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<td>AAU</td>
<td>Anand Agricultural University</td>
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<tr>
<td>AKRSP</td>
<td>Agha Khan Rural Support Programme</td>
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<tr>
<td>AMC</td>
<td>Ahmadabad Municipal Corporation</td>
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<td>BAIF</td>
<td>Bharatiya Agro Industries Foundation</td>
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<td>BISAG</td>
<td>Bhaskaracharya Institute for Space Applications and Geo-Informatics</td>
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<td>BMW</td>
<td>Biomedical Waste</td>
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<td>BSC</td>
<td>Behavioural Sciences Centre</td>
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<td>CAPP</td>
<td>Community awareness and public participation</td>
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<td>CEPT</td>
<td>Centre for Environmental Planning and Technology</td>
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<td>CESC</td>
<td>Centre for Environment, Science and Community</td>
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<td>Centre for Monitoring Indian Economy</td>
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<td>Food and Agriculture Organisation</td>
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<td>GWRDC</td>
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HRD: Human Resources and Development
HW: Hazardous Waste
HWMP: Hazardous Waste Management Project
ICT: Information and Communication Technology
ICTD: Information and Communication Technologies and Development
IMA: Indian Medical Association
IRMA: Institute of Rural Management
IT: Information Technology
ITI: Industrial Training Institutes
IWADP: Integrated Wadi and Agriculture Diversification Project
IWMP: Integrated Watershed Management Programme
JFM: Joint Forest Management
JFP: Joint Forest Program
JMC: Junagadh Municipal Corporation
K: Potassium
LEPNRM: Livelihood enhancement through participatory natural resource management in Rain fed and irrigated areas of rural Gujarat
MASS: Machimar Adhikar Sangharsh Sangathan
MIS: Management Information Service
MoEF: Ministry of Environment and Forests
MSW: Municipal Solid Waste
N: Nitrogen
NAIS: National Agricultural Insurance Scheme
NGOs: Non-Governmental Organisations
NSSO: National Sample Survey Office
P: Phosphorous
PIM: Participatory Irrigation Management
POA: Power of Attorney
PPP: Public-Private Partnership
PRA: Participatory Rural Appraisal
PSIR: Pressure, State, Impact and Response
RKVY: Rashtriya Krishi VikasYojana
RMC: Rajkot Municipal Corporation
RoR: Record of Rights
SAC: Space Application Centre
SAARC: South Asian Association for Regional Cooperation
SEWA: Self-Employed Women’s Association
SEZs: Special Economic Zones
SGDP: State Gross Domestic Product
SIPC: Salinity Ingress Prevention Cell
SIRs: Special Economic Zones
SLF cell: Sanitary Land Fill Cell
SMC: Surat Municipal Corporation
SoLR: State of Land Report
SSP: Sardar Sarovar Project
STP: Sewerage Treatment Plant
SWDC: State water data centre
TDS: Total Dissolved Salts
TERI: The Energy and Resources Institute
<table>
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<th>Acronym</th>
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<tr>
<td>TGA</td>
<td>Total Geographical Area</td>
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INTRODUCTION
1. INTRODUCTION

In India, land resources have enormous economic ecological and social relevance. Land, water and forests are the main life support systems of rural people. Gujarat continues to occupy a distinctive position in the Indian economy. With about 5 percent of the country’s population and about 6 percent of the country’s geographical area, Gujarat accounts for 7.2 percent of India’s GDP due to its rapid industrialisation and tremendous growth rate in the service sector. The agricultural sector of Gujarat, compared to the rest of India, is also on an upward trajectory far greater than any other state. Gujarat has the second highest per capita income among the major states of India. It contributes to about 16 percent of the country’s industrial production. The state has witnessed an annual average growth of 9 percent in the last three years and an average industrial growth of 15 percent for the same period. This high growth rate and increased urbanisation is due to the fast industrial growth and the growth of the tertiary sector. At present, the urban population in Gujarat is 42.58 percent.

It is clear that the state has taken advantage of new opportunities, created by the new economic environment. Despite these economic achievements the state suffers from several weaknesses such as massive degradation and depletion of natural resources, and pollution from industries and urban areas. Land in Gujarat plays a central role in social transformation. In addition to its main function of agricultural and forestry production, land is needed for many other purposes including regulation of atmospheric and water cycles, mineral supply, nature conservation, settlement, and waste disposal. This often leads to conflicts for various land uses.

Factors like a growing population, rapid industrialisation and urbanisation, and insistent demands from the agricultural sector are all exerting pressure on land that is already scarce. It is important to utilise natural resources in a sustainable manner. Proper management of land, water, forests and wildlife is very crucial for sustainable development. There is a distinct link between industrialisation and urbanisation. Industrialisation contributes to urbanisation and has increased the urban sprawl in Gujarat adding pressure to land. Urbanisation industrialisation and increase in population has also led to increased per capita waste generated and its unscientific disposal. Increase in waste generated areas is being untreated and dumped on land, degrading its quality. Industrialisation and population are not the only issues that degrade land resources. Agricultural practices in Gujarat have also led to the degradation of its soil quality. High cropping intensity and modernisation of agricultural practices through the increased use of chemical fertilisers, mono-cropping and groundwater exploitation are degrading land resources.

Land degradation and desertification lowers the productive capacity of land. The need for land development in response to economic growth needs to be weighed up against its protection for maintaining healthy ecosystems and natural resources. Land degradation is a widespread and major problem linked to urbanisation and industrialisation pressures as well as inappropriate land uses, poor agricultural practices, poor land management and drought. The livelihood security of the majority of Indians relies on land and water based occupations such as crop and animal husbandry, forestry, and fisheries. There is a competing and conflicting demand of land for different uses. Declining productivity, increasing input costs, and degradation are posing severe threats to the livelihoods of small and marginal communities.
There is an urgent need to move towards sustainable land reforms, Gujarat is a leader in land administration in India. It has achieved this distinction by stepping up its Information and Communication Technologies (ICT) deployment in programmes such as ‘e-Dhara’, efficient property registration, and in upgrading records. There is a need to improve land administration so that land degradation is reduced through appropriate measures. There is also a need to reduce disparities amongst people and ensure that land resources are allocated for sustainable development and that the surplus is distributed for the common good.

The state of land report takes into account assets as well as the enormity and complexity of the environmental changes being witnessed today. It attempts to analyse the causal factors and come up with recommendations for policy makers to reduce impacts. The State of Land Resources in Gujarat aims to support decision-making at all levels of society. It provides reliable information that may be used to foster a more integrated and long-term perspective to land management. It sounds an early warning of potential problems while allowing for the evaluation of possible scenarios for the future.

The state of Gujarat comprises 27 districts and 225 talukas (sub-district) comprising 18,618 villages and 242 towns. Kutch is the largest district of the state holding 23 percent of its total geographical area. The Dangs is the smallest district holding less than one percent of its total geographical area. The proper management of land, water, forests, minerals, pastures, and wildlife is crucial for sustainable development. For the purpose of this study the state is broadly classified into South, Central, North, Saurashtra and Kutch regions. Large parts of the state comprise the plains concentrated more or less in central and northern Gujarat.

South Gujarat: The southern region includes the districts of Surat, Bharuch, Valsad, Dangs, Tapi, Narmada and Navsari. Its total geographic area is 23.22 lakh hectares. The region has the highest forested area in the state. Annual rainfall averages between 1,000 and 1,500 mm and the climate varies from semi-arid to dry sub-humid. Deep black and coastal alluvial soil is predominant in this region.

Central Gujarat: The Central Gujarat region includes the districts of Kheda, Anand, Vadodara, Ahmadabad, Gandhinagar, Panchmahals and Dahod. The total geographic area of the region comprises 34.13 lakh hectares. The forested area is not extensive in the region and this region leads in agricultural development. Annual rainfall averages from 800 to 1000 mm and the climate is semi-arid while the soil is medium black in nature.
North Gujarat: The North Gujarat region includes the districts of Sabarkantha, Mehsana, Banaskantha, and Patan. Its total geographic area comprises 28.91 lakh hectares. This region has a very small area under forests. It receives 500 to 800 mm of annual average rainfall and the climate varies from arid to semi-arid. Grey Brown loamy, alluvial soils are predominant in this region.

Saurashtra: The Saurashtra region includes the districts of Amreli, Bhavnagar, Rajkot, Bhavnagar, Jamnagar, Surendranagar, Junagadh, and Porbandar. The total geographic area of the region consists of 60.95 lakh hectares. The climate here is dry sub-humid with very low average rainfall at 500 to 800 mm annually. The soil here is predominantly shallow to medium black and calcareous.

Kutch: The North-west arid region encompasses the Kutch district. This region receives very little annual rainfall between 300 and 400 mm - rendering it totally arid. The total geographic area of the region is 40.89 lakh hectares. Since sandy and saline soils are not supportive of agricultural activities the region has the lowest geographical area under agriculture. The Kutch region consists of the Ranns, which are salt-encrusted wastelands and rises only a few meters above sea level. Inundated during the monsoons they are divided into the great Rann to the north and the little Rann of Kutch to the east, the Banni Plains between the great Rann and the rocky mainland and the hilly region with the island belt of four rocky projections rising above the Rann, the Kutch mainland, and the southern coastal plains.
1.1 METHODOLOGY

Society is becoming more concerned with environmental issues nowadays. This increased awareness means that there is a willingness to protect the environment and limit the damage caused by human activities. Pressure-State-Impact-Response (PSIR) developed by Organisation for Economic Cooperation and Development (OECD) is a general framework for organising information about the ‘state of the environment’. The idea of the framework was, however, originally derived from social studies which was then widely applied internationally, particularly for organising systems of indicators in the context of the environment and, later, for sustainable development (Niemeijer & Groot 2008). Environmental Impact Assessments (EIA) has become mandatory for planning and decision-making for private enterprises, governments, and even international organisations.

Environmental indicators have come to play a vital role in environmental reporting as they provide signs for communicating complex messages. In recent years, environmental indicators have become a prerequisite for assessing environmental impacts and reporting the state of the environment in India and various other countries. This has increased the influence of environmental indicators on environmental management and policy-making along all scales of decision-making as well as for monitoring and evaluation (Organisation for Economic Cooperation and Development (OECD) 1999; Niemeijer & Groot 2008).

According to Kristensen (2004), the Driving force-Pressure-State-Impact-Response (DPSIR) framework is a chain of causal links starting with ‘driving forces’ (economic sectors, human activities) through ‘pressures’ (emissions, waste) to ‘states’ (physical, chemical and biological) and ‘impacts’ on ecosystems, human health and functions, eventually leading to political ‘responses’ (prioritisation, target setting, indicators). It is obvious that not all issues or themes of a state-of-the-environment report need a full DPSIR presentation; in many cases some aggregation of DPSIR elements will only make them easier to work with and understand. Here, for the report on “The State of Land Resources in Gujarat”, we have used a PSIR framework which is often adapted to the state of environment reporting for India.

The framework assumes cause-effect relationships between interacting components of social, economic, and environmental systems, which are

1. Cause of the problem: Pressure (P)
   Economic, social, institutional or other pressures on the environment that may contribute to or cause particular environmental states
2. Status of the issue: State (S)
   Condition or quality of the environment and trends in that condition brought about by human or other pressures
3. Impact of the issue: Impact (I)
   Effects of the issue on people, environment and economy
4. Response to the issue: Response (R)
   Measures taken by different stakeholders to improve the situation

Obviously, this report comprises chapters on pressures, status, impact and responses. In order to get the true picture of the state of land resources in Gujarat, one should read all the chapters together. Reading partial report will give only a skewed picture.
Figure 2: PSIR Framework

Pressure (Natural / Anthropogenic)

State (Status as a result of Pressure)

Impacts (Society, Economy Health)

Responses (by State, Market & Civil Society Including Policy Responses)
PRESSURES ON LAND RESOURCES
PRESSURES ON LAND RESOURCES

Population, urbanisation, industrialisation, agriculture, irrigation and livestock are dependent on land. There has been a rise in human population in the recent past placing a great demand on the earth’s land resources. Land enables the sustenance of ecosystems and the human population. To support the human population land has been consumed for agriculture, industries and urbanisation. These changes have brought about dramatic alterations in land use patterns and caused the rapid disappearance of valuable natural ecosystems and the services they provide. The need for more water, food, energy, consumer goods, is not only the result of a higher population, but the result of over-utilisation of resources by people from more affluent societies. Over the last few years, several small urban centres have become large cities; some have even become mega-cities. This has increased the disparity between what the surrounding land can produce and what the large numbers of increasingly consumer-oriented people in these areas of high population density end up consuming (University Grants Commission (UGC) 2004). There is a need to utilise common property resources in a sustainable manner as they provide us with goods and services necessary for our day to day living and sustenance. Environmental pressure by its nature often causes negative impacts on the environment. Efforts to contain such negative impacts are discussed in the response chapter.

1.1 POPULATION AS PRESSURE ON LAND RESOURCES

Population growth rate in Gujarat had been on the rise till the 1970s after which a minor but steady decline was observed. Figure 3 shows the decadal population growth rate of Gujarat. Figure 4 shows the decadal population growth rate of the rural and urban population of Gujarat. The urban population growth rate has witnessed a rapid rise since the 1970s. Figure 5 and 6 show the population growth rate (2001–2011) and population density for the year 2011. Urban population growth rate has been on the rise in Gujarat and Figure 8 shows a percentage increase in the urban population between 2001 and 2011. The urban population growth rate compared to the rest of India is also much higher (see Figure 8). As population increases so does the demand for food, water and shelter. This trend is set to continue. Population is a major driver for urbanisation; this has burdened agricultural practices stepping up intensive farming practices. The forthcoming chapter throws up the analysis that sustainable agricultural practices are on the decline thanks to the increased use of chemical fertilisers and depletion of groundwater table in many parts of the state. Shift in cropping patterns has reduced causing deficiency of micronutrients in the soil while letting fewer lands to fallow and recuperate for over a period of one year has also taken its toll. This will affect humans as lands will become unproductive over the long run. Figures on agricultural productivity have shown an increase in this phenomenon which may be attributed to the extensive use of chemical fertilisers rendering land unsustainable in the long run along with increased irrigation. A study by Gupta (2005) has shown that the soils in some parts of the country have already developed resistance to chemical fertilisers thus increasing potential food insecurity.
Figure 3: Decadal Population Growth Rate

Source: Census (2011)

Figure 4: Decadal Growth of Population of Gujarat

Source: Census (2011)
Figure 5: Population Growth Rate of Gujarat (2001-2011)

Source: Census (2011)

Figure 6: Population Density of Gujarat (2011)
Figure 7: Urban Population Growth Rate in Gujarat (2001-2011)

Figure 8: Percentage of Urban Population, Gujarat and India (1961-2011)

Source: Census (2011)
1.2 **URBANISATION AS PRESSURE ON LAND RESOURCES**

The rise in urban population, industrialisation and large-scale emigration to urban areas has increased the urban sprawl of Gujarat. Urbanisation and urban sprawl is caused due to increased industrialisation and growth in the service sector leading to transformation of land use classes in the neighbouring regions. Urbanisation leads to land degradation due to pollution from industries and waste generated from population. Figure 8 shows the decadal increase in urban population since 2011. Urban growth has also led to the problems of unregulated development, the high cost of urban infrastructure, and pollution of land and water resources due to the inadequate disposal of urban and industrial waste. The process of rapid urbanisation poses serious challenges to towns and cities that are struggling to provide and maintain the already inadequate level of urban services and amenities. The major environmental problems faced by urban areas include air, water, and soil/land pollution and the growing volume of solid, liquid and hazardous wastes. The metropolitan cities are experiencing environmental degradation and resource depletion while being pushed to their limit for sustaining human life. The entire urban population are affected and the urban poor are the most vulnerable as pollution and resource depletion increases (Sivaramakrishnan & Singh n.d.).

A survey carried out by the National Sample Survey Office (NSSO) (2010), suggests, that fast-paced urbanisation in Gujarat is mainly due to intra-state migration with large sections of the rural population migrating to urban areas within the state instead of going out. The report states that 6.5 percent of all urban households in Gujarat are those of migrants from within the state; this figure is the highest in the country. This can be attributed to the high performance of the secondary and tertiary sector. This is followed by Kerala (6.4 percent) and others. Again, 90.6 percent of Gujarat's rural migrants refuse to leave elsewhere finding, the state a better place to live in. Of these, 60.7 percent go to other districts and 29.8 percent shift to other places within the same district. The report attributes urbanisation in Gujarat to the trend of men from villages shifting their permanent place of residence to a nearby urban centre within the state. Figure 9 shows the percentage of urban population in Gujarat. Gujarat has seen an urban sprawl of tremendous proportions over the last five decades. A case study of nine cities has been conducted using geographical information system (GIS) to show the percentage increase in the urban sprawl of these cities. Places like Jamnagar have shown a modest increase-slightly over 1000 percent while Ankaleshwar has shown an increase of about 5400 percent. The urban sprawl has, undoubtedly, increased pressure on land. Table 1 shows the urban sprawl of three time periods. Figure 10 shows the increase in urban sprawl in five cities. As of 2011 the urban population has been registered at over 30 percent in most districts of Gujarat contributing to the urban sprawl, thereby, applying pressure and demand on land and natural resources.
Table 1: Growth of Major Urban Centres

(Percentage increase)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmadabad</td>
<td>3705</td>
<td>4704</td>
<td>26.3</td>
</tr>
<tr>
<td>Ankaleswar</td>
<td>4448</td>
<td>5425</td>
<td>21.5</td>
</tr>
<tr>
<td>Bhavnagar</td>
<td>1813</td>
<td>2563</td>
<td>39.2</td>
</tr>
<tr>
<td>Bhuj</td>
<td>1572</td>
<td>5378</td>
<td>227.6</td>
</tr>
<tr>
<td>Jamnagar</td>
<td>1141</td>
<td>1703</td>
<td>45.3</td>
</tr>
<tr>
<td>Porbandar</td>
<td>3609</td>
<td>5178</td>
<td>42.3</td>
</tr>
<tr>
<td>Rajkot</td>
<td>1407</td>
<td>2769</td>
<td>90.4</td>
</tr>
<tr>
<td>Surat</td>
<td>2039</td>
<td>3624</td>
<td>74.1</td>
</tr>
<tr>
<td>Vadodara</td>
<td>2128</td>
<td>2859</td>
<td>32.8</td>
</tr>
</tbody>
</table>

Source: Based on topographical maps of US Army map services 1955; LANDSAT TM 2000; Google Earth 2012.

Figure 9: Level of Urbanisation in Gujarat (2011)

Source: Based on Census of India, 2011
1.3 **Industrialisation as Pressure on Land Resources**

Having achieved tremendous growth in the industrial sector, Gujarat has emerged as one of the leading industrialised states of India. The state has attracted the highest Foreign Direct Investment (FDI) and is now the most favoured industrial investment destination of the country. According to a survey conducted by Federation of Indian Chambers of Commerce and Industry (2010) FDI accounts for 22 percent of the country’s investment flow and Gujarat happens to lead FDI investments in India. Economic activity in Gujarat is based on a strong foundation provided by the manufacturing sector. The state has shifted its industrial policy from cluster and industrial estates’ based industries to Special Economic Zones (SEZs) during 2002-2004 and it has now shifted towards Industrial Regions and Special Investment Regions (SIRs) expanding the state’s vision to become the largest business hub in Asia and global investment destination (Industries & Mines Department 2009). The state’s Vibrant Gujarat summit held between 2004 and 2011 successfully enticed industries to commit to investments in various industrial sectors.

The Gujarat Industrial Development Corporation (GIDC) is responsible for small and medium scale industrial development spreading in Gujarat since 1960s. The GIDC has acquired larger tracts of land for around 248 industrial estates in the most backward talukas and near urban centres. Around 34,000 hectares of land has been allocated to accommodate the industrial estates (Gujarat State Portal n.d.). Land acquisition for industries was minimal between 1960 and 2000, which accounted for 1.6 percent of the total land acquired. Thirty six
percent of the land acquired for industries was from Vadodara, Bharuch, Surat and Valsad districts, which contributed 35 percent to the state’s industrial investment and employment.

The state has planned 60 special economic zones (SEZs), which are currently under various implementation phases. The land for SEZ have been either acquired or purchased by public and private enterprises. GIDC has acquired nearly 31,966 hectares of land for the establishment of SEZs. The state has identified 13 total Special Investment Region (SIRs) locations and its land use plan aims at attracting industrial investment covering an area of 460,000 hectares in state. The concept of SIRs has been fuelled by the ongoing Dedicated Freight Corridors (DFC) encompassing 150 km on either side as industrial corridors, namely the Delhi Mumbai Industrial Corridor (DMIC). Of the total 1,483 km of the length of DFC, 546 km (38 percent) falls in Gujarat. The alignment of the proposed DFC passes through Palanpur, Mahsana, Ahmadabad, Kheda, Anand, Vadodara, Bharuch, and Valsad in Gujarat. About 62 percent of the state’s area falls within the influence area of DMIC. The lands acquired for industrialisation have been a combination of revenue, agricultural, forest and wastelands. As shown in Figure 13 the land has been allotted for two SIRs, numerous GIDC estates, and three industrial areas. Figure 11 and 12 show the sprawl of SEZ and SIR in Gujarat. They also show the rapid pace at which Gujarat wants to expand industrialisation. Gujarat has a high rate of industrialisation, which sometimes pollutes land and water resources.
Utilisation of land for industrial purpose has increased rapidly over the past few years in Gujarat.

Figure 11: Special Economic Zones in Gujarat

Figure 12: Special Investment Regions
Table 2: Scale of Industrial Development in Gujarat

<table>
<thead>
<tr>
<th>Mode of industrialisation</th>
<th>Area In ha.</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIDC estates</td>
<td>26,077</td>
<td>6.27</td>
</tr>
<tr>
<td>60 SEZs</td>
<td>29423.83</td>
<td>7.69</td>
</tr>
<tr>
<td>4 SIRs</td>
<td>373100</td>
<td>86.04</td>
</tr>
<tr>
<td>Total</td>
<td>4,28,601</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Based on data from SIR-Sectoral Profile (2011); Gujarat State Portal (n.d.)

Table 2 shows the various modes of industrialisation in Gujarat. The land acquired for GIDC estates is just 6.3 percent of the total land, while the SEZs and SIRs have taken up almost 94 percent of the total share. Gujarat has now become the fastest-growing state in terms of industrial development with chemical, petrochemical, drugs and pharmaceuticals, textiles, pesticide and fertiliser industries dominating. All these have an impact on natural resources including land and water. Any developmental activity is bound to put pressure on resources if it is not planned and carried out in a judicious manner. With increased industrial development there is a need for scientific disposal of waste and management of natural resources in the light of environmental sustainability and sustainable development. These practices will reduce the burden on natural resources allowing resources to regenerate and reduce the impact on land degradation.
1.4 Mining Activities

Mining is the extraction of valuable minerals or other geological materials from the earth. Materials recovered by mining include bauxite, coal, limestone, bentonite, marble, etc. in Gujarat. Mining in the wider sense could also include the extraction of petroleum and natural gas. Geologically, the state of Gujarat consists of rocks ranging from the oldest Precambrian to Dinosaur bearing Jurassic and Cretaceous and lignite, oil and natural gas bearing Tertiary and Quaternary rocks. Of the total geographical area, (1,96,024 sq. km) 1, 27,000 sq. km is rocky, which is also a mineral probable area (Industries and Mines Department 2012).

Mining invariably results in enormous land disturbance e.g. large-scale excavation, removal of top soil, dumping of solid wastes, cutting of roads, creation of derelict land, etc. In Gujarat, opencast coal mining is extensive because of its cost-effectiveness causing large-scale land disturbance. Opencast mining has more deleterious impacts on land than underground mining. The excavation of minerals is always accompanied by waste generation. The higher the waste generation the more would be the land required for its disposal. The waste material or overburdens generated from mining have a high potential for changing the physical and chemical characteristics of soil. Some mineral overburdens may release salt, heavy metals and radioactive pollutants, which easily leach out and contaminate land and water resources. Stone and sand quarrying causes damage to property, depletion of water, loss of fertile top soil, and degradation of forests and biodiversity. It also poses a threat to public health.

The state is directly or indirectly linked to mineral exploitation because of its large industrial base that is totally dependent on minerals leading to mining in the first place (Industries and Mines Department 2012). Some important minerals like agate, chalk and perlite are only found in Gujarat. The state is one of the major producers of cement because of the abundance of limestone mineral in the state. Gujarat has also established lignite-based power stations, bauxite-based calcinations, silica-based glass units, and bentonite-based pulverizing units. As far as the major minerals (including petroleum and natural gas) are concerned Gujarat ranks third in mineral production value and second in working mining leases. According to the Industries and Mines Department (2012) compared to 89 minerals that abound in the country, 50 minerals (33 major and 17 minor) are found in Gujarat. Gujarat has 7,334 leases of major and minor minerals and the total area under mining is around 42, 680 hectares. The policy also states that more areas would be explored for mining in a phased manner. It also aims to increase production of major and minor minerals to meet the demand of important industrial minerals by increasing the area and production by an annual rate of 10 percent (ibid).

Darji (2011) reports that the demand for lignite has increased at the rate of 10-12 percent in Saurashtra and Kutch because of rapid industrial development. The demand for lignite has also increased because of new power projects and cement plants in the coastal region. The Gujarat Mineral Development Corporation (GMDC) is planning to double its lignite mining capacity in Bhavnagar and Kutch in order to tackle growing demands. The capacity will be increased from three to five million tonnes in Bhavnagar and 2.4 million tonnes to 4.8 million tonnes in Kutch. Land degradation is directly linked to the production of minerals. Factors contributing to the degradation include unsustainable ways of mining, inadequate mine restoration, unscientific and illegal mining, use of conventional technologies, etc. It is appropriate that environmental impact assessments are conducted and results are out before the commencing of mining activities. Environmental damages and land degradation caused due to mining activities should be penalised under the polluter pays principle. Gujarat’s efforts to contain the adverse impacts of mining are given in the response chapter.
1.5 **DUMPING OF SOLID WASTES AND DOMESTIC WASTE WATER**

Solid waste refers to any solid or semi-solid substance resulting from human or animal activities, discarded as useless or unwanted. It is an extremely heterogeneous mass of wastes, which may originate from household, commercial, industrial or agricultural activities. Solid waste may be broadly classified into municipal solid waste (MSW), hazardous waste (HW) and bio-medical waste (BMW). Most of the MSW gets disposed in Gujarat in an unscientific and uncontrolled manner causing leaching and groundwater contamination, deterioration of soil etc. Thus, it is important to ensure the dumping of waste takes place in a controlled and scientific manner.

1.5.1 **Municipal Solid Waste**

Gujarat ranks third in per capita waste (0.451kg/day) generation after Delhi and Tamil Nadu (Ministry of Environment and Forests (MoEF) 2000). Disposal of solid wastes on land is the most common method employed. Waste dumps render the available space uneconomical. Waste is usually dumped in low lying areas, within or outside the cities this practice leads to unhygienic conditions and can cause serious environmental problems. Disposal of solid waste has become increasingly challenging as more land is needed for the ultimate disposal of solid waste. Increased urbanisation is concomitant with increased per capita waste generation driven by changing urban consumption patterns relevant to economic growth and improved living standards has exerted additional pressures on the already stretched municipal solid waste management system. Solid waste has the potential to pollute all the vital components of living environment i.e. land, water, air. Dumping of solid waste in unscientific landfill sites is degrading land. Chemicals and other contaminants from solid waste end up leaching through the soil thereby polluting soils. If these contaminants leach to greater depths they have the potential to even contaminate groundwater resources.

<table>
<thead>
<tr>
<th>Location of Landfill Site and Name</th>
<th>Quantity of solid waste generation</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyaspur Village, Dist. Ahmadabad. Ahmadabad Municipal Corporation</td>
<td>2550</td>
<td>In operation, compost facility, pallatisation in operation</td>
</tr>
<tr>
<td>Village Makarpura, Dist. Vadodara. Vadodara Municipal Corporation</td>
<td>510</td>
<td>Compost facility construction completed</td>
</tr>
<tr>
<td>Village Khajod, Dist. Surat Surat Municipal Corporation</td>
<td>1129</td>
<td>In operation, palletisation in operation</td>
</tr>
</tbody>
</table>

Source: GPCB, Annual Report 2011
1.5.2 Hazardous Waste
Hazardous waste poses a substantial threat to public health and the environment. Characteristic hazardous wastes are materials that are known or tested to exhibit ignitibility, reactivity, corrosivity, and toxicity. The major industrial sectors in the state produce large quantities of hazardous waste. The state has been coping with the increasing generation of hazardous waste by implementing a stringent law and policy and by creating numerous scientifically engineered disposal sites. Yet there have been some instances of sites being contaminated due to the illegal dumping of hazardous wastes.

Gujarat has 7,751 hazardous waste generating units contributing to 28.76 percent of the total hazardous waste generation of India, which is the highest in the country (Central Pollution Control Board (CPCB) 2009). The state has been generating major quantities of waste which is land disposable hazardous waste. The land disposable hazardous waste generation in the state accounts for 61.75 percent, while incinerable and recyclable waste together accounts for 38.25 percent. The contributions of various states with respect to the country’s total land disposable HW generation amounts to 40.58 percent while 36.75 percent comprises incinerable and remaining recyclable waste.

The major hot spots of waste generation may be found in the Bharuch and Ahmadabad districts. They account for 46 percent of the total amount of industrial hazardous waste generated in Gujarat. An inventory prepared by the Central Pollution Control Board (CPCB) (2009) reveals that the total land disposable hazardous waste generation in the state stands at 11,07,128 Tonnes Per Annum (TPA) while the total treatment stabilisation disposal facilities (TSDF) capacity is at 4,47,401 TPA. It shows that TSDF capacity has a deficit of 6,59,727 TPA in 2008. Immediate attention is called for to lower this gap to reduce environmental and land degradation.
The huge amount of hazardous waste generated by industries would require land for its disposal through scientific channels. Industrial hazardous waste contains certain heavy metals as well as phytotoxic organic compounds among other substances. When discharged on land, even at relatively low levels can affect the soil health, soil quality, and productivity of land. Industries also generate non-hazardous (high volume-low hazard) wastes that are mostly discarded over open, low lying land. This can degrade both land quality and the aesthetic value of the place.

The size of land required to dispose the waste in an engineered landfill, assuming the average density of waste to be around 1.2 tonnes/m³ and the depth of the landfill 4 meter, would be around 108 ha every year. This can be applied to future waste projections to arrive at future land requirements for the disposal of hazardous waste (United Nations Development Programme 2001). A state like Gujarat which generates the largest share of hazardous waste in the country, would require more land for waste disposal in order to prevent high rate of land degradation.

1.5.3 Bio-medical Waste

Our healthcare system should consider the bio-medical waste management system as an integral component to the proper functioning of the health and environment of the community. Hospitals and other healthcare establishments have a “duty of care” for the environment, public health and have particular responsibilities in relation to the waste they produce. As per Bio-Medical Waste (Management and Handling) Rules, 1998 and amendments, any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining there to or in the production of testing of biological and including categories mentioned in schedule 1 of the Rule, is the bio-medical waste. Some of the major human and environmental hazards are

- Children and rag pickers are particularly at risk to come in contact with infectious waste.
- Uncontrolled incineration causes air pollution.
- Dumping in drains, tanks and along the river bed causes water pollution.
- Unscientific and open area land filling causes soil pollution.

Bio-medical wastes need to have a benchmark system for collection, segregation, packaging, marking and disposal. An absence of a proper system can lead to human epidemics and environmental hazards.

The ‘Bio-Medical Waste (Management & Handling) Rules, 1998’ specify treatment and disposal options according for 10 different categories (see table) of waste generated in health care establishments in Schedule I of the rules. Table shows that total biomedical waste treated for the year 2011 amounts to 12636 tonnes in the state of Gujarat which is almost double the waste treated in 2010. This includes captive treatment facilities available with health care facilities and statewide centralized facilities. It is evident that major increase in treatment capacity has been in incineration based treatment of category VI solid waste whereas other categories show marginal change in quantity treated.
Table 4: Category-wise Bio-Medical Waste Treatment as on March 2012

<table>
<thead>
<tr>
<th>Category of Waste</th>
<th>Type of Waste</th>
<th>Mode of Treatment</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Waste</td>
<td>Waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Collected</td>
<td>Treated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(TPA)</td>
<td>(TPA)</td>
</tr>
<tr>
<td>Category I</td>
<td>Human Anatomical waste</td>
<td>Incineration</td>
<td>1293.78</td>
<td>1293.78</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category II</td>
<td>Animal waste (tissues,</td>
<td>Not Available</td>
<td>69.05</td>
<td>69.05</td>
</tr>
<tr>
<td></td>
<td>body parts, carcass etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category III</td>
<td>Microbiology and</td>
<td>Incineration</td>
<td>122.51</td>
<td>122.51</td>
</tr>
<tr>
<td></td>
<td>biotechnology waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(mainly Laboratory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>waste)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category IV</td>
<td>Sharp</td>
<td>Autoclave</td>
<td>427.57</td>
<td>427.57</td>
</tr>
<tr>
<td>Category V</td>
<td>Discarded medicines</td>
<td>Incineration</td>
<td>306.56</td>
<td>306.56</td>
</tr>
<tr>
<td></td>
<td>and cytotoxic drugs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category VI</td>
<td>Solid waste*</td>
<td>Incineration</td>
<td>2414.97</td>
<td>2414.97</td>
</tr>
<tr>
<td>Category VII</td>
<td>Solid waste**</td>
<td>Autoclave &amp;</td>
<td>832.84</td>
<td>832.84</td>
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<td></td>
<td></td>
<td>Shredding</td>
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<td>Category VIII</td>
<td>Liquid waste</td>
<td>Chemical Treatment</td>
<td>49.42</td>
<td>49.42</td>
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<tr>
<td>Category IX</td>
<td>Incineration ashen</td>
<td>TSDF</td>
<td>44.83</td>
<td>44.83</td>
</tr>
<tr>
<td>Category X</td>
<td>Chemical waste</td>
<td>Not Available</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Total 5561.53 5561.53 6976.94 6976.94

1.5.4 Domestic Waste Water
Domestic waste water is a major contributor to land pollution and water pollution as it contains chemical and biological pollutants. It also contains high levels of pathogens from excreta and inorganic and organic pollutants. A study by the Gujarat Urban Development Company (GUDC) (2010) looked at the area covered by treatment plants at the local body level. The percentage of area covered by these sewage treatment plants at each specific local body is given in Figure 15. Most of the sewage treatment plants in these local bodies cover nearly 60 percent of the total area. Figure 16 gives the pathway of disposal of the sewage waste; most sewage is discharged into surface water bodies, which also contributes to soil pollution. A high percentage of sewage disposals have been observed on land and water which will lead to deterioration in soil health and quality.
Figure 15: Local body wise area covered for sewerage treatment (2010)

![Local bodies-wise area covered for sewage treatment (percent) (2010)](chart15.png)

Source: Gujarat Urban Development Corporation (2010)

Figure 16: Present Location of sewage location, May 2011

![Present location of sewage disposal May 2011](chart16.png)

Source: Gujarat Urban Development Corporation (2010)
1.6 **Agriculture as Pressure on Land Resources**

Agriculture places a serious burden on the environment in the process of providing humanity with food, and nutrients. The key issue for the future is the environmental pressure from the intensification of land use and on land use changes. About 80 percent of the incremental crop production in developing countries will come from intensification and the remainder from arable land expansion (Food and Agriculture Organisation (FAO) 2003). Modernisation in agriculture encompasses **intensification** (e.g.: chemical fertilisers, new technologies and farm machineries) and **specialisation** (monoculture), both of these contributes to unsustainable agricultural practices. Modern agricultural practices has increases environmental problems such as loss of biodiversity, rising level of soil salinity, lowering of groundwater tables and even pollution of water resources. The impact of agriculture on the environment is often discussed merely in terms of pollution due to the leaching of agrochemicals or due to the erosion of contaminated soil particles. Chemical fertilisers are more resistant in the environment than natural fertilisers because they are combined with chemicals that are harmful to the environment, especially with regard to soil fertility since the presence of micro-organism decreases following the increase of the chemical fertilisers. The status chapter will deal with the changes in cropping patterns whereas this section will deal the main drivers that pressurises agricultural practices and further burdening land and water resources.

1.6.1 **Consumption of Chemical Fertilisers**

Gujarat has seen intensification in agricultural practices during the last two decades with increase in the consumption of chemical fertilisers (see Figure 17). This has been done in order to ensure food production as well as to maintain high economic growth in the agricultural sector. The increased use of chemical fertilisers could reduce the productivity of land, thereby, decreased food production in the future. The use of agrochemical fertilisers can reduce natural nutrients on the soil surface (Fred 1991). The major culprit responsible for soil degradation is due to the excessive use of chemical fertilisers on irrigated land causing loss of nutrients/organic matters which, in turn, causes loss of soil fertility (Katsunori 2003). Figure 18 gives the percentage usage of various fertilisers.
1.6.2 Groundwater Mining
Gujarat’s agriculture is heavily dependent on groundwater, especially in Saurashtra, Kutch and North Gujarat. Cash crops like cotton, groundnut, and rice have become favourable in the past two to three decades. These crops are water intensive and have brought about a rise in groundwater mining. Gujarat’s agricultural practices are largely dependent on groundwater resources and 79 percent of irrigation needs are supplied through groundwater irrigation. Increasing rural electrification was the main driver behind exploitation of groundwater resources during 1990s. Submersible electric pumps became increasingly popular during the
eighties and nineties. Between 1971 and 2001, the use of diesel and electric pumps in irrigation increased by 56 and 585 percent respectively. By the mid-nineties, of Gujarat’s 184 talukas, groundwater draft was more than long-term annual recharge rate in 31 talukas, 12 talukas, drafted 90 percent of the estimated safe yield and 69 talukas drafted 65 percent of the safe yield (Gulati, Shah and Shreedhar 2009). The number of government tube wells where irrigation water is supplied increased from 610 in 1960-61 to 2342 in 2007-08 i.e. the number of tube wells in 2007-08 increased three times during this period (Directorate of Economics and Statistics 2009). Apart from the government tubewells the private tubewells contribute to a higher rate of groundwater mining and have increased from 21 in 1960-61 to 57975 in 2002-2003. Uncontrolled groundwater drafting and three consecutive drought years (1985 to 1987) led to a decrease in the groundwater table causing a water scarce condition. Groundwater irrigation lowers groundwater table as the rate of extraction is generally greater than the natural rate of recharge. Groundwater overdraft can reduce the structural integrity of the aquifer as the water supporting the soil above is reduced. This results in land subsidence which is the lowering of elevation. Decrease in water table causes saltwater intrusion in coastal regions making the soil of that region saline. Improper and inefficient soil and water management in conjunction with inefficient and faulty irrigation facilities also contribute to the problem of salinity.

1.6.3 Soil Nutrient Mining
The consumption of NPK fertilisers has increased from 11,071 tonnes in 1960-61 to 12,79,924 tonnes in 2005-06 (approximately 1100 percent increase) (Agriculture and Cooperation Department, GoG 2012). Soil lacks micronutrients unbalanced fertilisation, prolonged crop harvesting periods, and inadequate technological responses have all contributed to the level of micronutrients falling in the soil. The soil of Saurashtra is deficient in zinc and iron. A part of the problem is often masked by the gains from unbalanced fertiliser use. This has led to a lowered nutrient status of the soil, to a level referred to as soil nutrient mining. Soil nutrient depletion adversely affects crop yield thereby, posing a serious threat to crop nutrient quality as well as food security (Tan et al 2005). Excessive use of fertilisers can cause soil acidification. Nitrogen is supplied as ammonium (NH$_4$) amendments which react in the soil and produce nitrates (NO$_3$) through the process of nitrification and in this process H+ ions are released, thus making the soil acidic, making land unfit for cultivation.

1.6.4 Soil Erosion
Tillage in addition to weathering agents like wind, water, and temperature can cause soil erosion as they break the soil into finer particles which could be easily carried away by the wind or water. Agricultural mechanisation has made it possible to plough deep into the soil increasing the amount of soil available for transportation by water and wind erosion. Tillage causes soil dehydration making it more prone to erosion. Mono cropping, row cropping, and the use of irrigation water are other major contributors of soil erosion. Also, when vegetation is cleared for agriculture it reduces the humus content in the soil (due to less availability of litter) making it more vulnerable to erosion. Soil erosion causes land degradation which reduces the efficiency of plant nutrient use. It also reduces the soil’s water holding capacity while increasing runoff and reducing infiltration (Pimentel 2001). Over-grazing also causes soil erosion as it reduces vegetative cover while increasing soil compaction, which, in turn increases soil erosion. Sheet erosion can occur in an irrigated field. If, during a single irrigation session, a layer of soil one millimetre thick is eroded from an acre of land then the loss of soil during the entire irrigation period could be roughly around 6.1 tonnes. Rill and
sheet erosion are the major contributors of soil erosion in the agricultural field (Green et al. 2006). The Saurashtra region and south Kutch are very prone to water erosion, while North Gujarat region is prone to wind erosion (Space Application Center (SAC) 2007).

1.6.5 Salinity Ingress
Natural factors like irregular and erratic rainfall, porous geographic formations and anthropogenic factors like excessive groundwater withdrawal have led to saltwater intrusion in the Saurashtra region. This led to lower crop yield (decreased in the range between 1/10 and 1/3 of the original yield) in the coastal belts, known for the cultivation of high value cash crops of Saurashtra and Kutch (Gujarat State Agricultural Marketing Board (GSAMB) 2007). In Saurashtra alone an area of 7,00,120 hectares of land has been affected by salinity which, in turn, has affected 32,750 wells. In Saurashtra 534 villages have been affected by salinity. Salt water intrusion makes land unfit for cultivation. Saline water used for irrigation raises the salt content in the soil (Narmada, Water resources, Water supply and Kalpsar Department 2012).

1.6.6 Small Agricultural Land Holding
Gujarat has seen an increase in the area and percentage of land holdings since 1970-1990. Figure 19 shows the trend of increase in small land holdings (<1 and <2-4 ha) and decrease in large land holdings’ size and area. The number of small land holdings have increased from 5,959 (2000-01) to 7,904 (2005-06) (Revenue Department, GoG 1991). This increase in the number of small land parcels is much higher than that of large land parcels. There is an increasing trend in the number of land parcels and a decreasing trend in the size of land parcels, primarily due to the heredity tradition of equal division of land amongst the inheritors. It is believed that small parcels are more productive than the large ones because of higher applications of inputs which increases near term productivity but often degrades the quality of land. Practising modern farming techniques and land and water management techniques on large agricultural holdings is easier compared to small land holdings. Small-holders intensify their farm operations through a more rigorous application of inputs like fertilisers, pesticides and so on. These increases agricultural productivity while reduces land fertility.
1.6.7 Livestock
The state has also shown remarkable progress in the dairy sector by contributing to the national growth rate of 5.5 percent between 1980-81 and 1990-91 and 4.5 percent during 1991-2000 (Planning Commission 2012). The last three state censuses on the livestock in Gujarat have also shown a considerable increase with 1,99,39,369 (in 1997), 2,16,71,374 (in 2003) and 2,35,24,542 (in 2007) (Directorate of Animal Husbandry 2011). Pastureland degradation is result of the increasing livestock population at a rate higher than its capacity to recover from grazing. Pastureland degradation also causes soil erosion and vegetation degradation. Land degradation due to over-grazing leads to desert-like conditions which, in turn, reduce animal productivity and productivity of the land. Increasingly farmers are shifting towards stall feeding which is reducing the burden on pastureland as cattle are fed crop residues and fodder crops. The nutritional value of crop residues shows that they are generally low in digestibility and protein content (FAO 2012; Keftasa n.d.). Increasingly, many dairy farmers are adopting fodder farming to sustain milk production.
STATE OF LAND RESOURCES
2. STATE OF LAND RESOURCES

This chapter deals with three main dimensions pertaining to the status of land resources – land use, soils, and agriculture. The first section of this chapter will deal with the different classifications of land use patterns. The trends followed to arrive at the current status of agricultural land, forest; wetland, wasteland, pastureland and build-up area are discussed here. In the second section the various types of soils, soil health (nutrient status), and the application trend of fertilisers and pesticides are highlighted. Finally, an overview of agricultural sector, cropping pattern and cropping intensity are looked into.

2.1 LAND USE

Land use is the manner and extent to which land is put to use. It may also be referred to as the human use of land. Land use is the modification of the natural environment into, settlements, road, rail networks, other infrastructure, agriculture, forests, wetlands, wastelands, etc. It has also been defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it (Gregorio & Jansen 1998). To maintain the balance between environment and development planners must have the knowledge about existing land use and the trends over the years. People dispute against the way land has changed over time. Sometimes there are conflicts over the usage of land. So there is a need for a proper land assessment and classification. Since various categories of land are within the ambit of different departments, there are inconsistencies of land use classes. There is a need to have a standard land use classification, which can be applied to the entire state. Land use classification has to be detailed and each class of land needs to be defined to reduce obscurity. Also, many scholars have highlighted the need for a systematic database to assess changes in land use. The reporting area of Gujarat for land utilisation is 1, 89,333 sq. km which is 96.6 percent of the total geographical area (1,96,024 sq. km). Under all the land use categories net sown area has dominance; its share is 54 percent with an area covering 1, 03,020 sq. km. Table 5 and figure 20 and 21 show the various land use classifications.
Table 5: Land Use classifications for Gujarat, 2009-10

<table>
<thead>
<tr>
<th>Land use classification</th>
<th>Area in sq. km</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net sown</td>
<td>103020</td>
<td>54.7</td>
</tr>
<tr>
<td>Current fallow</td>
<td>3790</td>
<td>2.01</td>
</tr>
<tr>
<td>Fallow other than current fallow</td>
<td>160</td>
<td>0.08</td>
</tr>
<tr>
<td>Forests</td>
<td>19130</td>
<td>10.1</td>
</tr>
<tr>
<td>Land under tree crops</td>
<td>40</td>
<td>0.02</td>
</tr>
<tr>
<td>Cultural wasteland</td>
<td>19790</td>
<td>10.5</td>
</tr>
<tr>
<td>Permanent pastures</td>
<td>6900</td>
<td>3.64</td>
</tr>
<tr>
<td>Land not available for cultivation</td>
<td>35280</td>
<td>18.63</td>
</tr>
</tbody>
</table>


Figure 20: Land Use Classification

Figure 21: Landuse/ Landcover Map of Gujarat (2000)

Legend
- Agriculture
- Built-up
- Forest
- Grass Land/Grazing Land
- Wastelands
- Water bodies
- Wetlands
- Ranns

Source: Bhaskaracharya Institute For Space Applications and Geo-Informatics
2.1.1 Agricultural Land

2.1.1.1 Net sown area

The net sown area represents the area sown with crops at least once during a crop season of the year. In other words: “This represents the total area sown with crops and orchards. Area sowed more than once in the same year is counted only once” (Agriculture and Cooperation Department, GoG 2012). The net sown area in Gujarat in 1961 was 93,970 sq. km which increased to 1,03,020 sq. km by 2010 (Agriculture and Cooperation department, GoG 2012). A sharp decline in the net sown area was observed during 2000-01 as it reduced to 943300 ha due to a severe drought. After 2000 this area increased and remained almost constant from 2003 to 2005 at around 9,74,69 sq. km. Figure 22 shows only a small increase in the net sown area since the 1960.

Figure 22: Net Sown Area in Gujarat

Figure 23 shows the area of land sown relative to the total geographical area of that district. Most of Gujarat has over 50 percent of the total area of a district under cultivation while Kutch has the least net sown area.
2.1.1.2 Current fallow
Land that is periodically left idle to recuperate is current fallow land. This represents the cropped area which is kept fallow over the current year. Current fallow lands are left without cultivation for one or less than one agricultural year (Agriculture and Cooperation Department, GoG 2012). Current fallow lands have also shown an increasing trend in Gujarat with 3413 sq. km in 1961 going up to 3790 sq. km in 2010 (Agriculture and Cooperation department, GoG 2012).

2.1.1.3 Other than current fallow
Other than the current fallow are lands which have been left uncultivated for at least 1 to 5 agricultural years. This includes the entire land which had been taken up for cultivation but is now temporarily out of cultivation for a period of not less than one year and not more than five years (Agriculture and Cooperation department, GoG). Since intense farming practices are carried out in Gujarat the land is not is allowed to recuperate for a long period of time. Letting lands recuperate for a longer duration helps maintain soil health and quality but this practice is not carried out due to the easy access of chemical fertilisers. Statistics show that other than fallow lands have decreased since 1961 from 4254 sq. km to 160 sq. km (Agriculture and Cooperation Department, GoG 2012).
2.1.1.4 Gross cropped area
Gross cropped area represents the total area sown once and/or more than once in a particular year, i.e. the area is counted as many times as there are sowings in a given year. This is also known as total cropped area or total area sown. Gross cropped area in Gujarat has been on the rise since 1960s. The gross cropped area increased from 97,676 sq. km in 1960-61 to 11, 36, 27 sq. km in 2003-04. A significant decrease was observed in 2000-2001 and can be attributed to the severe drought during this period. A slight decrease in area was observed in 2004-05. The total gross cropped area for the year 2004-05 was 112569 sq. km.

2.1.2 Forest Cover
Forest cover includes all lands with a tree canopy of over 10 percent. The forest and tree cover of the state as per the assessment in 2011 is 22456 sq. km, which is 11.46 percent of the geographical area. This includes 4 percent of the tree cover and 7.46 percent of forest cover (Forest Survey of India (FSI) 2011). Table 6 shows the distribution of forests and tree cover in Gujarat. However, as per the data provided by the Directorate of Economics and Statistics, forest land in Gujarat is 19130 sq. km. This study, in order to analyse regional variations of forests and tree cover we have used data available in the reports of Forest Survey of India. Variation in forest cover data of different agencies is due to different scale and resolution of surveys adopted. The state’s forest cover in Gujarat has evinced an overall increase since 1991 when the forest cover was only 11,907 sq. km and increased to a maximum of 15,152 sq. km in 2001. A gradual decline was observed after 2001 and the total forest cover is Gujarat is 14,619 sq. km. Figure 25 shows the spatial distribution of forest cover for the year 2000. Figure 26 shows the forest cover over the last two decades. There was an increase in forest cover during 1990-2000 after which a decline was observed. In 2011 Gujarat’s total forest area was estimated at about 14,619 sq. km. (Forest Survey of India (FSI) 2011). This increase has been due to management interventions like regeneration and departmental plantations. The Forest Survey of India (FSI) (2011) has categorised forest cover under very dense forests with canopy cover of 70 percent and above, moderate dense forest with a canopy cover between 40-70 percent, and open forest with a canopy cover ranging between 10 and 40 percent. But in the present case we have a combined dense forest and moderately dense forest under the category of dense forest so that we could show a continuous trend since the ‘very dense’ category was not defined till 1999. Figure 27 shows the distribution of open and dense forests in Gujarat. It
shows a decline in the dense forest category from 6,224 sq. km in 1991 to 5,607 sq. km in 2011 with an increase in open forests from 5,286 sq. km in 1991 to 9,012 sq. km in 2011.

Gujarat’s tree cover outside the forest area is about 8,390 sq. km (4.3 % of geographical area against only 2.8 % in India). The tree outside the forest area is the second highest amongst the states of India (Forest Department, Gujarat 2011). For forest resources to be valuable and productive in terms of providing ecosystem services it is essential that the dense forest cover increases. Figure 28 shows the percentage distribution of forest, region-wise to the total geographical area of that particular region during the period 1990-2011. Forest cover is highest in South Gujarat with over 20 percent of the total geographical area of South Gujarat, followed by Central Gujarat. The forests of Gujarat are concentrated in the hilly parts of the state in the south-east and in the hills of Saurashtra. This is due to the higher rainfall than what is observed in the plain areas. The hills of Kutch are bare because of the low rainfall ascribed to their northern-most locations and the absence of any orographic features that could come in the way of the monsoon and cause precipitation. A large part of the forest cover which is economically exploitable is distributed along the divisions of The Dangs, Panchmahals, Bharuch, Surat, Valsad, Junagadh, Sabarkantha and Banaskantha. The south and south-eastern parts of the state support the growth of a tropical deciduous forest typified by teak.

Figure 25: Forest in Gujarat (2000)
Table 6: Forest cover and tree cover of Gujarat in 2011

<table>
<thead>
<tr>
<th>Class</th>
<th>Area in sq. km</th>
<th>Percentage of geographical area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Forest</td>
<td>5607</td>
<td>2.86</td>
</tr>
<tr>
<td>Open Forest</td>
<td>9012</td>
<td>4.6</td>
</tr>
<tr>
<td>Total Forest Cover</td>
<td>14619</td>
<td>7.46</td>
</tr>
<tr>
<td>Total Tree Cover</td>
<td>7837</td>
<td>4.00</td>
</tr>
<tr>
<td>Forest Cover + Tree cover</td>
<td>22456</td>
<td>11.46</td>
</tr>
</tbody>
</table>

Source: Forest Survey of India (FSI) 2011

Figure 26: Forest cover from 1991 to 2011

Source: Analysis based on data from; Forest Survey of India (FSI) (1991-2011)
Figure 27: Forest cover density in Gujarat from 1990 to 2011

![Open and Dense Forest in Gujarat](image)

Source: Analysis based on data from Forest Survey of India (FSI) (1991-2011)

Figure 28: Forest cover distribution across regions of Gujarat from 1991 to 2011

![Region-wise Forest Cover (1991 - 2011)](image)

Source: Analysis based on data from Forest Survey of India (FSI) (1991-2011)
Figure 29: Forest Area in Percentage to the Total Area of a District (2011)

South Gujarat:
According to various FSI reports South Gujarat has far more dense forests than open forests. The Dangs recorded the highest forest cover of about 1,368 sq. km while the lowest forest cover was recorded at the district of Navsari with 288 km sq forest cover, as per an assessment in 2011. In South Gujarat the maximum increase in forest cover was observed in 2001, after which there was a sudden decrease in forest cover as shown in Figure 30. Drastic changes have been observed in the forest of South Gujarat showing fluctuations at about 2 percent. In 2011 its forest cover was computed at 5,174 sq. km and it constitutes about 21.83 percent of other regions total forest cover. Figure 31 shows the distribution of open and dense forests. Decline in dense forests and an increase in open forests has been observed in South Gujarat.
Central Gujarat:
The Central Gujarat region witnessed the highest forest cover in 2001. In 2011 the Dahod district had the highest forest cover (704 sq. km) in the entire region, which increased by about 2 sq. km from the previous assessment year of 2009. Anand (53 sq. km) and Kheda (94 sq. km) showed decline in their forest cover by 3 sq. km and 1 sq. km respectively (Forest Survey of India (FSI) 2011). Figure 32 shows the increase in overall forest cover in Central Gujarat. Dense forests have reduced over the past few years which can be seen from Figure 33 while open forests have increase. The highest number of open forests exists in the Dahod district (540 sq. km) and the lowest in Gandhinagar (36 sq. km).
Figure 32: Percentage of Forest cover in Central Gujarat

Forest Cover in Central Gujarat

![Bar Chart: Percentage of Forest cover in Central Gujarat](chart1.png)

Source: Analysis based on data from Forest Survey of India (FSI) (1991-2011)

Figure 33: Forest cover density in Central Gujarat from 1991 to 2011

Open and Dense Forest in Central Gujarat

![Bar Chart: Open and Dense Forest in Central Gujarat](chart2.png)

Source: Analysis based on data from Forest Survey of India (FSI) (1991-2011)

North Gujarat:
North Gujarat’s forest cover is dominant in the two main districts of Banaskantha and Sabarkantha, which have a forest cover of 842 sq. km and 804 sq. km respectively. Patan has the lowest forest cover of about 83 sq. km. Figure 34 shows the increase in forest cover for the period 1991 to 2011. Open forests have been showing a significantly increasing trend; they increased from 2.15 percent in 1991 to 3.38 percent in 2011. Dense forests, on the other hand, are showing an insignificant increase from 2.78 to 2.85 percent between 1991 and 2011 (Forest Survey of India (FSI) 1991-2011) as shown in figure 35.
Saurashtra:
This region’s forest cover showed an increasing trend from 1991 to 2011 with the maximum observed in 2011 at around 4.62 percent of the total geographical area. From figure 37 one can see the trend relevant to dense forests. Open forests have shown a drastic increase from 1.71 percent to 2.81 percent (Forest Survey of India (FSI) 1991-2011) while a gradual decline has been observed in dense forests from 2.24 percent in 2003 to 1.81 percent in 2011.
Kutch: 
The forest cover in Kutch has increased with time; maximum increase was observed since 2007 when the forest cover was at 5.06 percent of the total geographic area of the region as shown in Figure 38. The dense cover is negligible in Kutch and has been reducing. In 2001 the percentage of dense forest cover was 0.94; it has now reduced to 0.67 of the total geographical area of the region. Open forests, however, are on the rise and a massive increase of 1.8 percent to 4.37 percent from 1991 to 2011 has been registered as shown in Figure 39.
2.1.3 Mangroves
Mangroves are salt tolerant plant communities rich in biodiversity—both terrestrial and aquatic species. They provide a number of ecological services and play a key role in protecting coastal areas from erosion and rise in sea level. They are also beneficial for land accretion as they trap fine debris particles.
According to the Forest Survey of India (FSI) (2011), the mangroves in Gujarat account for 22.69 percent of India’s mangrove vegetation and they are spread over 1058 sq. km of Gujarat’s geographical area, along the coastline of Gujarat. Table 7 and Figure 41 shows an increase of 166 percent mangrove cover during 1991–2011 period.

Table 7: Mangrove cover assessment of Gujarat from 1991-2011 (area in sq. km)

<table>
<thead>
<tr>
<th>Reporting Year</th>
<th>1991</th>
<th>1993</th>
<th>1995</th>
<th>1997</th>
<th>1999</th>
<th>2001</th>
<th>2003</th>
<th>2005</th>
<th>2009</th>
<th>2011</th>
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<tbody>
<tr>
<td>Area</td>
<td>397</td>
<td>419</td>
<td>689</td>
<td>901</td>
<td>1031</td>
<td>911</td>
<td>916</td>
<td>991</td>
<td>1046</td>
<td>1058</td>
</tr>
</tbody>
</table>

Source: Analysis based on data from Forest Survey of India (FSI) (1991-2011)

It has been suggested by the Wetland Atlas (2010), that there are 746 mangrove wetlands in Gujarat. There spread is about 904.75 sq. km and it is covering 13 districts.
According to the Forest Survey of India (FSI) (2011), the highest mangrove cover in Gujarat is found in Kutch district (778 sq. km) followed by Jamnagar (159 sq. km) and Bharuch (43 sq. km). Table 8 shows the trend of mangrove in various districts under three main categories: very dense (canopy density of more than 70 percent), moderately dense (canopy density between 40-70 percent), and open mangrove (canopy density is between 10-40 percent). The FSI Report 2011 documents a net increase of 661 sq. km in the mangrove cover of the state due to plantation and regeneration of natural mangrove areas. Mangroves, as said earlier, provide a variety of ecological services. There is, however, a lack of dense mangrove cover with most mangroves in the open forest category hence they provide lower ecosystem services. Efforts need to be scaled up to ensure a significant increase in dense mangrove cover for the ecosystem to be productive of natural resources and protect the coastal communities and infrastructure against mighty cyclones.

Table 8: Mangrove cover assessment under various categories in 2011 (area in sq. km)

<table>
<thead>
<tr>
<th>District/ State</th>
<th>Very Dense</th>
<th>Moderate Dense</th>
<th>Open Forest</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmadabad</td>
<td>0</td>
<td>1</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Amreli</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Anand</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bharuch</td>
<td>0</td>
<td>21</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>Bhavnagar</td>
<td>0</td>
<td>6</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>Jamnagar</td>
<td>0</td>
<td>28</td>
<td>131</td>
<td>159</td>
</tr>
<tr>
<td>Junagadh</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Kutch</td>
<td>0</td>
<td>118</td>
<td>660</td>
<td>778</td>
</tr>
<tr>
<td>Navsari</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Porbandar</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rajkot</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Surat</td>
<td>0</td>
<td>7</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>Vadodara</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Valsad</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Gujarat</strong></td>
<td><strong>0</strong></td>
<td><strong>182</strong></td>
<td><strong>876</strong></td>
<td><strong>1058</strong></td>
</tr>
</tbody>
</table>

Source: Analysis based on data from; Forest Survey of India (FSI) (1991-2011)
2.1.4 Wetlands

Wetlands are areas in which water is the key factor regarding controlling the environment and allied flora and fauna. They occur where the water table is at or near the surface of the land. They are among the world’s most productive environments in terms of aquatic biodiversity. Many plant and animal species depend on wetlands for their survival. Wetlands have been described as “the kidneys of the landscape”, because of the functions they perform during hydrological and chemical cycles and as “biological supermarkets” because of the extensive food webs and rich biodiversity they support (Mitsch & Gosselink 1993). Figure 42 shows the different types of wetlands and their spatial distribution during 2000. Figure 43 gives the district-wise percentage of wetland area relative to the total wetland area. The largest share of wetlands is found in the Kutch district at 67.9 percent of the total wetland area followed by Jamnagar at 5.7 percent and Surat at 3.2 percent. Figure 44 shows the percentage of wetlands relative to the geographic area of the district.

Figure 42: Wetlands in Gujarat (2000)
Figure 43: Wetland Area in Percentage to the Total Wetland Area in Gujarat

Figure 44: Wetland Area in Percentage to the Total Geographical Area of a District
Wetland plants trap sediment suspended in water leading to improved water quality. In riparian areas their roots hold the soil together on river banks reducing soil erosion. Nitrogen and phosphorus enter waterways through groundwater; surface run-off and disposal of effluents and wetland vegetation uses some of these nutrients for growth. Bacteria living in wetland soils absorb and break down the nitrogen from farm run-off and leaching, which also helps improve water quality. Around 50 percent of the earth’s wetland area is estimated to already have disappeared over the last hundred years through conversion to industrial, agricultural, and residential developments (Wetland Report 2010). They are highly valued by the local communities for their educational, scientific, aesthetic, spiritual and cultural value. People use wetland soil for agriculture and extract timber and fuel wood from wetland trees (Barbier et al. 1997). There are two major categories of wetlands, the coastal wetlands (natural and manmade) and inland wetlands (natural and manmade).

**Inland wetlands** exist along rivers and streams (sometimes called riparian wetlands) and in some low-lying areas where precipitation saturates the soil as in bogs. Inland wetlands include lakes, ponds, water logged areas, rivers/streams, reservoirs, tanks, salt pans, etc. (Ornes 2012). Unlike coastal wetlands, inland wetlands always contain freshwater.

**Coastal wetlands** exist along the coastlines of mid to high latitude areas. They form near estuaries and are prone to different levels of salinity and water levels because of tidal action. They include lagoons, creeks, sand/beach, inter-tidal mud flats, salt marshes, mangroves, coral reefs, salt pans, and aquaculture ponds (Briney 2012).
**Figure 46: Wetlands in different Regions in the year 1998 and 2010**

Source: Analysis based on data from Space Application Centre (SAC) 1998 and 2010

**Figure 47: Type wise Wetland distribution in Gujarat**

Source: Space Application Centre (SAC) (2010)

**Kutch** had and still has the highest share of wetlands in Gujarat. In 2010 Kutch’s wetland share was 67.9 percent (23609.09 sq. km). There is an increase of 6.7 percent of wetland cover from 1998 to 2010. Intertidal mud flats, creeks, mangroves and salt pans are the major wetland categories in this region.
In the North Gujarat region there are 4,761 wetlands, including 1,939 small wetlands (< 0.0225 sq. km). This region comprises 3.7 percent (1288.74 sq. km) of the total wetland area. The major wetland categories here are rivers/streams, reservoirs and tanks/ponds. Banaskantha has the highest number of wetlands (1,477). But Patan has the largest wetland area (3426.88 sq. km) in North Gujarat. Mehsana has the lowest share of wetlands, about 84.62 sq. km in North Gujarat.

Central Gujarat has 6,013 wetlands including 2520 small wetlands. This region has 6.8 percent (2382.45 sq. km) of the total wetland share of the state. Major wetland sub classes are river/stream, tanks/ponds, inter-tidal mud flats, reservoir etc. Ahmadabad had recorded the highest number of wetlands-about 1255 in the region with 568 numbers of small wetlands. Anand’s wetland area is the maximum in the region-about 675.7 sq. km. Gandhinagar has the least number of wetlands and also the smallest wetland area in the entire region.

South Gujarat covers an area of 2723.88 sq. km (7.8 percent of the state) with 2,284 wetlands including 990 small wetlands. The main categories of wetlands in this case are reservoirs, salt marsh, rivers/streams, inter-tidal, mud flats, etc. Bharuch has the highest number of wetlands as well as the largest wetland area of the region (1124.53 sq. km). In The Dangs there are only 46 wetlands covering an area of 43.68 sq. km.

After Kutch, Saurashtra happens to be the wetland rich region containing the state’s 13.6 percent wetlands. It has 7,029 wetlands accommodating 2,386 small wetlands that cover an area of 4745.35 sq. km. The dominating categories of wetlands here are the inter-tidal mud flats, rivers/streams, salt pans, reservoirs, mangroves etc. Jamnagar has the largest wetland area (1986.57 sq. km) in the region. The highest number of wetlands i.e. 1,460 has been reported in the Surendranagar district of the region.
2.1.5 Wasteland

Degraded land is one which can be brought under vegetative cover with reasonable effort and which is currently under-utilised and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes (Department of Land Resources, MoRD n.d.). According to the National Wasteland Atlas, wastelands have been classified as the following 1) Gullied and/or ravinous land – medium 2) Gullied and/or ravinous land-Deep 3) Land with Dense Scrub 4) Land with Open Scrub 5) Waterlogged and Marshy land-Permanent 6) Waterlogged and Marshy land-Seasonal 7) Land affected by salinity/alkalinity-Moderate 8) Under utilised/degraded notified forest land-Scrub dominated 9) Under utilised/degraded notified forest land-Agriculture 10) Degraded pastures/grazing land 11) Degraded land under plantation crops 12) Sands-Coastal 13) Mining wastelands 14) Barren rocky area. The classification made by the National Wasteland Atlas cannot be compared over two time periods because of non-uniform classification schemes.

Figure 48: Change in Wasteland Area in Gujarat

Analysis based on data provided by the Nation Wasteland Atlas of India (2000) and Nation Wasteland Atlas of India (2010) shows the area of wasteland for 1992, 2003 and 2006. There is nearly 50 percent decline in wasteland area between 1992 and 2003 and a minor increase by around 1000 hectare between 2003 and 2006 as shown in Figure 48. This decline in wastelands may be due to their allotment to industries, and projects. Post 2003, there has been an increase in wasteland area. The reason could be, land degradation due to natural and anthropogenic factors. There is a need to prevent and combat land degradation to ensure sustain use of land resources. Moreover, the classification of wasteland by the National Wasteland Atlas of India is inconsistent between the years. While degraded pasturelands and agricultural lands should not be included in wastelands, efforts should be made to reclaim them instead of converting them into wasteland. Another issue that needs to be emphasised is on the inconsistency between agencies on classification of wastelands.
Data comparison for the two time series shown in Figure 49 indicate to a drastic wasteland decline in all the regions except South Gujarat where an increase in wasteland area of over 4 percent has been identified. According to the Wasteland Atlas of India (2000) for the year 1992 the Kutch region shows the highest concentration of wasteland- about 41.9 percent of the entire state followed by Saurashtra at about 20.3 percent and North Gujarat which has about 17.09 percent of wasteland share. In Saurashtra the Junagadh district accounts for the largest wasteland area extending up to 3,141.14 sq. km in the region and second largest in the state after Kutch. Central Gujarat’s Gandhinagar district has recorded the least area extending up to (26.89 sq. km) of wasteland in the region as well as in the state. In North Gujarat most of the wetlands are concentrated in the Banaskantha (2742.96 sq. km) and Sabarkantha (1521.55 sq. km) districts. Figure 50 shows the spatial distribution of wasteland area for the year 2000 prepared by BISAG.
Note: Narmada, Water resources, Water supply and Kalpsar Department 2012, Porbandar, Anand, Patan, Mehsana Dahod and Navsari are newly formed districts out of Bharuch, Junagadh, Kheda, and Banaskantha, Panchmahals and Valsad districts respectively. The statistics included are shared by both the new and old districts.
According to the Wasteland Atlas of India (2010) for the year 2006, Kutch still dominates the wasteland area although it has now evinced a large decrease. The percentage of wasteland area relative to the total geographic area of the region makes it evident that Kutch contributes to the maximum wasteland area of 16.7 percent followed by South Gujarat (15.5 percent) where Valsad contributes 38.36 of the total area of the district. Saurashtra’s contribution is 10.15 percent while Bhavnagar’s contribution is 12.9 percent to the total area of the district followed by Central Gujarat (9.3 percent) and, finally, North Gujarat (8.6 percent).

2.1.6 Pasture/Grazing Lands
Pasturelands are enclosed tracts of farmland or open grasslands; it is a primary source of food for domesticated livestock like cattle, sheep, etc. Known as gauchar’ in the vernacular, these lands account for around 4.35 percent of the total reported land use in Gujarat. Most of these lands occur in districts of Saurashtra and Kutch, where these are called vidis and rakhals, respectively. There is a decline of 1,89,600 ha of pasturelands from 1960-2007 (figure 53) (Agriculture and Co-operation Department (2012) and Directorate of Economics and Statistics (n.d.)). Many scholars have shown concerns over deficit of pasturelands for the rising livestock population (Ganguly 2011; Bharwada & Mahajan 2010; Iyenger 2004; Iyenger 2003). Table 9 shows the percentage share of pasturelands relative to the total area of a region in Gujarat. There is a need to either increase pastureland or plan proper stall feeding based on fodder cultivation for the large livestock population base available in the state.

Table 9: Percentage of Pasture/grazing land to the total geographical area of the region (1960-61 to 2006-07)

<table>
<thead>
<tr>
<th>Year/Region</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>South</td>
</tr>
<tr>
<td>1960-61</td>
<td></td>
</tr>
<tr>
<td>1970-71</td>
<td></td>
</tr>
<tr>
<td>1980-81</td>
<td></td>
</tr>
<tr>
<td>1990-91</td>
<td></td>
</tr>
<tr>
<td>2000-01</td>
<td>0.29</td>
</tr>
<tr>
<td>2001-02</td>
<td>0.29</td>
</tr>
<tr>
<td>2002-03</td>
<td>0.29</td>
</tr>
<tr>
<td>2003-04</td>
<td>0.29</td>
</tr>
<tr>
<td>2004-05</td>
<td>0.29</td>
</tr>
<tr>
<td>2005-06</td>
<td>0.29</td>
</tr>
<tr>
<td>2006-07</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Source: Directorate of Economics and Statistics (n.d.)
Figure 52: Region-wise Pasture/ Grazing land in percentage

Source: Directorate of Economics and Statistics (n.d.)

Figure 53: Percentage decrease in Pastureland since 1990-2007 in Gujarat

Source: Based on data from Directorate of Economics and Statistics (2008); Agriculture and Co-operation Department (2012)
2.1.7 Built-Up Area

Built-Up area consists of rural and urban areas. An urban area is characterised by higher population density in comparison to rural areas. Urban areas may be cities, towns or conurbations. For India urban are all places with a municipality, corporation, and cantonment board or notified town area committee, etc. and all other places which satisfy the following criteria:

1. A minimum population of 5,000;
2. At least 75 percent of the male main working population is engaged in non-agricultural pursuits; and
3. A density of population of at least 400 persons per sq. km (Census 2011).

Data collected from BISAG for the year 2000 (Figure 54) shows that South Gujarat has the highest built up of 2.96 percent with respect to the total reported area of Gujarat. The Kutch region accounts for 0.54 percent of its area which is the lowest with respect to the other regions. Figure 55 shows the spatial distribution of Urban and Rural built up areas of Gujarat. Figure 56 shows the built up area pertaining to urban and rural in terms of percentage with respect to the total geographical area of the region.

Figure 54: Region wise built up in percentage with respect to total reported area of the State

<table>
<thead>
<tr>
<th>Region</th>
<th>Built Up Area (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>2.96</td>
</tr>
<tr>
<td>Central</td>
<td>2.63</td>
</tr>
<tr>
<td>North</td>
<td>1.42</td>
</tr>
<tr>
<td>Saurashtra</td>
<td>2.41</td>
</tr>
<tr>
<td>Kutch</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Source: Based on data collected from Bhaskaracharya Institute for Space Applications and Geo-informatics (BISAG) (2000)
Figure 55: Built up Area - Urban and Rural (2000)

Source: Bhaskaracharya Institute For Space Applications and Geo-Informatics

Figure 56: Built Up Area in Percentage - Urban and Rural (2000)
2.2 SOILS

2.2.1 Soil Type
The state is endowed with a wide range of macro and microclimates, physiography, landforms, geology and vegetation that have an influence on the genesis of soil. Soil systems have developed over many millions of years. The soil characteristics in a given area at a given point of time are a function of both natural influences and human activities. This section deals with the different types of soils found in Gujarat.

Black Soil is the most dominant soil type of Gujarat. Three major variations recorded are:

Shallow black soils: Shallow black soils have been developed from the basaltic trap in Saurashtra and the Deccan trap in extreme eastern part while the remaining strips in Chhotaudepur and Saurashtra districts have been developed from granite and gneiss parent material. The depth of soil ranges from a few cm to 30 cm. (Gujarat State Agricultural Marketing Board (GSAMB) 2007). Shallow black soils are light grey in colour and mainly sandy clay loam in texture. The soil is poor in fertility.

Medium black soil: Medium black soils have a basaltic trap parent material. Such soils in some parts of Sabarkantha and Panchmahals have been also developed from the granite and gneiss parent material. These soils vary in depth from 30 to 60 cm. They are calcareous in nature except in the Panchmahals and Sabarkantha districts. A layer of murum (unconsolidated material of decomposed trap and limestone) is found below a depth of about 40 cm, especially in the Saurashtra region (GSAMB 2007). The soils are silt loam to clay in texture and neutral to alkaline in reaction. These soils are adequately supplied with potassium and poorly supplied with phosphorous and nitrogen.

Deep black soils: The districts of Bharuch, Surat, Valsad and southern part of Vadodara, and the Bhal region have deep black soils. Similarly, in the Ghed tract of Junagadh districts mostly covering the talukas of Porbandar, Kutiyana, and Manavadar and part of the Mangrol taluka, the deep black soils have been formed due to the deposition of basaltic trap materials transported by the rivers Bhadar, Minsar, Osat Madhuvanti etc. They have faced the problem of salinity and alkalinity. They are also impregnated with a fairly high amount of free lime. The soils are dark brown to very dark greyish brown in colour. They contain 40 to 70 percent clay minerals. The deep black soils, in general, are clay-like in texture, poor in drainage, and neutral to alkaline in reaction. These soils are most fertile soil in Black soils.

Mixed red and black soils: The mixed red and black soils are shallow in depth with reddish brown colour at higher and greyish brown colour at lower elevations. Texturally, they are clay loam to clay and skeletal in nature, with stony material as high as 50 percent in subsurface layer. This provides an ideal drainage conditions for these soils. The soils are highly calcareous in nature and alkaline in reaction. The soils are low in available nitrogen, medium in phosphorus, and high in potassium (GSAMB 2007).

Lateritic soil
True laterites in the real sense of the term don't occur in Gujarat. However, in the Dangs district, which has an abundant forest vegetation and high annual precipitation of about 250 cm, lateritic soils have developed. They support good forests. Clayey in texture they become hard within hours of receiving irrigation and rainfall.
Alluvial soils
These soils are very deep. These soils are further divided into alluvial sandy to sandy loam soils, alluvial sandy loam to sandy clay loam, and coastal alluvial soil.

Alluvial sandy to sandy loam soils: These soils cover all the northern districts, namely, Banaskantha and Mehsana except the southern part and the area of Sabarkantha bordering the Kheralu and Vijapur talukas of Mehsana district. The original alluvial material in Banaskantha and some parts of the Mehsana district has been overlaid by sandy material brought in by the winds blowing through the desert of Kutch. From a fertility point of view, these soils are low in available nutrients.

Alluvial sandy loam to sandy clay loam: Alluvial sandy loam to sandy clay soils are found in the Kheda, Gandhinagar, Ahmadabad and Mehsana district and the western part of the Vadodara district. These soils are the most productive soils in the state and contains fairly good amount of potassium.

Coastal alluvial soils: The coastal alluvial soils are sandy clay loam to clay in texture. The fertility of this type of soil is of medium class.

Hill soils
This type of soil occurs in the hilly areas and eastern strip of the mainland Gujarat. The soil profile is not well developed due to steep slope and erosion. Soil is shallow in depth formed by undecomposed rock and poor in fertility. Hill soils have been developed from parent materials existing in the respective areas. Shallow and composed of undecomposed rock fragments, they are poor in fertility.

Desert soils
Desert soil is generally found in the little and greater desert of Kutch. The soil is deep and light grey in colour with no definite structure. It is sandy to sandy loam with silt clay loam in structure. This type of salt has high salt content and sufficient amount of gypsum in the soil profile.
Figure 57: Soil type of Gujarat

Figure 57 shows the soil map of Gujarat referring to different types of soils spread across the different talukas of Gujarat.

2.2.2 Soil Texture

Soil texture is an important soil characteristic that could influence water retention capacity, aeration, drainage, and susceptibility to erosion which drives crop production and management. The textual class of soil is determined by the percentage of sand, silt and clay. Soils can be classified into one of four major textural classes including sands, silts, loams and clays. Broadly speaking, three textural classes are identified in the state. Clayey and loamy types are predominant in the state under fine and medium textured soils.

The soil texture of Kutch region belongs to the sandy class. The soils found in South Gujarat and Saurashtra are predominantly clayey. In Central Gujarat it is sandy loam to loam or clay loam to clay in midland, floodplains and the coastal saline area. The predominant texture of North Gujarat’s soil is sandy loam to loam. Figure 58 shows the region-wise textural classification of soils in percentage.
2.2.3 Soil Health

Soil is an important component of the earth’s system, functioning not only for the production of food, fodder and fibre but also in the maintenance of local and regional environmental quality (Pathak 2010). Soil health in the context of agriculture refers to its ability to sustain productivity. Healthy soil would ensure proper retention of water and nutrients, promote sustain growth, maintain the soil biotic habitat and respond to management and resist degradation. The fact of soil being an important source of supplying plant nutrients has been known since the dawn of agriculture. Improper fertiliser application and decline in soil organic matter can cause imbalance in soil nutrients (macro and micro). Therefore, it is important to monitor the nutrient supplying capacity of soils and ensure the sustainability of agriculture.

2.2.3.1 Macronutrient status

Plants require nitrogen, phosphorous and potassium for their growth and survival. The data from a soil testing laboratory was analysed to measure the fertility status of agricultural soils of Gujarat for the year 2010-11. Soil samples were classified into three categories i.e. low, medium and high based on the soil test value of N, P, and K. Nutrient index for different districts of the state has been calculated. This calculation of nutrient index is based on the Parker’s (1951) method, shown below:

\[
\text{Nutrient Index} = \frac{N_L \cdot 1 + N_M \cdot 2 + N_H \cdot 3}{N_T}
\]

Where, \(N_L\), \(N_M\), and \(N_H\) are the number of samples falling in low, medium, and high classes of nutrient status, and \(N_T\) is the total number of samples analysed for a given area. Analysis of this data shows the fertility status of the soils of Gujarat. The data was available for 21 districts of the state and was sourced from IFFCO, Gandhinagar. The sample size varies for

Figure 58: Textural classification of soils in Gujarat
each district. Table 10 gives the representation of Nutrient Index Value and the class which they fall under. Table 11 shows the N, P, and K Nutrient Index for 21 districts of the state. The fertility class was defined for each district by the following standard values.

**Table 10: Nutrient Index Value and Respective Class**

<table>
<thead>
<tr>
<th>Nutrient Index</th>
<th>Fertility Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 1.67</td>
<td>Low</td>
</tr>
<tr>
<td>1.67-2.33</td>
<td>Medium</td>
</tr>
<tr>
<td>Above 2.33</td>
<td>High</td>
</tr>
</tbody>
</table>

**Nitrogen (N) Fertility:** Nitrogen in the soil is the most important element for plant development. It is required in large amounts and must be added to the soil to avoid deficiency. Nitrogen always comes from fertiliser application and also from the air. Figure 59 shows the Nitrogen status of the soil in different districts of Gujarat.

The Nutrient Index shows the Junagadh, Amreli and Bhavnagar districts of Saurashtra region, Navsari, Bharuch and Surat districts of South region, Sabarkantha in North region are high in Nitrogen fertility (above 2.33). The Kutch region, Banaskantha and Mehsana of North Gujarat show medium fertility status (below 1.67) of N in their soils. The fertiliser consumption data also shows a lower intake of N fertilisers in these districts. Many districts show medium nitrogen fertility (1.67-2.33). So do Tapi in South Gujarat, Kheda, Panchmahals, and Vadodara in Central Gujarat, Patan and Gandhinagar districts in North Gujarat.

**Phosphorous (P) Fertility:** The phosphorous content in the soils of the state is of low class. The Mehsana district in North Gujarat shows medium fertility class. The former also has a nutrient index value of 1.79. The nutrient index value for the whole state is below 1.67. Figure 60 shows the Phosphorous status in the soil of the different districts of Gujarat.
Figure 59: Nitrogen status in Soil (2010-11)

![Nitrogen Status in Soil (2010-11)](image)

Source: IFFCO, Gandhi Nagar (2010-11)

Figure 60: Phosphorous status in Soil (2010-11)

![Phosphorus Status in Soil (2010-11)](image)

Source: IFFCO, Gandhi Nagar (2010-11)
**Potassium (K) Fertility:** Potassium is absorbed by plants in larger amounts than any other mineral element with the exception of nitrogen. The Nutrient Index calculated shows that potassium fertility ranges from medium to high class in all the districts of the state. Figure 61 shows the Potassium status in the soil of the different districts of Gujarat.

**Figure 61: Potassium status in Soil (2010-11)**
Table 11: Nutrient Index and Class for various Districts

<table>
<thead>
<tr>
<th>District</th>
<th>Nutrient Index (2010-11)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Rajkot</td>
<td>2.12</td>
</tr>
<tr>
<td>Patan</td>
<td>1.91</td>
</tr>
<tr>
<td>Junagadh</td>
<td>2.81</td>
</tr>
<tr>
<td>Kutch</td>
<td>1.52</td>
</tr>
<tr>
<td>Mehsana</td>
<td>1.65</td>
</tr>
<tr>
<td>Gandhinagar</td>
<td>1.97</td>
</tr>
<tr>
<td>Ahmadabad</td>
<td>1.37</td>
</tr>
<tr>
<td>Surendranagar</td>
<td>1.71</td>
</tr>
<tr>
<td>Amreli</td>
<td>2.72</td>
</tr>
<tr>
<td>Bhavnagar</td>
<td>2.91</td>
</tr>
<tr>
<td>Banaskantha</td>
<td>1.6</td>
</tr>
<tr>
<td>Sabarkantha</td>
<td>2.36</td>
</tr>
<tr>
<td>Bharuch</td>
<td>2.67</td>
</tr>
<tr>
<td>Tapi</td>
<td>2.08</td>
</tr>
<tr>
<td>Kheda</td>
<td>2.32</td>
</tr>
</tbody>
</table>
Table 12: Comparison of Nutrient Index for 1977, 1997, 2010-11

<table>
<thead>
<tr>
<th>Year</th>
<th>Nitrogen</th>
<th>Phosphorous</th>
<th>Potassium</th>
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<tbody>
<tr>
<td>1977</td>
<td>1.63</td>
<td>1.8</td>
<td>3</td>
</tr>
<tr>
<td>1997</td>
<td>1.71</td>
<td>1.64</td>
<td>2.6</td>
</tr>
<tr>
<td>2010-11</td>
<td>2.24</td>
<td>1.51</td>
<td>2.45</td>
</tr>
</tbody>
</table>


Table 11 shows the nutrient index and the different classes of soil health for the various districts of Gujarat in 2010-2011. Table 12 compares the nutrient index in the form of N, P, and K over the three time periods. This is an aggregate value for the whole state. Nitrogen fertility shows an increasing trend from medium to high class. Phosphorous and potassium show a decreasing trend on the other hand. Chemical fertiliser inputs were stepped up in order to attain self sufficiency in food grain production after the introduction of high yielding varieties of crops. The very commonly used fertilisers include nitrogen followed by phosphorous and potassium. Nitrogen fertilisers consumption is very high in Gujarat; it is the one major reason behind the rise in nitrogen levels.
2.2.3.2 Micronutrient status in the soil of Gujarat (Copper, Iron, Manganese, Zinc)

It is important to assess the present micronutrient status in the soils of Gujarat. This is because micronutrient deficiency has a direct impact on crop production and human health. About 48 percent of Indian soils are deficient in zinc, 11.2 percent in iron, 7 percent in copper and 5.1 percent in manganese (Gupta 2005).

Anand Agriculture University (n.d.) has carried out a comparative study on the soils of North and Central Gujarat. The study reveals that the North Gujarat soil is deficient in sulphur, zinc and iron compared to the soil in Central Gujarat. Sulphur deficiency has increased in middle as well as North Gujarat. Sulphur deficiency was 38 percent in 2001-2005 which increased to 55 percent in 2005-2010 while it increased from 33 percent (2001-2005) to 47 percent (2005-2010) in middle Gujarat. Zinc deficiency is high in the Saurashtra region ranging from 21 percent to more than 40 percent. Region-wise micronutrient deficiencies are given below. It is important to note that the entire state is copper deficient.

**Zinc**
Observations from Figure 62 show that in South Gujarat, Anand, Kheda and Dahod in Central Gujarat and Mehsana in North Gujarat are highly deficient in zinc content. Parts of central and North Gujarat have shown marginal deficiency in their soils. The Kutch district has shown low deficiency of zinc whereas Amreli and Bhavnagar has shown very low deficiency in Saurashtra.

**Magnesium**
It may be observed from Figure 63 that magnesium deficiency is very high in South Gujarat, Central Gujarat, Panchmahals, Kheda in Central Gujarat and Patan in North Gujarat are marginal deficient in magnesium. Ahmadabad in North Gujarat, Surendranagar in Saurashtra and Kutch have adequate amounts of magnesium in their soils.

**Iron**
As shown in Figure 64, South Gujarat, Central Gujarat and Kutch are high to marginally deficient in iron content in their soils. Banaskantha and Ahmadabad in Central Gujarat, Amreli and Bhavnagar in Saurashtra have adequate amounts of iron in its soils.
Figure 62: Zinc status in soil (2008)

Micronutrient (Zinc) Deficiency in Soil (2008)

Legend
- Very Low
- Low
- Marginal
- Adequate
- Moderately High

Source: Based on Micronutrient Fertility Mapping for Indian Soils, ICAR (2008)

Figure 63: Magnesium status in soil (2008)

Micronutrient (Magnesium) Deficiency in Soil (2008)

Legend
- Magnesium Deficiency
  - Marginal
  - Adequate
  - Moderately High
  - High

Source: Based on Micronutrient Fertility Mapping for Indian Soils, ICAR (2008)
2.2.4 Application of Agrochemicals

2.2.4.1 Pesticides
Agriculture in Gujarat is often faced with great risks from nature’s fury that include droughts, incessant and untimely rains, climatic changes, and unusually high temperatures during crucial periods. Yet the state has achieved about 9 percent growth in agriculture. The main factors contributing to the increase in agriculture production over the last few years are assured irrigation, high yielding varieties, agrochemicals (fertilisers and pesticides), credit facility, improved infrastructure etc.

Figure 65 shows pesticide consumption of the state during the previous decade. Total pesticide consumption was at around 4500 million tonnes in 2002-02, which drastically reduced to 2750 million tonnes in 2009-10. This shows an encouraging sign.
A study done by Anand Agricultural University (AAU) (n.d.) reveals that there has not been any impact on soil fertility as far as pesticides are concerned. Pesticides do not persist for a long time due to the climatic condition of the state. Also, the soil has become resilient to the pesticides. AAU surveyed 200 samples in the cotton and vegetable growing region of South Gujarat. While contamination was discovered in the samples but not to an alarming extent. Pesticide application often leads to the contamination of pesticide residue on vegetables, milk, spices etc. AAU has also carried out systematic monitoring on commodities. Some vegetables like cauliflower, cabbage, capsicum and spices like cummins are found with high quantities of pesticide residue.

2.2.4.2 Fertilisers
Fertilisers play a vital role in modern agriculture. The consumption of nutrients N, P, K has increased from 11071 tonnes (1960-61) to 1279924 tonnes (2005-06) (see figure 66). The government is also encouraging the use of fertilisers through subsidies. The fertiliser consumption in terms of nutrients (Nitrogen, Phosphorous, and Potassium) was the highest in 2005-06. Per hectare consumption of fertilizers was around 145 kg/hectares. There is a need to shift from chemical fertilisers to integrated micronutrient management to increase soil micronutrient as NPK level higher than the country’s average.
Figure 67 shows that the application of Nitrogen fertilisers in the total share of fertilisers varies between 60 and 70 percent. The nutrient value also shows that Nitrogen fertility has increased in the state from 1.63 in 1977 to 2.24 in 2010-11; this can be attributed to the application of nitrogen fertilisers. Thus, it is clear that a fertilizer input has improved the soil fertility status of the state.
2.3 AGRICULTURE

2.3.1 Trajectory of Agricultural Growth in Gujarat

Agriculture is a major user of land resource in Gujarat. In order to analyse how this aspect has been managed by the state, it is useful to examine agricultural share in state gross domestic product (SGDP). SGDP for Gujarat has been calculated at constant prices. The base year for calculating the SGDP in Gujarat is 2004-05. A comparison has been made between the SGDP share of agriculture and other sectors for Gujarat state. When sector-wise share in the SGDP was observed it was found that the agricultural sector’s share increased over the years in Gujarat from 24,802.6 cores (2005) to 30,917.5 cores (2010) (see Figure 68). Gujarat’s agriculture growth is flourishing in comparison to India but the other sectors in Gujarat i.e. industry and service sector’s contribution is much higher at around 2,46,980 cores (2010) to the GSDP of Gujarat.

Figure 68: Sectoral GSDP of Gujarat (at constant prices, base year: 2004-05)

Source: Centre for Monitoring Indian Economy (CMIE) 2012
Figure 69: Contribution of all sectors to GSDP in Gujarat, 1960-61 to 2009-10

Figure 70: Contribution of the Agricultural sector to SGDP (1960-61 to 2009-10)

Note: (P) stands for provisional; (Q) stands for quick estimate; (A) stands for advanced estimate

Figure 69 shows how the agricultural SGDP and the total SGDP of Gujarat have changed since 1960. Figure 70 shows the trend followed by the SGDP from agriculture (at constant
price). There has been a remarkable increase in the service sector and industrial sector contribution to the SGDP that overshadows the contribution of agriculture to the SGDP. Gujarat’s agriculture contributes significantly to the SGDP as compared to other states and has shown very high growth in the last 7–8 years (seen Figure 70). There have been times in which agricultural contribution to SGDP has been minimal; these have been mainly during the drought years of 1985-88 and 2000-01. Since 2001 the agricultural sector has contributed tremendously to the SGDP.

2.3.2 Agriculture Scenario in Gujarat- An Overview

Cropping systems of a region are determined by a number of parameters like soil type, temperature, rainfall, etc. Apart from these factors other factors like infrastructural facilities (irrigation, transport, storage facilities etc.), socio-economic factors and technological developments help to decide the cropping system of a particular region. Gujarat is divided into five regions namely South, Central, North, Saurashtra and Kutch. Seven agro climatic regions have been identified here on the basis of soil characteristics, temperature, and rainfall. These are South Gujarat (heavy rainfall area), South, Middle, North, South Saurashtra, North Saurashtra, North–West Arid (Kutch). Technological changes have favoured water intensive crops thus changing the cropping pattern of Gujarat since 1960s. These changes have favoured crops like cotton, rice, etc. at the cost of areas under pulses, oilseeds and coarse cereals. This shift could be attributed to the agro climatic conditions, technological changes, institutional changes and infrastructural changes associated with agriculture, which have taken place in recent years.

Gujarat has witnessed tremendous changes in cropping intensity in recent decades. These changes could possibly be attributed to the following factors – power supply, agricultural inputs like fertilisers, water supply (rainfall or irrigation) and the kind of cropping pattern adopted, which decides the duration of cropping activities during a particular crop year. Production of food grains in Gujarat have increased from 1.8 million tonnes in 1960-61 to 8.2 million tonnes in 2007-08 (76.9 percent increase has been observed from 1960-61 to 2007-08) (seen Figure 71), though there has been an only a small increase in net sown area since 1960. Gujarat accounts for about five percent of India but only about four percent of India’s total food production.
Figure 71: Production of Food Grains in Gujarat from 1960-61 to 2008-09

Production of food grains in Gujarat ('000' tonnes)

Sources: Directorate of Economics and Statistics (various reports)

Note: Production of food grains reduced in 2008-09 to 7.2 million tonnes (13.4 percent reduction has been observed from 2007-08 to 2008-09). Production data for the 1988-89 and 1990-91 is not available.

Animal husbandry is another important source of livelihood. In Gujarat, milk production having increased tremendously over the years. Figure 72 shows that milk production in 1983-84 was 30.93 lakh tonnes in Gujarat, which, increased to 88.43 lakh tonnes in 2009-10. This increased milk production has helped communities to diversify their livelihood options and improve their living standards.

Figure 72: Milk production in Gujarat from 1983-84 to 2009-10

Milk Production ('000' tonnes)

Source: Directorate of Animal Husbandry (2011)
2.3.3 Gross Irrigated Area to Gross Sown Area

Irrigation in Gujarat has seen an increasing trend in 23 districts this is to satisfy in agricultural demand and enhance productivity. Comparative analysis of figure 73 and figure 74 shows an increase in irrigation during the period of 1990-2005. There has been an increment of around 15 to 20 percent around Kheda, Surat, Tapi, Junagadh and Narmada. A drastic increase has been observed in the districts of Baruch (22.4 percent), Anand (26.6 percent) and Navsari (29.4 percent). Districts like Patan (-0.4 percent), Gandhinagar (-0.6 percent) and Valsad (-2.4 percent) have seen a minor decline in irrigation during this period as well.

Figure 73: Percentage of Gross Irrigated Area to Gross Sown Area (1990-91)
2.3.4 Net Irrigated Area in Gujarat to Net Sown Area

Gujarat’s net irrigated area has also seen an increasing trend in 22 districts to meet agricultural demands. There has been an increase of 15 to 20 percent of net irrigated area in Dahod, Narmada, Junagadh, Surat, Tapi and Kheda. The districts of Bharuch (21.4 percent), Navsari (34.7 percent) and Anand (48.6 percent) have witnessed a drastic increase in the net irrigated area. A decline has been observed, however, in the districts of Patan (-2.8 percent), Sabarkantha (-2.2 percent), and Gandhinagar (-9.9 percent). For district-wise details refer to Figure 75 and Figure 76.
Figure 75: Percentage of Net Irrigated Area to Net Sown Area (1990-91)

Figure 76: Percentage of Net Irrigated Area to Net Sown Area (2004-05)
2.3.5 Cropping Intensity and Cropping Pattern
Cropping intensity is one of the indices for assessing the efficiency of the crop in the agricultural sector. Cropping intensity is the ratio of gross area sown to the net area sown. Gross cropped area divided by the net cropped area is multiplied by 100 to give the percentage cropping intensity for all the districts. The level of cropping intensity generally moves in consonance with the behaviour of the monsoon and availability of irrigation water. Cropping intensity increased from 103.9 percent in 1960-61 to 115.4 percent in 2004-05. Cropping intensity dropped during the drought period of 2000-01 to 110.6 percent as shown in Figure 77. Figure 78 shows the cropping intensity map of Gujarat for 2006-07. Cropping intensity has been analysed by taking into consideration five-year intervals between 1990-01 and 2006-07.

Figure 77: Cropping Intensity in Gujarat from 1960-61 to 2004-05

![Graph showing cropping intensity from 1960-61 to 2004-05](image)

Source: Directorate of Economics and Statistics (various reports)

Figure 78: Cropping Intensity map of Gujarat (2006-07)

![Map showing cropping intensity in 2006-07](image)

Source: Based on data provided by Department of Agriculture, Gujarat
Cropping patterns for the major principal crops have been analysed from 1990s to 2008-09 on a decadal basis. The drivers responsible for contributing to the shift in cropping patterns include increased water availability due to increased irrigation. The crops included in the study are sugarcane, rice, jowar, lentil, groundnut, wheat cotton, mung, urad, maize, gram, castor, bajra, mustard, sesame, tobacco, chillies, potato, banana, cumin, onion, isabgul, mango, and chikoo. Data for the cropped area under these crops were taken for two decades i.e. 1990-91, 2000-01 and 2008-09. Figures 79, 80 and 81 show the variation of cropping patterns for the two decades from 1990-01 to 2008-09.

Figure 79: Cropping pattern in Gujarat (1990-91)
Figure 80: Cropping pattern in Gujarat (2000-01)

Figure 81: Cropping pattern in Gujarat (2008-09)
South Gujarat

In South Gujarat only a minor fluctuation has been observed in cropping patterns over the past two decades. Lentil cultivation increased, making it the second most dominant crop in the 1990s. Sugarcane, which was very scarcely grown in the previous decades, during this period, became the third most preferred crop of cultivation while rice remained the most dominant crop of the region. Cotton cultivation showed a decline from the 1980s till 2000. By 2000 cotton cultivation had reappeared as a preferred crop for cultivation and remained so in the following decade. Since 2000 the dominant crops for cultivation have been rice, followed by sugarcane and cotton. There has been a shift towards water intensive crops due to increased irrigation in the last decade (see Figure 83).

A fluctuating trend has been observed in the cropping intensity of South Gujarat. It increased tremendously from 100 percent in 2000-01 to 128 percent in 2004-05 (see Figure 82). This change could be due to the change in the percentage of net sown area and irrigated area which increased from 37 percent in 2000-01 to approximately 43 percent in 2004-05 (see Figure 85). A sudden decline in cropping intensity is observed in 2006-07 (91 percent) (see Figure 82). In Figure 84, The Dangs has shown tremendous increase in cropping intensity from 101 percent in 2000-01 to 223 percent in 2004-05. This increase could be attributed to increased percentage of net irrigated area to the percentage of net sown area.

Figure 82: Cropping Intensity in South Gujarat

![Cropping Intensity in South Gujarat](source: Directorate of Economics and Statistics (2009))
Figure 83: Net Irrigated area in South Gujarat

Source: Directorate of Agriculture (n.d.)

Figure 84: District wise cropping Intensity in South Gujarat

Source: Directorate of Economics and Statistics 2009; Directorate of Agriculture (n.d.)
Figure 85: District wise Net irrigated Area to the Percentage of Net Sown Area in South Gujarat

![District Wise Net Irrigate Area to the Percentage of Net Sown Area in south Gujarat](image)

Source: Directorate of Economics and Statistics 2009; Directorate of Agriculture (n.d.)

**Note:** Since Tapi was not formed till 2004-05, its statistics is combined with the statistics of Surat district with respect to the irrigated area. For analysing cropping patterns and cropping intensity, Tapi, Narmada and Navsari have been shown separately but with the same cropping pattern and intensity as in Surat, Bharuch and Valsad for the years before their formation.

**Central Gujarat**

In Central Gujarat the most dominant crop have been rice and cotton over two decades. An increase in maize cultivation was observed during the 1990s and 2000s. Since cotton cultivation took a plunge in 1990 maize replaced it as the preferred crop. During this period the favoured crops were rice, followed by bajara and maize. In 2000 the preferred crop for cultivation was rice followed by maize and cotton. In 2008 rice remained the most dominant crop with wheat being positioned as the preferred crop for cultivation followed by cotton.

Cropping intensity revealed a fluctuating trend from the 1990s to 2000s, by, first increasing from 117 percent in 1990-91 to 122 percent in 1995-96 and then decreasing to 114 percent in 2000-01. An increase of up to 128 percent, observed in 2004-05, remained rather constant in 2006-07 (see Figure 86.) Figure 87 indicates that the net irrigated area in Central Gujarat was 31 percent from observations in 1991; there has been a consistent increase in net irrigated area to 35 percent in 1995-96, which remained consistent till 2000-01. A further increase has been observed up to 46 percent in 2004-05. Therefore, this change in cropping intensity could be the result of change in net irrigation area. Observations from Figure 88 show Anand experienced a tremendous increase in cropping intensity from 127 percent in 2000-01 to 158 percent in 2004-05. This increase could be attributed to the increased percentage of net irrigated area. The latter has increased from 79 percent in 2000-01 to 98 percent in 2004-05, shown in figure 89.
Figure 86: Cropping Intensity in Central Gujarat

Cropping Intensity in Central Gujarat

Source: Directorate of Economics and Statistics (2009)

Figure 87: Net Irrigated Area in Central Gujarat

Net Irrigated Area In Central Gujarat

Source: Directorate of Agriculture (n.d.)
Figure 88: District-wise cropping intensity in Central Gujarat

![Cropping Intensity in Central Gujarat](image)

Source: Directorate of Economics and Statistics (2009)

Figure 89: District-wise Net Irrigated Area to Percentage of Net Sown Area in Central Gujarat

![Net Irrigated Area to the Percentage of Net Sown Area in Central Gujarat](image)

Source: Directorate of Agriculture (n.d.)

Note: For analysing cropping pattern and cropping intensity, Anand and Dahod have been shown separately but with the same cropping pattern and intensity as in Kheda and Panchmahals before 2000 as they were part of Kheda and Panchmahals before 2000.
North Gujarat
Water efficient crops have always been given preference in North Gujarat although cotton is a dominant crop in this region. During the 1990s a shift was observed in cropping patterns when castor followed by maize was the preferred crop. The dominance of castor as a preferred crop for cultivation continued into the next decade followed by cotton. In 2009 another shift was observed when castor lost out to cotton and bajara which became the favoured crop for cultivation followed by mustard.

From Figure 90 it is clear that cropping intensity in North Gujarat shows a fluctuating trend in 1990-1991; cropping intensity was at 126 percent after which, in the next decade, it increased to 130 percent. From 2000-01 onwards a declining trend was observed when cropping intensity went down to 126 percent and fell further in 2004-05 to 116 percent. A sharp increase in cropping pattern was observed in 2006-07 when it rose to nearly 131 percent. Figure 92 shows a district-wise distribution of cropping intensity with showing maximum cropping intensity in 2001 and 2006-07. The net irrigated area in Gujarat was on the rise since 1991 till 2001 after which a decline was observed; see Figure 91. There has been an overall fall in the net irrigated area in North Gujarat for all districts except Sabarkantha since 2001, in which period a slight increase was observed; refer to Figure 93 for district- wise percentage of net irrigated area.

**Figure 90: Cropping Intensity in North Gujarat**

![Cropping Intensity in North Gujarat](image)

Source: Directorate of Economics and Statistics (2009)
Figure 91: Net Irrigated Area in North Gujarat

Source: Directorate of Agriculture (n.d.)

Figure 92: District wise Cropping Intensity in North Gujarat

Source: Directorate of Economics and Statistics (2009)
Figure 93: District-wise Net Irrigated Area to Percentage of Net Sown Area in North Gujarat

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<thead>
<tr>
<th></th>
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</thead>
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<td>BANAS KANTHA</td>
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</tr>
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</tr>
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<td>30</td>
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</tr>
<tr>
<td>SABAR KANTHA</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>45</td>
</tr>
</tbody>
</table>

Source: Directorate of Agriculture (n.d.)

Note: For analysing the cropping pattern and cropping intensity in Patan, averaged out figures of Mehsana and Banaskantha have been taken together for the years prior to 2000-01 as Patan was formed out of the latter two districts in 2000.

Saurashtra
Groundnut remained as the dominant crop for the entire period while wheat and cotton started gaining more importance while the cultivation of bajara and jowar declined in various districts of Saurashtra in the 1990s. Another shift in cropping pattern was observed in the next decade, while groundnut remained the dominant crop cotton cultivation increased to become the second most favoured crop followed by bajara and seasum. Cropping patterns changed again in 2008-09 although groundnut and cotton remained the dominant crops. This period saw an escalation in wheat production. There has been a tremendous rise in cotton cultivation since the 1990s and if this continues groundnut, the most dominant crop, could lose out due to increased irrigation practices and for being a cash crop. It must be noted that Porbandar evinced 23 percent of the total gross cropped area under cumin while Bhavnagar had 5 percent of its total gross cropped area under onion cultivation during 2008-09.

Cropping intensity has been increasing in Saurashtra since 2000-01. It was at 104 percent in 2000-01 (drought year), 114 percent in 2004-05, and 123 percent in 2006-07; see Figure 94. Similar trends have been observed in the net irrigated area. Figure 95 shows that the net irrigated area was at 16 percent in 2000-01 and increased to 26 percent in 2004-05. This increase in the irrigated area could possibly be a reason for high cropping intensity. Also, better irrigation facilities along with other factors could possibly play an important role in determining the cropping pattern of a region. An increase in cropping intensity has been observed in the Junagadh district since 2000-01. It was 107 percent in 2000-01, 130 percent in 2004-05 and 147 percent in 2006-07 see Figure 96. This increase could be due to the increase in the net irrigated area, which increased from 35 percent in 2000-01 to 46 percent in 2004-05 as shown in Figure 97.
Figure 94: Cropping Intensity in Saurashtra

Cropping Intensity in Saurashtra

Source: Directorate of Economics and Statistics (2009)

Figure 95: Net Irrigated Area in Saurashtra

Net Irrigated Area in Saurashtra

Source: Directorate of Agriculture (n.d.)
Figure 96: District wise Cropping Intensity in Saurashtra

Figure 97: District-wise Net Irrigated Area to Percentage of Net Sown Area in Saurashtra
Note: While analysing cropping patterns and cropping intensity the same statistics as that of Junagadh have been used for the years prior to 1997. This is because Porbandar was formed out of Junagadh on 2nd October, 1997.

Kutch
Bajara in the Kutch region remained the most dominant crop from 1990 to 2000. Mung became the second most dominant crop in 1990. During this period jowar and cotton too, were the preferred crops of cultivation. In the 2000s the second most favoured crop for cultivation was the groundnut followed by mung. In 2009 there was a complete change in preference with bajara having lost its dominance and cotton gaining favour as the most cultivated crop followed by mung and groundnut.

Cropping intensity remained almost constant during 2000-01 and 2004-05 but increased in 2006-07. It was at 106 percent during 2000-01 and 2004-05 and went up to 111 percent in 2006-07. Figure 98 shows the changes in the cropping intensity of 15 years. The augmentation in cropping intensity since 1995 and the shift in cropping pattern could be supported by the fact that the percentage of net irrigated in Kutch increased in similar proportions. It was 9 percent in 1995-96 and 23 percent during 2000-01 and 2004-05 (see Figure 99).

Figure 98: Cropping Intensity in Kutch

Source: Directorate of Economics and Statistics (2009)
Cropping patterns have changed from the 1990s to 2008-09. During the 1990s, the entire state of Gujarat was classified into 15 crop regions on the basis of similar cropping patterns. In 1990-91, 18 crop regions were identified whereas in 2000-01, 19 crop regions were identified. In 2008-09, an increase in these crop regions was witnessed with the number going up to 23.

A major shift in the cropping pattern of Gujarat was observed, especially after 2000-01. In every region there have been certain shifts that need to be discussed. These shifts have been witnessed over a period of two decades i.e. 1990 to 2009. The worst drought occurred in 2000-01 covering over 92 percent of the total districts and affecting more than 5 percent of the total geographical area (TGA) (Center for Development Alternatives 2007) but a major shift in the cropping pattern was seen from 1990 to 2000 in almost every region. These shifts include:

- Narmada and Bharuch in South Gujarat shifted from lentil (1990) to cotton (2000-01)
- Bajra remained dominant in Central Gujarat in the 1990s whereas rice and cotton, two water intensive crops, took over in this region during 2000-01 and 2008-09.
- North Gujarat also witnessed a drastic shift to cotton and wheat in 2008-09.
- Groundnut, since the 1990s till date has been dominant in Saurashtra except in Surendranagar where cotton has always been cultivated. But a major shift was observed in the second most cultivated crop. Prior to 2000-01 bajra and jowar were the crops most cultivated after groundnut; but post 2000 cotton emerged as the second most cultivated crop in the region.
- Post 2000-01 Kutch also witnessed a major shift, its cropping pattern being dominated by two water intensive crops i.e. groundnut and cotton. In 2008-09, the net cropped area under cotton was the highest.
Per capita net sown area is on the decline; net sown area should be directly proportional to the population while ensuring food security and the agricultural contribution to GDP. If the net sown area declines, productivity is reduced. Therefore, it is essential that the per capita net sown area increase with the population. This trend is not seen in Gujarat. Efforts need to be made to increase per capita net sown area. Figure 100 shows the decline in per capita net sown area.
IMPACTS
3. IMPACTS

This chapter deals with the impacts of land pressures on environment, economy and the people of Gujarat. The chapter highlights land degradation and its impacts on ecosystem services, impacts of coastal salinity, mining, industrialisation, urbanisation and agricultural intensification.

3.1 LAND DEGRADATION AND ITS IMPACTS ON ECOSYSTEM SERVICES

Land degradation is a critical issue that adversely affects agronomic productivity. It has multiple and complex impacts on the local environment through a range of direct and indirect impacts on ecosystem functions and services. It also affects food security and quality of life. The following sections discuss the impacts of land degradation on various ecosystem functions and services.

There are two general categories of land degradation processes; one is the degradation by displacement of soil material caused by wind and water. The other type of degradation is the soil deterioration resulting from the accumulation of chemical substances like salts, loss of nutrients and also due to water logging. It has been reported that 68 percent of the total geographical area of Gujarat is under the process of land degradation, which is the highest percentage area in any state in the country has (Space Application Centre (SAC) 2007).

The Desertification and Land Degradation Atlas of India (2007) reveals that water erosion is the main cause of land degradation and desertification in Gujarat, accounting for 34.64 percent of the total land degradation and desertification. The whole of Saurashtra and south Kutch are affected by water erosion. In Saurashtra the terrain is undulating and the soil is loose. Prevalent agricultural practices and rainwater loosens the soil which gets washed away because of the sloppy terrain. Decreasing vegetation cover also contributes to the hastening of this process (Ajai 2009). This is followed by salinisation, in the same region, accounting for 14 percent of land degradation and desertification. Vegetal degradation (13.97 percent) has been witnessed in the Gulf of Kutch, Kambhat and The Dangs while wind erosion (2.77 percent) is causing erosion in Central and North Gujarat.

Table 13: Type and Area under process of Land Degradation

<table>
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<tr>
<th>Type of Land Degradation</th>
<th>Area under process of land Degradation/ Desertification (ha)</th>
</tr>
</thead>
<tbody>
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<td>Water Erosion</td>
<td>6790469</td>
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<tr>
<td>Vegetation Degradation</td>
<td>2737866</td>
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<tr>
<td>Wind Erosion</td>
<td>543322</td>
</tr>
<tr>
<td>Salinity Infestation</td>
<td>3294079</td>
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<tr>
<td>Rock</td>
<td>23521</td>
</tr>
<tr>
<td>Others</td>
<td>25951</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13415208</strong></td>
</tr>
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</table>


Soil erosion is one of the most destructive phenomena of land degradation. It results not only in the loss of water and plant nutrients but ultimately the soil itself is lost, which, in turn, affects crop productivity. Soil erosion is one of the most serious degradation problems faced
by the state. Fertility status of the soil may be reduced due to the loss of top soil. Water erosion affects 6.79 million ha of land, while wind erosion affects nearly 0.5 million ha of land. Bhumla and Khare (1988) estimated that 5.24 million ha area of Gujarat was under the influence of water erosion and 0.7 million ha of under the influence of wind erosion. The current (2007) value shows that the area affected by water erosion has increased whereas the area under wind erosion has decreased.

Improper crop rotations, extension of cultivation on lands of low capability/potential, unbalanced fertiliser use, non adoption of soil conservation practices, inadequate planning and management of irrigation resources and overdraft of groundwater exceeding recharge can all lead to soil erosion (Rao et al. n.d.).

In Gujarat, the second most dominating form of soil degradation has been recorded as salinity, which may be grouped under the salt-affected soils. Salts can have an adverse impact on agriculture as it makes land unsuitable for cultivation. So, the loss in productivity would be the major impact of soil degradation due to increase in salinity.

**Figure 101: Erosion affected area in Gujarat**

At micro level, owing to an undulating topography, coupled with loose and sandy to sandy-loam soil, the embankments of the 100-mile long river Mahi are highly susceptible to land degradation and erosion. The absence of vegetative cover has aggravated the situation, leading to the formation of deep gullies and ravines on common and private lands. Ravines not only impact the provisioning of ecosystem goods and services such as food, fuel wood, fibre, and water regulation (Foundation for Ecological Security 2006-2012).
3.1.1 Impacts on Provisioning Services of Ecosystem

Land resources play an important role in delivering key ecosystem services. Land provides the basic life supporting elements like food, water, and fodder. Land Degradation has an adverse impact on the ecosystem’s provisioning services. Soil erosion and nutrient depletion caused (directly) by inappropriate land management are often the main causes of decline in the ecosystem’s provisioning services. Nutrient loss lowers the fertility of the soil; it requires, therefore, more agriculture inputs which may further deteriorate the soil. An overall impact of this is the decline in crop productivity which can lead to food insecurity. Land degradation can threaten the food security of poor people in fragile environments, particularly those whose livelihoods rely largely on agricultural activities.

The impact of land degradation and desertification includes a reduction in crop and pasture productivity and fuel wood and non-timber forest products, which are closely linked to poverty and food insecurity. The damage to soil, loss of habitat, water shortage, and siltation reduce biodiversity and ecosystem services and has economic consequences (Kenya Land use Alliance n.d.). Land degradation also affects water resources reducing water availability and quality. Potential impacts include flooding; silting of reservoirs and estuaries, groundwater depletion, salt water intrusion into aquifers, pollution of water, and salinisation.

Gujarat is witnessing high levels of salinity affecting approximately 1048 villages in an area of about 35000 km. The groundwater in such area is non potable. Its 66 percent of the land area is found to be unsuitable for groundwater development. This salinity issues is faced by coastal areas of Saurashtra (between Una and Madhavpur) and Kutch among the others. The Groundwater in Saurashtra is found not suitable for irrigation. Similar phenomena are in the North Gujarat region (GIDB 2006). Sardar Sarovar Project (SSP) on Narmada River was planned to address many of these issues as the water from Narmada is high in quality and is supposedly one of the purest. Various programmes and schemes based on SSP are already providing better quality drinking water in many parts of the state. Once completed it is expected that several diseases due to Fluoride and Nitrate in Porbandar or Amreli districts can be mitigated forever. Availability of Narmada water will also reduce the setting and operating costs of de-salinisation plants in the coastal regions.

3.1.2 Impacts on Regulating and Cultural Services of Ecosystems

Soils play a key role in climate regulation, water supply, and water purification. Land degradation in the form of water and wind-driven soil erosion changes the soil structure and can have a negative impact on the cycling of nutrients, particularly those that are soluble or in some other way mobile e.g. nitrogen. Water regulation is regarded as another important service of forests and other natural vegetation. Recent reviews of global evidence show, however, that flooding is more often associated with inappropriate land use practices rather than deforestation per se (Global Environment Facility 2006). Climate change is the global impact that has received due attention, both in terms of its presumed seriousness and in the scope and breadth of scientific enquiry addressing it. Land degradation contributes to climate change through two main processes: the production of green-house gases (GHGs) and direct contribution of dust to the atmosphere. Deforestation and forest degradation lead to reduced carbon fixation. These processes also often catalyse other land degradation processes such as erosion and leaching (Global Environment Facility 2006). Long-term good health relies on continued stability and functioning of the ecosystem (Collins 2001). Many possible impacts of land degradation on human health are indirect, mediated through impacts on climate, biodiversity, hydrological systems, agriculture etc. However, there is not much of documented study on the regulating and cultural services of land ecosystem in Gujarat.
3.2 IMPACTS OF COASTAL SALINITY

In this section we discuss the impacts of coastal salinity on soil salinisation, agriculture, animal husbandry, drinking water and health, and fisheries.

3.2.1 Soil Salinity
Salinity in soil occurs due to two major causes- inherent salinity and manmade salinity. A report prepared by the Coastal Salinity Prevention Cell (2012), estimates that Gujarat accounts for 1.2 million hectares of saline soil in coastal areas. The report (ibid) also says, “Gujarat comes next only to West Bengal in the total extent of coastal salt affected soils. It comes to 59 percent of the reported salt affected area in the state and 21 percent of total coastal saline soil of the country.”

Salinity in coastal area is a widespread problem caused by individual or combined effects of inherent salinity, tidal effect, irrigation by saltwater and by seawater intrusion due to extensive withdrawal of water. Salinity ingress could be caused by natural as well as human activities. Natural factors contributing to salinity are saline winds and flat topography. Human activities contribute to the salinity increase in a major way through groundwater exploitation for agricultural purposes, rapid growth of industrialisation via deforestation, pollution and exploitation of precious groundwater. Various kinds of saline and alkaline lands of Gujarat are shown in figure 102.

Figure 102: Saline and Alkaline Lands in Gujarat
### Table 14: Total Area affected by soil salinity in Saurashtra and Kutch regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Affected Area (ha)</th>
<th>Length (km)</th>
<th>Villages affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhavnagar-Una</td>
<td>1,40,000</td>
<td>180</td>
<td>166</td>
</tr>
<tr>
<td>Una-Madhavpur</td>
<td>1,00,000</td>
<td>160</td>
<td>120</td>
</tr>
<tr>
<td>Madhavpur-Maliya-Miyana</td>
<td>4,60,120</td>
<td>425</td>
<td>574</td>
</tr>
<tr>
<td>Kutch</td>
<td>3,65,200</td>
<td>360</td>
<td>245</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10,65,320</strong></td>
<td><strong>1125</strong></td>
<td><strong>1105</strong></td>
</tr>
</tbody>
</table>

Source: Coastal Salinity Prevention Cell (2010-11)

Inland salt affecting soils is emerging as a new threat. The salinity problem is starting to occur in the mainland, away from the coastal belt and not contributed due to sea water intrusion. It can be either natural salinisation or secondary salinisation which occurs widely in the irrigated belt. The causes for inland salinity may be aridity, topography, basic poor parent material, poor drainage, over irrigation, poor quality of water, etc. Similarly rise in water table as a consequence of canal irrigation and poor drainage is major factors for salinity of certain areas of Gujarat. About 15-16 percent area in the Mahi command in Central Gujarat is affected by water logging due to rise in the water table (CSPC 2012).

### Table 15: Area Affected by Sea-Water in Coastal Saurashtra

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamnagar</td>
<td>Kambhaliya</td>
<td>7420</td>
<td>23410</td>
<td>25993</td>
<td>20938</td>
</tr>
<tr>
<td></td>
<td>Lalpur</td>
<td>1690</td>
<td>4181</td>
<td>1845</td>
<td>2438</td>
</tr>
<tr>
<td></td>
<td>Jamnagar</td>
<td>1170</td>
<td>25998</td>
<td>25975</td>
<td>19562</td>
</tr>
<tr>
<td></td>
<td>Jodiya</td>
<td>47250</td>
<td>47383</td>
<td>57400</td>
<td>43375</td>
</tr>
<tr>
<td></td>
<td>Kalyanpur</td>
<td>57880</td>
<td>63150</td>
<td>63982</td>
<td>57620</td>
</tr>
<tr>
<td></td>
<td>Okhamandal</td>
<td>67510</td>
<td>62460</td>
<td>61877</td>
<td>56054</td>
</tr>
<tr>
<td></td>
<td><strong>Sub Total</strong></td>
<td><strong>192920</strong></td>
<td><strong>226582</strong></td>
<td><strong>237072</strong></td>
<td><strong>199987</strong></td>
</tr>
<tr>
<td>Rajkot</td>
<td>Maliya</td>
<td>77000</td>
<td>77000</td>
<td>77000</td>
<td>77000</td>
</tr>
<tr>
<td></td>
<td>Morbi</td>
<td>6840</td>
<td>6840</td>
<td>6840</td>
<td>6840</td>
</tr>
<tr>
<td></td>
<td><strong>Sub Total</strong></td>
<td><strong>83840</strong></td>
<td><strong>83840</strong></td>
<td><strong>83840</strong></td>
<td><strong>83840</strong></td>
</tr>
<tr>
<td>Junagadh</td>
<td>Mangrol</td>
<td>8800</td>
<td>8800</td>
<td>8800</td>
<td>8800</td>
</tr>
<tr>
<td></td>
<td>Una</td>
<td>1295</td>
<td>10781</td>
<td>11554</td>
<td>13959</td>
</tr>
<tr>
<td></td>
<td><strong>Sub Total</strong></td>
<td><strong>10095</strong></td>
<td><strong>19581</strong></td>
<td><strong>20354</strong></td>
<td><strong>22759</strong></td>
</tr>
<tr>
<td>Porbandar</td>
<td>Kutiyana</td>
<td>6200</td>
<td>6200</td>
<td>6200</td>
<td>6200</td>
</tr>
<tr>
<td></td>
<td>Ranavav</td>
<td>2410</td>
<td>3310</td>
<td>3999</td>
<td>684</td>
</tr>
<tr>
<td></td>
<td>Porbandar</td>
<td>66450</td>
<td>72310</td>
<td>71576</td>
<td>57196</td>
</tr>
<tr>
<td></td>
<td><strong>Sub Total</strong></td>
<td><strong>75060</strong></td>
<td><strong>81820</strong></td>
<td><strong>81775</strong></td>
<td><strong>64080</strong></td>
</tr>
<tr>
<td>Bhavnagar</td>
<td>Bhavnagar</td>
<td>467</td>
<td>498</td>
<td>1016</td>
<td>2109</td>
</tr>
<tr>
<td></td>
<td>Talaja</td>
<td>475</td>
<td>2570</td>
<td>3745</td>
<td>5019</td>
</tr>
<tr>
<td></td>
<td>Mahuva</td>
<td>542</td>
<td>6673</td>
<td>11115</td>
<td>11999</td>
</tr>
<tr>
<td></td>
<td><strong>Sub Total</strong></td>
<td><strong>1484</strong></td>
<td><strong>9741</strong></td>
<td><strong>15876</strong></td>
<td><strong>19127</strong></td>
</tr>
<tr>
<td>Amreli</td>
<td>Rajula</td>
<td>357</td>
<td>2450</td>
<td>4203</td>
<td>5750</td>
</tr>
<tr>
<td></td>
<td>Jafrrabad</td>
<td>480</td>
<td>309</td>
<td>1544</td>
<td>2485</td>
</tr>
<tr>
<td></td>
<td><strong>Sub Total</strong></td>
<td><strong>837</strong></td>
<td><strong>2759</strong></td>
<td><strong>5747</strong></td>
<td><strong>8235</strong></td>
</tr>
<tr>
<td><strong>Total for 6 Districts</strong></td>
<td><strong>535552</strong></td>
<td><strong>622064</strong></td>
<td><strong>652256</strong></td>
<td><strong>596069</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Salinity Ingress Prevention Cell (SIPC) 2012
It has been observed that due to the unavailability of surface water and erratic rainfall, the farmers of the Banaskantha and Kutch districts used saline groundwater for irrigation. The severity increased with the withdrawal from the deeper aquifers since the salinity of groundwater is seen to increase with the depth in this region.

3.2.2 Impacts on Agriculture

The baseline study carried out by Coastal Salinity Prevention Cell says that agriculture is affected in the highest number of villages due to salinity within the five kilometres distance from the coastline areas. Increase in salinity can reduce crop productivity and affect the quality of agriculture produce. Also, the use of saline water can turn soil saline. In Saurashtra and Kutch, reduction of area under horticulture, pulses, and groundnut crops has been observed. Farmers with mango orchards are facing a major challenge to their plantation since irrigating mango orchards with saline water affects the production in terms of quality as well as quantity. The horticulture crops of mango and coconut are giving way to chickoo, sitafal and pomegranate plantations in the coastal areas of Junagadh. An increase in the level of salinity in water and soil has led to drastic changes in the cropping pattern. The cropped area of pulses has reduced in coastal areas. Groundnut, one of the major crops, is losing its acreage to cotton which is known for its salt tolerance capacity (Coastal Salinity Prevention Cell 2008).

Since cotton, castor and wheat are salt tolerance crops, farmers have been growing these crops abundantly in certain patches. Saline water is being used to irrigate these areas causing salinity to go up in soils. Salinity is one of the major reasons for change in cropping patterns in the coastal villages. The change in cropping pattern is also observed in the coastal region of the state. Crop change due to salinity is taking place in 46 villages out of the 255 villages studied in Kutch and 154 villages out of the 297 villages studied in the Junagadh district in Saurashtra. These villages are equally spread across all distance categories from the coastline (Coastal Salinity Prevention Cell 2008).

Groundwater irrigation intensification has led to salt water intrusion in coastal areas leaving the farmers with no options but to use this saline water for irrigation. Soil structure and salt balance of the soil are affected by the usage of saline water (Khanna 1996). Poor soil quality (saline soil) and a decreased water table have resulted in reduced natural vegetation. Extent of mixing of seawater with local groundwater also increased and it was evident from the increased ratio of chloride/carbonate, bicarbonate towards the sea coast. This has resulted into decrease in the yields as well as the quality of local cash crops. About 10 million people living in approximately 1500 villages are affected due to salinity ingress (Coastal Salinity Prevention Cell 2010).

The inland intrusion of sea water was observed up to a distance of 5.0 - 7.5 km. from the coast in 1977 whereas it was 2.5 - 4.5 km from the coast in 1971. However salinity ingress in certain areas has reduced considerably due to corrective measures taken by the government, NGOs, communities and favorable rainfall intensity during last decade. Table No.16 given below shows significant reduction in the extent of salinity ingress in five HLC-1 talukas of coastal Saurashtra. Management of water resources is one of the most important efforts taken up towards tackling the coastal salinity especially promotion of water efficient technologies to manage the demand in agriculture. This can probably be attributed to large scale creation of rain water harvesting structures as part of drainage treatment of watersheds and to the unusually high rainfall witnessed by this region during last decade.
Table 16: Extent of Salinity Ingress in HLC-I Talukas

<table>
<thead>
<tr>
<th>Taluka</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangrol</td>
<td>6</td>
<td>8.25</td>
<td>5.27</td>
</tr>
<tr>
<td>Malia (H)</td>
<td>4.75</td>
<td>6.87</td>
<td>5.7</td>
</tr>
<tr>
<td>Veraval</td>
<td>7.5</td>
<td>9.37</td>
<td>3.69</td>
</tr>
<tr>
<td>Kodinar</td>
<td>9.6</td>
<td>6.83</td>
<td>5.21</td>
</tr>
<tr>
<td>Una</td>
<td>7.2</td>
<td>7.75</td>
<td>5.42</td>
</tr>
</tbody>
</table>

Source: Salinity Ingress Prevention Cell (SIPC) 2012

3.2.3 Impacts on Animal Husbandry
Animal husbandry is a part of farming activity in Saurashtra and Kutch. Due to the salinity ingress it has been facing larger consequences. Increased salinity has affected the health of the animals that have been consuming salt through fodder and water. Drinking water for animals is a major constraint in the coastal area. Salinity ingress has reduced fodder availability for the animals. Common land where grass was grown has become saline. Consuming saline grass and water deteriorates the health of animals. The major animal diseases are related to the kidney and digestive system.

Poor health of animals has been reported due to consumption of saline fodder and water (Coastal Salinity Prevention Cell 2008). In many villages people have reported early death of animals owing to the same reason. The average life of milch animals has been reducing in the area compared to animals in non-saline villages. The farmers have reported that animals yielding 15-20 litres’ milk in North Gujarat produce less than 10 litres’ milk per day in coastal villages. Due to salinity the livestock rearers are concentrating on small animals in Saurashtra and Kutch regions (ibid).

Although dairy as an economic activity in the state of Gujarat has been on the rise during last two decades, animal husbandry as a source of livelihood is getting reduced in the coastal villages. The most dependent indicator is the reduction in number of Maldhari families and in the number of animals they reared (Coastal Salinity Prevention Cell 2008). Probably adoption and capacity building in improved animal husbandry practices are need of the hour. Recent initiatives of the government for the better health of its cattle and milch animals will also help in this process.

3.2.4 Impact on Drinking Water and Health
Drinking water availability is a chronic problem affecting the entire coastal area in Kutch and Saurashtra, which can further lead to various diseases. The occurrence of diseases like kidney stone, fluorosis, skin and gastric diseases are common in this area due to the consumption of poor quality drinking water and use of saline water. Gujarat state has attempted to mitigate these problems through 332 km long Sujalam-Sufalam Yojana and a state wide drinking water supply grid based on Narmada waters from Sardar Sarovar Dam.

The study conducted by Coastal Salinity Prevention Cell in Bhavnagar district shows that 129 villages, out of the 194 surveyed, have reported kidney stone cases. The second most
prevailing disease in the study area is skin problem which has been reported in 44 percent cases of the total villages covered.

3.2.5 Impact on Fisheries
A greater number of people are involved in fishing activities in the coastal region. Industrial development on the coast has resulted in the cutting of mangrove forest and increased shipping activity on the ports, which has led to increased salinity in many parts of the region. The change in natural conditions on the coastal area has reduced the fish catch.

In a study of the coast of Khambat, several remote villages are characterised by vast stretches of saline mudflats. Here, severe salinity ingress renders water below the depth of 25 feet completely unsuitable for drinking. The TDS (total dissolved solutes) and chlorine have increased in the groundwater over a period of 25 years in the Saurashtra and Kutch regions. The TDS has increased from 500 to 5040 ppm and chloride from 176 to 2320 ppm (FES 2010). Kalpsar project which envisages creation of a sweet water lake in Bay of Khamabhat is one of the ambitious projects of state government. Once completed as planned, it is supposed to be the biggest sweet water lake in the world. It is expected to mitigate the salinity issues in this region permanently.

3.3 Impacts of Mining
Land faces the major consequences of mining. The impacts that may be imposed by mining include loss of agricultural land, loss of biodiversity due to forest land conversion, livelihood loss due to displacement, and the loss or degradation of local water resources. The impacts of mining on land during its operational phase include loss of agricultural productivity, depletion of groundwater, siltation of rivers, etc. Post operational impacts can be reduced by taking certain reclamation measures.

3.3.1 Land Degradation due to Mining
Mining invariably causes enormous land disturbances e.g. large scale excavation, removal of top soil, dumping of solid wastes, cutting of roads, etc. Opencast mining has more potential impact on land than underground mining. Improved technology opencast coal mining is being used extensively because of its cost effectiveness even though it leads to large-scale land disturbances. Underground mining has considerably less impact on land compared to surface mining. But in this case, there is risk of land subsidence.

The excavation of minerals is always accompanied by waste generation. The higher the waste generation the greater would be the land required for its disposal. The waste material or overburdens generated from mining have a high potential regarding changing the physical and chemical characteristics of soil. Some mineral overburdens may release salts, heavy metals and radioactive pollutants, which easily leach out and contaminate the land and water resources.

Production of limestone has seen a significant increase post 2000 in the Kutch region. Production of limestone in Kutch has been increasing at a 15 percent since 1995 till 2002 (GIDB 2005). The similar trend continuous for the entire state as production for the state has been increasing between 2005 and 2010 (Soci-economic review 2012). Land degradation is one of the significant impacts arising out of mining and quarrying which is mainly in the form of alteration of land structure due to excavation, stacking of top soil and loss of land due to dumping of mine waste and soil overburden. Stone and sand quarrying causes damage to
3.3.2 Biodiversity loss
Mining activities have a direct impact on biodiversity loss. Mining and quarrying (whether open cast or underground) destroys the landscape and forest ecosystem. The waste materials that remain after the extraction are dumped on the surrounding land, thus causing loss of top soils, nutrients and supportive micro and macro flora. As per section 3 (v) of the Environment (protection) act and rule 5 sub rule (viii) and (x) of the environment protection rules land falling within 10 km of boundaries of national parks and sanctuaries are considered as eco-fragile zones. There have been reports pointing out the operational mining units within ten km radius of Gir Protected Area (Kamboj et al. 1997; CAG 2009). The Central Empowered Committee (CEC) recommended keeping safety zones (eco-sensitive zones) around wildlife sanctuaries and national parks to two km to 100 metres from the national park's boundary. However, this matter is sub judice.

3.3.3 Increases in Salinity
The coastal region of Gujarat stretching from Kutch to the district of Bhavnagar contains large deposits of limestone, which are geologically known as miliolite. These stones act as barriers between seawater and the underground sweet water of the land. 79 percent of Gujarat’s limestone as of 2002 comes from the Saurashtra belt (Amreli – Jamnagar – Junagadh) (GIDB 2005). Further these areas are affected by salinity. Continuous removal of limestone from these coastal zones can have detrimental effect salinity ingress and further degrade land resources. In order to mitigate salinity ingress, a band of limestone should be left unaltered along to coast in the process of its mining.

3.3.4 Water Pollution
Water Pollution is a major concern in open cast mining operations. Spill over/ leakage of effluents containing toxic chemicals or discharge of leachate from mine waste, surface run off from overburden dump during rains, result in degradation of water quality. The degradation is mainly due to the contamination of water with heavy metals/ toxic chemicals or siltation. In the areas where sulphides are present in the ore, water interacts and forms acid mine drainage which has low pH and contains high levels of sulphides, iron, and total dissolved solutes. These deplete the oxygen level in water, increase toxicity by rendering heavy metals, sulphides and fluorides soluble, and create corrosion problems. Effective reclamation measures must be followed to reduce water pollution.

3.3.5 Health
Mining and quarrying can severely affect the human health. Studies have shown that stone quarrying and crushing cause silicosis, exposure to iron ore dust may cause pneumoniosis, and respiratory problems among workers of lime stone quarries.

Mining activity results in enormous noise and vibrations in surrounding areas, which constitutes a source of disturbance. Drilling, explosion etc. are the major sources of noise and vibrations in and around the mining complexes which could lead to noise-induced hearing loss. In addition, it can produce other health effects and influence work performance. Flora and fauna also get affected by noise if mining is done in nearby forest areas, because wildlife is more sensitive to noise and vibrations than human beings.
3.3.6 Impacts on livelihoods
Soil scaling due to crust formation and temporary water logging, shallow depth of soil and high permeability leads to degradation of soil. In Gujarat, about 26.40 million hectares of soil is shallow, 13.75 million hectares of soil has high permeability, 10.25 million hectares of soil is affected by surface crusting and 6.24 million hectares of soil is affected by temporary water logging (SAARC Agriculture Centre 2011). This deterioration in physical, chemical, and biological functions of the soil due to compaction and scaling adversely affects the productivity of agricultural crops thus, affecting the livelihood of the farmers especially the small and marginal farmers (SAARC Agriculture Centre 2011).

3.4 Impacts of Industrialisation
The final report of a study on development potential of Kutch makes a specific mention that “industries and construction activities in region may have adverse impact on environment and ecology of the region, which can be checked and minimised through adoption of environmental management plans and procedures. Particularly, region’s depleted water resources, wild and marine life, rich traditional culture, grasslands and other environmentally sensitive aspects are important dimensions to consider in such plans” (Gujarat Infrastructure Development Board (GIDB) 2005). Although, there is such an emphasis on environmental concerns what is required is internalisation of suitable measures while implementing policies.

3.4.1 Pollution impacts
Responses are discussed in the next chapter of this report these discussions on the adverse impacts of rapid industrialisation in Gujarat are no way to suggest that governments’ efforts towards industrial growth per se are misplaced. This is to highlight the negative outcomes which are part and parcel of industry driven economic growth. This is also to point out the need for commensurate measures to first mitigate and then adopt an approach which facilitates economic growth along with sustainable land management in the state. Such an approach can have extensive engagement with local populations which will help in reducing apprehensions, speculations on one hand and it can also help in building strong government–people partnership for development in the state.

The rapid industrial growth in the state has created tremendous pressure on land resources which are required to be converted into non-agricultural land, particularly in the fringe areas of the urban centres and in the neighbourhood of industrial estates. Another dimension is the industrial pollution. The toxic effluents from industries are causing damage to crops and neighbouring land resources (Iyenger 2003). Tenth Five Year Plan of the Government of India points out that relatively more industrialised states like Gujarat, Maharashtra, Tamil Nadu and Andhra Pradesh face problems relating to toxic and hazardous wastes which include sludge contaminated with heavy metals, wastes from paints, dyes and organic chemical units and highly acidic and alkaline wastes (GoI 2002). Industries in Gujarat have been classified into Red, Orange and Green, based on the total quantity and characteristics of different types of hazardous wastes generated, and type of production in industrial units. These are the followings

- Red - highly polluting industries
- Orange - moderately polluting industries
- Green – non polluting industries
There are 16,770 (Red Category) industrial units registered under highly polluting industry category in Gujarat, which has increased by more than three times during 2006 and 2012 (see Table 17). Similarly the Orange category industrial units have also increased three fold during the same period. Green category of industries has increased from merely 828 units in 2006-07 to 4654 units in 2011-12 indicating more than five times increase in a period of five years duration, showing a positive sign of green development trajectory. Examples of industrial pollution are observed along the 400 km stretch between Ahmadabad in Central Gujarat to Vapi in the southern part of the state, though efforts are being made to reduced pollution. This area is dotted with hundreds of small and medium factories that manufacture chemicals, dyes, paints, fertilisers, plastic, pulp, and paper. Untreated waste from these factories is the main cause for the pollution of air, water, farmland in the vicinity of these industrial units. The Gujarat Pollution Control Board has taken up many initiatives to treat effluents from industries.

Six areas namely - Ankleshwar, Vapi, Ahmadabad, Vatva, Bhavnagar and Junagadh are identified as critically polluted (GPCB 2010; Chhokar, Pandya and Raghunathan 2004). Ankleshwar, a hub of chemical industries, is located on the Narmada estuary. Gujarat’s 1600 km long coastline provides a great opportunity for port-based development planning along the coastline but that also means a greater risk to the ecosystems along the cost (Chhokar, Pandya and Raghunathan 2004; The Indian People's Tribunal 1999). In Nandesari village of Vadodara district, almost 220 hectares of fertile agricultural land has been converted into a chemical industrial estate (ibid). The coastal regions of Kutch and Saurashtra have witnessed the establishment of mega cement plants and giant refineries which may have implications for the protected marine national park in the Gulf of Kutch (GIDB 2005).

Although, Gujarat Industrial Policy - 2000 warrants strict implementation of pollution control and environmental protection measures for safeguarding nature and natural resources there is a need for greater emphasis on the internalisation of the adverse impacts of industrial development (Vyas n.d.). Vyas (n.d.) in her report of EIA on industrial activity in Vapi-Vadodara industrial corridor found that out of the 16 talukas chronically affected by heavy metal contamination of groundwater, 12 talukas fall in this region of the state. The changing economy has also shown indirect impacts on the environmental conditions and had also brought about changes in the socio-economic profile and the settlement patterns in the belt.

### 3.4.2 Ecological disturbances

The Gulf of Kutch is one of the few coastal zones in the world blessed with rich biodiversity. It comprises mangroves, coral reefs, biota of the mudflats, seaweeds, commercial fishes etc. The mangroves of the gulf are the second largest after the Sunderbans in the mainland of India. Destruction of any of the above components of the fragile ecosystem will disrupt it
entirely. Mangroves help the ecosystem by contributing to the oxygen budget and in soil conservation.

3.4.3 Water Security
Industrial agglomerations are likely to have implications on water security if sustainable uses of water resources are not practiced to satisfy the needs of both industry and population supporting these industries. There are three kinds of potential impacts that SEZ/ SIR can have on access to water for the people in the concerned area: i) Diversion of water for various purposes within the area can lead to the water insecurity; ii) Effluents released from the area due to industrial activity can have severe impact on water bodies present in the area if treatment plants are not in place; iii) Conversion of land to SEZ would mean destruction of groundwater recharge systems (Soundarapandian 2012).

3.4.4 Loss of Pastureland
The land required for industrialisation usually comes from lands classified as wastelands which at times also include gauchar lands, i.e. pasturelands. Pasturelands are essentially for the sustainable livelihoods based on animal husbandry. Earlier all gauchar lands were brought under forest department for plantations and by late 1990s there were plans to provide such lands for industrial development where feasible (Iyenger 2003). For every 100 animals, 16 hectares of gauchar land should be available whereas at present, 424 villages in Gujarat do not have any gauchar land. According to Bharwada and Mahajan (2010) there is a shortage of gauchars (pasturelands) in Gujarat. According to their estimates gauchars in Gujarat have decreased by almost 18 percent since 1960 to 2003 although there seems to be a marginal increase in the gauchar lands since then.

Rakhal in Kutch, vidi in Saurashtra covering seven districts, and gauchar jamin in Central Gujarat are some of the traditional practices with respect to pastureland in Gujarat. There is a decline of 1,89,600 ha of pasturelands from 1960-2007 (Agriculture and Co-operation Department (2012) and Directorate of Economics and Statistics (n.d.)). Several scholars have shown deep concerns over deficit of pasturelands for the rising livestock population (Ganguly 2011; Bharwada & Mahajan 2010; Iyenger 2004; Iyenger 2003). There is a need to either increase pastureland or plan proper stall feeding based on fodder cultivation for the large livestock population base available in the state. Though there is a deficit in pasturelands, the state has taken measures to ensure fodder development to meet the deficit. Programmes include development of Banni grasslands in Kutch and Gujarat livestock development board has proposed a model for fodder production and seed production.

3.4.5 Impacts on livelihoods
Industrialisation could also have a impacts on fishing communities of the coastal region. The entire coast of Gujarat has been either industrialised which, is a mixed bag in terms of new employment opportunities for the local communities with pitfalls of adverse impacts on their traditional vocation of fishing. Industrial activity on the coast blocks the access of fishermen to the sea (Rodriguez & Sridhar 2010). Another dimension is the pollution of sea waters which has the potential to affect the fishing community of the state adversely. It may lead to a decrease in fish catch.

3.5 IMPACTS OF URBANISATION
Gujarat has witnessed rapid urbanisation over the last few decades with implications on land. This usually gets manifested through urban sprawl, ribbon development, unregulated development, and often improper disposal of urban and industrial waste. Increasing urbanisation has led to a situation in which more and more agricultural areas are being converted for urban use (Shivramakrishnan & Singh n.d.).

Domestic and industrial waste will continue to increase with the increase in population and urbanisation. The per capita domestic solid waste generated in cities is 0.451 kg/per day. Gujarat is the third highest producer of solid waste in India. The entire solid waste generated in Gujarat does not have scientific transport, disposal and treatment facilities. The seven municipal corporations have taken up initiatives to ensure proper disposal and treatment of wastes. Disposal of solid waste is mostly done on land in an unscientific manner. Disposal of solid waste on land causes soil contamination and further leaching of toxins in soils has the potential to contaminate groundwater and surface water bodies as well. Domestic sewage disposal is also a major issue in the state. According to a study by the Gujarat Urban Development Company (2010), shows that local bodies are not provided with sufficient sewerage treatment facilities. At the best sewerage disposed of in a few oxidation ponds and some STPs and CETPs. Figure 103 shows the sewage treatment facilities in some local bodies. The present location of disposal of untreated sewage waste takes place mainly in surface water bodies and on land. Figure 104 shows the discharge pathways of sewage waste. Improper treatment and disposal of waste can cause severe implication as it causes immediate degradation of land resources. It is the smaller urban centres which are facing major problems in terms treatment of domestic wastes.

**Figure 103: Sewage treatment facility – local body wise**
3.6 IMPACTS OF MODERN AGRICULTURE

The shift in cropping patterns towards modern agricultural practices in the short run may lead to better production. Modern agricultural practices exhibited by intensification and specialisation have stimulated economic development of the small and marginal farmers. Irrigation development and market connectivity has supported cash crop cultivation and has encouraged horticulture. This has enabled farms to practices monoculture thereby enhancing economic returns. Apart from improving the economic conditions of the people, modern agriculture it also further increased soil nutrient mining due to the excessive usage of chemical fertilisers and not allowing lands to fallow. Monocultures, which have the same nutritional demands, deplete micronutrients in the soil over a prolonged cultivation period.

3.6.1 Impacts of Intensive Agriculture led Irrigation

The amount of water used per unit of land has increased due to increased cropping intensity. The shift in cropping pattern towards water intensive, value-added crops has further raised the demand for irrigation water which has ultimately resulted in the increased rate of withdrawal of groundwater. Irrigated area by groundwater sources has increased from 1930100 hectares in 1990-91 to 3307000 hectares in 2006-07 (Directorate of Economics and Statistics, GOG 2008-09 and Directorate of Agriculture, GoG 2010-11).

It has been estimated by Gujarat Government’s taskforce that most of Gujarat’s accumulated groundwater deficit of around 30 BCM is concentrated in Saurashtra, Kutch and North Gujarat Regions (Shah et al. 2009). As shown in Table 18, and figure 104 and 105, groundwater scenario in different part of Gujarat has witnesses a bit of improvement except
in Kutch in North Gujarat. Despite this the overall analysis suggests that the state is still facing the groundwater fall.

Table 18: Groundwater fluctuation over last two decades

<table>
<thead>
<tr>
<th>Regions</th>
<th>1990-2000</th>
<th>2000-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kutch</td>
<td>215492</td>
<td>-725870</td>
</tr>
<tr>
<td>North Gujarat</td>
<td>-1323886</td>
<td>-83535</td>
</tr>
<tr>
<td>Central Gujarat</td>
<td>-554412</td>
<td>184861</td>
</tr>
<tr>
<td>South Gujarat</td>
<td>231169</td>
<td>142137</td>
</tr>
<tr>
<td>Saurashtra</td>
<td>-2601952</td>
<td>2742142</td>
</tr>
<tr>
<td>Gujarat</td>
<td>-4033589</td>
<td>2259735</td>
</tr>
</tbody>
</table>

Source: Based on spatially interpolated surface of the pizometer level data provided by Central Ground Water Board and Ground Water Resource Development Corporation

Note: Positive figures indicate rise, negative figures indicate fall. One metre rise/fall is not taken into consideration

Figure 105 shows that irrigation by groundwater sources was much higher than surface water sources in 2006-07, indicating over exploitation of groundwater in Gujarat, especially in Saurashtra and North Gujarat (see figure 105). Banaskantha was identified as an overexploited zone in 1997 as groundwater development increased from 89.75 percent in 1991 to 111.49 percent in 1997 and then to 118 percent in 2004 (Central Ground Water Board 2012). Maximum exploitation of groundwater for irrigation has been seen in Banaskantha. This could possibly lead to decrease in water table and could, therefore, lead to inland soil salinity which, in turn, will degrade the land.

Figure 105: Source wise Irrigated Area in Gujarat (2006-07)
Sometimes areas with canal irrigation are faced with the problem of water logging. Increased water table and poor drainage are the two main factors for salinity development in Gujarat. About 15-16 percent area in the Mahi command is affected by water logging due to an amplified water table. The salinity near Nal Sarovar Lake in Gujarat is due to flat topography and aridity (Raman n.d.).

Irrigation with saline groundwater also leads to soil salinity. A study carried out by GUIDE (Singh et al. 2000) cites groundwater over-exploitation as one of the major causes of inland salinity in Gujarat. In many arid and semi-arid areas, farmers use high TDS groundwater for irrigation. This has led to the increase in soil salinity causing the hardening of soil surface and lump formation. In order to break the soil lumps to enable better growth of crops, farmers have had to increase the water application rates. Overtime salts have been accumulating on the soil surface. Excessive irrigation to leach the salts causes faster loss of organic matter and nutrients. All this ultimately results in soil degradation leading to a decline in water productivity and land use productivity. As a consequence, farmers are forced to increase irrigation for maintaining the yields. In the Daskroi taluka the average number of watering for *kharif* paddy went up steadily from 2.5 in 1970 to 5.5 in 2000. Similar differences were found in the case of wheat and summer jowar. The average number of watering for jowar went up steadily from 3.3 in 1970 to 4.75 in 1985 to 6.2 in 2000. This has reduced economic returns from farming. The poor will be the worst affected as economic constraints would limit their ability to invest more in farming (Kumar 2003).
RESPONSES
4. RESPONSES

The Government of Gujarat has come out with some progressive initiatives to address the issues faced with respect to land resources in Gujarat. This was mainly done to synchronise the functioning of different arms of the government dealing with land and to make the entire process of land management more people-friendly. The second set of most relevant government responses are aimed at facilitating industrialisation in Gujarat for sustainable economic growth. Besides civil society organisations also made concerted efforts in the right direction.

This chapter brings out significant efforts made by the Government of Gujarat and civil society organisations in agriculture, forestry, mining, municipal, bio-medical and hazardous waste management. Initiatives by the government in land administration are also discussed.

4.1 RESPONSES IN AGRICULTURE SECTOR

4.1.1 Government Responses

4.1.1.1 Soil testing laboratories and soil health card

There are 20 soil testing laboratories working in the state covering all its districts and providing free of charge testing facilities to farmers of all the districts of Gujarat under the soil health card programme. Total soil samples analysed during 2005-06 was 291855 against a target of 1,90,000 soil samples. There is only one laboratory existing for the testing of soil micronutrients, though. Total soil samples analysed for micronutrients amounted to 483 against a target of 7500 soil samples during 2004-05. On the basis of the soil test analysis report, soil health cards were prepared by entering computerised data of the soil test, recommendation of fertilisers, reclamation of soil, crop planning etc. Computerised soil health cards were distributed to 4.92 lakh farmers in 2005-06. During Krishi Mahotsava, about 2.35 lakh soil health cards were distributed to farmers (Agriculture and co-operation Department, GoG 2012).

4.1.1.2 Krushi Mahotsav

The Krushi Mahotsav campaign started in 2006, covering 18,600 villages by June 2009, with 230 krushiraths (vans) reaching farmers with researchers, scientists, experts, agriculture officers and ministers, interacting and providing information and counselling them on soil health, organic farming, technology, agricultural inputs, irrigation, etc., besides infusing a new spirit of change and mass mobilisation (Agriculture and co-operation Department, GoG 2012). During the 8th Krishi Mahotsav in 2012 the present Chief Minister interacted with over one crore farmers via video conference. Around 15 lakhs farmers were provided with an assistance of worth Rs.720 crore. Farmers were also given an assistance to purchase 11,000 tractors and 34,000 rotavators. 4400 Krishi Rath visited all the talukas of the state with around one lakh government official, agro-scientists and experts to disseminate helpful information and to get farmer acquainted with scientific methods of farming. 3.5 lakhs soil samples were tested in laboratory and 2.75 lakhs health cards were given to farmers. During the 2012 Krishi Rath 40 lakhs animals were vaccinated and 4.5 lakh animals were treated for various diseases (Agriculture and co-operation Department, GoG 2012).
4.1.1.3 Micro Nutrient Training
It has been proposed in the state agriculture plan that micro-nutrient training be held in all 18309 villages of Gujarat state. A provision for the fund of Rs.5000 per training has been made. Total fund available to hold micro nutrient training in 18309 villages is Rs.1083.29 lakhs, which would be made available over the period of 4 years.

4.1.1.4 RKVY (Rashtriya Krishi VikasYojana)
In order to boost development and modernisation in India’s agricultural sector, the Government of India has introduced the Rashtriya Krishi Vikas Yojana. Apart from production, research and farming, marketing and post harvest management received importance in the RKVY scheme. Assistance has been provided for distributing soil health cards, micro nutrient demonstration, training of farmers for promotion of organic farming; assistance has been provided to the state government for strengthening existing soil testing and fertiliser testing laboratories and setting up new ones. Assistance has also been provided for nursery development and micro irrigation. Under this scheme, construction of percolation tanks, contour bunds, farm ponds, reclamation bunds, check dams and terrace farming have also been suggested. Banaskantha, Amreli, Dahod, Surendranagar, Vadodara, Sabarkantha, Panchamahal, and Jamnagar are some of the districts covered under this scheme (Gujarat State Agriculture Marketing Board 2007).

4.1.1.5 Integrated Wadi and Agriculture Diversification Project (IWADP)
The “Wadi” model of tribal development is holistic in its approach towards addressing production, processing, and marketing of the agri-horticultural produce, which has led to improved incomes. Critical inputs for the wadi programme include vermi-compost, technical know-how for soil and water conservation, and micro irrigation. The other development interventions include required measures for soil conservation in the wadis, water resource
development by digging of wells, creation of farm ponds, gully plugging, and installing permanent check dams to ensure protective irrigation during the gestation period.

Gujarat’s IWADP and on-going Wadi project for tribal areas seek to cover 2, 65,000 Schedule Tribe (ST) farmers. For the implementation of such a large scale agriculture-based project funds are received mainly from Rashtriya Krishi Vikas Yojana (RKVY), National Rural Employment Guarantee Scheme (NREGS), Gujarat Green Revolution Company Ltd. (GGRC), Tribal Development Department and beneficiary contribution, all of which is collected at the time of the farmers’ registration for the project. IWADP consists of two groups of sub projects including Project Sunshine and Jeevika. It is an integrated project that includes water resources’ development, provision for micro-irrigation facilities, the soil testing facility, quality seeds, saplings and fertilisers, assured extension services, training to participating farmers, and farm mechanisation.

4.1.1.6 Integrated Watershed Management Programme (IWMP)

Area development programmes of the Ministry of Rural Development (MoRD) like the Drought Prone Area Programme (DPAP), Drought Prone Area Programme (DDP), and Integrated Wasteland Development Programme (IWDP) have been following the watershed development approach since 1995-96 when the first watershed development guidelines came into force. Since the new common Guidelines (2008) became operational all individual watershed development programmes have been merged to form one comprehensive programme, namely the Integrated Watershed Development Programme.

The main aim of the IWMP is to restore ecological balance by harnessing, conserving, and developing degraded natural resources such as soil, vegetative cover, and water. The expected outcomes include prevention of soil run-off, regeneration of natural vegetation, rain water harvesting, and recharging of the groundwater table. All this enables multi-cropping and the introduction of diverse agro-based activities paving the way for sustainable livelihoods to residents of the watershed area. Gujarat is among the front runners in the country for taking up new projects. The Government of India has sanctioned 151 watershed projects covering 7.08 lakh hectares to the tune of over Rs. 930 crore.

4.1.1.7 Contract Farming Schemes

In order to facilitate for industries the procurement of a specific quality of agro-commodity directly from the farmers, the state government has been keeping up with the reforms of Model Act 2003. It adopted the Contract Farming scheme in 2005 to that end. Under this scheme farmers benefit from the latest farming technology and improved quality of inputs. They also get price security and an opportunity to diversify in other crops. Farmers get the advantage of the technical research that is sponsored as well as financial support in the form of seeds, fertilisers including harvesting techniques (GSAMB 2007).

The GR on Corporate Farming expressing the Gujarat Government policy on application of modern technology for converting Government-owned wasteland to cultivable land allows only big industrial houses and individuals capable (big farmers) of taking a lease for 20 years. These government-owned wastelands are given to industrial houses for converting them to cultivable land, carry on agriculture production, and produce value-added products. Incentives and encouragements are provided by the state government, which charges nominal
rents only from the sixth year on (Agriculture and Co-Operation Department, GOG 2012). Some examples of beneficiaries of this programme are as follows:

Agro cell Corporation Ltd., Atreyas Agro Organic Pvt. Ltd., Godrej Agrovat Ltd. and Pepsi India, Arvind Mills, Jojoba Oil Industries Ltd. These are some of the companies that approached the government (GSAMB 2007).

4.1.2 Institutional Responses

4.1.2.1 Coastal protection works
The total coastal length of Gujarat is about 1600 km. The state’s western border is bounded by the Arabian Sea. Valsad, Navsari, Surat, and Bharuch districts share boundaries with the latter. Severe erosion has been observed on the coastal boundaries of Valsad, Navsari, Surat, Bharuch, Bhavnagar, Amreli, Junagadh, Porbandar, and Jamnagar districts. Coastal erosion has been found to affect 449 villages. The erosion has been taking place mostly under the action of strong tidal currents accompanied by wave action.

In view of the above, and keeping in mind the occurrence of natural damage, anti-sea erosion works are carried out by the Narmada Water Resources Water supply and Kalpsar Department. The protection work is being carried out by providing gabion walls, thus preventing damages due to coastal erosion.

4.1.2.2 Salinity Ingress Prevention Scheme
Work has been categorised in four different systems under this scheme, which has been implemented by the Narmada Water Resources Water Supply and Kalpsar Department.

<table>
<thead>
<tr>
<th>Management system</th>
<th>Regulation of lifting of groundwater and change in crop system</th>
<th>Change in crop system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recharge system</td>
<td>Check-dam</td>
<td>Recharge dam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recharge well</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recharge reservoir spreading channel</td>
</tr>
<tr>
<td>Salinity ingress system</td>
<td>Tidal regulators, weirs</td>
<td>Fresh water barrier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extraction water barrier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Static barrier</td>
</tr>
<tr>
<td>Coastal land reclamation</td>
<td>Rejuvenation of saline land of oceanic areas</td>
<td></td>
</tr>
</tbody>
</table>

Source: Salinity Ingress Prevention Scheme (2012)

Benefits accrued by the salinity ingress projects, as claimed by the Narmada, Water Resources, Water Supply and Kalpsar Department are as follows:

- About 36,130 hectare lands have directly or indirectly been benefitted in terms of irrigation upon the storage of 247 million cubic meters of fresh water
- Looking to the advancement rate of salinity line of 0.50 to 1.00 km. per annum, another 2.26 lakh hectares of land has been prevented from the onslaught of salinity on the basis of completion of these works
- The 2000 line of T.D.S has been moved towards the coastal region from non-coastal regions in keeping with the situation observed in 1988.
4.1.2.3 Sagarkhedu Sarvangi Vikas Yojna

The Government of Gujarat has announced Sagarkhedu Sarvangi Vikas Yojana in 38 Talukas of 13 districts for the development of the coastal region. Plans are on to execute the following works under the Narmada Water Resources Water supply and the Kalpasar Department Bandharas

- Tidal Regulators
- Recharge Tanks
- Spreading Channels
- Anti sea erosion work
- Irrigation scheme

In total, 15,116 soil and water conservation structures have been constructed under this scheme in Gujarat (Sagarkhedu Sarvangi Vikas Yojna 2012). These soil and water conservation structures have helped reduce the velocity of sheet flow and run-off, which avoids the loss of the thin fertile topsoil through rill erosion and the scouring of drainage gullies. These structures also help in retaining water, thus maintaining soil moisture. This ultimately provides remunerative crop-based agriculture.

The parched lands of Gujarat remained unutilised for centuries. The planners of independent India realised the need for exogenous water in order to meet the water needs of Gujarat and thus Sardar Sarovar Project (SSP) was envisioned. Although the foundation stone was laid in the early 60s it was made operational only during the last decade. It has brought a lot of benefits, particularly in terms of meeting the irrigation, domestic, and industrial water uses. Schemes like Sujalam Suflam and interlinking of rivers have only helped the state maximise the benefits from the available Narmada waters for recharging the groundwater and relinquishing the soil.

The Sardar Patel Sahakari Jal Sanchaya Yojana (SPSJSY) was a government response recognising civil society initiatives around water and the water movement in the Saurashtra region. It focused on the recharging of wells and, later, on the treatment of watershed drainages to conserve rain water through the construction of check dams. Government scaled up check dam construction through this scheme to Gujarat level.

Both these initiatives have almost had a miraculous impact on water and agriculture in Gujarat. SSP on the one hand provided a reliable alternative for regular water supply whereas SPSJSY has helped treat the watersheds across the state and, in the process, improved the productivity and quality of land.

4.1.2.4 Sardar Sarovar Project (SSP)

Over the Narmada is Gujarat’s largest project that has helped irrigation in a great way. Its main canal’s reach is up to Banaskantha, Sabarkantha, Patan, Gandhinagar, Kutch, Surendranagar, Dahod, Bharuch, Narmada, Vadodara, Ahmadabad, Bhavnagar, Kheda, Mehsana, Panchmahals and Rajkot. It has been irrigating only 80-100 thousand hectares of land mostly in Narmada, Bharuch and Vadodara (Shah et al. 2009). Other canal irrigation systems – Mahi, Ukai – Kakrapur, Karjan, and Damanganaga – provide irrigation in central and South Gujarat. They have 70 percent of Gujarat’s command area (Shah et al. 2009). Interlinking of rivers is also underway for providing water to seven water deficit districts through a 332-km long canal under the Sujlam Suflam Yojana.
Power reforms have helped farmers use better and efficient irrigation facilities thus helping them growing water intensive crops. Jyotigram Yojana is one such scheme which has changed the agricultural scenario of the entire state of Gujarat. Under this scheme, a three-phased power supply for 8 hours at 440 volts is continuously supplied to the farmers to facilitate uninterrupted flow of water for irrigation. And separate feeders are used for providing electricity to the domestic and agriculture sectors (Devalah 2010).

4.1.2.5 Sardar Patel Sahakari Jal Sanchaya Yojana
This was implemented in 2000. Under this scheme approximately 50,00,00 structures that were constructed included 113738 check dams, 55917 boribands, 240199 farm ponds and 62532 large and small check dams (Shah et al 2009). Of the total check dams 54.6 percent were constructed in Saurashtra (Rajkot, Amreli, Bhavnagar, Jamnagar, Junagadh, Porbandar and Surendranagar) and 21.2 percent in the north-eastern districts (Kutch, Banaskantha, Sabarkantha, Mehsana and Patan) (Gulati 2009).

4.1.2.6 Participatory Irrigation Management (PIM)
Under PIM, some of the important irrigation management responsibilities in government-owned irrigation projects have been transferred to the farmers’ water users associations. PIM focuses on building farmers’ organisations at village as well as at project levels and enhancing their capacity through various means such as training and community organising. The Development Support Centre (DSC) and Aga Khan Foundation are involved in direct implementation of the PIM programme in 56,800 hectares of 1 major and 2 medium irrigation projects of North Gujarat. The DSC is also in the process of implementing PIM in 5000 hectares of Sardar Sarovar Project (Narmada Project) to serve as a pilot project for implementing PIM over an 18 lakh hectare area.

4.1.2.7 Agro Clinics
It is proposed to set up 224 agro clinics all over the state (at every taluka). The purpose of the clinic will be to act as poly clinic –a place where, a farmer gets solutions to many problems they face at one place. It may have to do with soil characteristics, organic farming, pest management, use of high yield variety seeds and other aspects. Agro clinic may serve as counselling centres, hub of IEC activities, knowledge centre for various agricultural aspects, pest management centre etc. The unit cost of an agro clinic is estimated to be 5 lakhs. Assistance equivalent to one third of the unit cost (1.67 lakhs per unit) will be provided to the agro entrepreneurs interested to set up the clinics. The clinic should work on commercial model and should be in interest of both – entrepreneurs and farmers. Total provision of Rs.383.28 lakhs as assistance amount for 224 units has been made in the plan.

4.1.3 Civil Society Responses

4.1.3.1 Watershed Management: Soil and Water conservation
Activities under the Watershed Development Program encompass a range of interventions. They include social afforestation, grass land development, fodder, soil and water conservation, agriculture, drinking water supply, livelihoods, community development, farm pond, farm protection bunds, field boundaries protection bunds, salinity protection bunds around the village, tidal regulation, well recharging, hand pump repairing, pond inlet channel repairing, check dam, animal husbandry, and rain water harvesting.

Interventions also include the formation of watershed groups and participatory irrigation management in Gujarat, irrigation and groundwater recharge systems, promotion of micro-
irrigation devices like drips and sprinklers, river basin management including the construction of over 1000 check dams and irrigation tanks and other watershed management measures (Aga Khan Foundation 2007).

Several NGOs like the Mahiti Foundation, Aga Khan Foundation, Uthaan, Sarthi, VIKSAT (Vikram Sarabhai Centre for Development Interaction) have been working for watershed development. Mahiti has, so far, implemented Watershed Development Programs under the Employment Assurance Scheme and the Drought Prone Area Planning Scheme in the Bhavnagar and Dhandhuka blocks covering 15 coastal villages under the watershed development program. Presently, Mahiti is also implementing an Integrated Wasteland Development Program in 07 villages Dholka block of Ahmadabad district. Over the years, Mahiti has treated more than 15000 hectares of land under the watershed development program (Mahiti Rural Development Centre n.d.)

4.1.3.2 Livelihood enhancement through participatory natural resource management in Rain fed and irrigated areas of rural Gujarat (LEPNRM)

After the augmentation of natural resources through watershed and PIM programmes agriculture-based livelihood enhancement programmes were initiated by various NGOs like the Development Support Centre (DSC) in six field units of Gujarat in 2007 in order to further enhance agricultural income. The areas in which LEPNRM is being implemented include Dharoi (Mehsana district), Guhai, Mazum and Meghraj (Sabarkantha district), Vehlal (Ahmadabad district), and Dhari (Amreli district) covering more than 180 villages and about 45,000 households. The project focuses on five main components of agriculture enhancement: cost reduction, risk mitigation, increased productivity, value addition, and market linkages with the aim of increasing incomes of farmers, especially those of small and marginal farmers (Development Support Centre n.d.).

4.1.3.3 Wadi Programme

The Ministry of Tribal Affairs, GOI has launched a Wadi programme for implementation by state governments and various voluntary organisations. The BAIF Development Research Foundation is one such organisation involved in its implementation. 12,336 hectares of land has been managed under this programme in Gujarat.

4.1.3.4 Cooperative Farming

Cooperative farming refers to pooling of small plots of land and their joint management. Cooperative farming societies are formed to introduce improved methods of farming. Land is collectively cultivated by small groups of farmers. Activities like ploughing, purchasing of inputs, irrigation, and marketing of produce are taken up by these groups. The Gambhira Cooperative Model, in line with the cooperative farming model, may prove to be a model for small and marginal farmers

4.1.3.5 Training on Micro-Irrigation

It is proposed that 13820SHGs/farmers’ clubs out of 138200 SHGs (to be created out of 12, 39,008 small and marginal farmers in the state) be imparted training about micro irrigation system for encouraging horticulture in the state. It is emphasized that the training be imparted in groups to encourage promotion of micro-irrigation in group mode where group of farmers whose land is adjacent to each other, go for micro-irrigation system collectively.
4.1.3.6 Sustainable agriculture
In order to improve the quality of land suitable cropping systems are being promoted with a preference for tree-based farming which, in turn, increases agricultural productivity. To promote sustainable agriculture and organic farming, research and demonstration on composting, vermi-composting, bio-fertilisers like Rhizobia, Asatobacter, and bio-fungicides have been undertaken. Low cost, user-friendly liquid bio fertilisers and bio pesticides are being produced and distributed to the farmers (BAIF Development Research Foundation 2012).

4.2 RESPONSES IN FORESTRY

4.2.1 Social Forestry
For a decade (1970 to 1980) the state government had made budgetary provisions for implementation of the social forestry works. A separate social forestry wing was also created in the Forest Department to look after this activity. Subsequently, external funding from the World Bank was sought for extending the social forestry programme on a massive scale. The social forestry wing was further strengthened during the World Bank aided projects. Gujarat was been recognised nationally and internationally for its successful implementation of the Social Forestry programme during the 80s (Forest Department 2011).

Table 20: Social Forestry programme in Gujarat

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (Ha)</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969-70 to 1979-</td>
<td>37085</td>
<td>Social Forestry Plantations carried out through the state scheme</td>
</tr>
<tr>
<td>1980</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980-81 to 1984-</td>
<td>78,780</td>
<td>Word Bank Phase 1, first phase of Social Forestry called Community Forestry Project was implemented with assistance from the Word Bank.</td>
</tr>
<tr>
<td>1985-86 to 1992-</td>
<td>1,05,643</td>
<td>Word Bank Phase 2, second phase was implemented with assistance from the World Bank and USAID.</td>
</tr>
<tr>
<td>1993-94 to 1995-</td>
<td>46,410</td>
<td>Social Forestry plantations were undertaken under the state schemes.</td>
</tr>
<tr>
<td>1996-97 to 2001-</td>
<td>94,241</td>
<td>Integrated Forestry Development Project (IFDP) with assistance from the OECF (Japan)</td>
</tr>
<tr>
<td>2002-03 to 2010-</td>
<td>1,39,066</td>
<td>Social Forestry plantations were largely undertaken under the State Scheme and some under GFDP Phase II</td>
</tr>
</tbody>
</table>

Source: Forest Department, GoG

Table 21: Cumulative achievement of social forestry works (1969-70 to 2010-11)

<table>
<thead>
<tr>
<th>Particular</th>
<th>Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip plantations</td>
<td>1.02 Lakh ha.</td>
</tr>
<tr>
<td>Panchayat lands (village forest)</td>
<td>1.31 Lakh ha.</td>
</tr>
<tr>
<td>Private degraded lands</td>
<td>2.39 Lakh ha.</td>
</tr>
<tr>
<td>Other lands</td>
<td>0.28 Lakh ha.</td>
</tr>
<tr>
<td>Seedling distribution (van mahotsav)</td>
<td>558 Crore plants.</td>
</tr>
</tbody>
</table>

Source: Department of Forest, GoG
4.2.2. Joint Forest Management

Participatory forest management in Gujarat was an outcome of the National Forest Policy of 1988 and the involvement of the local communities and voluntary agencies in forest protection, management and regeneration for the rejuvenation of degraded forestlands. The Joint Forest Management (JFM) programme was launched in Gujarat by government resolution in March 1991. Since then the act of involving the people in the protection and regeneration of forests has been expanded to other areas. A decentralised approach of participatory management based on the broad principal of care and share is in progress and has been increasingly gaining recognition and acceptance as a major strategy for the eco-restoration and rehabilitation of degraded forest land in the state. The state has total area of 429447.86 ha under JFM involving 3271 JFM committees (Forest Department 2012). Forest Development Agencies have been created in the state in 22 forest divisions for the integrated development of villages with the afforestation activity and to make the people more responsive in Joint Forest Management.

Several NGOs have been active along with communities in the JFM programme of Gujarat. The prominent ones are Agha Khan Rural Support Programme (AKRSP), Viksat, SARATHI, N.M.Sadguru Watershed Development Foundation, and the Development Support Centre (DSC). NGOs have been active in promoting and facilitating the JFM programme. Training programmes for awareness motivation, human resource development skill up gradation, capacity building, micro plan preparation, and leadership development have been organised by the NGOs to strengthen the programme. Micro planning through Participatory Rural Appraisal (PRA) is organised jointly by the NGOs and the forest department in order to make people aware of natural resources and their judicious usage. The forest department and NGOs, separately or jointly, organise training programmes and other HRD interventions to equip the Range Officers’ Foresters. The Centre for Participatory Natural Resource Management (CPNAR) has been working in the state at the Gujarat Ecological and Environmental Research (GEER), Foundation to facilitate the progress of the programme. Government of India has awarded three Van Kalyan Samitis- Pingot, Bapda, and Balethi in recognition of their service for the protection and regeneration of the degraded forest (Forest Department 2010).

Besides JFM in the forest areas, the department has developed a project for the areas in the villages outside the forest up to a limit of 5 km from the forest fringe, with the objective of covering under a special drive for afforestation involving local people. Under the project villagers will be organised into a committee called VLO (village level organisation) to create a shelter belt through afforestation to reduce the pressure on the forest. Benefits from such a drive will be shared with the VLO including the sharing mechanism followed during social forestry plantation. This expansion requires legal and policy support. In order to give a fillip to the programme the forest department has designed a project amounting Rs. 250 Crore for the different activities (Forest Department 2010). One thousand seven hundred and thirty four Van Kalyan Samitis had been formed under JFM by 2005. Under the latter, 23,8242 hectares of land have been managed in Gujarat. There are several success stories of the VLOs doing a great job under JFM in Gujarat. In order to understand its impact, VIKSAT conducted it in three divisions’ viz. Baria, Rajpipala and Sabarkantha covering 24 villages. Vegetation parameters such as species’ richness, density of trees, basal areas, Shanon Weiner’s diversity index, woody biomass and MAI were observed and compared with control plots in a non-JFM village. Stem density, species’ richness, species’ diversity, basal area, biomass and mean annual biomass increment were higher in JFM forests as compared to controls. This study also indicates that JFM forests are meeting the substantial biomass needs of the community.
and contributes towards achieving sustainable forestry (Patel et al. 2006). NGOs in Gujarat have played an important role in making JFM a success story.

4.2.3 Awareness Initiatives in Forestry

4.2.3.1 Awareness initiatives by the Forest Department, Gujarat
The State of Gujarat has initiated the concept of “Vanmahotsav” in the 1950s. This concept has undergone a change since 2004, wherein it was decided to celebrate it at the state level precided by the Chief Minister himself. Vanmahotsavs are celebrated at the districts, taluka and the village level, which has led to greater mass involvement and thus serve the purpose better. Generally historical, cultural and religious places are selected for the creation of Vans. The state department has created the scheme of “Vankutir” to spread awareness about tree plantation and environment, especially in rural areas. Under this scheme, the Department constructs an RCC hutment of standard design at public places such as village chauraha, bus station, etc where people gather in considerable numbers. The Vankutir will have slogans and messages related to environment, forestry and tree farming prominently displayed on them. Vankutirs also are used to hold “Khedut Shibirs” (Farmer's camps) for promotion of Social Forestry. The state government has taken up tree plantation in schools, colleges, Government premises, institutions of public importance, places of tourist and religious importance, etc under the Environmental Plantation scheme. Till date, a total of 4640 ha area has been covered under this plantation model (Forest Department, Gujarat).

4.2.3.2 Awareness initiatives by the Gujarat Ecology Commission
Gujarat Ecology Commission (GEC) functions as the State Project Management Unit (SPMU) for the ICZM project for Gulf of Kutch region of Gujarat State. GEC has the mandate to provide a platform for sharing of information and other relevant inputs necessary for policies and programmes essential for ecological conservation and sustainable development. As an implementing agency for ICZMP, the agency has the role of Increasing the sensitivity, understanding and acceptance of local communities, Government and coastal industries towards the need to protect, conserve and regenerate mangroves, Capacity building of coastal communities and staff of Forest Department for community-based mangrove regeneration, Increasing livelihood opportunity through plantation and regeneration activities (Gujarat Ecology Commission 2011).

The Commission has also come out with various action plans and programmes like “The Green Action for National Dandi Heritage Initiatives” is implemented in and around the famous village of Dandi, Navsari district, by creating Eco Sensitive Areas under the Environment (Protection) Act 1986. This programme is in collaboration with the Society for Integrated Coastal Zone Management (SICOM) and Gujarat Vidyapith. Among other awareness activities the commission also conducts street plays and coastal camps for the involvement of the common masses (Gujarat Ecology Commission 2012).

4.3 RESPONSES IN MINING SECTOR
There are sufficient existing provisions formulated by Government of India like Mineral Concession Rules (1960) and Mineral Conservation Development Rules (1988) which makes the restoration of mining areas mandatory. Gujarat state policy has an additional addendum on striking ecological equilibrium in the mining activities. It states that in order to establish systematic and scientific mining, ensure safety, minimize wastage, control the impact of mining on environment, the mining plan will be strictly implemented, and the environment
impact assessment norms will be constantly monitored in leases of major minerals. Every lease will be inspected at least once a year by Indian Bureau of Mines.

Gujarat Ecology Society has undertaken the study, “Ecological Restoration of Mining Sites of Gujarat” at the instance of Gujarat Mineral Development Corporation to step up the protection and conservation of natural environment in mining areas. The study provided an action plan for long-term ecological rehabilitation of the three mining sites: 1) Panandhro Lignite mine; 2) Ambamata multimetal mine; and 3) Ambadungar Fluorspar mine. Suitable guidelines and strategies have also been proposed for efficient development of mineral resources in the State without disturbing the balance of nature (Gujarat Mineral Development Corporation (GMDC) 2010).

GMDC has adopted corporate environment policy to take various pro-active measures for protection of environment and ecosystem around its projects. It has implemented best environmental management practices to prevent and control pollution at its facilities. GMDC has initiated greenbelt development in the mining affected area. Fifteen lakh plant saplings have been raised over 1200 ha area of land at different projects and affected areas. It has achieved the target of 820.60 ha of plantation in phased manner in last 11 years. Also mining area of 953 hectares, 104 hectares is covered under plantation and other 20 hectares has been rehabilitated through water storage. About 12 lakh cubic meters of rain water has been collected and utilized for dust suppression on haul roads and for plantation inside the mines.

A one day training program on environmental awareness in regional language among lower staff was organized by corporate office for all GMDC Projects. This training program covered following aspects like environment, air, water, land and noise pollution, solid and hazardous waste management, reclamation of mining area, environmental monitoring, environmental audit, consent process and other basic environmental issues and their management in mining and thermal power plant. Total 393 people took the benefits from this training program. This type of training program in local language was highly appreciated by GMDC top management. GMDC celebrated “Van Mahotsav - 2011” from 2nd July to 16th of July 2011 in all GMDC projects by involving its employees, colony resident, school teachers

<table>
<thead>
<tr>
<th>Year</th>
<th>No of Plant</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td>52530</td>
<td>23</td>
</tr>
<tr>
<td>2002-03</td>
<td>99675</td>
<td>48.8</td>
</tr>
<tr>
<td>2003-04</td>
<td>103285</td>
<td>78.7</td>
</tr>
<tr>
<td>2004-05</td>
<td>70990</td>
<td>82.7</td>
</tr>
<tr>
<td>2005-06</td>
<td>116088</td>
<td>49.5</td>
</tr>
<tr>
<td>2006-07</td>
<td>58962</td>
<td>20.4</td>
</tr>
<tr>
<td>2007-08</td>
<td>36862</td>
<td>17.79</td>
</tr>
<tr>
<td>2008-09</td>
<td>74589</td>
<td>47.64</td>
</tr>
<tr>
<td>2009-10</td>
<td>192005</td>
<td>145.18</td>
</tr>
<tr>
<td>2010-11</td>
<td>273200</td>
<td>169.69</td>
</tr>
<tr>
<td>2011-12</td>
<td>224899</td>
<td>130.55</td>
</tr>
<tr>
<td>Total</td>
<td>1310585</td>
<td>820.60</td>
</tr>
</tbody>
</table>

Source: GMDC (2010)
and students, local communities, representative of local government bodies, etc. inside project area, colony area, schools of nearby villages, along the roadside in villages and other public places etc. for plantation in mined areas (Gujarat Mineral Development Corporation 2010).

4.4 RESPONSES IN MUNICIPAL WASTE MANAGEMENT

4.4.1 Government Responses
Municipal Solid Waste (Management and Handling) Rules, 2000 was brought into force from 25.9.2000 by the Government of India. It is mandatory on the part of all the municipal authorities to arrange for the collection, segregation, transportation, and suitable disposal of municipal wastes of the municipal towns/ cities as per Rule no. 4. As of now 159 nagarpalikas, 8 municipal corporations, 4 notified areas and 1 Urban Development Authority in the state have been identified as responsible authorities for complying with MSW Rules-2000.

4.4.2 Institutional Responses
The Government of Gujarat has constituted a nodal agency, the Gujarat Urban Development Company Ltd (GUDC), for the development of infrastructure for treatment, transportation and disposal. The GUDC has divided the area of Gujarat in four different regions and identified 24 clusters for regional landfill sites for different local bodies located in Gujarat. Eight Municipal Corporations have been developing their individual landfill sites. Eighteen landfill sites are currently under progress covering almost all the districts of the state and are expected to dispose of MSW in a scientific manner. The GUDC has conducted a municipal solid waste management project for the ULBs of the state of Gujarat.

Main components of the municipal solid waste management project:
1. Procurement of tools and equipments / vehicles for municipalities for primary as well as secondary collection of wastes
2. Construction of compost plant per municipality for composting bio-degradable wastes
3. Construction of regional landfill sites among the group of municipalities for final disposal of non-biodegradable and non-recycled wastes
4. Preparation of Nagarpalika Action Plan for 126 municipalities
5. Conducting of training programs for safai kamdars of various municipalities
6. Operation and Maintenance
7. Asset Management
8. Community awareness and public participation (CAPP)
9. Privatisation of such facilities / private sector participation (Gujarat Urban Development Company 2011)

4.4.3 Technological Responses
Solid waste management is a sector that requires attention due to a growing population, unplanned development and lack of land. Due to poor financial assistance both small and big cities are unable to manage waste processing and disposal. Gujarat recognised the need for an integrated approach to Municipal Solid Waste Management in 2005 and adopted an estate-wide, regional approach for meeting the requirements of safe disposal. The Gujarat Urban Development Corporation, in collaboration with the Ahmadabad Urban Development Authority, has planned regional integrated composting facilities for approximately 150 tonnes
per day at the village Fatehwadi. It has also planned a scientific landfill site of 50 TPD capacities.

The basic model that evolved was for the initial treatment of wastes, through vermi-composting, to be undertaken individually by each ULB (Urban Local Bodies). It was also aimed at reducing volumes to be transported for land filling. Individual ULBs were required to identify sites for vermin-compost facilities on the basis of area and location criteria provided. Each vermi-composting facility was also meant to serve as a transfer station at the ULB level, for transportation of residual waste for land filling on a regional basis. To date, 77 such facilities have been constructed and are being operated by non-governmental organisations (NGOs). The effort focused on government-owned wastelands closest to the largest generator of waste in each cluster. The sites identified were acquired and handed over to the GUDC for development.

4.4.4 Initiatives Taken Up By Various Municipal Corporation

4.4.4.1 Ahmadabad Municipal Corporation

The Ahmadabad Municipal Corporation has achieved 80 percent efficiency in door-to-door collections covering 700 thousand households. Total waste generation in the city is tantamount to 2100 tonnes per day. Waste collected from the city is disposed at the 84-hectare Pirana land fill site. Ahmadabad plans to build the largest landfill site at Gyaspur with a total capacity of 2550 tonnes per day.

The Ahmadabad Municipal Corporation, with the financial support by the United Nations Centre for Regional Development (UNCRD), has taken the initiative of introducing a waste-free city. It will, among other things, analyse the process of making garbage management a people’s affair by involving the private sector, research institutions, and the UN and donor organisations. The project will focus on the management of waste in a sustainable manner. The Ahmadabad Municipal Corporation has launched a campaign based on information, education, and communication in the city to spread awareness on solid waste management making citizens aware of their responsibility towards keeping the city clean. The activities include door-to-door awareness campaigns, public events (clean up drives) etc.
The Ahmadabad Municipal Corporation and Airport Authority of India have set a new guideline for keeping the area near the Ahmadabad airport garbage free. The Ahmadabad Urban Development Authority clubbed together 12 municipalities situated around the city of Ahmadabad, Chandkheda, Kali, Ranip, Chandlodiya, Ghatlodiya, Memnagar, Jodhpur, Vejalpur, Sarkhej, Thaltej, Bodakdev, and Vastrapur. By doing so it created a common regional facility for integrated treatment and disposal of waste.

4.4.4.2 Surat Municipal Corporation (SMC)

Surat is one of the 25 cities of the country to have introduced door-to-door garbage collection (Federation of Indian Chambers of Commerce and Industry 2007). The door-to-door garbage collection system has been made operative in seven zones covering almost the entire area of the old city. After extension of the city area eight nagarpalikas and 27 villages were merged into the city last year. The door-to-door collection system with closed body vehicles is operative in 8 nagarpalikas area whereas this system is operative through tractors for 27 villages. A total of 11 lakh units are covered under this system with 96 percent door-to-door collections.

The SLF (Sanitary Land Fill) cell with a capacity of 1, 25,000 cubic metres is in use and one more SLF cell with a capacity of 6,25,000 cubic metres is under construction. The design for a closed transfer station at Pal, Varachha, Bhestan, Katargam, Anjana, Bhatar and for the SLF cell is proposed to cope with future demand. Surat has opted for multiple waste processing technologies for the treatment of MSW. The Surat Municipal Corporation has been converting MSW into compost and Refused Derived Fuel (RDF) pallets. SMC is also coming
up with a semi closed body transfer station with an elevated platform (Surat Municipal Corporation n.d).

4.4.4.3 Vadodara Municipal Corporation (VMC)
VMC has achieved 100 percent door-to-door collection efficiency. The dumping site for Vadodara is located at Vadsar, about 10 km away from the city with a total area of 12145 sq. metres. The Vadodara Municipal Corporation is developing a new sanitary landfill site as per MSW Rules-2000 and also setting up an incinerator for the ultimate disposal of small dead animals and carcasses. It is also planning to set up waste to energy plant for converting plastic waste into hydro-carbon fuel with the association of GSFC; the plant is likely to become operational soon.

The waste process facility (compost plant) is located at the Atladara (Vadodara) STP premises. The capacity of this plant for treating un-segregated solid waste is 250 TPD. The biodegradable waste is segregated and composted in the plant and the reject is transported to the dumping site. VMC has installed a scientific landfill site in Makarpura-Jambuva on 25 hectares of land. It has also constructed an additional processing plant adjacent to the landfill site with a capacity of 300 MT/day based on integrating processing technology with the intention of minimising the waste load on the land fill site and increasing the life span of the landfill site.

4.4.4.4 Rajkot Municipal Corporation (RMC)
The Rajkot Municipal Corporation has achieved 75 percent of total city coverage. Out of 330 MT/day, 300 MT/day waste is being treated. The RMC has introduced privatisation in the primary and secondary collection activities. The work involves collecting solid waste from all the collection sites and transporting it to the waste disposal site. It has two landfill sites viz. Sokhada having a land area of 11 acres 12 km away from the city while Manda Dungar has 2.5 acres and is 7 km away from the city. Since both landfill sites are about to be filled to the brim the RMC has already put forward a proposal for a new landfill site with the Government of Gujarat for 40 acres of another landfill site near Nakrawadi, 15 km away from the city (Rajkot Municipal Corporation n.d).

4.4.4.5 Junagadh Municipal Corporation (JMC)
The JMC has achieved 90 percent of total city coverage with 60 percent door-to-door collection efficiency (Junagadh Municipal Corporation n.d).

4.4.4.6 Solid Waste Management of Gujarat International Finance Tech City (GIFT)
The GUDC, in partnership with IL&FS Services Limited, is preparing the concept design for solid waste management of the city. The design envisages automated waste collection and transportation system for a different processing and treatment facility. The system will treat waste to the tune of 280 tonnes per day. A fully mechanised system for waste recycling has been conceptualised which is expected to recover valuable recyclable material with the highest efficiency. The non-recyclable material will be incinerated by a plasma gasification unit to produce energy. The design of solid waste management in GIFT would be the first of its kind in the country (Infrastructure Leasing &Financial Services Ltd. 2008).
4.4.5 Capacity Building
The Self-Employed Women’s Association (SEWA) has taken up door-to-door waste collection in Vejalpur and in Gandhinagar near Ahmadabad and provides employment to over 500 rag-pickers. Many other NGOs in the state, including the Clean Ahmadabad Abhiyan, have taken up public awareness programmes (India Infrastructure Report 2006).

The GUDC has conducted a series of state-wide workshops to build consensus among ULBs for the approach. It has developed a strong scientific planning process starting with mapping and needs’ assessments in all the urban bodies.

Municipal Corporations are also involved in awareness programmes to educate the public regarding waste management. They have been conducting workshops and training programmes to educate staff.

4.5 Responses in Biomedical Waste Management

4.5.1 Government Responses
Biomedical Waste (Management and Handling Rules) 1998 was published by the Government of India, under Sections 6, 8 and 25 of the Environmental Protection Act, 1986 on 20-7-98 and appeared in the official Gazette of India on 27-7-98. According to it, the Gujarat Pollution Control Board has been monitoring the disposal of biomedical waste. The rules regulate the disposal of medical waste including human anatomical waste, blood, body fluids, medicines, glass wares, solid, liquid and biotechnology waste and animal waste. The objective is to take all steps necessary to ensure environmental health and safety. The rules have been formulated as the framework for handling and managing biomedical wastes. The rules are applicable to all persons handling Biomedical Waste. The duty of the occupier in the Biomedical Waste (Management and Handling) Rule pertains to dealing with the generation/handling/treatment/disposal of bi-medical waste.
Under the Biomedical Waste rules, the waste producer is responsible for managing the waste. Each generator is expected to segregate the biomedical waste from municipal waste and to keep different categories of biomedical waste in colour-coded bags/containers as prescribed under the Bio Medical Waste (Management and Handling) Rules, 1998. Hence, hospitals treating more than 1,000 patients are required to register themselves with the State Pollution Control Board. Hospitals/research laboratories are expected to be responsible for proper collection, reception, treatment, storage, and disposal of biomedical waste.

### 4.5.2 Technological Responses

Biomedical waste management includes waste minimisation, segregation, collection, storage, transport, treatment, and disposal. Gujarat has 13 common biomedical waste facilities; 21 hospitals of Gujarat have their own BMW incinerator.

The Vadodara Municipal Corporation has one incineration plant located at Gajrawadi, which was set up in 1999. This facility is meant for the disposal of small animals. The Indian Medical Association (IMA) deals with biomedical waste in Vadodara. Approximately, two percent of the total waste generated is biomedical waste which is handled by an incinerator, an auto calving and waste shredding facility. About 800 hospitals and private clinics have been registered under this facility (VMC n.d). The centralised biomedical waste treatment facility with a required capacity of incinerator, autoclave and shredder established in line with the norms prescribed by Bio Medical Waste (Management and Handling) Rules-1998 has been in operation at Bhatar since January 1, 2003 with a concession period of 14 years on BOOT (build–own–operate–transfer) basis. This has been recognised as a best practice adopted by an ULB (SMC n.d).
4.5.3 Capacity Building in Bio-medical Waste Management
Gujarat Pollution Control Board has been organizing awareness workshops for medical staff, doctors and other related practitioners since inception of rules. Recently training cum workshop for the operators of Common Bio-Medical Treatment Facilities of Gujarat was organized by GPCB in April 2012. The objective of the programme was to train the operators about the ‘XGN’ facility provided by the board which allows the operators to submit daily data on biomedical waste received and treated. It allows filing online submission of application for grant/renewal of authorization as operator by the Board.

4.6 RESPONSES IN HAZARDOUS WASTE

4.6.1 Institutional Responses
The Government of India notified Hazardous Waste (Management and Handling) Rules 1989 under the Environment (Protection) Act 1986. These rules were amended in 2000 and 2003. Gujarat was the first state to address hazardous waste issues and brought about a novel concept pertaining to common treatment stabilization and disposal facility (TSDF) for a cluster of industries. The development of TSDF by individual industries is commonly unviable due to small quantities of waste generated. GPCB has issued closure directives under section-5 of EPA-1986 for the closure of the unit and sealed the premises. There have been 96 notices and 157 closure directions issued between 2008 and 2012 to defaulter industrial units under Environment Protection Act, 1986 by GPCB.

4.6.2 Technological responses
The GPCB has allowed TSDF imposing compliance of the guidelines issued by central and state levels from time to time. Gujarat has eight common hazardous waste TSDFs with a treatment capacity of 9068239 MT. Certain non biodegradable waste water and liquid hazardous waste have been recommended for disposal in an environmentally sound manner. The process of detoxification regarding the treatment of non biodegradable waste water is not viable economically. The concept of individual common incinerators for the safe disposal of toxic hazardous waste was adopted in late 1990. As of now, the state has five common hazardous incineration facilities and 39 individual incineration facilities (Gujarat Pollution Control Board 2011). In order to prevent with immediate effect the further contamination of groundwater, soil, and other environmental entities from the uncontrolled disposal of hazardous waste, the GPCB acted promptly for the isolation and encapsulation of major uncontrolled sites resulting in the safe disposal of more than 6 million tonnes of hazardous waste (Gujarat Pollution Control Board (GPCB) 2007).

4.6.3 Capacity Building
The GPCB organises awareness programmes including poster exhibitions, seminars in major cities and towns, and addresses other areas of environmental importance by educating all concerned, including medical and para-medical individuals, regarding effective implementation of municipal solid wastes, biomedical wastes, plastic waste issues, noise pollution, etc. The GPCB has been promoting resource conservation and waste minimisation in industries. It has also been using geographic information systems for hazardous waste tracking. The GPCB has implemented satellite mapping to identify the practices leading to damage of land and to take preventive action under different laws.
4.7 RESPONSES IN LAND ADMINISTRATION

Land is a key asset that provides an important foundation for economic and social development. That is the reason land issues are politically charged. There should be measures to increase land tenure security, reduce transaction costs of transferring land rights, and establish regulatory frameworks to prevent undesirable externalities. The need of the hour is to get a strong response from the government, the private sector, and the community groups so that we can have sound and sustainable land management. Policy on land reform was spelt out in the first Five Year Plan (1951-56). After independence four major policy interventions were the main components of land reforms: first- the abolition of intermediaries (most successful component of the reform process; by 1960 legal enactment was completed); second-tenancy reforms; third-fixing of ceiling on land holdings, and fourth-consolidation of holdings. This sections deals with the initiatives taken by the Government of Gujarat in land administration.

4.7.1 Village Information System (VIS)

The VIS is a Geographical Information System (GIS) based application, which provides details pertaining to the demography, infrastructure, and natural resources of every village, district, and state. It is an attempt to transform rural governance development. The challenge lies in ensuring the easy flow of public information to rural citizens irrespective of caste, class, gender, and literacy level. Gujarat is among the leading states to invest money and resources for IT implementation in governance and citizen services. Achievements have been made in policy, infrastructure, application development, and data-warehousing. The Gujarat government has set up an e-Governance programme by providing computer-based services to its people through projects like e-Dhara, Mahiti Shakti, Talim Rojgar, and Jan Seva Kendras. Gyanganga, enabled for the first time, the rural people of Gujarat to access information through internet services and introduced them to a new world of possibilities. These services have been provided through a Village Computer Entrepreneur (VCE). The state government has strengthened the e-Governance programme, linked it with various development initiatives through ICT-based services, and brought it to the doorsteps of rural communities bridging the digital divide in the process. Gyanganga, a pilot project to serve rural communities, was developed on the basis of public-private partnership. Community participation being a key feature of this project, Gramsabhas have been organised in villages to brief the locals on it. Various categories of people have covered in these meetings viz. farmers, women, students, scheduled caste, etc. This system can provide a single point of contact to various services in a simplified, easy, and an efficient way.

Linkage to the existing database for retrieval and computations is expected to ensure transaction accuracy. This is expected to benefit both villagers and the government. Data validation to avoid misuse is another major feature of the VIS. Commercial services available at village level would save time, money and the effort to get those services. The parameterisation of data set out in the database could facilitate easy consolidation at taluka, district and state levels which, in turn, could help the government get an overview. MIS reports at taluka, district and state levels on consolidated data could help assess and improve the existing process. Employment opportunities could be generated in villages by training the rural people to operate the kiosks and by involving them in the product selling process in the villages. The VIS could bring ICT to rural areas in Gujarat and improve the quality of life facilitating improved production and marketing of agricultural products, and providing equal and growth-oriented opportunities for education, health, employment, and entertainment to rural industries. The project was expected to commence in mid-2006 (ICTD Project
Newsletter, April 2006). Currently, 100 VIS centres are operational. However, these VIS centres have now been integrated under e-Gram. The total numbers of e-Gram centres are – 13,695 including VIS centers (National Institute for Smart Governance 2009).

4.7.2 ‘E-Dhara’: Land Records Management System

Land records are maintained for various purposes including the levy and collection of various taxes and land revenue. Any changes brought on by sale, inheritance, hire, distribution, etc, are recorded manually with updates conducted through the talati at the village. Land being the primary source of sustenance for a majority of the population, maintenance of proper land records is extremely important. Traditionally, the talati maintains this data in a manual register known as Village Form 6. The talati being the custodian of this data carries out the changes authorised by a competent revenue officer (circle officer, deputy mamlatadar – land, mamlatdar, etc.) who approves the changes in the land records. However, the manual system of record keeping is cumbersome, opaque, susceptible to manipulations, and hard to administer. Therefore, the e-Dhara land records’ management system was conceptualised using information technology (IT) as a tool. The envisaged system was designed to provide prompt issuance of computerised RoR (Record of Rights) across the counter along with online updating of land records (Ramchandran 2010).

The revenue department took the initiative in digitising 7/12 and 8A forms by computerising land records. It took a mammoth effort to digitise 1.5 crore land records across the state. Elimination of manual records, a computer-controlled mutation process, and self-sustainability are the leading objectives of e-Dhara. It not only maintains the data but also updates it whenever a change in RoR is required. However, only textural records are digitised under e-Dhara. It is important that Gujarat takes a lead to digitise spatial records too.

4.7.3 ‘E-Vishwagram’ Project

The e-Vishwagram project was set up to help with the computerisation of certificates including certificates of birth, death, income, caste, domicile, property, residence proof, agriculture, tax collection, land ownership, etc. The project was conducted in a phased manner. The e-Gram mission has a provision to provide basic and very important services to their citizens in the Gujarati language with the availability of VSAT (Very Small Aperture Terminal) connectivity in all gram panchayats. In January 2008, Asia’s Biggest VSAT connectivity project for the public was rolled out which covered all 13,693 gram panchayats with broadband internet connectivity. The intention is to directly involve rural citizens so that they can receive services at their doorstep. The project fully covers all 13,693 gram panchayat offices, 225 taluka panchayats, and 27 districts of Gujarat. The project was initiated in March 2003 by providing 700 computers via public and state government funds in the districts Kheda and Anand. Before this, rural citizens would have to be present at the headquarters of a taluka or district to avail of services, which was both time-consuming and expensive with least assurance of 100 percent service delivery. The project also provides technical and training support at all four levels i.e. state, district, block, and gram panchayats. Its main responsibility includes backstopping panchayats offices and imparting training programs to village computer entrepreneurs. This initiative has adopted the five Es of governance, which are- ease, economy, efficiency, effectiveness, and ethics.

Now there is no waiting period as regards the issuance of certificates, documents and application forms, all of which are available at nominal fees at one’s doorstep. It has ensured quick redressal of grievances. The key challenges associated with the project included the
involvement of line ministries and determining incentive mechanism for the village level revenue officials, connectivity, transition/switching from a manual and free system to a transparent and paid service, identifying kiosk operators and setting up public-private partnerships. Overcoming these hurdles the e-gram mission is to now ensure that all the villagers are issued land records, notices, receipts, collection centres for utilities like electricity, telephones, etc. The final mission is to emerge as an IT hub for all administrative and commercial services at the village level with a provision of a high-tech state data centre established at Gandhinagar discharging safe and secure e-services. However, in several gram panchayats computer systems are not working condition.

4.7.4 The New Age of Property Registration
The Gujarat Government has simplified the property registration process by making a move to regularise land deals. With the new regulation in place, the Power of Attorney (PoA) holder will face no hassles and be easily able to register the property in his or her name. Furthermore, a Government Resolution (GR) has been issued by the state revenue department, which mentions that each PoA holder having land ownership has to submit a copy of PoA along with an affidavit copy signed by the original owner on transfer of the ownership to the PoA holder along with the address details, both permanent and present of the original owner and an undertaking stating that the PoA has not been withdrawn.

After submitting the documents the PoA holder is required to provide a photograph, biometric details (fingerprints), and ownership documents. Then, the sub-registrar will send a notice to the original owner to confirm the genuineness of the PoA. In case, no objection is received within a month, the PoA holder will be automatically registered with the government as the current occupant of the land. This GR will prove beneficial to the Gujarat government’s effort regarding computerisation of land deals, as it will provide a comprehensive data of the biometric details of land owners.

A senior official from the Stamp and Registry Department states that “as many as 40 percent of all land deals have taken place on the basis of PoA. How to charge impact fee to regularise the illegal structure on a plot owned by a POA holder was something that seemed difficult to implement. The latest GR is helpful. It requires just a month’s notice for the original owner to raise objections, if any. If no objection is received, the PoA holder will be considered the landowner.” However, in the entire process, genuineness of PoA holders must be ensured by suitable means.

Various departments under land administration have responded in various ways in the past few years. The Stamp and Registration Department has made rural land records online banning manual records. There is compulsory registration in the state. Under the Registration Act, 1908 the objective was to provide a method of public registration of documents to inform people regarding their legal rights and obligations arising or affecting a particular property, and to perpetuate documents that may be of legal importance afterwards, and also to prevent fraud. It laid down what documents require compulsory registration.

4.7.5 Survey and Updating of Records
The Supreme Court has emphasised that sale of property could be done through the power of attorney but not the transfer of property. In 2011, the Government of Gujarat conducted a survey and decided the rates that are in effect now. The system of rates is called 

"jantry in
Gujarat which an elaborate register that maintains the price of land according to the area and location. While the registration system has been rendered efficient the land system needs to be improved for the adoption of title registration. *Jantry* rates and the annual statement rates were revised only last year. While other states too, are undergoing revisions, yet Gujarat’s revision has been much more detailed. Other states have circle rates like the Delhi circle rate, meaning that there is one rate for one entire area. The rates are decided according to the type of land with agricultural land (generally not seen in the cities) commanding its own price. Maps (of cities and villages) have been digitised first and foremost. Then, with the help of BISAG and CEPT grids and valley zones have been marked out on the maps. The *jantry* was made after a survey was conducted on the basis of the grids and the valley zones. This has been much more elaborated compared to what the other states have done.

The Government of India has launched a scheme nation-wide called the ‘National Land Resource Modernization Program’. The automation and integration of registration and land records is done in Gujarat. Auto notices are also generated. Auto entries as well as auto notices reach everyone within 30 days. In August 2008, it is high time to move decisively towards title registration or the Torrens System in order to create more secure private property rights than the current system.

The government official of Survey Settlement Department stated that Gujarat is the first state in the country to start this exercise. The objectives of conducting the original survey and maintaining the land record was to collect land revenue from the land holder in proportion to the area possessed. Levying land revenue from the holder has been suspended in Gujarat. Modernised land records are required not only for land revenue but also for planners of national development. Digitised and geo-referenced data obtained by modern land survey technologies including DGPS (Differential Global Positioning System) and ETS (Electronic Total Station Machine) under resurvey are expected to lead to the latest, accurate, and people-friendly digital land records. This would help eradicate the drawbacks of the present land record keeping system which, in turn, can help the government and the public maintain clear and conclusive titles of land and property (Resurvey and Modernization and Computerization of Land Records in Gujarat State, Revenue Department, Government of Gujarat).

### 4.7.6 The New Land Acquisition Policy 2010

The minister for industries stated that the GIDC wouldn’t acquire land forcefully from farmers and landowners but with their consent will be required. Land transactions would be held as per the market price. Ten percent of the profits earned by the industry would be shared with the original land owners. And once the land would have developed, one percent of its area would be given to the original owners.

### 4.7.7 ‘Participative Policy’ for Land Development in Industrial Estates

The Gujarat Government announced a novel ‘Participative Policy for Land Development in Industrial Estate’, offering a slew of incentives for the affected landowners over and above the prevailing policies or practices elsewhere in the country. The policy, termed ‘Participative Policy for Land development in Industrial Estates’, is aimed at partnering landowners with the GIDC as far as economic growth on their land is concerned. The new land development policy to be implemented by the GIDC has been necessitated by a growing demand for land required by projects signed during the four editions of Vibrant Gujarat Global Investors Summit (GSSIS). These projects are already under various stages of implementation. The new land development policy takes care of the industry demand as well as adequate compensation for the farmers selling their land.
4.7.8  **Response In Gauchar Land**

Gujarat government’s revenue department has prepared a policy draft on pastoral land (gauchar). The policy has provisions stating that no pastureland will be given for industrial or commercial purposes, that it will be insured by the government and that it will not get encroached upon against the interest of local community. The government will denotify and sell the land and develop pastures at an alternate site if the gauchar land is in the middle of an urban area. The new gauchar (pastoral) land policy will restrict the state government from selling government-owned pastoral land for industrial or commercial use. In some cases, the government has given land for some public purposes including schools. In such cases, government sells the land to such institutions and uses the money for developing new pastoral land.
CONCLUSIONS
5. CONCLUSIONS

Land is valuable asset as it provides a base to support all economic activities. Ever increasing population, agriculture, urbanisation and industrialisation are responsible for competing and conflicting demands for land. Sustainable land practices and management have been followed in the western world but no serious efforts in this direction are made in Gujarat. Further population rise, which is inevitable, will create additional pressure on land resources. Trends show there is an increase in migration towards urban centers from rural areas thereby burdening the limited natural resources.

In Gujarat, urbanisation is rapid especially in the past 50 years. Urban sprawl has been greater than 1000 percent in several cities between 1955 and 2012. This rapid urbanization has burdened and even led to the destruction of natural resources such as forests, pasturelands, etc. Besides, there has been rapid industrialisation resulting in increased pollution, which has degraded land resources. With increased population and industrialisation comes increase in wastes. Dumping of untreated domestic, hazardous and medical wastes leads to immediate and continuous degradation of soils and water resources. A growth in the built-up area has been observed exerting the pressures on the natural resource base of Gujarat. Another important factors adding pressure to land is agriculture and livestock which are required to feed the ever increasing population. Modern agricultural practices are water intensive and over exploitation of groundwater and chemical fertilizer based agricultural practices have degraded soil quality.

Land resource encompasses a variety of other natural resources and it is essential to understand the wealth of these natural resources. There has been an overall increase of forest cover in Gujarat since 1991 but a gradual decrease has been observed since 2001. Dense forest cover in all five regions of Gujarat has shown a decreasing trend since 2001. This decrease reduces forest productivity as well ecosystem services. Open forest cover has shown an increasing trend but is of lower ecosystems services. There is need to increase dense forest cover of Gujarat than open forest in order to protect the ecosystem and valuable biodiversity that the forests contains. Mangroves have shown an increase of 166 percent in the past two decades. Though there has been an increase, most of the mangrove cover comes under open forest thereby providing low ecosystem services.

Wetlands in Gujarat has shown an increase in all regions, this increase will bring about better ecosystems services and help increase the biodiversity base. Wastelands in Gujarat have seen a decreasing trend by nearly 50 percent from 1992 till 2003. This is due to the allotment of wastelands to for development related activities. Efforts need to be made to reclaim wasteland area and increase the natural resources base such as forests, pasturelands, etc. Pasturelands have been on a decline from 1960 to 2007. Many scholars have shown concerns over deficit of pasturelands for the rising livestock population. There is a need to either increase pastureland or plan proper stall feeding based on fodder cultivation for the large livestock population base available in the state.

There is high level of inconsistency among various departments on the issue of land use classification and land use data. There is a need to have a standard land use classification, which can be applied to the entire state.
Soil nutrients in Gujarat with regard to nitrogen and potassium are higher than all India levels whereas phosphorous content in the soil is low. The increase in fertiliser use might have contributed to the high nitrogen and potassium content in the soil. Micronutrient status in the soil of Gujarat is very low. North Gujarat soil is deficit in sulphur and zinc. Zinc deficiency in the Saurashtra region has increased to 40 percent in the last decade. Pesticide usage in Gujarat has shown a decreasing trend while the consumption of chemical fertilizers is showing an increasing trend. The increased use of chemical fertilisers reduces the micronutrients in the soil. In Gujarat not enough efforts are taken to increase the micronutrient status that can further increase productivity. Even the soil health card programme has only one micronutrient testing laboratory. There is a need for more of these testing laboratories and organic farming practices must be promoted to increase the soil health and sustainable agricultural practices in Gujarat. Chemical fertilizer use will lead to unproductive soil in the future and will decline agriculture productivity and its contribution to the SGDP.

About 68 percent of the total geographical area of Gujarat is under the process of land degradation and desertification. The deterioration in physical, chemical and biological functions of soil due to compaction and scaling adversely affect the productivity of agricultural crops thus affecting the livelihood of small and marginal farmers. Water erosion is the main cause of land degradation and desertification in Gujarat. The area affected by water erosion has increased whereas the area under wind erosion has decreased. Loss in productivity is the major impact of soil degradation due to increase in salinity in many parts of the coastal region. Soil erosion and nutrient depletion caused (directly) by inappropriate land management are often the main causes of decline in the ecosystem’s provisioning services.

Industrial pollution in several parts of the coastal regions of Gujarat has adversely affected the fisheries and communities dependent on it. Mining, especially stone and sand quarrying has caused depletion of water, loss of fertile top soil, degradation of forests, loss of biodiversity and adverse effects on public health. Miliolite (limestone) mining in the coastal region also contributes to increase in coastal salinity.

Groundwater over-exploitation happens to be one of the major causes of inland salinity in the state. Gujarat is witnessing high levels of salinity affecting approximately 1048 villages in an area of round 35000 km. Its 66 percent of the land area is found to be unsuitable for groundwater development. Of the 3.7 million ha of salt-affected soils in Gujarat, about 0.5 million ha are estimated as inland salinity affected area. Farmers in North Gujarat, Kutch and Saurashtra have been using saline groundwater for irrigation, increasing the severity of salinity in the region. This has led to the reduction of areas under horticulture, pulses and groundnut crops in Saurashtra and Kutch. Groundnut, which is one of the major crops, has been replaced by cotton known for its salt tolerance ability. This decrease in crop output in salinity affected coastal regions which has stimulated emigration of local communities searching for alternative livelihood options. Sardar Sarovar Project (SSP) on Narmada River including other linked schemes is envisioned to mitigate this problem.

Irrigation development and market connectivity has encouraged crop diversification leading to better livelihood opportunities for the small as well as marginal farmers. But the amount of water used per unit of land has increased due to increased cropping intensity, shift towards non-traditional water intensive crops, thereby increasing the demand for irrigation water making agricultural practices unsustainable. Irrigation with saline groundwater leads to soil salinity in several parts of the state. All these ultimately result in soil degradation leading to a
decline in land and water productivity. This reduces the economic returns from farming. The poor will be the worst affected, as economic constraints would limit their ability to invest more in farming.

Situation of land resources in Gujarat is complex. There is a need for serious efforts to increase natural resource base, promote sustainable and organic agricultural practices. Appropriate measures of land acquisition which could provide a win-win situation for all the stakeholders is need of the hour. There is also a need for increasing the number of common hazardous incineration facilities and common effluent treatment facility as land allotted to SEZ, SIR and GIDC estates are large and the increase in the number of industries many fold in Gujarat is likely to generate more wastes. Establishment of Gujarat Urban Development Company was done to look into affairs of solid waste management. However, solid waste management system must be further modernised.

Some efforts have been made by the Government to reduce these impacts. The initiatives worth noting are looking at increasing agricultural productivity and ensure land tenure security. Gujarat’s high growth in agriculture has drawn a lot of attention from agricultural planners and policy makers. Such remarkable results were possible due to meticulously planned and coordinated schemes of action that ensured eight hours of uninterrupted electricity supply in agricultural fields across the state (under the Jyotigram scheme), water conservation and management including watershed development, construction of recharge structures, micro-irrigation, inter-linking of rivers, the creation of marketing infrastructure among other things. The soil health card programme is also once such initiative that tries to increase land productivity by looking at improving soil health. Twenty soil testing laboratories covering all the districts of the state provides free of charge testing facilities to the farmers. On the basis of soil test analysis report, soil health cards were prepared with maintaining computerized data of soil test, fertilizers recommendation, reclamation of soil, crop planning etc. Another capacity building initiative to increase sustainable agricultural practices worth, further promoting is the Krishi Mahotsava, where farmers with researchers, scientists, experts, agriculture officers and ministers, interacting and providing information and counseling on soil health, organic farming, modern technology, agricultural inputs, irrigation, etc., besides infusing a new spirit of change and mass mobilization. Gujarat’s forest cover is low as compared to the national average. Mission mode in social forestry and joint forest management (JFM) could help to improve forest cover. Several NGOs have also been active along with communities in the JFM programme of Gujarat. Awareness programmes have also been initiated by the Gujarat Ecology Commission and the Forest Department of Gujarat to communicate and share the benefits that can be derived and livelihood support can be gained from the forest ecosystems.

Looking at efforts in the mining and waste sector Gujarat Ecology Society has undertaken the study, “ecological restoration of mining sites of Gujarat” at the behest of the Gujarat Mineral Development Corporation to step up the protection and conservation of natural environment in mining areas. This is a small initiative that needs to be scaled up as Gujarat is a state with the second largest mining leases in the country.

To ensure security and land tenure/possession, Government has done extensive work and is a leader in land administration in India. Gujarat has established village information system. This provides detailed information pertaining to demography, infrastructure and natural resources for every village, district and state. ‘e-Dhara’ – land records management system records any changes such as brought on by sale, inheritance, hire, and distribution, etc. ‘e-
Vishwagram’ project is for computerization of different types of certificates birth, death, property, residence proof, land ownership, etc. This project has reduced waiting period for certificates and these are available at nominal fees at doorstep. Survey of records is being conducted, which would also help in setting up fair land prices. The National Land Resource Modernization Program launched by the government has incorporated updating of records through automation and integration of registration and land records. Since about 62 percent of the state’s area falls within the influence area of DMIC, special agricultural zones (SAZs), in the line of SEZs should be created in the areas of fertile agricultural lands in DMIC. Farmer’s collectives should be encouraged to take part in SAZs. In Gujarat’s Land Acquisition Act of 1961 there are loops holes that industries use to their favour. There is a need for public debate on the issues of an appropriate act on land acquisition and resettlement.

There is a need for a dynamic and scientifically advanced land use and land records management system to better govern the land resources. Advanced scientific tools should be used for land use mapping. The standard land use classification system should be adopted by the departments dealing with the land issues. There must have a land use policy with could reconcile the ecological, economic and equity dimensions prevailing in the state.
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# Annexure

**List of Participants of the Stakeholders Consultation**

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