited their range, but the extension of irrigation canals and proliferation of tube-wells in the Thar Desert has helped them colonise the desert districts (Prater, 1998).

Habitat use in command area

Observations on encounter rates and group sizes were made for nilgai in different land categories for summer and winter seasons.

The largest group size as well as the highest encounter rate for nilgai was observed in the ‘grazing land’ category in both summer and winter months **(Fig. 6.5 & 6.6).** Grazing lands serve as suitable wildlife refuges as they are devoid of human habitation. Also, as most of the grazing lands surveyed in the command area were located within the irrigable lands, they are surrounded by agricultural fields which provide ample food supply for these species.

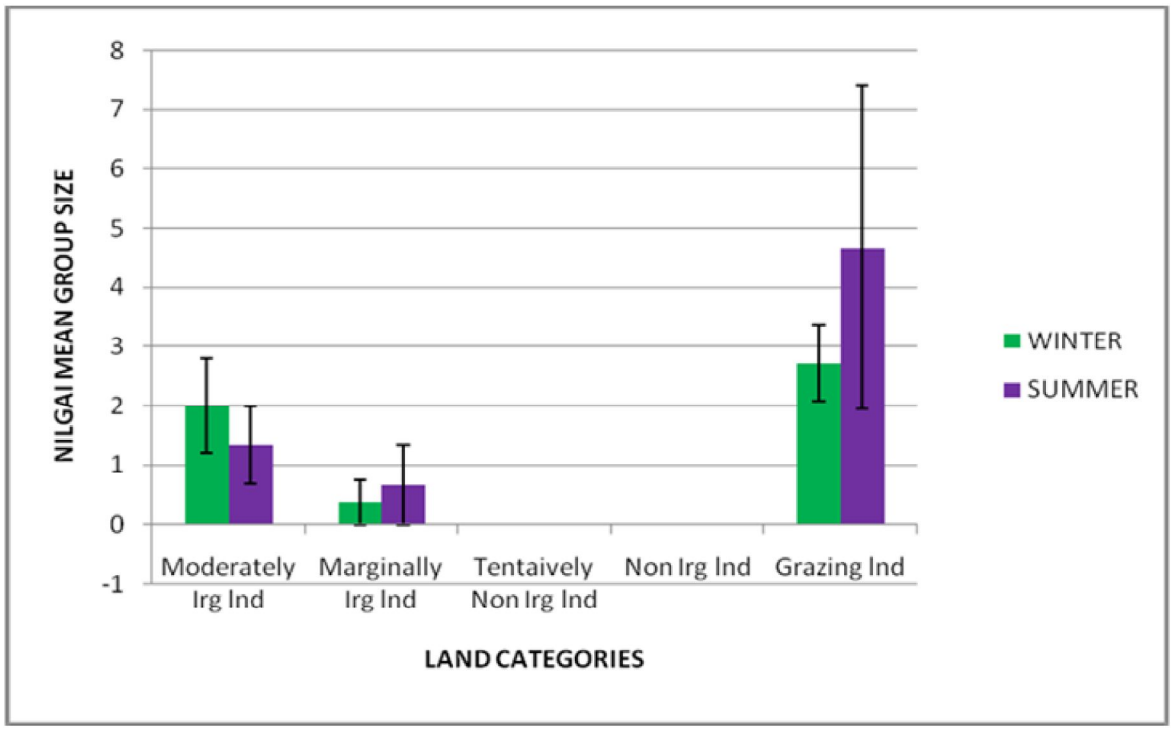


Fig. 6.5 Group sizes for nilgai observed in various land categories in the command area.

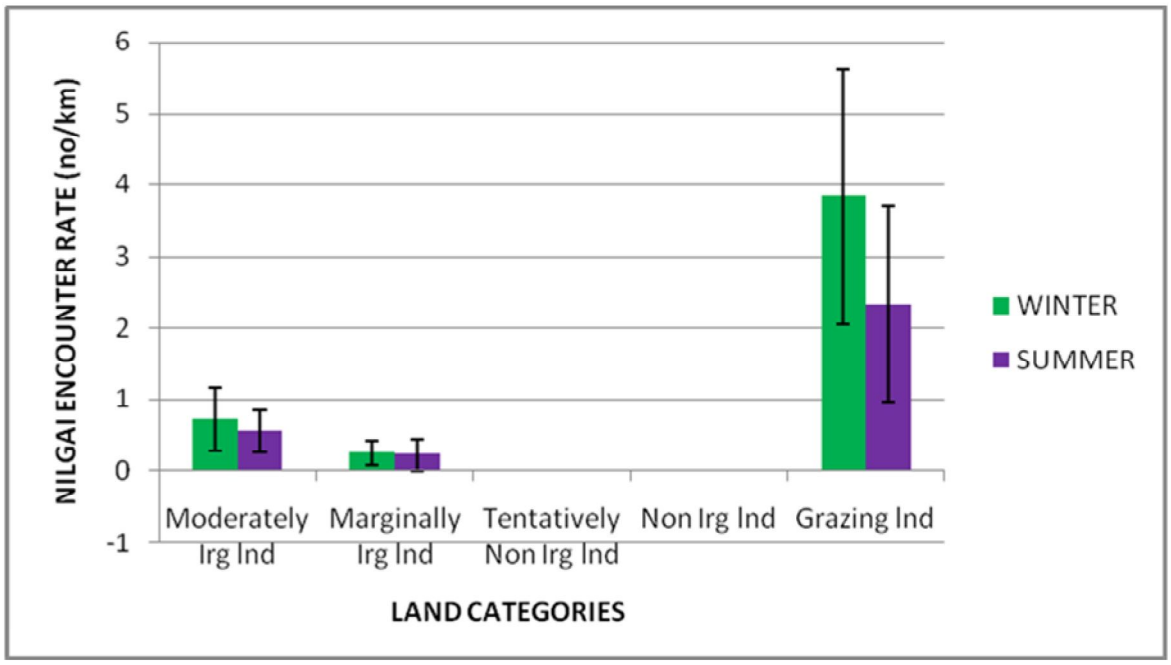


Fig. 6.6 Encounter rates for nilgai observed in various land categories in the command area.

6.4 Wildlife Values of Grazing Lands

Interspersed between agricultural areas are present lands known as *'gochar bhoomi'* or grazing lands. Historically, the native people of the Thar Desert have traditionally preserved the village grazing lands. They serve as 'mini biosphere reserves' in the desert region and have greatly helped in the maintenance of ecological stability of the region (Sinha *et al.,* undated). In the present study, a total of 8 grazing lands of different sizes were surveyed to determine the ecological status of grazing lands present within the command area.

The vegetation in the grazing lands is predominantly represented by tree species such as *Tecomella undulata* and *Prosopis cineraria* and shrub/herb species such as *Capparis decidua*, *Salvadora oleoides, Crotolaria burhia* and *Tephrosia purpurea*. Among fauna, presence of species such as chinkara, nilgai and wild pig and Indian fox, was recorded through direct sightings. Chinkara and nilgai were sighted in high numbers. Indirect evidence of striped hyena was also recorded in grazing lands in *Palari* villgae. People residing around these grazing lands also reported presence of species such as jackal and striped hyena. 15 out of 55 bird species representing mostly generalist species were recorded in grazing lands. Among these, purple sunbird *Nectarinia asiatica* was sighted in exceptionally good numbers in almost all the grazing lands. This bird depends on plant species such as *Prosopis cineraria, Acacia leucophlea* for food and shelter. It plays an important role as a pollinator.

6.5 Wildlife Values of Reserved Forest

The area under Reserved Forest (approx. 1200 ha) was located near Bhawatra and Sunthadi villages within the canal command area. The vegetation within the forest is solely dominated by *Prosopis juliflora.* Indirect evidences of striped hyena were recorded from this area. Also, people reported presence of wild pig in this area.

6.6 People's Perception of the Canal and its Effects on Wildlife

Informal consultations with local people during the field visits gave an impression that by and large, people welcomed the canal development because of the foreseeable benefits of such a development in their economic well being.

In the context of the perceived impacts of canal development on the wildlife species and their habitats, most of the people felt that there has been an increase in wild pig and nilgai numbers after the coming of the canal. According to the people, nilgai and wild pig are the major crop raiders. Wild pig is more of a menace in “Ned” area, *i.e.* the drainage basin of Luni river, of the command area. Nilgai, also a menace, prefers to feed on rye and wheat. As for chinkara, it was also reported to raids crops but does not pose to be much of a nuisance at present. It prefers to eat *Plantago ovata* (isabgol).

7. IMPACT PREDICTION

The predictive stage of EIA follows the likely impacts due to the proposed project activities and investigates its subsequent impacts on the various environmental components. The brief of this study was to specifically evaluate the project induced direct and indirect impacts on the ecological (flora and fauna) receptors and suggest mitigation measures to avoid, reduce or remedy the impacts of the canal development project on wildlife species and their habitats in the project area.

The process of prediction of ecological impacts was based on straight forward approach of relating sources of stress, *i.e.* activities related to canal development and irrigated agriculture to ecological receptors, i.e. the floral and faunal components, identified in the project area. Effort was also made to present the spatial extent.

On one hand, the prospects of irrigated agriculture are likely to increase many fold with the development of Narmada canal. Better irrigation inputs, would provide direct benefits of multi-cropping cycles that would allow the farmer community to grow multiple crops almost all the year round in contrast to earlier situation when agriculture practices not supplemented with irrigation inputs allowed farmers to raise crops only during 3-4 months period. On the other hand, Prakash (2001) is of the view that the proposed canal and the network of secondary canals bringing water from Sardar sarovar dam, i.e. the Narmada canal, is likely to alter the land use pattern in the southern district of Rajasthan (Jalore district). Activities such as clearing and levelling of lands, application of water to the arid soils, and application of pesticides/fertilizers are bound to increase in the coming years and will have a range of impacts on the biodiversity of the region.

The anticipated impacts of Narmada canal development on floral and faunal elements are elaborated as follows:

7.1 Impacts on Flora

The development of canal is likely to bring about changes in the floral composition, and diversity in different land categories within the command area. Many of these changes can be attributed to land take for canal route, soil degradation and compaction during the construction phase of the project and to changes in soil texture, moisture and cropping patterns subsequently in areas under the command. The following are some of the observed/predicted ecological impacts of the project:

Primary Impacts

i) **Habitat alteration:** The construction of the main Narmada canal is currently under progress. Loss of natural vegetation due to clearing/ removal from the canal route is one of the direct impacts that pose threat to several plant species (**Plate 7.1**). The threats are more significant due to removal of the endemic species of the region such as *Calligonum polygonoides, Prosopis cineraria, Lasiurus sindicus, Cenchrus biflorus, Tecomella undulata, Citrullus colocynthis, Tamarix aphylla, Salvadora oleoides, Capparis decidua, Aerva pseudotomentosa, Crotolaria burhia, Leptadenia pyrotechnica.* Many of these species characterise the Thar desert ecosystem and represent some species such as *Calligonum polygonoides, Crotolaria burhia, Prosopis cineraria* that are vital sources of food and fodder for desert animals. Species like *Aerva javanica and Lasiurus sindicus,* provide good ground cover for ground dwelling birds species and gerbils, and trees species like *Capparis decidua, Prosopis cineraria, Tecomella undulata* offer shade and resting grounds for species for relief from the scorching heat.

ii) Loss of many of the above plant species that are habitat for important animal species is seen as a significant impact of the project.

Secondary Impacts

i) **Alteration of floral composition due to increased water-logging and salinity**: Increased intake of canal water, seepages from poorly maintained canals is likely to lead to rise in water-logging and soil salinity. With altered water and salt concentrations in soils, species such as *Leptadenia pyrotechnica, Tamarix aphylla* that are adapted to thrive in xeric conditions might be lost. Gradually, they might get replaced by water and salt loving plant species. Moreover, increased water-logging can lead to introduction and spread of weeds into the command area. Replacement of xeric species from the desert can have an important bearing on the structure and faunal diversity of such a specialised ecosystem.

Plate 7.1 Clearing of vegetation for canal construction creates disturbance and changes in ecological character of the area.

ii) **Clearing of vegetation for agricultural purposes**: It is already known that increased irrigation-based agro-pastoral activities have adversely influenced the natural vegetation, especially *Crotolaria burhia* and sewan *(Lasiurus scindicus)* grassland which are natural habitat areas for chinkara (Dookia, 2009).

Similar impacts are also predicted as a consequence of Narmada Canal development. As more area will get converted into agricultural lands, clearing of vegetation as a part of the preparation of agricultural fields will lead to removal of the natural vegetation of the command area. Clearing activities are mostly likely to affect the herb/shrub species such as *Crotolaria burhia, Aerva javanica, Aerva pseudotomentosa, Tephrosia purpurea, Leptadenia pyrotechnica, Calligonium polygonoides* (**Plate 7.2**) which in turn would adversely impact the wild animal species dependent on them.

Tertiary Impacts

i) **Increased lopping pressures and resource extraction**: Due to increased influx of people in the area from surrounding region because of improved prospects of irrigation and related commerce, anthropogenic pressures are likely to also increase. This will lead to higher probability of exploitation of important medicinal, fodder and fuel species such as *Prosopis cineraria, Acacia nilotica, Calligonum polygonoides, Leptadenia pyrotechnica, Salvadora oleoides.* This is seen as another factor that will cumulatively contribute to the loss of many plant species from the desert ecosystem.

7.2 Impact on Fauna

Primary Impacts

i) **Direct or Indirect mortality due to drowning in canal**: The canal poses a perpetual risk of drowning for the animals such as nilgai, hog deer, wild pig, jackal using the canal for drinking water. These risks are associated with animals that may not be able to gain footing on the steep-concrete lined sides and become trapped and get drowned.

Published studies from other part of the world (Monda, 2002; Rautenstrauch *et al*., 1989) have confirmed this to be one of the major impacts associated with large canals (>6 m deep and >30 m wide) where deer have been trapped. In the Columbia Basin Irrigation Project, an estimated 200-300 deer die in the canal each year. Deer that enter the canal during the irrigation

season are drowned. During winter when the canals are dry or have shallow water, deer have been known to perish through a combination of starvation, predation by coyotes, or exposure. Deer that become trapped for relatively short periods of time have significant injuries from abrasions on their feet and prolonged exposure to water.

ii) **Habitat Fragmentation**: The introduction of the canal in a landscape can lead to fragmentation of contiguous animal habitats into smaller patches. The wild animals present in the command area such as chinkara are typical desert species which are adapted to thrive in large open landscapes. In the present case, the command area is representing a landscape that is already a mosaic of grazing land, agriculture fields and habitation areas. The impacts of fragmentation owing to construction of the Narmada Canal are therefore not likely to be pronounced. The threats would be more associated with the reduction in the size of larger arid habitats into smaller stretches that may not remain viable as independent parcels of habitats for ranging desert animals.

Secondary Impacts

i) **Increase in animal populations**: Better resource (food and water) availability in the command area may lead to surge in the populations of animals such as chinkara, wild pig, nilgai. This is especially anticipated the area under Irrigable Land category within the command area where the maximum inputs of irrigation is likely to result in high crop productivity. In a study conducted by Kankane (2009) in western Rajasthan, a slight increase in the population of the gazelle was reported after a few years due to changes in land-use patterns in the neighbouring areas, forcing animals to move to safer, greener pastures for survival. Yoakum *et al.,* (1980) and Knighton (1985) also stated that increased availability of water throughout the year can increase wildlife populations.

iii) **Habitat reduction/degradation**: Improved opportunities for irrigation in the command area would lead to an increase in the area under agricultural fields in the coming years. Hence, more and more areas suitable for supporting wild animal populations would be converted into agricultural lands, thereby reducing wild animal habitats. For example, Indian gerbil and Indian desert gerbil, lizard and snake species inhabiting loose sandy soils. Conversion of

these areas into agricultural fields would lead to soil compaction thereby destroying their habitat.

Removal of shrub species (such as *Salvadora oleoides, Capparis decidua*) and grasses would have a negative effect on avifauna especially the ground dwelling species such as grey francolin.

Encroachment of grazing lands for agriculture would also endanger habitats for chinkara, Indian fox, jackal and striped hyena. As is evident from figure 6.4E, chinkara populations are dependent on the presence of grazing lands. Important habitats such as grazing lands that would also be subjected to greater pressures of overgrazing by livestock and wild animals would degrade more rapidly. According to Conroy and Lobo, 2002, trends of open access and unregulated use of grazing lands in Rajasthan in past the few decades have already led to degradation of large proportion of such lands.

Degradation and reduction of areas under these lands may push chinkara populations to occupy areas under non-irrigable lands, which represent small proportion within the project command and will receive less intensive agricultural practices. As a consequence, chinkara will become confined into certain small pockets in the command area, which may have long term impacts of restricted distribution on their population size.

iv) **Habitat alteration**: Introduction of water in the arid command area of the canal would obviously lead to alteration of soil moisture levels in the area. Moreover, increased inputs of irrigation and seepage from canal might lead to accumulation of water leading to creation of many temporary wetlands. Such changes in desert environment would encourage the mesic species to invade in the command area ultimately replacing the xeric species. The canal sections that are already filled up are receiving water birds such as Common coot, Common pochard, Gadwall, Eurasian spoonbill, Great white pelican, Painted stork. Baseline information indicates that the command area is being dominated by bird species which prefer to live in and around miscellaneous habitat types or wetlands. Mammal species such nilgai and wild pig that are ideally not desert species, have invaded the desert landscape due to the better accessibility of water and crops as food. Gerbil populations likewise are also threatened

to get replaced by rodent such as bandicoot *Bandicota bengalensis* and the metad *Millardia meltada* that invade the crop fields. Experience from already implemented IGNP amply support above predictions of species replacement (Prakash, 2001).

iv) **Change in community structure**: Replacement and reduction in species such as jirds, gerbils, birds which are an important food component of other dependent species of mammals, reptiles and birds of prey would negatively affect the entire community structure of wild animals of the desert ecosystem.

Tertiary Impacts

i) **Human-wildlife conflicts**: Highly productive crop fields, may contribute to incremental increase in populations of nilgai, wild pig and chinkara that may to greater incidences of crop raiding thereby leading to frequent clashes between humans and wildlife. Consequently, this might lead to people becoming insensitive towards species such as chinkara which has been well tolerated and protected historically. The gravity of crop losses may also lead to the risks of retaliatory killing.

ii) **Livestock-wildlife conflicts**: Livestock are often considered a threat to ungulates and other large mammals which share the same habitats, such as grazing lands, with livestock species. Increase in livestock population, especially in irrigable lands, due to the rise in number of farmer communities is likely to result in greater incidences of livestock-wildlife conflict.

Plate 7.2 Clearing of vegetation for preparation of agricultural fields affect the habitat of ground dwelling species.

8. MITIGATION PLANNING

8.1 The Concept of Mitigation

Mitigation is both a creative as well as a practical phase in EIA process. The broad objective of mitigation is to help safeguard 'resources' and 'receptors' of impacts to ensure that the development does not relegate the environmental profile and biodiversity conservation priorities of the region. Although mitigation is a widely acknowledged approach to address ecological impacts, ecological solutions sometimes fall short in offering complete and perfect solutions for arresting/addressing all impacts. Nevertheless, the merits of adopting well-conceived, pragmatic and feasible options for mitigating ecological impacts are generally realized in reducing the residual impacts and improving the prospects of conservation of valued components within the project area.

With growing realization of the importance of mitigation stage as a 'problem solving' stage in impact assessment, increasing efforts are being made to encourage approaches based on creative management of wildlife habitats.

This section of the report attempts to review strategies for encouraging environment friendly development by incorporating appropriate conservation measures in all stages of development, from planning to implementation of canal development with an objective to reduce threats of habitat reduction and degradation; promote protection of species within existing wildlife habitats; and create new habitats for conservation of wildlife species within the command area. Such strategies are essential for achieving ecologically sustainable development.

It is apparent from the foregone description of the nature of impacts associated with the canal and other related activities that habitat reduction and degradation will be the most significant impacts of such a linear development on the assemblage of plants and animals that make desert unique and distinct from other ecosystems. The need to address the impacts of habitat alteration is extremely important as it can have implications for population structure of several species in the long term. Developing strategies for securing and maintaining habitats of these

species and addressing other ecological impacts together is an important part of an impact assessment study.

8.2 Mitigation of the Impacts of Narmada Canal Project

Section 7.0 of the report focusing on evaluation of project impacts has highlighted the primary, secondary and tertiary impacts of the Narmada Canal. This section of the report attempts to outline mitigation options based on valuation of the significance of the impacts and portrayal of different scenarios of some of the key ecological and biodiversity related impacts of the project outlined through this study.

8.2.1 Protection of grazing lands

Around 2.7 per cent of land mass in Rajasthan is permanent pasture/grazing land or popularly known as “Gochar bhoomi”. Most of these areas are interspersed with agricultural lands around villages and are protected by the village community. As biological systems, these Common Property Resources (CPRs) are dynamic and have traditionally provided sustainable benefits in the form of food, fodder, fuelwood and plant resources of medicinal importance. Grazing lands in the entire State of Rajasthan are also considered as repositories of biodiversity (Rajasthan Forest Policy, 2010). These areas representing nearly 8.5 per cent of the desert ecosystem of Rajasthan are crucial habitats in this hostile ecosystem for conservation of endemic flora and fauna of this region (Prakash, 1988). These areas have extensively been used as breeding grounds, foraging areas and refuges during day time by a number of faunal species such as Indian gazelle and Nilgai. Among the carnivores, Indian Fox, Jackal and Hyena also utilise these habitats. Over time, these areas have also become seed banks for desert species of plants as herbivores and carnivores in desert ecosystem have been one of the major agents of seed dispersal **(Plate 8.1).**

At the same time, local communities are highly dependent on grazing lands for animal husbandry practices and dairying which is one of their major sources of livelihood. Encroachment of grazing lands is not uncommon in Rajasthan for growing crops and for settlements. This is generally done by people owning land near grazing land and sometimes also by people from other neighbouring villages (Conroy and Lobo, 2002).

Considering that grazing lands are of vital importance as parcels of wildlife habitats outside the protected area network in Rajasthan and that these are also valuable common property resources for sustaining livelihood of local communities, their protection is of paramount importance both, from ecological and economical standpoint.

Permanent pasture/grazing land is around 94437 ha and 15357 ha in Barmer and Jalore districts respectively (Resource Atlas of Rajasthan, 1994). During the course of this study, 11 different pasture/grazing lands in the command areas were surveyed (**Table 8.1**).

Table 8.1 Grazing lands located in the project area and their wildlife values.

Sl. No	Name of the grazing land	GPS Location	Area (ha)	Faunal evidences seen	Faunal Encounter Rate (no.of animals seen/kilometer walked)
1.	Dhabal	N 24° 45' 57.21" E 71° 41' 23.23"	137.55	Chinkara, Nilgai, Indian fox	10
2.	Karawadi	N 24° 54' 46.64" E 71° 49' 09.24"	128.6	Chinkara, Nilgai	7
3.	Palari	N 24° 48' 25.22" E 71° 45' 22.51"	194.38	Chinkara, Nilgai, Striped hyena	9
4.	Sarvana	N 24° 44' 36.29" E 71° 30' 56.02"	19.00	Chinkara, Nilgai, Wild pig	1.6
5.	*Arna	N 24° 52' 00.21" E 71° 54' 08.21"	162.46	Chinkara, Nilgai	3
6.	Hadecha	N 24° 49' 34.37" E 71° 41' 20.91"	150.40	Chinkara, Nilgai	12
7.	Golasan	N 24° 41' 19.57" E 71° 44' 03.22"	425.55	--	0
8.	*Jhajhusan	N 24° 45' 01.38" E 71° 48' 22.23"	25.00	Nilgai	10
9.	*Badsam	N 24° 43' 02.42" E 71° 48' 53.84"	97.40	Nilgai	16
10.	Jaisla	N 24° 41' 30.22" E 71° 34' 59.08"	78.50	Nilgai	7
11.	Kiraudi	N 24° 56' 46.82" E 71° 49' 10.3"	96.74	--	0

***Grazing lands located outside the project command area*

These areas varied widely in their size, ranging from the smallest (Sarvana) covering an area of 19.0 ha to the largest (Golasan) spread over an area of nearly 425 ha. Of these, 8 grazing lands were located within the command area and remaining three were located outside the command area but within the same landscape. Almost all of the grazing lands surveyed were degraded mainly due to uncontrolled grazing over years.

One of the immediate priorities under the project is to ensure protection within the grazing lands located within the command area. Among the grazing lands surveyed during the course of the study, Palari, Golasan, Dhabal, Arna deserve special attention for protection.

In order to identify that all grazing lands within the command area that are ecologically viable wildlife habitats are effectively protected for conservation of rare and endemic flora and fauna of Rajasthan, the following actions are recommended:

i. All grazing lands within the command area should be mapped using satellite remote sensing technology.

ii. Once this is achieved, grazing lands should be prioritized through a consultative process involving all stakeholders and mechanisms of their sustainable management should be evolved through consultations.

iii. The maps of prioritized grazing lands should be superimposed on soil maps and the land irrigability maps to aid in understanding of the probability of their conversions due to subsequent intensification of irrigation in the area.

iv. An action plan for the conservation and management of prioritized grazing lands should be prepared by the Water Resources Department, Govt. of Rajasthan through a consultative process.

8.2.2 Habitat improvement and management within grazing lands

Following measures are recommended to be undertaken to improve the habitat potential of all the grazing lands that are identified for protection:

I. Plantation of indigenous plant species providing palatable forage and cover

Species that should be considered for plantation for this purpose include *Prosopis cinceraria, Zizyphys nummularia, Calligonum polygonoides Capparis species, Salvadora persica, S. oleioides, Tecomella undulata*.

II. Restoration of degraded areas:

Restoration of degraded areas should be taken up by raising grasses species which have both high nutritive value as fodder and wildife values. These may include: Lasiurus sindicus, Eleusine compress, Cenchrus biflorus and Boerhavia diffusa etc. Director, Desert Afforestation and Pasture Development, Department of Forest, Government of Rajasthan may be requested to submit the proposal for habitat improvement of these crucial areas for wildlife conservation. No plantation of exotic mesquite (*Prosopis juliflora*) should be done.

III. Development of nurseries for fodder and pasture

In the Jaisalmer district of Rajasthan, schemes have been launched for the cultivation of green fodder in 200 ha, pasture development in 3,000 ha, and the establishment of one hundred 'wood lots' and 'nurseries'. Similar schemes can be implemented under the project in Sanchore.

IV. Planning of Grazing regimes

In order to maintain the vigour of the grasses/shrubs/herbs, the grazing land should be subjected to (ii) Deferred grazing, (iii) Rotational grazing and (iv) Deferred rotational grazing for a given site at a specific period as per requirement. In arid grazing land situation, Das and Paroda (1980) observed a 22% increase in dry matter yield of cenchrus sp under deferred rotational grazing compared to only 6.3% under continuous grazing. This will improve the prospects of better utilisation of the grazing lands by chinkara, gerbils, Indian fox, hyena, jackal and various reptile and avifaunal species.

8.2.3 Creation of Community Reserves

The concept of establishing community managed areas for conserving valuable gene pool, reducing rate of degradation and preventing species loss in modified rural environments outside protected areas is not an uncommon approach (Shepherd, 1993; Patricia and Gilmour, 1995). Conservation Reserves are the new categories of protected areas after national parks and wildlife sanctuaries that were included in the Wildlife (Protection) Amendment Act of 2002 - the amendment to the Wildlife (Protection) Act of 1972. Community reserves are the first instances of private land being accorded protection under the Indian legislature.

This category was added because of reduced protection in and around existing or proposed protected areas due to private ownership of land, and land use. Designation of a community reserves provide a mechanism for recognition and legal backing to the community initiated efforts in wildlife protection. It provides a flexible system to achieve wildlife conservation without compromising community needs. Community based conservation models seeks to protect larger areas of land, species and habitats by encouraging local stewardship and integrating social, ecological and environmental priorities.

Tiruvidaimarudur Conservation Reserve in Thanjavur district of Tamil Nadu with 2.84 ha area was the first conservation reserve to be established in the country.

Conserving Giant Clams through community reserve in the Lakshadweep Islands, in India is one of the more recent examples towards species conservation through participatory support (http://www.lead.org/). Establishment of Jhilmil Jheel Conservation Reserve in Hardwar, Uttarakhand is another example of seeking greater community involvement in protecting Swamp Deer (*Cervus duvaucelli*), which is a highly endangered species.

In the state of Rajasthan, 3 Conservation Reserves have been notified (as per the minutes of the Rajasthan State Wildlife Advisory Board Meeting held on 22/9/2010). These are: Bisalpur in Tonk District, Joad Beed Gadwala in Bikaner District and, Sundamata in Jalore district. Although the Sunda Mata Hills range forest area is situated in Jalore district, this does not fall within the Narmada Canal command area.

Considering the ecological and economic importance of grazing lands within the project command for raising pasture and for sustaining many of the desert species that command high conservation significance, their protection must be driven by community supported initiatives. Such initiatives will have to secure the socioeconomic dynamics that determine current and future use of resources on land owned by community and but jointly managed by the state conservation agency for creating opportunities to maintain both ecological function and human land use options.

The State Government should consider declaring two of the already surveyed grazing lands viz. Golasan (425 ha) and Palari (194 ha) within project command area as Community Reserves for protecting the endemic flora and fauna and the traditional conservation values and practices of the Thar Desert ecosystem. This should be accomplished by the State Forest Department taking a proactive role in

this action with the participatory support of local people. The initial effort should lead to creation of partnership with local community for revisiting the objective of developing and conserving grazing lands and evolving mechanisms for incentivising local community for their support in conservation efforts. The local people should be subsequently involved in establishment of land protection systems and decision-making, development of nurseries, seed planting, management of fodder requirement and habitat improvement through rotational grazing. The State Forest Department should also set up a system of assessing the conservation benefits and local benefits accruing over time from setting up of Community Reserves. The long term success and efficacy of this mitigation action should be assessed in the context of the following:

- Conserving biodiversity
- Managing natural resources
- Meeting social needs, such as maintaining local culture, increasing opportunities for income generation, and improving health and well-being
- Lowering management costs
- Sustaining outcomes over time

Similar approaches of recommending areas for setting up of community / conservation reserves to mitigate the impacts of development projects on biodiversity values of the receptor environment have been adopted in other countries (Rio Tinto Ltd., 2008) and also within the country (WII, 2008).

8.2.4 Protection of gerbil habitat

Indian gerbil and Indian desert gerbil, lizard and snake species inhabit loose sandy soils. Conversion of areas into agricultural fields would lead to soil compaction thereby destroying their habitat. Further, replacement and reduction in species such as jirds, gerbils and birds which are an important food component of other dependent species of mammals, reptiles and birds of prey would negatively affect the entire community structure of the desert ecosystem. Bunding and fencing of areas around the crop fields will not only protect crops from being raided by wildlife but would also create habitat for gerbils, and jirds. These bunds with fences of species such as Euphorbia caudicifolia, Maytenus emarginata, Capparis sp. Aerva sp. Calligonum polygonides will be ideally suited for promoting protection of endemic desert fauna including the gerbils.

Project authorities must facilitate free distribution of seeds/seedlings for raising these fences from the nurseries of State Forest Department and those owned by the Panchayats. Biological control of pests like bandicoots and metads should be

promoted to avoid the risk of replacement of gerbils by these pest species. Awareness building programmes for farmers and technical know- how for practicing biological control of pest species must be organised by the project authorities who must contact specialised agencies such as Afforestation and Pasture Development, Department of Forests, Government of Rajasthan for building capacity. The Project Authority must also have a supportive role in terms of making the information accessible, providing financial support for training and ensuring favourable policy support for conservation of endemic fauna on private lands with farmer support.

8.2.5 Erection of natural fences around crop fields

In Rajasthan desert, native vegetation is mostly used for fencing around agriculture fields.. At present existing fences between agriculture fields under the command areas are of very poor in natural vegetation. For conserving biodiversity of native flora and fauna under agriculture dominated landscapes, farmers should be sensitized about the importance of conserving flora and fauna under agriculture dominated landscape. Small wildlife habitats interspersed between agriculture fields can be created by undertaking plantation of plant species on existing fences such as *Maytenus emarginata, Capparis sps., Euphorbia cauducifolia; Aerva sps., Calligonum polygonides*. These would provide home for a number birds species like Grey partridge, *Francolin pondicerianus*, the quails *Coturnix coturnix* and *C. coromedelica*, reptilian fauna like lacertid, *Acanthodactylus cantoris* and desert rodents like Indian gerbil (*Tatera indica*) and Indian desert gerbil (*Merinoes hurrianae*).

8.2.6 Creative management of 'escape areas' as wetland habitats

A canal escape at km. 51.45 (N25^{o}01'26.09" E71^{o}42'06" of the Main Canal and another escape at km. ±65 (N24^{o}57'46.06" E71^{o}33'22.15") have been provided in the project design. These escape structures are planned to divert excess water from the canal to maintain levels to avoid risk of flooding the areas. As the water from escape areas of canal system would flow out of the canal outlet, it is most likely to be misappropriated and wasted. Excessive use of the canal water that is released at escape points can also cause problems of water logging, salinity, and consequently lead to suboptimal crop patterns. It is recommended that this excess water from the canal be retained at the escape sites no. 2 and be managed as a wetland to provide an ideal wintering habitat for many of the migratory species of birds that have started visiting the command area ever since the water regime has improved in this area after the development of irrigation facilities. During the survey of command area, temporary wetland created in low lying agricultural fields along the Highway (NH-15) near Gandhav village was observed during the survey within the command area. Species such as Great White Pelican, Painted Stork, Eurasian

Spoonbill, Pied Avocet, River Tern, Great Cormorant, Grey heron, Common Coot, and Gadwall were seen visiting these areas. The functional value of this wetland is however limited as it is dependent on period of water retention in the agricultural fields.

An area that can be objectively maintained for conservation of wetland species of birds will have a far greater benefit for conservation of wetland species. The creation and scientific management of the Escape site -2 as a wetland is therefore recommended (**Plate 8.2**). This task should be taken up in consultation with agencies such State Forest Department, and NGOs working in the field of nature conservation such as Environment Cell, Gandhi Peace Foundation Centre, Jodhpur.

The likely impact of creating such a wetland could be increased salinity in adjoining areas if adequate measures are not put in place to prevent salinity. It is therefore recommended that Department of Soil and Water Conservation, Rajasthan, should be actively involved to provide prescriptions for soil enrichment and for undertaking plantation of salt tolerant species in the adjoining areas to avoid the formation of saline waste lands.

Plantations, particularly in dry arid regions, can transpire a large quantity of groundwater and therefore can be used to control the rise of groundwater table. Plantations also draw salts and minerals from the soil to some extent. Bio-drainage through plantations can help achieve both the water balance as well as the salt balance in the groundwater regime.

8.2.7 Protection of saline lands as wildlife habitats

Saline flats and depression in these two districts are at present in degraded form due to overgrazing. A large saline patch was observed near lift pumping station location near Manki distributary off-take point at 74 Km of Narmada Main Canal. This saline patch locally known as Rann saline waste is one of the largest saline patch in the command area of the project (**Plate 8.3**) Plantation of salt tolerant plant species like *Salvadora oleoides; Atriplex sps; Haloxylon sp.; Indigofera oblongifolia; Chloris virgata; Sporobolus helvolus; Dactyloctenium aegyptium*) will greatly improve the habitat potential of this area to support a number of desert species like Indian gazelle, grey partridge, quail and a number of reptile species. The project authorities seek the support of Desert Afforestation and Pasture Development, Department of Forest, Government of Rajasthan for habitat improvement of Rann Saline wasteland. A technico financial proposal for habitat improvement should be developed by Desert Afforestation and Pasture Development, Department of Forest, and funding support for its implementation should be committed by the Govt. of Rajasthan.

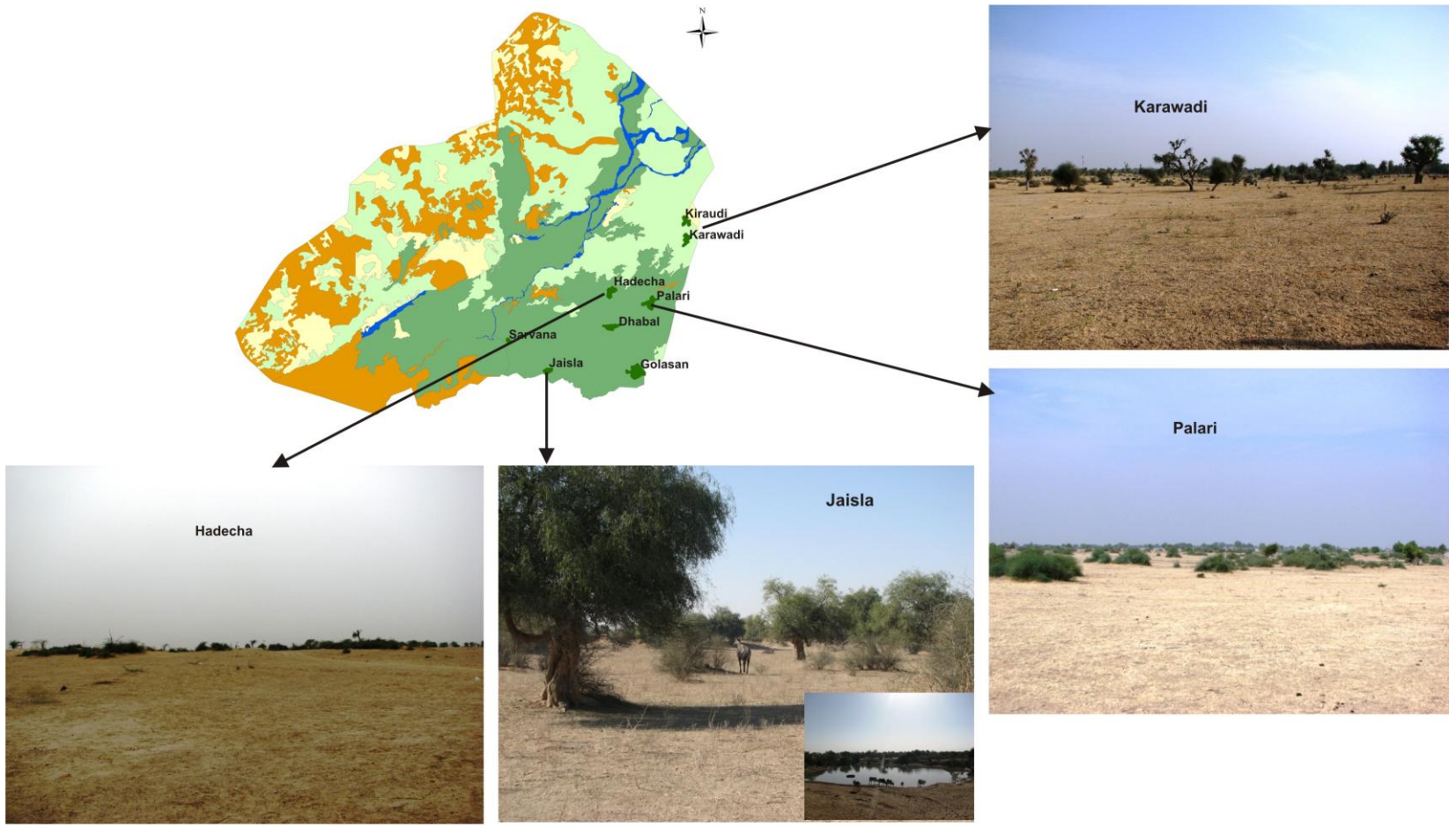


Plate 8.1 Representatives of the grazing land surveyed during the study.

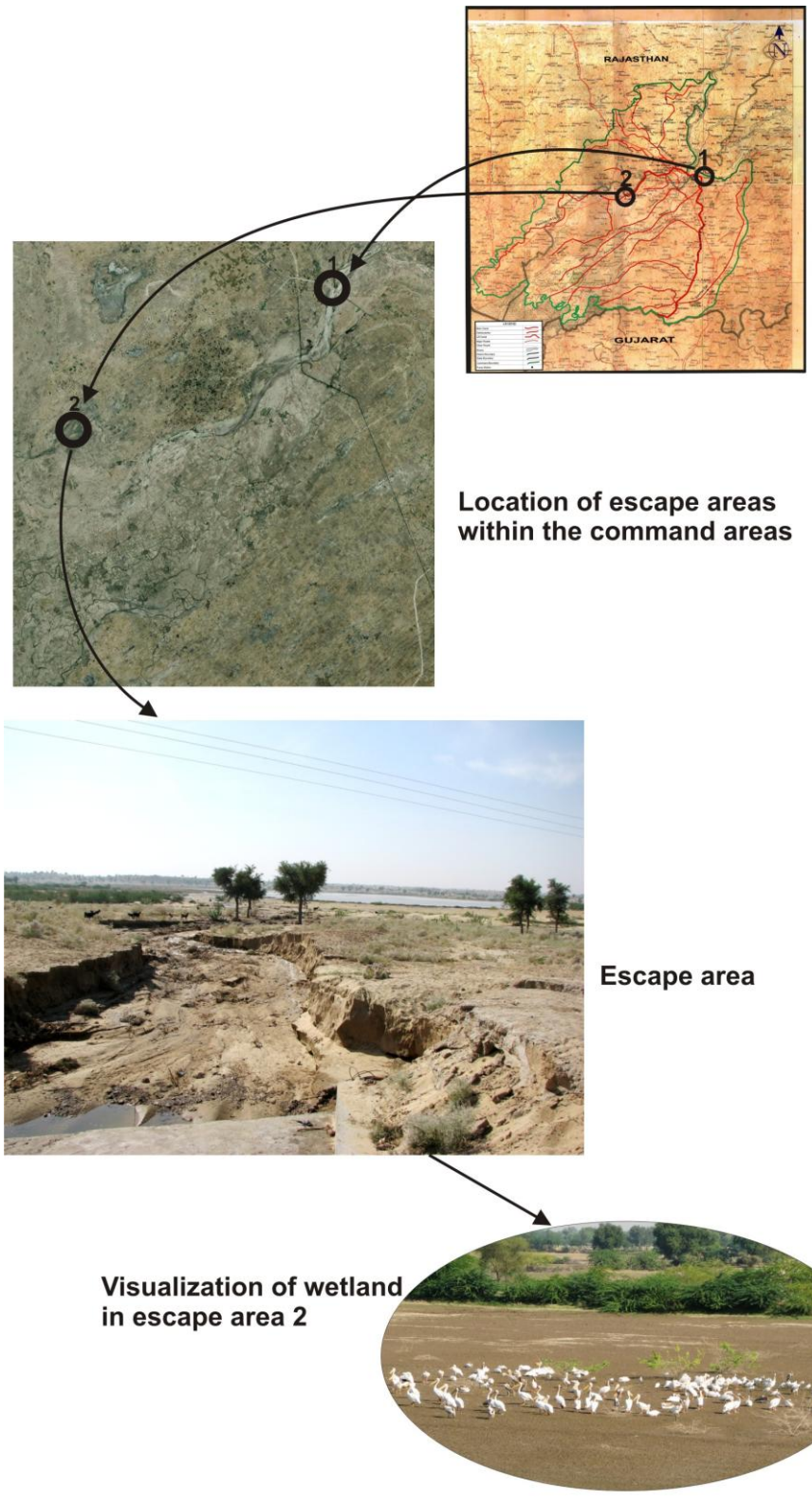


Plate 8.2 Creative management of escape area as a wetland habitat.

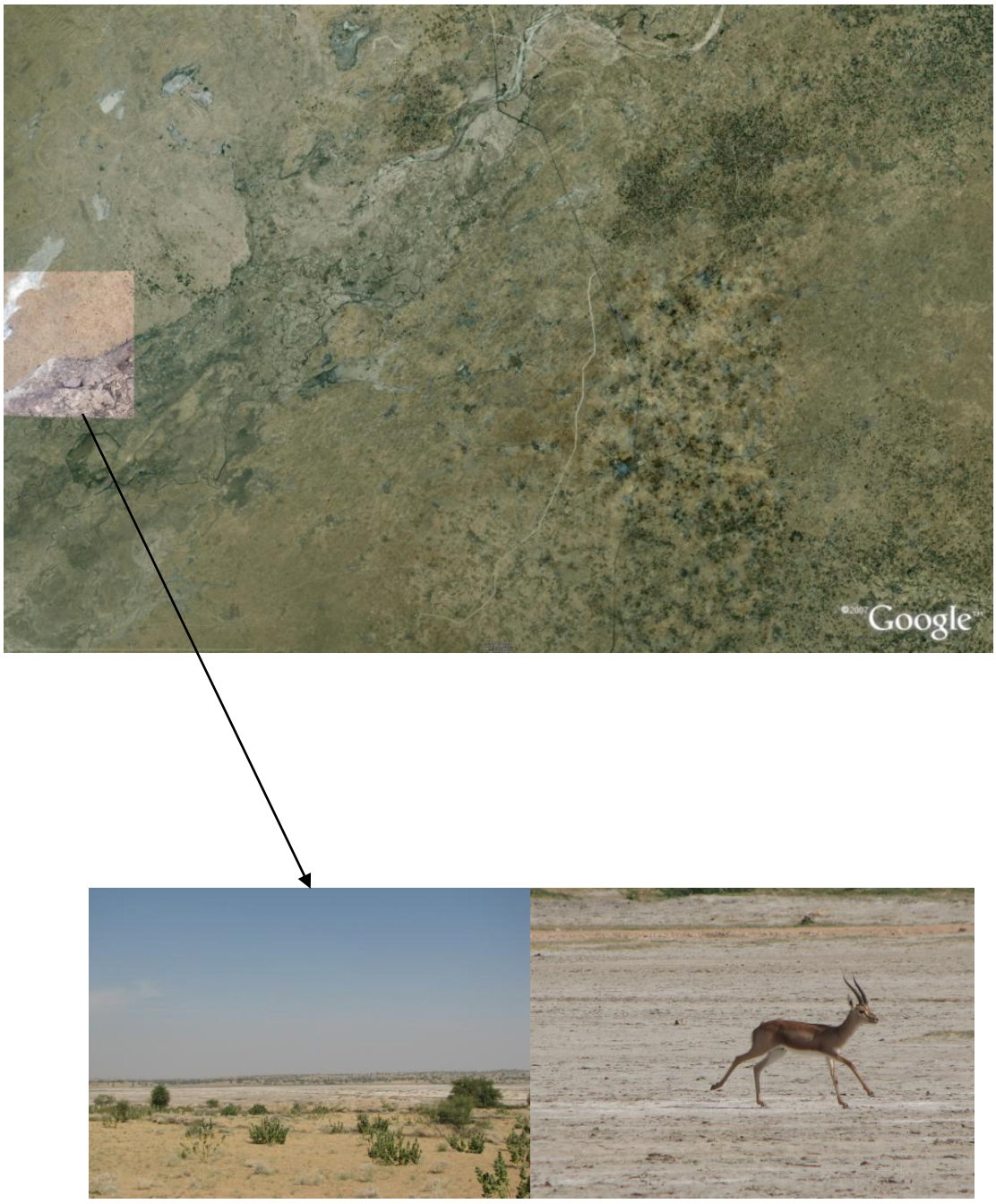


Plate 8.3 Rann saline wasteland, the largest saline patch in the command area merits protection and improvement.

8.3 Roles and Responsibilities

While participation of the 'Water Users Association (WUA)' in the management decisions particularly those relating to distribution of water, cost recovery, and maintenance and repairs is essential for efficient water management, it is also essential to develop mechanisms for participatory wildlife conservation in the command area to ensure that canal development is harmonized with wildlife conservation priorities of the Jalore and Barmer districts of Rajasthan.

Mechanism will have to be evolved for (i) delegation of authority and provision of incentives commensurate with the additional responsibilities and duties assigned to farmers; (ii) promotion of group activities aimed at organizational development for giving immediate and tangible benefits to people involved in wildlife and biodiversity conservation (iii) monitoring for ensuring compliance of actions proposed for mitigation of project related impacts on ecological, environmental and economic impacts on key receptors species of conservation importance; characteristic elements of desert ecosystems, essential goods and ecosystem services and (iv) post-project monitoring for evaluating environmental performance of the project with respect to impacts on flora and fauna. The allocation of responsibilities for all mitigation actions proposed **(Table 8.2)** must be made for achieving positive outcome for biodiversity within the command area and the adjoining areas that hold significant importance for conservation of desert species outside protected area network in Rajasthan.

Table 8.2 Proposed mitigation plan and institutional responsibilities for plan implementation

Potential impacts on biodiversity	Mitigation measures	Institutional responsibility	
		Implementation	Supervision
Reduction and degradation of areas under grazing lands	**Protection of grazing lands by undertaking following actions:** Mapping of all grazing lands and delineating select areas for protection. Preparation of Action Plan for sustainable management of grazing lands	Departments of Forest and Wildlife, Revenue and Water Resources, Govt. of Rajasthan	Govt. of Rajasthan and Environment Sub group, Narmada Control Authority
Impacts of land use changes on existing wildlife habitats and species meriting high conservation priorities such as chinkara,	**Habitat improvement and management within grazing lands by undertaking the following activities:** i. Plantation of indigenous plant species providing palatable forage and cover; Restoration of degraded wildlife habitats; ii. Development of nurseries for fodder and pasture; iii. Selective grazing regimes	Project authorities to mobilise this through the support of Afforestation and Pasture Development, Department of Forest; Panchayats; Local communities for participatory role in protection of saplings and plantations Mechanisms of incentives for protection/compensation for adopting selecting grazing norms to be also evolved in consultation with local people, herders and other dependent communities	Govt. of Rajasthan; Environment Sub group, Narmada Control Authority
Impacts on desert ecosystems, habitats of endangered floral and faunal species of desert ecosystems	**Creation of community reserves**	State Forest Department, in consultation with local communities; and conservation organisations including civil society	Govt of Rajasthan; Environment Sub group, NCA

Potential impacts on biodiversity	Mitigation measures	Institutional responsibility	
		Implementation	**Supervision**
		representatives	
Impacts of intensified agriculture and changes in soil texture on gerbil habitats within the command area	**Protection of gerbil habitat through the following actions:** **i.** Bunding and fencing of areas around the cropfields. **ii.** Awarness building of farmers for protection of gerbils	Project Authority, Afforestation and Pasture Development, Department of Forest, Government of Rajasthan Farming community owning the lands	State Forest Department, Govt of Rajasthan
Impacts on ground dwelling reptiles and burrowing rodent species that are characteristic species of desert	**Erection of natural fences around crop fields**	Project authorities; Farmer community	
Impacts on wetland bird species and migratory species visiting the command area during winter months due to hydrological changes	**Creative management of escape areas as wetland habitats for wetland birds visiting Rajasthan**	State Forest Department; NGOs working in the field of nature conservation such as Environment Cell, Gandhi Peace Foundation Centre, Jodhpur.	Govt of Rajasthan; Environment Sub group, NCA
Risk of increased salinity in saline areas and more areas becoming saline	**Protection of saline lands as wildlife habitats**	Department of Soil and Water Conservation, Govt. of Rajasthan	Govt. of Rajasthan

For the desired effectiveness of the proposed mitigation plan, efforts should be made to raise biodiversity awareness among contractors and builders. It would be essential to monitor the impact that contractors and builders may have on biodiversity and then work on ways to ensure what kind of guidance is needed for project contractors. Writing biodiversity requirements into performance contracts and reporting guidelines and working with relevant project personnel to develop a code of practice encompassing biodiversity can be other positive approaches for mainstreaming biodiversity in mitigation.

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Annexure - I

Office of The Chief Engineer Narmada Canal Project, Sanchore,Dist. Jalore, (Rajasthan)

No.CE NCP/NCA/T-13F/07-08/ 52 Date 01.01.2008

Sh.V.B.Mathur, Dean
Faculty of Wild Life Sciences,
Wild Life Institute ofIndia,
Dehradun.

Sub : Terms of References (TOR) for Environmental Impact Assessment Study on Flora and Fauna in the Narmada Canal Project (NCP) Area in Rajasthan.
Ref : N.C.A.Env., Director letter No.Env.-4(4)/2007/3934-3940 dated 06.12.2007.

Sir,

A meeting was held on 23rd October 2007 in the N.C.A. liaison office, at New Delhi, under the chairmanship of Shri M.K.Sinha, Member (E&R) for framing Term of References (TOR) for the consultant towards preparation of Environmental Impact Assessment Study (EIA) & Environmental Management Plan (EMP) for Narmada Canal Project Area in Rajasthan.

You were also present in the meeting and you agreed to take the study with respect to Biological Resources of the command. The T.O.R. for studies on Flora & Fauna is enclosed at **Annexure-i**.

You are requested to kindly send your financial offcer, so that further necessary action may be taken.

Encl.: As above.

Chief Engineer
Narmada Canal Project
Sanchore

No.CE NCP/NCA/T-13F/07-08/ Date

Copy submitted to The Additional Secretary cum Chief Engineer, Water Resources, Rajasthan, Jaipur.

Chief Engineer
Narmada Canal Project
Sanchore

Annexure - II

OFFICE OF THE EXECUTIVE ENGINEER NARMADA CANAL DIVISION-I, SANCHORE (RAJ.)

No. 1387 Date: 24/7/09

Dean,
Wildlife Institute of India Dehradun
Chaudabani Dehradun

Sub: - Memorandum of understanding (MOU) between the water Resources Department, Government of Rajasthan and your Institute for the Environmental impact assessment study on flora and fauna in the Narmada Canal Project Rajasthan.

Ref: - The office letter No. 1322 dated 21/07/09 and WII, Dehradun office letter No. WII-EIA-NCP-2007 dated 10/06/09

Sir,

Kindly find enclosed herewith copy of MOU between WII Dehradun and Govt. of Raj. For carrying out study in Narmada Canal Project, Rajasthan.

The above study has been sanctioned by GOR vide letter No. NCF/C-21/III/184 dated 19/05/08 and subsequently the MOU has also been approved by GOR vide letter No. NCF/C-24/IV/170 dated 05/05/09.

20% of the total amount (DD No. 603557 dated 20/07/09 Rs. 485596/-) has already been sent to your office for further necessary action please.

It is requested to initiate the process of study so that the work can be completed within the scheduled period.

Enclosure
1. One Set of MOU

Executive Engineer
Narmada Canal Division-I,
Sanchore

Copy Submitted to the following for information:-

1. The Chief Engineer, Water Resources Dept., Jaipur.
2. The Chief Engineer, Narmada Canal Project, Sanchore.
3. Superintending Engineer, Narmada Canal Project, Circle1st, Sanchore.

Executive Engineer
Narmada Canal Division-I,
Sanchore

Annexure - III

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
1.	*Acacia leucophloea*	Reonja	Fabaceae	--	Important dry-season fodder and pasture tree throughout its range. Leaves, tender shoots and pods are eagerly eaten by goats, sheep and cattle. Leaves contain 15% crude protein and 19% crude fiber. However, due to hydrocyanic acid toxicity should not be used as a sole feed (www.winrock.org/fnrm/factnet/factpub/FACTSH/A_leucophloea.html. FACT 96-04, June 1996)
2.	*Acacia senegal*	Rfaudraksha	Fabaceae	Gum used for soothing mucous membranes of the intestine and to treat inflamed skin; has astringent properties, used to treat bleeding, bronchitis, diarrhoea, gonorrhoea, leprosy, typhoid fever and upper respiratory tract infections (Wikipedia).	--
3.	*Acacia tortilis*	Israeli Babool	Fabaceae	Leaves, bark, seeds, and a red gum are used in many local medicines (Wikipedia). Two pharmacologically	The pods and foliage, which grow prolifically on the tree, are used as fodder for desert grazing

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
				active compounds for treating asthma have been isolated from the bark (Hagos et al. 1987)	animals. http://www.winrock.org/fnrm/factnet/factpub/FACTSH/A_tortilis.html.
4.	*Aerva javanica (Aerva persica)*	Kapok bush/ Safed Shamli	Amaranthaceae	In Ayurveda, the leaves, seeds and the roots used for treatment of kidney stones, and as astringent. (http://www.herbsnspicesinfo.com/medicinal-herbs/aerva-javanica.aspx)	--
5.	*Alhagi maurorum*	Camelthorn	Fabaceae	Used for gastrointestinal disorders, gastric ulcer and rheumatism. An aqueous extract of the whole plant used in Iranian traditional medicine to treat heartburn resulted from gastric reflux (Naseri and Mard, 2007).	--
6.	*Aloe vera*	Guarpatha/ medicinal aloe	Asphodelaceae	Used for healing of first to second degree burns. Juice consumed to relieve digestive issues such as heartburn and irritable bowel syndrome. Application may reduce symptoms and inflammation in patients with ulcerative colitis and may be effective for genital herpes and psoriasis (Wikipedia).	--
7.	*Azadirachta indica*	Neem	Meliaceae	Parts have anthelmintic, antiperiodic, antiseptic, diuretic and purgative actions. Used to treat boils, pimples,	The leaves, though very bitter, are used as a dry season fodder (world agroforestry

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
				eye diseases, hepatitis, leprosy, rheumatism, scrofula, ringworm and ulcers. Leaf teas used to treat malaria. Twigs effective in preventing periodontal disease. Oil is a powerful spermicide. A neem oil-based product, Sensal, is being marketed in India as an intravaginal contraceptive. Oil used traditionally as a topical treatment for skin symptoms in both humans and livestock. (world agroforestry centre)	centre).
8.	*Balanites aegyptiaca*	Hingoto	Zygophyllaceae	Medicinal uses of this plant are many. The fruit is mixed into porridge and eaten by nursing mothers, and the oil is consumed for headache and to improve lactation. Bark extracts and the fruit repel snails and copepods, organisms that host the parasites schistosome and guinea worm, respectively (Wikipedia). The fruits have been used in the treatment of liver and spleen diseases. Gum from the wood is mixed with maize meal porridge to treat chest complaints (Eckman and Hines, 1993).	Protein rich leaves and shoots are an excellent source of fodder. (Eckman and Hines, 1993)
9.	*Calligonum*	Phog	Polygonaceae	Exerts cooling	Good food

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
	polygonoides			effect and good for health. Decoction of roots mixed with catechu is used as gargle for sour gums (Wikipedia).	plant for cattle (Wikipedia).
10.	*Calotropis procera*	Akra	Apocynaceae	Healing, laxative and anthemintic properties that relieves strangury, cures ulcers, acts as an expectorant. Used to relieve stomach pain (leaves). Its flower is a tonic, appetiser, stomachic, that cures piles, asthma and wounds. Its milky juice is a blistering agent. Its flowers are useful in cholera (herbal monograph).	--
11.	*Capparis decidua*	Kair	Capparaceae	The very bitter roots are used in the Indian and Farsi pharmacopoeia and the root bark is used to cure swollen joints (Agroforestry database).	Its browse value is probably its most important asset, despite being low in nutritional value. (Agroforestry database).
12.	*Cenchrus biflorus*	Indian sandbur	Poaceae	--	Its young shoot is used as fodder (http://www.jircas.affrc.go.jp/project/africa_dojo/FakaraPlants/Contents/Species_pages/Cenchbif.html).
13.	*Citrullus colocynthis*	Tumba	Cucurbitaceae	Its dried pulp is being used for amenorrhea, ascites, bilious disorders, cancer, fever, jaundice, leukemia, rheumatism, snakebite, tumors (especially of the	--

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
				abdomen), and urogenital disorders (Duke, 1983).	
14.	*Clerodendrum phlomidis*	Arni	Verbenaceae	Root is bitter tonic and given in convalescence of measles. Juice of leaves is alterative and given in neglected syphilitic complaints. The root is given as a demulcent in gonorrhoea, and decoction of the plant is considered as an alternative. It helps cure stomach troubles and swellings in cattle (http://www.flowersofindia.net/catalog/slides/Arni.html).	--
15.	*Convolvulus microphyllous*	Bindweed/Shankhpushpi	Convolvulaceae	Whole plant used. Remedy for hair related problems. Excellent brain tonic and provides strength to the nervous system. It also is helpful in conditions like insomnia. Also acts as an appetizer and promotes better digestive actions. Effective in hypertension and relieves undue pressure on the arteries; throat related problems ; acts as diuretic and is helpful in conditions like urinary tract infections. Also used as an aphrodisiac agent. Reduces burning sensations in the body and also relieves from general body weakness (http://www.ayushveda.com/herbs/con	--

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
				volvulus-microphyllus.htm).	
16.	*Cressa cretica*	Rudravanti/Littoral bind weed	Convolvulaceae	According to Ayurved, the whole plant is used for medicinal purposes. It is useful herb for asthma, bronchitis, dyspepsia, flatulence, colic, anorexia, anaemia, diabetes and skin disease (www.flowersofindia.net/catalog/slides/Rudravanti.html).	--
17.	*Crotolaria burhea*	Saniya	Leguminosae	Roots of one plant boiled in water and its filtrate taken orally, makes a good coolant (Kumar et al,2008)	--
18.	*Euphorbia caducifolia*	Danda-thor	Euphorbiaceae	Latex used in cough, applied on blisters, purgative, expectorant and earache (Mohammed, 2004).	--
19.	*Fagonia cretica*	Dhamaso	Zygophyllaceae	Whole plant is used as bitter tonic, diuretic, astringent, prophylactic against small pox, disorder caused by poisoning, in dropsy, cough, fever, asthma, skin diseases and cooling agent (Mohammed, 2004).	--
20.	*Heliotropium curasaviccum*	Salt heliotrope/Kunjaro	Boraginaceae	--	It has fodder values (Quasim et al., undated).
21.	*Heliotropium ovalifolium*	Grey leaf heliotrope/Kunden	Boraginaceae	It is used against syphilis and is reported to have analgesic properties. In Tanzania the dried plant is mixed with butter and the mixture is smeared thickly over painful places during fever.	Also has fodder value for livestock

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
				In both Ethiopia and Tanzania it is applied to scorpion stings (http://plants.jstor.org/upwta/1_587)	
22.	*Heliotropium supinum*	Dwarf heliotrope	Boraginaceae	Plant used as medicine for tumours and cancers (http://plants.jstor.org/upwta/1_591)	--
23.	*Indigofera*	--	Fabaceae	Leaves used in treatment of persistent wounds (Quasim et al., undated)	--
24.	*Leptadenia pyrotechnica*	Khimp	Asclepiadaceae	Used for rheumatism, joint pains, sciatica, backache and as anti-helimintic. Used for kidney stones (stem). (http://www.haad.ae/HAAD/LinkClick.aspx?fileticket=QiGd8lhGZ20%3D&tabid=791).	--
25.	*Lycium barbarum*	Wolfberry/Goji	Solanaceae	Has antioxidant properties, including potential benefits against cardiovascular and inflammatory diseases, vision-related disease such as age-related macular degeneration and glaucoma, having neuroprotective properties or as an anticancer and immunomodulatory agent (Wikipedia).	--
26.	*Oligochaeta ramosa*		Asteraceae	Plant tonic, aperients, deobstruent, febrifuge. Mucilage used in coughs (Pullaiah, 2006)	--
27.	*Pergularia daemia*	Utarni	Asclepiadaceae	Used in folk medicine for the treatment of liver disorders. (http://www.flowers	--

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
				ofindia.net/catalog/slides/Pergularia.html)	
28.	*Polygala*	--	Polygalaceae	Some species have medicinal uses	--
29.	*Prosopis cineraria*	Khejri	Fabaceae	Flowers consumed as safeguard against miscarriage. Water-soluble extract of the residue from methanol extract of the stem bark exhibits anti-inflammatory properties. Anthelmintic; tonic, cures leprosy, dysentery, bronchitis, asthma, leukoderma, hemorrhoids and muscle tremors. The smoke of the leaves is good for eye troubles. The fruit is dry and hot, with a flavour, indigestible, causes biliousness, and destroys the nails and the hair. The pod is considered astringent in Punjab. The bark is used as a remedy for rheumatism, cough, the common cold, asthma, and scorpion stings. The plant is recommended for the treatment of snakebite (Wikipedia)	Provides green as well as dry fodder. Leaves have high fodder value (Wikipedia). .
30.	*Prosopis juliflora*	Vilayati babool	Fabaceae	Folk remedy for catarrh, colds, diarrhea, dysentery, excrescences, eyes, flu, headcold, hoarseness, inflammation, itch, measles, pinkeye, stomachache, sore throat, and wounds (Duke, 1983)	--

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
31.	*Salvadora oleoides*	Jaar	Salvadoraceae	Leaves are used to relieve cough, and are given to horses as a purgative. Root bark is used as a vesicant. Fruits are used in the treatment of enlarged spleen, rheumatism and fever. The seed fat is used in the treatment of rheumatic pains, in preparation of suppositories and as a base for ointments. Unspecified part used to treat throat swelling of domestic animals in India. (http://www.worldagroforestrycentre.org/sea/Products/AFDbases/AF/asp/SpeciesInfo.asp?SpID=17991)	The tree is often lopped for camel fodder. Fruits fed to cattle are said to increase milk production. Seed cake is suitable as livestock fodder and contains 12 % protein. Sheep and goats graze the tree. (http://www.worldagroforestrycentre.org/sea/Products/AFDbases/AF/asp/SpeciesInfo.asp?SpID=17991)
32.	*Salvadora persica*	Meswak/Peelu	Salvadoraceae	The roots are prepared as a salve and rubbed on the face for headaches. They are used for general body pain, gonorrhoea, back pains, chest diseases, and stomach aches. Latex from the bark is used for treating sores. Seeds are used as a tonic and seed oil is used on the skin for rheumatism (Eckman and Hines, 1993).	Leaves make good fodder as they have a high water content (15 to 36%) and are rich in minerals (FAO 1986). The leaves are readily consumed by goats and cattle and the fodder is available during the dry season. The high salt content of the leaves is said to affect the taste of the milk (Eckman and Hines, 1993).
33.	*Solanum surattense*	Nili-kateli	Solanaceae	Anticancer (fruit and plant); alleviates spasms, stimulates the	--

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
				cardiovascular system and antiarrhythmic (fruit); antiviral and spermicidal (plant); expectorant and carminative (plant). (http://www.impgc.com)	
34.	*Suaeda fructicosa*	Shrubby sea-blite	Chenopodiaceae	The leaves are used as a poultice in the treatment of ophthalmia. When infused in water, they have been used as an emetic (Chopra et al, 1986).	--
35.	*Tamarix aphylla*	Salt cedar	Tamaricaceae	Flower galls are used as an astringent and gargle, bark for treating eczema and other skin diseases. (http://www.worldagroforestrycentre.org/sea/Products/AFDbases/af/asp/SpeciesInfo.asp?SpID=1590)	Tender branches and leaves provide high value forage, particularly during the dry period. (http://www.worldagroforestrycentre.org/sea/Products/AFDbases/af/asp/SpeciesInfo.asp?SpID=1590)
36.	*Tecomella undulata (m)*	Rohida	Bignoniaceae	The bark obtained from the stem is used as a remedy for syphilis. Also used in curing urinary disorders, enlargement of spleen, gonorrhoea, leucoderma and liver diseases. Seeds are used against abscess. Traditionally in Musakhel, Pakistan its flower used for Hepatitis (Wikipedia).	Cattle and goats eat leaves of the tree. Camels, goats and sheep consume flowers and pods. (Wikipedia)
37.	*Tephrosia purpurea*	Wild indigo, sarphonk	Fabaceae	According to Ayurveda, the plant is anthelmintic, alexiteric, alterative, and antipyretic; it is	--

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
				used in the treatment of leprosy, ulcers, asthma, and tumors, as well as diseases of the liver, spleen, heart, and blood. A decoction of the roots is given in dyspepsia, diarrhea, rheumatism, asthma and urinary disorders. The root powder is salutary for brushing the teeth, where it is said to quickly relieve dental pains and stop bleeding.	
38.	*Trianthema portulacastrum*	Santhi	Aizoaceae	Whole plant: vermifuge, diuretic, promotes urination. Used in curing swelling of body caused by disorders of liver or kidney, in rheumatism and dropsy (Mohammed, 2004).	--
39.	*Tribulus terrestris*	Chhota-gorkhu/puncturevine	Zygophyllaceae	It is a diuretic drug useful in urolithiasis, dysurea, impotence and kidney dysfunction. It has tonic and aphrodisiac properties. It is known to increase the quantity of semen and is useful in diseases of the genitourinary tract. The plant and seeds have spasmolytic and cardiotonic activity (http://www.himalayahealthcare.com/aboutayurveda/caht.htm)	--

Sl.No	Scientific name	Common name	Family	Uses	
				Medicinal	Fodder
40.	*Ziziphus nummularia*	Jharber	Rhamnaceae	--	The dried leaves, called *pala*, are used as fodder for goats and cows (Wikipedia).
41.	*Zizyphus mauritiana*	Ber	Rhamnaceae	The fruits are applied on cuts and ulcers; are employed in pulmonary ailments and fevers; and, mixed with salt and chili peppers, are given in indigestion and biliousness. The dried ripe fruit is a mild laxative. The seeds used to halt nausea, vomiting, and abdominal pains in pregnancy. They check diarrhea, and are poulticed on wounds. Used for rheumatism. The leaves are helpful in liver troubles, asthma and fever and, together with catechu used as an astringent. Bark used to relieve diarrhea, dysentery and gingivitis; applied on sores. The root is purgative; said to alleviate gout and rheumatism. An infusion of the flowers serves as an eye lotion (Wikipedia)	The leaves are readily eaten by camels, cattle and goats and are considered nutritious. (Wikipedia)
43.	*Cyperus sp.*	--	Cyperaceae	Some species used in folk medicine	--

Annexure - IV

LIST OF PERSONS MET

1. Mr. R.K. Nigam
   Chief Enginner
   Narmada canal department
   Sanchore, Dist Jalore,
   Rajasthan

2. Mr. Rajesh Mathur
   Junior Engineer
   Narmada canal department
   Sanchore, Dist Jalore,
   Rajasthan

3. Mr. B.R. Bishnoi
   Junior Engineer
   Narmada canal department
   Sanchore, Dist Jalore,
   Rajasthan

4. Mr. Sankhala
   Assistant Engineer
   Narmada canal department
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   Rajasthan

5. Mr. Amarchand
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6. Mr. V.K. Purohit
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