Study of Saltpan Increment in Gulf of Cambay using GIS.

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Abstract:

In recent years, the country's coastal stretches have become a pressure point for indiscriminate and unsustainable development pressures. Satellite data and Geographic information system provide an enviable tool of huge potential. Gujarat is one of the largest salt producing State in India. The coast of the Gulf of Cambay of Gujarat is enclosed by a number of estuaries, mud flats, salt marshes, islands, cliffs and mangrove forests. A study was carried out using IRS 1C/1D LISS III imageries to delineate changes in saltpan over the period of time of year 1995 to 2003. ERDASIMAGINE 8.7 and ArcGIS 9 software were used. Also supervised classification was done to study various landuse and landcover changes. There was remarkable increment in saltpans, 53.91 Km^2 from the year 1995 to 2000, 22.56 Km^2 in 2000-2001 and 35.73 Km^2 in 2001-2003. Coastal villages face problems due to devastation of natural habitats.

Introduction

Coastal Zone is always on the forefront of civilization and has been by far the most exploited geomorphical unit of earth. Its easy access and resourcefulness have always attracted human activities, but its complexity in understanding has led to misuse and abuse. In recent years, the country's coastal stretches have become a pressure point for indiscriminate and unsustainable development pressures. The coastal zone - the land that extends from the beginning of the coastal plain to the beginning of the continental shelf - occupies only a marginal portion of the country's territory yet it is home to a disproportionately large section of the population. And the numbers are ever on the increase. The coastal zone of world is under increasing pressure due to high rate of human population growth, development of various industries, fishing, mining, discharge of municipal sewage and industrial waste effluents. This industrial development on coast has resulted in degradation of coastal ecosystems and diminishing the living resources. Coastal area is vital to the prosperity of the country and are biologically most productive area, supporting wealth of living marine resources. The coastal areas are also facing serious problems such as erosion, siltation, over population, salt water incursion, flooding, pollution, devastation of natural habitats to name a few. Thus there is urgent need to conserve the coastal ecosystems and habitats by implementing the coastal regulation zone notification and integrated coastal zone management study.

In view of above-mentioned facts generation of sound database for the coastal zone requires collection of enormous field data. Conventional ways of data collection are laborious, expensive and present a picture of only a small area. On the other hand satellite remote sensing with its synoptivity, repetitivity, and wide area coverage has proved to be extremely useful in obtaining information on various components of the coastal environment such as wetland, mangrove degradation, coastal landforms, shoreline changes, tidal boundaries, suspended sediment dynamics, coastal current, oil pollution etc. Using satellite data the brackishwater areas such as estuaries, lagoons, backwaters with their marshy tract and mudflats can be recognized (Desai. *et al*.2000). While visual interpretation of satellite imagery can be advantageously employed to obtain details on wetland categories, it has limitations for deriving turbidity levels of coastal waters. Digital analyses of satellite data by virtue of its use of spectral information provide an enviable tool of huge potential. Geographic Information System (GIS) is designed to bring varied data together in a form that allows efficient statistical and geographic analysis. GIS permits user to efficiently use the integrated data storage and data processing and updating capability to serve the need of problem identification by demarcating it on map, get statistical understanding, provide futuristic statements or prediction and predict the actions needed in problem solving, abetting or providing protection.

Gujarat is the largest salt producing State in India accounting for around 80-85 lakh metric tonnes of the national salt production of around 110 lakh metric tonnes annually. The main salt production season begins in the month of November and is upto the month of March, often extending upto the month of June. There are more than 1600 salt producing units and few iodizing plants in Gujarat alone. The production units vary in sizes of 10 to 100 acres plots, 100 to 500 acres and more than 500 acres plots. The individuals, cooperative societies and the bigger private companies own these salt pans. Landless people belonging to socially and economically backward castes and communities are compelled to work on salt pans as seasonal laborers in the absence of better income generation opportunities. The remotely sensed imageries used for this study are IRS 1B/1C LISS II and LISS III of year 1995, 2000, 2001 and 2003 of Gulf of Khambat.

Study Area

Gulf of Cambay, also called Gulf of Khambhat, trumpet shaped gulf of Arabian Sea, indenting northward of the coast of Gujarat state, western India, is selected as the study area (Figure. 1). The geographical coverage of the study area is as follows:

Latitude N 21^{o} 33’ 00” to 22^{o} 05’ 03”

Longitude E 72^{o} 11’ 24” to 72^{o} 40’ 12

The Gulf comprises an area of high tides and is characterized by domination of strong tidal currents. The tidal current directions during flood and ebb tides follow almost identical paths and reflect bathymetric features of the gulf. The tidal currents have mainly been responsible for most of the depositional and erosional features of the gulf. The topography of the gulf bottom comprises numerous underwater ridges, deep channels and shoals.

The coast of the Gulf of Cambay is enclosed by a number of estuaries, mud flats, salt marshes, islands, cliffs and mangrove forests. The Gulf is characterized by a number of large and small estuaries appearing as if enclosed within a large one. All major estuaries like the Tapi, the Narmada, the Mahi, the Sabarmati, the Kim and Dhadar are marked by funnel shaped outline and tidal meanders. The estuaries are classified into salt –wedge estuary, fully mixed estuary and partially mixed estuary. The low islands in the mouth of the estuaries have smooth outline, normally above the high water line.

Extensive mudflats, 6-8 km wide have developed all along the coast except along the coast of Narmada estuary. These mudflats are classified on the basis of their relation with tidal condition into sub tidal, intertidal and the high tidal flats. The sub tidal zone is exposed during very low tide. The intertidal zone lie between high water and mean low water mark while the high tidal flats lie above the mean high water marks. The tides in the Gulf of cambay are typical semi-diurnal types having a very high tidal range, up to high as 12m at some locations. The large tidal variations in Gulf of Cambay cause strong tidal currents during both, the flood and the ebb tides. These strong currents are responsible for most of the depositional and erosional features. The velocity of the currents is reported to be as high as 8 to 9 knots during peak tidal propagation, but most of the times it is between 3 and 5 knots.

Methodology

Satellite data processing and information extraction

Geometric correction is applied to raw data to correct errors of the perspective due to the earth's curvature and sensor motion. Polynomial rectification is the process of transforming the data from one grid system using an nth order polynomial. Since the pixel of new grid may not align with the pixels of the original grid, the pixel must be resampled which is the process of extrapolating data values for the pixels on the new grid from the values of the source pixels. (ERDAS,1999).

In this present work rectification process for the images dated 2003 was based on the rectified reference image of 2001, which was georefereced and resample earlier. All the images were projected UTM zone 43 of Northern hemisphere and Modified Everest as datum with units in meters (Figure. 2).

Also district and taluka level maps with village information were created using ARSGIS (Map1 and Map2).

Multispectral Image classification

Multispectral classification of imagery of 1995, 2000, 2001 and 2003 was done using maximum likelihood supervised classification 7 classes of land use and land cover were generated (Map 3, 4, 5 and 6). Training sites were selected according to classes. For classification signatures were assigned using signature editor. The following land use categories were identified: Mangrove, Water, Agricultural land, Mudflats and reclaimed mudflats, Salt pan, Salt affected land, Water bodies (Singh, 1989).

Overlay

Classified images were then imported to ArcGIS where saltpans were digitized as polygon theme for year 1995, 2000, 2001 and 2003. Then the polygon were cleaned and built.

In order to find out areas of increment in saltpans the polygon themes of following year were overlaid using ArcGIS.

Results and Discussion

Using ArcGIS overaly was done for saltpan polygon for the year 1995, 2000, 2001 and 2003 (Map 7). Increment in the saltpan was found to be 53.91 sq km for the year 1995 to 2000. For the year 2000-2001 increment was found to be 22.56 sq km. Also vector overlay showed increment of 35.73 sq km for the year 2001-2003 (Table 2).

Due to the very high tides, large coastal plains, good spreading of seawater and a very hard working sun, large tracts had salt encrustations for centuries in this region. Hence, salt is traditionally collected and commercially sold by the people. The salt was not only edible, it also had many good chemicals and the Government even set up a national institute for research into the salts. A few enterprising local people easily recognized the potential of salt and they set up large salt farms in the coastal plains. These salt farms started close to tidal creeks from where seawater could be pumped in and spread over large tracts. When the plains near to tidal creeks were no more available, lands a little farther were also bought up for salt farming. The 50 m aquifer was known to be salty while the deeper one was better and potable. Pumps are set up to draw water from the shallow aquifer and the ground water replaced the tidal water in many salt farms. As more and more water was drawn from the ground over the years, ground water turned saltier and even the deeper layers turned salty. The 250-mg/L chloride isoline migrated miles away from the coast and people adapted themselves to drinking water with high chloride . In many villages near the coast, even that water became unavailable. Now, every drop of water has a pinch more of salt. It was also observed from ground truthing that in 'Bhavnagar bhal' (Bhavnagar dry lands), agriculture is nearly non-existent. It was also observed that there are changes in landuse and landcover of this region . Mangrove showed increasing trend from 1995-2000 & then decreased in 2001. Conditions are ideal for mangrove afforestation in Bhavnagar & in 2003 it showed growth of 28 Sq. Km. Salt pans have increased area over the years 1995 to 2003. The area showed increase in agricultural land with reclaimed mud flats.

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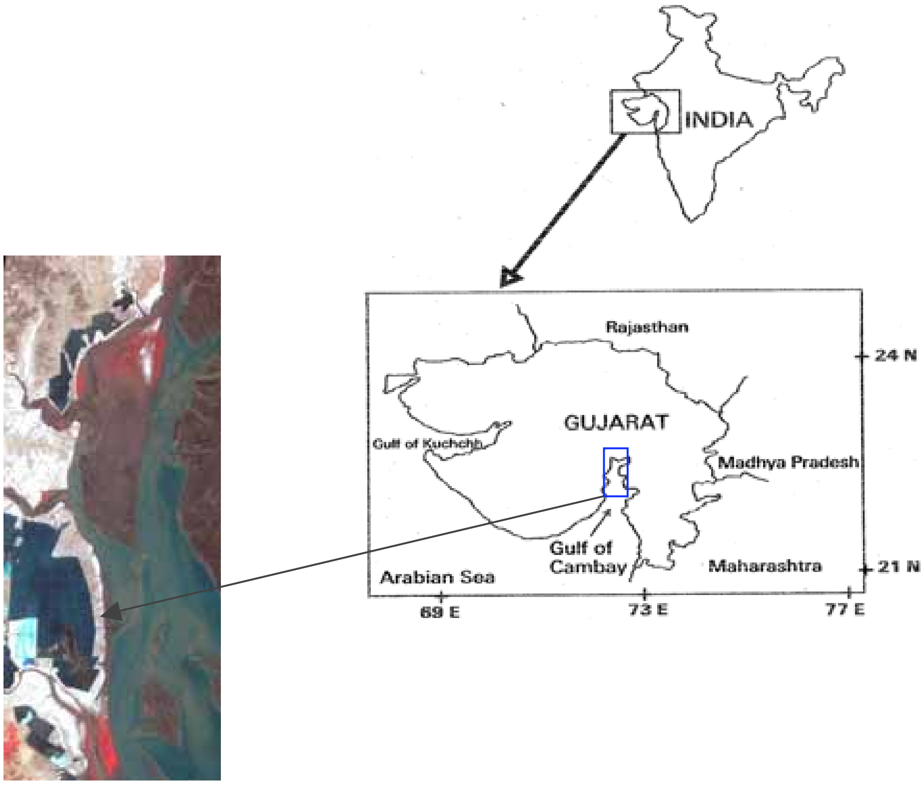


Figure 1. Figure showing Geographical position of the area of study

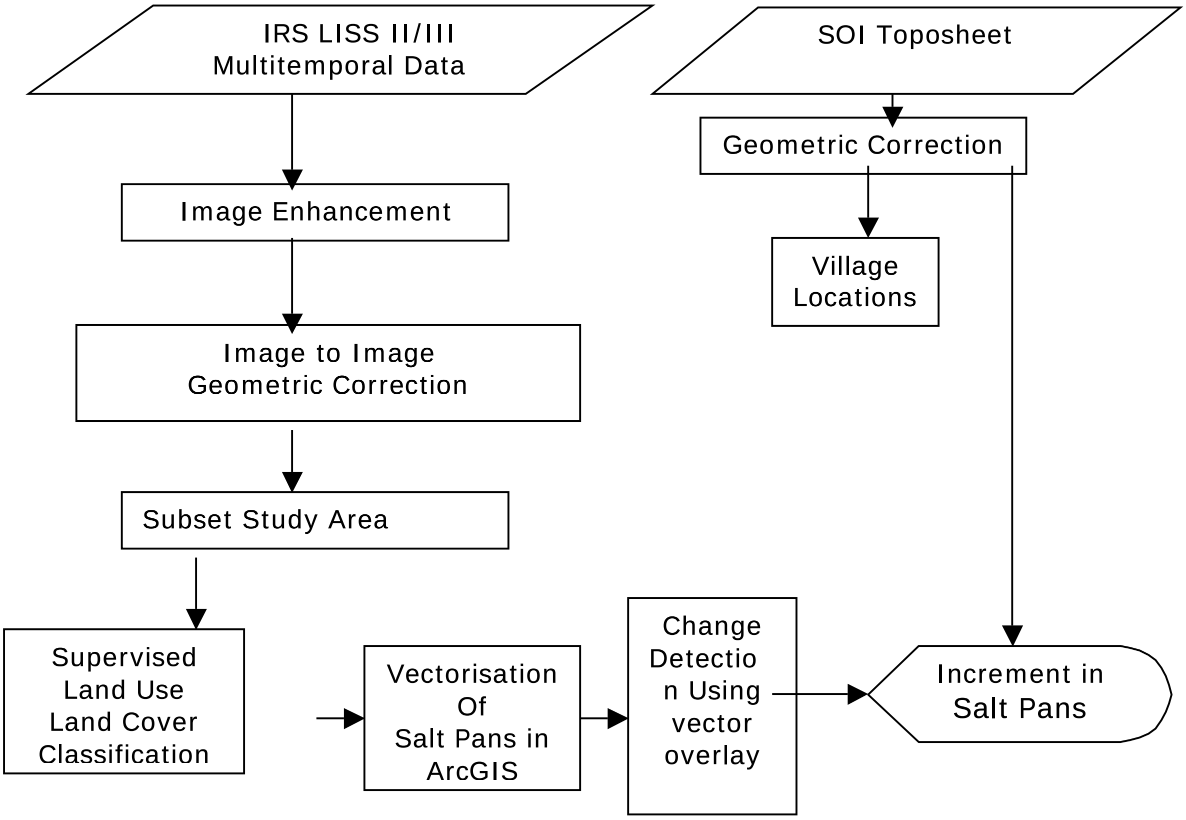
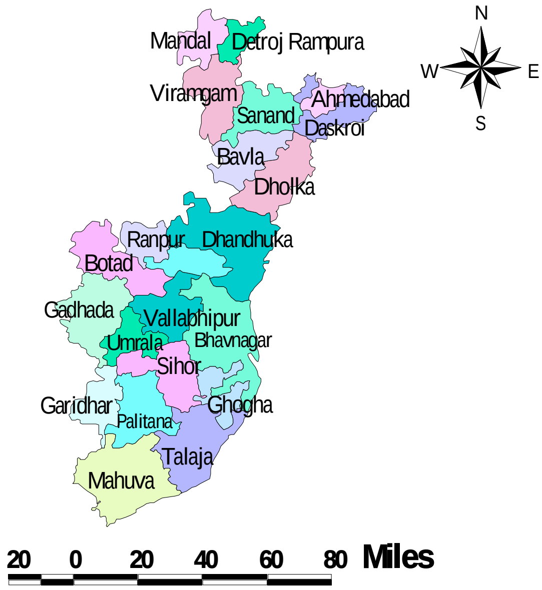


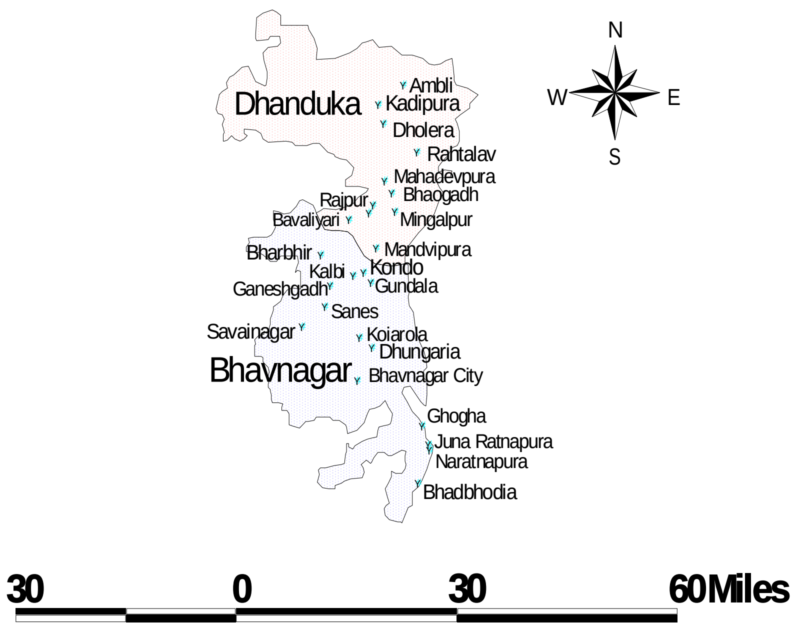
Figure.2 Flow diagram of methodology

Talukas of the Bhavnagar and Ahmedabad Districts



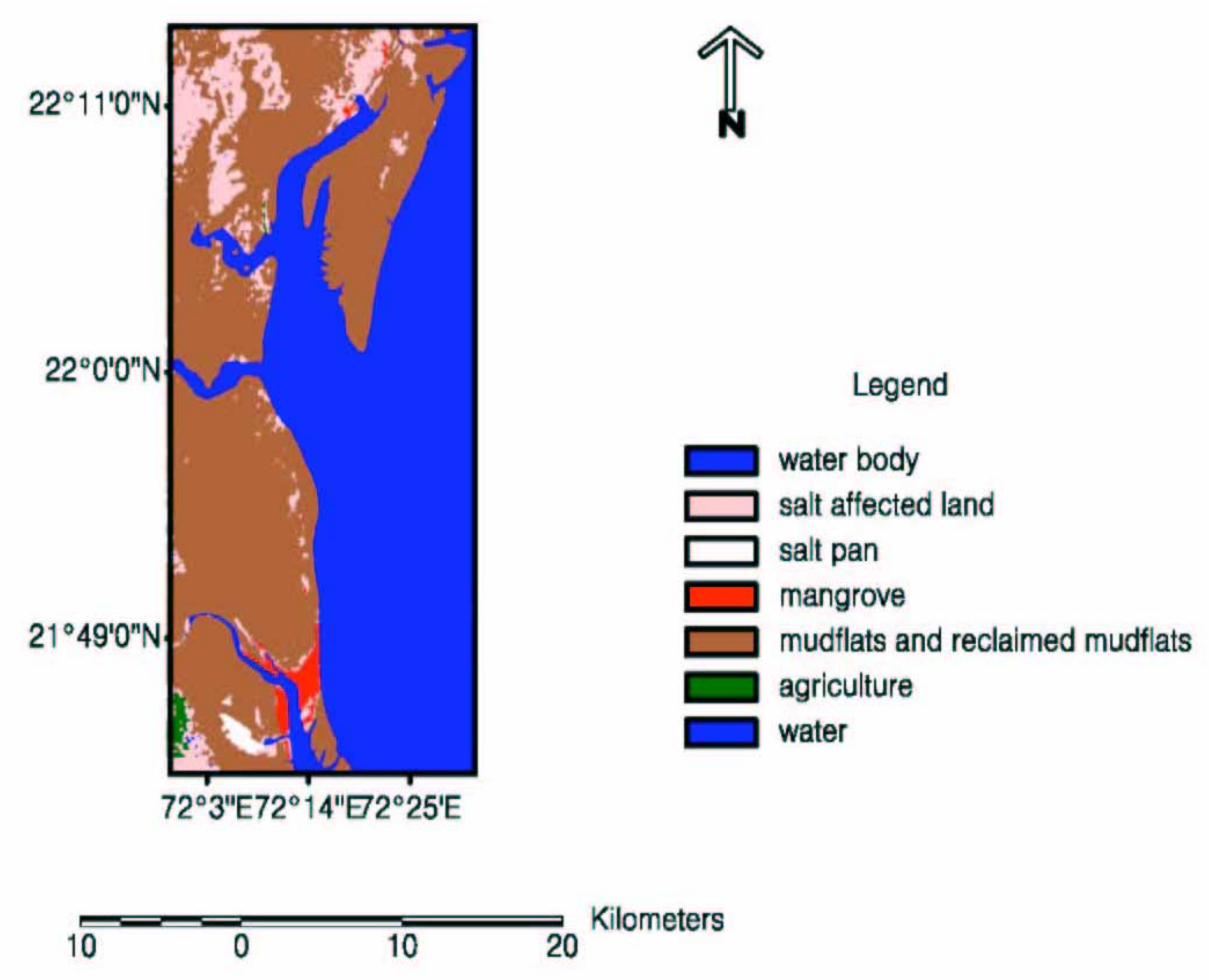
Map 1.

Coastal Villages in Area of Study

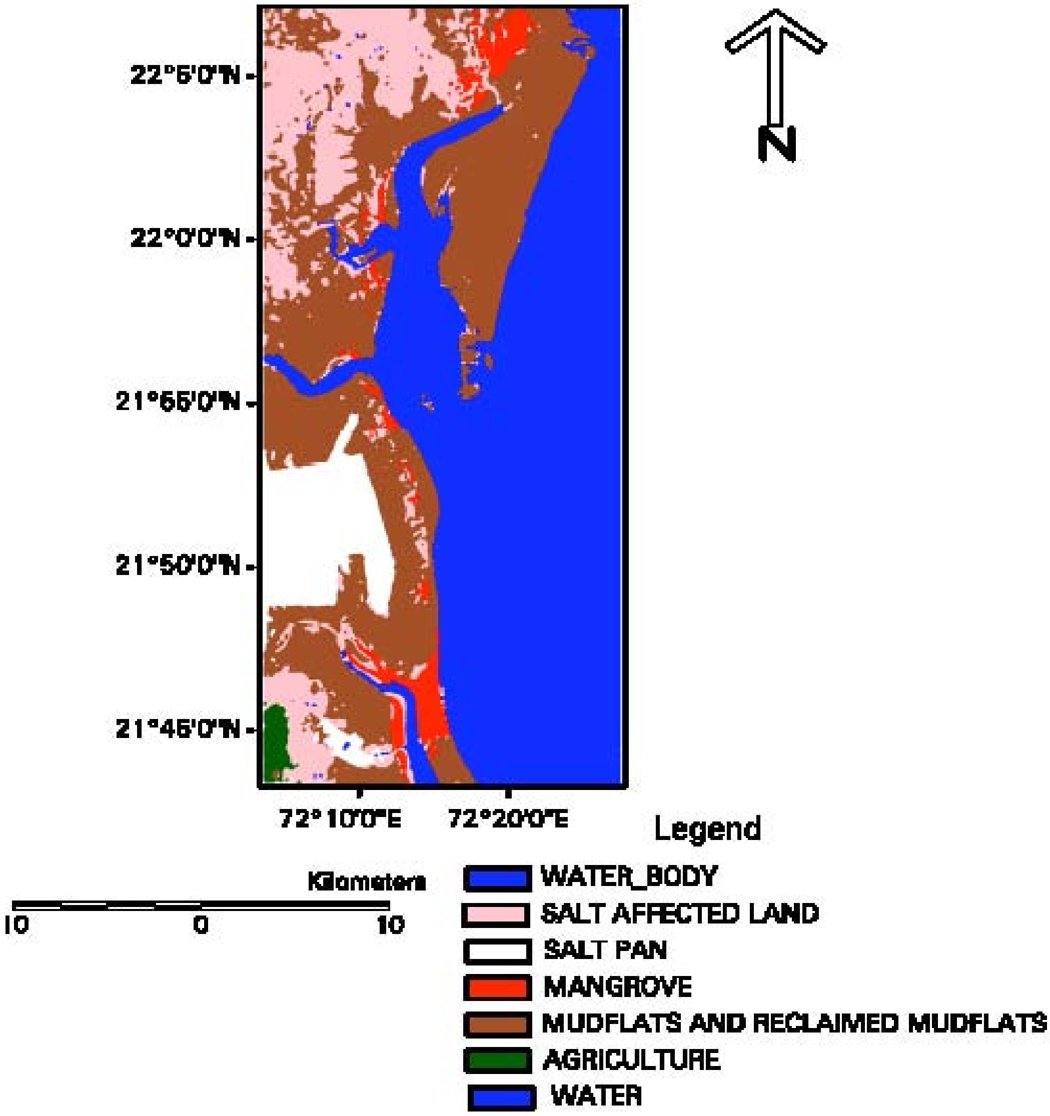


Map 2.

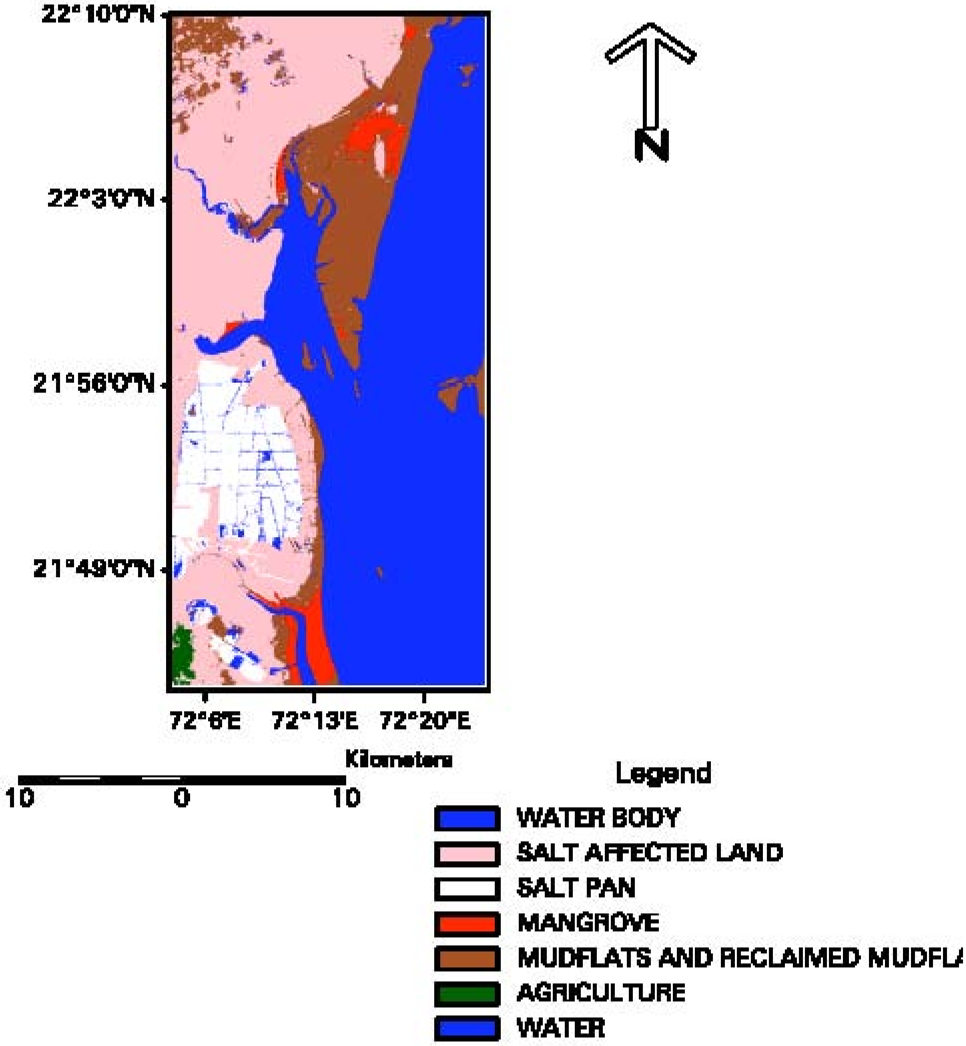
Map 3. Landuse and Landcover classification (1995)



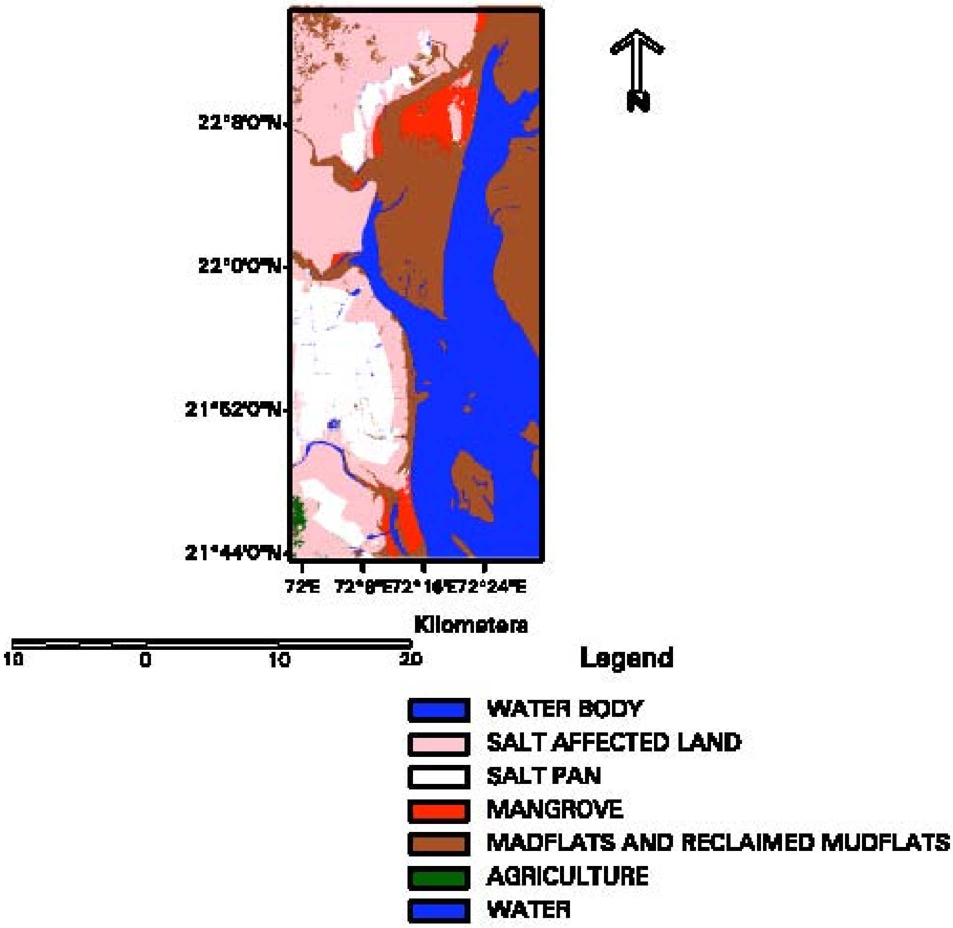
Map 4. Landuse and Landcover classification (2000)



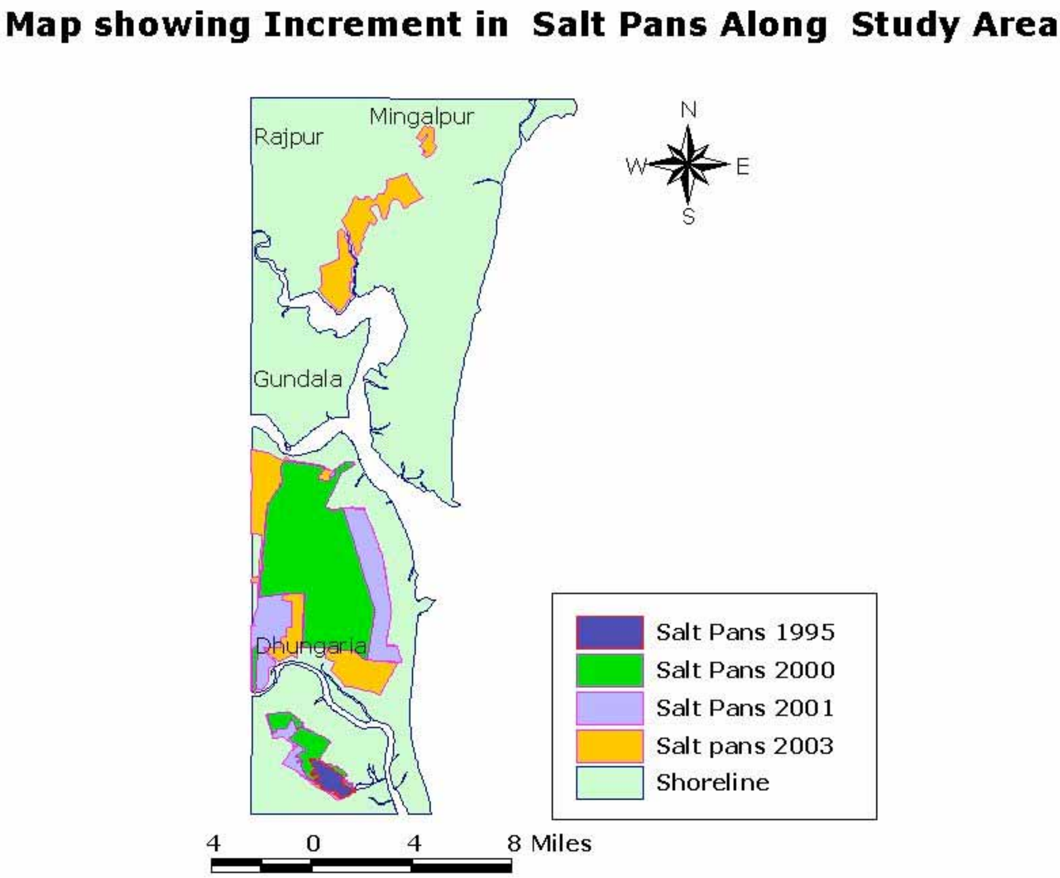
Map 5. Landuse and Landcover classification (2001)



Map 6. Landuse and Landcover classification (2003)



Map 7.



These are the increment of salt pans in the years 1995, 2000, 2001 and 2003

Table 1. Landuse and landcover changes along study area using change detection

Class	1995 Sq. Km	2000 Sq. Km	2001 Sq. Km	2003 Sq. Km
Water	881.06	352.58	319.07	215.05
Salt affected land	142.54	178.65	221.13	188.89
Salt pan	6.84	58.79	78.64	112.32
Mangrove	19.78	24.97	18.17	28.85
Agriculture	9.56	8.77	4.32	14.49
Mud Flats and reclaimed Mudflats	818.53	137.85	100.39	203.35

Table 2: Increment in Salt pan Area along Study area using overlay function

Year	Increment (Sq Km)
1995-2000	53.9138602
2000-2001	22.56937415
2001-2003	35.73120757