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Draft Report

Economic Valuation of Landscape Level Wetland Ecosystem and its Services in Little Rann of Kachchh, Gujarat

07

THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY-INDIA INITIATIVE

WETLANDS

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- The Economics of Ecosystems and Biodiversity - India Initiative (TII)
- India Business and Biodiversity Initiative (IBBI)
- Conservation and Sustainable Management of Existing and Potential Coastal and Marine Protected Areas
- Himachal Pradesh Forest Ecosystem Services Project
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Economic Valuation of Landscape Level Wetland Ecosystem and its Services in Little Rann of Kachchh, Gujarat

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Under: The Economics of Ecosystems and Biodiversity (TEEB) India Initiative

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THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY-INDIA INITIATIVE

The Economics of Ecosystems and Biodiversity – India Initiative (TII) aims at making the values of biodiversity and linked ecosystem services explicit for consideration and mainstreaming into developmental planning. TII targets action at the policy making levels, the business decision level and awareness of citizens. TII has prioritized its focus on three ecosystems - forests, inland wetlands, and coastal and marine ecosystems - to ensure that tangible outcomes can be integrated into policy and planning for these ecosystems based on recommendations emerging from TII.

In addition to the existing knowledge, TII envisions establishing new policy-relevant evidences for ecosystems values and their relation to human well-being through field-based primary case studies in each of the three ecosystems. In response to an open call for proposals for conducting field-based case studies in the context of relevant policy or management challenges for conservation and the sustainable use of biodiversity and ecosystem services, over 200 proposals were received. A Scientific and Technical Advisory Group (STAG), comprising eminent ecologists and economists, appraised the proposals and recommended 14 case studies for commissioning under TII.

These studies in forests deal with issues such as hidden ecosystem services of forests, conflicts between humans and wildlife, and the economic consequences of species decline. In wetlands, the studies draw lessons on water resources management, community stewardship and equity, and the economics of hydrological regime changes. In coastal and marine ecosystems, the studies explore the opportunities and economic efficiency of interventions such as eco-labelling, seasonal fishing bans, mangrove regeneration, and the challenge of bycatch in marine fisheries.

The reports of these 12 case studies have been published in this TII series.

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11 Economic Valuation of Seasonal Fishing Ban on Marine Fisheries Services in Selected Maritime States of India

12 Economic Valuation of Biodiversity Loss: A Study of By-Catch from Marine Fisheries in Andhra Pradesh

KEY MESSAGES

Little Rann of Kachchh (LRK), a salt marsh spanning over 3,500 sq km, is the source for one-third of India's inland salt production. It is also the main source of ginger prawn export. The two production systems are sustained in a protected area of high biological diversity. The ecosystem services of LRK are increasingly threatened by upstream hydrological regime changes.

FINDINGS

- Livelihoods of 12,000 households are linked with the lake's ecosystem services. LRK provides annual economic benefits worth **₹1.51 billion** (**US$ 25.3m**).
- In 2014, the average annual net value of salt production from LRK was around **₹694 million** (**US$ 11.6m**). However, the growth potential is only through low-value underground, highly saline brine water-based salt production, at much higher costs.
- Metapenaeus kutchensis, an endemic prawn species constitutes more than **90%** of total fish biomass. The revenue from prawn fisheries was **₹746 million** (**US$ 12.4m**) and **₹400 million** (**US$ 6.7m**) in 2013 and 2014 respectively.
- In 2013-14, LRK biodiversity tourism generated **₹276 million** (**US$ 4.6m**).
- Runoff, annually stored in dams and check-dams, reduces **48%** of the freshwater flow into LRK.

RECOMMENDATIONS

- Existing hydrological function needs to be understood before recommending trade-off in upstream or downstream areas.
- Implement policies to improve water depth and maintain hydrological flow and balance. Dynamic hydrological regimes which underpin ecosystem services of LRK should be maintained.
- Such a large area with several streams of ecosystem services needs an integrated institution for governance in the domains of fisheries, tourism, conservation, agriculture and irrigation.
- Tourism needs to be optimised with long-term goals that ensures biodiversity is not harmed.
- Protect traditional rights of fishers and salt workers without serious harm to ecological services.
- Currently, salt production is altering habitats and impinging upon the prawn production. These production systems need to be optimised in a sustainable manner.
- Conserve, create and manage additional habitats for migratory birds, including nesting grounds for the lesser flamingo.

Photo: Ajay Dhamecha

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EXECUTIVE SUMMARY

Economic Valuation of Landscape Level Wetland Ecosystem and Its Services in Little Rann of Kachchh (LRK), Gujarat

Background

Wetlands in arid and semi-arid areas are seasonal in nature and often water-stressed during the dry period. Biotic adaptations under such conditions are typically opportunistic, with critical life-cycle activities synchronized with the seasonal variations in hydrology. Landscape features, hydrology and land-water interactions are prime determinants for wetland ecosystem's structure and function, influencing the nature of ecosystem goods and services provided.

In India, the total value of ecosystem services, of around 13.1 million ha of wetlands, is estimated to be ₹665 billion ($14 billion) annually. The Economics of Ecosystems and Biodiversity – India Initiative (TII), launched by the Ministry of Environment, Forests and Climate Change (MoEFCC), aims to highlight the economic consequences of the loss of biological diversity and associated decline in ecosystem services. The TII effort is to make the hidden values of ecosystems explicit, so as to support their mainstreaming in economic development policies and programmes. The present study seeks to contribute to TII by uncovering the values of ecosystem services and biodiversity of wetland in the context of the arid landscape of Gujarat.

The study focuses on the Little Rann of Kachchh (LRK) – the largest wetland system of Gujarat – to understand various ecosystem services and estimate their economic values that maybe relevant and useful in the context of improved development policy. The specific objectives of this study are to:

- Record key hydrological characteristics and thus, the structure of LRK wetlands at local and landscape levels, describing the key ecological functions and goods and services generated from these;
- Identify major developmental processes that affect the ecological structure and functions of the LRK wetland ecosystem;
- Measure the economic values of key goods and services of LRK wetland systems; and
- Evaluate key policy trade-off areas for better LRK wetland management.

Ultimately, this study attempts to address the following key research questions:

- What are the landscape level changes in the catchment areas of LRK wetland system?
- How do landscape level changes influence the economic values of LRK wetlands in terms of prawn fishing, salt production, tourism and migratory birds?
- What are the key policy trade-offs for sustainable

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The LRK supports two major primary economic production systems – salt production and prawn fisheries. LRK is responsible for the production of about 30% of the country's inland salt and is the main source of export of Ginger Prawn (Metapaeneus kutchensis)

delivery of ecosystem services from LRK wetlands, considering its PA status and landscape level linkages?

Study Area

The Little Rann of Kachchh (LRK), situated between Great Rann of Kachchh and Gulf of Kachchh, covers an area of about 3,570 sq. km. It is a unique land mass with a vast, flat topography and illustrates strong seasonal hydrological as well as biological dynamics. Actually, during monsoons, several ephemeral rivers drain their water into LRK. Hydrological catchment of LRK is spread over an area of about 11000 sq. km of Gujarat and Rajasthan. The freshwater mix with sea-water, entered from Surajbari creeks of Gulf of Kachchh. Such mixing of fresh and saline water creates a large, shallow brackish water lake. In subsequent months the water evaporates, transforming the Rann into a saline, dusty desert. Due to extreme weather conditions, the LRK is free from any permanent human settlements. In administrative terms, the entire LRK is notified under Protected Area-Wild Ass Sanctuary.

The LRK supports two major primary economic production systems - the salt production and prawn fisheries during non-overlapping seasons. While, LRK is responsible for the production of about 30% of the country's inland salt, it is the main source of export of Ginger Prawn (Metapaeneus kutchensis). Agriculture and animal husbandry are the two other major occupations in the upland areas.

Approach & Methodology

In methodological terms, the study covers four major aspects (a) understanding of ecological and economical settings of LRK's three major uses - the prawn fishery, salt production and tourism; (b) documentation of biodiversity values of LRK; (c) economic valuation of use and non-use values of LRK wetland, and (d) understanding of major drivers that are altering the key ecosystem goods and services. For the purpose, study relied on (i) review of literature, analysis of secondary data and, meetings, consultations and workshops with major stakeholder groups, and (ii) intensive primary data collection through focus group discussions (FGD) and household sample surveys. The primary surveys were undertaken mainly to ascertain the economic values of four use and non-use values of wetlands of LRK: prawn fishing, salt production, tourism and biodiversity. For the valuation of prawn fisheries and salt production we apply the market value approach, while for valuation of tourism we adopted a travel cost approach. For non-use value of biodiversity, however, contingent valuation method (CVM) was applied. Except, for salt, where secondary time series data was used for valuation purpose, other values were determined by conducting primary household surveys. All the primary surveys were completed between July 2014 and March 2015.

Prawn Production

From LRK waters 11 species of prawns/shrimp and 20 species of fish had been reported. However, one endemic prawn species – *M. kutchensis* – constitutes more than 90% of total fish/prawn biomass. Therefore, fisheries of LRK wetlands essentially relate to the ecology and economics of this species. The prawns breed in deep sea and their larvae reach LRK during monsoons through creeks and use LRK as a nursery ground. Once they grow to the juvenile stage, they start migrating back to sea water and at the time of their return journey, fishers capture them. In LRK, prawn fishing is conducted in temporary fishing settlements mostly by fisher families migrated from nearby villages and towns. During our survey, number of fisher families varied between 1300 to 2000 families.

Needless to say, there is a strong correlation between rainfall and production of *M. kutchensis* (as reflected by the total catch). However, the total average catch was about 3637 tons (over a period of 1992 to 2009 and 2013 and 2014). Prawn catch in LRK was found determined by following factors:

- Inflow of sea water, and along with it seed and larvae of *M. kutchensis* and other species;
- Inflow of rain water which brings large quantity of nutrient and detritus materials, essential food items;
- Micro-habitat heterogeneity in each fishing location due to slight topographical variations;
- Customary institutional norms to provide access to fishing grounds having different degrees of habitat quality for prawn production.

We also estimate average per family catch of about 3.38 tons and 2.86 tons for 2013 and 2014 seasons, respectively. Thus, each family generated an income of ₹1.38 lakh for 2013 season (i.e. about ₹2300/- per day over 60 days of fishing season).

Salt Production

In LRK, solar evaporation of sub-surface 'brine' is the main method used for salt production. Sub-surface brine having salt density of 9-24 0B (degree Beume) is pumped from deep wells and spread over 8-10 condensers for evaporation. From there, it moves from one condenser to another and finally reaches the crystallizer. In the crystallizer, the highly concentrated brine is allowed to settle and form salt crystals. This is the traditional method of inland salt production in LRK. In LRK, the salt production areas are actually the dry beds of the wetland. Around 10,000 families from more than 100 villages are involved in this occupation. Recently, (between 2008-09 and 2011-12) on an average 30.8 lakh tons of inland salt was produced from LRK, which had about 22% share in the total salt

Figure 1: Catchment Area of LRK

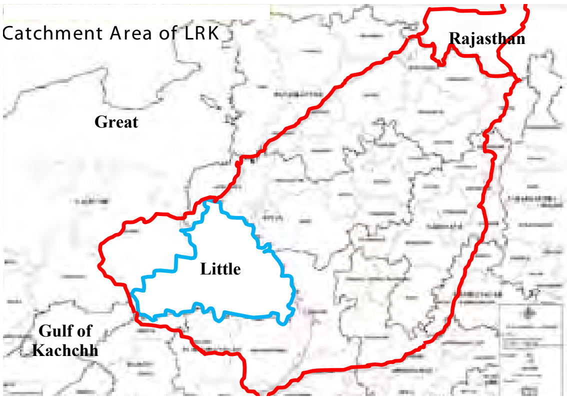


Table 1: Study Approach

Study Aspect	Data/ Information Collection Approach	Valuation Method Applied	Sample Size of Primary Surveys	Sampling Period
Bio-physical & socio-economical description of LRK	Secondary data collection, review of literature and consultations with subject experts	-	NA	NA
Description of landscape level drivers of change	Secondary data, review of literature & consultations with subject experts; Primary survey: Satellite imagery analysis of salt works; HH survey of farmers	-	91 Farmer HH	
Economic Valuation – Prawn fish	Secondary data collection; Primary survey: FGD and HH Surveys of fisher families	Market value assessment	13 FGDs 62 Fisher HH	July-Aug.'14 Sept.–Oct.'14
Economic Valuation – Salt	Secondary data collection Primary survey: FGD with Salt producers	Market value assessment	4 FGD	Jan.'15
Economic Valuation – Tourism	Secondary data collection Primary survey: Interviews of tourists	Travel cost	38 Tourist HH	Dec.'14-Jan.'15
Economic Valuation – Biodiversity	Review of literature; Primary Survey: HH Surveys of fishers, salt producers, farmers and other general public	CVM	62 Fisher HH 26 Agariya HH 91 Farmer HH 42 Urban HH	Sep.- Oct. '14 Jan. ' 15 Oct.' 14 Jan.' 15

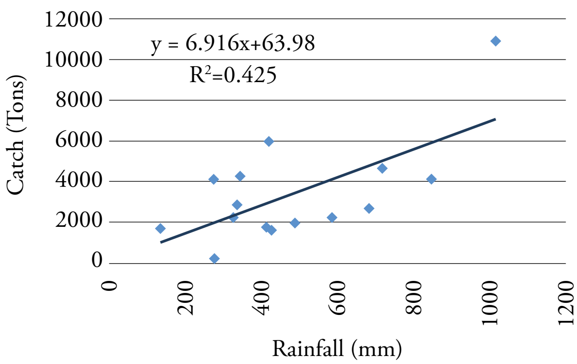
LRK is considered a unique landscape due to its marked seasonal dynamics of dry and wet phase. It is reported to have four major physiographical entities- the saline flat Rann, small islands (bets), fringe areas and tidal creeks- yet remains poorly studied and researched

production of Gujarat. However, this traditional inland salt making is loosing out in the competition with large marine salt production sectors, where large corporate houses like Tata and Reliance are engaged. Importantly, the sub-surface brine does not form due to any existing ecological or hydrological functions of LRK wetlands, rather it is highly concentrated sea water which is trapped due to thousand years of geological processes.

Biodiversity & Tourism

LRK is considered a unique landscape due to its marked seasonal dynamics of dry and wet phase. Also, the sheer size of the area (i.e. about 4,000 sq. km) with particular reference to its flatness makes it a distinctive landscape in the country. In terms of understanding biodiversity, the landscape is very poorly studied and researched. Nevertheless, it is reported to have four major physiographical entities- the saline flat Rann, small islands (bets), fringe areas and tidal creeks. These different areas support 11 vegetation types. This area also supports a rich assemblage of species - more than

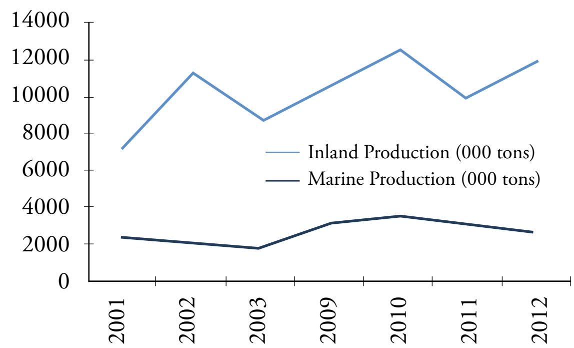
Figure 2: Relationship between rainfall and prawn catch in LRK



250 species of plants, 33 species of mammals, 180 species of birds, 29 species of herpetofauna etc. Overall, following are considered as rich and unique biodiversity values of LRK and its associated system:

- Last remaining population of about 4000 Wild Asses (Equus hemionus khur) using different habitats of LRK.
- Good network of shallow wetlands and record of large assemblage of birds – aquatic and semi-aquatic, including many rare and threatened ones

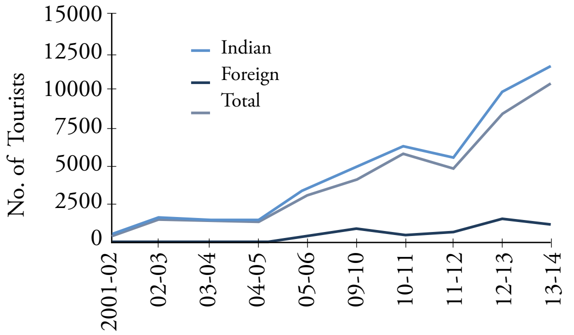
Figure 3: Inland & marine salt production in Gujarat



- Two of the total five nesting grounds of Lesser flamingos in the world
- Large congregation of cranes and other migratory bird species
- Fish and prawn diversity including endemic prawn species – *M. kutchensis*
- Unique assemblage of salt tolerant plants (halophytes) in the fringe and bet areas
- Large extent of saline grasslands mainly of *U. setulosa* and *A. lagopoides*

Ironically, most of the biodiversity values of LRK are threatened due to reasons that emerged from direct

Tourist Flow in LRK



competition for resources in spatio-temporal terms. Livestock grazing, salt production, appropriation of fresh water of catchment and creek resources etc. are some of those causes.

Due to above described wilderness and wildlife values and also presence of several sites of cultural, archaeological and religious value, the LRK attracts tourists from different parts of country as well as from abroad. Tourism activities are restricted mainly to winter season. Tourism as a sector is picking its pace, recently. In the year 2013-14 total tourist inflow to LRK was 11587 including 1185 foreigners.

Economic Valuation

Use Value – Prawn Production

In order to capture the total value of prawn fisheries of LRK (mainly the *M. kutchensis*), we covered three potential biomass off-take areas viz. the LRK water, Gulf of Kachchh water and open sea waters. So basically, we estimated prawn catch from two major sources- captured in LRK and captured of escaped animals at different landing sites. Accordingly, the total cumulative annual catch of *M. kutchensis* from different locations including within and outside LRK is at least about 6177 tons, of which about 60% is from LRK and remaining 40% is from escaped zones. *M. kutchensis* goes to the market in two forms — fresh and dry. Dry prawn is done with some fraction of total prawn only in LRK sites. Following was estimated as value of prawn fisheries:

- The Gross Market Values from prawn fisheries at LRK (consisting of fresh and dried prawns) stood at an estimated ₹746 million and ₹400 million during 2013 and 2014 respectively.
- The cost for each ton of fresh prawn catch from LRK was estimated as ₹22183 and ₹24417 for fishing seasons 2013 and 2014, respectively.
- The cost of making one ton of dry prawn in LRK area is ₹1.04 lakh and 1.20 lakh for the fishing seasons in 2013 and 2014, respectively.
- Net Market Value of *M. kutchensis* (consisting of fresh and dried) was estimated to be ₹613 million and ₹320 million, during 2013 and 2014 fishing seasons, respectively.
- Historical data (1992 – 2014), estimated an average annual catch of 3645 tons of *M. kutchensis* from LRK.
- At 2014 values of cost and price, the average net annual value of *M. kutchensis* from LRK wetland was ₹307 million.
- About 2540 tons of *M. kutchensis* is estimated caught from escape zone (outside LRK), every year. We ascribed 72% of total biomass of *M. kutchensis* caught from escape zone as contribution from wetland function of LRK.
- At current price (2014), the average gross annual value of *M. kutchensis*, which are caught outside LRK, was around ₹137 million.
- After deducting the operational cost of prawn fishing (25% of total value) in escape zone, the average net annual market value of *M. kutchensis* is ₹103 million.

Overall, LRK wetlands through its nursery ground for *M. kutchensis* by maintaining the food-chain, generate a total net annual monetary value of ₹410 millions (₹307 million directly from LRK and ₹103 million attributed to the escape zone).

Table 2: Fresh and Dry Fish Value at Market

Type	Fishing Season	Total Biomass Sold (Tons)	Gross Market Value (Million ₹)	Cost per tons (₹)	Net Market Value (Million ₹)
Fresh	2013	4474	671.10	22,183	571.9
	2014	2398	359.70	24,417	301.2
Dry	2013	325	74.68	1,03,555	41.1
	2014	174	40.05	1,20,149	19.1

The use value of biodiversity is estimated in terms of tourists' visits to LRK and their travel costs. While travel costs vary between local, national, and foreign tourists, tourists generated about ₹276 million of total use value for LRK

Use Value – Salt Production

LRK produced an average of about 30.8 lakh tons of salt every year between 2008 and 2012. In 2014 the landing site market price of salt was around ₹500 per ton (this is the price at which traders sold to industries and other bulk purchasers). At this price, the gross market value of salt production in LRK is about ₹1539 millions. However, we estimated total cost of one ton of salt production as ₹274.50. At 2014 values of cost and price, thus the average annual net value of salt production from LRK wetland was found to be approximately ₹694 millions.

Use value – Biodiversity: Tourism

The use value of biodiversity is estimated in terms of tourists' visits to LRK and their travel costs. Total costs include different fares and fuel charges, all the accommodation costs, food, entrance fee and purchase of souvenir items. In addition to the above, we also estimated opportunity cost of time (i.e. per capita household income per day corrected for the days spent in LRK). Thus, we estimated per capita travel expenses as ₹7600/-, ₹17576/- and ₹53417/- for local, national and foreign tourists, respectively. Similarly, average per capita opportunity cost of time was estimated as ₹3417, ₹3654 and ₹24493 for local, national and foreign tourists, respectively.

Finally, the above per capita costs were extrapolated to number of tourists visiting LRK in 2013-14 seasons, separately for Indians and foreigners. Thus, for the year 2013-14, tourists generated a total use value of about ₹276 millions for LRK.

Non-Use value – Biodiversity: Migratory Birds

Non-use value of biodiversity in LRK was estimated through contingent valuation method which elicits household's willingness to pay for conservation of biodiversity elements of LRK, especially the habitats of migratory birds. A total of 218 local households from different occupational groups (including farmers, fishers, salt producers, and urban dwellers) responded to the questionnaire. Accordingly, average annual per household WTP of farmers, fishers and salt makers of rural areas and other occupations from urban centers, in LRK landscape, are around ₹336/-, 226/-, 685/- and 596/-, respectively. Finally, we extrapolated these average WTP to the total households of respective occupational groups. Thus, the total annual non-use value of biodiversity in LRK comes out as ₹137 millions.

Table 3: Willingness to Pay of Households in Gujarat

Respondents	Total HH	Avg. Annual WTP (₹ per HH)	Total WTP (Million ₹)
Rural	290489	348.98	101.4
Agariya	7500	684.62	5.13
Fishers	1300	226.13	0.29
Farmers & Others	281689	336.36	94.75
Urban	54293	596.43	32.4
Overall	344782	396.65	136.8

Finally, the above described use and non-use values of LRK wetlands, estimated an annual benefit of approximately ₹1517 million. Furthermore, the Net Present Value (NPV) of these goods and services amount to be ₹24732 and ₹20483 million for 20 years period and ₹75865 and ₹37932 million for infinitum using 2% and 4% discount rate, respectively. These

Table 4: LRK Functions and Benefits

Functions & Benefits	Net Annual Value (Million ₹)	NPV (in Million Rupees)			
		20 years		Infinitum	
		2% DR	4% DR	2% DR	4% DR
Prawn Prod.	410	6685	5537	20507	10254
Salt Prod.	694	11317	9375	34715	17358
Tourism	276	4500	3727	13803	6901
Biodiversity	137	2230	1847	6840	3420
Total	1517	24732	20483	75865	37932

estimations demonstrate that the wetlands of LRK have a significant economic value which is critical for the survival of the local economy in such semi-arid regions of Gujarat.

Threats to Wetland Sustainability

The study estimated that LRK wetland had three main sources of water in different proportion and play different ecological roles. These sources include: surface runoff from catchment area (21%), rainfall that landed directly on LRK surface (52%), and saline sea water (27%). For sustainable flow of benefits these sources of water need to be maintained. While study demonstrated high economic value of LRK wetland system, providing substantial benefits to local population, it also identifies some of the major threats to sustainable flow of ecosystem goods and services. These threats include:

- Increasing freshwater appropriation in the LRK catchment – a total of 16,858 million cubic feet of total runoff is annually stored in dams and check-dams, curtailing the freshwater flow into LRK by about 48%. Such reduced water flow amounts to an estimated rise of water column by about 29 cm. Ultimately, this water could help providing additional habitats for many bird species and even could help in restoring the flamingo nests, which the birds often abandon due to lack of water.
- Degradation of fish habitat in creeks – the area under salt pans increased almost 6 times in Surajbari creek region i.e. 7,646 ha in 1977 to 44,655 ha in 2013. Local people also perceive many threats to wetland ecosystem and associated flow of benefits. Thus, it is also mapped that out of total 29,000 ha of potential area of 14 fishing grounds in Surajbari creek, about 18,250 ha area is totally lost due to salt works. In other words, about 2/3rd of total fishing grounds were lost. Also, annually 455 million cubic meter of freshwater is harvested in 11 reservoirs, curtailing their flow in the creeks.
- Once fully operational, the Narmada canal will provide irrigation water to about 5.5 lakh ha. of lands in 621 villages of LRK landscape. Such massive irrigation intervention will certainly alter the agro-ecological setting of LRK landscape.

Policy Implications

The Study identifies many important policy issues, which need to be understood and addressed for wise-use of LRK wetland system. Some of the issues include:

- Conflict between production functions (comprising prawn and salt production) and protection functions (comprising biodiversity and habitat conservation).
- Trade-off among the two major production functions (prawn and salt farming) to optimize both systems in a sustainable manner. Currently, salt work is impinging upon the prawn production system by altering habitats. Fishing population decline over the years.

LRK wetlands, by maintaining the food-chain for M. kutchensis, generate a total net annual monetary value of ₹410 million, and a net value of salt production of approximately ₹694 million

- Future trajectory of prawn production vis-à-vis changing ecosystem services as determined by hydrological flows and balance. Importance of surface run-off and tidal flows from creeks, is well established.
- Future trajectory of biodiversity values including wildlife habitats vis-à-vis changing ecosystem services. Reduced freshwater flow in LRK due to impoundments in the catchment area. Improved water depth may create additional habitats for many more species including the nesting grounds for lesser flamingoes.
- Tourism is a growing sector for LRK and there is need to optimize this with long term goals and objectives, especially in view of its heavy reliance on biodiversity values which in-turn depend upon local as well as landscape level processes.
- Engagement of local communities as a major stakeholder is possible as reflected by their WTP for biodiversity conservation. However, it is important to find ways for protecting traditional rights of fishers and salt workers without doing serious harm to ecological services.
- The Study demonstrates the importance of freshwater runoff into the LRK system as a driver of its key ecosystem services. However, competing demands mainly from agriculture sector need to be balanced. Narmada canal may provide opportunities for some trade-offs.

Key Recommendation

It is recognised that a large extent of LRK and its catchment area falls under several districts and has a mosaic of private and common resources lying either in protected area systems or open-production systems. For planning and implementation for such a large area with several streams of flow of ecosystems goods and services, there needs to be an umbrella institution – say 'LRK Landscape Authority'. The key responsibility for such an authority would be to create an over-arching framework for governance, approve sectoral plans and provide for the participation of diverse stakeholders.

The Authority would: (a) develop guidelines and frameworks for projects in the region; (b) publish status and policy reports that seek to achieve a desired result; (c) expand high-quality facilities to monitor critical indicators; (d) provide a platform for sectoral plans to be discussed and approved. Some of the sectoral plans/ policies are typically in the domains of fisheries, tourism, industry, conservation, agriculture and irrigation etc.; (e) communicate with stakeholders on a periodic basis; (f) support specific research and training programmes.

The Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP) Society, set up by the Government of Gujarat under a World Bank funded project, is ideally suited to craft a tourism policy to promote LRK, conduct regular studies, initiate discussions with stakeholders and ultimately evolve into the LRK Landscape Authority.

For planning and implementation for such an area there needs to be an umbrella institution. Such an authority would have to create an over-arching framework for governance, approve sectoral plans and provide for the participation of diverse stakeholders

1. Introduction

1.1. Background

Human well-being is dependent upon the continued flows of ecosystem goods and services which are otherwise declining steadily in most parts of the world due to pressures from competing uses. Deterioration or losses in ecosystem goods and services maybe regarded as the 'cost of degradation'. Since the allocation of differentially distributed and scarce natural resources is at the core of the problem, economic instruments, such as 'valuation' techniques are now being increasingly used to measure these costs.

Valuation – recognition and estimation of economic values of natural resources and various environmental assets, goods and services – is a useful tool to formulate and appraise natural resource-linked development projects and determine key trade-offs between economic development and ecological securities. However, valuing natural resources and associated services that are external to the market mechanism involves a number of techniques that are still evolving (Singh and Shishodiya, 2007).

The Economics of Ecosystems and Biodiversity – India Initiative (TII), launched by the Ministry of Environment, Forests and Climate Change (MoEFCC), aims to highlight the economic consequences of the loss of biological diversity and associated decline in ecosystem services. The effort is to make the hidden values of ecosystems explicit, so as to support their mainstreaming in economic development policies and programmes (TEEB, 2010). The present study seeks to contribute to TII by uncovering the values of ecosystem services and biodiversity of a wetland in the context of an arid landscape of Gujarat.

1.2. Significance of wetlands

Russi et al. (2013) summarized the significance of wetlands as follows:

- The timely availability of water in appropriate quantity and quality is a fundamental requirement for sustainable development. Water security is widely regarded as the key natural resource challenge facing humanity.
- Wetlands are crucial in maintaining the water cycle which, in turn, underpins all ecosystem services and therefore sustainable development.
- Wetlands provide vital water-related ecosystem services at different scales (e.g. clean water provision, waste water treatment, groundwater replenishment), which are critical for life and the economy.
- Wetlands provide a network of important natural and man-made infrastructure that deliver significant societal benefits like water supply, sewage treatment and energy.
- Wetlands are of importance to the livelihood and cultural identity of many diverse, indigenous peoples.

Wetlands are highly productive ecosystems, providing a number of goods and services that are of value to people. The open-access nature and the public-good characteristics of wetlands are often undervalued in decisions relating to their use and conservation. The range of services provided by wetlands is related to geophysical processes such as sediment retention and the provision of flood and storm buffering capacity.

It also provides climatologic, biological, and socio-cultural functions, including impact on local and global climate change and stabilization, preservation of biodiversity, and the provision of natural environmental amenities. In addition, wetlands provide ecological processes enabling the extraction of goods and services in the form of natural resources such as water, fish and other edible animals, wood, and energy, and they provide the natural surroundings for recreational activities (Barbier, 1991, 1997; Brouwer et al. 1999; Woodward and Wui 2001).

Wetlands are reservoirs of biodiversity. As per Zoological Survey of India, Indian wetlands harbour one-fifth of known faunal species. The floral diversity supported by these ecosystems range from unicellular algae, bryophytes, mosses and ferns to woody angiosperms. As per a conservative estimate, the number of plant species within Indian wetlands is nearly 1,200 (MoEFCC and GIZ, 2014).

Wetlands are important breeding areas for wildlife and provide a refuge for migratory birds. In many wetland areas of India, like Bharatpur Wildlife Sanctuary in Rajasthan, and Little Rann of Kachchh and coastal areas of Saurashtra in Gujarat, many migratory species of birds from western and European countries come during winter. According to certain estimates, the approximate number of species of migratory birds recorded from India is between 1200 and 1300, which is about 24% of India's total bird species (Agarwal, 2011).

Recognizing the importance of wetlands, signatories to Ramsar Convention (1971) agreed to conserve and make wise-use of these resources. The Convention identifies three major categories of wetlands – coastal-marine, freshwater inland and man-made.

1.2.1. Definition

Wetlands are areas where the water table is at or near the surface level, or the land is covered by shallow water. For the purpose of the Convention, IUCN defined wetlands as: "areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meter"'.

Defining wetlands is difficult due to the complex spatio-temporal interactions of land, water and vegetation that they exhibit. In ecological terms, wetlands are ecosystems that depend on sustained inundation/ saturation of the substrate and the presence of physical, chemical, and biological features reflective of recurrent, sustained inundation or saturation. Thus, they are mainly characterized in terms of:

- Hydric soils: soil that is saturated, flooded or ponded long enough favouring anaerobic conditions;
- Vegetation: hydrophytic, adapted to wet conditions; and
- Inundation: presence of water, permanently or seasonally.

As defined above, wetlands are found in a range of forms and positions. In general, they function as 'sink sites' in terms of soil-nutrients and hydrological processes. Specifically, they are positioned so as to respond to upstream water inputs, and to influence patterns of downstream flow (Ingram, 1991). Given these characteristics, wetlands support a large variety of plant and animal species adapted to fluctuating water levels, making the wetlands of critical ecological significance.

1.2.2. Extent

Globally and regionally, inland wetlands cover a tiny fraction of the earth's surface. However, estimates for global area of inland wetlands vary considerably — 5.3 million sq. km (Matthews and Fung, 1987), 5.6 million sq. km (Dugan, 1993), 5.7 million sq. km (Aselmann and Crutzen, 1989), 7.48-7.78 million sq. km (Ramsar Convention) and 12.8 million sq. km (Finlayson et al. 1999). Lehner and Doll (2004) reported that wetlands occupy about 6-8% of world's total land area (Table 5, Figure 4).

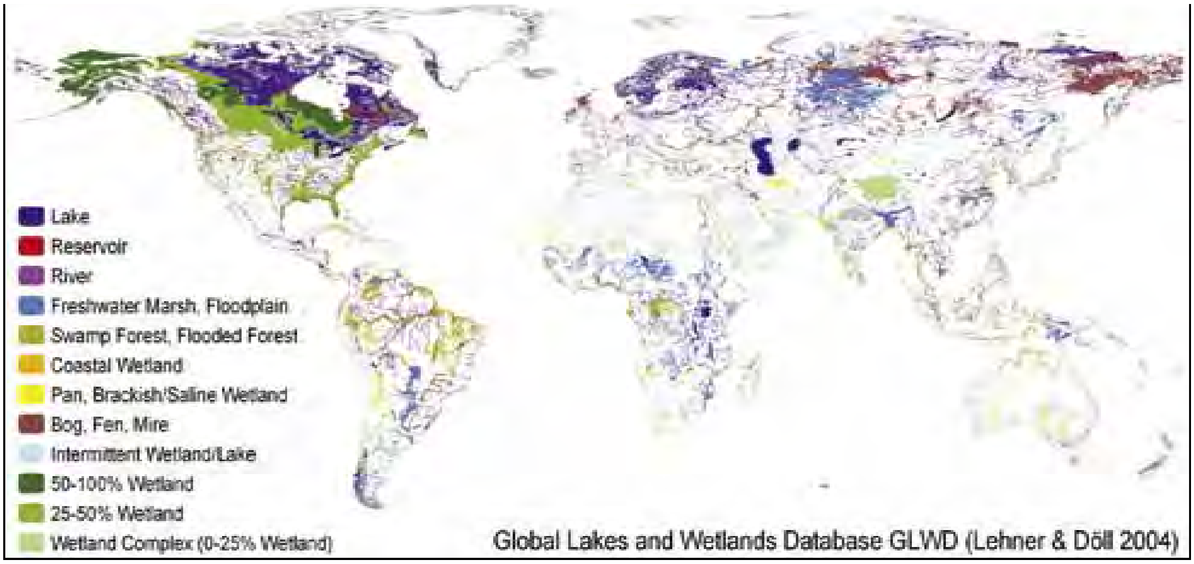
India, with its varying topography and climatic regimes, supports diverse and unique wetland habitats (Prasad et al., 2002). The first country-level survey of wetlands was undertaken in 1976 by the Department of Science and Technology (Biswas, 1976) which reported 39,045 sq. km area under 1,193 wetland units of different categories. Of these, 938 wetlands were freshwater and 134 brackish water. The second survey reported 5.83 lakh sq. km area under wetlands (excluding rivers, but including paddy fields), equivalent to 18.4% of the country area (Scott, 1989).

Table 5: Extent of different wetland types

Wetland Type	Area ('000 sq. km)	% of Total Global Land Surface*
Lake	2428	1.8
Reservoir	251	0.2
River	360	0.3
Freshwater Marsh, Flood plain	2529	1.9
Swamp forest, flooded forest	1165	0.9
Coastal wetlands (mangrove, lagoon etc)	660	0.5
Pan, brackish/Saline Wetland	435	0.3
Bog, Fen, Mire	708	0.5
Intermittent Wetland/Lake	690	0.5
50-100% wetland	882-1764	0.7-1.3
25-50% wetland	790-1580	0.6-1.2
Wetland complexes (0-25%)	0-228	0.0-0.2
Total Lakes and Reservoirs	2679	2.0
Total Other Wetland Classes	8219-10119	6.2-7.6

* *Total area (excluding Antartica and Glaciated Greenland)- 133 million sq. km*
Source: *Lehner & Doll (2004)*

Figure 4: Global distribution of different types of wetlands.



Recently, however, by using high resolution satellite imageries, under one of the most comprehensive national level exercises, SAC (2011) reported a total of about 7.57 lakh wetland units of more than 2.25 ha size covering a total extent of about 15.26 million ha (i.e. about 4.6% of the total geographical area of the country). Out of these, about 10.56 million ha area (i.e., 69% of the total area of wetlands) were under different categories of inland wetlands. Furthermore, 6.6 million ha (i.e. 62.5% of all inland wetlands) were natural, while the remaining were man-made (Table 1.2). Coastal wetlands account for 27% of all wetlands, while other wetlands (smaller than 2.25 ha) account for only 4% (SAC, 2011).

Table 6: Estimates of different types of Wetlands in India

Wetland Type	No. of Wetlands	Total Area (ha)	% of Total Area
Inland-Natural	45658	6623067	43.40
Inland-Man-made	142812	3941832	25.83
INLAND TOTAL	188470	10564899	69.23
Coastal-Natural	10204	3703971	24.27
Coastal- Man Made	2829	436145	2.86
COASTAL TOTAL	13033	4140116	27.13
Small Wetland (<2.25ha)	555557	555557	3.64
TOTAL WETLANDS	757060	15260572	100.00

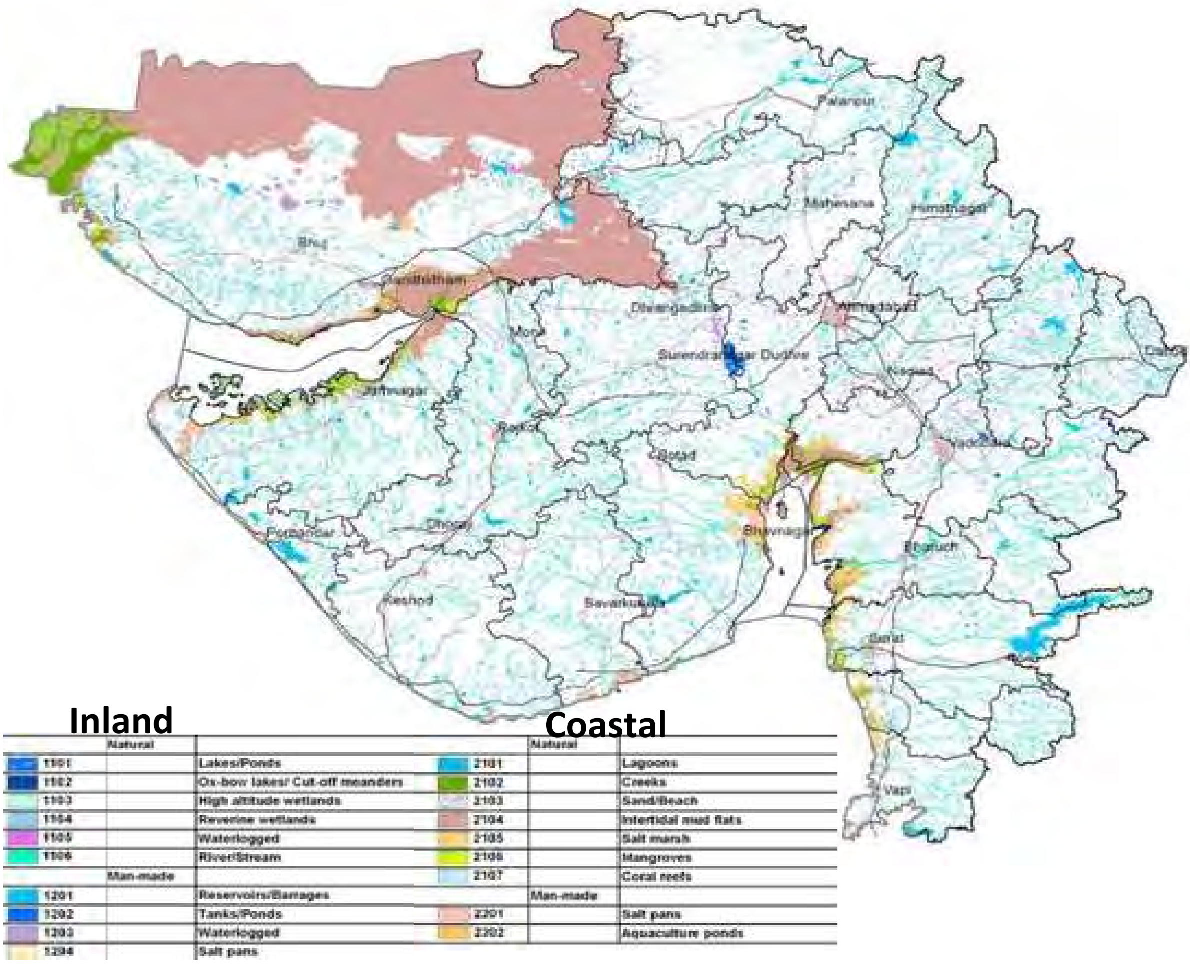
Source: *SAC (2011)*

Gujarat supports a total of 23,891 wetlands (including wetlands <2.25 ha size) covering an estimated extent of 3.47 million ha, i.e. about 17.6% of country's total. Of these, 0.65 million ha are categorized as inland (SAC, 2011). However, Gujarat also has vast areas (about 2.2 million ha) of saline depressions — the Great and Little Rann of Kachchh — which display characteristics of both coastal and inland wetlands (Figure 5).

Moreover, owing to pre-dominantly arid and semi-arid climate, most of the wetlands in Gujarat are temporary and seasonal. Nevertheless, these wetlands support large congregation of aquatic birds, particularly during winters, as the state is on their migratory route. About 19.5 lakh waterfowls and other aquatic birds were reported from these wetlands during 2008, signifying their overall conservation value (Anon, undated).

Some specific habitats like the two Ranns support very large populations of one or few species like Flamingos and Cranes. Also, many of the migratory bird species use these wetland ecosystems for important phases of their life cycle, like breeding and nesting. In addition to birds, quite a large number of wetlands in Gujarat also provide valuable grazing grounds for livestock and many other wild animal species.

Figure 5: Wetland Map of Gujarat State.



1.2.3. Threats

Ironically, wetlands are facing continuous threats from different human activities, facing shrinkage and degradation (Zedler and Kercher, 2005). Although wetland loss statistics are not precise, it is clear that a substantial portion of historical wetland area had been lost in recent decades. Some of the striking observations are given below:

- Between 1993 and 2007, inland wetlands have decreased by 6% globally (Prigent et al. 2012);
- In Asia alone, about 5,000 sq. km of wetland are lost annually to agriculture, dam construction, and other uses (McAllister, et al. 2001);
- In USA, about 260,700 ha of wetland area was lost during 1986 and 1997 (Dahl, 2000);
- In New Zealand, between 1840 and 1976 natural wetlands declined from about 1,614 sq. km to just 262 sq. km — a loss of over 90% (Finlayson and Moser, 1986);
- In China, natural inland wetland area decreased by 33% between 1978 and 2008 (Niu et al. 2012);
- In Morocco, 25% of inland wetland area was lost in 20 years in the late 20th century, with losses of some types of wetland being up to 98% (Green et al. 2002).

Some of the major causes of wetland loss and degradation are summarized by Dugan (1990) as presented in Table 1.3.

Table 7: Summary of Major Causes of Wetland Loss and Degradation

Causes	Estuaries	Open coasts	Flood Plains	Freshwater marshes	Lakes	Peat lands	Swamp forest
Drainage for agriculture, Forestry and mosquito control,	*	*	*	*	x	*	*
Dredging for navigation	*			x			
Filling for solid waste disposal, roads	*	*	*	x			
Conversion for aquaculture	*	x	x	x	x		
Construction of dykes, dams for flood control	*	*	*	*	x		
Discharge of pesticides, herbicides, nutrients from domestic sewage	*	*	*	*	*		
Mining of wetlands for peat, coal gravel, phosphate & other minerals	x	x	x		*	*	*
Ground water abstraction			x	*			
Sediment diversion by dams, deep channels	*	*	*	*			
Hydrological alterations by canals, roads and other structures	*	*	*	*	*		
Subsidence due to extraction of ground water, oil, gas and minerals	*	x	*	*			
Natural subsidence	x	x				x	x
Sea level rise	*	*					*
Drought	*	*	*	*	x	x	x
Hurricane and other storms	*	*				x	x
Erosions	*	*	*			*	
Biotic effects			*	*	*		

* *Important cause of degradation and loss; x Present, but not a major cause of loss*
Source: *Dugan (1990)*

Wetlands in India, especially those in the arid and semi-arid regions, are particularly vulnerable due to their strong seasonality. Across all categories of wetlands, the water spread area from post monsoon to the peak of summer reduces significantly indicating the uses and losses that wetlands go through. This has major implications for the total water availability of these wetlands and the various functions that they can perform in different seasons.

Overall, however, wetlands in most of the developing countries, including India, are facing threats from various proximate causes. Some of these include:

- Agricultural conversion;
- Hydrologic alteration;
- Inundation by dammed reservoirs;
- Alteration of upper watersheds;
- Degradation of water quality;
- Ground water depletion;
- Introduced species and extinction of native biota.

1.3. Need of the Study

Wetlands are an important component in the hydrological and bio-geochemical cycles because they store and recycle large amounts of water and nutrients for long periods of time. Landscape features, hydrology and land-water interactions are prime determinants for wetland ecosystem structure and function, influencing the nature of ecosystem goods and services provided.

Inland wetlands are commonly formed among depressions in the landscape, where freshwater runoff can accumulate. As an open sink, hydrological characteristics are determined by rainfall, surface run-off, groundwater conditions and, in the case of coastal wetlands, tidal movements in the connecting channels. Hydrologic factors, such as depth, duration, amplitude and timing of flooding, operate at different scales in the context of a landscape. As there are reciprocal interactions between spatial patterns and ecological processes, wetland values depend on the hydro-geomorphic location in which they situate (Turner et al., 1997, Mitsch and Gosselink, 2000).

Wetlands in arid and semi-arid areas are seasonal in nature and often water-stressed during the dry period. Biotic adaptations under such conditions are typically opportunistic, with critical life-cycle activities synchronized with the seasonal variations in hydrology. The system as a whole exhibits a production bloom at the onset of the wet period that triggers different food-chains, uniquely exploited by higher animals such as migratory birds that temporarily nest and breed in these areas.

However, availability of water during this critical wet season is often further restricted due to competing upstream demands. Landscape characteristics in the catchment areas are influenced by policies and programmes which, therefore, needs to be analysed for their impacts on the wetland, particularly in arid and semi-arid regions.

Human use of seasonal wetlands is also adapted in unique ways, often revealed through seasonal fishing and seasonal tourism. Responding to seasonal and annual fluctuations through appropriate deployment of time and resources is traditional knowledge passed down through generations of families in the same occupation, organized in India as castes. Typical caste groups in traditional livelihood professions often pose challenges in development planning, particularly where natural resources are seasonally available.

Ecologically insensitive development planning has often ignored or under-estimated the importance of either traditional use values of such wetlands or, worse still, much more intangible non-use values of various ecosystem services and biological diversity. For instance, declaring wetlands as 'Protected Areas' extinguishes traditional user rights if enforced, or else leads to open access conditions if not enforced. Such policies and development plans inevitably force a 'choice' between conservation and development, rather than explore an inclusive sustainable development pathway.

While effort is now being made to integrate the value of biodiversity and ecosystem services from wetlands into development plans for the region, it is apparent that, along with various structural changes, credible estimates for such values are a pre-requisite.

1.4. Aims and Objectives

The overall idea is to assess the value of key wetland benefits such as (a) Provisioning (e.g. fish/ prawn and salt production); (b) Supporting (biodiversity); and (c) Cultural (recreation/ tourism; education). The study seeks to identify threats to conservation as well as to provide management options for wise-use of wetlands based on quantifiable trade-offs using insights from economic valuation of ecosystem services and biodiversity.

This study focuses on the Little Rann of Kachchh (LRK) — the largest wetland system of Gujarat — to understand various ecosystem services and estimate their economic values that maybe relevant and useful in the context of improved development policy.

Some of the key research questions include:

1. What are the landscape level changes in the catchment areas of LRK wetland system?
2. How do landscape level changes influence the economic values of LRK wetlands in terms of prawn fishing, salt production, tourism and migratory birds?
3. What are the key policy trade-offs for sustainable delivery of ecosystem services from LRK wetlands, considering its PA status and landscape level linkages?

This study aims to understand the ecological-economic settings of a large, arid wetland system which will inform resource users and managers for improved

Ecologically insensitive development planning has often ignored or under-estimated the importance of either traditional use values of such wetlands or, worse still, much more intangible non-use values of various ecosystem services and biological diversity

The objectives of this study are to characterize the wetlands of LRK, identify disturbances in them, estimate the economic value of services and trade-offs associated with them, in order to propose policy and management options

conservation and management mechanisms including effective trade-off mechanism. Ultimately, the study intends to help formulate wise-use of wetland resources in LRK system.

The specific objectives of this study are to:

- Characterize the wetlands of LRK, with particular reference to hydrological and salinity regimes, and identify ecological functions that support key economic activities;
- Identify disturbances in LRK wetland system and its catchment that affect above regimes and their impact on goods and services; and
- Estimate the economic value of these services, evaluate trade-offs and propose policy and management options.

1.5. Structure of the Report

The report is organized into nine chapters, a reference and bibliography section and five annexures. A brief description of the content of each chapter follows:

Chapter 1 explains why the study has been conducted, its need in the context of wetlands in general and the specific aims and objectives for studying LRK wetlands.

Chapter 2 provides an overview of the various wetland ecosystem services and functions, methods of valuation and a meta-analysis of the various valuation studies done till date, with particular emphasis on studies in India. Methodological issues pertaining to valuation of biodiversity is also discussed.

Chapter 3 is about the landscape of LRK – its location, origin and physiography – and, from the perspective of ecosystem services, details of hydrology and socio-economic characteristics. The legal and administrative set-up is discussed, along with recent development initiatives in and around LRK, for their policy implications.

Chapter 4 provides details of the methodology used in the study. The focus is on primary surveys, where standard practices have been considered, along with their strengths and weaknesses, and adapted appropriately for the present study. Methodological issues in travel cost method and contingent valuation method have been discussed.

Chapter 5 explores various production systems in LRK — prawn fisheries, salt manufacturing and tourism. Ecological variability, and associated differences in ecosystem services have been discussed in detail, given the sparse and fragmentary knowledge of LRK ecosystem at the moment. Traditional livelihoods and linkages with modern markets help understand the relationship between ecosystem services and economic sub-systems.

Chapter 6 provides a complete overview of the biodiversity of LRK as is understood today. In addition to geographic, physiographic and habitat level diversities, specific flora and fauna of significance to LRK has been discussed. Major threats, along with current management initiatives, have been identified and prioritised.

Chapter 7 attempts to calculate and present the economic value of biodiversity and various ecosystem services. These include the use value of prawn fisheries, salt manufacturing and tourism and the non-use value of biodiversity. The valuation is conservative, but the approach is comprehensive. Gross revenues and net benefits have been calculated as annual flows from each of the values of LRK. The net present value of LRK, though of limited practical use, provides a gross estimate for comparison.

Chapter 8 evaluates the major threats to the sustainability of LRK ecosystem. Landscape level linkages in hydrology, including appropriation for other use as well as recent availability from Narmada canals, is discussed in the context of its impact on various use and non-use values of LRK. Ecological changes within the LRK are also discussed in terms of their impact on habitat for wildlife and prawn fisheries.

Wetlands are among the most productive of all ecosystems, being generally associated with an abundance of water, nutrients and sunlight. Natural variability creates conditions for high biological diversity as well. Wetlands, therefore, provide an array of benefits

Chapter 9 discusses various implications of the findings for policy and action. Opportunities for sustainable growth have been identified and recommendations have been made for integrating ecosystem services into development planning. Both short and long term benefit flows have been discussed in the context of the recommendations.

2. Valuation of Wetland Ecosystem Services

Wetlands are among the most productive of all ecosystems, being generally associated with an abundance of water, nutrients and sunlight. Natural variability of the same, both on spatial and temporal scales, creates conditions for high biological diversity as well. Wetlands, therefore, provide an array of benefits. These benefits could be grouped into three categories namely, functions, values, and attributes (Russi et al, 2013):

- Functions: e.g., ground water recharge, groundwater discharge, flood control, shoreline stabilization and erosion control, retention of nutrients, sediments and pollutants, water storage and purification, and storm protection.
- Values: e.g., water supply, fisheries, agriculture, grazing, timber production, energy resources, wildlife resources, recreation, and tourism opportunities.
- Attributes: e.g., biological diversity and cultural heritage

2.1. Wetland Ecosystem Services and Functions

Ecosystem is the complex of living organisms and the abiotic environment with which they interact at a specified location and biodiversity is the sum total of organisms including their genetic diversity and the way in which they fit together into communities and ecosystems (TEEB). According to Millennium Ecosystem Assessment (MEA 2005) 'ecosystem services are the benefits people obtain from ecosystems'. Thus, the term "ecosystem services" is intended to imply the contribution of nature to a variety of "goods and services", which could be classified under four different categories (TEEB 2010):

i. Provisioning Services — food (e.g. fish, game, fruit), water (e.g. for drinking, irrigation, cooling), raw materials (e.g. fiber, timber, fuel wood, fodder, fertilizer), genetic resources (e.g. for crop-improvement and medicinal purposes), medicinal resources (e.g. biochemical products, models and test-organisms).

ii. Regulating Services — air quality regulation, climate regulation (including carbon sequestration, influence of vegetation on rainfall, etc.), moderation of extreme events (e.g. storm protection and flood prevention), regulation of water flows (e.g. natural drainage, irrigation and drought prevention), waste treatment (especially water purification), maintenance of soil fertility (incl. soil formation), pollination.

iii. Habitat Services — maintenance of life cycles of migratory species (incl. nursery service), maintenance of genetic diversity (especially in gene pool protection).

iv. Cultural and amenity services — opportunities for recreation and tourism, spiritual experience, information for cognitive development.

2.2. Methods of Economic Valuation of Wetlands

There are different approaches to determining and presenting the value of wetlands. These include:

i. Qualitative analysis, based on qualitative information, describes values and benefits that are not easily translated into quantitative information (e.g. landscape beauty, impacts on security and wellbeing, cultural and spiritual values).

ii. Quantitative data, used to represent the state of, and the changes in, the ecosystems and the services they provide using numerical units of measurement (e.g. tons of carbon per hectare per year sequestered annually in wetlands; tons of fish produced per year). The value of ecosystems can be demonstrated using physical stock and flow indicators as well as social indicators (e.g. proportion of households benefitting from access to clean water).

iii. Geospatial mapping allows quantitative data to be linked with geographical information (e.g. which community benefits from clean water provision from a given wetland). It can also be the basis of modeling the outcomes of alternative land and water management decisions on specific wetland sites.

iv. Economic valuation gives an indication of the society's preferences that is easily understandable and communicable.

Economic "valuation" is the process of establishing a price for a good or service. Marketable goods have the great advantage that markets establish prices through the process of buying and selling. For environmental goods and services that are not exchanged in ordinary markets, a variety of different valuation approaches may be required. Barbier (1994), Gren et al. (1994) and Turner (1995) have discussed functions in relation to costs and benefits in the context of a total valuation of wetlands. Groot, Wilson and Boumans (2002) discuss the appropriate techniques for valuing different ecosystem services.

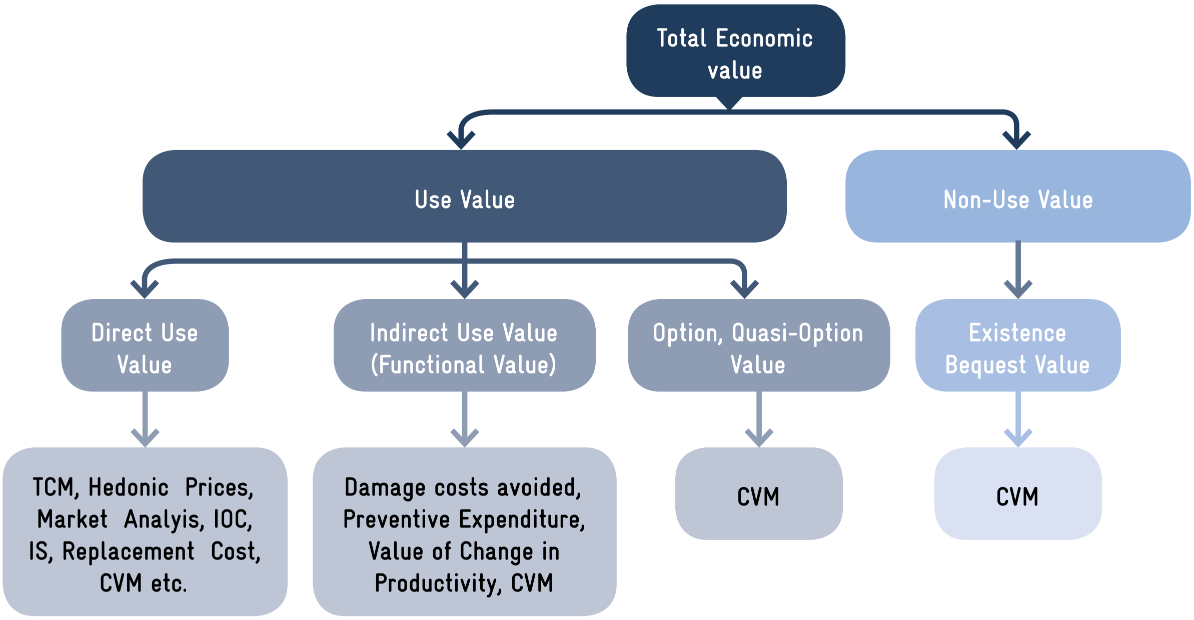
In the absence of market prices, two theoretically valid benefit estimation techniques would be hedonic pricing and the travel cost method (Turner et al 1997). However, these are based on preferences being 'revealed' through observable behaviour, and are restricted in their application to where a functioning market exists, such as that for property, in the case of hedonic pricing, or where travel to the site is a prerequisite to deriving benefit, such as with recreational visits, in the travel cost method. Contingent valuation, based on surveys that elicit 'stated preferences', has the potential to value benefits in all situations, including non-use benefits that are not associated with any observable behaviour.

Non-market valuation techniques can be further divided according to whether they measure use values (either for goods and services that are consumed or for goods and services like bird watching whose enjoyment does not involve "consumption" in the usual sense of the term) or non-use values (where there is no actual contact or encounter with the resource). The values associated with use are often revealed through the behavior of individuals, while non-use values are such that economists tend to rely more on the stated preferences of individuals, such as can be established through surveys. Though there are a few methods developed to measure economic values of a wetland, in the neoclassical economic literature four important valuation methods have been used to place money values on wetland resources. These methods are market based approach, contingent valuation method (CVM), the travel cost method (TCM), and the hedonic price method (HPM). A good review of their definitions, computation procedures, suitability for wetland evaluation, strengths and limitations is readily available (Singh, Katar and Anil Shishodia 2007). Figure 6 summarizes the general techniques available for assessing different wetland values.

Economic valuation distinguishes between use values and non-use values, the latter referring to those current or future (potential) values associated with an environmental resource which rely merely on its continued existence and are unrelated to use (Pearce and Warford, 1993). Typically, use values involve some human 'interaction' with the resources whereas non-use values do not. The framework of total economic valuation, as applied to wetlands, is illustrated in Table 8. Use values are grouped according to whether they are direct or indirect. The former refers to those uses, which are most familiar to us: harvesting of fish, collection of fuel wood and use of wetlands for recreation. Direct uses of wetlands could involve both commercial and non-commercial activities, with some of the latter activities

Economic "valuation" is the process of establishing a price for a good or service. Marketable goods have prices established through buying and selling in markets. For environmental goods and services that are not exchanged in ordinary markets, a variety of different valuation approaches may be required

Figure 6: Framework of wetland values and valuation methods



often being important for the subsistence needs of local populations depending on it.

The various regulatory ecological functions of wetlands may have important indirect use values. Their values derive from supporting or protecting economic activities that have directly measurable values. The indirect use value of an environmental function is related to the change in the value of production or consumption of the activity or property that it is protecting or supporting. However, as this contribution is un-marketed, it goes financially unrecognised and is only indirectly connected to economic activities.

In general, the value of marketed products (and services) of wetlands is easier to measure than the value of non-commercial and subsistence direct uses. As noted above, this is one reason why policy makers often

Table 8: Different values of wetland systems

Use values (in production and consumption)			Non-Use values (relating to safeguarding the existence of resources related to actual use)
Direct Use Value[1]	Indirect Use Value[2]	Option and Quasi-Option Value	Existence Value[3]
Fish	Nutrient retention	Potential future (direct and indirect) uses	Biodiversity
Agriculture	Flood control	Future value of information	Culture, heritage
Fuel wood	Storm protection		Bequest values- Value for future generations
Recreation	Groundwater recharge		
Transport	External ecosystem support		
Wildlife harvesting	Micro-climatic stabilisation		
Peat/energy	Shoreline stabilisation, etc.		

Source: *Adopted from Barbier (1994); Pearce and Moran (1994) cited in Bedamatta et al. 2012*

Table 9: Key wetland functions, values and valuation approaches

Ecological function	Economic goods and services	Value type	Commonly used valuation method
Flood and flow control	Flood protection	Indirect use	Replacement cost Market prices
Storm buffering	Storm protection	Indirect use	Replacement cost Production function
Sediment retention	Storm protection	Indirect use	Replacement cost Production function
Groundwater recharge/ discharge	Water supply	Indirect use	Production function, Net factor income, Replacement cost
Water quality maintenance/ nutrient	Improved water quality	Indirect use	CVM
	Waste disposal	Direct use	Replacement cost
Habitat and nursery for plant and animal species	Commercial fishing and hunting	Direct use	Market prices, Net factor income
	Recreational fishing and hunting	Direct use	TCM, CVM
	Harvesting of natural materials	Direct use	Market prices
	Energy resources	Direct use	Market prices
Biological diversity	Appreciation of species existence	Non use	CVM
Micro-climate stabilization	Climate stabilization	Indirect use	Production function
Carbon sequestration	Reduced global warming	Indirect use	Replacement cost
Natural environment	Amenity	Direct use	Hedonic pricing, CVM
	Recreational activities	Direct use	CVM, TCM
	Appreciation of uniqueness to culture/ heritage	Non use	CVM

Source: *Brander et al. 2005*

fail to consider these non-marketed subsistence and informal uses of wetlands in many development decisions.

Brander et al. described different sets of ecosystem functions, goods and services of wetland systems and also appropriate valuation tools (Table 9).

2.3. Studies on Economic Valuation of Wetlands

Although economic valuation of wetlands is being done since the ‘70s, the bulk of the literature is from the ‘90s, a period that saw the gradual build up of a global database (Table 10).

2.4. Meta-Analyses of Valuation of Ecosystem Services

Through a meta-analysis of 66 values estimated for regulating services of wetlands, Brander (2010), concluded that:

Table 10: Global publications on economic valuation of wetlands

Authors	Year	Valuation Method	Measurement units
Bateman et al.	1992	CVM	UK £ per person per year
Bateman et al.	1995	CVM	UK £/ pa
Bergstrom et al.	1990	CVM	US $ per user
Bergstrom et al.	1990	CVM and TCA	US $ per annum
Broadhead et al.	1998	CVM	FF/ha/year
Brouwer and Slangen	1998	CVM	Dutch Guilders per year
Copper and Loomis	1993	TCA	US $ per acre- foot additional water supply
Copper	1995	TCA	US $ per hunter day and total for kesterson
Cordell	1993	CVM	US $ per Individual (>=12 year old) for access to TVA reservoirs per yr
Costanza et al.	1989	MV	US $ per acre per year
Costanza et al.	1989	Production function, revenue accounting, TC & WTP	US $
Dalecki et al.	1993	CVM	US $/ person/ yr
de Groot,	1992		Converted to US $ 2003
Emorton and Kekulandala	2003	CVM, TCM Market approach, Damage cost avoidance and Hedonic method	Million Indian ₹ per year
Foster et al.	1998	MV	UK£ Per mailing UK£
Gren	1993	RC	SEK millions (1US$=SEK 5.8) SEK/kg N
Gupta and Foster	1975	DC	US $ per acre
Heimlich	1994	RC	US $ per acre
Klein and Bateman	1996	CVM	UK £ / HH /year or per visit; UK £ per party per annum

Result	Country
Use values: 78-105; non-use values of local population: 14.7, non-use values of the rest of UK: 4.8	UK
-	UK
360	USA
Estimated aggregate wetland protection related expenditures: $118 million; Aggregate consumer's surplus: $27 million	World wide
Mean WTA for programme 1,373 FF/ha	France
WTP: south Holland/ Friesland / Limburg/ total: 131.4/ 113.6/ 64.5/ 124.5	The Netherland
0.93-20.40 (OLS), 0.64-14.05 (Poisson)	USA
55.41	USA
41.70-75.05	USA
• Present value of the marginal product of an acre of wetland through production of five commercial fishing products) is reported at 3% DR: 845 • Estimated value of annual average product of an acre of marsh and open water area.	USA
Commercial fishing, trapping, recreation, and storm protection: $ 194 per annum/ acre. NPV: $ 24,29 - $ 89,77 D.R: 8%	USA
• Individual median WTP estimate for wetland preservation of the first wave : 24.4 & 6.54	USA
Total Economic value of the Dutch Wadden Sea is 2,329,614,000	The Nether- lands
Total economic value of Muthurajawela Marsh, Sri Lanka: 726.49	Sri Lanka
• Mean donation per mailing to raise fund for the land purchase of maritime health habitat on Ramsey Island. Average donation: £ 1.73 • Total value of donation for the protection of reed bed habitat for bittern in 1993 £ 268,430	UK
• Total cost of restoring wetlands that reduce the load of nitrogen by 1194 tons. Cost reduction through restoring wetlands: 49	Sweden
• Value represents average benefits from flood control per year acres :10	Jordan
• Value is the high estimate of the marginal costs of 5 million acre of wetland reserve: 1184 • Value is the high estimate of the total average cost (in US$/acre)that minimizes reserve costs for wetland reserve of 1 million acres: 286	USA
• WTP fee (incl. zero-birds, in UK £) 1.58; WDP fee (excl): 2.22. • WTP tax (incl.) 48.15, WDP tax (excl.) 62.08	UK

Contd...

Authors	Year	Valuation Method	Measurement units	
Kooten	1993	OM	US$ per acre per year	
Kosz	1996	CVM	Austrian schillings 1993/pa	
Kirkland	1988	CVM	2003 US $ converted	
Kuriyamma	1998	Choice Experiment Method	Yen/Year/HH	
Loomis and Larson	1994	CVM	US $	
Mannesto and Loomis	1991	CVM	US $	
Miyata and Abe	1994	HP	Yen per sq. km CM and unit area	
Roberts and Leitch	1997	CVM	US $ per year per acre	
Schuijt and Jansen	1999	-	US $	
Seild and Moraes	2000	-	US$	
Steever et al.	1998	CVM	Aus $/ person/year for 5 years	
Stevens et al.	1995	CVM	US $ per Respondent	
Thibodeau and Ostro	1981	CVM	US$ 2003 converted	
Verma et al.	2000	Hedonic Pricing, CVM	Indian Rupees	
Whitehead	1990	CVM	US $/person/year	
Whitehead	1991	CVM	US $/person/year	
Wills	1990	CVM	UK £/ha	

Source: *Adapted from Turner et al. 2008*

Result	Country
• Marginal value of waterfowl habitat as cropland. Government subsidy of $ 4.50 per bushel of grain and an average yield of 30 bushels/ acre were assumed: 37.97	USA
2a) 919.80; 2b) 329.25;	
3a) 694.9; 3b)122.21;	
4a) 689.85; 4b)69.63	Austria
• Economic value of Whangamarino wetland, North Island such as Non-use preservation, Recreation, Commercial fishing and Flood control: 9,881392	New Zealand
• Average WTP is 16,414 Yen/Year/ Household and the aggregate WTP is 36 Billion Yen/Year; when all the land around the wetland is protected for the ecosystem	Japan
WTP-$ 18 per household	World wide
1a) 69.80; 1b) 37.12; 1c) 37.85; 2a) 59.27; 2b) 39.47; 2c) 33.14 25% increase or 50% increase of total delta wetlands	USA
Total annual average cost of flood control for Chitose river (in million yen) : 84052.4/300.5 The corresponding total cost is estimated as 310.4 billion yen and the total estimated benefit computed from the land price variations is 84 billion yen.	Japan
Flood control total: $ 440; Water supply Conservation: $ 94; WTP regarding fish/ wildlife habitat recreation and aesthetics: 1. $7 2. $8 3. $6	USA
Lake Chilwa Wetland total economic value per year converted to 2002 US$ 21,056.392	Malawi
Total economic values 15,644.09 million (1994 US$) per year	Brazil
• Value represents median WTP for the pooled sample. Value from the pooled sample those respondents who did not express WTP: 100. • Value represent aggregate value for wetlands in new south Wales Australia • Assuming a WTP per household or AUS$ 17.10 and 2.23 million households in the state:38	Australia
• Value in the high and estimate of respondent yearly WTP to protect New England wetlands that provide food protection, water supply and pollution control; 80.41; • Value is the low and estimated of respondents yearly WDP to protect New England wetlands that provide flood protection. Water supply and pollution control:73.89	USA
Economic value of the Charles River Basin wetlands is 95,487,051	Massa- chusetts, US
Recreational value of Bhoj wetland is ₹4, 84, 68, 956 (as voluntary payment) and ₹59, 32, 922 (as Compulsory tax)	India
Value measures mean WTP for wetland preservation estimated from log-linear from of model: 6.31	USA
A. Value is the average WTP per person/year in the general sample for the preservation of the clear creek wetland area assuming 15% of the general population belongs to an environmental interest group : 4.12 b. value is the average WTP per person/year in the environmental	USA
Interest group for the preservation of the current state of the clear creek wetland area: 42.83 a. Total use value: 44 b. Total non-use value: 807	UK

- Values (per unit of area) are lower in larger wetlands;
- Ecosystem service values are lower in areas with abundant wetlands;
- Ecosystem service values are higher in areas with more people; and
- Ecosystem service values increase with rising incomes.

Similarly, de Groot et al (2012) presented various estimates of wetlands from different east and south-east Asian countries (Table 11 and 12).

de Groot et al (2012) made the following conclusions:

a. The positive effect of the income variable (GDP per capita) indicates that most wetland ecosystem services have higher values in countries with higher incomes. This indicates that the demand for wetland ecosystem services increases with income; in other words (most) wetland ecosystem services are not 'inferior goods' for which demand falls as incomes rise.

b. The positive effect of population on the value of wetland ecosystem services reflects the market size or demand for ecosystem services. A larger population in the vicinity of a wetland means that more people benefit from the ecosystem services that it provides.

c. The positive effect of the area of lakes and rivers in the vicinity of a wetland indicates that lakes and rivers are complementary to wetland ecosystem services, i.e., the combination of surface water-bodies results in higher value for ecosystem services. The negative effect of the total area of other wetland sites in the vicinity of the study site indicates substitution effects between wetlands. The ecosystem services from a specific wetland will be of higher value if there are fewer wetlands in the vicinity.

Another study (Brander and Schuyt, 2004), based on a sample of 89 case-studies, shows that recreational opportunities and amenities, flood control and storm buffering are the highest valued wetland services (Table 13).

Brander et al. (2005) reviewed wetlands values from 190 studies, in order to present a more comprehensive meta-analysis. To enable comparison, these values were standardized to 1995 US dollars per hectare per year. The following emerged from this analysis:

- The average annual value of wetlands is just over US $ 2,800 per hectare. The median value, however, is 150 US $/ ha/ yr, showing that the distribution of values is skewed with a long tail of low values.
- The average wetland values are highest in Europe, followed by North America, Australasia, Africa, Asia, and finally South America.
- It also shows that the un-vegetated wetland type sediment has the highest average value of just over 9,000 US$ /ha/yr. Mangroves have the lowest average value of just over 400 US$ ha/ yr.
- The biodiversity service of wetlands has the highest average value 17,000 US$ ha/ yr and the use of wetlands for collecting fuel wood and other raw materials has the lowest values 73 and 300 US$/ ha/ yr respectively.

Table 11: Summary of different values of wetlands in S-E Asia

Parameters	South Asia	Korea region	South East Asia	China	Indonesia	Japan
Area (Million ha)	2	0.32	7	8	17	0.10
Total Value (Million US$/year)	2252	231	2061	1338	896	193
Value (US$/ha/year)	1126	722	295	168	53	1930

Source: *de Groot et al., 2012*

Table 12: Summary of different values of coastal and inland wetland

Wetland Type	Estimated numbers	Total of mean values (TEV)	Total of St. Dev. of means	Total of median values	Total of minimum values	Total of maximum values
Coastal	139	193845	384192	12163	300	887828
Inland	168	25682	36585	16534	3018	104924

Source: *de Groot et al., 2012*

Table 13: Median wetland economic values by functions (US$ per hectare per year, 2000)

	Flood Control	Recreational Fishing	Amenity/ Recreation	Biodiversity	Habitat Nursery	Water Supply
Value	464	374	492	214	201	45

Source: *Brander and Schuyt, 2004*

- The coefficient on the GDP per capita variable is positive and highly significant which shows that a 10% increase in GDP per capita, results in roughly a 12% increase in wetland value.

2.4.1. Ecosystem Service Values of Indian Wetlands

The total value of ecosystem services from wetlands in India is estimated to be ₹665 billion ($14 billion) annually, and the average is ₹38,000 ($800) per hectare (Mani, 2014). Although many of the sites have a per hectare value greater than that, the largest sites have much lower values.

India has, according to a very conservative figure, around 13.1 million ha of wetlands, including inland, coastal, mangroves and rivers. Total intangible service values of these ecosystems, using the global average as reported by Costanza et al. (1997), would be around ₹7,151.08 billion per year. Including the ecosystem service values of the 55.1 million ha of paddy fields in the country, the total values go up to ₹14,396.80 billion per year. In other words, if we just protect and maintain the country's wetlands as they are today, we get indirect services/ benefits worth ₹14,396.80 billion. It is to be noted that this is much higher than the annual receipt shown in the national budget (₹5,639.91 billion) for 2007 - 2008.

2.5. Valuation of Biodiversity – Methods and Key Issues

People from the poorest nations are mostly dependent on biodiversity; such as direct reliance on natural resources for food, fuel, natural medicines etc. Hence a better understanding of the role of biodiversity is fundamental for securing the livelihoods and well-being of people in developing countries. For example, while the value of forest services such as fresh water, soil nutrients, and non-timber forest products was only around 7% of national GDP, it amounted to some 57% of the livelihood incomes of India's rural poor.

Economic valuation of biodiversity is important since it provides a useful channel to highlight and quantify the range of benefits provided by biodiversity. Placing monetary values on biodiversity and its ecosystem services allows biodiversity benefits to be directly compared with other development scenarios. Ecosystems require a minimum quality (e.g. abundance and diversity of species) to maintain the ecosystem functioning that allows for many important ecosystem functions. Below critical thresholds levels, uncertainty and irreversibility define the functioning of ecosystems. Also the restoration of such ecosystems is likely to be very difficult and costly.

Missing markets, Imperfect markets and Market failures are important points in evaluating the role of biodiversity in economic valuation. Also, uncertainty involving demand and supply of natural resources is likely in the future to affect the sustainability and choice of development alternatives. Loss of biodiversity will result in loss of functioning, and consequently, loss or degradation of these ecosystem services.

The travel cost method is widely used to value amenities as recreational opportunities through expenditures incurred on visits to particular areas. In other words, approximate economic value of biodiversity of any given area is reflected in the "travel cost" incurred by tourists to visit the area. Bergstrom et al (1990) employed travel cost method to estimate recreational value of wetlands and found that aggregate estimated value were at approximately $118 million and aggregate consumer's surplus at approximately $27 million annually. Similarly, Costanza et al (1989) followed travel cost approach to know the recreation value of coastal wetlands (Louisiana) and found that recreational value was $194 annual/ acre.

Woodward and Wui (2001) summarized various economic tools to value different biomass and biodiversity related functions of wetlands (Table 14).

For economic valuation, biodiversity and ecosystems are considered as part of natural capital and the flow of ecosystem services is the interest on that capital that society receives (Costanza and Daly, 1992). Costanza et al. (1997) estimated that wetlands are 75% more valuable than lakes and rivers, 15 times more valuable than forests, and 64 times more valuable than grasslands and rangelands. In 1997, the global value of ecosystem services was estimated to average $33 trillion/ yr in 1995 $US ($46 trillion/yr in 2007 $US). Costanza

Table 14: Key biodiversity related functions of wetland and their valuation approaches

Function	Economically valuable goods and service	Technique used to quantify value of the service
Habitat for aquatic species	Improvements in commercial and/or recreational fisheries either on or offsite. Nonuse appreciation of the species (habitat)	Net factor income, replacement cost, travel cost or contingent valuation
Habitat for terrestrial and avian species	Recreational observation and hunting of wildlife (bird watch & bird hunt). Nonuse appreciation of the species (habitat)	Travel cost or contingent valuation
Biomass production and export (both plant & animal)	Production of valuable food and fiber for harvest	Net factor income

Source: *Woodward and Wui (2001)*

et al. 2014 updated estimate based on updated unit ecosystem service values and land use change estimates between 1997 and 2011. Using the same methods as in 1997, the estimate of the total global ecosystem services in 2011 was $ 125 trillion/yr (Table 15). The result indicates that the value of wetlands increased by US$ 119770/ha/yr during the period of 1997 and 2011.

3. Study Area

3.1. Location

The Little Rann of Kachchh (LRK) is situated between 22O55' N to 24O35"N latitude and 70O30' to 71O45'E longitude and covers about 3,570 sq. km area (Parmar et al. 2014).The north-western part of LRK is linked to the Great Rann of Kachchh (GRK) while its south western corner is connected with the Gulf of Kachchh (GoK) (Figure 7).

Table 15: Global estimated unit values of ecosystems

Ecosystem	Unit value (1997) $/ ha/ yr	Unit value (2011) $/ ha/ yr	% Change 2011-1997
Estuaries	31509	28916	-2593
Wetlands	20404	140174	119770
Lakes/rivers	11727	12512	785
Forest	1328	3800	2462
Grassland	321	4166	3845

Source: *Costanza et al. 2014*

The climate of the LRK landscape is of tropical monsoonal type (the Tropic of Cancer passes right through the LRK), but is characterized by very high variations in rainfall. The mean annual rainfall varies between 325 mm in Rapar taluka in west to 533 mm in Dhrangadra taluka in south east. The evaporation rate in the region is considered to be one of the highest in the country. The area is prone to natural disasters like droughts, cyclones and earthquakes.

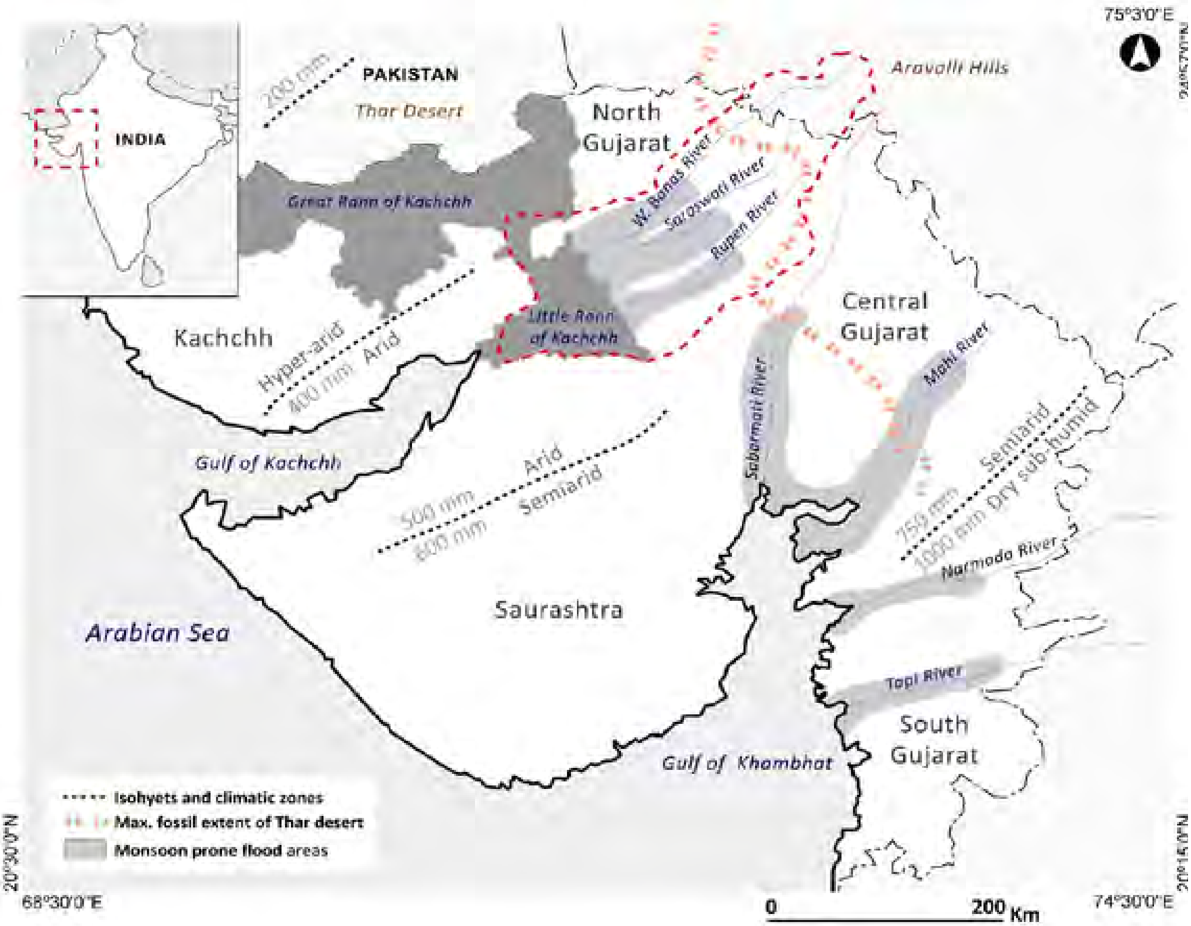
3.2. Origin of LRK

The Ranns represent the uplifted floor of a former sea that existed around 2,000 years ago. The navigator's guide from the 1st century BC, 'Periplus of the Erythrean Sea', was translated from Greek by McCrindle (1879). His use of the term Eirinon Sea appears to be close to the Vedic description of Irina. He provides an eyewitness account of the northwest coast of India, as it existed some two thousand years ago, and mentions seven islands amidst the shallow sea area of present day Ranns. It describes both the Great and the Little Ranns, their seasonal dry and wet cycles and even notes the presence of wild ass.

Iyenger et al. (2008), Bisht (1989) and Agarwala (1953) suggested that in the ancient Vedic times the Rann of Kachchh (including both GRK and LRK) was known as Irina. Iyengar and Radhakrishna (2007) also propose that in the Rigvedic times Irina was located slightly north of the present day Ranns.

Historians aver that during the invasion of Alexander the Great (i.e. 325 BC) the Rann was a large navigable lake. Sivewright (1907) carried out engineering surveys of the Kachchh region and

Figure 7: Landscape level setting of the Little Rann of Kachchh, along with the catchment area of major river courses draining into it (dotted boundary). (Adopted from Conessa et al. 2014).

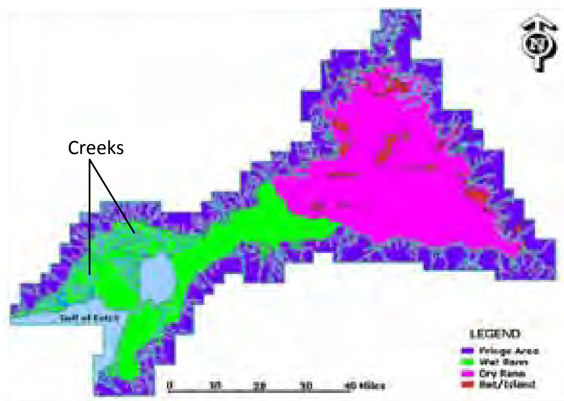


constructed a map showing the probable shoreline two thousand years before present. He felt that the present 100 feet (i.e. 33 m) contour on land could be treated as the shoreline around 100 BC. Accordingly, the northern shores almost coincided with the 25th parallel, supporting the view that the Rann was navigable during Alexander's time. Remnants of a port structure from the 13th century in Zhinjuwada village inside the present-day LRK lends further credence to the navigability of the Ranns, or at least parts of it, in the historical past.

While the contiguity of the present day LRK with the sea was well established among early geologists (Frere 1870), some believed it was actually a delta of rivers like Indus, rather than an uplifted sea-floor, given the monotonous ground character of the Ranns (Wynne 1872).

Recent geological studies provide a much clearer understanding of the origin of the Ranns. Merh and Malik (1996) state that both the Great and the Little

Figure 8: Key geo-morphological regions of LRK



Rann were parts of the Arabian Sea during the Mesozoic period i.e. 248 to 65 million years ago. During the last Holocene transgression, when the sea-level was high, the present day location of the LRK was an extension of

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the Gulf of Kachchh.

Gradual recession of the sea changed the area to an estuary. Malik (1999), like Wynne (1872), believed that a few thousand years ago, the area was a delta complex, where water and sediments from a number of Himalayan Rivers like the Indus, Sarasvati and Shatadru (Proto-Sutluj) drained.

It is now understood that tectonic activities from post tertiary to recent periods have resulted in the upliftment of the basin and diversion of river courses, such as those of the Indus and the Saraswati, with simultaneous increase in aridity of the region. The vast deposition of water and sediments have now given way to only a few smaller ephemeral rivers and streams that currently drain into the LRK.

3.3. Physiography of LRK

LRK is a unique land mass with vast, flat topography and seasonal dynamics, a result of evolutionary changes over an intricate interplay of tectonic activities, oceanic dynamics, hydrologic regimes and climate change.

Gupta and Ansari (2012) identified four key geomorphic regions, based on geomorphic and ecological feature: (a) low-lying saline dry Rann, covering the eastern and central parts of LRK;(b) wet Rann, including creeks and coastal alluvial wet plains in the western parts; (c) bets or islands; and (d) fringe area of ephemeral rivers that flow NE-SW towards the LRK and their watersheds (Figure 8).

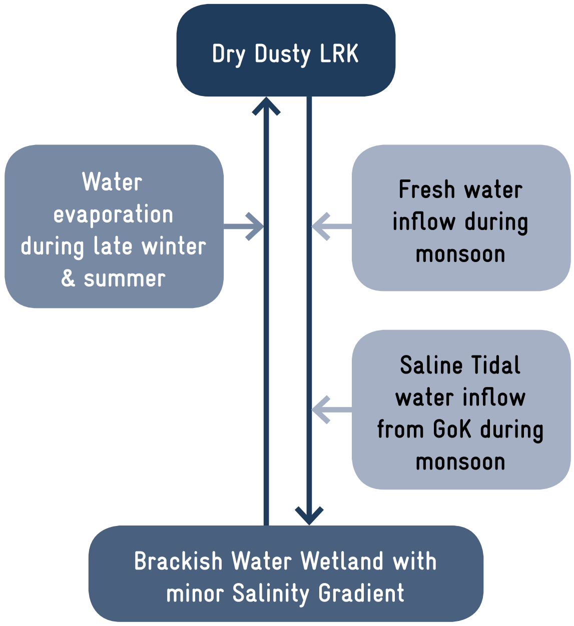
3.3.1. The Rann

It is a unique saline desert landmass of about 3,384 sq. km area. The Rann is unique in the sense that it has characteristics of both deserts and wetlands. It is a low lying area with altitude varying between 1–9 m above mean sea level.

During the monsoon, several ephemeral rivers drain their water into the Rann, which then functions as a hydrological 'sink'. Almost at the same time, saline sea-water from the Gulf of Kachchh enters the south-western part of the Rann through the Hadakiya and Chhachh Creeks (commonly known as Surajbari creek). Seasonal inflow of water transforms the Rann into a large shallow wetland (Figure 9). Further, mixing of saline seawater and fresh rainwater create brackish conditions, with a gradient in salinity.

In subsequent warmer months, however, the floodwaters evaporate, transforming the Rann gradually into a saline, dusty desert. Excessive salinity and long dry spells create conditions inhospitable for most life forms during the greater part of the year. It is, therefore, free from any permanent human settlements, providing high wilderness value.

Figure 9: Seasonal dynamics of LRK



LRK is a unique land mass with vast, flat topography and seasonal dynamics, a result of evolutionary changes over an intricate interplay of tectonic activities, oceanic dynamics, hydrologic regimes and climate change

Rann, bets, creeks, and rivers comprise four different geomorphic areas within the LRK. Each region faces unique conservation challenges, stemming from both man-made and natural alterations over time

3.3.2. The Bets

Bets are slightly higher grounds (or islands) interspersed in the vast matrix of Rann. There are about 70 bets in LRK, the size of which varies from about 5 to 3,000 ha and cumulatively extends to a total area of about 185 sq. km. The altitude of bets varies between 25 and 55 meters asl. Edaphically, bets are of two types – with rocky outcrops, like in Jilandhar and Mardak bets, or sandy deposits.

While Nanda is the only bet with permanent human habitation, human presence is substantial also in Wasraj Solanki bet due to the presence of a temple. Jhilander bet on the other hand is covered under special grazing rights for local people of Zhinjuwada village.

These raised lands are low in salinity compared to the surrounding Rann and support good vegetation cover including grasslands and thorny-scrubs. Better green cover and availability of forage materials attract many wild animal species to the bets. The bets provide critical breeding habitat for highly threatened wild ass during the monsoon. They also offer good denning sites for many carnivores like wolf, striped hyena and Indian fox. Houbara bustard is considered as a flagship species for these bets.

Being islands of higher productivity within the LRK and their significance to wildlife conservation, bets occupy central focus in the biodiversity conservation of the landscape. Many of the centrally located bets like Pung, Dhut, Mardak, Khijadiya etc. effectively function as important breeding areas for many wild species in the LRK landscape.

Conservation of wildlife on the bets is, however, challenged by excessive grazing by local livestock and migratory pastoral herds from Kachchh and Rajasthan. Also, invasion of Prosopis juliflora in the bets significantly downgrade the quality of habitats of many floral and faunal species.

3.3.3. The Creeks

This region, exposed to diurnal tidal activities, forms a transitional zone between the Gulf of Kachchh (GoK) and the LRK. There are five major creeks that connect GoK with LRK, viz. Kandla, Nakti, Hansthal, Chhachh and Hadakiya creeks. Of these, Hadakiya and Chhachh are directly linked with LRK. The total length of the creek channels in the area is around 40 km. Collectively the area connecting LRK to the GoK is commonly known as the Surajbari creek (Figure 10).

While the western parts of LRK is regularly kept wet by the daily tidal waters, the creeks within the LRK receives seawater for a short period during the south-west monsoons (when it also receives freshwater inflows from ephemeral rivers).The creek area receives negligible freshwater inflow during the dry season. Hence, evaporation exceeds precipitation leading to salinities higher than that of typical seawater (35–36 ppt).

There have been major alterations in the creek systems over the past 50-60 years, both natural as well as man-made. Presently, there are extensive salt pans along both the banks of Surajbari creek.

3.3.4. Rivers and Watershed Areas

The fringe areas effectively form transitional zones between slightly elevated mainland and the saline desert area of Rann. Due to the 'edge' effects, fringe areas are quite diverse in vegetation and include long stretches of short, saline grasslands and dense thickets of Prosopis juiflora. The dense thickets of Prosopis juliflora provide ideal shelter ground for wolf, jackal, blue bull and even the wild ass. The ground layer, dominated by saline-tolerant grass and herbaceous species like Aeluropus lagopoides, Suaeda fruticosa, Cressa cretica, Scirpus littoralis etc. provide high forage value for large number of wild herbivores including the wild asses.

In wildlife conservation context, the fringe areas function like a 'buffer' area for the LRK. Most importantly, fringe areas are part of 12 'macro-watershed' areas of ephemeral rivers like Banas, Rupen, Brahmani, Kankavati, Phulku etc. that drain into the Rann. The draining of water is important in maintaining hydrological and nutrient dynamics of the Rann and thus supports rich aquatic faunal diversity of prawn, fish and birds. The fringe areas also possess many important seasonal water bodies that support large number of waterfowls. However, this ecologically important zone is threatened by intense grazing pressure from the local and migratory pastoral herds and invasion of Prosopis juliflora.

The natural resources of fringe areas are vital for overall biodiversity conservation of the landscape. Also, being located between Rann desert and village areas, the resources of fringe areas have central roles for the dependent rural communities.

3.4. Hydrology of LRK

The net inflow of water into a wetland is positive due to a constant inflow of groundwater or surface-water within the same or from an adjacent river basin. Large wetlands, particularly in arid and semi-arid regions, are also dependent upon the amount and frequency of precipitation. In such regions, wetlands are usually 'wet' due to the presence of an impermeable layer in the soil, such as a heavy clay soil or an iron pan which prevents water from leaving the wetland basin.

The LRK ecosystem is grossly characterised by its seasonal patterns of inundation and drying. Several ephemeral rivers, like the Machhu, Godadhoroi, Brahmani, Kankavati, Umai Chandrabhaga, , Fulku etc. from the south; the Rupen and Saraswati from the east; and Banas from the northeast, drain monsoonal waters into the Rann (Figure 11), which is spread over a large area due to its nearly flat topography. Gupta and Ansari (2012) reported that the three rivers, Banas, Rupen, and Saraswati, alone carry annually 140 million cubic meter (MCM) water to the LRK.

It is imperative to recognize the fact that the flow of freshwater monsoonal runoff is the main driver which actually facilitates various ecosystem functions and from there generates many important goods and services. The water catchment of LRK is spread in 35 talukas of 7 districts and covers an area of about 10,500 sq. km. In addition to that, some parts of Banas River in Rajasthan side also form the catchment area of LRK (Figure 12).

Conesa et al (2014) examined the spatial monsoonal inundation pattern of LRK using satellite imageries. They explained that the "mean elevation of LRK surface is about 6 masl, which gradually decreases to 2-m towards the south-western part (Maurya et al, 2009). This gentle, regional slope drives the monsoonal spill and the post-monsoonal run-off from the coastal alluvial fans to the ocean". In subsequent weeks and months LRK progressively dries up from many relatively higher areas and water remain only in some deeper areas and channels. Ironically, however, despite the key roles these large scale hydrological processes play

Figure 10: Network of Surajbari creeks. There are marked changes in the overall physiography of creek system as reflected from Toposheets of 1953 (left) and recent satellite imagery (right). The large whiter area near Kandla port in 1953 is not seen in recent imagery. Also, the Chachh creek was seen much shorter in 1953. Overall many alterations are visible in the orientation and length of creeks.

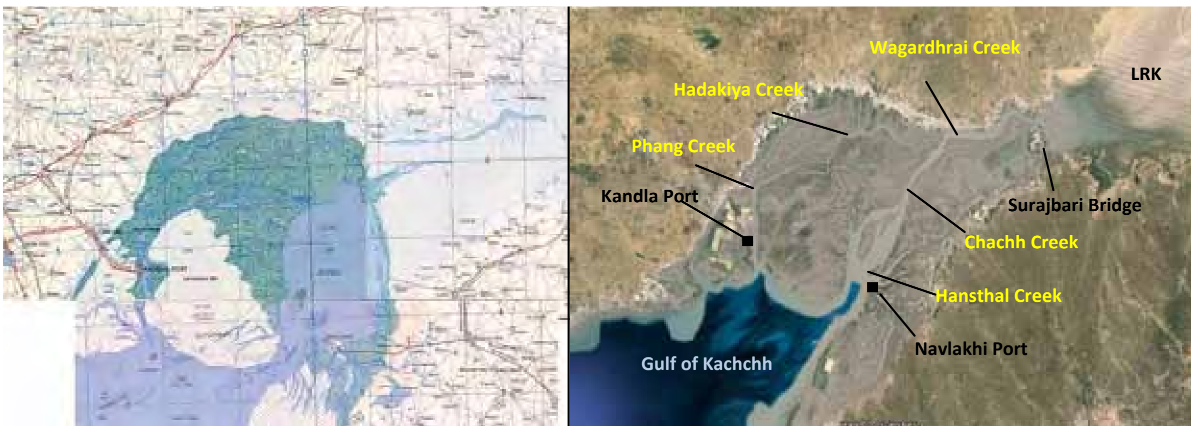
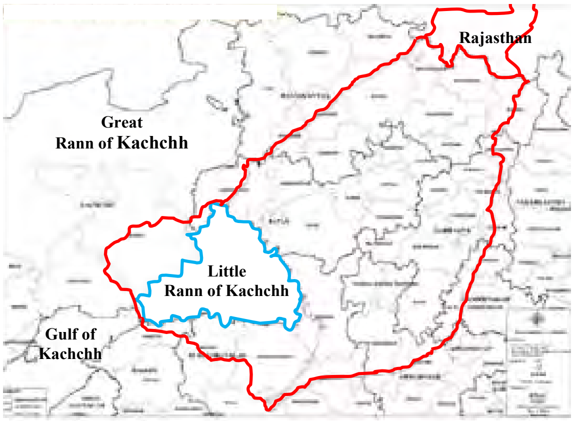


Figure 11: River and drainage pattern in and around LRK landscape. Small blue dots and areas are check-dams & reservoirs.

Figure 12: Gujarat & Rajasthan parts of catchment area of LRK (Dark red line). Adopted from GSWMA prepared by BISAG



in shaping the ecology of LRK, no-systematic study has been conducted so far to understand these, especially in the view of natural stochastic rainfall conditions its catchment.

For the purpose of this study, where the understanding of flooding and thus wetland formation is critical, we used satellite imageries to determine the movement and flooding pattern runoff water. Accordingly, it is quite clearly seen that majority of water is drained into LRK through about 10 major river/stream mouths (Figure 13).

It can be seen that maximum flow is coming from Banas river in the northern most part of LRK, which then flows southward through deeper channels, encircling first the Nanda bet and then the Mardak bet. From Mardak, the water flows further south. However, slightly higher grounds can be seen clearly between Mardak and Keshmara bet and between Keshmara bet and western edge of LRK. Due to these higher grounds, water course shift slightly eastward and flow along with Keshmara, Bhangarwa, Ratadiya and Saheblana bets .

Saraswati and Rupen rivers drain their water near Kordha village at north-eastern boundary of LRK. From here the water flows in a south-westerly direction and spreads in LRK by encircling Wasraj solanki and Khijadiya bets. Finally it merges with Banas waters near Ratadiya and Saheblana bets and creates most extensive water pool. The water of ephemeral rivers like Phalku, Kankavati and Brahmni also drain near the Southern boundary of LRK, mixing with the large water pool created after the merging of Banas, Saraswati and Rupen river channels.

Tidal waters enter LRK from the Surajbari creek during high tide and mix with the available freshwater pool forming a salinity gradient along the south and south-western part of LRK. The tidal influence is strong near the seas where only a few species can survive saline conditions.

3.5. Socio-economic Characteristics of dwellers in and around LRK

3.5.1. Demography

As per the 2011 census, the landscape of LRK supports a human population of about 17.5 lakhs in the ten surrounding administrative blocks (talukas). It is predominantly a rural landscape, withonly seven small towns – Bhachau, Rapar, Radhanpur, Maliya, Dhrangadhra, Halvad and Kharaghoda.

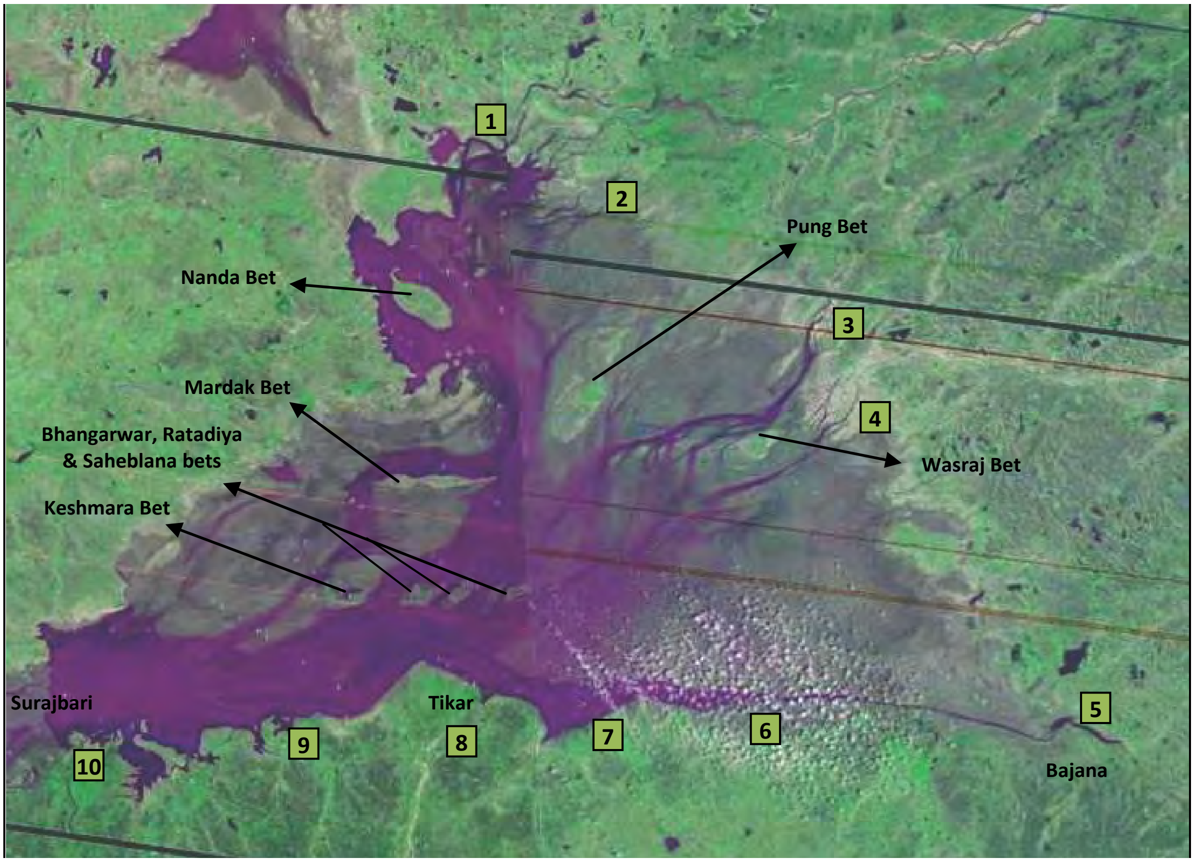
Human populations which register about 14.8% growth during the last decade. In the landscape, urbanization is yet not picking up as the contribution of urban population was found increased from 12.2% in 2001 to 14.9% in 2011 (Table 16).

The LRK landscape support about 10.6% SC population. ST population is quite small. The literacy rate has increased from 41.8 in 2001 to 55.2% in 2011. In economic terms, however, main and marginal worker's population had declined by 0.7 and 2.5 percentage points. This indicates overall poor economic employment opportunities in the LRK landscape mainly due to constrained natural resource situations.

3.5.2. Livelihood System

The LRK, as discussed earlier, had two distinctly separated production areas-the vast saline seasonally wet flat land of LRK and slightly elevated, well drained

Figure 13: Mosaic of satellite imageries of LRK (Landsat MSS-Sept. 1977) showing water channels through which rivers drain their water in LRK. Numbers indicate river/streams draining into LRK. 1 & 2- Banas; 3- Saraswati; 4- Rupen; 5-Bajana; 6- Phalku; 7-Kankavati; 8-Brahmni; 9-Godhadharoi; 10- Machhu



watershed area under different village boundaries. The LRK area, although it looks dry and barren, supports two of the major economic production systems of the region- the salt production and prawn fisheries having non-overlapping season. The LRK is responsible for the production of about 30% of the country's inland salt. The upland area predominantly supports rain-fed agriculture, but in some pockets where Narmada canal reaches, they are irrigated. Cotton, Jeera (cumin), castor and pulses (like mung and math) are the major crops. Animal husbandry, both the settled and transhumant, are very common in the region and generate economy mainly through milk, wool and meat. Industrial development in the region is poor and mainly based on salts and cotton. LRK based tourism is there and recently get picked-up by engagement of private players. However, majority of population is still earning their livelihood through farm and non-farm wage labor.

The LRK landscape is bound by two culturally distinct regions i.e., Kachchh and Saurashtra and supporting distinct religious and caste groups. Kolis are numerically the largest group, yet they have very poor political voice and are mostly engaged in small farming practices. Due to harsh working conditions, traditionally

The LRK area, despite appearing dry and barren, supports two of the major economic production systems of the region- salt production and prawn fisheries

Table 3.1: Key demographic characteristics of LRK landscape

Taluka	Population		% Decadal Growth (2001-11)	Sex Ratio		Literates (%)		Main & Marginal Workers (%)	
	2001	2011		2001	2011	2001	2011	2001	2011
Vav	193260	243528	27.4	931	921	33.3	49.5	51.6	46
Bhachau	147891	186035	25.8	932	900	39.2	50.0	40.5	35.6
Rapar	198000	217315	9.8	928	938	32.4	44.7	40.6	36.5
Radhanpur	120177	144266	20.0	935	947	41.6	54.2	42.5	40.4
Sami	164705	182805	11.0	947	944	39.2	54.9	46.3	44.6
Santalpur	109487	128791	17.6	935	930	30.6	48.3	45.8	42.2
Maliya	83471	78692	-5.7	945	947	49.3	61.8	38.5	38.5
Dasada	169123	180641	6.8	922	933	50.0	65.3	46.3	41.7
Dhrangadra	195085	218041	11.8	908	913	55.0	65.0	41.9	40.9
Halvad	144305	171000	18.5	932	941	49.2	62.7	43.3	40.6
Total LRK	1525504	1751114	14.8			41.8	55.2	44.0	40.8

only the Kolis undertake salt work in the Rann. Darbar and Patel are the most powerful communities in terms of social organization, economic affluence and political connections. Rabaris and Bharwads are the two traditional pastoralist communities in the landscape and in local parlance known as Maldharis. Miyana and Wagher Muslims are in the business of fishing. After the fishing season is over, majority of them moves into nearby cities and towns and work in various sectors.

3.6. Legal and Administrative Set-up

3.6.1. Un-Surveyed Land

In the context of present study, it is very important to understand the overriding legal and administrative arrangements under which LRK's natural resources are used and managed. As discussed earlier, the LRK's boundary touches five districts. While, the villages located in the fringe areas are under the administrative control of one or the other district collector, the entire geographical area of Rann is included with Kachchh district. Interestingly, the area of about 4500 sq, km has yet not surveyed for revenue land records, mainly because of its stark barrenness and presence of no human habitations. The entire 4500 sq, km area is, however, grouped under revenue survey number 'zero'. Because entire land is survey number zero, in the past, land lease for salt production works were given in lands with 'survey number zero'. This often create serious confusion because, unlike in other areas where each land survey number is unique identity, here there is no fixed location (as all the area having same survey number). Thus, it is up to the leased holder to decide where he wants to set-up his salt pans.

3.6.2. Protected Area: Wild Ass Sanctuary

In 1973, the entire Rann along with all the bests and some part of fringe areas were notified as Wild Ass Sanctuary, a Protected Area, under the erstwhile Gujarat Wild Animals and Wild Birds (Protection) Act, 1963) . A total of 4840.90 sq. km area was notified under PA. Later, in 1978, additional 112.81 sq. km area was included in the sanctuary, although from Great Rann of Kachchh side. These two notifications include mainly three types of areas: (i) the LRK and bets (ii) the forest lands in the fringe areas, and (iii) government wastelands of 108 surrounding villages of five districts. In total, the Wild Ass Sanctuary extends in 4953.71 sq. km area.

Although created in 1973 and 1978, the process of settlement of boundaries and rights and privileges of local communities had yet not been completed, causing lots of problems for the management of PA. As a matter of fact, in recent years, resource use related conflicts with salt producer and fishing communities are escalating.

3.6.3. Coastal Regulation Zone

The surajbari creek is considered to be a critical coastal area and is governed under the Coastal Regulation Zone Notification (1991) issued under the Environment Protection Act, 1986. The CRZ notification declares the coastal stretches as the Coastal Regulation Zone

The LRK functions as an estuarine system in one season and a saline desert during the other. Both these systems are increasingly disturbed due to land use changes in creek area and water resource appropriation in upper catchments

(CRZ) and regulates the activities that may or may not be allowed in a manner as provided under the said Notification. The Coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action (in the landward side) up to 500 meters from the High Tide Line (HTL) and the land between the Low Tide Line (LTL) and the HTL are said to be the Coastal Regulation Zone.

3.6.4. Eco-Sensitive Area

It is important to understand that the LRK functions as estuarine system in one season and as saline desert during other. During its estuarine phase, it receives rainwater from its catchment area as well as tidal water from Gulf of Kachchh. These external input systems, which are otherwise beyond any jurisdictional control of LRK management, are major controllers of ecology of LRK. It is understood, that both these systems are increasingly disturbed due to land use changes in creek area and water resource appropriation in upper catchments.

In such situations, the recently enacted Eco-sensitive Area notification around PAs may provide some regulatory instruments for sustainable flow of benefits from ecosystem services and better conservation and management of resources.

3.7. Major Development Initiatives

3.7.1. Irrigation Infrastructure

Traditionally, the LRK landscape support low-input, rain-fed agriculture system. Irrigation was mostly by ground water or to some extent by small ponds etc. In addition to the above, many irrigation dams had also been constructed in on many rivers that are flowing into LRK. Some of these reservoirs are operating since 1950s. Dantiwada and Sipu in Banas and series of reservoirs on Machhu and Brahmni rivers create huge irrigation potential in the areas. Also, under different watershed development programs large number of check-dams had been created to further enhance the irrigation potential of landscape.

Importantly, most part of the LRK landscape is planned to be covered under command area of Narmada canals. The irrigation canal network is spreading rapidly in the landscape. As per plan, once done it will provide irrigation water to about 5.5 lakh hectare of cultivable lands covering a total of 621 villages of LRK landscape. Needless to say such massive intervention will significantly alter the entire setting of LRK landscape by rapid land-use changes.

3.7.2. Linear Development Infrastructure

The LRK landscape falls in the junction of three major economically vibrant regions of Gujarat- the Kachchh, the Saurashtra and the north Gujarat. Thus, many infrastructure projects are passing either through LRK or along the boundaries of LRK. Highways, railway lines, electricity lines, water pipelines etc. are expanding very rapidly along the LRK landscape.

3.7.3. Industrial Settings

The landscape is very close to the emerging hub of automobile industries e.g. Tata's Nano plant in Sanand and Suzuki plant in Hansalpur had already set-up their plants. However, there are many other companies in the pipeline to set-up their plants in these areas. With these, and other small manufacturing units, the landscape is going to get major employment generating units. Area around Maliya and Surajbari are flourished and expanding with salt industries. Tourism is also picking up fast with the investments of many private players in developing hotels and resorts to cater services to tourists visiting LRK.

4. Research Methodology

4.1. Background

This chapter provides details of various methods adopted in three major aspects of the study (a) understanding ecological and economic settings of LRK's two major production systems – prawn fishery and salt; (b) documentation of biodiversity values of

LRK; (c) economic valuation of use and non use values of LRK wetland; and (d) understanding of major drivers that are altering the key ecosystem goods and services. Importantly, this is the first attempt to examine and understand the above elements of ecological-economic interfaces in the context of LRK wetland.

For achieving different objectives we attempted a multi-pronged methodological approach, which embodies two broad classes of investigations:

- Desk reviews of literature, secondary data collection and meetings, consultations and workshops with major stakeholder groups to recognize and understand key ecological, hydrological and socio-economical characteristics and their inter-connectedness including the major drivers of change.
- Intensive primary data collection through focus group discussions (FGD) and household sample surveys and essential statistical treatments to collected data mainly to estimate various use and non use values of LRK wetlands.

4.2. Literature Survey, Secondary Data Collection & Consultations

Keeping in view the objectives of the study, two different sets of literature were collected to derive better comprehension of the subject. First, theoretical understanding about the ecological-economic aspects of natural ecosystems, with special focus on wetlands. For this, relevant global as well as Indian literature was accessed from libraries of universities and research institutions. The internet search also helped in gathering relevant materials on ecological economics of wetlands including valuation methodologies and economic values of different wetland systems of the world, using different methodologies. Second, the ecological-economic settings of LRK and understanding of development trajectories in the surrounding landscape. For this, existing published and unpublished literature such as research articles, technical reports, mimeographs and Ph.D. theses were accessed from researchers, universities, colleges, institutions and relevant Govt. Departments.

Review of this collected literature formed the foundation for a detailed understanding of ecological-economic issues of wetlands in general and economic valuation approach for LRK in particular. While the global and Indian literature on ecological-economics is summarised in Chapter 2, the LRK related information is recapitulated in Chapter 3 (Study Area) and also in other relevant places (like Chapter 5 – Production System; and Chapter 6 – Biodiversity Value).

Furthermore, at LRK level, data on demography and land use pattern; livelihood systems in terms of time series data on fish/ prawn and salt production and their extent; number of dams/ reservoirs and check-dams and their water storage capacity; floral and faunal diversity and distribution etc. was collected from relevant Government departments such as Forest, Revenue, Fisheries, Irrigation, Salt, District and Taluka panchayats, District Statistical Office etc. Many of above data were accessed through RTI applications. In

Table 17: Summary of secondary data & information collected from different sources

Source	Details of the information	Remarks
Forest Dept.	• Management plan of Wild Ass Sanctuary • Floral and Faunal diversity • Wildlife census data • Time series data of tourists	
Fisheries Dept.	• Site specific fish production data of different years	Since 2004, Fishery Dept is not recording fish catch data in LRK
Revenue Dept.	• Salt lease area	District & taluka level offices
Salt Commissioner	• Time series data on salt production • Annual reports	
Irrigation Dept.	• River catchment wise details of reservoirs	Also collected information from Rajasthan irrigation department
District Panchayats	• Watershed development activities under different schemes including number of check-dams	
LANDSAT Imageries	• Area under salt work around Surajbari creeks for years between 1977 to 2013	

addition to this, we also used multi-year freely available digital imageries of LANDSAT satellite to obtain synoptic views of wetland and analyze growth of salt work around Surajbari creeks. A brief description of secondary data collection under this study is presented in Table 17.

As discussed above, in addition to above data collection approach, efforts had also been made in meeting and consulting key government officials, NGO representatives, researchers, subject matter experts and local communities to understand various issues related with ecological and economic aspects of LRK (Table 18).

4.3. Primary Data Collection

In the context of primary data collection, this work mainly focuses on economic valuation and associated socio-economic drivers associated with wetlands of LRK. Review of literature highlights many valuation methods for different functions of wetlands (Table 19).

As discussed in the introductory chapter and spelled out in study objectives, to ascertain the economic value of wetlands of LRK, four types of goods and services provided by LRK wetlands were measured: (i) Prawn fishing (ii) Salt production (iii) Tourism, and (iv) Biodiversity.

For the valuation of fisheries and use and non-use values of biodiversity, we conducted household surveys. For salt, however, secondary time series data was used for valuation purpose. In addition to this, the study also conducted a household survey to understand farmers' perception about water harvesting practices and Narmada canal irrigation induced land use changes in catchment area of LRK and their implications on wetland system of LRK.

The entire primary survey was completed between July 2014 and March 2015.

4.3.1. Prawnn Fisheries

In LRK, except in a few locations, prawn fishing activities are seasonal in nature. Fishers from nearby villages and many of their relatives from other parts of Gujarat, with the onset of monsoon migrate to the margins of the Rann and settled for 2-3 months in temporary settlements in slightly raised areas (local people called such areas as 'dhassi'). The number of settlements varies over year to year depending upon the goodness of monsoon season. During our survey year (2014), there were only 9 fishing 'dhassis' along the Rann border. In order to capture fishing practices in LRK, their key socio-economic characteristics, prawn catch and marketing etc. we collected both qualitative and quantitative information through Focus Group Discussin (FGD) and household (HH) surveys.

4.3.1.1. Focus Group Discussion

FGDs were conducted in migrant fishing settlements. To collect overall settlement level information, we have conducted 13 FGD in 9 fishing Dhassis (temporary settlements) with the help of an open ended questionnaire (see Annex 1). This aims to get macro-picture of the fishing practices in LRK and thus collect quantitative as well as qualitative information on number of fisher families/population, active fishers, labour, native place, occupational assets (like boats, nets etc), basic amenities in settlements (like water, sanitation), fishing history, fish catch, market and institutional arrangements; conflicts and opportunities, perception on key issues etc. Table 20 gives details of FGD conducted for the study analysis.

Table 18: Summary of various meetings and consultations

Source	Details of the information	Remarks
NGOs	• NGO working on issues related with fishing and salt making like SEWA, Agariya Hitrakshak Manch, SETU; Aanandi etc.	
Subject Experts	• Fishery scientists from CMFRI & CIFT at Veraval; Salt scientists from CSMCRI, Bhavnagar; Biodiversity experts of GEER Foundation; Hydrology Scientists/ Professors from Hyderabad & MS University, Baroda	For feedback we presented our data and preliminary analysis with concerned State Forest Department officials; CMFRI & CIST scientists
Local barefoot experts/ practitioners/ traders	• Fish and Salt traders; Individual salt producers and fishers; travel and tour operators; hotel and resort owners; local naturalists working in the landscape; frontline staff of Forest Department	Fish traders shared their multi-year prawn catch data from different sites

Table 19: Environmental valuation techniques relevant to present study

Type	Name of Technique	How they are applied	Applicability to LRK Wetlands
Market Price Based	Market Values	Based on assumption that value of good is based on its price in the market. Value of the good is taken as the market price, less the cost of production & any transfer payments made, such as taxes & subsidy.	1. Fisheries catch over a period of time. Catch/ cost per effort (cost of net, diesel, boat, labor etc.) 2. Salt production
	Change in productivity	Primarily for the marketable goods like fisheries. Assumptions is that the changes in environmental quality can lead to changes in productivity and production costs, which in turn lead to changes in the volume and price of goods. For example, a decline in wetland quality will lead to decline in artisanal fishery catch and hence loss of market value.	
	Damage Costs avoided	Under this approach, the value of an environmental asset, such as flood protection, is taken to be represented by the saving made by avoiding damage to assets it protects. For example, the land protection value provided by wetland would be considered to be equal to the cost of repairing or replacing land values and other infrastructures damage by flooding.	Not applicable in the case of LRK as the wetland's outlet is in creek area
	Defensive or preventative expenditure	Defensive expenditures, such as the provision of extra-filtration for purifying water or waste assimilation capacity of wetland, are considered as minimum estimates of the benefits of environmental improvements. Such an increase in quality must provide a benefit to the society at least as great as the cost of the defensive equipment, because otherwise the society would settle for lower quality and avoid spending the money.	Not applicable in the case of LRK as at present there is no pollution load in LRK.
Cost-based	Replacement cost	Value of an environmental asset or function it performs can be given a proxy value based on the cost of replacing the function with an alternative.	Not applicable
Revealed Preference/ surrogate market (uses market-information to infer a non-marketed value)	Travel cost method	This technique revolves around the expenditure incurred by households or individuals in order to reach recreational sites. The sum of the cost of travelling, including the opportunity cost of time and any entrance fee, gives a proxy for market prices in estimating demand for the recreationa1 opportunity provided by the site under investigation. By observing these costs and the number of trips that take place at each of the range of prices, it is possible to derive a demand curve and hence overall value for the particular site.	Used to estimate value of tourism in LRK
	Hedonic price	This approach seeks to isolate the contribution that environmental attributes make to the total market value of an asset. For example, the proportion of the price differential between two otherwise identical houses accounted for by being closely located to a healthy wetland reveals an individual purchaser's valuation of the importance of that attribute.	Not applicable as wetland formation in LRK is quite seasonal

Contd...

Type	Name of Technique	How they are applied	Applicability to LRK Wetlands
Stated Preference/ construed market approach (questionnaire surveys to ask people's direct willingness to pay)	Contingent valuation	This is a carefully constructed and analyzed questionnaire survey technique asking a representative sample of respondents how much they are willing to pay (WTP) for an environmental benefit or what they are willing to accept (WTA) in compensation for a loss. The questionnaire format thus stimulates a hypothetical (contingent) market for a particular good.	Used to estimate value of biodiversity and habitat for migratory birds in LRK
	Choice experiments	Same as above but respondents are also presented with several short descriptions or a composite good (e.g. a good, such as a destination having number of valuable characteristics, such as fish diversity, fish abundance and price to pay). Each description is treated as complete package and differs from the other packages in respect to one or more of the good's characteristics. Respondents then select their preferred package (pair wise comparison) based on their personal preferences. It is then possible to isolate the effects that variation in individual characteristics has on the price.	Not applicable for LRK wetlands
Transfer of values	Benefit (value) transfer	This uses the transfer of economic values estimated in one context and location in order to estimate values in a similar or different context and location. The values should ideally be adjusted based on key criteria and variations that apply in the different context and locations. This technique is increasingly being used when it is not feasible to carry out primary data collection	Not Applicable as LRK wetland has unique characteristics and thus difficult to find similar sites

4.3.1.2. Household Survey

It is important to mention here that our survey year (2014) is considered 'below average' in terms of fishing operations (due to untimely and less rains) and thus, many fishing locations were not in operation. However, we covered all 9 operational fishing settlements for the household (HH) survey.

We conducted a random sampling approach for HH survey in each of the 9 settlements. For the purpose of recording of HH level data and information, we undertook a questionnaire based survey. A structured schedule was used for the survey purpose (See Annex 2). The questionnaire was developed and pre-tested in one settlement, modified and finally employed in all the fishing settlements. The study has collected information on HH Demography, income from different sources, fishing assets, fishing methods, quantity of fish catch (this was collected for two years- 2014 and last year i.e. 2013), value-addition, cost of fish catch and value addition, marketing of prawn, perceptions about fisheries related issues.

A total of 62 fisher families were interviewed for recording the above information. The broad characteristics of sampled households are presented in Table 21.

4.3.2. Salt Production

In the context of salt production from dry bed of LRK wetland, we conducted 4 FGDs to understand the brine quality and salt production in unit area, cost of production and value addition, market price realized for inland salt, and perception about various issues related to salt production. We also had several rounds of meetings with salt traders and recorded various costs incurred and borne by them (e.g. transportation cost, labor, pilferage loss, iodization cost etc.). The overall salt production data, as discussed earlier, was collected from salt commissioner's office.

4.3.3. Use and Non-Use Value of Biodiversity

One of the important objectives of the study is to estimate use and non-use values of biodiversity in LRK. In terms of use-value, we measured tourism value of LRK and for that Travel Cost Approach was adopted to measure non-consumptive use value of biodiversity. However, for non-use value of biodiversity, we employed Contingent Valuation Method (CVM) to estimate Willingness to Pay (WTP) for conservation and management of LRK's biodiversity.

4.3.3.1. Travel Cost Approach

To understand the tourism values of LRK, we conducted interviews of tourists to collect information on total travel cost with the help of structured schedule (see Annex 3). The schedule was pre-tested and modified and then employed.

Table 21: Sample Household Characteristics

Name of Dhassi	N	Avg. Age of Respondent	Avg. years of fishing experience
Cherowadi	2	47.5	35.0
Enjar	2	53.0	22.5
Gadhaboard	3	41.7	33.4
Koparani	8	40.3	33.5
Mandaraki	7	32.1	33.6
Murvadar	8	41.5	36.3
Nangavadi	4	34.5	26.0
Setudi	2	30.0	21.0
Tikar	20	39.6	27.4
Tundi	2	55.0	25.0
Venasar	4	50.5	7.5
Overall	62	40.4	29.5

During the study, we undertook on-site interviews of 38 tourists (families or individuals) who at the time of our survey were present in LRK. Out of 38 sampled tourists, 3 were foreigners, 7 were from different parts of Gujarat and 28 were from other parts of country.

For the purpose of the interview, priority was given to those tourists who had completed at least one round of visit inside LRK, so that they could give their views on tourism value of LRK and their level of satisfaction. In order to capture variations in the expenditure pattern of tourists, we chose our sample tourists from six different resorts . We recorded information about tourists' age, place of origin, education, occupation and income; tour details like mode of travel, days spent, total cost of trip, their preferences, suggestions etc. Additionally, respondent's perception about importance of conservation of biodiversity, geographical, cultural and landscape features were also collected. It is important to mention here that to avoid issues associated with multiple site visit, we have carefully collected travel cost associated with visit to LRK only.

4.3.3.2. Contingent Valuation Method

The present study attempts to value LRK's biological diversity, especially in the context of congregation of large number of migratory aquatic birds. For this, we applied contingent valuation method (CVM) and recorded willingness to pay (WTP) of households belonging to local communities and are part of stakeholder groups. For this purpose we prepared a questionnaire, pre-tested, modified and finally employed (see Annex 4).

We surveyed a total of 221 randomly selected households, belonging to different occupational groups

Table 20: Summary of Focus Group Discussion conducted with Fishers in LRK

Fishing settlement & villages	Approx. Number of Fisher Families Present in 2014	No. of FGDs Conducted	Approx No. of Fishers Presented in each FGD
Koparni	17	1	5
Moravadar (Navu Hanjiyasar)	145	2	10-15
Hanjiyasar	300	2	10-15
Nangavadi	50	1	10
Cherawadi	300	2	7-10
Mandarki	70	1	10
Venasar	83	1	15
Kharaghoda	150	1	8
Tikar	150	2	20

(viz. fisher, farmer, salt producers and general public), from rural as well as urban centers surrounding LRK (Table 22). The survey schedule covered the following key aspects, necessary for contingent valuation: the demographic, educational and economic details of households; their knowledge and understanding about values of and threats to biodiversity element of LRK (especially the migratory birds); their willingness to conserve and also willingness to pay for biodiversity conservation.

4.3.4. Farmers' Perception

Considering the fact that the farmers, although not directly dependent upon LRK, had strong presence in the LRK's catchment and, thus influence its ecology by changing agricultural practices, including water harvesting, use of chemicals etc. Thus, as part of assessment of drivers of change, we exclusively conducted a household level survey using a structured schedule (see Annex 5). The key issues covered under that survey include, present agricultural activities, change in irrigation source and extent, especially in terms of use of Narmada canal, changing land use, application of chemicals and perception about impact of these extensive alteration on LRK ecology, mainly the wetland system.

A brief summary of data collection schemes, valuation methods and sample size with respect to different aspects of study is presented in Table 23.

4.4. Addressing Key Methodological Issues

4.4.1. Travel Cost

Despite being used widely in different studies, travel cost estimation has a few inherent issues which need to be recognized and addressed. Chopra (1997) opines that, "this cost expresses the revealed preference of people interested in deriving tourism, education and ecological values from it". It suggests travel cost incurred by the individual to reach the site as a surrogate for the price of the site. In this method the first step is to collect data from the tourists to a recreation site. The simplest method assumes that individuals take a trip for a single purpose – to visit a specific recreational site. Thus, if a trip has more than one purpose, the value of the site may be overestimated.

In the context of our study, we address this problem by asking tourists to provide the cost they have incurred only for visit to LRK. Accordingly, we collected their total travel cost. Moreover, defining and measuring the opportunity cost of time, or the value of time spent travelling, can be problematic. Because the time spent travelling could have been used in other ways, it has an "opportunity cost." This should be added to the travel cost, or the value of the site will be underestimated. However, there is no strong consensus on the appropriate measure—the person's wage rate, or some fraction of the wage rate—and the value chosen can have a large effect on benefit estimates. Thus, we have taken opportunity cost of time as per capita HH income per day corrected for the days spent in the LRK (see Chopra, 1997).

It is important to note here that standard travel cost approach provides information about current conditions, but not about gains or losses from anticipated changes in resource conditions. The travel cost method is limited in its scope of application because it requires user participation. It cannot be used to assign values to on-site environmental features and functions that users of the site do not find valuable. It cannot be used to value off-site values supported by the site. Most importantly, it cannot be used to measure non-use values. Thus, sites that have unique qualities that are valued by non-users will be undervalued.

4.4.2. Contingent Valuation

Despite being widely used in different studies, CVM approach has a few inherent issues which need to be recognized and addressed. In order to address some of the known issues, we developed and used an open-ended WTP questionnaire so that responders would not be restricted by defined values, as in binary choice or closed-ended questions (Venkatachalam, 2004).

In addition, we finalized the WTP questionnaires

The survey covered the following key aspects: the demographic, educational and economic details of households; their knowledge and understanding about values of and threats to biodiversity element of LRK; and their willingness to conserve (and pay for) biodiversity conservation

Table 22: Summary of household survey for CVM purpose

Respondent Group	No. of HH Sampled	Sample Location
Fishers	62	9 fishing temporary settlements along the southern border of LRK
Farmers	91	20 villages from 10 talukas surrounding LRK
Salt producers	26	Southern and eastern parts of LRK
Other Urban public	42	4 towns near LRK; Dhrangadhra, Halvad, Patdi and Bajana

and the pre-testing process with expert guidance to validate and make the questionnaire clearer for the respondents. People are generally conversant in making choices with market goods, so their purchasing decisions in markets are likely to reflect their true willingness to pay. CVM assumes that people understand the good in question and will reveal their preferences in the contingent market just as they would in a real market. However, most people are unfamiliar with placing monetary values on environmental goods and services. Therefore, they may not have an adequate basis for stating their true value.

We have addressed this issue in the questionnaire with a few warm-up questions regarding their understanding of biodiversity of LRK. Rather than expressing value for the good, the respondent might actually be expressing their feelings about the scenario or the valuation exercise itself. For example, respondents may express a positive willingness to pay because they feel good about the act of giving for a social good (referred to as the "warm glow" effect); although they believe that the good itself is unimportant. Respondents may state a positive willingness to pay in order to signal that they place importance on improved environmental quality in general. Alternatively, some respondents may value the good, but state that they are not willing to pay for it, because they are protesting some aspect of the scenario, such as increased taxes or the means of providing the good.

In the present study we have elsewhere mentioned

Table 23: Summary of data collection approach

Study Aspect	Data/ Information Collection Approach	Valuation Method Applied	Sample Size of Primary Surveys	Sampling Period
Bio-physical & socio-economical description of LRK	Secondary data collection, review of literature and consultations with subject experts	-	NA	NA
Description of landscape level drivers of change	Secondary data collection, review of literature and consultations with subject experts; Primary survey: Satellite imagery analysis of salt works; HH survey of farmers	-	91 Farmer HH	
Economic Valuation – Prawn fish	Secondary data collection Primary survey: FGD and HH Surveys of fisher families	Market value assessment	13 FGDs 62 Fisher HH	July-Aug. 2014 Sept.–Oct. 2014
Economic Valuation – Salt	Secondary data collection Primary survey: FGD with Salt producers	Market value assessment	4 FGD	Jan. 2015
Economic Valuation – Tourism	Secondary data collection Primary survey: Interviews of tourists	Travel cost	38 Tourist HH	Dec. 2014- Jan. 2015
Economic Valuation – Biodiversity	Review of literature; Primary Survey: HH Surveys of fishers, salt producers, farmers and other general public	CVM	62 Fisher HH 26 Agariya HH 91 Farmer HH 42 Urban HH	Sep.- Oct. 2014 Jan. 2015 October 2014 Jan. 2015

LRK wetlands show very strong seasonal dynamics, thus generating various goods and services. Local people depend upon these goods, including prawn fisheries, salt production and tourism, for recreational and educational purposes

that our respondents' WTP is genuine due to the fact that they are concerned about biodiversity, as is reflected from their norms to provide grains on a daily basis to local avifauna.

It is important to select a realistic payment vehicle (i.e., how respondents pay the WTP amount) in CVM. Taxes and donations are often used as payment vehicles associated with conservation values. However, donations are more useful payment vehicles for contingent valuation because they provide a reasonable approach for estimating the economic value, while respondents may object to mandatory payment schemes (i.e., entrance fees or taxes), Champ et al 1997. Therefore, we used donation as the payment vehicle in this study.

Many early studies attempted to prompt respondents by suggesting a starting bid and then increasing or decreasing this bid based on whether the respondent agreed or refused to pay such a sum. However, it has been shown that the choice of starting a bid affects respondents' final willingness to pay response.

In the current study this problem has already been addressed by providing open ended questions. Strategic bias arises when the respondent provides a biased answer in order to influence a particular outcome. If a decision to preserve a stretch of river for fishing, for example, depends on whether or not the survey produces a sufficiently large value for fishing, the respondents who enjoy fishing may be tempted to provide an answer that ensures a high value, rather than a lower value that reflects their true valuation. It is important to mention here that for valuing use of LRK for fisheries we have employed direct market approach. The study has employed CVM for the valuation of non-use values (biodiversity, especially migratory birds) provided by LRK ecosystem.

5. Use of LRK Wetlands

As discussed in the earlier chapter, LRK wetlands show very strong seasonal dynamics which in turn generate various goods and services. Local people depend upon these goods which include prawn fisheries, salt production and tourism for recreation and education purpose.

5.1. Production of Prawn Fish

A lucrative monsoon fishery, especially of prawn species (mainly the Metapaenus kutchensis), flourishes and provides livelihoods to a number of fishermen families belonging mostly to the Miyana Muslim and Koli communities. Fishing activities are mostly concentrated in the southwestern part of the LRK. With the onset of the rainy season, there is an upswing of tidal water in the creeks of Gulf of Kachchh that facilitate movement of juveniles of different species of fishes and crustaceans from the Gulf of Kachchh, into the Rann. After the first spate of heavy rains, freshwater influx from the mainland inundates the Rann and mixes with saline tidal water to create suitable nursery ground for *M. kutchensis*. The fishermen keep track of entry and growth of juvenile (post larva) of prawns. During this period, the fishermen, along with their families, leave their villages in caravans and set up camps on raised, sandy areas (locally known as dhasis). Kuda, Koparni, Jogad, and Tikar are important dhasis on the southern side of the LRK. On an average, fishing season in LRK is between Jul-Aug to Sep-Oct, which depends upon rainfall.

GEER (1999) reported 11 species of prawns/shrimp (Metapenaeus kutchensis, M. brevicornis, M. affinis, Parapenaeopsis sculptilis, P. hardwickii, P. stylifers, Trachypenaeus pescadorensis, Solenocera crassicornis, Acetes indicus, Palaemon styliferus and Hippolysmata ensirostris) and about 20 species of fishes (e.g. Coilia reynaldi, Chirocentrus dorab, Labeo rohita etc.) from LRK landscape. However, Rao (1983), Dash et al. (2012) and Ghosh et al (2012) reported that *M. kutchensis* constitute more than 90% of the total biomass among all the fish and prawn species captured. Therefore, for all practical purposes, fisheries of LRK wetlands essentially relate to the ecology of a single, endemic prawn species – *M. kutchensis*.

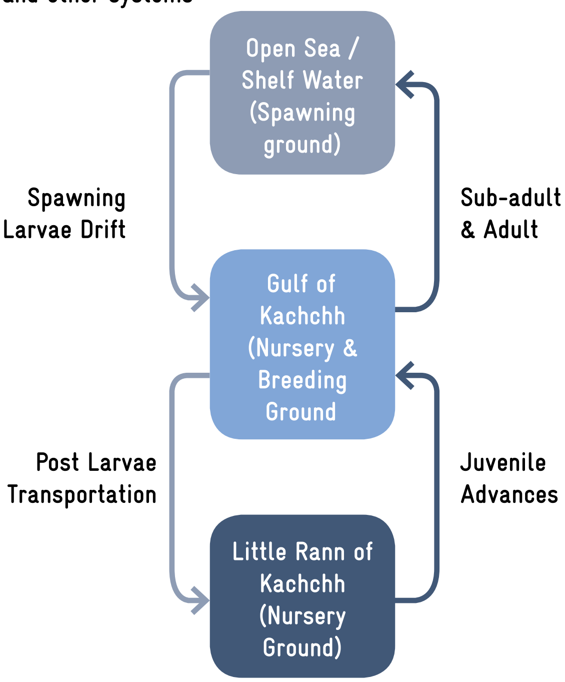
In the context of the present study, it is important to understand (i) which ecological factors determine the biomass production of *M. kutchensis* in LRK? and (ii) which socio-economic factors determine the catch of *M. kutchensis* in LRK?

5.1.1. Ecological Understanding of Prawn – *M. kutchensis*

M. kutchensis is a catadromous species that migrates to the deep seas for spawning. Deshmukh (2006) suggested that the 40-80 km wide continental shelf off the northwest coast of India (including Gujarat and Maharashtra) is used for the purpose. Joseph and Soni (1990) reported brooding females near Okha, at the mouth of the Gulf of Kachchh (GoK). The spawning period extended between December and August when it lays eggs at bimonthly intervals (Deshmukh 2006). However, the spawning period between May and August is considered critical for the maintenance of its stock.

The pre-larval and larval stages of *M. kutchensis*, especially those spawning during May-August, drift northwards towards the mouth of GoK, aided by the south-west monsoon winds. The nearshore currents, especially during the spring tides, transport the larvae further towards the interiors of GoK. Inside GoK, the larvae use vast stretches of mud-flats and creeks, which provide them suitable habitats for growth and survival

Figure 14: Life-cycle stages of *M. kutchensis* in LRK and other systems



till the monsoon sets in. During spring tide, and with the onset of monsoon, the larvae are transported into LRK waters (Ghosh et al. 2012). Connectivity between GoK and LRK is enforced by tidal waters during the entire course of the monsoon.

During monsoons, LRK is flooded with fresh water that mixes with the tidal water from the sea. This creates brackish water habitats, ideal for post-larvae of *M. kutchensis*, which utilize the nutrient, detritus and other food resources brought mainly by fresh-water runoffs. In subsequent weeks and months, larvae grow in size to the juvenile stage and head back to the GoK, and from there to the open sea areas in the shelf region. They continue to grow in GoK and shelf waters and form sub-adults and adults, ready again for spawning. This cycle continues every year. Deshmukh (1975) and Naik et al (1991) reported that percentage contribution of *M. kutchensis* in the total catch is maximum in the inner part of GoK. In the context of LRK, the key life cycle stages of *M. kutchensis* vis-à-vis its spatio-temporal use of different areas (e.g. deeper open sea water, mudflats and creeks of GoK and brackish water wetland of LRK) is schematically presented in Figure 14.

It is evident that the LRK plays a critical role for the maintenance of *M. kutchensis* population, a species endemic to GoK, by providing the largest nursery ground for its post-larvae. At the same time, it also emphasizes the larger ecological role of the head-end of GoK, including the Hadakiya and Chhachh creeks (commonly known as Surajbari creeks) and adjoining mudflats.

5.1.2. Role of Freshwater

Rainfall affects the growth of *M. kutchensis* (and other fish/prawn species) in two major ways:

1. Maintaining the salinity regime of LRK water; and
2. Supporting the food chain by bringing enough nutrient and organic matter along with runoff water.

Rainfall is the most critical parameter that determines the quantity and quality of prawn production in a particular season. Strong correlation is observed (Figure 15) between rainfall and production of *M. kutchensis* (as reflected by total catch). Ramamurthy (1967) remarked that the success of shrimp fishery in the LRK, consisting almost entirely of the juveniles of *M. kutchensis*, depended on the rainfall. Deshmukh (1975) also noticed that the success or failure of recruitment of larvae and juveniles influenced the abundance of shrimp in the GoK. But, rainfall and consequent lowering of salinity of the creek water were more important factors that affected the shrimp landing in the LRK. Deshmukh (2006) further highlighted the direct relationship between rainfall and shrimp fishery in LRK. It is obvious that good rainfall ensures flooding and large-scale immigration of post-larvae to LRK waters, where under estuarine conditions they grow rapidly to juveniles and thus support huge seasonal fishery during Jul-Sep.

It is important to mention here that since the prawn production in LRK is highly dependant upon the rainfall, its production remains vulnerable to the climate change related anomalies in rainfall patterns.

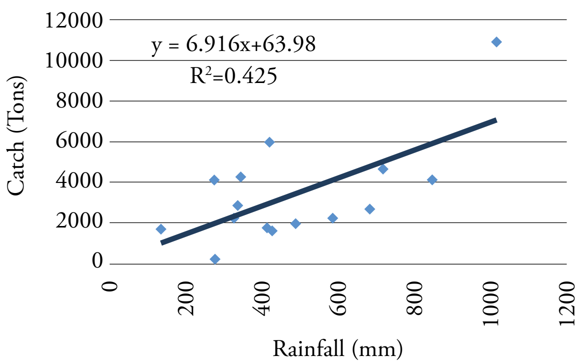
5.1.3. Availability of Food for *M. kutchensis* in LRK

Zingde et al. (1988) and Paulinose et al. (1998) explained that the rains lower the salinity of creek waters and produce a salinity gradient within LRK during Jul-Sep. Tidal inflows also bring in zoo-planktonic crustaceans, polychaetes, cephalopods and algae that show prolific growth in low salinity but nutrient-rich waters of the LRK creating, in the process, a congenial feeding (nursery) ground for *M. kutchensis* and other shrimps, which grow to remarkable size within three months.

Analysis of food items of mature *M. kutchensis* reveal that Polychaetes, Acetes sps. and other smaller crustaceans constitute about 45%, 20% and 13% of the bulk, respectively (Deshmukh, 2006). Detritus, mud and sands were also found mixed with food items, contributing another 8.6%, suggesting their possible importance in nutrient assimilation. Ramamurthy (1967) and Rao (1983) observed algae, detritus and crustaceans as the major food items of juveniles of *M. kutchensis* in LRK. It is evident that the species forage on a wide range of food items and detritus materials.

It is important to mention here that Polychaetes, Acetes, are crustaceans and marine (sea water) organisms, whose larvae should also be entering LRK through the Hadakiya and Chhach creeks (=Suarajbari creeks) along with larvae of *M. kutchensis*. Paulinose et al. (1998) clearly established that during pre-monsoon and monsoon months, the density of larvae of Acetes, *M. kutchensis* and other crustaceans are quite high in the creeks of GoK that are linked with LRK. However, it is also important to understand that tiny larvae of these invertebrates also need to grow for their own life-cycle. In terms of growth and biomass accumulation in *M. kutchensis*, the volume and growth of these other invertebrates is very critical. Similarly, growth of *M. kutchensis* is also affected by algal growth, which is mainly dependant on the quantity of different nutrients in run-off waters.

Figure 15: Relationship between rainfall and prawn catch in LRK



Reduction in growth of juvenile panaeid prawns due to lack of monsoon is reported by Staples (1980). Actually, poor monsoon means higher salinity level in creek and other water and also low availability of food/detritus materials. This affects the growth of prawns.

In sum, the growth of all the essential food items of *M. kutchensis* depends upon the quality and quantity of nutrient, organic matter and detritus matters which in-turn depend upon the volume and quality of runoff water that reach LRK.

5.1.4. Other Factors

As understood above, the production of *M. kutchensis* in LRK is highly influenced by the ecological health of LRK itself and also the ecological condition of and connectivity with Surajbari Creek and GoK.

Based on the review of literature and discussions with fishermen and actual visits of fishing grounds, it was found that that the production of *M. kutchensis* in the LRK landscape is the result of many ecological and climatic factors. Since most of these factors are dynamic in nature, the prawn biomass production also varies spatio-temporally. Dixit et al. (2008) summarizes the key natural factors that broadly determine the prawn biomass production in LRK (Table 24).

5.1.5. Prawn Fishing Practices

Dixit et al (2008) described in details the fishing operations in LRK and identified many fishing areas in the LRK landscape. Accordingly, following are the key fishing sites: Kharaghoda, Kanachar, Kuda-Dhaka, Tundi, Koparni, Enjar, Jogad, Boda, Tikar, Banth, Venasar, Mandarki, Karadiya, Hanjiyasar, Cherowari, Surajbari, Kajarda and Adesar. However, depending upon the rainfall and possibilities for higher catch, a few other sites can also be used for fishing camp purpose.

The approximate locations of these fishing points are presented in Figure 16

Based on physiography, inundation and drying patterns, and fishing practices, four distinct types of fishing grounds are recorded in the LRK landscape:

a. Extensive prawn fishing, restricted during monsoon, along the southern border of LRK — what is generally termed as Rann Fishing.
b. Extensive prawn fishing in and along the Surajbari and other creeks, mostly during the monsoon period, what generally termed as Creek Fishing. However, limited fishing is extended even during the winter. In such areas water level fluctuates diurnally due to tidal effects.
c. Extensive fishing around Nanda and Shedwa bets near Adesar what generally termed as Winter Fishing. The prawn fishing is extended over winter season.
d. Small scale, monsoon fishing near Kharaghoda in the eastern parts of LRK.

The broad characteristic of these four fishing grounds is given in Table 25.

5.1.6. Method of Prawn Capture

Dixit et al (2008) describe the detail modus operandi of prawn capture within the above different fishing typologies. They described that in the LRK fishing sites, fishermen used long barrier nets (locally called Katar) for driving and concentrating the prawns into their fishing ground and later by using long bag nets (Gunja) to catch prawn. The arrangement of Katar nets in LRK is schematically presented in Figure 17. In a fishing site, there are many lines of Katar nets. While, there are no fixed norms for leaving open space between two adjacent lines of Katar, yet in most of cases a distance of about 100 to 200 meters separates them.

The setting-up of Katar nets is a specialized job and each fisherman has an informal right over the fishing space where they set-up their Katar every fishing season. It is important to mention here that the rights ver fishing space is strictly followed in the near-shore, deeper water areas (in local term most of these deep-water drainages are known as ver). But, in the shallow water areas farther from shore, such strict rights over fishing space are not followed (since such areas are least preferred for fishing purpose).

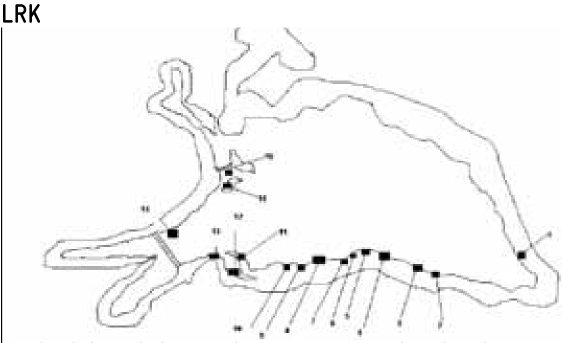
Katar nets are placed in a 'V' shaped manner and normally measured in terms of weight of nets. For example, while some fishermen place about 20 kg of nets, some others place 40 or 60 kg of nets. Obviously, more the weight of nets the larger the coverage area, and thus, in each site one can find different sizes of Katar (a reflection of the economic condition of the fisherman). Upper part of the net is fixed by rope while bottom part of the net is fixed by wooden hooks. Between two poles 3-4 hooks are fixed which protect the net from the water current and prevent prawns and fishes from escaping the net. The height of Katar nets varies between 3 and 5 feet, and fishermen use the nets according to the water depth i.e. as water depth increases fishermen stretch the nets up to six feet height and optimize the catch.

Of late, the fishermen are making a separate storage area of approximately 20 feet x 6 feet at the end of Katar net, locally termed as "Puchha". The Puchha is made-up of two parts: (i) the large storage area made up of mosquito nets having very small mesh size (locally known as chatti) and (ii) a small fixed gunja net to direct the prawn movement from Katar to Chatti. The gunja net does not allow prawns to turn back, getting trapped in the chatti net to be collected by fishermen periodically (Figure 18). It is important to mention here that while the use of Puchha net is a recent phenomenon (according to local fishermen, the technique was introduced to them by some Bihari fishermen) but as

Table 24: Factors affecting the production of *M. kutchensis* inside & outside LRK

Area	Eco-climatic Factors for *M. kutchensis* Biomass Production
Within LRK	Amount of rainfall; Freshwater runoff; Duration of water availability; Tidal water inflow; Water quality; Water depth & Availability of food items
Outside LRK	Amount of rainfall; Wind direction for drifting of larvae; Spawning ground in open sea; Availability of residual habitats of mud flats, creek etc.

Figure 16: Location of important fishing centers in LRK



1=Kharaghoda; 2=Kuda Dhassi; 3=Tundi; 4=Koparni; 5= Ejar; 6=Jogad; 7=Boda; 8=Tikar; 9=Venasar 10=Mandarki; 11= Karadiya; 12= Kajarda Talav; 13=Nangavadi (Hanjiyasar); 14= Cherovari (Surajbari); 15=Shedava Bet; 16= Nanda Bet it saves the fishermen's labour substantially (the local traditional practice is using hand held Gunja within the Katar area), most of the fishermen are now adopting this method of prawn catching. Many of the local fishermen, however, consider this method as a highly unsustainable practice as it does not allow even the smallest (juvenile) fish and prawns to escape the final catch.

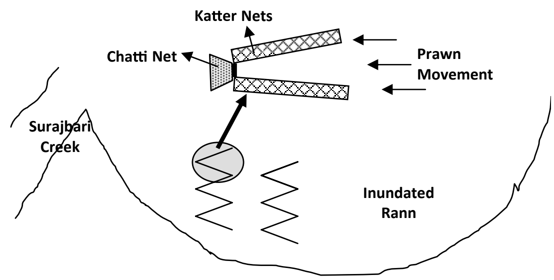
The modus-operandi of prawn fishing in most locations of LRK can be summarized as follows:

- At the beginning of fishing season, fishers set their barrier nets (Katar net) and appropriate the prawn stock that exists within the limits of the Katar net.
- Within the limits of Katar nets, prawns moved in one direction and finally get trapped in a long-tapering stake net (i.e. Gunja net) and finally collected in a chatti net (fine mesh - mosquito net)
- The prawn movement is diurnal in nature and thus is collected in the chatti mostly during the dusk to dawn period. In the morning fishermen go and collect all the captured catch.

5.1.7. Water Depth: Micro-Topographical Variation

Dixit et al. (2008) suggested the important role of water depth in prawn production and catch. According to them, even after good monsoon rainfall, water depth varies in different locations of the LRK due to topographical variation. For prawn fishing, fishermen set-up their nets only up to a certain depth (ideally 3-4 feet of water depth is good). The higher grounds with lower water depth are normally avoided. Fishermen have a very good understanding of the dynamics of inundation and drying, as well as the network of water channels (ver) of varying depths in LRK, especially along its southern border. The area around Tikar has maximum coverage with sufficient depth of water, and is considered the best fishing ground in the landscape (Figure 19).

Figure 17: Schematic diagram showing arrangement of Katar nets in Rann



Satellite pictures clearly distinguish important water channels and major fishing grounds in the LRK landscape (see Figure 20). Although images show large waterlogged areas, all these areas are not suitable for prawn fishing, mainly because of water depth and to a lesser extent due to the long operating distances. Images also highlight breaking up of water connectivity in the landscape as it starts to dry up. While water tends to stay around Nanda bet, areas along the northern corner and entire eastern fringe dries up early. Keeping all these factors into account, fishing areas are mainly restricted

Table 25: Major Characteristics of Fishing grounds in LRK landscape

#	Fishing Ground	Key Fishing Sites	Fishing Period	Scale of Operation	Catch Type
1	Along the western fringe of Rann (Rann Fishing)	Kuda, Tundi, Koparni, Enjar, Jogad, Tikar, Venasar, Mandarki, Karadiya, Kajarda, part of Hanjiyasar	August –1st Week of October	Covering very large area with intensive catch in each site	Mostly Prawns
2	Along the Surajbari creek (Creek Fishing)	Cherovari, Part of Hanjiyasar,	August – Last Week of October	Covering large area with intensive catch in each site	Mostly Prawns
3	Near Nanda and Shedwa bets (Winter Fishing)	Surrounding waters of Nanda and Shedwa bets	August- Last Week of November	Covering small area with intensive catch in few location	Mostly Prawns and sufficient fish catch
4	Near Khara-ghoda (Khara-Ghoda Fishing)	Khara-ghoda, Kanacha	August- September	Localized and very low intensity catch	Mostly fish catch

Source: *Dixit et al., 2008*

No permanent fishing base exists in the LRK landscape. With the onset of monsoon and once the Rann is inundated, fishermen families set up their transit camps and remain there untill the end of the fishing season

to certain areas (Figure 19).

5.1.8. Fisher Population

Rao (1983) quoted Lakumb (1960) that in 1960 there were many fishing camps along the Suarajbari creek, some of which were abandoned later. Rao (1983) recorded that in 1980 about 2,770 active fishermen, representing approximately 500-600 families, were engaged in prawn fishery in LRK with 307 boats. Later on, Dixit et. al. (2008) reported engagement of between 1,100 to 1,300 families in prawn fishing with about 1,500-1,700 boats. Evidently, fishing operations in LRK have scaled-up during the period.

It is important to mention here that no permanent fishing base exists in the LRK landscape. With the onset of monsoon and once the Rann is inundated, fishermen families from different parts of the landscape and even from far off places, set-up their transit camps on most of the dhassis, to remain there with their entire family till the end of the fishing season (i.e. September or mid October). Fishermen reported that people from far-off places like Dhrangadhra, Surendranagar, Maliya, Morbi, Ahmedabad, Surat, Veraval, Porbandar, Jamnagar, Rajkot etc. are regularly joining the local fishing families during good fishing seasons. In the case of Nanda/ Shedwa site, fishing labours from other states like Bihar and Uttar Pradesh are actually catching the fish on behalf of some local people.

5.1.9. Marketing Mechanism

In LRK, catch of *M. kutchensis* goes to the market via two product streams – fresh and dry. In case of fresh produce, local traders generally purchase high grade prawns. In local parlance the grade of prawn is measured in terms of 'count' and the price of prawn catch varies as per the 'counts'. Dixit et al (2008) reported the differential price of prawn as determined by 'count' in one landing centre of LRK. In 2006, the price of one kg prawn varied between ₹55 for <150 count to ₹30 for 300-350 counts. Thus, the overall ecological health of a fishing zone is reflected, to large extent, by the prawn 'count'. Also, most of the fishers in LRK boil and dry some fraction of their total catch, generally ones that are smaller in size. Thus, fishers realize the prawn value through selling of both fresh and dry prawns. The key characteristics of prawn marketing is presented in Table 26.

5.1.10. Socio-Economic Aspects of Fishery

Primary surveys during 2014 revealed the presence of about 1,265 fisher families in nine fishing locations. In the same locations, however, there were more than 2,000 fishing families in the year 2013 (Table 27). Fishers reported that 2013 was a relatively better fishing season than 2014.

5.1.10.1. Demographic Characteristics

Of the total 1,265 families, 62 fisher families (i.e. 5% of total HH) were surveyed, and details of 422 family members were obtained. 54 families (i.e. 87% of the sample) migrated with all their family members to these fishing locations (Dhassis). Thus, almost 95% of all the

Figure 18: Schematic diagram of setting of Katar & Chatti net

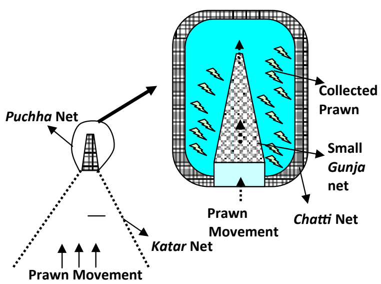
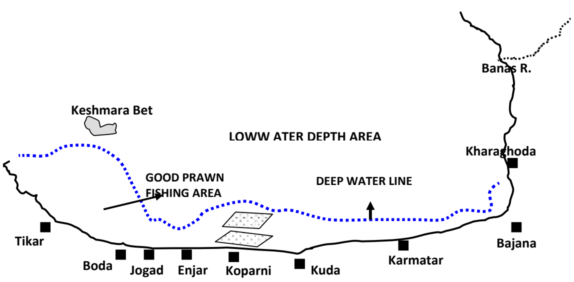


Figure 19: Schematic diagram of setting of Katar & Chatti net



family members were present in the fishing areas, while only 5% members were left behind in their native places. So, those families who are engaged in LRK fishing had nearly complete engagement in this seasonal activity. Out of 402 family members who were present in nine dhassis during the 2014 fishing season, 265 members (i.e. 66% of the total surveyed) were reportedly engaged in various fishing and associated activities like boiling, drying, sorting etc. About 75% of the total non-engaged members were either children or elderly persons (Table 28).

Interestingly, while women constitute about 45% of total work force in all the fishing related engagements, among the active fishermen members their numbers are limited to just about 6%, indicating that fish capture is dominated by men and there is gender disparity in fishing related decision-making. Among all the members who are present in dhassis 48.3% members are in 12-35 year of age group, while the proportion of same age group is about 71% among active fishermen. More than 20% of total active fishermen are in 36-55 year age group. Only 3.5% active fishers are older than 55 years.

About the education status, almost 81% of total member engaged in fishing and allied activities were illiterate and those who are literate, they have an average of 5.46 schooling years. Among the active fishermen, however, illiterate population is about 75% and those who are literate they have an average of 5.47 schooling years.

Importantly, out of 265 members, 141 members (i.e. 54%) are engaged in direct fish capturing activities in other word almost 35% of total members present in all the dhassis this season, only 35% were active fishermen. Average age of these active fishermen was 34.7 years (mini. 10 and max. 65).

5.1.10.2. Fishing Assets

In the context of LRK fishing, four major physical assets are considered important –the wooden boats and three types of nets viz. Katar, Gunja and Chatti. Unlike other fishing areas where boats are used mainly to tap large and diverse fishing grounds, use of boats in the LRK fishing sites are limited to transporting captured prawn from a fixed net location. About 79% of total fisher families own boats (Table 29). Those who do not own

Figure 20: Important prawn fishing areas in LRK landscape. Dotted orange lines indicate important fishing area. Imagery showed drying-up phase of LRK.

Recently, fishing activities in the LRK landscape have increased significantly. Data shows that the number and size of Katar nets under higher weight categories has increased substantially, indicating more intense fishing activities in some sites

boats normally borrow from others for transportation of catch.

Dixit et al. (2008) raised the issue of excessive fishing and thus concerns of sustainable prawn fishing in LRK landscape. It is reported that during last many years, fishing activities in the LRK landscape have increased many folds. One of the important indicators of this is the changing number and size (in terms of weight) of Katar nets. Based on a series of Focus Group Discussions that compared earlier years, the number of nets under higher weight categories have been increased substantially (Table 30), indicating more intense fishing activities in some sites.

The present study observes 38.5% of total households to be using Katar nets of 51-80 kg size, while another 20% fisher families used nets above 80 kg size (Figure 31).

5.1.10.3. Occupation and Income

It is important to understand the overall livelihood profile of the fishing families and the contribution of fishing income in their total economic status, especially during non-fishing season. Other than fishing, the families are engaged mostly in farm labour and salt work. Importantly, these activities are started once the LRK fishing season is over. Out of total sample households, only few (8%) reported their engagement in fishing activities in areas other than LRK. Surprisingly, only about 13% of total fisher families reported their engagement in farming (most of the households are

Table 26: Summary of Prawn marketing system in LRK

Product Type	Basis of price realization	Marketing Channels	Value Chain and Current Price (2013-2014)
Fresh Prawn	Quantity: Dabba (each measure around 13-14 kg prawn) Quality: Count (number of individual per kg of fresh weight)	Local traders collect prawn from fixed fishing locations; they have demarcated areas of operation. For each location traders are fixed and with long term relationship with fishers. Traders supply the collected fish to processing units at Veraval, Porbandar, Jamnagar etc. Sometimes, traders sell to other traders from Mumbai, Kerala, Hyderabad etc.	Fishers get: ₹350-400 per dabba; i.e. ₹25-30 per kg from traders. Traders get: ₹125-150 per kg from processing companies. Fish processing company export: $ 6-10 per kg
Dry Prawn	Quantity: Mund (one mund is 20 kg) Quality: Dryness of prawn	Mostly outside traders collect dry prawns and sell to other traders from different parts of Gujarat and even from other far flung states like Benagal, Orissa, Bihar, Kerla etc	Fishers get: ₹3,500-5,000 per mund i.e. ₹175-250 per kg (7 kg fresh catch is converted into 1 kg of dry fish)
Dry Dust	Quantity: Bori (one bori is about 30 kg) Quality: Not an issue	Not sold but donate the entire volume to some fixed Mosque as part of their contribution to various religious causes.	No idea what mosques ultimately do with the collected dusts. Seems, they sell to some company who make poultry feed and also to some chitin making unit.

Source: *FGD and HH Surveys, Present Study*

Table 27: Key aspects of prawn fishing in year 2013 & 2014

Fishing Settlement	Approx HH (2013)	Approx HH (2014)	Native Place and Number of Families
Koparni	300	17	Kuda-15; Drangadra-2; Surendranagar-1
Moravadar (Navi Hanjiyasar)	150	145	Kajarada-50; Morbi-20; Vad Vinjya-15; Maliya-20;Patti-5; Bhimasar-5; Hanupalar-5; Khirai-5; Dhrangadhra-5; Halvad-10; Rajkot-5
Hanjiyasar#	150	300	Kajarda-150; Hanjiyasar-150 (750 daily up & down)
Nangavadi	250	50	Maliya-5; Juna Hanjiyasar-30; Nava Hanjiyasar-10; Morbi-2; Dhrangadra-3
Cherawadi	300	300	Cherawadi-150; Surajbari-150
Mandarki	150	70	Kajarda-30; Maliya-15; Morbi-20; Surendranagar-2; dhrangadra-2; Kuda-1
Venasar	83	83	Morbi-15; Dhrangadra-11; Maliya-15; Hanjiasar-26; Kuda-5; Surendranagar-5; Nava hanjiyasar-9
Kharaghoda	150	150	Kharaghoda-150
Tikar	500	150	Maliya-20; Viramgam-12; Dhrangadra-25; Kajarda-20; Surendranagar-15; Tikar-10; Sara-8; Morbi-10; Hanjiyasar-6
TOTAL	2033	1265	

Source: *FGD, Present Study*

landless).

In terms of income, on an average each fisher family earns approximately ₹2.05 lakh per annum from varied sources. It is recorded that, LRK related fishing and LRK based salt work generated maximum income to those who are engaged in these activities i.e. ₹1.38 lakh from fishing (i.e. about ₹2300/- per day for a total of 60 days of fishing season) and ₹60 thousand from salt work (Table 31). This highlights the criticality of LRK for livelihood generation for fisher families. It is important to note that LRK fisheries also provide important source of protein and other nutritional values to fisher families and improve their overall health.

5.1.11. Prawn Catch

5.1.11.1. *M. kutchensis* Catch in LRK

In the LRK landscape, the Surajbari Creek is known as traditional prawn fishing grounds. The Miyana Muslims are the main fishing community. Fisheries Department records suggest that in the early 1950s Fisheries department used to give license to fishermen and also collected some tax on total fish catch. During those days, prawn fishing was restricted only to the Surajbari (Cherowari) creek areas. However, there are no records that suggest prawn fishing from current fishing sites like Tikar, Koparni etc. during the late 1960s or early

Table 28: Key demographic characteristic of sample fisher families

Type of Fishing Members	N	Sex		Education		Age (in Years)			
		M	F	Illiterate	Avg. Schooling Years	Upto 12	12-35	36-55	>55
Members present in Dhassis	402	52.7	47.3	80.8	5.0	30.8	48.3	15.7	5.2
Members engaged in fishing & allied activity	265	54.3	45.7	81.1	5.5	8.7	64.9	21.9	4.5
Active Fishermen	141	94.3	5.7	71.6	5.5	4.3	70.9	21.3	3.5

Source: *FGD and HH Survey, Present Study*

1970s. In most fishing locations, prawn (*M. kutchensis*) is the main catch.

Further, number of fishing days is one important determinant of total prawn catch. Among all fishing sites, while the amount of rainfall mainly determines the number of fishing days; local micro-topography and inundation and drying-up patterns have a major influence. Rao (1983) recorded 50 to 70 fishing days at different locations. Dixit et al. (2008) used daily records of fish traders and suggested while fishing season may be large, the actual fishing days are quite limited and mainly determined by tidal pattern and wind direction and speed. Overall, fishermen describe the length of fishing season in terms of how frequently the Rann is inundated. In their definition, a good fishing year will be one when the Rann gets inundated regularly (Dixit et al. 2008). While no site-specific time series prawn production data for LRK landscape is available, Dixit et al. (2008), based on available literature and personal records of fish traders, presented site specific catch data of *M. kutchensis* (Table 32).

At LRK landscape level, some studies reported annual prawn catch data for different years. Accordingly, the prawn catch showed very high inter-year variation with a minimum of 176 to a maximum of 10,925 tons (Table 33), which is directly correlated with the total annual rainfall (Figure 15). Thus, in LRK, there is huge spatio-temporal fluctuation in prawn catch, mainly determined by amount of rainfall and inundation patterns, which is again determined by micro-topographic variations.

5.1.11.2. *M. kutchensis* Catch outside LRK

In order to estimate, with some approximation, the total catch of *M. kutchensis*, available catch data outside LRK was also collected. Multi-year *M. kutchensis* catch data is available from Surajbari, Kandla, Navlakhi, Okha and Mumbai representing the three key habitats of species viz. Surajbari creek, GoK and open seas. On an average 2,694 tons of *M. kutchensis* was captured outside the LRK (Table 34). However, the above estimated value (of 2,694 tons) does not represent total catch of *M. kutchensis* because it is also known to be caught at other locations of GoK and open seas, but for those sites catch data is not available. In fact, the estimated value of 2,694 tons of catch outside LRK is only a fraction of total catch (and thus the total prawn biomass escaped from LRK). Nevertheless, it clearly indicates the minimum *M. kutchensis* catch available outside LRK.

5.1.11.3. Contribution of LRK in Outside Catch of *M. kutchensis*

Keeping in view that LRK is the largest and main nursery ground of *M. kutchensis*, it is interesting to know the contribution of LRK to the total biomass of the catch outside LRK. One way of measuring the contribution

Table 29: Distribution of different types of fishing assets in sample households in LRK

Type	No. of families own	Total Number (or kg)	Avg. per family possession	Avg. Years of Possession
Wooden Boat	49 (79%)	54	1.1	6.6
Fibre Boat	01 (02%)	1	1.0	25.0
Gunja Net	56 (90%)	108	1.9	3.6
Katar Net#	52 (84%)	3575	68.8	4.1
Chhatti	45 (73%)	51	1.2	2.9

 # Katar net possession is reported in Kilogram. More the kg of Katar net, more the fishing area a fisher family appropriate

Source: *Present Study*

Table 30: Change in Katar size in different fishing locations

Weight of Net (Kg)	Venasar		Nangawadi		Kajarda		Nanda/Shedwa	
	Past	Present	Past	Present	Past	Present	Past	Present
Upto 20	25	10	1000	35	215	0	225	0
20-50	40	55	0	500	40	40	0	60
>50	0	10	0	500	15	415	0	60

Source: *Dixit et al., 2008*

of LRK to the *M. kutchensis* catch outside LRK is to estimate the marginal addition (gain) in the body length (and thus the biomass) of *M. kutchensis* during the period when it leaves the LRK and reaches the open sea where normally their mature stages only are found. The catch data of Surajbari and Cherowari (i.e. at the mouth of LRK) as recorded by Sarvaiya (1981) and Rao (1983) reported the length of *M. kutchensis* in the range of 37 to 115 mm. Interestingly, Joseph and Soni (1990) presented 1986-1988 *M. kutchensis* catch data of Okha coast and found that the size ranged between 106 to 160 mm. Although there is difference between male and female sizes, at a very crude level the above recorded differences in size at LRK mouth and open sea area indicate that there is only about 28% additional gain in the length (and biomass) of *M. kutchensis* once it leave LRK waters. In other words, the LRK contribute 72% of the total growth of individual *M. kutchensis* (as reflected by length of prawns) even before they leave for GoK and open sea areas. Thus, we can safely assume that nursery ground of LRK contributes 72% of the total biomass of mature *M. kutchensis* that are caught outside LRK.

5.1.12. Livelihood from Prawn Fisheries in LRK

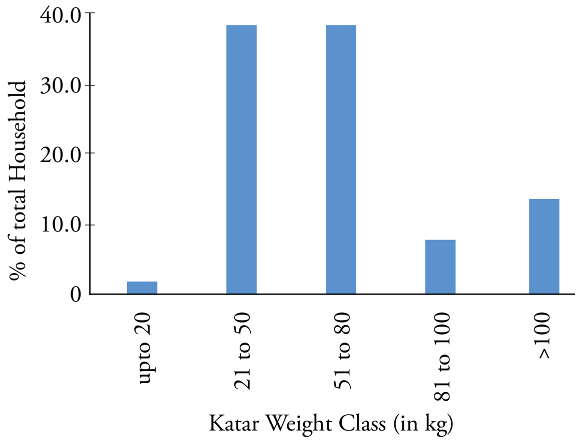
During present study, we estimated total prawn biomass catch for 2013 and 2014 fishing season by sampled fisher families. Accordingly, in the 2014 season, on overall basis, average per family prawn catch was estimated to be about 2,860 kg (Table 35). Among the fishing sites, Nangavadi and Enjar registered very low per family prawn capture (455 Kg and 544 Kg, respectively), while Murvadar Dhassi in Hanjiyasar registered very high per family prawn catch of about 8,417 Kg (Table. 35.). Compared to this, in 2013 per family prawn catch was about 600 kg more with an average catch of 3,479 kg.

Table 31: Family level income from various sources

Occupation	No. of HH	% of total	Avg. annual Gross HH income (₹)
Fishing-Inside LRK	62	100.0	138302
Farm Labor	39	62.9	33031
Salt	28	45.2	60089
Agriculture	8	12.9	NA
Self Employed	8	12.9	20600
Fishing-Outside	5	8.1	27920
Livestock	5	8.1	11100
Non-farm Labor	5	8.1	84600
Service	5	8.1	73600
TOTAL			204780

Source: *Present study*

Figure 21: Frequency use of Katar nets of varying sizes in LRK



It is interesting to record from the household level catch data that there is marked inequality in terms of resource appropriation. In 2013, about 60% of total fishing families captured only about 30% of total prawn biomass, while 20% families appropriated about 50% of the total catch of the season (Figure 22). In 2014, the inequality in prawn biomass appropriation is more pronounced as only 20% families captured 60% of the total prawn biomass resources (Figure 23). Relatively poor fishing season in 2014 seems to have influenced disparity in capture of biomass resources.

In LRK, number of fishing days varies depending upon rainfall. In a good rainfall year, the fishing season can operate up to 90 days which reduces drastically in low rainfall years. Therefore, fishing days are not pre-defined and it is essential to estimate per day catch (and income). According to fishers, 2013 and 2014 fishing years were not good compared to normal. Despite this, average prawn catch per family was 3.5 and 2.9 tons, generating an income of ₹1.38 lakh for 2013 season (see Table 31). This indicates that during 2013, when actual number of fishing days was about 60 days, each family earned at a rate of ₹2,300 per day from LRK fishing alone. It suggests that LRK fisheries generate substantial livelihood for the fishing communities that depend on it, especially in view of the fact that majority of fisher families are landless migrants. It is important to highlight that wetlands in arid region like LRK could sustain livelihood of about 2,000 landless families, even in below normal monsoon years (such as in 2013).

Livelihood based on seasonal fishing in LRK, although lucrative, is quite uncertain in term of production and catch and thus fluctuates extremely in a short run. Further, it is also established that among fisher families there is huge inequality in incomes from fisheries (Figure 22 and 23). Still, in combination with salt work, it generates good income for predominantly landless societies in the LRK landscape. Poverty, however, is also defined by many other systemic factors that deprive fisher families various services such as health and education, housing and safe drinking water, rights over land and water resources, and, continuous fear of losing occupation due to PA's legal settings. Most importantly, the imperfect and exploitative market system further constrains their income generating abilities.

The above factors pose serious policy challenges in conserving and enhancing fishery resources in LRK for not only generating revenues but also supporting livelihoods of fishing communities on a sustained basis.

5.2.13. Understanding the Ecology and Economics of Prawn Fisheries

5.2.13.1. Ecological Factors affecting *M. kutchensis* catch

Based on discussions in the above sections, the following facts are evident:

Table 32: Summary of Prawn catch data in different fishing sites of LRK

Fishing Ground	Fishing Site	Approx. Prawn Catch (Tons)	Year of Catch	Source
Rann Fishery	Koparni	300	1980	Rao (1983)
		57.4 to 275.7	1990 to 2001	Kanuba Jadeja (Pers. Record)
		14	2007	Hasan Mohd. Movar (Pers. Comm.)
Rann Fishery	Kuda	126	1980	Rao (1983)
		8.8 to 193.1	1990 to 2001	Kanuba Jadeja (Pers. Record)
Rann Fishery	Tikar	128	1980	Rao (1983)
		9.1	1990 to 2001	Kanuba Jadeja (Pers. Record)
		275	2006	Karim bhai (Pers. Comm.)
		165	2007	Karim bhai (Pers. Comm.)
Rann Fishery	Mandarki	160	1980	Rao (1983)
Rann Fishery	Venasar	56	1980	Rao (1983)
Rann Fishery	Kajarda	512	1980	Rao (1983)
Rann Fishery	Tundi	15.4 to 138.2	1990 to 2001	Kanuba Jadeja (Pers. Record)
Rann Fishery	Enjar	39.7	1990 to 2001	Kanuba Jadeja (Pers. Record)
Creek Fishery	Surajbari	688.7	1980	Rao (1983)
	Lakhiyasar (Hanjiasar)	103.3	1980	Rao (1983)
		224.65	2006	Bandhani bhai (Pers. Record)
	Nangavadi (Cherowari)	192	1980	Rao (1983)
		381	1973-74	Sarvaiya (1981)
Adesar Fishery	Sukhpar	11.2	1973-74	Sarvaiya (1981)
	Nanda/	80	2006	Gafur bhai/ Amir Bhai (Pers. Record)
Khara- ghoda Fishery	Kharaghoda	32.5	1980	Rao (1983)
		2.0 to 5.0	2005 to 2007	Umar bhai (Pers. Comm.)
	Kanachar	13	1980	Rao (1983)

Source: *Dixit et al., 2008*

Prawn production areas appear to be mainly controlled by their proximity to creek water and the opening of a river/stream mouth. Average biomass capture was significantly higher at locations near river mouth openings and was highest at sites near to both a creek and river mouth

- In terms of fishing operations, fishing in LRK may be considered along four typologies, with monsoon Rann fishing and creek fishing being the predominant ones.
- Production of *M. kutchensis* in LRK is largely dependent upon rainwater inflow which brings nutrients and other detrital materials to support its food-chain.
- Creek waters bring the seeds and larvae of *M. kutchensis* as well as its many food organisms (zoo and phyto-planktons).
- Spatio-temporal variation in prawn catch is quite pronounced. Thus, while different years produced different levels of *M. kutchensis* catch, there are also variations across the sites in a same year.

It is important to note that geographically separate zones have different potentials for the production of *M. kutchensis* biomass within the LRK. Although no previous studies have discussed this aspect of prawn production in LRK, there is awareness among the fishers about better production areas. It appears that the prawn production areas are mainly controlled by two major factors:

- Proximity to creek water, so that the area is continuously connected with GoK, which bring new seeds and larval stock to LRK area.
- Proximity to the opening of river/ stream mouth where the rainwater drains into LRK and in turn brings rich feed of nutrients and detritus materials. Although the river/ streams are ephemeral in nature, the large catchment areas provide enough weathered rock materials and agri-wastes which flows into LRK and spread in nearby areas. Thus, they function like micro-estuaries, although for a very short duration.

Realizing the importance of above factors in prawn production, for the purpose of present study, we grouped all the sample fishing locations into one of the four types (Table 36).

Interestingly, as expected, average prawn biomass capture (a reflection of total production) revealed that locations near the river mouth openings recorded a significantly higher biomass capture compared to those sites where river mouths do not open. More importantly, the sites which are close to the creek, and also had a river mouth nearby, the prawn biomass capture was found to be the highest (Table 38). The site like Koparni, which has neither creek connectivity nor river mouths, reported catch of smaller size prawns (Rao, 1983). This further corroborates the role of creeks and river mouth openings in prawn production cycle. (Table 37).

The above data further substantiates the view that in the context of prawn fishing in LRK, rainwater discharge into LRK and continuous connectivity with sea water through creeks are playing important roles in biomass production.

M. kutchensis is a 'euryhaline' species i.e. having a wide range of salinity tolerance. In other words its adult does not have any problem in living in either saline sea water or in less saline (brackish) LRK wetland water. Then, it is interesting to question the key function of

Table 33: Prawn catch in different years

Year	Rainfall (mm)	Total Catch (in Tons)
1992	422	5969
1993	137	1777
1994	1019	10925
1995	276	4086
1996	336	2935
1997	719	4730
1998	345	4297
1999	277	176
2000	324	2260
2004	428	1589
2005	591	2256
2006	848	4162
2007	686	2721
2008	491	1970
2009	421	1740

Source: *Deshmukh 2006; Ghosh et al 2012*

Table 34: Average catch of *M. kutchensis* from inside and outside LRK waters

Fishing Location	Data Source	Data Year	Avg. catch (Tons)	Remark
Surajbari	Rao, 1983	1980	688.7	Actual *M. kutchensis* catch data
	Parvez, 1990	1977-1987	648.3	Actually reported total prawn catch and for the present study we estimated the catch of *M. kutchensis* by its proportion in total prawn/shrimp catch
	Fisheries Dept.	2008-2010	67.2	
Kandla	Fisheries Dept.	2008-2013	103.2	
Navlakhi	Fisheries Dept.	2008-2013	72.2	
Okha	Joseph & Soni, 1990	1986-1987	1263.0	Actual *M. kutchensis* catch data
Mumbai	Deshmukh, 2006	1990-2000	566.4	
Total Catch Outside LRK			2693.5	

saline water inflow from creeks and also the discharged runoff water in LRK? Based on literature review presented in earlier sections and the prawn production related evidences generated under this study, we can construe that:

a. The main role of sea water in prawn production system of LRK is to bring seeds and larvae of both *M. kutchensis* and its diverse zooplanktonic food items.
b. The main role of freshwater runoff flow into LRK is to transport nutrient and detritus which are necessary for the growth of both *M. kutchensis* and its food items.

Although there are serious gaps in knowledge about the ecology of *M. kutchensis* in LRK, this study is able to assert that while for the ecosystem services of prawn production to continue, some minimum freshwater flow is essential (i.e. e-flow) from nearby catchment areas. However, it is clearly observed that in order to increase prawn production more and more freshwater flow should reach to LRK.

5.1.13.2. Economic factors affecting *M. kutchensis* catch

The volume of fish catch at family level is generally assessed against the quantum of effort. In the present study, factors like use of fishing gears (like nets and boats), availability of number of active fishermen in the family and their fishing experience were examined to understand their relationship with prawn catch during the 2014 fishing season. Surprisingly, no such correlations were recorded between family level prawn capture and (a) quantity of Katar net used (Figure 24), (b) number of active fishermen in the family (Figure 25) and, (c) average year of experience of active fishermen (Figure 26).

Table 35: Average Prawn catch in 2013 & 2014 years across fishing locations

Name of Dhassi	No. of Sample HH	Average Per HH Fresh Biomass Capture (in Kg.)	
		2013	2014
Cherowari	1	1583.4	1037.6
Enjar	2	1266.7	543.7
Gadhabet	5	2081.6	2319.5
Koparani	7	2156.4	1225.1
Mandarki	6	2463.1	1565.1
Murvadar(Hanjiyasar)	8	8761.5	8416.7
Nangavadi	2	1372.3	455.0
Setudi	2	4222.4	2952.3
Tikar	18	2721.1	1953.8
Tundi	2	3061.2	3819.7
Venasar	2	5278.0	4315.0
Overall	55	3478.9	2859.5

This absence of correlation with fishing effort is interesting and further highlights the difference of LRK fisheries with other, stable, open-access fisheries (such as in the open seas). Fish catch in LRK is dependent on trapping, rather than catching, which relate primarily to the site, rather than the effort.

As discussed in the previous section, sites within the LRK are the prime determinants for the catch, and this is known to the fishermen communities who have traditional norms for occupying these sites. Fishermen families allocate fishing rights every season for areas in LRK according to these informal institutional arrangements.

Figure 22: Distribution of prawn catch across families in 2013

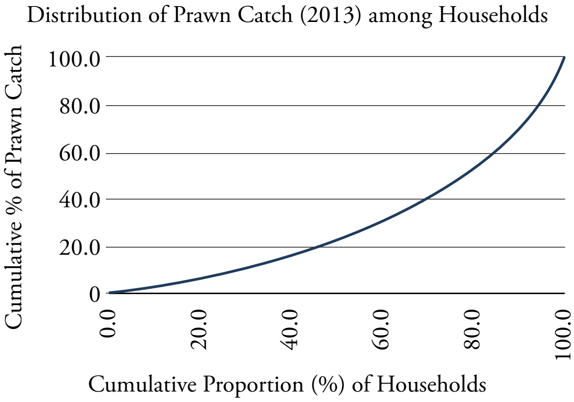
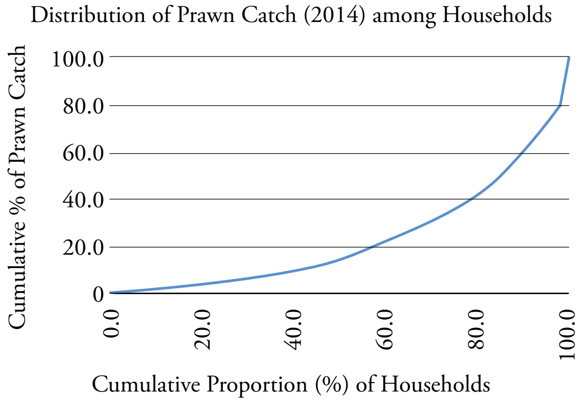


Figure 23: Distribution of prawn catch across families in 2014



Furthermore, as discussed earlier, due to slight topographical variations, in each of the fishing locations there is heterogeneity in fishing areas which ultimately provide different quality of micro-habitats for prawn fishing. Thus, for example, in each location, there will be some fisher families which have fishing rights in good fishing habitats; others may have traditional rights in poor quality fishing habitats.

It is also interesting to recognize that unlike other marine fishing areas, in LRK there is no diversity in catch (all are capturing *M. kutchensis*) and thus no diversity in fishing tools (like nets and boats to exploit different habitats and different species). Importantly, such fishing does not require any specific skills and knowledge. In other words, in multi-species fishing operations, use of appropriate technology as well as skilled human resources is a pre-requisite to extract marginal benefits from fish / prawn catch. While in the present context of LRK these factors are quite redundant. This is quite evident with the fact that quite a large number of families and their members are engaged in fishing related activities in LRK for just 2-3 months and thus, act like floating (migratory) fishing population.

Theoretical understandings of open access fishing system also suggest that once the fishing efforts are more, systems sooner or later reach to the point generally known as 'common property resource equilibrium' (CPRE). Once fishing reaches beyond CPRE level there will be no marginal benefits in putting extra fishing efforts. In LRK, poor rains in 2013 and 2014 seasons seems to set-up CPRE like situations and thus even bigger net may not be able to provide marginal gains in prawn production, as reflected by poor correlation between net quantity and prawn catch.

Considering above fishing characteristics of LRK, it can be inferred that for day to day fishing there is no marginal benefit of having more boats or engaging more labour with more years of fishing experience. In a practical sense, after setting the nets etc., the prawn capture in LRK runs in "auto-function mode". Even more fishing efforts, as reflected by the use of more nets covering more fishing areas, do not bring marginal gains in prawn catch. This is because the volume of prawn catch is determined by where actually a family gets its traditional fishing right (where he can set-up his Katar net). If he gets better fishing micro-habitat it is more likely that he would get a better catch, if he gets access to a poorer habitat then naturally the catch will be low.

In nutshell, the prawn production and catch in LRK is determined by following factors:

- Inflow of sea water and along with it seed and larvae

Table 36: Distribution of sample location across different ecological conditions

Proximity to River Mouth	Proximity to Creek Water	
	No	Yes
No	Tundi, Koparni *Sample HH : 9*	Cherowari *Sample HH : 1*
Yes	Enjar, Tikar, Mandarki, Venasar *Sample HH : 28*	Gadehdabet, Murvadar (Hanjiyasar), Nangavadi, Satedi *Sample HH : 17*

For many years, LRK was the leading salt producing area of India. Today, more than 59,000 people from over 100 villages are involved in salt making activities in LRK. Agariyas migrate from their respective villages to Rann area during the fall, and they remain there until the onset of the monsoon

of *M. kutchensis* and other species;
- Inflow of rain water which brings large quantity of nutrient and detritus materials;
- Micro-habitat heterogeneity in each fishing location due to slight topographical variations;
- Customary institutional norms to provide access to fishing grounds, having different degree of habitat quality for prawn production.

5.2. Salt Production in LRK

Traditionally, salt is collected as salt precipitate from saline soils. Over a period of time, the process of collection of salt evolved into a sort of farming through solar evaporation of seawater (marine salt) or subterranean brine (inland salt). In 2012, global salt production was about 276 million tons, of which India's contribution was about 9% (China's contribution was about 22.5%). Within India, Gujarat alone contributes about 77% to the total production, followed by Tamil Nadu (11%) and Rajasthan (10%).

Within Gujarat, there are two major natural sources of salts – marine and inland (mainly from LRK). It is estimated that about 55,000 salt workers (locally known as Agariyas) are engaged in the salt making process in the State. Around 10,000 Agariya families are involved in inland salt farming in LRK between the month of September and May. Kolis are the numerically predominant community (60%) who are engaged in salt manufacturing, followed by Muslims (35%) and other communities. The literacy rate among salt workers in LRK is quite low at 22.8%. This is mainly because children also migrate to saltpans with their parents and thus drop-out from schools. Although recently state government with the help of NGOs provide education at the salt-pan sites, the response remains quite inadequate.

For a very long time, LRK was the leading salt producing area of the country. Various historical documents suggest that salt production is an age old activity in the LRK. Early history of salt making is not known but according to government records, salt production in LRK is carried out since 1874. However, it is believed that large scale salt making had been going on in the areas of Patadi, Jhinjuwada and Kharaghoda since 10th century (Campbell, 1887 – cited in Bharwad and Mahajan, 2008).

People from more than 100 villages are involved in salt making activities in LRK. Every year during late October, when Rann starts drying, Agariyas migrate from their respective villages to Rann area for a period of 7 to 8 months and remain there till the end of May i.e. just before the onset of monsoon. Bharwada and Mahajan reported that around 59,600 people from 102 villages of five districts are involved in salt making and other related works (like transport, loading-unloading) (Table 38).

However, the Industries Commissioner, in response to an RTI application, reported that in 2007 there were about of 48,400 Agariyas distributed in 5 districts surrounding LRK (Banaskantha- 3400; Patan- 7000; Kachchh - 19,000; Surendranagar - 15,000 and Rajkot- 4000).

Table 37: Average prawn capture (kg) at different fishing sites in two sample years

Proximity to River Mouth	Proximity to Creek water				Overall	
	2013	2014	2013	2014	2013	2014
	No	Yes	No	Yes		
No	2358	1583	1802	1038	2280	1725
Yes	2745	5393	1938	5044	3745	3112
Overall	2650	5182	1905	4821	3479	2860

Figure 24: Relationship between prawn capture and net quantity in LRK

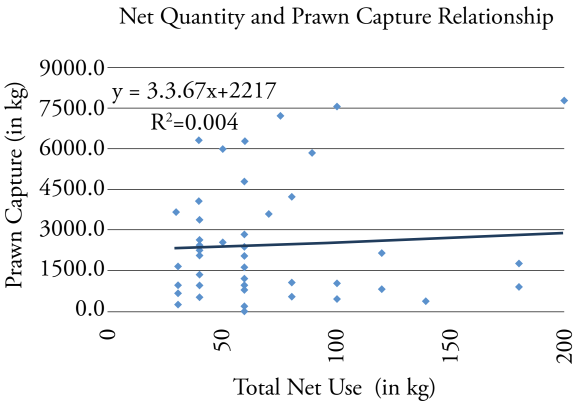
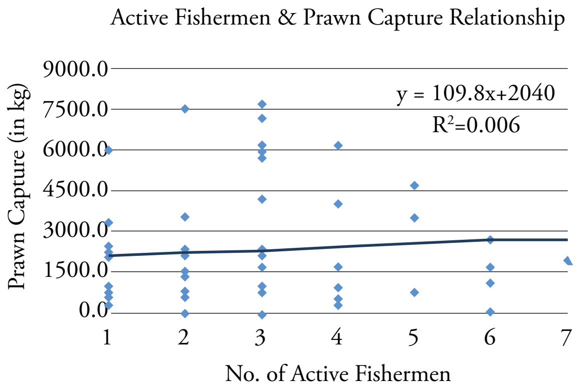


Figure 25: Relationship between prawn capture and active fishermen in family in LRK

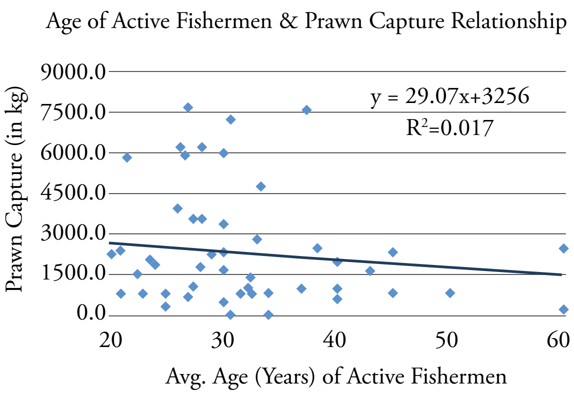


5.2.1. Salt Production System in LRK

In LRK, salt is not produced from all over the place, rather they are mostly located in the places where good quality sub-soil brine is available or where sea water can be drawn into the pans. As per the geographical spread of current salt making areas in LRK, there are clearly six salt zones. They are Dhrangadhra, Kharaghada, Santalpur, Adesar, Maliya and Halvad (Figure 27). Dhrangadhra is considered as the oldest inland salt making region.

Presently two types of salts are produced in LRK, the Vadagaru (Poda) and the Karkach. All the salt production in the LRK is done manually. In LRK, salt preparation requires special skills and only those, with long experience gained through generations, get involved in it. Average production of Vadagaru is 1500 tonnes per 10 acre unit whereas Karkach productivity is about 2000 tons.

Figure 26: Relationship between prawn capture and average age of active fishermen in LRK



The production structure of inland salt making consists of multiplicities of vertical linkage and is a factor of area of operations in terms of land holding. Land holding units (recognized and unrecognized) are classified into four categories. They are:

- Category I: Plots of over 100 acres, owned by public and private limited company.
- Category II: Plots between 10-100 acres, owned by private traders and manufacturers.
- Category III: Plots with less than 250 acres in name of cooperative societies.
- Category IV: Plots up to 10 acres.

In the LRK, two major companies, Hindustan Salt Works – a public sector company in Kharaghoda, and Dhrangadra Chemical Works – a private sector company in Dhrangandra, hold lease for over 24,000 acres of land. However, due to rising cost of production and rigid labour laws, they prefer to buy salts from producers of II, III and IV categories.

To most people, manual salt making appears to be a very simple system – making pans, spreading the brine, drying it and harvesting the salt. But it is far more creative and complex, subject to many risks and uncertainty. Except Drangadhra zone, agariyas (salt-producing communities) migrate to LRK from 8-45 km away in different zones. Quality of sub-soil brine also varies across zones, low in Halvad (9-12 0B) and high in Kharaghoda (18-24 0B). In order to counter uncertainties related to availability of brine, agariyas use multiple bore wells (Table 39).

Diesel engine run on crude oil is the main source of underground brine extraction. However, during our field survey it was found that a few salt farmers

Table 38: Summary of scale of salt work in different districts

District	Taluka	Village	Communities	People involved		Total
				Production	Transport	
Surendra - nagar	Kharaghoda	25	Koli, Darbar, Dalit, Muslims	15341	7675	23016
	Dhrangadhra	23	Koli, Darbar, Dalit			
	Halvad	15	Koli, Miyana, Dalit, arbar			
Patan	Santalpur	12	Sandhi Muslim, Koli, Darbar, Ahir, Dalits	19031	9928	28959
Kachchh	Adesar	9	Sandhi Muslim, Ahir, Koli	1488	744	2232
Rajkot	Maliya	18	Koli, Miyana Muslims, Dalits	3629	1785	5414
	Total	102		39489	20132	59621

Source: *Bharwada and Mahajan (2008)*

have adopted solar pump-sets for extracting brine. Discussion with agariyas revealed that there is a mixed response though majority agreed that introduction of solar pump as a new technology has reduced energy cost of brine extraction. Major problem identified by agariya is initial capital for technology acquisition. Apart from brine extraction, the entire process of salt making is quite labour intensive.

It is important to mention here that extraction of sub-surface brine leads to a drop in its level, forcing agariyas to use higher capacity pumps to extract brine from deeper zones. It has its own cost escalation cycle. On the other hand, inland salt is losing market share against marine salt, which is more competitive given its lower input costs. Procurement price remains stagnant while there is a constant rise in cost of production. Finally, the profit margin is declining for LRK agariyas. However, since majorities are landless or very small hand holders, they do not have other alternative source of income, and mostly resort to daily wages during non-salt farming season.

5.2.2. Salt Production Process in LRK

Solar evaporation of brine is the main technology used for salt production. In LRK, sub-surface brine having salt density of 9-24 degree Beume (0B) is pumped from a 25-200 feet deep dug well and spread over 8-10 condensers through mud channels for evaporation. From there it moves from one condenser to another, finally reaching the crystallizer. In the crystallizer, the highly concentrated brine is allowed to settle and form salt crystals. This is the traditional method of inland

Table 39: Characteristics of salt production system in different zones of LRK

Details	Dhrangadhra	Kharaghoda	Santalpur	Adesar	Halvad
Salt type	Crystal Poda	Crystal Poda	Crystal Poda	Karkach	Karkach
Distance of Salt pans from the village (km)	5 to 10	15 to 45	10 to 18	10 to 20	8 to 12
Brine Degree (0B)	18-20	18-24	16-20	16-18	9-12
Bore Depth (in feet)					
2007	75	150	200	190	60
1997	50	70	45	50	30-35
Avg. no. of well	50%-1 well 50%-2 wells Max of 2 wells	50%-1 well 25%-2-3 wells 25%-6-7 wells (max. 10-12 wells)	50%-1 well 50%-2-3 wells	50%-1 well 50%-2-3 wells	90%-1 well
Fuel used (Barrels per season)	7 to 10	8 to 12	7 to 12	7 to 10	5

Source: *Bharwada and Mahajan, 2008*

Figure 27: Areas of salt extraction and processing in LRK. Salt Zones: 1-Dhrangadra; 2 – Kharaghoda; 3 –Santalpur; 4- Adesar; 5- Maliya; 6- Halvad

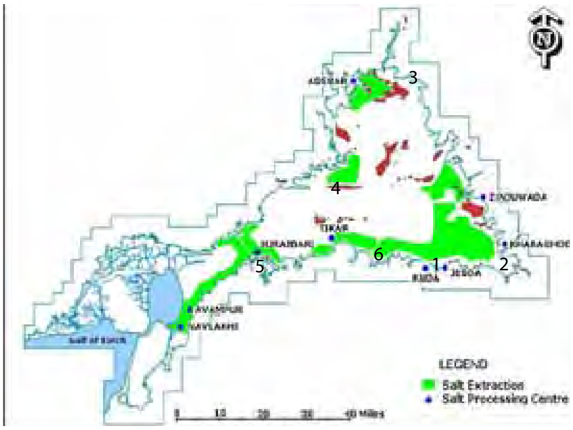
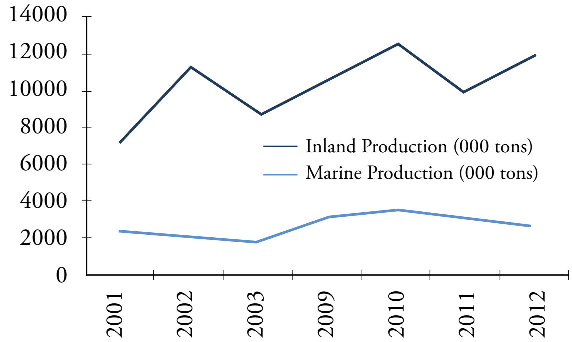


Figure 28: Inland & marine salt production in Gujarat



salt production in LRK, which is used to supply almost 50% of the total salt need of the country. Ironically, however, the contribution from this inland sector is consistently declining due to upsurge in industrial demands and engagement of major industrial groups like Tata, Reliance, Adani etc. who operate in cost effective marine salt sector (Figure 28). Importantly, in the landscape, such marine salt making units are rapidly increasing in and around Surajbari creek areas.

Nevertheless, the inland salt production sector of LRK still produces substantial volume of salt. In 2012, 26.5 lakh tons of inland salt was produced from LRK. However, between 2008-09 and 2011-12 on an average 30.8 lakh tons of inland salt was produced from LRK wetland area, which had about 22% share in the total salt production of Gujarat. (Table 40).

5.2.3. Role of LRK Wetland in Brine Production

In the context of the present study, it is important to check how the underground brines are formed and what role wetland ecosystem services play in creating brines and finally the salt?

Natural brines are waters with very high to extremely high concentrations of dissolved constituents – atomic elements, ions, and molecules. Brines are commonly more concentrated than sea water, which normally contains 35 ppt of dissolved salts, mostly sodium chloride. Concentration of salt in brine can be more than five times of average sea water.

Natural brines are formed by several mechanisms including: evaporation, formation of sea ice, and solution of salt domes. Global literature suggest that

Table 40: Summary of marine and inland (LRK) salt work and production in Gujarat

Year	Total Lease Area (Acre)	Total Cultivated Area (Acre)	Total Salt Production in Gujarat (in 000 tons)	Marine Production ('000 tons)	Inland* Production (LRK) ('000 tons)	% of Inland in Total
2001	NA	NA	9647.8	7408.0	2239.8	23.22
2002	NA	NA	13107.8	11254.9	1852.9	14.14
2003	NA	NA	10585.9	8816.7	1769.2	16.71
2008-09	72311	27496	13616.7	10450.8	3165.8	23.25
2009-10	80619	36323	15975.4	12492.2	3483.1	21.80
2010-11	87457	36144	13224.4	10210.3	3014.2	22.79
2011-12	81177	34906	14628.6	11976.5	2652.1	18.13
Avg. 2008 -to 2012	80391	33717	14361.3	11282.5	3078.8	21.44

* *Inland salt in Gujarat actually meant salts produce from LRK*
Source: *Annual Reports. Salt Dept, Ministry of Commerce and Industries*

Box 1: Little Rann of Kachchh & Brine Formation

Brine containing sand bed formed the brine aquifer of confined type; but without any significant pressure conditions. Level depletion caused by eight months of non-monsoon pumping gets replenished during the four months of monsoon non-pumping. It should be noted here that the replenishment is not because of the monsoon recharge but it happens due to the level balancing within the aquifer, between depletion in the pumped out areas unaffected non-pumped areas. Unchanged chemistry of the brine quality, after the seasonal pumping pause, is the evidence of such argument. Almost all the freshwater discharge from the rivers (Banas, Saraswati, Rupen etc.) on the eastern border of LRK gets evaporated rather than recharging the aquifer below the 10m thick almost impermeable top soil. The aquifer, on the western side would open out far away from the shoreline in the open sea. The level difference between the freshwater river discharge in the east and the aquifer mouth opening in the sea bed in the west could be of the order of few tens of meters against the distance between the two locations is few thousands of meters. Such hydrostatic conditions under the confining impervious cover of more than 10m thickness can not affect the brine chemistry. Some exceptional conditions of creeks and surface water pools may case recharge and affect the chemistry at a very local scale. Periodic earthquake occurrences could affect the sand bed conditions that, in turn, could affect the brine chemistry along the lines of disturbances. However it may be noted that the brine chemistry has remained almost unaffected in spite of century's long extraction and natural disturbances.

Here it is very necessary to make sure about salinity relation between the brine underground and that of the top soil on the ground. It is very clear that the difference in the salinity concentration between the brine and that of the top soil on-ground is very high. Chemical difference between the two is required to be studied. Chemistry will indicate the source of salinity; whether it is common or different. Depth and extent of capillary movement of the salinity in the top soil can be ascertained. And if that its connection with the brine at 10m depth is possible or not can also be ascertained. Further, the top soil on the ground is subject to sea water by way of tide, wind and underground ingress. River discharges would also contribute some salinity as brought from the upland. Amount of all that different salinity from different sources need be ascertained and be compared with the chemistry of the brine. Physical and hydraulic properties of the different soil layers from top to those hosting the brine also need to be determined to help establish relations between the brine with the surface salinity. Geomorphic mapping of the LRK can also help understanding the pattern of surface water movement in terms of trends of salinity transfer. Once the relation between the brine and the top soil is established it would help in planning for the course of development of the brine resource and the land resource. It will open several options at local scale & regional scale.

Personal Comm. (Prof P. P. Patel, Retd. Professor, Geology Dept., MS University, Baroda)

brines are often found along with oil and gas wells occupying most pore spaces within rocks or clay or silt deposits and are a process which occurred in the geological time scale (Dresel and Rose, 2010, Poth 1962). Often these geologically trapped resources are locked in apparently stable gravity-stratification which allows brine to persist in geological time scale (Dresel and Rose 2010). Formation of brine, therefore, is not a seasonal or annual phenomenon; rather it is a result of geological processes, where evaporation and other chemical processes also play important roles.

In case of LRK, brine is available in highly permeable sub-surface sandy horizon of about 30-40m thickness below the top soil of silts and clay which is almost impermeable. It is trapped deep underground due to specific fluvio-marine geologic environments and changing climatic conditions.

Since, no systematic work has been carried out so far to understand the genesis and hydrological properties of brine in LRK, several hypotheses exist; e.g. Sathyapalan et al. (2014) indicated that after the rains, freshwater percolates inside and mix with a layer of salt and thus create highly saline brines. Narie (1964) suggested that brine in LRK is formed by sea water that is connected to LRK through the lower soil strata. However, according to a leading geohydrologist (see Box 1), brine did not form due to any existing ecological as well as hydrological functions of LRK wetlands.

However, it is important to understand that even though the brine formation is considered as a geological service (not as an ecosystem service), in the context of salt production in LRK, seasonal flooding has a role in salt production, in addition to the land available for the pans. During our field survey and in-depth interaction with salt traders and Agariyas, it emerged that seasonal flooding leads to:

a. clearing of salt wastes and other chemicals that were left at the end of previous cycle of salt production. It is very important that before starting the new production cycle, all the salt remains are cleared, otherwise making of condenser and crystallizer pans is difficult and thus process of brine storage and conversion to salt is affected.
b. control of wind-induced soil erosion. During the course of salt formation, it is important that it should not be exposed to soil-dust. The wetlands bind and suppress the soil against the strong winds, a normal phenomenon in LRK. This actually helps in producing better quality salt. Some of the Agariyas had strong views that if there is no formation of wetland in LRK, quality of salt production will declined drastically, and thus there is no point of making salts in such poor years.

A household survey of 80 agariya families recorded that 93% had a strong perception that the wetland play above two functions in salt production and thus supporting monetrary value generation.

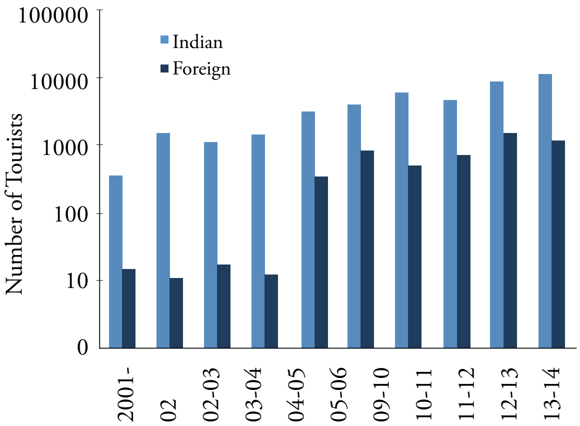
Importantly, they reported that in a year if there is poor flooding of LRK (or wetland formation) there will be about 45% reduction in the total value of the salt due to a combine factor of production loss as well as quality loss.

The above discussion clearly establish that although the salt production in LRK is mainly a function of geological services (by providing brines), the wetland's waste assimilation and soil-holding (or thus erosion control) functions help in improving quality and production of salts to quite a significant manner. It is important, however, that although majority of Agariyas perceived thatthe above two functions of wetlands are critical for production and quality of salts, these need further corroboration by collecting empirical data on these aspects.

Table 41: Key features of LRK that have educational and recreational value for tourists

Key Values	Description
Seasonal wetlands	• Recognised as 'Wetland of National Importance' by MoEFCC • Aquatic birds of importance for tourism • Habitat for aquatic biodiversity • Important spawning, nursery/ feeding ground of prawn (*M. kutchensis* - endemic) and other fish that migrate from GoK. • Habitat for aquatic migratory birds • Breeding sites of Lesser Flamingos
Dry Rann/ mud flat	• Mesmerizing landscape/ mud flat and salt pan • Habitat of Indian Wild Ass • Importance of tourists for wild ass and other wild species like chinkara, blue bull, hyena, wolf, Fox and desert cats etc • Halophytic vegetation (Suaeda and many grass species.)
Bets	• Tourists importance of Mardak bet • Habitat of Indian Wild Ass • Habitat for threatened terrestrial birds like Houbara Bustard • Pung bet - the largest bet in LRK • Religious and sacred places (temples in Bachharaj in bet) • Traditional habitation in Nanda bet
Dhassi	• Of-late, of lesser importance for tourists • Important for fishers communities for temporary settlements and fishing • Habitat for terrestrial flora and fauna
Creek System	• Not important for tourists activity yet, though it is life line for very survival of LRK wetland • Through creek, saline water travels from GoK and maintain a unique brackish water habitat • Provides habitat for fish species and fisheries for communities
Fringe areas	• Gaining importance for tourists • Tourists resorts established especially on the eastern and southern regions of LRK supports vegetation and human habitation • Provides habitat for wild life • Around 43% of wild ass inhabits the fringe area (Management Plan for WAS, Dept of Forest, Gujarat, 2014) • Grazing of livestock (local and migrated)

Figure 29: Number of Indian and Foreign Tourists



5.3. Tourism in LRK

LRK landscape as a whole is amenable to various forms of tourism services for various reasons. It has unique wildlife values thanks to vast tracts of flat wilderness of Rann, magnificent mirage effect, population of wild ass, diversity and abundance of migratory and resident aquatic and terrestrial birds like cranes, flamingos, pelicans, houbara bustard etc. Other than the wildlife, the landscape also provides several sites of cultural, archaeological and religious values (Table 41). Tourists visit the place because of all these aspects, rather than for any one thing in particular.

However, despite these values the potential for tourism development is not fully tapped in the landscape. There are quite a few private tourism complexes that provide facilities for wildlife and nature viewing. While the number of tourists is growing over the last few years, yet considering its vast potential, the numbers are too low to sustain tourism as an industry.

The major factors that attract tourists are flamingos, wild ass, LRK landscape and other biological diversity. There are 6 functional private resorts that provide tourism facilities in LRK. During our field visit we observed many new resorts coming up in the fringe areas of LRK, mainly near its eastern parts.

Currently, tourism activities and services are conducted and provided by private tour operators. In the year 2013-14 total tourist inflow to LRK was 11,587; among them, 10,402 were Indian and 1,185 were of foreign origin (Figure 29, Table 42). The decadal compound growth rate is about 24%. In LRK, generally private resorts (tour operators) take permission from the Forest Department by paying an entrance fee. There are 3 entrance points from where tourist can enter (Bajana, Dhrangadhra and Rapar). Moreover there are no tourist zones in LRK, and it is up to the private tour operators where they want to take their tourists. In LRK, tourism activities are mainly restricted to winter season. Therefore, tourism activity in LRK is quite seasonal in nature.

5.4. Conclusion

Based on discussions presented in this chapter, it is clearly established that LRK support two major primary production systems – prawn and salt. Of these two systems, while prawn production is empirically proved to be associated with the ecosystem functions of wetlands formed in LRK, the salt production system perceived to have clear associations with wetland's ecosystem services. Importantly, the salt works in LRK are actually operational on those wetland beds which get drier in post-monsoon months.

Also, recently tourism sector is growing rapidly, which is heavily relied upon health of wetland ecosystem and associated biodiversity.

Therefore, in subsequent sections, economic valuation of three of the use-values of LRK wetlands is described. These include, production of prawn and salt, and biodiversity based tourism.

Table 42: Growth of tourists in LRK

Year	Indian	Foreign	Total
2001-02	359	15	374
2002-03	1485	11	1496
2003-04	1103	17	1120
2004-05	1375	12	1387
2005-06	3048	355	3403
2009-10	4079	855	4934
2010-11	5797	503	6300
2011-12	4739	728	5467
2012-13	8376	1440	9816
2013-14	10402	1185	11587
% CGR-2001-02 to 13-14	27.00	36.37	27.61
% CGR-2004-05 to 13-14	22.43	58.29	23.65

Source: *Wild Ass Sanctuary Office, Dhrangadhra*

6. Biodiversity of LRK

6.1. Bio-Geographical Settings

The Little Rann of Kachchh (LRK) is considered as a unique landscape due to its marked seasonal dynamics of dry and wet phase. Also, the sheer size of the area (i.e. about 4,000 sq. km) with particular reference to its flatness makes it a distinctive landscape in the country. Barrenness is widespread and found in the form of saline desert, stony and rocky areas, sandy patches etc. Bio-geographically, the LRK landscape is a confluence zone of three major Biotic Provinces (a) 3A-Kachchh Desert (b) 4B- Semi-arid Gujarat-Rajwara (c) 10A-West Coast (Rodgers and Panwar, 1988).

In terms of understanding its biodiversity, the LRK landscape is very poorly studied and researched. There are only few studies undertaken in the past dealing with the inventories and other concerns of biodiversity conservation in LRK landscape (e.g. Parvez, 1990; Shah 1993; GEER 1999; GEER 2006; CESC, 2007; Dixit et al. 2008, Dave, 2010).

6.2. Physiographic Diversity

As described earlier, the LRK landscape is an amalgamation and interaction of four major physiographical entities:

(i) The saline flat land — the Little Rann. The soils are heavy and contain high quantity of sodium salts and thus high salinity. Several ephemeral rivers like the Machhu, Brahmani, Kankavati, Falku etc. from the south and Banas, Rupen and Saraswati from the north and eastern parts discharge their water during the monsoon.

(ii) Bets and Dhasis. These are sandy or rocky and salt free slightly higher grounds amidst the Rann. There are 74 such bets and of this Pung is the largest and Mardak is the highest ones.

(iii) The fringe. They are saline and sandy transitional area between low lying Rann and the village uplands. In terms of vegetation and habitat types, this is the most diverse area. The fringe further extended into larger undulating watershed upland area of villages, which are either under rainfed

Table 43: Vegetation types and their characteristics

Vegetation Type	Major Location and Characteristics
Prosopis juliflora forest	Entire Rann fringe, almost all the bets, village grazing lands (*Gauchars*), wastelands. Seed dispersal mainly by the livestock and herbivorous grazing. Spread rapidly and forming dense thickets
Salvadora persica - Suaeda nudiflora Scrub	Mostly in saline periphery of few bets including the Dhut bet
Cassia auriculata scrub	Mainly in the village wastelands
Salvadora persica-Tamarix scrub	Saline periphery of few bets
Suaeda fruticosa scrub	Entire Rann fringe and saline periphery of bets like Saheblana, Dhut, Khijaliya, Lai etc. form association with saline tolerant grasses and herbs like *Aeluropus lagopoides, Cressa cretica*
Capparis scrub	Interior parts of bets and less saline fringe areas and village surroundings
Short grasslands	Patchily on bets and other open areas in the village-ward fringes and village Gauchars
Saline grasslands	Vast extent in the southern fringe areas and on bets having saline alluvial soil. *Aeluropus lagopoides* is the most dominant grass. Wild ass feed on these grasslands. In certain areas *Urochondra setulosa* form the patches.
Saline herbaceous	Almost pure patches of Cressa cretica in the Rann mudflats, which local people collect for fodder purpose. Also, vast areas in the fringe and saline periphery of bets are covered by patches of Sueada fruticosa. Wils ass feed on the plant
Marsh	Patches of Cyperus species (Theg) are present in the waterlogged areas. Its bulbs are the major food for cranes and many other birds and reptiles.
Mangrove scrub	Patches of Avicenia marina are found in the creeks near the Surajbari area.

Source: *GEER (1999); CESC (2007)*

The 'dry-phase' and 'wet-phase' of the Rann create a mosaic of habitat condition in LRK landscape, supporting a rich assemblage of faunal species. Many of these species are globally threatened and endemic to either India or the LRK landscape

cultivation or common or open access property use system including low productive pasture lands

(iv) Tidal creeks. These are located in the south-western corner of LRK and link with Gulf of Kachchh.

The physiographical variations coupled with seasonal dynamics of dry and wet phases create a mosaic of habitats supporting different vegetation types and thus, rich biodiversity values including many rare and endangered species.

6.3. Vegetation & Plant Diversity

GEER (1999) reported 11 different forest types from LRK landscape. These are found mixed in different combinations and broadly form four major physiognomic types' viz. grasslands, savanna, scrublands and marshlands. Later, CESC (2007) reported different vegetation types and their key characteristic from LRK (Table 43).

In general, the vegetation is very sparse, except in fringe and Bets where bushy and thorny vegetations are common and constituted by Prosopis juliflora and other natural species like Suaeda nudiflora, Tamarix troupii, Salvadora persica, Capparis decidua. Ground vegetation is predominantly found during monsoon season. Despite severe natural constraints there were 253 plant species reported by GEER (1999). These include 157 herbs, 37 grasses, 23 shrubs, 18 trees and18 climbers and twiners. Quite a few of these species are reported as threatened in BCPP-CAMP Workshop in 1997 (Table 44).

Table 44: List of threatened plant species of LRK landscape

Species	Type	Global Threat Level
Aeluropus lagopoides	Grass	En
Urochondra setulosa	Grass	En
Arthrocnemum indicum	Herb	Vu
Suaeda maritime	Herb	En
Polycarpea spicata	Herb	?
Suaeda nudiflora	Shrub	En
Tamarix troupii	Shrub	En
Commiphora wightii	Small tree	?

Source: *GEER (1999)*

6.4. Habitat Diversity

CESC (2007) presented a detailed classification of wildlife habitats for LRK and its ecologically connected systems and identified more than 35 wildlife habitats. It is important to understand that such diversity is the outcome of a natural matrix of physiographical differentiations and seasonal dynamics of dry and wet phases (see Figure 9).

Some of the important terrestrial habitats include dry saline barren desert of Rann; Prosopis juliflora thickets, Salvadora persica scrub and Sueda thickets; Saline grassland; etc. Similarly, there are quite a few type of aquatic habitats including, brackish and fresh water shallow wetlands with or without vegetation; rivers, reservoirs, ponds and check-dams; creeks, mud flats and mangrove scrub; abandoned or operational salt pans; fallow and cultivated agriculture lands etc. Importantly, these habitats while supporting various flora and fauna, including many rare and endangered species, also provide opportunities to local population to extract different wood and non-wood resources

6.5. Faunal Diversity

Above descriptions clearly suggest that diverse vegetation types and strong seasonal dynamics of wet and dry phases create a mosaic of habitat conditions in LRK landscape which support a rich assemblage of faunal species. While the 'dry-phase' of the Rann provides suitable habitat for endangered mammalian species such as Wild Ass, Indian Grey Wolf etc., its 'wet-phase' is equally important for bird species such as Lesser Flamingo, Greater Flamingo, Dalmatian Pelican, Painted Stork, Eurasian Spoonbill, Black necked stork etc.

Many of these species are globally threatened and also endemic to either India or even to the LRK landscape (GEER 1999). A summary of the list of faunal species is presented in Table 45.

Table 45: Summary of faunal diversity in LRK landscape

Taxa	Total No. of Species	Rare and Threatened Species@
Zooplanktons	25	
Crustaceans	11	*Metapenaeus kutchensis#*
Insects	24	
Molluscs	12	
Spiders	27	
Fish	21	
Herpetofauna	29	*Lissemys punctata* (Indian Flapshell Turtle); *Geochelone elegans* (Star Tortoise); *Uromastyx hardwickii* (Spiny-tailed lizard); *Varanus griseus* (Desert Monitor); *Varanus bengalensis* (Common Indian Monitor); *Elaphe helena* (Trinket Snake)*; *Echis carinatus* (Saw-scaled Viper)*; *Ophisops microlepis* (Skink)*
Birds	178	*Pelecanus crispus* (Dalmatian Pelican); *Marmaronetta angustirostris* (Lesser Flamingo); *Aythya nyroca* (Ferruginous Duck); *Rynchops albicollis* (Indian Skimmer); *Grus antigone* (Sarus Crane); *Phoeniconaisa minor* (Marbled Teal); *Chlamydotis undulata* (Houbara Bustard); *Platalea leucorodia* (Spoonbill); *Falco tinnunculus* (Kestrel); *Falco peregrinus japonensis* (Peregriene Falcon)
Mammals	33	*Equus hemionus khur* (Indian Wild Ass) #; *Antilope cervicapra* (Black buck); *Gazella bennetti* (Chinkara); *Canis lupus* (Wolf); *Hyaena hyaena* (Hyaena); *Vulpus bengalensis* (Common Indian Fox); *Vulpes vulpes pusilla* (Desert fox), *Felis caracal* (Caracal); *Felis sylvestris* (Desert Cat); *Mellivora capensis* (Honey Badger); *Manis crassicudata* (Indian Pangolin); *Paraechinus micropus* (Pale Hedgehog); *Hemiechinus collaris* (Longeared Hedgehog)

*@ Rare and threatened status based on BCPP-CAMP Workshop (1997), IUCN- Red Data book and Wildlife Protection Act.; # Endemic to LRK Landscape; * = Endemic to India*

Source: *CESC (2007)*

6.6. Biodiversity of Significance

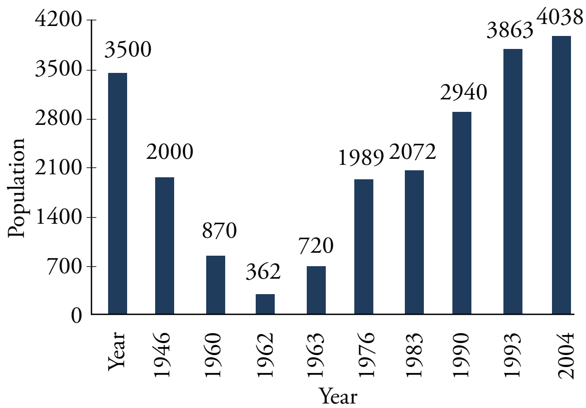
While it is understood that in a given ecosystem all the species and habitats has important roles to maintain ecological integrity though their structural and functional characteristics, in the context of LRK, following are considered as rich and unique values (USP) of biodiversity of LRK and its associated system:

1. Last remaining population of Wild Ass using different habitats and large extent of LRK.
2. Good network of shallow wetlands and record of large assemblage of birds — aquatic and semi-aquatic, including many rare and threatened ones
3. Nesting ground of Lesser flamingos — one of the very few sites in the world
4. Large congregation of cranes and other migratory bird species
5. Fish and prawn diversity including endemic prawn species — Metapenaeus kutchensis
6. Unique assemblage of salt tolerant plants (halophytes) in the fringe and bet areas
7. Saline grassland — Urochondra setulosa and Aelurpus lagopoides (dolri) grass

6.6.1. Wild Ass

Last remaining population of Wild Ass (Equus hemionus khur) is found only in LRK and its fringe areas. Because of their overall influence on the landscape and its resources, they are considered as the 'flagship' species. Historically, Wild Ass was distributed widely in the arid zone of north–west India including Pakistan. Today they are more or less restricted to the LRK and thus considered as 'endemic' to the region. Recently, however, animals are dispersed out towards the north and south-east of the LRK to the Bhal region- another saline flat tract. It is well documented that in 1963 the population of wild ass was sitting at the verge of extinction as just 360+ animals were left and remained in the wild. However, population starts recovering from that lowest point and reached ,about 3863 animals in 2004 (GEER 1999; Figure 30). Wild ass in LRK is a remarkable story of population recovery mainly due to its adaptability and most importantly the absence of any natural predator. Within LRK, wild ass predominantly uses bets, fringe and Rann areas, suggesting their importance and critical roles in the life-cycle of wild ass.

Figure 30: Wild Ass population trend in LRK



Census repeated at every five years clearly suggest that population is dispersing and moving out of LRK area.

6.6.2. Wetlands and Aquatic Bird Diversity

As discussed earlier, while LRK is dry and dusty for most of the year, after the rains, it is transformed into a large, shallow wetland. Soon after, the water contiguity breaks at many plains and then creates many smaller pools of water bodies. While in the fringe areas there are many natural depressions which get filled during monsoons and turn into wetlands. In addition to that, smaller reservoirs and many large check-dams also stored runoff water and provide habitats for many bird species. On the Surajbari creek side, tidal water regularly inundate the low lying marshlands and smaller creeks and thus create vast stretches of mud flats which support habitat for many species of birds, fish, crustaceans etc. It is important to note that these water bodies / wetlands are quite diverse in terms of their size, depth, salinity and other water qualities, seasonality, connectedness etc. Due to such structural diversity in wetlands present in LRK landscape, they attract large number of migratory waterfowls. Following are the typologically different wetlands present in LRK landscape:

- Natural shallow open water, solely or mostly formed by rain water e.g. Bajana, Tundi and Savla
- Natural shallow open water, formed by mixing of rain and tidal waters eg. Nanda and Shedwa.
- Natural shallow water formed mostly by rain water with some mixing of tidal water and with herbaceous cover e.g. wetlands near the southern fringes
- Man-made shallow waterbodies in the bets e.g. Pung, Mardak, Wasraj Solanki etc.
- Man-made reservoirs and check-dams near human habitations mainly for irrigation support
- Tidal water near creeks e.g. Surajbari

Some of the important wetlands in the LRK landscape include Bajana, Nanda, Shedwa, Nava Talav, Tundi, and mudflats of Surajbari. Bajana wetland (commonly known as Bajana Creek) is a large, linear shallow wetland, support more than 50 species of birds. Dalmatian Pelican, Lesser and Greater Flamingoes, Plovers, Shovellers, Coot, Avocet etc. are visiting this wetland in large numbers. Common cranes feed on the seeds of Cyperus sp. (locally called Theg) that grows in the draw-down areas of the wetland. Similalrly, slightly deeper wetland between Tikkar and Mandarki along the southern fringe of LRK support many species of aquatic birds including flamingoes.

Due to such diversity in the wetland configuration, a total of 97 aquatic bird species were recorded from the landscape (GEER 1999). It is important to highlight here that out of total 97 species, 73 were reported as winter migratory. Among the species, seven are reported under rare and threatened categories (Table 45). Lepage (2014) reported 318 bird species form LRK landscape, including 117 aquatic species. A total of 18 species were reported under globally threatened categories.

While the Shoveller (Anas clypeata), Lesser flamingo (Phoeniconaias minor), Grater flamingo (Phoenicopterus ruber), Demoiselle cranes (Anthropoides virgo), Common cranes (Grus grus),

WETLANDS

The LRK wetlands are diverse in terms of size, depth, salinity, and other qualities. Due to such diversity in the wetland configuration, over 300 bird species have been reported in the LRK landscape, 18 of which are considered to be globally threatened

Spoon bill (*Platalea leucorodia*), White Pelican (*Pelecanus onocrotalus*), Coot (*Fulica atra*) etc. are the most abundant species, some other species of conspicuous presence include, Wigeon (*Anas Penelope*), Pintail (*Anas acuta*), Avocet (*Recurvirostra avosetta*), Blackwinged Stilt (*Himantopus himantopus*), Black-tailed Godwit (*Limosa limosa*), Slender-billed Gull (*Larus genei*), Whiskered tern (*Chlidonias hybrida*) etc.

Despite pronouncing their conservation significance globally, the wetlands of LRK landscape are very poorly understood. GEER (1999) did a comprehensive inventory of these wetlands and status of their bird fauna but after that no serious efforts had been made to undertake such aquatic bird inventories.

6.6.3. Nesting of Lesser Flamingo

According to global single species action plan prepared for Lesser Flamingo (*Phoeniconaias minor*), the species mainly occurs in 30 countries from West Africa, across sub-Saharan Africa and along the SW Asian coast to South Asia (Childress et al 2008). However, its global population is concentrated only in 12 primary range states including India where regular breeding is confined to only five sites in four of these countries including, one each in Botswana and Namibia and Lake Natron and two in India. Most importantly, both the Indian sites are located in the Little Rann of Kachchh (Zinzuwada and Purabcheria salt pans). This fact itself highlights global conservation significance of LRK.

In LRK, large number of Greater and Lesser Flamingos used various locations of landscape for making their nesting mounds. In 1998 between Jhilandar and Wasraj Solanki bets, between 70-75 thousand lesser flamingos were reported from a nesting colony that spread over 250 acres. The average height of nest mound was around 30 cm. This site is regularly used for nesting purpose by Lesser Flamingos. However, there are reports of nest abandonment, on regular basis. The site is located very close to the water channels of Saraswati and Rupen rivers. The selection of this nesting site seems to have the advantage of getting good amount of fresh water by two rivers and thus maintain some minimum water depth. GEER (1999) concluded that 'higher water levels around the nests are favorable for nesting activity". Also, careful examination of satellite imageries reveals that other nearby areas are either receive heavy water flow or get dry very quickly, risks to survival of eggs and chicks. So the birds choose a very optimum site for breeding purpose. Water levels are also critical to successful breeding. If the level is too high, the birds are unable to build their nests. If it is too low, terrestrial predators are able to reach the nests and destroy the breeding attempt. Considering that water inundation is critical for the success of breeding, it is important to maintain, and restore favourable hydrological conditions and water quality from Saraswati and Rupen rivers.

Another breeding and nesting site of lesser and greater flamingos was recorded near the Cherwari village near Surajbari creek, where a population of about 12000 flamingos were recorded (GEER 1999). Mundkur et al. (1987) suggested that this site was also a traditional nesting area of the flamingos.

6.6.4. Congregation of Cranes

Common and Demoiselle crane are other migratory species which used various habitats (both aquatic and terrestrial) of the landscape in large numbers. The cranes were reported using wetlands like Nanda/ Shedwa, Bajana and Nava talav in huge numbers (GEER, 1999). In the 2005 state level waterfowl census, a total of about 11500 cranes were reported just from the Dhrangadra, Halvad and Dasada taluka in Surendranagar district (Uday Vora, Pers. Comm.). It is important to mention that many migratory species including Common and Demoiselle crane generally congregate in large number

Despite pronouncing their conservation significance globally, the wetlands of LRK landscape are very poorly understood. Since 1999, no serious efforts have been made to undertake aquatic bird inventories

11 species of prawns, 22 species of fish, and numerous species of halophytes are reported in LRK. This biodiversity faces many proximate threats, though, with dangers arising from different types of direct competition for resources in the time and space domain

before starting their return journey. In this context, saline tract of Ramgiri-Majethi-Rajpur, near Bajana, support area for large pre-migratory congregation of common cranes.

6.6.5. Fish and Prawn

The seasonal dynamics of mixing of tidal water from the Gulf of Kachchh and the nutrient and silt-loaded monsoonal runoff water in the vast expanse of LRK, support very rich diversity and abundance of brackish water prawn and fish species. There are report of 11 species of prawns and 22 species of fish from the LRK landscape (GEER 1999). *Metapenaeus kutchensis* is an endemic prawn species that occurs only in the Gulf of Kachchh and used the vast flooded expanse of LRK as their nursery ground. Among the different sites in the entire Gulf of Kachchh, Parvez (1990) reported the area near Surajbari as the best site for this species. Among the fishes, the landscape supports many commercially important species. The *Hilsa ilisha* (Indian Shad) and *Hilsa toli* (Giant Herring) are reported from the landscape. However, interaction with local fishermen and fish-traders revealed that till mid 1980s they had good catch of these fishes but now these species are not found in the waters of the LRK landscape. The damming of Banas river and thus reduced fresh water flow in the LRK seems to be the major factor of their disappearance.

6.6.6. Halophytic Species Assemblage

LRK being a saline tract provides limited ecological window for plant species to adapt. Different assemblage of halophytes (i.e. salt tolerant plant) is, therefore, uniqueness of LRK. There are two major halophytic assemblage recorded in LRK. First, that forms vast tracts of saline grassland in certain fringe areas of LRK. Two dominant species species viz. *Aeluropus logopoides* and *Urochondra setulosa* along with other halophytic species like *Cressa cretica* and Scirpus species forms their association in different proportions at different locations. These grasslands are important habitat for wild ass especially during the winter and summer period. Also, good numbers of raptors like kestrel, peregrine falcon, shikra, pale harrier, tawny eagle etc were also reported using these grasslands in different seasons. Also, during the first monsoonal shower, when new shoots grows, cattle graze on these grasslands, and thus have livelihood linkages, too.

In the bet area, especially those parts which inundate during monsoons, salinity is generally high compared to the interior slightly higher elevated portions. In the higher saline areas halophytic succulent plants species like *Suaeda nudiflora* (locally known as Unt morad), *Suaeda fruticosa* and *Suaeda meritima* (locally known as Morad) form associations. Among them, the *S. nudiflora* is taller shrub and rare species, while other two species are herbaceous in nature. Such assemblage of halophytes is unique botanical and vegetation feature of LRK. Importantly, these species provide rich source of food to wild ass population of LRK.

6.7. Major Threats

Despite having a rich and unique biodiversity assemblage, LRK face many proximate threats. Based on understanding derived from this study and also by reviewing relevant literatures, many proximate causes for biodiversity losses can be recorded. In most of the cases these proximate reasons emerged from different types of direct competition for resources in the time and space domain. Some of these causes are:

1. Degradation of bets and fringe habitats mainly due to excessive grazing and, as a result of this, the spread of Prosopis juliflora. In certain bets, the problem of soil erosion also found in greater extent.
2. Fragmentation of Rann desert mainly due to unregulated spread of inland salt-work
3. Degradation of wetland habitat mainly due to change in hydrological regime

4. Degradation of creek habitat mainly due to blockade and diversion for marine salt-works
5. Human-wildlife conflicts in the form of crop depredation by wild herbivores and lifting of sheep and goats by wolf
6. Emergence of Narmada canal based irrigation in immediate catchment of LRK
7. Local people's antipathy to PA based conservation and non-participation in conservation practices

While these threats directly or indirectly impact the floral and faunal diversity of LRK landscape including terrestrial and wetland systems, it is important to understand that the root causes of many of these problem lies in complex interplay of socio-economic, legal and institutional aspects which more than often operate at larger landscape level, way beyond the LRK boundaries. In the context of this study, some of the root causes which undermines the, development and conservation of biodiversity and other important natural resources include:

- Legally, non-settlement of boundaries of PA (Wild Ass Sanctuary) and associated with that the rights and privileges of local communities mainly the salt producers (known as Agariyas) and fishers. Thus, both salt work and fishing activities are going on unabated. Legal issues aside, lack of credible scientific evidences of impacts of these activities on key biodiversity indicators creates further ambiguities and confusions among the local people who press for right of resource use in LRK.
- Due to its sheer size, there are overlapping administrative jurisdictions and promotion of cross-purpose landuse practices under different sectoral plans, which often complicate the ground situations for ecosystem management and biodiversity conservation.
- Vigorous policy pushing of rainwater harvesting in the catchment areas through irrigation dams and check-dams affect the water flow into LRK and thus jeopardize the ecological health of wetlands and its derived goods like production of fish and prawn.
- The land and water areas of Surajbari creeks face unregulated expansion of marine salt-works and other small port and jetties. This is mainly due to overlapping jurisdiction of area between Forest Department, the Revenue Departments, Gujarat Maritime Board and Kandla Ports and lack of coordination between these agencies. Further, being a critical link between Kachchh and Saurashtra, many infrastructure projects pass through this area. Despite such multi-dimensional pressures, there is no long term land-use planning for this ecologically critical area.
- Considering the size of the LRK and presence of many stakeholders on land and water resources, not only from LRK limits but also from its associated landscape, there is growing voice for participatory management approach. LRK is part of a PA and is managed and administered by Forest Department alone. The lack of institutional space for participation and decision making about LRK and its resources, actually create greater antipathy towards current PA management system.
- The study of GEER (1999) observes that expansion of salt zone may adversely affect the very conservation objective of creating of Wild Ass Sanctuary. Further, the study identified a few possible impacts of salt work on wildlife including habitat loss, hindrance in the free movement of wildlife, increase in disturbance level and threat to breeding site of flamingo. It is also indicated a high opportunity cost of conservation in terms of forgone access to the ecosystem for livelihood uses (CESC, 2008). In addition to this, the study argues salt production and storage activities might adversely affect wildlife. The study of Bharwada and Mahajan (2008) suggests that salt areas are not in conflict with wildlife's food and water needs as salt pans are made in the areas where nothing grows.

6.8. Existing Management Efforts

As discussed above, while there are several root causes for degradation of LRK, current management focus is mainly to address proximate causes. In other words, instead of tackling the root causes, efforts are mainly towards handling the symptom. One of the major reasons for this lies in different sectors' attitude of 'working within their own jurisdiction'. Forest Department, the sole administrator of LRK (ad PA), does not have any mechanism in place to engage other sectors, while other sectors are not keen to be part of this due to several bindings imposed through legalities of PA.

Since, LRK is a sink area of larger landscape; they get affected by many externalities coming from the catchment area. Ironically, there is no landscape level vision for the LRK. Recently, however, under World Bank funded Biodiversity Conservation and Rural Livelihood Improvement Program (BCRLIP), some beginning had been made to bring landscape in focus. But, still, so far no clear landscape level governance issues and institutional arrangement have been evolved.

7. Economic Valuation of LRK Wetland

7.1. Overview

Economic valuation is important for two reasons (Barbier, 1999): First, as the economic contribution of wetland is often non-marketed, it is generally ignored in development decisions and policies that affect the allocation of the resources and systems. Second, failure to take into account such environmental values may distort development and investment decisions, leading to unnecessary and inefficient depletion, degradation and over-exploitation of wetland resources and environments. The result can be a net loss of economic welfare to the society.

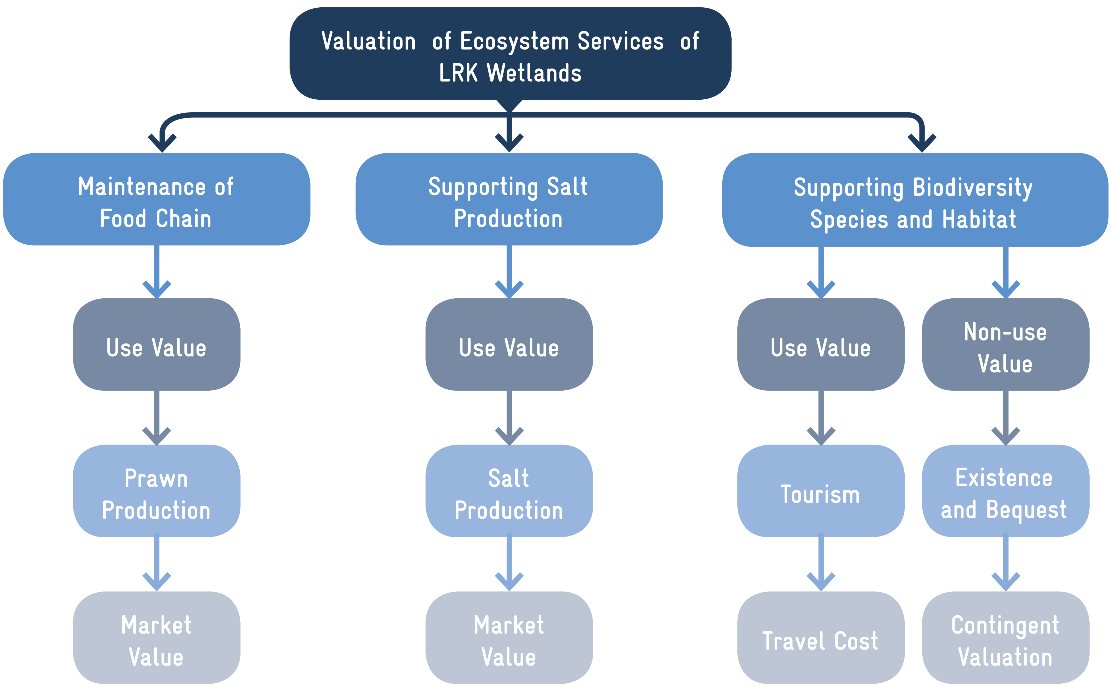
For the purpose of this study, we attempt to value the key ecosystem services of LRK wetland system. Keeping in view the general ecological structure and function of LRK wetlands three major ecosystem services were identified for valuation purpose — maintenance of food chain, provisioning of salt and supporting biodiversity:

1. For the maintenance of the food chain, we focused on prawn production, since it is an overwhelmingly dominant species in the fish catch of LRK, is ecologically placed at the apex of the food chain, and lends itself to analysis of its market values.
2. Salt production is supported primarily by the availability of dry land in the post-monsoon period, sea-water or underground brine (as the case may be) and seasonal flushing of the waste from the previous cycle of production. Again, we applied the market value approach to value the support of LRK for salt production.
3. For biodiversity, we measure both use and non-use values. Tourism for recreation and education offer opportunities to measure use values by adopting the travel cost method (TCM). The non-use value, incorporated existence and option values, was measured using the contingent valuation method (CVM).

The methodological approach adopted is presented in Figure 31.

This chapter is divided into three main sections (i) prawn production value, (ii) salt production value and (iii) biodiversity value, which is further divided into two sub-sections – tourism and existence and conservation value of biodiversity, with special emphasis on migratory birds.

Figure 31: Methodological approach adopted for the valuation of LRK wetlands



7.2. Use Value - Prawn Production

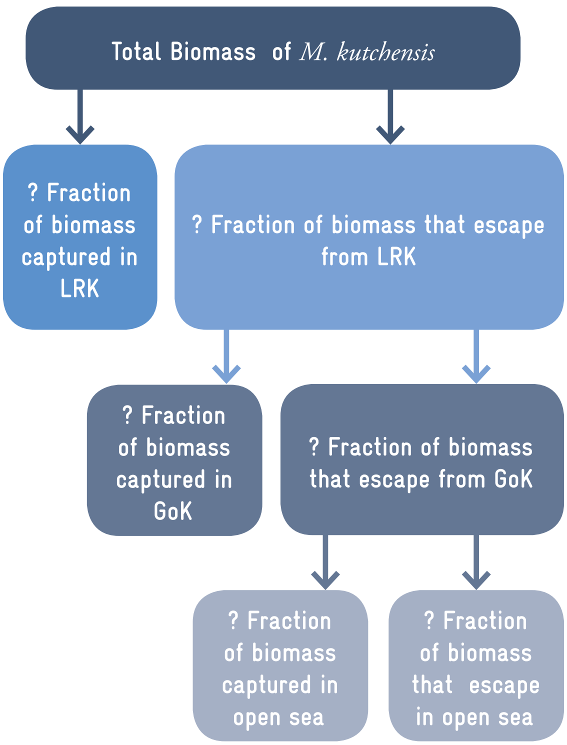
7.2.1. Approach

To understand prawn fishing related issues and values in LRK landscape, we undertook Focus Group Discussions with fisher communities and employed questionnaire-based household surveys (see Chapter 4 on Methodology). Those primary surveys generated several critical numbers which were then analysed in order to compute the gross benefit and the net benefit per annum.

It is important to understand that *M. kutchensis* spends only a small part of its annual life-cycle in LRK (about 2-3 months) and the remaining part of its life is spent in other habitats including mud-flats of creeks in GoK and open sea water along the northwest coast of India. However, whichever area it uses, a fraction of it is captured by one or the other fishing operation. Still, substantial *M. kutchensis* escapes the catch to mature and finally produce the next generation of *M. kutchensis*.

We believe that the stock of *M. kutchensis* found and captured in GoK and open sea water is critically dependent upon the LRK and thus some part of its biomass development needs to be considered as a contribution of LRK ecosystem services. Effectively, thus, in order to capture the total value of prawn fisheries of LRK (mainly the *M. kutchensis*), it is essential to examine their capture in entire seascape or its distribution range.

Figure 32: Biomass distribution of *M. kutchensis* in and around LRK



Clearly, there are three potential biomass off-take areas for *M. kutchensis*: (i) in LRK water (ii) in GoK waters and (iii) open sea waters. At each location, however, many individuals escape catching efforts to move to the next area. The entire understanding of distribution of population / biomass of *M. kutchensis* is presented in Figure 32.

7.2.2. Total Prawn Production Potential in LRK

Keeping above discussion in view, it is important to appreciate that no data and study estimates the total prawn production of LRK i.e. total catch in LRK and those which escape from LRK. However, two separate data sets are available which can be useful in determining the same:

i. Total catch in LRK: few earlier studies and present study provide approximated values of total catch (landing value) of *M. kutchensis* in LRK in different years.
ii. Escaped prawn: There are no systematic studies available which could provide this value. However, it is believed that some fractions of those escaped prawns can be estimated by examining the landing data of *M. kutchensis* in other landing sites that are located in GoK and open sea sites. Summing of this landing data at different locations provides us a fairly good estimate of volume of escaped prawns from LRK. Based on available data from various sources, landing sites of Surajbari, Navlakhi, Kandla and Okha (in GoK) and Mumbai provide catch of paeneid shrimps including *M. kutchensis*.

Accordingly, the total cumulative annual catch of *M. kutchensis* from different locations including within and outside LRK is about 6,177 metric tons (Table 46).

7.2.3. Economic Value of *M. kutchensis* of LRK

In order to ascertain the total value of prawn fishery (mainly of *M. kutchensis*) of LRK, we estimated two values. One is the value generated in LRK itself. Second, the value of *M. kutchensis* that escapes from LRK and is subsequently caught at different locations outside LRK. As described earlier, for the present study's purpose we ascribe 72% of the total biomass catch from outside LRK waters, to the nursery value of LRK (see Prawn Production section in Chapter 5).

Table 46: Summary of *M. kutchensis* catch from different locations

Site	Year of Data	Data Source	Catch in Tons		
			Average	Minimum	Maximum
LRK	1992 to 2009, 2013-14	Deshmukh, 2006; Ghosh et al. 2012, present study	3637.0	176.0	10925.0
Surajbari	1977 to 2010	Rao, 1983; Parvez, 1990	534.8	10.7	1353.2
Navlakhi	2008 to 2013	Fishery Department	72.2	11.6	114.5
Kandla	2008 to 2013	Fishery Department	103.9	35.3	230.9
Okha	1987 to 1988	Joseph and Soni, 1990	1263.0	1153.0	1373.0
Mumbai	1990 to 2000	Deshmukh, 2006	566.4	225.0	1648.0
Total Estimated Catch of *M. kutchensis*			6177.3	1611.6	15644.7

7.2.3.1. Value of *M. kutchensis* Caught in LRK

As discussed earlier (see Chapter 5), in the LRK, the catch of *M. kutchensis* goes to the market via two product streams. Fishers generally sell bulk of their good size prawn catch as fresh to a fixed local trader. Also, most of the fishers convert some fraction of their total catch, generally smaller size prawn, into dry and then sell it in the market. Thus, fishers realize the prawn value through selling of both fresh and dry prawn. Some of the key values we used for the estimation of *M. kutchensis* value in LRK are presented in Table 47.

Based on interviews of fisher families, present survey estimates that during the fishing seasons of 2013 and 2014, total catch of *M. kutchensis* was 6,747 metric tons and 3,617 metric tons, respectively. Of this, 2/3rd is sold as fresh and remaining 1/3rd was converted as dry and then sold. Interview of fishers also indicated that in the year 2013 and 2014, the price at which they sold fresh and dry prawns was ₹28.20 per kg and ₹230 per kg, respectively. However, it is important to note that traders collect and sold fresh prawns to fish processing companies directly from the landing centre and fetch a price between ₹125-150 per kg. The factory-gate price (rather than the landing site price) is considered as the sale price for fresh prawn.

Table 47: Important numbers used in estimating prawn value in LRK

Parameter	Value
Average Sale price (Fresh Prawn) (2014)	₹150 per kg
Average Sale Price (Dry Prawn) (2014)	₹230 per kg
Proportion of total prawn catch converted and sold as dry prawn biomass	33%
Requirement of fresh prawn biomass to convert into One kg of dry prawn biomass	7 kg

Source: *FGD & HH Survey, Present Study*

The Gross Revenues from prawn fisheries at LRK (including fresh and dried prawns) stood at an estimated ₹745.78 million and ₹399.75 million during 2013 and 2014 respectively. The Net Value of prawn fishry in LRK i.e. actual sale price minus the total cost incurred on prawn catch, transportation and value addition is estimated (Table 48).

Using above values, we estimated the cost of production, transportation and value addition for each

Present estimates are that during the fishing seasons of 2013 and 2014, total catch of M. kutchensis was 6,747 metric tons and 3,617 metric tons, respectively. The gross revenues from prawn fisheries at LRK were estimated at ₹745.78 million and ₹399.75 million during 2013 and 2014 respectively

Table 48: Different costs of prawn fishing in LRK

Heads	Unit	Cost (₹)
Depreciated value of temporary hut	₹ per HH per season	2581
Depreciated value of Boat		3049
Depreciated value of Katar net		4010
Depreciated value of Gunja net		1294
Depreciated value of Chattai net		1139
Actual costs of wood sticks for putting the nets		1703
Actual cost of diesel for prawn catch and transportation from fishing area to landing areas		5800
Actual maintenance cost of fishing equipments		7800
Actual labour cost in prawn catch		18750
Actual cost of prawn transportation from landing area to trader/company procurement site	₹ per ton of prawn catch	5000
Actual cost of Ice		3200
Actual cost of management		85
Actual labour cost for prawn boiling & drying	₹ per HH per season	14000
Actual cost of fuel-wood for prawn boiling		2000
Depreciated value of prawn boiling vessels		540

Source: *FGD & HH Survey, Present Study*

ton of fresh prawn catch and dry prawn sold for both 2013 and 2014 seasons:

- The cost for each ton of fresh prawn catch from LRK (including value addition in the form of storage in ice) is ₹22,183/- and ₹24,417/- respectively for the fishing seasons during 2013 and 2014.
- The cost of making one ton of dry prawn in LRK area is ₹1.04 lakh and 1.20 lakh for the fishing seasons in 2013 and 2014, respectively.

During the fishing season of 2013 and 2014, the Net Market Value of *M. kutchensis* (both fresh and dried) was estimated to be ₹612.9 million and ₹320.3 million respectively (Table 49).

The catch data from different sources reveals that between 1992 and 2014 (including estimates of present survey), on an average 3,645 tons of M. kuchensis has been captured annually from LRK. At 2014 values of cost and price, the average net value of *M. kutchensis* from LRK wetland was found to be approximately ₹307.3 million per year.

7.2.3.2. Value of *M. kutchensis* Catch Outside LRK

As described earlier, a large proportion of *M. kutchensis*

Table 49: Gross and net market value of *M. kutchensis* catch from LRK wetlands

Year	Total Fresh Weight Catch (tons)	Sale as Fresh (tons)	Sale as Dry (tons)#	Gross Market Value (Million ₹)		Avg. Cost (₹ Per Ton)		Net Market Value (Million ₹)*		
				As Fresh	As Dry	As Fresh	As Dry	As Fresh	As Dry	Total
2013	6747	4474	325	671.10	74.68	22183	103555	571.9	41.1	612.9
2014	3617	2398	174	359.70	40.05	24417	120149	301.2	19.1	320.3
Avg. of 17yrs**	3645	2442	172	366.3	39.53	29165	158800	295.1	12.2	307.3

* *as per 2014 market price*
\# *For making 1 kg of dry prawn, it need 7 kg of fresh prawns*
** *Catch data of 1992 to 2000, 2004 to 2009 & 2013, 2014*

prawns escape from LRK catch and enters into the GoK and other coastal waters, where some fraction of these are caught at different locations. Thus, in addition to average annual catch of 3,645 tons in LRK, another average 2,540 tons of *M. kutchensis* is reportedly caught from GoK and open sea water (see Table 46). While we discuss average numbers, we need to remember that there is major year to year variation in landing volume and is mainly determined by rainfall (Figure 33).

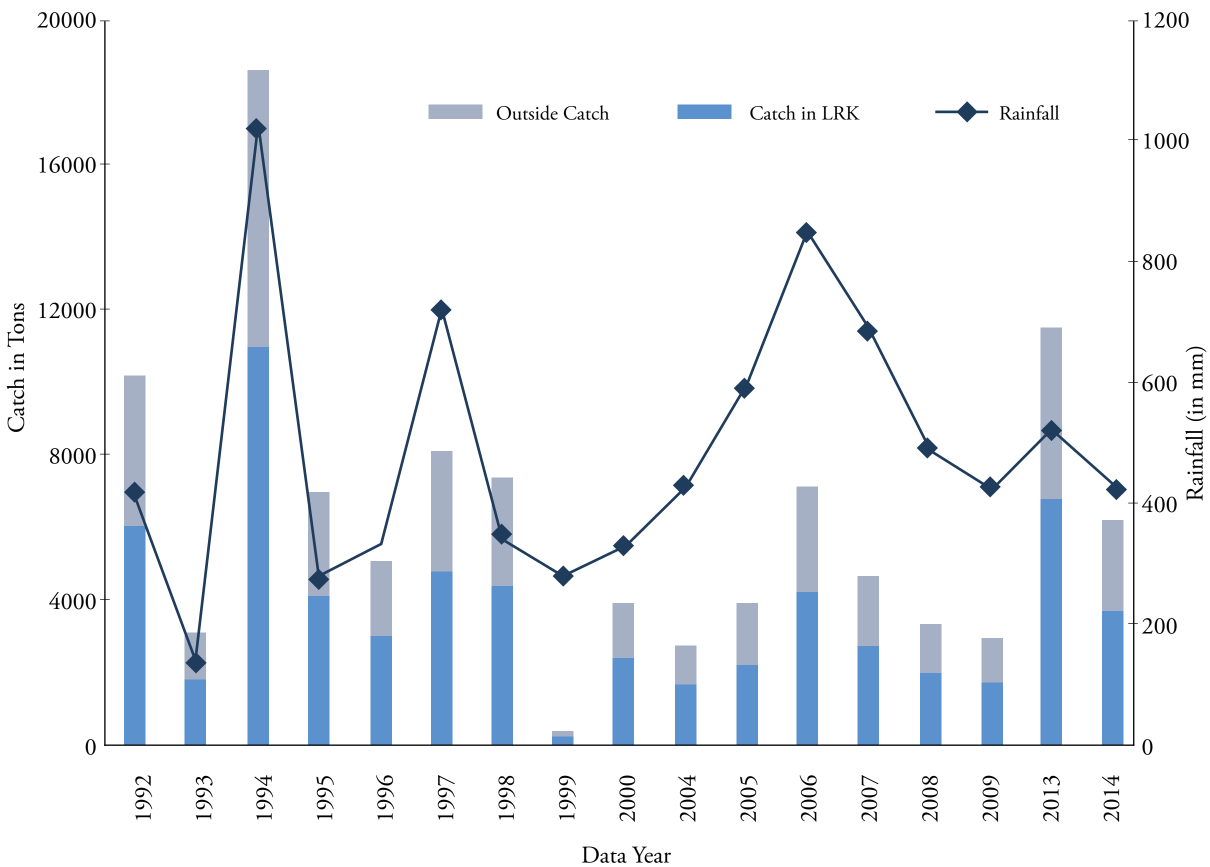
Based on an understanding of length and biomass gain in *M. kutchensis*, it is estimated that LRK actually contributes almost 72% of the total individual growth of matured prawns that are caught outside LRK waters. Thus, for the purpose of this study, we impute 72% of the total catch of *M. kutchensis* outside LRK actually to LRK. In other words, out of total 2,540 tons of *M. kutchensis* catch outside LRK, about 1,828 tons can be ascribed to LRK's prawn nursery role.

Recent annual report of State Fisheries Department (2011-12) revealed that the landing site sale price of one kg of fresh weight of *M. kutchensis* was ₹68.20 per kg which is adjusted to ₹75 per kg for 2014 fishing season. At this current price, thus the average gross annual value of *M. kutchensis*, which are caught outside LRK, was found to be around ₹137.16 million per year. It is also important to mention here that in open marine system the operating cost of fish capture is about 25% of the total value (Dixit et al. 2010). Thus, if we deduct the operational cost of prawn fishing in the area outside LRK, the net market value of prawn is found to be ₹102.82 million per year. This value can be attributed to LRK's ecological support services and can be added to LRK's nursery value. It is important to state here that these values are not considered final, as data of many landing sites within *M. kutchensis* escape zone were not available.

7.2.4. Total Prawn Capture Value of LRK

Finally, LRK wetlands through its nursery ground for *M. kutchensis* by maintaining the food-chain,

Figure 33: Estimated catch of *M. kutchensis* within and outside LRK



generate a total net annual monetary value of ₹410.14 millions (direct from LRK wetlands – ₹307.32 million; attributed catch value from escape zone – ₹102.82 million).

7.3. Use Value - Salt Production

7.3.1. Approach

To understand salt production related issues and values in LRK landscape, we relied heavily on secondary data available from Salt Commission's office. Our cost of production data is based on recently conducted studies and interactions with key informants — both salt manufacturers and salt traders.

For estimating the value of salt production in LRK, we apply simple market value approach, where the salt is used as a production good and market price a determinant of the value of ecosystem good.

7.3.2. Value of Salt Production in LRK

Salt production is a seasonal activity, where the produce is marketed for both industrial as well as domestic consumption. For domestic consumption, however, they need to undergo an iodization process. Often the product goes in bulk, mostly through rail or trucks. At the LRK level, the value of raw salt flows to two sets of people – Agariyas (the salt producers) and financiers-cum-traders. Both bear some costs towards the production and also for storage, transportation, iodization etc.

As mentioned earlier, LRK produced an average of about 30.8 lakh tons of salt every year between 2008 and 2012. In 2014 the landing site market price of salt was around ₹500 per ton (this is the price the traders sold to the industries and other bulk purchasers). At this price, the gross market value of salt production in LRK is about ₹1,539 millions.

The net value of salt production in LRK is obtained by deducting the total cost incurred on salt production, storage loss, transportation and value addition (mainly iodization). Based on discussions with many salt producers and traders and information in recent reports (e.g. Bharwad and Mahajan, 2008; Sathyapalan et al, 2014), we estimated different costs for 2014 season (Table 50). The cost was converted into per ton basis, and for that, we considered a salt pan of 10 acre to be producing an average of 1,600 tons (between 1500 and 1700 tons) of salt. Accordingly, for each ton of salt production, the total cumulative cost is estimated to be ₹274.50. In other words, the net value of one ton of salt produced in LRK is ₹225.50.

Table 50: Different costs of salt production

Heads	Cost (₹ per ton)
Total labour cost (hired)	11.80
Total labour cost- family	42.80
Fuel cost (diesel for pumping the underground brine)	83.30
Other cost for production (pump maintenance, zipta plant, minor equipments, construction and maintenance of hut, pipes etc.)	6.60
Transportation, storage loss and value addition costs	130.00
Total Cost	274.50

At 2014 values of cost and price, thus the average net value of salt production from LRK wetland was found to be approximately ₹694.3 million per year (Table 51).

It is important to mention here that the actual salt producers (the Agariyas) actually get only about ₹170 per ton as gross value from traders and they incurred almost ₹145 as production cost. Therefore, they get only a profit of ₹25 per ton, which is not very lucrative in any sense. However, we can also see this in different perspective, where, the major gain to an Agariya family is to get labour engagement for almost 6 months. That may be the driver for pushing them into such hard endeavour, without any substantial season end savings.

7.4. Use Value – Biodiversity: Tourism

7.4.1. APPROACH

We estimated per capita travel costs of tourists visiting

Table 51: Gross and net market value of salt production from LRK

Average Annual Production of Salt in LRK (Lakh tons)	Landing site market price (₹ per ton)	Gross market value of Salt from LRK (Million ₹)	Cost of production and transportation etc. (₹ per ton)	Net market value of Salt from LRK (Million ₹)
30.8	500*	1539	274.50	694.3

* *as per 2014 market price*

Table 52: General characteristics of sample tourists

	No of Sample	Sex %		Avg. Age	Avg no. of days visit to LRK	General Visit rate %			Origin place		
		M	F			Once a while visit	Visit	Very frequent	Gujarat	Indian	Foreigners
N	38	28	10		38	16	15	8	7	28	3
%		74	26	39	2.47	41	38.5	20.5	19	73	8

LRK, through a sample survey (see Chapter 4 for detailed description of methodology). The number was then extrapolated to total tourists visiting LRK in different years, separately for Indians and foreigners. Further, in order to get a better understanding of travel expenses incurred by tourists' vis-à-vis different biodiversity and cultural values of LRK, perceptions were recorded and analyzed.

7.4.2. PERCEPTION OF TOURISTS ABOUT LRK

As discussed in methodology chapter, we interviewed 38 tourists who visited LRK during 2014-15. The key characteristics of the respondent tourists are given in Table 52.

The study sample covers 74 % male and 26% female respondents. The average age of the respondent is 39 years (range 16 to 80 years). The nature of tourists suggests that 38.5% of the respondents are frequent visitors to different places for recreation. Travel cost survey covered 19% from local (Gujarat) respondent, 73% from national (other Indian States) and 8% from foreign origin. It is observed that tourists are staying a minimum of 1 day to a maximum of 5 days with an average of 2.47 days in LRK for recreational activities.

It is important to note that over 92% respondents revealed that their decision to visit LRK was quite important in their travel itinerary. Further, we collected tourists' perception on biodiversity of LRK and their preferences to visit the place (scale of 1-6 rank). Perceptional analysis suggests that 76.3% of respondents give a high rank to watching flamingos and other migratory birds (Table 53). Respondents have also expressed their preference for wild ass, blue bull and other wildlife and the beauty of LRK landscape (Figure 34).

During our survey we collected tourists' perception (ranking) on various activities, i.e. watching of flamingos, wild ass, hyena and fox, jeep safari, relaxation, salt pan, walking in Rann, local food, local culture, staying in huts and others (photography, hospitality). Around 72% of tourists gave high rank to watching flamingos and other migratory birds (Figure 35). Around 54% of tourists gave a high rank to wild ass. This suggests that tourists value the two flagship species of LRK (Table 54).

Importantly, visitors gave high value to jeep-safari in LRK — wandering in the wilderness of LRK landscape. In overall terms, 55% of total respondent tourists reported very high level of satisfaction in visiting LRK. Similarly, majority of respondents (71%) emphasize that biodiversity conservation effort in LRK needs to be carried forward.

7.4.3. TRAVEL COST AS RECREATIONAL VALUE OF LRK

The use value of biodiversity is estimated in terms of tourists' visits to LRK and their travel costs. More the travel cost, more the value assigned to the site and its various biodiversity elements. Total costs include

Table 53: Tourists' preferences for different biodiversity values of LRK

Values	% of total Respondents						
	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	No Perception
Migratory Birds and flamingos	76.3	13.2	7.9	0	0	2.6	0
Wild ass	13.2	26.3	28.9	10.5	10.5	2.6	7.9
Blue bull	0	13.2	15.8	26.3	15.8	10.5	18.4
Other wildlife	2.6	26.3	10.5	18.4	21.1	5.3	15.8
Landscape	5.3	18.4	18.4	23.7	18.4	2.6	13.2

Rank 1 is highest preferred and rank 6 is lowest preferred

Figure 34: Tourists' preferences for different biodiversity values in LRK

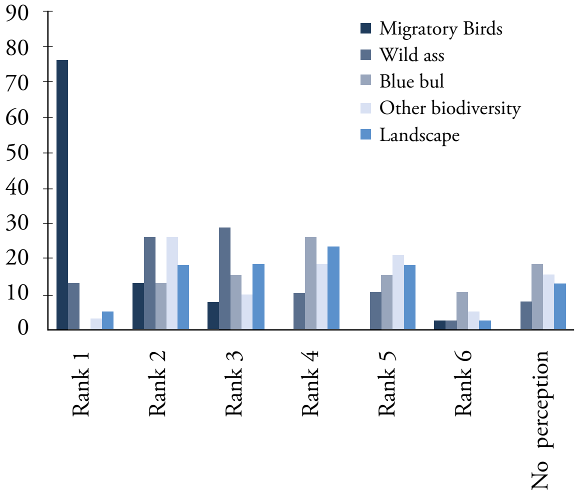
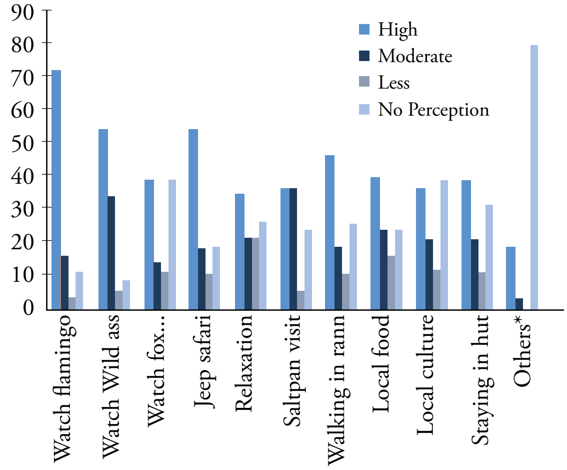


Figure 35: Level of satisfactions with different activities in LRK



different fares and fuel charges (e.g. plane, train, bus, car), and all the accommodation costs, food, entrance fee and purchase of souvenir items. Travel expenses vary depending upon distance travelled and number of days stayed in LRK. Per capita travel expenses are ₹7,600, 17,576 and 53,417 for local, national and foreign tourists, respectively (Table 55).

We define opportunity cost of time as per capita household income per day corrected for the days spent in the LRK. Hence, study recorded an average per capita opportunity cost of time as ₹3,607 and 24,493 for Indian and foreign tourists respectively.

The study revealed that the LRK landscape generates tourism values for the flat wilderness of Rann, existence of endemic Indian wild ass, diversity and abundance of migratory and residential aquatic and terrestrial birds and other biodiversity.

The result of travel cost approach suggests that tourists generated a total use value of ₹276 million during 2013-14. However it is important to mention here that in the present study we have not covered local villagers' recreational value. This is due to the fact we have covered our sample from functioning 6 resorts (most of the tourists were from faraway of LRK landscape) on the fringe areas of LRK.

While the number of tourists has grown in the last few years, yet considering its vast potential, the numbers

Table 54: Perception of important activities and satisfaction level

Activities	High	Moderate	Low	No Perception
Watch flamingo	71.8	15.4	2.6	10.3
Watch wild ass	53.8	33.3	5.1	7.7
Watch fox & hyena	38.5	12.8	10.3	38.5
Jeep safari	53.8	17.9	10.3	17.9
Relaxation	33.3	20.5	20.5	25.6
Salt pan visit	35.9	35.9	5.1	23.1
Walking in Rann	46.2	17.9	10.3	25.6
Local food	38.5	23.1	15.4	23.1
Local culture	35.5	20.5	10.5	38.5
Staying in hut	38.5	20.5	10.3	30.8
Others	17.9	2.6	0	79.5

While the number of tourists has grown in the last few years, the numbers remain insufficient for sustaining tourism as an industry. Enhancement of tourism facilities should be encouraged, but proper regulation, monitoring and maintenance should be made judiciously

are too low to sustain tourism as an industry. Therefore, enhancement of tourism facilities should be encouraged. In addition to this, proper regulation, monitoring and maintenance should be made judiciously. These would enhance the benefits to local communities and management authority that ultimately used it for ecosystem management. The interaction between the tourism sector and local economy in LRK needs to be studied.

7.5. Non Use Value – Biodiversity: Migratory Birds

7.5.1. Approach

The earlier chapter on biodiversity values of LRK discussed unique assemblage and richness of bird species including many migratory species that visit mainly to use the seasonally created wetland habitats. Some of these values include:

- More than 90 species of aquatic birds, including 70 that migrate in winters;
- Large congregation of cranes, pelican and flamingos;
- Nesting site of lesser flamingo; and
- More than 15 species under globally threatened categories.

In the present study an attempt was made to assess non-use value (especially migratory birds) of LRK ecosystem. For this, we employed the contingent valuation method to elicit household's willingness to pay. Contingent valuation, based on surveys that elicit 'stated preferences', has the potential to value benefits in all situations, including non-use benefits that are not associated with any observable behavior.

To estimate non-use value of LRK landscape, we surveyed more than 200 households across different communities (including fishers, farmers, agariyas and general public) residing in LRK landscape. Samples were taken from both rural and urban centres (see Chapter 4 for detailed description).

7.5.2. Sample Characteristics

For getting proper representation from different section of the society living in LRK landscape, we covered both rural and urban centres and interviewed adequate number of households representing major occupational groups, e.g. salt workers, fishers and farmers (Table 56).

Location of sample households suggests that it was well spread and covered quite a large area around LRK. The average age of respondents varies from 33 years (general public) to 45.5 years (fishers). Only drawback in sampling was, perhaps, a poor representation of women respondents. (Since economic decisions are largely in the male domain among poor families in general, perhaps this contributes to a more accurate result.) Except urban respondents, all others had very poor educational attainment levels.

Table 55: Different elements of travel costs across tourist types

Tourist Type	N	Avg. Per Capita TC (₹) (A)	Avg. Per Capita Opportunity cost of time (₹) (B)	Avg. Per capita Total TC (A+B) (₹)	No. of Tourists Visited (2013-14)	Total TC in 2013-14 (Million ₹)
Local-Gujarat (a)	7	7600	3417	11017	10402	199.59
Other States (b)	28	17576	3654	21230		
Indian (a+b)	35	15581	3607	19188		
Foreigner	3	53417	24493	77910	1185	92.32
Overall	38	18568	5255	23824	11587	276.05

WETLANDS

Table 56: Summary characteristics of sample households

Respondent Group	No. of sample	Sex %		Avg age	Avg yrs of schooling	Sample Location
		M	F			
Fishers	62	92	8	40.4	1	Southern part of LRK, 9 fishing temporary settlements
Farmers	91	100	0	45.5	6	20 villages from 10 talukas across LRK
Agariya	26	100	0	38.8	3	Southern and eastern parts of LRK
Other Urban public	42	100	0	33.0	10	4 towns near LRK Dhrangadhra, Halvad, Patdi and Bajana

7.5.3. Willingness to Pay for Biodiversity Conservation

From the sample of 221 respondents, we considered 218 responses for our analysis (3 outliers were removed). In the analysis we have considered all valid respondents including 'positive and negative' WTP responses. Our findings suggests that the average annual WTP of farmers, fishers, salt makers and general public from urban centres are around ₹336, 226, 685 and 596, respectively (Table 57, Figure 36). Overall, the average annual WTP worked out to around ₹397 for the conservation of biodiversity, especially the migratory birds.

It is interesting to point out here that during our field work we observed that most of the HH are engaged in grain feeding to various bird species as a practices and norms.

In addition to this, each village has a community grain feeding structure, locally called Chabutara, where village communities feed local birds. This type of practices and norms also reflected while they were attributing their Willingness to Pay. Therefore cultural norms have a major role in determining the respondents' WTP.

7.5.4. TOTAL NON-USE VALUE OF BIODIVERSITY Conservation

In order to arrive at the total non-use value of biodiversity of LRK, the average annual WTP per family was extrapolated to the total number of families of LRK landscape. In the present context, we define boundaries of LRK landscape as adjoining talukas. This approach is justified due to the fact that the study draws its samples from villages and urban centres in these 10 talukas.

In order to get a more realistic estimate we separately computed values for rural and urban areas, covering 772 villages and 9 urban centres. As per 2011 census, there were about 2.9 lakh rural households and 54 thousand urban households in the LRK landscape (10 adjoining talukas). Further, based on review of literature and use of 2011 census data, we estimated and desegregated the total number of rural households into three major user groups, viz. agariyas, fishers and farmers.

By extrapolating the average annual WTP of different categories of stakeholders to the total number

Table 57: Summary of per family willingness to pay across communities

Type	Valid Sample	Average Annual WTP (₹)	Minimum WTP (₹)	Maximum WTP (₹)
Farmer	88	336.36	100	2000
Fisher	62	226.13	30	1000
Salt work	26	684.62	100	1500
General	42	596.43	100	1500
Overall	218	396.65	30	2000

Figure 36: Average annual per family WTP across communities

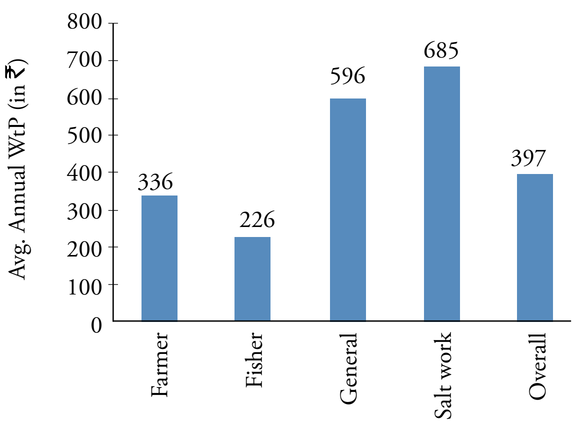


Table 58: Total Annual WTP for cnservation of biodiversity values in LRK

Respondents	Total Number of Households	Average Annual Per HH WTP	Total Value of WTP (in Million ₹)
Rural	290489	348.98*	101.4
Agariya	7500	684.62	5.13
Fishers	1300	226.13	0.29
Farmers & Others	281689	336.36	94.75
Urban	54293	596.43	32.4
Overall	344782	396.65**	136.8

** the value represent average of all 176 households considered as rural   ** The value represent average of all the 218 respondents*

of households under these categories, we estimated the total WTP and thus the non-use value of biodiversity. Thus, the total non-use value of biodiversity in LRK comes out as ₹136.8 millions, annually (Table 58).

7.6. Total Biodiversity Value of LRK

The study estimated total use and non-use values of biodiversity, using travel cost and contingent valuation methods, respectively. Accordingly, the annual recreational use value of biodiversity in LRK was found to be ₹276 millions while annual non-use biodiversity existence value was imputed as ₹137 millions. Thus, total annual biodiversity value of LRK was found to be around ₹413 millions (Table 59)

7.7. Economic Valuation – Summary

The discussions in the different sections of this chapter outlined various goods and services provided by wetland system of Little Rann of Kachchh. Based on the existing scientific knowledge, available socio economic information and designed field surveys, the study estimates the economic values of following four services:

i. Prawn production
ii. Salt production
iii. Tourism and Recreation
iv. Biodiversity

The estimated values of above services of LRK wetland system are summarized in Table 60.

Table 59: Use and non-use values of biodiversity of LRK

Use Value* (in Million ₹)	Non-use Value** (in Million ₹)	Total Biodiversity Value (in Million ₹)
276.05	136.80	412.85

** Travel Cost Methods; ** Contingent valuation method*

Accordingly, in terms of above goods and services, wetlands of LRK provide an annual benefit of approximately ₹1,517.3 million. Table also suggests that for the wetlands of LRK, the maximum value is derived from salt production followed by prawn fisheries. It is important to mention here that these two sectors are the mainstay of traditional production systems and thus heavily depend upon LRK. The biodiversity benefits are usually hidden from the mainstream economic analysis and thus reported for the first time for LRK. The tourism and recreational values associated with wetlands and other elements of LRK are steadily growing recently.

It is also very important to understand, that while any decline in the 'wetland health' would essentially entail some quick losses in the values of three functions viz. Prawn fishery, tourism and biodiversity, due to their strong network and relationship with wetland as system. In other words they have low tolerance levels and thus,

Table 60: Total estimated annual value of wetland system of LRK

Goods & Services	Method	Total Annual Value* (Million ₹)
Prawn Fisheries	Market Revenue Analysis	410.14
Salt production	Market Revenue Analysis	694.30
Tourism & Recreation	Travel Cost	276.05
Maintenance of Biodiversity	Contingent Valuation	136.80
Total		1517.29

** For Prawn production and Salt production, we estimated net annual value*

The wetlands of LRK have a significant economic value which is critical for the survival of the local economy in the tri-junction of the semi-arid belt of Kachchh, Saurashtra and north Gujarat

with wetland degradation, these values may fall rapidly. On the other hand, salt production, per se, is not very closely linked with 'wetland health', and thus may not be affected with degradation of wetland system of LRK.

7.8. Net Present Value

Discounting is done because economists assume that today's investments and technical change will produce economic growth. Growth is then the reason for undervaluing future consumption and future enjoyment. It is also a reason to undervalue future needs for environmental goods and services. Discounting is a procedure that allows computing the present value of financial flows that will take place in the future. Discounting is needed in cost benefit analysis to calculate net present values which are the key criterion for investments. Discount rates relate to investment rates: the lower the former, the higher the latter. As such, discounting reflects the balance between present and future well-being.

Discounting is probably one of the most disputed issues in ecological economics. Current human activities may cause immediate and long-term environmental damages. Discounting, the usual procedure to give a present value to financial flows occurring in the future, seems to give outrageously low values to future damages, and thus, to "play against" the environment and future generations. On the other hand, low discount rates would imply more sacrifices for present generations, although future generations may be richer. In case of environment, the most important point is to recall that environmental assets that are not substitutable or reproducible should be given a value growing over time at a rate close to the discount rate. This would give greater net present values to future damages arising to the environment.

The practice of discounting means how to allocate scarce resources at a particular point in time. In general, an individual would prefer to have something now rather than in the future. This is the main argument for a positive discount rate. But a higher discount rate will lead to the long-term degradation of biodiversity and ecosystems. For example, a 5% discount rate implies that biodiversity loss 50 years from now will be valued at only 1/7th of the same amount of biodiversity loss today. With a constant discount rate of only 4%, the present value of benefits accruing in one hundred years' time is only one fiftieth of the value of those benefits today. This ratio, which is one fiftieth in this instance, is what is known as the 'discount factor'

In terms of annuity benefits of LRK wetlands, using discount rate of 2% and 4%, the values turned out to be 24732 and 20483 million Rupees for 20 years time horizon, respectively. However, the benefit for infinitum (i.e. perpetually) varies between 75865 and 37932 million rupees, respectively (Table 61). These estimations demonstrate that the wetlands of LRK have a significant economic value which is critical for the survival of the local economy in such tri-junction of semi-arid belt of Kachchh, Saurashtra and north Gujarat, where livelihood options are limited and are totally dependent upon monsoonal rainfall.

Table 61: Net annual benefit and net present value (in Million ₹) of different ecosystem functions of wetlands of LRK (2014)

LRK Wetland Functions & Benefits	Net Annual Benefit (2014) Million ₹	20 years		Infinitum	
		2% DR	4% DR	2% DR	4% DR
Prawn Fisheries	410.14	6685.28	5536.89	20507.0	10253.5
Salt Production	694.30	11317.09	9375.05	34715.0	17357.5
Tourism	276.05	4499.62	3726.68	13802.5	6901.3
Biodiversity	136.80	2229.84	1846.80	6840.0	3420.0
Total	1517.29	24731.82	20483.41	75864.5	37932.3

8. Major Threats to Sustainability of LRK Ecosystem

As described and emphasized in earlier chapters, LRK wetlands are natural assets which through their ecological structure and functions, generate different goods and services for the local and regional communities. However, these wetlands are facing threats mainly from three different sets of drivers viz. natural, human and policy. Considering the fact, that LRK is a large wetland having very large catchment area, the above drivers are often operating at landscape levels. This ultimately altered the landuse system surrounding LRK and most importantly the hydrological system. In the context of this study, it is essential to identify, discern and explain major, if not all, threats for sustainable flow of ecosystem goods and services of LRK wetlands. Some of the important drivers of change of LRK wetland system are described below.

8.1. Increasing Freshwater Appropriation in the LRK Catchment

As discussed in an earlier chapter, LRK has a catchment area of about 10,500 sq. km, spread over Gujarat and Rajasthan. The catchment area consists of south flowing rivers like Banas, Saraswati and Rupen of North Gujarat and Aravalli hills of Rajasthan. Also, quite a few north flowing rivers like Kankavati, Brahmni, Phalku, Ghodadhoroi and Machhu construct the Saurashtra part of LRK catchment.

It is important that for the functioning of the food–web of LRK wetland to continue, run-off water from above catchment areas needs to reach to LRK. This water, as discussed earlier, actually brings large amount of nutrients, detritus and organic matters and even seeds and eggs / larvae of many phyto and zoo-planktons and other organisms. These chemical and biological materials form the basic ecological structure of wetlands of LRK which are transferred into different trophic levels and through a food chain finally accumulate in biomass of *M. kutchensis*. The maintenance of such a food chain and creation of biomass is one major ecological function of these wetlands. The off-take of some fraction of this biomass by fishermen is thus a direct 'good' which is linked to ecosystem service of LRK wetland. Unequivocally, a continuous and sustained level of runoff water is needed to run these services so the biomass off-take is maintained.

However, during last few decades, especially after 1960s, there is serious curtailment in runoff water to reach LRK due to construction of water harvesting structures in the entire catchment area of LRK. Such rain water harvesting or appropriation practices are mainly aimed to improve only one production system viz. agriculture, ignoring the water needs of other production systems like fisheries. More importantly it is essential to meet various habitat needs of many floral and faunal species including the rare and endangered ones. The downstream impacts of such water resource development have generated serious debates. The issues

Table 62: Summary of reservoirs constructed on rivers discharging water in LRK

Dams	River	Region	Operational year	Gross Annual Storage Capacity (MCM)
20 Minor Irrigation Schemes	Banas	Rajasthan	NA	68.73
Dantiwada	Banas	North Gujarat	1965	464.00
Sipu	Banas	North Gujarat	1992	177.80
Saraswati Barrage	Saraswati	Gujarat	1972	1.42
Mukteshwar	Saraswati	Gujarat	1990	40.00
Machchhu-1	Machhu	Saurashtra	1959	72.74
Machchhu-2	Machhu	Saurashtra	1986	100.55
Ghodadhroi	Ghodadhroi	Saurashtra	NA	8.34
Falku	Falku	Saurashtra	1986	11.37
Brhamani-1	Brahmani	Saurashtra	1953	75.00
Brhamani-2	Brahmani	Saurashtra	2000	16.32

Source: *NWRWS website*, NA-*Not available* like minimum mandatory flow (e-flow) has recently been taking center-stage in water resource related policy discourses.

In the present context of LRK, there are two major types of rainwater harvesting related interventions in its large catchment area. These include construction of irrigation dams on some of the major south flowing rivers of North Gujarat and north flowing rivers of Saurashtra. In addition to that, large numbers of check-dams are also constructed on small order streams (nalas).

The study compiled data from Namada, Water Resource and Kalpasar Department and estimated that Gujarat and Rajasthan collectively constructed about 30 small and medium size irrigation dams in LRK catchment area with a total annual water storage capacity of 1036.27 million cubic meter (MCM). Of

Table 63: Number of check dams constructed under different schemes in LRK catchment

District	Taluka	DDP (1999-2003)	Hariyali (2003-2012)	DPAP/ EAS/ IWDP	IWMP	Total
Ahmedabad	Mandal	0	109	205	24	338
Ahmedabad	Viramgam	0	126	195	19	340
Banaskantha	Amirgardh	209	109	0	0	318
Banaskantha	Danta	173	107	5	0	285
Banaskantha	Dantiwada	207	119	0	0	326
Banaskantha	Deesa	203	107	0	0	310
Banaskantha	Deodar	191	103	0	0	294
Banaskantha	Kankrej	181	92	0	0	273
Banaskantha	Vadgam	217	98	0	0	315
Banaskantha	Vav	169	114	13	9	305
Kachchh	Bhachau	224	100	0	22	346
Kachchh	Rapar	220	140	0	6	366
Mehsana	Becharaji	0	34	0	39	73
Mehsana	Mehsana	0	0	0	8	8
Mehsana	Unjha	0	0	0	0	0
Mehsana	Visnagar	0	0	0	0	0
Patan	Chanasma	203	103	12	0	318
Patan	Harij	206	93	7	0	306
Patan	Patan	204	106	13	0	323
Patan	Radhanpur	193	123	7	0	323
Patan	Sami	223	103	5	0	331
Patan	Santalpur	213	111	0	7	331
Patan	Sidhpur	198	95	9	0	302
Patan	Vagdod	163	109	13	0	285
Rajkot	Maliya	206	117	4	4	331
Rajkot	Morbi	187	104	8	2	301
Surendranagar	Dasada	96	68	0	11	175
Surendranagar	Dhrangadra	100	120	0	28	248
Surendranagar	Halvad	103	120	0	0	223
Surendranagar	Lakhtar	48	42	2	1	93
TOTAL	4337	2772	498	196	7803	

Source: *District Panchyat Office*

these, only about 7% of total capacity is created on the Rajasthan side. Thus, majority of reservoir storage capacity is available in Gujarat. It is important to note that 20 minor irrigation schemes in Rajasthan and Dantiwada and Sipu dams on river Banas, collectively accounting to about 69% of total storage capacity. The Dantiwada dam is operational for last 50 years while the Machchhu-1 and Brahmni-1 are relatively older dams. Although, in total 7 major river systems of LRK catchment area were dammed, it is strikingly clear that Banas River and its main tributaries are dammed most (Table 62).

In addition to the above, we also collected data on construction of check-dams in the entire LRK catchment area under different Government schemes. Thus, numbers of check dams in 30 talukas of 6 districts which falls within LRK catchment were collated. Accordingly, a total of 7803 check dams had been constructed using Government funds in the LRK catchment area (Table 63).

Based on the above two data sets, we estimated the volume of total harvested rainwater in the LRK catchment. However, it is important to realize that in a semi-arid tract, the actual water storage in the reservoir rarely filled in its total capacity. Thus by analyzing reservoir storage data of 44 years period for Dantiwada dam, which is located in highest rainfall zone within the LRK catchment, we found that on an average only about 45% of the total dam capacity is filled every year. Thus, we assumed that with the kind of year to year rainfall fluctuations, on an average only about 45% of the total storage capacity of reservoirs are filled annually. Accordingly, therefore, the reservoirs stored a total of about 466 million cubic meters (MCM) (16468 million cubic feet, MCF) of rain water.

Table 64: Estimated water storage & harvesting in reservoirs & check-dams in LRK catchment

Parameter	Value
A. Total Storage Capacity of Reservoirs (MCM)	1036.27
B. Avg. Annual storage (% of total storage capacity) in Reservoir	45.00
C. Total average annual storage of all the reservoir (MCM)	466.32
D. Total average annual storage of all the reservoir (MCF)	16468.00
E. Total Number of Check-dams in LRK catchment	7803.00
F. Avg. water storage capacity of each check-dam (MCF)	0.05
G. Total water storage in all the check-dams (MCF)	390.00
H. Total Water Storage in reservoir and & check-dams (D+G)(MCF)	16858.00

Further, we believed that on an average each check-dam stored about 0.05 million cubic feet of rain water. Thus, a total of about 11 MCM (or 390 MCF) rainwater of LRK catchment area are harvested into check dams. Thus, we estimated about 16858 MCF of total runoff of entire LRK catchment is stored annually in dams and check-dams (Table 64). In the above scenario, the key question is to know what this stored water should mean for LRK? In other words, what are the possible effects, if LRK does not receive 17000 MCF of runoff-water?

Considering that due to slight topographical inclination towards south-western side, most of the water flowing into LRK accumulates in central to southern part of the LRK; other remaining areas may not be able to retain water for longer durations. Thus, for the present study context, we can safely delineate an area of about 1500-2000 sq. km which actually functions as wetland where water is stored for longer duration and thus perform various wetland functions like prawn production and provide habitat for birds and other animal species. Thus, we considered potential wetland area of LRK is about 1700 sq. km.

Interestingly we estimated that if the 16858 MCF water is not blocked but allowed to reach LRK and flood the potential wetland areas (which may be around 50-60 years back was actually happening), then water column in these wetlands may rise to another 0.92 feet (i.e. ~28 cm). In the context of LRK where the average depth of wetland is only ranging around 4 to 5 feet, the availability of around one additional feet of water column may have many serious ecological-economical implications. For example:

- Extension of fishing season by 10-15 more days which in turn means more catch for fishers. Dixit et al. (2008) also reported that "…due to massive water harvesting efforts, the freshwater flow in the LRK is drastically reduced. And, only in exceptionally good monsoon years the Rann gets fully inundated. Due to such reduction in the freshwater flow, particularly post 1980s, there was total extermination of high value fish — the Hilsa (locally known as Palla) — from the LRK. Such reduced freshwater flow, also declined the availability of key food items of the

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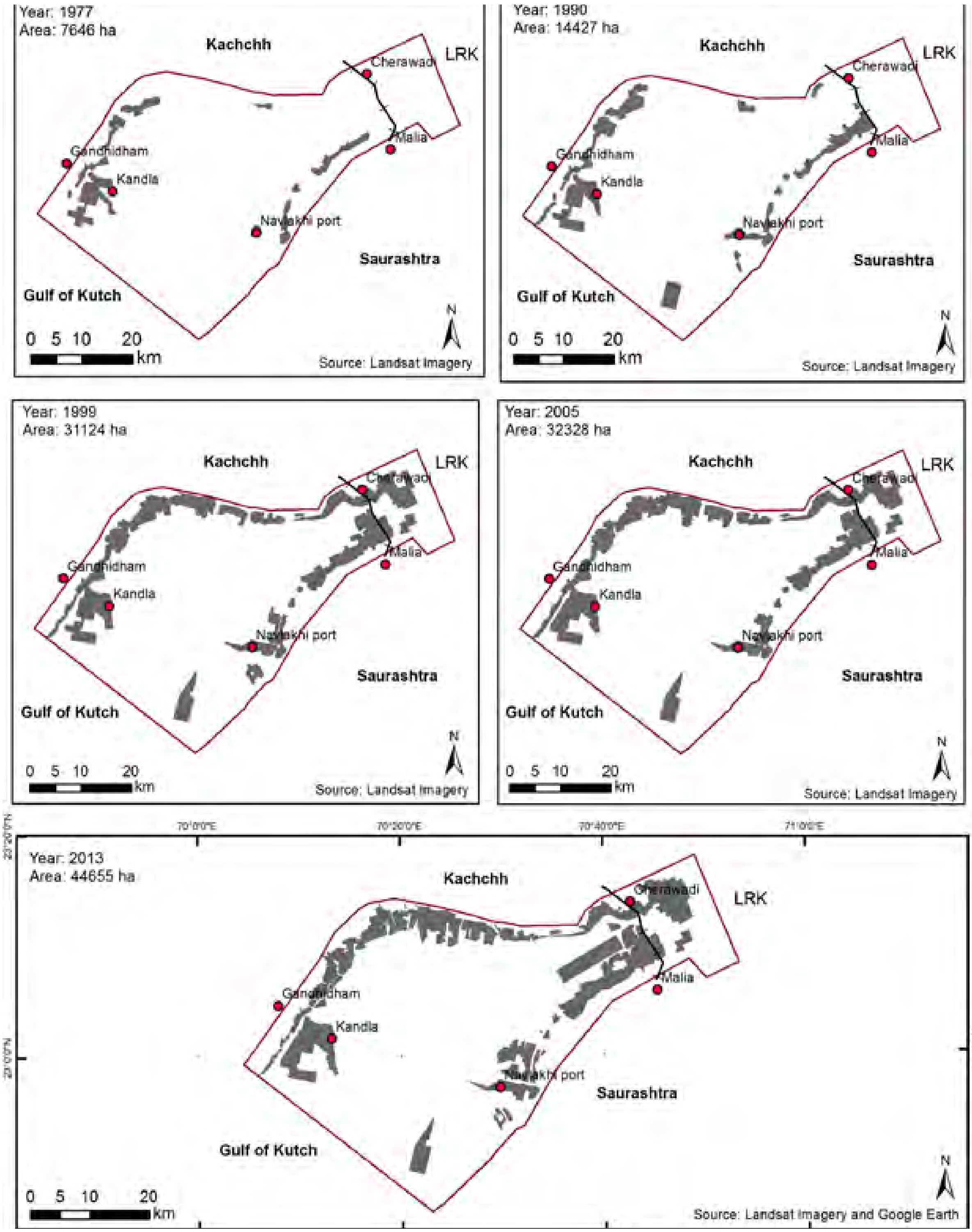
Figure 37: Expansion of salt work in and around network of Surajbari creek system



Prawns and many other fish species".
- Higher probability of success of Lesser Flamingo nesting near Wasraj Solanki, as often the nest is abandoned due to lack of water and food.

8.2. Deteriorating Ecological Integrity of LRK Habitats

In the earlier sections, it was well established that other than freshwater inflow, the ecology of wetlands of LRK is heavily determined by the ecological linkage with Surajbari creeks . The connectivity with a creek actually supplies the tidal saline water which in turn carries seeds and larvae of many marine organisms, including the flagship prawn species (*M. kutchensis*) to LRK- their nursery grounds. In the context of LRK, Surajbari creek is the most critical system for the very functioning of ecosystem of LRK wetland. As also described earlier, for the life cycle of *M. kutchensis* and other fish and crustaceans, Surajbari creek is as vital as the GoK and LRK. Clearly, while there are flows of water, material and energy through these creeks, the mudflats surrounding these creeks also provide ideal residual habitat for many species of fish, crabs, crustaceans and birds. In totality, therefore, for the sustained flow of ecosystem services from LRK, it is imperative to maintain the overall ecological health of Surajbari creek. Literature clearly suggests that Surajbari network of creeks actually provide habitats to *M. kutchensis* throughout the year, in two major ways. First, it provides transitional habitats for about 2-3 months (June to August), mainly the mud-flats along the creeks, for pre-larvae to settle and take final journey towards LRK. Second, the same habitats support juvenile prawns, which are escape uncaught from LRK, for rest of the year, and where they attained maturity.

However, of-late the ecological health of these networks of creeks is compromised on many accounts, jeopardizing the live ecological linkage with LRK and thus the ecosystem functions of wetlands. Some of the key factors which cumulatively assisting the physical and ecological changes of Surajbari creeks include:

8.2.1. Port Development

Kandla Port, one of the major ports of Western Coast, was constructed along Kandla Creek, during 1950s in the north western part of GoK. On the southwest end of GoK, Navlakhi port was constructed along the Hansthal creek during 1980s. These ports actually trigger the major changes in creeks' physical and ecological characteristics.

8.2.2. Salt Work Expansion

It was observed that over the years the marine salt work activities in and around these creeks had been increased manifold. Satellite imagery based assessment recorded that between 1977 and 2013 the area under salt pans and its ancillary production areas were increased almost 6 times i.e. 7646 ha in 1977 to 44655 ha in 2013 (Figure 37). As per official records, collected under this study, a total of 21601.4 Ha (216 sq. km) of mud-flats and creeks had been officially given on lease (of different periods) for salt work purposed in Kachchh and Rajkot districts (Table 65).

The salt work expansion in creek areas causes degradation of fish/prawn habitats by three accounts: blocking and diverting of creek and thus creek water, reduced residual feeding areas for larvae and juvenile *M. kutchensis* and other species; and altering of water quality by discharging the huge volume of waste from the salt work. Literature search reveals no study to assess the true magnitude of these impacts on prawn fishery, especially on *M. kutchensis*.

8.2.3. Linear Expansion of Roads & Railways

It is important to realize that Surajbari creeks are the border between two of the economically vibrant regions of the state of Gujarat- the Kachchh and Saurashtra. Thus, of-late many of the infrastructures related

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Port development, salt work expansion, expansion of roads and railways, and diversion of freshwater flow are among the key factors jeopardizing the ecological linkages with LRK and the ecosytem function of the wetlands

Table 65: Village-wise summary of lease area given for salt work in Surajbari creek region

District	Village	Lease Area (Acre)	District	Village Name	Lease Area (Acre)
Kachchh	Ambaliyara	170	Rajkot	Bagasara	1508
Kachchh	Bharapar	390	Rajkot	Bhavpar	837
Kachchh	Bhimsar	400	Rajkot	Bodki	2506
Kachchh	Chudva	450	Rajkot	Chikhli	630
Kachchh	Gandhidham	851	Rajkot	Haripar	5026
Kachchh	Jangi	525	Rajkot	Jajasar	3964
Kachchh	Kidana	580	Rajkot	Maliya	835
Kachchh	Kumbhariya	20	Rajkot	Varshamedi	5367
Kachchh	Mithi Rohar	390	Rajkot	Vavaniya	1411
Kachchh	Moti Chirai	1306	Rajkot	Venasar	80
Kachchh	Nani Chirai	500			
Kachchh	Nani chirai	10			
Kachchh	Padana	130			
Kachchh	Shikarpur	13790			
Kachchh	Tuna	10			
Kachchh	Vandhiya	10688			
Kachchh	Vondh	1004			
Total Kachchh		31214	Total Rajkot		22165
TOTAL IN CREEK		53379 Acre (=21601 ha)			

Source: *Revenue Department Records of Kachchh and Rajkot Districts (2014)*

projects had passed through these creeks, especially to link recently industrialized Kachchh to other regions of Gujarat. Due to physical barriers, most of these linear infrastructures, mainly the power lines, roads and railway lines, are passing through a narrow area on both side of Surajbari Bridge. Due to these developments, the creek's sedimentation and flooding patterns are altered at many critical locations.

8.2.4. Diversion of Freshwater Flow in Creek Area

It is well understood that for better ecological health of Surajabari creeks and their mud-flat areas, fresh water flow is one major determinant. In the Surjabari creek area, three west-flowing rivers from Saurashtra region, namely Machchhu, Demi and Aji, drain their water between LRK mouth and Navlakhi (Figure 38). On Kachchh side, there is only one major river — the Adhoi which drains into Surajbari creek area. These rivers used to discharge huge volume of freshwater and help in the ecology of these different creek systems.

However, as described earlier for other river systems, these rivers are also dammed and thus reduce the freshwater flow into creek system. In total there are 11 reservoirs constructed on these rivers with total storage capacity of 455 MCM water (Table 66).

The earlier chapter on prawn fisheries (Chapter 5) established strongly the critical importance of GoK, in general, and Surajbari and other creeks, in particular, for the life cycle of *M. kutchensis* and production of prawn fishery in LRK. It describes that these river discharges bring huge quantity of nutrients and detritus material which provide food materials for seeds and larvae of *M. kutchensis* and other species, before they move into their major nursery ground — the LRK.

8.2.5. Loss of Fishing Habitat & Livelihood

The above description clearly suggests that there are major economic and developmental pressures on Surajbari creek systems — a major habitat for *M. kutchensis*, other fish and prawn species, and many bird species. Needless to say, these developmental pressures contribute their share of impacts on Surajbari creeks

Table 66: Summary of reservoirs constructed on rivers discharging water in Surajbari creeks

Dam Name	River	Region	Operational Year	Total Storage Capacity (MCM)
Machchhu -1	Machchhu	Saurashtra	1959	72.74
Machchhu - 2	Machchhu	Saurashtra	1986	100.55
Aji-1	Aji	Saurashtra	1954	29.09
Aji-2	Aji	Saurashtra	1988	22.09
Aji-3	Aji	Saurashtra	Na	65.15
Aji-4	Aji	Saurashtra	1983	35.31
Demi-1	Demi	Saurashtra	1958	21.53
Demi-2	Demi	Saurashtra	1988	18.91
Demi-3	Demi	Saurashtra	2001	9.60
Adhoi-1	Adhoi	Kachchh	Na	59.91
Adhoi-2	Adhoi	Kachchh	Na	20.16
Total				455.04

Source: *http://guj-nwrws.gujarat.gov.in/*

and their various ecosystem services. One of the major indicators of impacts of such large scale and chronic problems is the loss of fishing habitats and livelihood loss to the dependent fisher-folks. With these, it is safely assumed that such large scale alteration in fish/prawn habitats, in terms of loss of area due to salt pans and diversion of creek water and change in its quality, ultimately affect the population and ecology of *M. kutchensis* and thus the fish economy of LRK.

In the above context, under this study we record the knowledge of local fishers in identifying important creeks and other fishing grounds. Subsequently, by using satellite imageries and carrying out focus group discussions, we identify extent of loss of fishing habitats due to salt work and also displacement of families and livelihood. Accordingly, fishers identified a total of 17 important creeks for prawn and other fisheries (other than the well known creeks, described in earlier section) (Figure 39). They reported that in 8 out of 17 creeks now fishing is almost stopped (Table 67) and four creeks are considered still good for fishing purpose.

More importantly, fishers identified and mapped 14 important fishing locations in the entire Surajbari creek area (Figure 40) and reported that compared to 10-15 years back the number of fisher families in these locations is declined drastically, i.e. 5255 to 1100 (Table 68). This is due to the degradation or diversion of fishing areas mainly owe to rapid expansion of salt work. Interestingly, it is also recorded that out of total reported potential area of 14 fishing grounds in Surajbari creek (covering about 29000 ha), around 18250 ha area is totally lost due to salt works. Thus about 2/3rd of total fishing grounds were lost (Table 69).

Figure 39: Important fishing creeks (A) North of Surajbari bridge (B) Near Navlakhi port. Find locations in Table 67.

It is very clearly visible from this study, that there are serious losses of fishing areas in Surajbari creeks in last 10-15 years time which actually causes loss of

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Figure 40: Important fishing areas in Surajbari creeks. Refer numbers in Table 8.6. Source: FGD, Present Survey.

livelihood opportunity for about 4000 families.

8.3. Changes in the Water Balance in LRK

8.3.1. Freshwater Availability to LRK

In the context of LRK, while the above estimation of water captured in different reservoirs and check-dams has its own consequences, it is equally important to know how much water is actually available to LRK for its inundation. So, there are two major sources of water for LRK — the runoff discharge and rainfall water that directly fall on LRK. It can also be expressed as:

Total Available Water for LRK = Water discharged

Table 67: Description of different creeks and their current fishing potential

Code*	Centre name	Creek name	Current Fishing Potential**
c-1	Navlakhi (jumavadi)	Haital 1	1
c-2	Navlakhi	Gadba	2
c-3	Navlakhi	Marevali	3
c-4	Navlakhi	Suibhag	0
c-5	Navlakhi	Lara 1	0
c-6	Navlakhi	Muraghai	1
c-7	Navlakhi	Lara 2	2
c-8	Navlakhi	Vaghi	2
c-9	Cheravadi	Bavavari	0
c-10	Cheravadi	Katiyavari	0
c-11	Cheravadi	Bhativari	0
c-12	Cheravadi	Sama	0
c-13	Cheravadi	Manak	0
c-14	Cheravadi	Saicha	0
c-15	Cheravadi	Cheravadi	2
c-16	Navlakhi	Haital 2	1
c-17	Navlakhi	Fatak	1

** *1-good fishing, 2-moderate, 3- low, 0-loss of fisheries;*
* *Refer Figure 3 for the location*
Source: *Participatory Resource Mapping during present study*

Table 68: Description of different fishing areas and their fishing potential

Code*	Fishing Area	Years of last fishing	No. of Fisher Families Present (10-15 years back)	No. of Fisher Families Present (Current)	Current Fishing Potential**
1	Kajarda talav	NA	400	150	1
2	Luravaro Rann	2	150	100	2
3	Nangavadi	NA	300	50	0
4	Cherovadi	10	300	300	0
5	Navlakhi	25	2500	300	No
6	Tapalvari	NA	300	20	No
7	Amaliyari	NA	55	10	No
8	Panakha	50	NA	0	No
9	Bangali	NA	150	20	No
10	Nani Chirai	30	150	50	No
11	Surajbari bridge	10	350	100	No
12	Jummavari	NA	NA	NA	No
13	Venasar katho	10	300	0	0
14	Cherovari-2	10	300	0	0
	TOTAL		5255	1100	

** *1-good fishing, 2-moderate, 3- low, 0-loss of fisheries, No – total loss of fshing;*
* *Refer Fig 4 for the location;* Source: *Participatory Resource Mapping during present study*

Table 69: Loss of potential fishing area due to salt work

Code*	Fishing Area	Potential Fishing Ground area (ha)	Area of Salt work within fishing ground (ha)	Remaining fishery ground (ha)	% of total Fishing Ground Remain
1	Kajarda talav	1049.43	0.00	1049.43	100.0
2	Luravaro Rann	1158.47	0.00	1158.47	100.0
3	Nangavadi	750.94	433.14	317.8	42.3
4	Cherovadi	115.90	92.29	23.61	20.4
5	Navlakhi	2374.66	1335.48	1039.18	43.8
6	Tapalvari	917.39	846.5	70.89	7.7
7	Amaliyari	1700.77	1312.12	388.65	22.9
8	Panakha	974.63	730.01	244.62	25.1
9	Bangali	768.83	338.5	430.33	56.0
10	Nani Chirai	4102.07	3082.44	1019.63	24.9
11	Surajbari bridge	7992.45	6224.13	1768.32	22.1
12	Jummavari	4.19	0.34	3.85	91.9
13	Venasar katho	2436.39	0.00	2436.39	100.0
14	Cherovari-2	4663.21	3849.78	813.43	17.4
	TOTAL	29009.33	18244.73	10764.6	37.1

* *Refer Fig 4 for the location*
Source: *Present Study*

into LRK + Rainfall directly fall on LRK surface

The basic reservoir specific data like their catchment area, average annual rainfall and average runoff generation potential in reservoir catchment is readily available (Table 70).

We used this data to estimate the total annual freshwater available to LRK from its entire catchment of about 11000 sq. km area and which receive average rainfall of about 670 mm. Accordingly, the entire LRK catchment had a annual water yield potential of 7369 MCM. However, with only about 13% runoff generation, only about 980 MCM runoff water is available for LRK. However, as discussed earlier about 466 MCM water is trapped in different reservoirs. Finally, only 514 MCM of runoff water is available to inundate the LRK plains (Table 71). More importantly, about 1249 MCM water from average rainfall of 350 mm, directly falls on LRK surface and helps its flooding. Thus, on an average about 1762 MCM of fresh water annually floods the LRK (in this, volume of sea water from Surajbari creek is not considered).

Based on above estimations, it can safely be assumed that with average annual rainfall of 670 mm and 13.3% of average runoff generation in the 11000 sq. km catchment area of LRK and; average rainfall of 350 mm directly fall on 3569 sq. km of LRK surface; and with the existing storage potential of reservoirs in the LRK catchment; only about 1763 MCM of monsoonal water floods LRK.

8.3.2. Creek Water Availability to LRK

Table 71: Estimated water storage & harvesting in reservoirs & check-dams in LRK catchment

Parameters	Value
a. Total catchment area of LRK (sq. km)	11000.0
b. Avg. annual rainfall in LRK catchment (mm)	670.0
c. Total Catchment area covered by reservoirs (sq. km)	8949.0
d. Avg. total water yield potential of LRK catchment (MCM) (a x b)	7368.9
e. Avg. % Runoff of total yield	13.3
f. Avg. actual annual runoff generation (MCM) (d/e)	979.9
g. Avg. annual total water capture in dams of LRK catchment (MCM)	466.3
h. Total water available to LRK from its catchment (MCM) (f-g)	513.6
i. Area of LRK (in sq. km)	3569.0
j. Avg Annual rainfall of LRK (in mm)	350.0
k. Avg. total rainwater available to LRK which directly falls on LRK surface (MCM) (i x j)	1249.2
l. Avg. total water available for inundation of LRK (MCM) (h+k)	1762.7

Table 70: Key statistics of reservoirs present in LRK catchment

Dam	Catchment Area (sq. km)	Avg. Annual Rainfall (mm)	Total Water Yield in Catchment (in MCM)	Total Mean Annual Runoff (in MCM)	% Runoff of Total Yield
Dantiwada	2862	940	2690.28	283.00	10.5
Sipu	1222	885	1081.47	69.00	6.4
Saraswati Barrage	1457	1016	1480.31	124.00	8.4
Mukteshwar	306	907	277.54	56.50	20.4
Falku	184	550	101.20	6.00	5.9
Brahmni-1	699	406	283.79	56.63	20.0
Brahmni-2	152	437	66.21	17.51	26.4
Ghodadhoroi	144	490	70.56	4.90	6.9
Machhu-1	730	508	370.84	64.44	17.4
Machhu-2	1193	560	668.08	71.40	10.7
Overall	8949	670	7090.29	753.38	13.3

In addition to freshwater, LRK also receives saline sea water from Surajbari creek areas and mix with it and create habitat suitable for *M. kutchensis* nursery. It is important to realize that unlike in case of freshwater flow, rainfall had very little bearing on tidal water ingress in the LRK. Rather it is mainly driven by the physical and oceanographic factors like tidal amplitude, bathymetry etc which usually had fixed diurnal as well as seasonal cycles of entry into LRK and assist in its inundation.

In the context of this study, it is important to understand that the tidal amplitude in the creek waters is very high – about 7.2 meter (Mean High Water Spring, MHWS) and 6.6 meter (Mean High Water Neap, MHWN) at Navlakhi port, which further rises towards its northern tail due to narrowing of cross-section of area. Such high tidal amplitude pumps large volume of sea water in the LRK regularly (Singh et al. 2004). When the LRK gets flooded during the south west monsoon it establishes a live connection with the tidal sea water near Surajbari creek area. Such mixing of freshwater and sea water creates a brackish water condition mainly due to physical process of dispersion and dilution of salinity.

There is no prior knowledge exist on dynamic process of sea water entry into LRK, mixing with freshwater and creation of brackish water condition through process of dilution and dispersion of salinity. However, for the purpose of this study we roughly estimate the contribution of sea water in the inundation process of LRK. For this we used simple formula of dilution of higher saline water by fresh water.

Generally, the sea water had the salinity in the range of 30 to 35 ppt. However, due to shallow depth and high evaporation losses, the sea water salinity near Surajbari was reported as high as 55 ppt. During peak monsoon season the salinity at various locations of LRK was varying between 12 to 34 ppt depending upon the rainfall amount, depth of water column, distance from river mouth etc. However, for the purpose of this study, we assume that during peak flooding period of LRK it maintains an average salinity of about 15 ppt. So, 55 ppt sea water needs 3.7 times of dilution to bring the salinity to 15 ppt (assuming that fresh water had nearly zero salinity). Putting it differently, 27 litre of 55 ppt sea water if mixed with 73 litre of fresh water, the resulting 100 litre water will have the 15 ppt salinity.

With the help of above dilution formula, we estimated that in order to have average saline water of 15 ppt in LRK wetland, which receives about 1763 MCM of monsoon fresh-water, it was required to mix about 652 MCM of sea water (of 55 ppt salinity). Thus, on an average year LRK must have total water of about 2415 MCM water (1763 MCM from monsoon and 652 MCM from sea).

In conclusion, it is estimated that in LRK there are three main sources of water- (i) the surface runoff generated from large catchment area (ii) the rainfall that landed directly on LRK and (iii) saline sea water. Under this study, it is estimated that, at a given time, on an average the proportional share of above three sources of water in total water available for LRK include:

Total Water in LRK = Runoff from Catchment (21.3%) + Direct Rain on LRK (51.7%) + Saline sea water inflow in LRK (27%).

Based on above understandings along with the knowledge presented in earlier chapter on Prawn Production system, broad ecological functions can be ascribed to different types of water, especially in terms of ecology and production of prawn- *M. kutchensis* (Table 72).

8.4. Decreasing Catch of Prawns: Perception of Fisher Folk

The study attempts to understand the perception of fishers on the overall status of fishing in LRK. Accordingly, 100% respondents (n=61) reported that fishery ecosystem in LRK has been deteriorated over the years. Importantly, 59% of total respondents recognize

Table 72: Key functions of different types of water that inundate LRK

Water Type	% Contribution	Key ecological function
Sea water	27.0	Brings larvae of *M. kutchensis* and other species also provide food items for *M. kutchensis.* Maintain subtle salinity (brackishness) of water in LRK
Direct rain water	51.7	Provide volume of fresh water which mix with sea water and bring the depth to water so that it can stay longer and provide habitat for fish and prawns
Runoff water	21.3	Provide nutrient and other detritus materials to LRK, essential for growth of food items of *M. kutchensis*

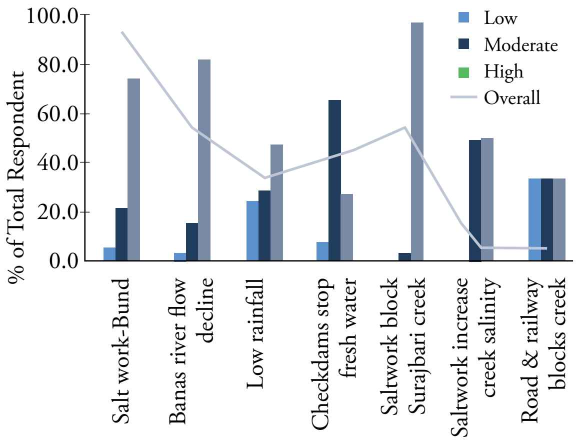
high degree of degradation and 36% reported moderate level of degradation.

Further, on enquiring about different causes for such degradation, respondents identified seven major factors. Majority of respondents reported that increasing bunds around salt works in LRK causes serious damage to prawn fishery. Disruption in fresh water flow due to damming of rivers (like Banas) and water storage in large number of check-dams in Kachchh, Saurashtra and north Gujarat part of LRK catchment are also identified as major drivers of change in ecology of prawn fishing in LRK (Table 73). Other areas of concerns include ecological changes in Surajbari and adjoining creeks due to salt work. Some of the respondents also reported infrastructure development across the creek near Surajbari had some degree of impacts on LRK prawn fishery (Figure 41). Many of these perceptions of fisher families strongly corroborate the above identified and described drivers of change in ecology of LRK wetlands and associated goods and services.

8.5. Land Use Change Due to Narmada Canal Waters

As discussed earlier, the LRK landscape traditionally supports low-input, rain-fed agriculture system. The irrigation was mostly by ground water or to some extent by small ponds etc. However, now most part of the LRK landscape is planned to be covered under command area of Narmada canals. The Narmada irrigation canal network is spreading rapidly in the landscape. According to master plan, once fully operational, the canal will provide irrigation water to about 5.5 lakh hectare of cultivable lands in 621 villages of LRK landscape. Needless to say such massive irrigation intervention will significantly alter the entire setting of LRK landscape and trigger rapid land-use changes.

Figure 41: Ranking of problems for prawn ecology & production



Some of these land use changes may include conversion of long standing private fallow-lands. Otherwise, these lands provide various ecosystem good and services including supply of fuel and fodder and conservation of biodiversity.

Also, the intensive irrigated agriculture may generate agro-chemical load, which ultimately sinks into LRK wetlands and thus disturbs the normal food chain of LRK water. As part of this study, we also conducted interviews of 92 farmers from the near catchment of LRK. It was observed that farmers are now using the canal water extensively, and even carrying this water long distance, through pipes by directly pumping water from canal (Photo). Survey also revealed that due to availability of canal water and thus the change in cropping pattern, the use of chemical fertilizers and pesticides have been increased recently. While almost

Table 73: Perception of fishermen on causes of degradation of prawn fishery in LRK

Cause of Degradation	Overall#	Level of Impacts*		
		Low	Moderate	High
Bunds of salt works in LRK	93.4	5.3	21.1	73.7
Disruption of Banas and other river flow	54.1	3.0	15.2	81.8
Recent low rainfall events	34.4	23.8	28.6	47.6
Freshwater harvest by Check-dams	42.6	7.7	65.4	26.9
Blocking of creek water by Salt work near Surajbari	54.1	0.0	3.0	97.0
Increased Salinity by Salt works near Surajbari creeks	6.6	0.0	50.0	50.0
Blocking of Creek water by roads/railways	4.9	33.3	33.3	33.3

 # Values are percentage of total respondents
** Values are percentage of only those respondents who gave the particular cause*

all farmers (97%) reported use of chemical fertilizers, nearly 85% reported use of pesticides. Interestingly, about 54% of total farmers had a view that such extensive use of agro-chemicals can have some degree of negative impacts on LRK wetlands and associated life-cycle of many species.

8.6. Concluding Remarks

This chapter emphatically presented the case that with the kind of development trajectories LRK landscape is facing and anticipating, the ecosystem services of wetland system are going to be impaired in nearly certain terms. The ecological roles of runoff water, creek water and even the direct rain water clearly emphasize their criticality and importance in maintaining wetland services, especially in terms of prawn production. Thus, their sustainable supply is essential.

9. Implications for Policy and Action

9.1. Introduction

Mitsch and Gosselink (2000) described the valuation of wetlands at four levels:

1. The scale principle, which says that wetland values are different, accrue to different 'stakeholders', and probably have different importance depending on the spatial scale on which estimations are based.
2. The marginal value paradox, which implies that fewer wetlands do not necessarily imply greater value in situations where human populations have overwhelmed the functions of the last remaining wetlands.
3. The hydro-geomorphic principle, where wetland values depend on the hydro-geomorphic location in which they are found.
4. The ecosystem substitution paradox says that if different ecosystems are imputed different values in a given landscape, recommending the substitution of more valuable types for less valuable ones would be a logical extension of economic analysis

The economic value of natural products and ecosystem services generated by wetlands is generally underestimated (Barbier, 1994). This may be attributed to two factors (Hamilton et al, 1989): (i) many of the goods and services provided by these ecosystems are not traded in markets and thus do not have an observable value; and (ii) some of these goods and services occur off-site and are therefore are not readily accepted as being related to wetland ecosystems. As a result it is often concluded that wetlands should be developed for uses which generate directly marketable products. Therefore, wetland ecosystems become prone to conversion into large scale development activities, such as agriculture, aquaculture, forestry and other uses. The undervaluation of natural products and ecological services generated by wetlands ecosystems is a major driving force behind the conversion of this system into alternative uses (Costanza et al 1997). However, such decisions ignore the opportunity cost of development. Methods for valuing environmental/ecological goods and services offer a more comprehensive valuation of the many goods and services provided by wetland ecosystems, and thereby contribute to better informed decision-making.

Keeping the above in view, the value of ecosystem services and biodiversity is a reflection of what the society is willing to trade off to conserve natural resources. Economic valuation of ecosystem services and biodiversity has shown that these services are scarce and that their depreciation or degradation has irreversible costs to society. If these costs are not calculated, then policy options would not represent correct options and society would be worse off due to misallocation of resources (TEEB, 2010).

Choices often need to be made between ecological well-being and human well-being (Kumar, 2011). While the ideal policy solution is to seek a win-win opportunity, it may not always be feasible (Figure 42). However, our understanding of ecosystem services, and what value they provide, often helps us decide the urgency and importance of conserving and investing in improving ecosystem well-being.

9.2. Key Policy Issues for LRK

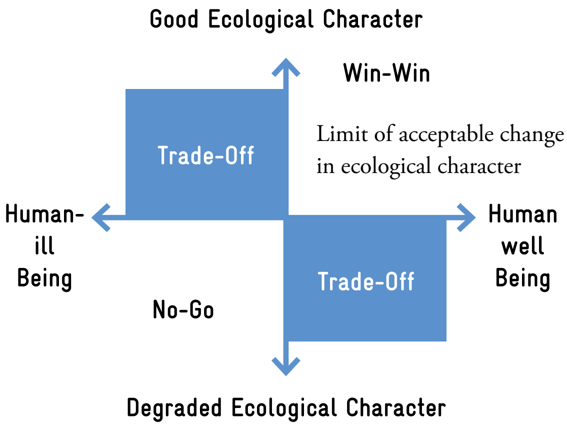
In the context of LRK, the following key policy issues have been identified, while valuation of its biodiversity and ecosystem services are able to provide pointers to how they may be addressed.

9.2.1. Production Functions Versus Protection Functions

Is there a conflict between production functions (comprising prawn and salt production) and protection functions (comprising biodiversity and habitat conservation)?

Although unique biodiversity values of LRK have been implicitly recognized and the area has been protected by law, the system provides direct economic benefits to the tune of ₹1100 million per year through prawn fishing and salt farming. Since these are traditional livelihoods and pre-date the notification of legal protection for conservation, these production

Figure 42: Potential scenarios of changes in wetland character and human well-being due to policy interventions (Kumar et al. 2011)



functions constitute the first order of issues that need resolution.

From a purely legal perspective, the LRK has been prioritized for conservation and any existing rights are to be "settled" in order to ensure compliance with the law. However, in reality, this is hardly ever achieved and in the case of LRK it does not appear to be either necessary or desirable. Existing levels of production not only seem to have little impact on the biodiversity conservation values of the LRK, they also provide a rationale for maintaining ecosystem services by providing a direct economic value to both local communities as well as the state.

In fact, the annual production of *M. kutchensis* from LRK not only provides an average annual household income of ₹1.38 lakh to around 2,000 families that are traditionally dependent on it but is also critically dependent upon rainfall and run-off – the ecosystem and climatic factors. Our study estimates that beyond the threshold, every MCM of runoff water assists in increased catch of *M. kutchensis* by 2.2 tons. The production of prawns in the LRK, therefore, is a surrogate indicator for the runoff water available to the wetland from its catchment area.

Our study suggests that the quantity of prawn catch is, therefore, an indicator of the ecosystem's well-being rather than human disturbance in the LRK. Our study also suggests that the number of fishermen families in the system have remained low, traditionally attuned as they are to the varying opportunities provided by the hydrological peculiarities of LRK. If their traditional livelihoods are recognized through licenses it would not only help improve their livelihoods but also provide a stable mechanism for regulation.

9.2.2. Trade-Offs Among The Production Functions

Is there a trade-off among the two production functions (prawn and salt farming)? Is it possible to maximize the production of both in a sustainable manner?

The area under salt work has increased 587%, from 7.6 thousand ha to 44.6 thousand ha, over the past 36 years, in the Surajbari creek area. This growth is associated with a 60% reduction of fishing areas in the same region, along with a reduction of fishermen families from 5,200 at its peak a couple of decades ago to around 1,100 at present.

Although the Surajbari creek area is technically outside the limits of the protected area, it remains an eco-sensitive zone, particularly for its links with the Gulf of Kachchh which is vital for the recruitment and sustenance of *M. kutchensis*- an endemic species of prawn. Rapid growth of salt farms will, therefore, have an obvious impact on the flow of water in the creek, jeopardizing its biological characteristics.

However, as our study suggests, this need not be the case in LRK area. First, salt and prawn productions generally follow different seasonal cycles and are therefore mutually exclusive and non-competitive. Second, salt and prawn production within the LRK is different from those in the Surajbari creek area. Within the LRK, fishing areas are determined by availability of seasonal waters in the certain relatively deeper channel while salt farming is more random, determined by

The LRK has been legally prioritized for conservation and any existing rights are to be "settled" in order to ensure compliance with the law. In reality, this is hardly ever achieved and in the case of LRK it does not appear to be either necessary or desirable

availability of underground brine, traditions and transport logistics. The varieties of salt produced inside the LRK have different market values but are dependent on the quality of sub-surface brine and the monsoon cleansing. Salt in the Surajbari creek area, on the other hand, is only dependent on the tidal waters and hence more predictable, leading to its expansion.

Since Gujarat produces around 30% of the salt produced in the country, with LRK being a major contributor within the state, it is important to recognize that organized salt production within the LRK does not conflict with fishing activities. Where it does, such as in the Surajbari creek area, it may be possible to create zones for salt farming that do not threaten livelihoods of fishing communities. However, some of these zones may be within parts of the PA necessitating openness, broader considerations and dialogue.

9.2.3. Sustaining Prawn Production By Maintaining Ecosystem Services

What is the value of the ecosystem services that sustain prawn production? In a degrading environment, what are the risks? In an improving environment, what are the gains?

Prawn production in the LRK is sustained by wetland habitats created by the network of creeks and depressions, most of them seasonal in nature. These wetland habitats provide a nursery ground for *M. kutchensis*, by maintaining its food-chain, to generate a total annual monetary value of ₹464 millions.

This study also indicates that in order to maintain such high prawn production it is important to recognize the role of water in the system from different sources. The LRK receives over half of its annual waters directly from rains which, in an arid context, is important in many ways. Although it does not add to the available nutrients directly, it plays an important role in increasing the duration and depth of water bodies — habitats for fish and prawns. It also plays a role in determining the salinity of the water which, in turn, determines the species assemblage. Factors affecting climate will have serious consequences on rainfall, and its associated ecological services.

A little over a quarter of the available waters in the LRK is sea water, mostly restricted towards the western parts of LRK, but spreading further inlands when pushed by the seasonal monsoon winds. Its main service is to provide connectivity with the Gulf of Kachchh for inflow of larvae (both *M. kutchensis* as well as other species, some of which are food for *M. kutchensis*) and outflow of adults. Availability of nutrients and maintenance of the food-chain is a key ecological service of the LRK, but without its links with the Gulf of Kachchh, there would not be opportunities for realizing this value.

A little less than a quarter of the water available annually in the LRK is obtained from the run-off generated in its catchment area. However, this water is most important for the provisioning of nutrients and other detrital material that sustain the food-chain inside LRK. Increased water storage in the catchment has reduced the run-off significantly over the past few decades. How much more reduction is possible without seriously affecting prawn production in LRK is a good question to ask.

We have already noted in this study that the best fishing spots within the LRK are those where ephemeral rivers are directly discharging their monsoon water flows. Restoring the direct discharge points will certainly add to the number of viable fishing zones. A zoning system that prioritizes freshwater runoff in identified locations will benefit and expand prawn fisheries within the LRK.

9.2.4. Sustaining Wildlife Habitats By Maintaining Ecosystem Services

What is the value of the ecosystem services that sustain wildlife habitats? In a degrading environment, what are the risks? In an improving environment, what are the anticipated gains?

The hydrological characteristics described above in the context of prawn fisheries within the LRK are also applicable to all other plants and animals, including wild birds.

Our study indicates that reduced runoff as a result of storage and diversion of rainwater in the catchment area may have deprived the LRK an additional depth of at least 0.9 feet during the peak monsoon period. Increased depth of water during this period may have helped not only fish and prawn species but also various aquatic bird populations such as the lesser flamingo, whose nesting sites, would have improved.

In recent years, there is also an additional factor in the form of Narmada canal irrigation that not only threatens to convert large fallow lands in the fringe areas into multi-cropped systems but also alter the quantity, quality and location of freshwater runoff depending on the nature of agricultural practices.

9.2.5. Optimising Tourism

What is the optimal number of tourists for LRK? What facilities are necessary to achieve this optimization objective? How can the value from tourism be sustainably maximized?

Tourists in LRK have shown a sharp rise in recent years, numbering about 12,000 people in 2014, contributing an economic value of at least ₹276 million. New hotels and lodges are coming up in the fringe area and safaris are being organized. While increasing tourism definitely expands the value of an ecosystem, regulation and management systems are necessary to ensure that the worth is not undermined in the process.

Trails, observatories and facilities will need to be developed on the basis of an understanding of breeding and nesting sites of wildlife as well as preferences of tourists. The good news is that foreign tourists constitute at least a tenth of the volume of annual tourism which not only expand incomes and promotes it abroad as a coveted site but also offers opportunities for eco-tourism that integrate social and ecologic considerations.

9.3. Framework for Sustainable Development of LRK

Our study demonstrates the importance of freshwater runoff into the LRK system as a driver of its key ecosystem services. It also raises the issue of competing demands, particularly from agriculture, in the catchment area that has steadily led to the decline of this freshwater runoff. The average annual water stored in irrigation dams and check-dams within the catchment area prevents the flow of at least 17,000 million cubic feet of water into the LRK. There is very little catchment area available for freshwater runoffs into the LRK. How close are we to the threshold levels at which the ecosystem services come to a grinding halt and drastically alters the character of the region? A good question, which we can only speculate at the moment. Global experiences, such as those from the Aral Sea, reveal that these concerns are not ill-founded.

A business-as-usual scenario can only lead to a quantitative and qualitative reduction in ecosystem services and biodiversity in LRK as a result of (a) increased efforts to maximize production values under conditions of open access; (b) infrastructure and other landscape alterations that do not fully consider their impacts on flow of ecosystem services; and (c) conflicting sectoral policies that often have a narrow objective and a short timeline.

Any reduction in the value of ecosystem services and biodiversity from a wetland is borne by society in general and may be termed as the 'cost of inaction'. Furthermore, wetlands in an arid landscape are fragile and prone to irreversible changes below certain ecological 'thresholds' that are, as yet, very poorly understood.

In the case of LRK, for instance, unique species that contribute to the biodiversity values of the wetland are sustained by food and habitat characteristics that flourish within a narrow, but predictable, set of hydrological and other environmental conditions. In case of environmental disturbance, resident species are more likely to be affected than the migrants, and even

Figure 43: Different economic values of LRK wetland vis-à-vis tolerance to degradation and scale of human engagement

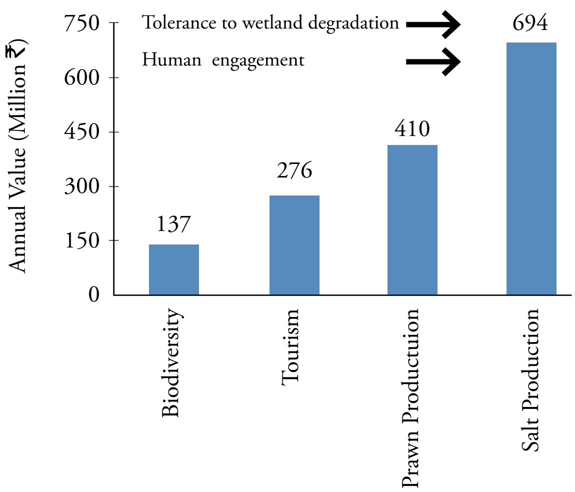
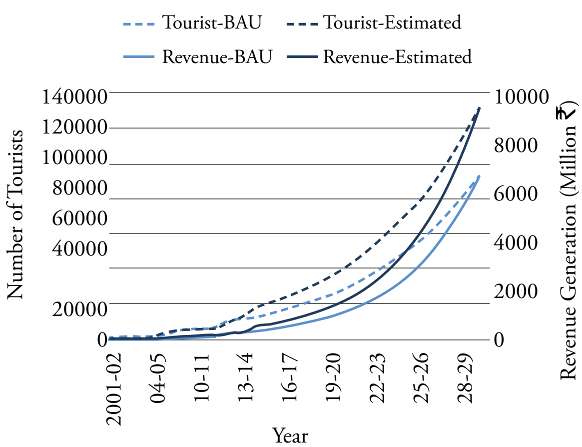


Figure 44: Projected tourist flow and revenue generation



Business as usual (BAU) consider tourist growth based on last few years growth (i.e. around 14% CGP); Estimated scenario considers recent growth of tourists at Gir NP after serious promotional activities & improved management (62% CGP)

When ranking the four economic sub-sectors according to their respective tolerance to environmental degradation, biodiversity is the least tolerant, while salt production is the most tolerant. This means that the most tolerant sector is the one with the greatest economic value, while the least tolerant possesses the lowest economic value

among the migrant species, the brooders are more likely to be affected than the foragers e.g. the lesser flamingos, which use LRK wetlands for nesting purpose.

Tourism is directly linked to biodiversity. While reduction in biodiversity will negatively impact tourism, infrastructure and marketing efforts are likely to compensate for specific biodiversity losses for a while. Moreover, even if less attractive, wetland tourism is likely to shift towards desert tourism. Tourism in LRK wetlands, therefore, is likely to be affected after significant losses to biodiversity.

Production from prawn fisheries is likely to be more stable compared to biodiversity, in the face of environmental disturbance. This is due to (i) higher stability in the tidal regimes (as compared to freshwater flow regimes); (ii) ability of *M. kutchensis* to tolerate a broad range of environmental conditions (such as salinity) and disperse in order to exploit relatively favourable conditions in and around the mouth of the LRK; and (iii) relatively stable number of fishing families whose efforts correspond to the environmental conditions, guided by traditional norms. Fisheries may gain very substantially from improved ecosystem services, but is unlikely to slump below a minimum level unless there is a major environmental disturbance.

Production of salt is likely to be least affected by environmental disturbances, since degradation of the wetland will lead to an expansion of land available on the LRK for salt manufacturing.

If the above four economic sub-sectors are organized according to their relative tolerance to environmental degradation (Figure 43), it is interesting to find that the least tolerant sector is also the one that reveals the lowest economic value (and the most tolerant sub-sector with the highest economic value). This is perhaps fitting, since the x-axis also represents increasing human engagement in deriving value from the sector.

This overall finding has two major implications. First, economic values for ecosystem services and biodiversity only provide us a starting point for dialogue intended to enhance the value of natural resources rather than negotiate the price of alternate landuse plans. And, second, there is need to better understand ecosystem services, including underlying ecosystem functions to improve valuation techniques.

Let us now review the trends in economic values of the different sub-sectors in order to understand their growth potential. It is observed that inland salt production is rather stable over the years. This is because of traditional rights for agariyas inside LRK that have not expanded over the years, since it is a Protected Area. Also, seasonal nature of salt works that use brine as raw material restrict its production potential. However, brine also offers numerous important chemicals that are gaining in demand. The real growth of salt production is in the creek areas, where sea water is used as raw material, a much simpler and cheaper salt variety. Increasing benefit in salt, therefore, is at the cost of quality of produce as well as lost fishing grounds.

Fishery, on the other hand, is clearly related to the availability of freshwater, which is primarily linked to uncertain rainfall in a semi-arid/ arid region.

Tourism, however, is showing a continuous growth in LRK. Though the numbers are low at the moment, the sub-sector shows enormous growth potential in the near future. More importantly, the proportion of foreign tourists is growing fast, which means increased spending. Since this sub-sector depends on non-extractive use of biodiversity, it implies that an emphasis on tourism is likely to bring in sustained growth in economic benefits from LRK without compromising on the quality of ecosystem services. Figure 44 provides a comparison between business-as-usual scenario, and a scenario with some amount of promotional activities. The growth estimates for the next decade and half are not only impressive but are also sustainable. More importantly, this sustainable growth scenario actually sets in motion a virtuous cycle of increased incomes for local communities, higher valuation and increased conservation activities.

Further sustainability initiatives require strong institutional foundation for regular studies, dissemination of information and facilitating dialogue among members.

9.4 Crafting an Institutional Mechanism for Sustainability

Conservation policies increasingly recognize the need to keep local communities at the center of any sustainable management strategy. Our present study also indicates that a very high proportion of the local people are willing to pay for biodiversity conservation in LRK and that these payments could be as high as ₹400 per annum.

However, neither do our policies provide space for the participation of local communities in a meaningful manner nor do we have institutional space that strives to secure such partnerships. Creating a platform for different local interests to understand, discuss and, if necessary, negotiate space for increased economic activity, albeit within the framework of an overarching conservation framework, might provide opportunities for maximization of values.

LRK is an open system with huge variability in both temporal and spatial scales. However, natural variability is rapidly being replaced by disturbance, with both proximal and distal causal factors, leading to unforeseen changes and challenges. Rapid transformation and high degrees of uncertainties run the risk of depleting valuable ecosystem services from wetlands such as those in the LRK.

Institutional mechanisms that develop, and implement, frameworks for sustainable and holistic policy actions might provide a viable solution. A similar effort has already been made in the eastern seaboard of the country in the form of the Chilika Development Authority (CDA).

While small wetlands can be brought under the district level planning mechanisms for a holistic management framework, large wetlands such as the LRK needs an umbrella institution to coordinate planning and implementation. The key responsibility for such an authority would be to create an overarching framework for governance, approve sectoral plans and provide for the participation of diverse stakeholders on the basis of evidence.

Such a state Authority would (a) develop guidelines and frameworks for projects in the region; (b) publish status and policy reports that seek to achieve a desired result; (c) expand high-quality facilities to monitor critical indicators; (d) provide a platform for sectoral plans to be discussed and approved; (e) communicate with stakeholders on a periodic basis; (f) support specific research and training programmes; and (g) promote the model nationally and internationally. Some of the sectoral plans/ policies are typically in the domains of fisheries, tourism, industry, conservation, agriculture and irrigation etc.

The priority tasks for such an Authority would include

- Identifying 'go and no-go' areas for salt works near the Surajabari creeks. Supporting studies and inputs from major stakeholders will be important for this.
- Regulating canal irrigation in LRK landscape. Studies will include those on water pricing, agriculture practices, landuse changes and livelihood shifts. Negotiation with farmers on water and chemical use would also be important.
- Managing fallow lands in the fringe areas, especially in the context of increased access to canal irrigation, to demonstrate mechanisms to protect their conservation values.

The idea is to move towards a comprehensive, landscape level governance system that incorporates diverse interests such as fisheries, industries, conservation, agriculture and irrigation, tourism etc. The quality of governance will progressively improve with enhanced knowledge of hydrologic features, its role in ecosystem dynamics and mechanisms to allocate water towards best use.

In 2008, Gujarat Government has constituted a Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP) Society, specifically for LRK landscape. It visualizes a multi sector and, seemingly antagonistic, multi-theme project on a landscape which has often been talked about but not addressed before in a time bound project mode.

With many senior officials of key Govt. Dept. on its Board, the Society strives to mainstream traditional knowledge in conservation and livelihood generation, establish improved information technology, conduct landscape-level research and promote awareness and community-based tourism. It is also tasked with the development of relevant policies for use of natural resources and for allocation of water from canal networks for maintenance of regional ecological stability.

To start with, The BCRLIP Society may be tasked with the development and implementation of a tourism policy for LRK and then upgrading it as a "LRK Landscape Authority", and to develop holistic conservation and management policies for sustained flow of ecosystem goods and services.

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Annex 1

Traditional Capture Fisheries and Livelihoods in LRK, Gujarat

Focus Group Discussion

Name of Fishing Centre   Date of Discussion

1. Basic information of fishing site

Parameters	Details
Date of first Arrival to site:	
Expected date to leave this site	
Total Fishing Families present (this year) (How they define the Family?) Total fishing families in last year	
Total Labour Families (this year) Last year	
Total Persons/Population (this year)	
No. of active fishers who goes for actual fishing	
No, of persons engaged as: Small Traders /Middlemen Labourer for fishing operation: Net weaving, boat making, repairing etc	

Native Places of Fisher Families

Place	Approx no of HH (Chhapra)	Remarks

Type of Families (Give approx number of HH out of total HH)

	Fishing in own Area	Given their own fishing area to other on lease	Not own any Fishing area but take area on lease	Providing Fishing labour on wage or on sharing basis	Any other
No.					
Remarks					

2. Asset holding (approx in the settlement)

Items	Quantity	Avg Life	Avg. Purchase value	remarks
1-Country boat (Odie)				
2- Mechanized boat				
3-Net (types)				
4-Trap (type)				
5-Vehicle (type)				
6. High power torch				
7. Other				

3. Facilities near fishing settlement (mostly temporary but in few cases even the villages)

Facilities	Details (Quality/ quantity)	Remarks
Roads connectivity Type and approx km from main road		
Local Conveyance /Transport (bus, jeep, chhakda, auto etc.)		
Drinking Water Sources Other Domestic Use [Tanker, tube well, pond, tap water, well etc)		
What are the major occupational health issues? Health care facilities (type and distance)		
Electricity (Y/N) If yes, approx number of fisher HH had? Solar Lights (Y/N) If yes, approx number of fisher HH had Who finance for Solar lights and cost Common Public street light (Y/N)		
Nearest Market for provision/other daily use items (Place and distance)		
Where do the children go for School? (Place, Type and Distance) Nearest Anganwadi		
Sanitation at Fishing Centre Sanitation at Native Settlement		
Fish Storage facility		
Ice factories		
Ice crushing machine		

4. Occupational Dependency and Profile of families who are present in the fishing site

	Approximate No. of HH involved	Remarks (change in pattern)
Agriculture		
Livestock		
Farm Labour		
Non-Farm Labour		
Work in salt pan		
Skilled Self Employed (Carpenter, Mistry, etc.)		
Forest		
Others like Stall, Vendors (specify)		
Service (Govt. / Private)		

5. What kind of fishing methods does the villagers/settlement group practice?

6. Types fish catch in the village/settlement site:

Fish /Prawn type	Change in last 10-15 years (Increase; Decrease, No Change, No Idea) and Scale the change in 1-5 score	Major Cause for Change
1.		
2.		

7. Do fishers receive any assistance from Government /Traders to individual or group (cooperative)?

Items	Government	Fish Trader	Other (specify)
Subsidized Diesel			
I-Card			
Subsidized Net			
Boats			
Motor			
Ice			
other			

8. Ranking of fishing season

	Ranking (between 1 and 16 Ana)	Major Causing Factor for Fishing Catch (e.g. Poor rain; untimely rain; change in wind etc)
Current Year		
Last year		
Last to Last year		

According to you in recent years (say in last 10 years) which was the best fishing year?

9. Labour engagement (give approx % of total labour)

Purpose	Family labour (Own family and Relatives)	Hired labour	Payment method (Cash/ Share of produce etc.)
Fishing Operation			
Sorting Fresh Fish/Prawn			
Boil, Drying and Beating (Prawn)			
Others, specify			

10. Changes in fish prawn price

Type	Current season (Amount per box or kg)	Last season (Amount per box or kg)
Fresh Prawn High quality Medium Quality Low quality		
Dried Prawn		
Prawn Bhusi		
Other Fishes		

11. Whom/where do the fishers normally sell the fish/prawn catch? Fish/Prawn Selling Arrangement (% of total production)

Type	Traders (Name and %)	Direct Company (Give Name and %)	Local Selling	Self Consumption	Others (Specify)
Fresh Prawn					
Dry Prawn					
Prawn Bhusi					
Other Fish					

12. Do fishers have any other options of selling their produce?

13. In different fishing season, what is the approximate ratio (%) of prawn catch:

Season Quality	Sold as Fresh	Converted into Dry
Good season (12-16 Ana)		
Medium season (8-12 Ana)		
Poor season (4-8 Ana)		

14. Finance in fishing season

	Source of credit/ Borrowing	Rate of Interest	Other conditions
Fishing Purpose:			
Non-fishing Purpose:			

15. Changes in fishing families engaged; equipments (nets and their mesh size/boats etc); mesh Size techniques

	Earlier	Now
No. of Fisher Families Engaged		
Type of Net used		
Quantity of Net Used		
Mesh Size		
Type of boat and Number		

16. Institutional arrangements (WHO ARE TAKING VITAL DECISIONS ABOUT FISHING RELATED ACTIVITIES including start/end of fishing; type and quantity of fishing tools use; appropriation of fishing areas; SALE OF PRODUCT etc.)

Issue	Details/Mechanism
Fishing area related (within settlement)	
Fishing method / Tools/equipments/ timing etc. (within settlement)	
Fishing area related (among the settlement)	
Fishing method / Tools/equipments/ timing etc. (among the settlement)	
Settlement related issues (e.g. chhapra making, water etc.)	
Information Sharing related to price, legal aspects etc	
Cooperation with Forest/Fisheries/Revenue dept.	
Existence of Primary Fish Cooperatives	
other	

17. Community spending related to operationalization of fishing centre

Heads	Spending/yes/no/amount
Road maintenance	
Site cleaning	
Rent/ Fees	
Community Functions	

Perception of Fisher Folks on changes in fish catch, general ecology of LRK, threat to the system and fisheries

1. What is your perception in respect to the changes in the fish/prawn catch during the last 15 years?

Quantity# (Total catch)	Quality# (Size)	Impact Extent (low, medium, high)	Remarks
# 1. Highly decreased; 2. Decreased; 3. Remain same; 4. Increased; 5. Highly increased			

2. What according to you are the major Causes for this change in fishery? (external/internal)

Causes	Ranking (Low/Moderate/High)

3 What according to you are the impacts of other economic production system on wetlands and fishery system?

Production system	Impacts
Salt work in Little Rann	
Salt work around Surajbari Creek	
Infrastructure development (like road, railway, power lines, pipelines etc) along Surajbari Creek	
Agriculture expansion due to Narmada Canal	
Harvesting of freshwater runoff by dams, check-dams etc	

4. Do you think that the fisheries ecosystem in Rann has been deteriorated over the years? [Y/N]

5. If yes, in your opinion what are the key indicators that suggest such deterioration?

Indicators/ Criteria	Rank (Low/Moderate/High)	Description/Remarks
1.		
2.		

6. According to you, is it possible to improve the fishery habitat and fish production? (Y/N)

7. If yes, according to you what type of efforts/measures can be undertaken?

Suggested Efforts/ Measures	Description	Rank in order of effectiveness (Low. Moderate, High)	Who can bear the cost? (Govt; Fishing Community; Industry; Collective; etc.)
1.			
2.			

8. As a direct user of LRK fisheries, are you willing to contribute, financially or otherwise, the improvement of fisheries habitats of LRK, which ultimately enhance your income/livelihood?

Raise the hands that are willing to contribute? Total person agreed.......... out of total...........present.

Annex 2

Traditional Capture Fisheries and Livelihoods in LRK, Gujarat

Household Survey

Name of the Respondent:		Date of Interview:	
Settlement region:		Settlement name (if any):	
Native Village:	Taluka:	District:	State:
Caste and sub-caste:		Mob no:	

1. Demographic information

Sl.no	Name	Sex	Age	Education	Occupation (Give List of Occupational Engagement in last year)	Is person present in this fishing settlement? (Y/N)
In case of fishing, explain the site e.g. F(LRK); F(outside)						

2. Housing & Other facilities

	Origin Place	In the Settlement
House Type (Kucha/Pucca/ Temporary)		
No. of Rooms in House		
Electricity (Y/N)		
Solar light (Y/N)		
Drinking Water Sources and distance		
Drinking Water Quality		
Sanitary facility		

3. Entitlements:

Ration Card?(Y/N)	BPL Card? (Y/N)	NAREGA Job ard? (Y/N)	Kissan Credit Card?(Y/N)	Insurance Policies? (Y/N)	Bank Account? (Y/N)	Post Office Account? (Y/N)	Fisher ID/ License (Y/N)

4. Asset- Land

Category	Total Area (acre/ bigha)	Irrigated area (acre/ bigha)	Cultivated Crops/ Horticulture/ Vegetables	Fallow Land (in acre or bigha)	
				Last year	Current Year
Owned					
Joint/Shared					
Lease in					
Lease out					

5. Asset- Livestock

Type	Total Numbers	Left in Native Village	Bring with you	No. Purchased in last 3 years	No. sold in last three years
Cattle					
Buffalo					
Goat					
Sheep					
Poultry					
Other					

6. Assets- Durable Goods

ITEM	NUMBERS
Radio / Cassette / DVD Players	
Computer/Laptop	
Mobile handset	
Bicycle	
Motorcycle / Scooter	
Motor car / Jeep etc./Auto/ Chhakda	
B/W Television	
Color Television	
Solar Lights	
Cooking Gas (LPG)	
Ceiling/Table Fans	
Refrigerator	

7. Have you ever shifted your occupation over the last one decade? If yes, give details

8. Approximate income from different sources during last year

Sector	Sources	Net Annual Income (in ₹)
Agriculture	Sale of Agriculture Crop	
	Sale of Agriculture Residues	
	Sale of Horticulture/Vegetables	
Livestock	Sale of livestock product (milk, egg, wool)	
	Sale of livestock	
Wage Labour	Farm Labour	
	Non-farm labour	
Self Employment	Small business/ skilled job	
	Sale of Handicraft items	
Service	Salary from service	
	Other	
Fishing in LRK	Fresh Fish/Prawn sale	
	Boil/dried fish/prawn	
	Sale of prawn bhusi	
	Fishing related labour	
	Providing fishing related other services (boat/ net repairing)	
	Providing other facilities in settlement (water, provisions etc.)	
	Income by leasing fishing ground/ renting boat and net	
	Other	
Others	Salt	

9. Approximated expenditure pattern of HH (per month or year in ₹) (give details of last year)

Items	Approx. Expenditure (in ₹)	Remarks
Food grains (Yearly)		
Education (Yearly)		
Health (Yearly)		
Cloths (Yearly)		
Purchase of durable goods (Yearly)		
Tobacco/liquor		
Marriage, other ceremonies (Yearly)		
Maintenance of House (Yearly)		
Maintenance of Agri Assets (Yearly		
Maintenance of Fishing Assets (Yearly)		
Temporary hut construction in settlement		
Others		

10. Do you take loan? Y/N, give details:

Purpose (General, Fishing and Non-fishing purpose)	Sources of money lending	Amount (₹)	Rate of interest	Any special Condition

Information on Fishing Methods, Equipments (techniques), Practices and Marketing

11. Since when you are engaged in fishing activities? Since how long you are visiting this site for fishing?

12. Whether you have own traditional fishing ground in this site?

13. Do you fish in other areas also? If Yes, give details.

Place	Period (give months)

14. In the current season, when did you come this place (starting time___________ Expecting to go back_________

WETLANDS

15. According to you, how good the fishing season for LRK ?

	Ranking (between 1 and 16 Ana)	Remarks
Current season		
Last season		
Last to last season		
Best season in last 15 years	Year:	

16. What types of fish you catch in LRK and other fishing places

Fish type in LRK	Fish type (Outside LRK)	Remarks
1.		
2.		

17. Fishing Related Assets

Items	Number; Kg		Approx Life (year)	Approx Current Value (₹)	Purchased by own or provided /lended by traders/ middlemen
	In LRK	Whether own or rented			
1-Country boats (Odie)					
2- Mechanized Motor boat					
3-Net (type)					
4-Trap (type)					
5-Other items					

Note: mention if you use same boat/nets for fishing outside LRK

18. If you do not have boat/net, do you share with others?

19. If share basis, what is the arrangement of cost and benefit sharing:

20. What was your fish catch ? (in dubba or Kg.)

Type of fish catch	Last week	Last month	Last year season	Remarks
Prawn (High quality; less count/kg)..toTraders	Q Price:	Q Price:	Q Price:	
Prawn (Low Quality; high count/kg)...To trader	Q Price:	Q Price:	Q Price:	
Low quality (not sold to traders)...Convert to dry	Q Price:	Q Price:	Q Price:	
Other fishes (specify...)	Q Price:	Q Price:	Q Price:	
By-catch fish (avg per day)				

21. Whom do you sell your different fish/prawn product?

Product	In LRK	Remark
Fresh Prawn		
Fresh Fish		
Boiled &Dry Prawn		
Dry Prawn		
Dry Fish		
Dry prawn bhusi		
Other		
Trader; Middlemen; Local Market; Direct to fish processing company; Cooperatives; any other		

22. Per day household consumption (kg/day)
Fresh Dry

23. Sources of finance for buying the boats/nets

Boat				Net			
Sources	Amount	RoI	Other conditions	Sources	Amount	RoI	Other conditions

24. Wood use in fishing (current season)

Items	From where do you buy		
	Nearby forest area	Purchased from Market	Cost (₹)
Setting of Nets			
Boat and net making			
Hut construction			

25. Do you engage labourers for fishing purpose in this season? [Y/N]

26. If yes, give the following information:

Purpose	Family labour (avg per day) (own family, shared groups, relatives etc)	Hired labour, Avg. Per day)	Payment system
Fishing operation, Boating			
Processing n drying			
Others, specify			

Are you compelled to sell your catch to traders/ middlemen,
if you take loan from them? [Y/N] ______
Do you sell your fish catch at a predetermined price? [Y/N]
If yes, how it is determined? …………………………………………..
Do you get payment on the same day, after selling your catch? [Y/N]
If no, give the reasons………………………..

Perception of Fisher Folks on changes in fish catch, general ecology of LRK, threat to the system & fisheries and WTP for Biodiversity Conservation

9. What is your perception in respect to the changes in the fish/prawn catch during the last 15 years?

Quantity# (Total catch)	Quality# (Size)	Impact Extent (low, medium, high)	Remarks
# 1. Highly decreased; 2. Decreased; 3. Remain same; 4. Increased; 5. Highly increased			

10. What according to you are the major causes for this change in fishery? (external/internal)

Causes	Ranking (Low/Moderate/High)

11. What according to you are the impacts of other economic production system on wetlands and fishery system?

Production system	Impacts
Salt work in Little Rann	
Salt work around Surajbari Creek	
Infrastructure development (like road, railway, power lines, pipelines etc) along Surajbari Creek	
Agriculture expansion due to Narmada Canal	
Harvesting of freshwater runoff by dams, check-dams etc	

12. Do you think that the fisheries ecosystem in Rann has been deteriorated over the years? [Y/N]

13. If yes, in your opinion what are the key indicators that suggest such deterioration?

Indicators/ Criteria	Rank (Low/Moderate/High)	Description/Remarks

14. According to you, is it possible to improve the fishery habitat and fish production? (Y/N)

15. If yes, according to you what type of efforts/measures can be undertaken?

Suggested Efforts/ Measures	Description	Rank in order of effectiveness (Low. Moderate, High)	Who can bear the cost? (Govt; Fishing Community; Industry; Collective; etc.)

Scenario-1

16. For the improvement of fisheries, are you willing to pay in ₹ for the conservation/habitat improvement.... Y/N If, No. Reasons (and go to....)_______

If Yes,
What is the Willingness to Pay for conservation effort:
(Option given by Respondent) Option-I: in ₹________per year/season (iteration process involve)
(Option given by Respondent) Option-II: in ₹________per year/season (iteration process involve)
(Option given by Respondent) Option-III: in ₹________per year/season (iteration process involve)
Option given by interviewer Option-IV: in ₹________per year/season
Or in Other Means like Labour-days/Man-days ____________and the months of contribution___________ (in a rural setting, labour contribution has a important value)

Scenario-2

17. Do you think that there is a change in the number of migratory birds? [Y/N]
(i) If yes, give the following information:

Name the birds that have Increased	Reasons	Name the birds that have Decreased	Reasons

18. As a direct dependent on wetlands of LRK, how importance you give for the conservation of birds in LRK? Highly_________moderately____________less importance________

19. Give reasons for giving above importance

20. Considering that you gave importance to birds in LRK, are you willing to contribute in conservation of birds, especially the migratory birds? Y/N if, No. Reasons (and go to....)_______
If Yes,
What is the Willingness to Pay for conservation effort?
(Option given by Respondent) Option-I: in ₹________per year/season (iteration process involve)
(Option given by Respondent) Option-II: in ₹________per year/season (iteration process involve)
(Option given by Respondent) Option-III: in ₹________per year/season (iteration process involve
Option given by interviewer Option-IV: in ₹________per year/season
Or in Other Means like Labour-days/Man-days ____________and the months of contribution___________ (in a rural setting, labour contribution has a important value)

Annex 3

Valuation of Ecosystem for Conservation and Management in LRK, Gujarat

1. Respondent's basic information

Respondent's Name		Email	
Mobile No		Country	
Sex		State	
Age		Dist.	
Highest Education Level		Village/Town/City	
#Occupation: Student Private/Govt service, Business, Agriculturalist, Others (give detail)		@Approx Annual or monthly Income from mentioned source(s)	In Rupees/ in \$/in£/in €

#only respondent's occupation and income

@This is purely for research purpose and full anonymity will be maintained

2. Household Demographic and Occupational Information (please write the number of family members)

Total no. of members in your Family		Occupation: Govt Job/ pension	
Total male members		Private job	
Total female members		Business	
Age group <15		Student	
Age group 15-60		Agriculturalist	
Age group >60			
Education: Primary school			
High School			
Collage/University			
Illiterate			

Demographic and occupational factors influenced travel decision....

3. What is your family monthly/annually income (including fellowship/scholarship/allowances) from various sources

Income sources	Amount in Rupees/ in $/in£/in €
Govt Job and pension	
Private job	
Business/Service provided	
Fellowship/scholarship/other allowances	
(For students/others)	
Agriculture/farms/livestock/Forest	
Others. Please specify...	
Total Family income (approximate)	

Total family income also determines travel decision

4. How frequently do you visit places like this?
1-Once in a while, 2- frequent (twice a year), 3- very frequent (more than twice a year)

5. What are the places you have visited in last 2-3 years?

Places/Country/state	Year of visit	Total no. of days	Remarks

6. How did you know about LRK landscape/biodiversity/ecosystem?
i. I know before ii. Internet, iii. Friends/relatives iv. TV/news papers

7. Have you or any family members visited LRK before? Y/N, when_______

8. What would you like to see in LRK? (give ranks)

BD Elements	Rank	Remarks
Migratory Birds		
Wild Ass		
Blue Bull		
Other Biodiversity		
Landscape		
Observation of local culture		
Others		

9. Is it a visit exclusive to LRK, Please specify your travel plan to LRK

Exclusive to LRK	Part of larger tour programme
Visit plan by you/your family	Visit plan by Tour operator

10. Are you/or your family visit under a 'tourism group'? Y/N
If Yes, Name of the tourism group? And what is the package amount in ₹ or in Dollar/Euro?

WETLANDS

11. Please specify about this visit to Little Raan of Kachchh?
1. Visit alone, 2. Visit with family 3. With friends 4. With unknown visitors

12. Total number of days you plan for entire larger tour programme?

13. Total number of days you plan for LRK visit?

14. Is this a day-trip to LRK? Y/N

15. How many Family members are with you for this LRK visit?

Alone	Children	Adult (Male and female)

16. Rank your decision to visit this place?

Very Important	Moderate Important	Less important	Not Important at all
3	2	1	0

17. Main activities you will undertake in Little Rann of Kachchh visit (rank them). High-3, Moderate-2, Low-1, No observation-0, (preference level before visiting the LRK)[ask this question who has not visited LRK yet)

Watch Flamingos		Walking in Rann		Remarks
Watch Wild Ass		Local food		
Watch Blue Bull		Interaction with locals culture		
Watch Fox		Camel riding		
Bullock Cart-riding		Staying in huts		
Jeep- safari				
Relaxation		Any other		
Salt Pan visit				

17.1 Important activities you undertook in LRK visit. (Rank them). High-3, moderate-2, Low-1, No observation-0, (level of satisfaction after visiting the LRK) [ask this question who has completed LRK visit]

Watch Flamingos		Walking in Rann		Remarks
Watch Wild Ass		Local food		
Watch Blue Bull		Interaction with local culture		
Watch Fox		Camel riding		
Bullock Cart-riding		Staying in huts		
Jeep- safari				
Relaxation		Any other		
Salt Pan visit				

Please answer below question; it is very important for our study analysis

18. Please give approximate cost for your visit to LRK?

A. If this visit conducted through Tour operator (paid to operator, Please break up activities), then please provide in details?

LRK Exclusive In ₹/$/Euro	Larger tour Programme In ₹/$/Euro

Please mention travel cost to this site/back (if not added in 18)______

B. If visit plan by you (individual), then what is your approximate cost to you and your family for the entire trip?

Various Heads (cost)	Amount in Rupees (Indian Tourists)	Amount in Dollars, Pounds, and Euro (For Tourists outside India)	Remarks if any?
Flights			
Train			
Bus			
Car personal (fuel)+ Hired			
Local Transport if any			
Accommodation			
Accommodation at transit place (if any)			
Food and drink			
Entrance fees for this site only			
Indian / Foreign			
Any souvenier purchase or planning to purchase (symbolic wild ass, birds or other thing in craft form?)			
Others???			
If it is a package program (with local service provider), then how much cost per day (for how many days).			
Mention item it covers??? Please provide other costs you incurred...			
Total (if difficult to break up activities)			

C. If it is for a day-trip, give approximate expenditure for this visit including entry fees, travel cost, food cost and other expenses? In ₹__________?

WETLANDS

19. Please give your overall satisfactory level (Value of Money)-

Very high 4 ff	High 3	Moderate 2	Low 1

20. Are you planning to visit again?
1-Yes, definitely, 2- Yes, probably, 3- Not sure, 4- No, probably not, 5- No, definitely not?

20.1. If yes please describe why? _____

20.2 How often you will visit LRK?

Every year		More than once per year	
Once in 2 years		Once in 5 years	
Once in 5-10 years		Never again	

21. Do you refer your friends/relatives to visit this site? Y/N

22. Please mention how important is it to you that the biodiversity, geographical, cultural and landscape features of LRK should be protected (conservation) for the future generation

Extremely important		Less important	
Very important		Not at all	
Moderately important		Do not know	

23. If it is important to conserve LRK ecosystem, are you willing to contribute for LRK Conservation? Y/N
If yes, to whom you want to pay? 1. Government 2. Non-Government sector, Others (specify.....)

24. What is your willingness to pay_______in ₹ or in Dollar/Euro for annually and ________ in ₹ or Dollar/Euro for one time?

25. Please suggest measures to improve tourism facilities in and around LRK?

26. What can be done to attract more tourists to Little Rann of Kachchh?

Annex 4

Valuation of Ecosystem for Conservation and Management in LRK, Gujarat

Contingent Valuation

This is a survey for valuing Biodiversity of LRK (especially aquatic migratory birds). Please answer the questions as accurately as possible. Your responses are confidential. Your help in this study is appreciated.

Name of the Respondent: Age

Male/Female: M/F Contact No:

Village: Taluka: District: Caste and sub-caste:

Respondent's Education: No Schooling, Primary, High school, College, University

Occupation: Primary: Secondary:

1. Family Basic Information (number of members)

Total no. of HH members	Total male members	Total female members
Total working Members	Total male working Members	Total Female working members
Occupation: Govt service	Private service	Self employed/business
Agriculture	Salt Pan	Fishing
Engaged in Livestock	Wage labour	Others
Age group <5	Age group 5-14	Age group 15-60
Age group >60	Primary school	High School
Collage	Illiterate	

2. Primary and Secondary Sources of Annual Net Household Income (Chhokhi Avak) #

Income sources	Details in ₹	Income sources	Details in ₹
Govt. Employment-Salary/pension		Farm Wage Labour	
Private Employment-Salary		Non-Farm Wage Labour	
Business /Self employed		Fishery	
Salt Production		Livestock	
Agriculture		Others	

#your response is confidential

Perception of Respondent on General Ecology of LRK and Threat to the System

3. Do you know about LRK? Y/N
If yes, what is your understanding about LRK? Pls Describe (e.g. aquatic migratory birds, fishing, wild ass, nil gai, chinkara, salt production, water source both saline and fresh water, any other)

4. You described LRK. Now according to you what are the three major values of LRK?

5. Do you think that the above mentioned Values of LRK has changed over the years?

#	Values	Values Changed (Improved/ Deteriorated/ Remain same/ Do not know)	Scale of Change (Low, Moderate, High)	Possible Causes of Change
I				
II				
III				

Contingent Valuation (WTP) for Migratory Birds

6. According to you, how important are the presence of aquatic birds in LRK? (Rank 1-5):

7. You gave above value to the birds in LRK, now according to you how important are the presence of different habitats (prakritik awas) of these aquatic birds?

Habitat Types	Rank (0-5)	Remarks
Water bodies in LRK		
Water bodies close to LRK (eg. gam talav, check dams etc)		
Bets		
Rann Flat (Rann Kantha)		
Other		

8. Do you visit LRK wetlands to watch aquatic migratory birds? [Y/N]

9. If yes, how frequently:

10. As per your knowledge, what are the different aquatic bird species found in LRK? Name a few?

11. Do you think that there is a change in the number of migratory bird species? [Y/N]
(i) If yes, give the following information:

Name the birds that have Increased	Reasons	Name the birds that have Decreased	Reasons

12. Do you think that birds of LRK should be conserved and protected? Y/N
If yes, as a resident of LRK region, how importance you give for the conservation/protection of birds in LRK?
Highly Moderately Less importance

13. Considering that you gave importance to birds in LRK, suppose any group (like ours/ Government/NGOs etc) is interested in conservation and protection of these birds and their habitats (like the water bodies); are you willing to contribute in those efforts? Y/N If no, give reasons:

14. If Yes, What is the Willingness to Pay for conservation aquatic migratory birds?
a. (Option given by Respondent) Option-I: in ₹________per year/ (iteration process involve)
b. (Option given by Respondent) Option-II: in ₹________per year/ (iteration process involve)
c. (Option given by Respondent) Option-III: in ₹________per year/ (iteration process involve)
d. Option given by interviewer Option-IV: in ₹________per year

Annex 5

Farmers Perception on Water Use in Catchment and their Willingness to Pay for Biological Diversity Conservation in LRK, Gujarat

Household Survey

Name of the Respondent: Age Male/Female: Education

Village: Taluka: District: Caste and sub-caste:

27. Demographic information

Total no. of HH members	Total male members	Total female members
Total working Members	Total male working Members	Total Female working members
Occupation: Agriculture	Salt Pan	Fishing
Wage labour	Govt service	Private service
Self employed	Engaged in Livestock	Others
Age group <14	Age group 15-60	Age group >60
Primary school	High School	Collage
Illiterate		

House condition?	1	Single family	0	Jointed family

V. good, Good, Moderate, Bad; Single kitchen considered as one HH

28. Housing & Basic Facilities/amenities

	Details
House Type (Kucha/Pucca) Wall type /Roof Type	
No. Of Rooms in House	
Electricity (Y/N) and since when	
Drinking Water Sources and distance	
Drinking Water Quality/Quality	
Sanitary facility: Open, have toilet (separate or common)	

29. Entitlements:

Ration Card?(Y/N)	BPL Card? (Y/N)	NAREGA Job ard? (Y/N)	Kissan Credit Card?(Y/N)	Insurance Policies? (Y/N)	Bank Account? (Y/N)	Post Office Account? (Y/N)

30. Asset holdings in HH

ITEM	NUMBERS
Radio / Cassette / DVD Players	
Computer/Laptop	
Mobile handset	
Bicycle	
Motorcycle / Scooter	
Motor car /Auto/ Chhakda	
B/W Television	
Solar Lights	
Cooking Gas (LPG)	
Ceiling/Table Fans	
Refrigerator	
Dish TV	

31. Agricultural implements/ Assets

Types	Numbers/Remarks
Bullock Cart/Cart	
Plough	
Bore-well	
Pump set (diesel/electric)	
Tractors	
Other machines	
Drip irrigation	
Sprinkler irrigation	
Others (specify)	

31. Agricultural implements/ Assets

Type	Total Numbers	Hybrid	Average income (₹/month/year)	
			By selling milk/ wool/egg	By selling livestock
Cow				
Bullock (Badad)				
Buffalo (He/she)				
Goat				
Sheep				
Poultry				
Other				

33. Livestock feeding/drinking

	Details/Remarks
CPR*	
Own land	
Crop residue	
Green fodder cultivation	
Stall feed (in Kg)	
Source of drinking water	

*Common village land, Near-by forest, Tank bund, Canal bund etc

34. Primary and secondary sources of income (Approx Avg. Last 2-3 years)

Income sources	Details in ₹
Agriculture	
Wage Labour	
Livestock (take hint from above)	
Salt Production	
Fishery	
Govt. Employment- Salary/pension	
Private Employment- Salary	
Business /Self employed	
Others	

35. Any Major shift in family occupation over the last one decade?
If yes, give details

36. Approximated expenditure pattern of HH (per month or year in ₹) (give details of last year)

Items	Approx. Expenditure (in ₹)	Remarks
1.		
2.		

37. Farm Characteristics (area in acres/bigha)

Category	Total area	Irrigated area	Fallow (last/current year)
Own			
Joint/shared			
Lease in			
Lease out			

38. Narmada Irrigation Water Availability

	Under Plan (Y/N)	Already Receiving (Y/N) and since when?	Receiving by lying Pipes from nearest canal (Y/N) since when?
Your Village			
Your Farm			

39. Cropping Pattern:

		Area (in acre/ bigha)						
Season	Crop	Non-irrigated	Irrigated	Source of Irrigation	Frequency of Irrigation	Total Production	Total Sale	Selling Rate

40. Status of Fallow Land

	Area kept as Fallow (acre/bigha)
Last /current year	
Year 2000-2005	

(i) Major Change in the cropping pattern in the last ten years? [Y/N] ______
Give details:

(ii) Give reasons:

41. Cost of Cultivation

Expenses in cash		Crops				
		1	2	3	4	5
Seeds						
Fertilizer						
Pesticide						
Hired labour	Animals					
	Human					
Own labour						
Hired Machines						
Irrigation/water Bore well, pump and pipe						
Transportation						
Any other cost e.g. storage, grading packaging etc. (specify)						

42. Fertilizers and Pesticides Application

(i) Do you use chemical fertilizer/pesticide for your crops? [Y/N] __________

(iii) If yes, give following information:

Crops	Name of the Fertilizers/ Pesticides	Current (Last/this season)		Earlier (During 2000-2005)	
		Quantity	Frequency of application	Quantity	Frequency
1.					
2.					

Get input from this table while discussing inflow of agricultural effluents to LRK (later section)

43. Do you think that the highly intensive water use for agriculture in the LRK catchment has impact on LRK ecosystem? Y__ /N__. Please elaborate__________ Highly/moderately/less/none

44. Do you have made any check dam/bund in your farm (personal, Govt, NGO etc?
Give details/ ________________________________

	Canal	Check dam/water bodies	Ground water
100% water			
75% water			
50% water			
25% water			
10% water			
< 10% water			

47. With irrigation available, how much net income from farming is increased over without irrigation situation? Give in %

(Example: Before irrigation–bajra, desi cotton etc and income 20000 ₹
After irrigation–cash crops/Bt cotton etc and income 40000 ₹
T his suggests increase of 100%)

(Please ask this question other way also like now and before and which way the respondent is comfortable)

Perception of Respondent on general ecology of LRK, threat to the system

1. Do you know about LRK? Y/N
If yes, what is your understanding about LRK? Describe.
(About birds, fishing, Wild ass, Nil gai, Chinkara, Salt production, water source both saline and fresh water, any other)

2. Do you think that the ecology of LRK and biodiversity has deteriorated over the years? [Y/N/ not sure] ___________

(i) If yes, give your criteria of deterioration of LRK

Components	Norm Your judgement

WETLANDS

(ii) What extent do you categorise this? _____
[1-Highly deteriorated, 2-Marginally deteriorated 3- Moderately deteriorated]

3. What according to you other economic production systems have impacts of on LRK wetlands

Production system	Impacts (High, Moderate, Low, no idea)
Salt work in Little Rann	
Salt work around Surajbari Creek	
Infrastructure development (like road, railway, power lines, pipelines etc) along Surajbari Creek and northern side of LRK	
Agriculture expansion due to Narmada Canal	
Intensive fishing	
Expansion of tourism activities	
Harvesting of freshwater runoff by dams, check-dams etc	
Any other	

4. Do you think intensive water use for agriculture using Narmada canal in the catchment has ecological implications to LRK? (inflow of agricultural pollutant)
Y/N/do not know
If yes, give rank? High, Moderate, Low

5. Do you think intensive water use for agriculture in the catchment by harvesting surface water has ecological implications to LRK? (reduce water flow)
Y/N/do not know
If yes, give rank? High, Moderate, Low

6. To clean-up and treatments of effluents need costs, are you willing to contribute? Y/N

7. What would you be willing to accept in compensation for 'not-using' 10 %, 25 % and 50 % of current water use for agriculture? (Non-Narmada water users)
If Yes, What is your willingness to accept, ______________₹ in Summer___________₹ in winter]
Follow iteration process

Contingent valuation (WTP) for Migratory Birds

1. Do you think that there is a change in the number of migratory birds? [Y/N]
(i) If yes, give the following information:

Name the birds that have Increased	Reasons	Name the birds that have Decreased	Reasons

Do you think that birds of LRK should be protected? Y/N
Give you reasons (with rank)

2. **As a resident of LRK region, how importance you give for the conservation of birds in LRK?**
   Highly_________moderately____________less importance________

3. **Give reasons for giving above importance**

4. **Considering that you gave importance to birds in LRK, are you willing to contribute in conservation of birds, especially the migratory birds? Y/N If, No. Reasons (and go to….)_______**
If Yes,
   What is the Willingness to Pay for conservation effort?
   (Option given by Respondent) Option-I: in ₹________per year/season (iteration process involve)
   (Option given by Respondent) Option-II: in ₹________per year/season (iteration process involve)
   (Option given by Respondent) Option-III: in ₹________per year/season (iteration process involve)
   Option given by interviewer Option-IV: in ₹________per year/month

Or in Other Means like Labour-days/Man-days ____________and the months of contribution___________ (in a rural setting, labour contribution has a important value)

WETLANDS

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Dr. Arun M Dixit
Dr. Somnath Bandyopadhyaya

Abbreviations

ASL	Above Sea Level
BCRLIP	Biodiversity Conservation and Rural Livelihood Improvement Program
C	Carbon
CDA	Chilika Development Authority
CESC	Centre for Environment and Social Concerns
CIFT	Central Institute of Fisheries Technology
CMFRI	Central Marine Fish Research Institute
CPRE	Common Property Resource Equilibrium
CRZ	Coastal Regulation Zone
CSMCRI	Central Salt and Marine Chemical Research Institute
CVM	Contingent Valuation Method
DDP	Desert Development Programme
DO	Dissolved Oxygen
DPAP	Drought Prone Area Programme
DR	Discount rate
EAS	Employment Assurance Scheme
FGD	Focus Group Discussion
GWRDC	Gujarat Water Resource and Development Corporation
GDP	Gross Domestic Product
GDP	Gross Domestic Product
GEER	Gujarat Ecological Education and Research
GoK	Gulf of Kachchh
GRK	Great Rann of Kachchh
Fig.	Figure
Ha. / ha.	Hectare
HH	Household
HLC	High Level Committee
HPM	Hedonic Price Method
HTL	High Tide Line
IOC	Indirect Opportunity Cost Approach
IS	Indirect Substitute Approach
IUCN	International Union for Conservation of Nature
IWDP	Integrated Waste Land Development Program
TC	Travel Cost
Kg / kg	Kilogram
MoEFCC	Ministry of Environment, Forest and Climate Change
sq. km	Square Kilometer
LRK	Little Rann of Kachchh
LTL	Low Tide Line
m	Meter
M$	Million US Dollar
m2	Square Meter
m3	Cubic Meter

MCF	Million Cubic Feet
MCM	Million Cubic Meter
MEA	Millennium Ecosystem Assessment
mg	Milligram
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
ml	Milliliter
mm	Millimeter
Mm3	Million Cubic Meter
km	Kilometer
MSY	Maximum Sustainable Yield
MT	Million Tons
NA	Not Applicable
NE	North East
NGO	Non Government Organization
NIO	National Institute of Oceanography
NPV	Net Present Value
NWRWS	Narmada, Water Resources, Water Supply and Kalpasar Department
P/R	Production/Respiration ratio
PA	Protected Area
ppm	Parts per million
ppt	Parts per thousand
PV	Present Value
R&D	Research and Development
Rs.	Rupees
RTI	Right to Information
SAC	Space Application Centre
SC	Schedule Caste
SE	South East
Sq. km	Square Kilometer
ST	Schedule Tribe
SW	South West
IWMP	Integrated Watershed Management
Program	
TCA	Travel Cost Approach
TCM	Travel Cost Method
TEEB	The Economics of Ecosystem and Biodiversity
TEV	Total Economic Valuation
TII	TEEB India Initiative
US$	United States Dollar
WAS	Wild Ass Sanctuary
WTA	Willingness to Accept
WTP	Willingness to Pay
yr	Year

India a biodiversity hotspot

India is one of the megadiverse countries in the world. It faces unique circumstances as well as challenges in the conservation of its rich biological heritage. With only 2.4% of the world's geographical area, her 1.2 billion people coexist with over 47,000 species of plants and 91,000 species of animals. Several among them are the keystone and charismatic species. In addition, the country supports up to one-sixth of the world's livestock population. The rapid growth of her vibrant economy, as well as conserving natural capital, are both essential to maintaining ecosystem services that support human well-being and prosperity.

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