SHORE LINE CHANGE ATLAS OF THE INDIAN COAST

(Volume-II)

Maharashtra and Goa

SPACE APPLICATIONS CENTRE, ISRO
Ahmedabad

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Abstract	This Atlas comprises of shoreline change maps prepared using satellite data of 2004-06 and 2014-16 time-frames on 1:25,000 scale for the entire country (Volume – II shows maps of Maharashtra and Goa). The maps show eroding, stable and accreting areas of the coast. Data used, methodology, results, area under erosion and accretion and status of coastal protection measures are briefly described. Around 589 km of the Maharashtra coast is stable in nature, while erosion is estimated along 75 km and accretion along 60 km. Due to the deposition Maharashtra is estimated to have gained an area of 210 ha of land while due to erosion an area of 105 ha is lost. In Goa, 117 km of the coast is stable, while erosion is along 22 km and 7 km of the coast is accreting. Area of lost due to erosion is around 29 ha for Goa and the area that have accreted is about 14 ha.
Keywords	Shoreline change map, erosion, accretion, stable coast, coastal protection measures.
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PROJECT TEAM

Shri Ratheesh Ramakrishnan
Ms. Preeti Rajput
Shri Hiren Bhatti
Shri Sudhanshu Raghubanshi
Ms. Samarpita Sarkar
Dr. A.S Rajawat
Dr. D. Ram Rajak

Map Quality Check Team

Shri T.V.R Murthy
Shri J.G Patel
Shri R.J Bhanderi
Shri B.P Rathore
Shri Manish Parmar

एस. के. हालदार
अध्यक्ष
तथा पदेन सचिव, भारत सरकार
S. K. HALDAR
CHAIRMAN
& *ex-officio* Secretary
to the Government of India

सत्यमेव जयते

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग,
केन्द्रीय जल आयोग
Government of India
Ministry of Jal Shakti
Deptt. of Water Resources,
River Development and Ganga Rejuvenation,
Central Water Commission

MESSAGE

The Coastal Zone represents a complex environmental entity, which is in constant interaction with the marine and terrestrial processes. The coastal zone has been receiving increased attention due to the immense anthropogenic pressure and inevitable development activities related to trade and transport. The coast is bestowed with rich bio-diversity and fragile ecosystems like mangroves and coral reefs that are highly sensitive to any climatic and environmental changes.

The coastal region, due to the influence of natural and anthropogenic forces and the sporadic events like cyclones undergo severe erosions leading to loss of human livelihood and crucial biodiversity besides critically damaging the coastal constructions and aesthetic quality that attracts huge economic benefits. Quantifying coastal change is essential for calculating trends in erosion, evaluating processes that shape coastal landscapes and predicting the response of coast to future storms and sea-level rise.The dynamic natures of the coast prompt for frequent monitoring and comprehending the coastal erosion activities. Space technology has been effectively deployed in identification and measurement of such activities.

Space Applications Centre (SAC) in collaboration with a large number of scientific organization & universities of the country has carried out various scientific investigation/inventory of the entire coastal zone of India using satellite data like impact of sea level rise on the Indian coastal environment, development of Coastal Zone Information System (CZIS), mapping and monitoring of coral reefs and mangroves, inventory of the coastal land use etc. One such significant work was preparation of Shoreline Change Atlas of India for the time frame 1989-91 and 2004-06.

The present Shoreline Change Atlas is an outcome of the shoreline change mapped for the entire Indian coast between the time frames of 2004-06 and 2014-16 carried out by Space Applications Centre, ISRO, Ahmedabad based on recommendation of Coastal Protection and Development Advisory Committee (CPDAC) at the request of Central Water Commission, Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, Government of India.

I congratulate the team of scientists for carrying out such an important study for the entire Indian coast. This study assumes greater significance in the context of planning shoreline protection measures to be constructed by various maritime States and UTs. I am sure this atlas will be highly useful not only to the coastal zone managers and to the authorities involved but also to the scientific community working in the coastal environment and climate change studies.

(S.K. Haldar)
Chairman
Central Water Commission

द्वितीय तल (द), सेवा भवन
आर. के. पुरम, नई दिल्ली-110066
दूरभाष : 011-26715351, 26195415
फैक्स : 011-26108614

2nd Floor (S), Sewa Bhawan
R. K. Puram, New Delhi-110066
Tel. : 011-26715351, 26195415
Fax : 011-26108614
Email : chairman-cwc@nic.in

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भारत सरकार GOVERNMENT OF INDIA
अंतरिक्ष विभाग DEPARTMENT OF SPACE
अंतरिक्ष उपयोग केंद्र
SPACE APPLICATIONS CENTRE
अहमदाबाद AHMEDABAD - 380 015
(भारत) / (INDIA)
दूरभाष / PHONE : +91-79-26913344, 26928401
फैक्स / FAX : +91-79-26915843
ई-मेल / E-mail : director@sac.isro.gov.in

एन एम देसाई / N M Desai
विशिष्ट वैज्ञानिक/Distinguished Scientist
निदेशक / Director

FOREWORD

Coastal zone is one of the most fragile ecosystems having rich biodiversity and is characterised by constant interactions between various natural processes and human activities. Human interventions along the global coastal zones are profoundly increasing and may lead to disastrous consequences, if developmental activities are carried out with improper understanding of the coastal processes. In addition, the coastal ecosystems are also vulnerable to natural phenomena such as waves, tides, storm surges, erosion etc.

India has more than 7500 km. long coastline with diverse coastal ecosystem and hence, Coastal Zone in India, assumes its importance, more so because of high population pressure, development of various industries, spurt in recreational activities, exploitation of renewable and non-renewable natural resources, discharge of waste effluents and municipal sewage etc. The Indian shoreline is also dotted with vital coastal habitats like mangrove and coral reefs, ecological sensitive and biologically diverse regions and archaeologically and culturally important places. The natural and anthropogenic activities change the equilibrium of sediment transport along the coast and induce coastal erosion, thereby threating the valuable resources. In view of its dynamic nature, frequent monitoring of the coast is also required and that can be achieved only through satellite based methods.

In India, the use of satellite data for coastal zone studies have been initiated by Space Applications Centre (SAC), ISRO, Ahmedabad in collaboration with various scientific organisations and universities across the country. For the past 30 years, SAC has been engaged in conducting various national level programmes aimed at detailed scientific investigations and preparing inventory of the entire coastal zone of India. I am happy to know that geo-sciences team at SAC/ISRO has completed Indian coastal shoreline change analysis (for 2004-06 and 2014-16 time frames) using Resourcesat-1&2 LISS-IV data and publishing these maps in the form of an atlas in six (6) volumes.

I am sure, this 6-volume atlas will be useful to the scientific community and decision makers in investigating the coastal challenges as well as for taking appropriate actions to protect the Indian coast, which will go a long way in conserving the coastal environment of the country. I would like to place on record my deep appreciation for all those scientists and support staff, who have made contributions for the successful execution of this project.

16/08/2021

(एन एम देसाई) / (N M Desai)
निदेशक / Director

Place: Ahmedabad
Date: 16 August 2021

भारत सरकार
अंतरिक्ष विभाग
अंतरिक्ष उपयोग केन्द्र
आंबावाडी विस्तार डाक घर,
अहमदाबाद-380 015. (भारत)
दूरभाष : +91-79-26913050, 26913060
वेबसाईट : www.sac.isro.gov.in/www.sac.gov.in

Government of India
Department of Space
SPACE APPLICATIONS CENTRE
Ambawadi Vistar P.O.
Ahmedabad - 380 015. (INDIA)
Telephone : +91-79-26913050, 26913060
website : www.sac.isro.gov.in/www.sac.gov.in

I M Bahuguna
Deputy Director, EPSA

PREFACE

Coastal regions of the world undergo a continuous process of erosion & accretion due to natural reasons and anthropogenic as well. The climatic change and consequently the rise in sea level is likely to be one of the major factors causing coastal erosion and accretion in the near future. The risks and hazards arising due to coastal erosion have raised a serious concern for the Indian coastal regions too, as a large population survives on the economy of its resources. Coastal erosion and accretion are reflected as the shift in the shoreline. Hence, a systematic and repetitive inventory and monitoring of shoreline change are the pre-requisite for a proper coastal management and forms the baseline data to carry out coastal protection measures by the maritime States and Union Territories besides its use by the scientific community.

Space Applications Centre (ISRO) had brought out Atlas of maps showing shoreline changes for the entire Indian coast between time frame 1989–1991 and 2004–2006 at 1:25,000 scale. The project was funded by Coastal Management Directorate, Central Water Commission, Ministry of Water Resources, New Delhi. Coastal Protection and Development Advisory Committee (apex body concerned with planning of coastal protection measures at the national level in India) requested Space Applications Centre to update the existing shoreline change maps using recent satellite data (2014-16 time frame) for assessing status of coastal erosion. The mapping has been completed at 1:25,000 scale using IRS LISS IV data and changes in shoreline have been brought out between 2004-06 and 2014-16 time frame.

The atlas also shows location and type of coastal protection measures taken up by maritime states and UTs based on the data provided. The atlas has been brought out in six volumes covering the entire Indian coastline. Six volumes contain 618 maps prepared covering 7549 km of the Indian coastline. The maps suggest that about 1144 km is under erosion, 1084 km is under accretion and 5321 km of the coastline has been observed showing no change.

I congratulate the entire team specially Mr. Ratheesh Ramakrishnan, Scientist SF and Mrs. Preeti Rajput, Scientist SD of Space Applications Centre, ISRO Ahmedabad.

(I M Bahuguna)

SUMMARY

Shoreline is a dynamic geomorphological entity that coincides with the physical interface of land and ocean. The shoreline responds to the coastal processes exerted by waves, tides, nearshore currents and the resultant sediment transport and the pressure exerted by anthropogenic influences. The equilibrium in the sediment supply gets disturbed due to either natural phenomena or human intervention causing shoreline changes. The shoreline changes are attributed as erosion (accretion), where the shoreline shift landwards (seawards). The change in shoreline positions are of essential importance to the coastal scientists, engineers and managements, where the shoreline change information is required in the design of any sustainable management plans.

Coastal erosion ails threat to the life and livelihood along the shoreline, destroying settlements and infrastructures like road and pose major hazard to the ecologically sensitive habitats like mangroves and turtle nesting grounds. Coastal erosion, as in other maritime countries, is a serious problem along the Indian coast. India forms a peninsula and has a long coast on its east and west regions with varied coastal processes dominating the coastal dynamics. The Indian coast is relentlessly modified by the mounting development activities along the coastal region, which under improper management at times leads to severe coastal erosion.

Inventory related to coastal erosion are a pre-requisite in understanding the coastal dynamics of the region. Planning measures for sustainable development along the coastal region require a systematic inventory of shoreline changes. In this view, Space Applications Centre in collaboration with Central Water Commission, mapped the shoreline changes for the time frame 1989-91 and 2004-06 on 1:25, 000 scale for the entire Indian coast based on multidate remote sensing data in GIS environment. The database were then used to generate A3 size Shoreline Change Atlas of all the maritime states of India. Central Water Commission requested to update the existing shoreline change maps (1989-91 & 2004-06 time-frame) using the satellite data of 2014-16 time-frame. The major objective was to prepare digital shoreline change atlas on 1:25, 000 scale in GIS environment using the shoreline delineated for the time-frame 2004-06 and 2014-16, depict and quantify shoreline changes as eroding/accreting/stable, show status of shoreline protection measures taken by respective states.

Assessment of shoreline change using satellite images have gained its applicability owing to the synoptic observations covering a large spatial scale and its availability in temporal domain. LISS-4 images of 2014-16 (on board Resourcesat-2) and 2004-06 (on board IRS P6) time-frames

have been used to delineate the shoreline for entire Indian coast. The high tide line (HTL) is considered as the shoreline and on-screen digitization of the HTL has been carried out based on the geomorphic indicators.

The shoreline change status along 7549 km of the Indian coast is assessed that excludes river/creek mouths. About 1144 km of the Indian coast is under erosion, while 1084 km of the coast is accreting and the coastline is observed to be stable along 5321 km. The Indian coastal region have in total lost around 3680 ha of land due to erosion whereas around 4042 ha of area have been gained due to accretion. West Bengal coast is having around 35 percentage of its coast under erosion, which is the largest among the Indian coastal state and percentage of shoreline under accretion is the largest for Andhra Pradesh state (26%). Percentage of stable coast is largest along the Gujarat coast (87%) followed by the Lakshadweep Islands (82%), while more than 57 percentage of the West Bengal coast is under either erosion or accretion. A long coastal stretch to the northern Andhra Pradesh coast is eroding whereas a long coastal stretch along the Saurashtra coast of Gujarat is stable in nature.

The major natural processes involved in the coastal erosion are the wave induced erosion and littoral drift. Alongshore shift of inlets are observed due to growth of spits and erosion at the other side and is dominant at Chilika inlet, Odisha and Mulki-Pavanje Estuary, Karnataka. The processes of longshore sediment transport occurring naturally along the coasts are highly altered by the constructions of breakwaters and have triggered coastal erosion due to obstruction of the littoral drift. Sand mining and land reclamation are the other anthropogenic activities altering the sediment dynamics and triggering coastal erosion. Andaman and Nicobar Island is observed to have critical shoreline changes, where the coast is regaining the equilibrium after the subsidence, uplift and erosion due to tsunami associated with the 2004 mega earthquake. The inventory along with current status of coastal protection measures taken up by concerned state departments has been used to prepare a Shoreline Change Atlas of the Indian Coast.

The baseline data are aimed towards initiating appropriate action by concerned Maritime states and UTs besides use by the scientific community as well decision makers of the country. The Atlas shall function as a reference material to obtain information on the status of shoreline changes during 2004-06 and 2014-16 time-frames along entire Indian coastline. Areas under coastal erosion and status of coastal protection measures taken up by respective maritime State and Union Territory are depicted and can be used for planning coastal protection measures.

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1. INTRODUCTION

The coastal zone is in constant interaction between various natural processes and human activities that leads to a modification of its geomorphology. Coastal zone in India assumes its importance due the presence of fragile ecosystems and its interaction with anthropogenic activities. The coast is also subjected to exploitation of natural resources and is used as a medium for discharge of waste effluent and municipal sewages. The coastal regions are also overburdened with mounting developmental activities, increasing load on harbours, spurt in recreational activities and above all petroleum exploration activities.

Shoreline is a dynamic geomorphological entity, which responds to the external forces exerted by waves, tides, nearshore currents and the resultant sediment transport. When the resultant sediment transport entering a particular area is greater than the sediment going out from the area, accretion or beach development takes place. On the other hand, when there is a deficit of the incoming sediment supply into a particular area with reference to the sediment going out of the same area, beach erosion takes place. The equilibrium in the sediment supply is fairly maintained by the coastal geomorphic environment. However, sometimes this equilibrium gets disturbed due to either natural phenomena or human intervention. Natural phenomenon like intense wave activities during monsoon, cyclones and changes in river mouth during flood conditions contributes towards disrupting the equilibrium, while construction of coastal structures like breakwaters, dam construction in the rivers are the human interventions

India has a long shoreline of about 7500 km including its island territories. The destruction and loss of land due to erosion is a severe problem, particularly for a country like India facing an increased population growth. Erosion of the coastal region poses a major threat not only to the human population, but also to the vital coastal ecosystem. The dynamic interaction between nearshore features and the hydrodynamics of the region, termed as coastal processes, determines the stability of the adjacent shoreline. Moreover, various developments along the coast enhance the changes in the shoreline. Indian coast forms a peninsula and has a long coast on its east and west regions with varied coastal processes dominating the coastal dynamics. These include tide-

dominated regions along the northern parts of the west coast, open coast with high wave energy along the southern parts of the west coast, strong longshore sediment transport along the southern parts of the east coast and the coast strongly influenced with river discharges along the northern parts of the east coast. The coastal geomorphology and the land-use pattern along the Indian coast also show a varied range, which includes coral reefs, mangrove belts, tidal mudflats, rocky coasts, wide sandy beaches and deltaic and bay environments.

The Indian coast is relentlessly modified by the mounting development activities along the coastal region, which under improper management at times leads to severe coastal erosion. Management plans with proper understanding of the coastal processes and coastal dynamics are needed to achieve sustainable development along the coastal region, where planning measures have to be taken up at the national level. Inventory related to coastal erosion are a pre-requisite in understanding the coastal dynamics of the region. Planning measures for sustainable development along the coastal region require a systematic inventory of shoreline changes occurring along the entire Indian coast on 1 : 25,000 scale. Space Applications Centre, along with Coastal Protection and Development Advisory Committee (CPDAC) (apex body concerned with planning of coastal protection measures at the national level in India) have brought out shoreline change atlas (SAC, 2014 and Rajawat et al, 2015). The atlas depicts the shoreline changes for the time-frame 1989-1991 (using SPOT-1/2 HRV1-MLA) and 2004–2006 (using IRS-P6 LISSIV), that was mapped on 1 : 25,000 scale for the entire Indian coast.

Coastal Management Directorate, Central Water Commission, Ministry of Water Resources, New Delhi have requested to update the existing shoreline change maps (1989-91 & 2004-06 time-frame) using recent satellite data (2014-16 time-frame) for assessing coastal\ erosion. CPDAC recommended the need for preparation of Shoreline Change Atlas of the Indian coast showing information related to coastal erosion derived from satellite data and protection measures undertaken by all maritime states of India. It is in this context, Space Applications Centre in collaboration with Central Water Commission, have mapped the shoreline for the time-frame 2014-16 on 1:25, 000 scale for the entire Indian coast based on LISS-IV images of 2014-16 in GIS environment. The information is

catalogued as per Survey of India topographical map indexing which is 1:25000 Scale.

The major objective is to prepare digital shoreline change atlas on 1:25, 000 scale in GIS environment using the shoreline delineated for the time-frame 2004-06 and 2014-16. The atlas shall depict and quantify shoreline changes as eroding/accreting/stable, show status of shoreline protection measures taken by respective states and generate A3 size state wise Coastal Atlas of all the maritime states of India.

The detailed objectives are:

i) To prepare shoreline database of 2014-16 time-frame for all the maritime states and UT.

ii) To quantify and classify the shoreline as shoreline under erosion, stable and accretion for entire Indian coast by integrating shoreline using database of 2004-06 and 2014-16 period.

iii) To integrate the information on coastal erosion and shoreline protection measures of all the maritime states and UT of India in GIS environment.

iv) To generate Six Volumes of A-3 size coloured Coastal Atlas of India (Volume I covering Gujarat, Daman & Diu, Volume II covering Maharashtra & Goa, Volume III covering Karnataka & Kerala, Volume IV covering Tamil Nadu, Pondicherry & Andhra Pradesh, Volume V covering Odisha & West Bengal and Volume VI covering Lakshadweep & Andaman & Nicobar).

2. DATA USED

High tidal line is demarcated using IRS-P6 LISSIV data of 2004-06 period and Resourcesat-2 LISS-IV data of 2014-16 time-frame procured from NRSC. The LISS-IV is a multispectral (three-VNIR-band) push-broom camera having a spatial resolution of 5.8m with a swath of 23.9km for IRS-P6 and 70km for Rescourcesat-2. Both the satellites orbits in a sun-synchronous orbit at an altitude of 817km with a 5-day revisit cycle.

Detailed list of the satellite data used is given in the Annexure-III. In few cases where suitable data were not available, the data of nearest time-frame was used. Shoreline changes are computed with respect to the spatial changes in the Highest High Tide Line. The status of coastal protection measures taken up by maritime states and UTs was provided through Central Water Commission (CWC), New Delhi. These were prepared in spatial format and were put in the GIS database.

DATABASE Standards

Satellite images of Resourcesat LISS-IV, having a spatial resolution of 5 m is used for both 2004-06 and 2014-16 time frame. Geometric projection for the images are set to UTM (Standard LANDSAT projection for Indian region). Image to image rectifications are carried out with an overlap error less than 1 pixel.

The vector layers are projected in polyconic projection system, with a planimetric accuracy of 6.25 m and weed tolerance of 3.125 m. Onscreen digitization are carried out in 1:12,500 scale. “State” and “year” attributes are created for the high tide line digitised using the satellite images.

3. METHODOLOGY

We have undertaken following steps to prepare shoreline change atlas:

i. LISS-IV images of 2014-16 (on board Resourcesat-2) and 2004-06 (on board IRS P6) time-frames have been used to delineate the shoreline for entire Indian coast. LANDSAT orthorectified products are used as base map. Image to image co-registration is carried out on LISS-IV images of both time-frames to bring the data set to same geo-reference with an error of +/- 1 pixel.

ii. High tide line (HTL) is considered as the shoreline. On-screen digitization of the HTL has been carried out based on the geomorphic indicators (NCSCM, 2015). Image interpretation keys based on Nayak et al (1991) is used to identify the geomorphic indicators to delineate the HTL.

iii. The HTL is prepared for all maritime states and Union territories of India on 1:25,000 scale. The 1°X1° grid consists of 8X8 rectangular grids or cells. Each rectangular grid or cell represents one Survey of India (SOI) topographic area on 1:25,000 scale.

iv. Limited field checks were carried out and based on field observations, corrections were incorporated while finalizing the map. Field photographs were also taken during the field visits.

v. Accuracy Assessment: Classification as well as planimetric accuracy of the maps was assessed while carrying out the fieldwork. Overall, the classification accuracy of these maps range from 90-95% at 90% confidence level. The Planimetric Accuracy of these maps is 6.25 m as per SOI standard.

vi. Spatial layer for habitation (as point feature) and, rail and road (as line features) are taken from CZIS database.

vii. Spatial analysis techniques are used to compute the spatial shift among the HTL of different time frame.

viii. Polygons for areas under erosion and accretion were created.

ix. Areas under erosion and accretion were measured for the main shoreline (excluding creeks, river mouths, estuaries). Shore length under erosion, accretion and stable categories were measured for the main shoreline (excluding creeks, river mouths, estuaries). Areas with no changes were consider as stable.

x. A table containing the length of eroding, accreting and stable coast along with the area of erosion and accretion for each SOI grid has been generated for the maritime state and U.T.

xi. Shoreline protection measures have been depicted as per the information provided by the maritime State/UT agencies through Central Water Commission.

xii. A standard map composition and layout were finalised and have been used for final map composition of each map.

xiii. Final maps depicting shoreline changes were utilized for preparing shoreline change Atlas of the Indian coast (Six Volumes). Volume I covers Gujarat, Daman & Diu, Volume II covers Maharashtra & Goa, Volume III covers Karnataka & Kerala, Volume IV covers Tamil Nadu, Puducherry & Andhra Pradesh, Volume V covers Odisha & West Bengal and Volume VI covers Lakshadweep & Andaman & Nicobar Islands.

4. RESULTS

The shoreline change maps of Maharashtra and Goa coasts at each SOI grid at 1:25000 scale are given in Section-II.

Maharashtra

The Maharashtra coast, lies between 15^0 45' - 20^0 00' N latitudes and 68^0 00' - 73^0 30' E longitudes. The Sahyadris Western Ghats run parallel to the coast. The Dudh, the Vaitarna, the Ulhas, the Amba, the Kundalika, the Vashishthi, the Savitri are major coastal rivers draining into the Arabian Sea in the west. The coastal region is hilly, narrow, dissected with transverse ridges of the Western Ghats, extending as promontories at many places. It is characterized by pocket beaches flanked by rocky cliffs of Deccan basalt, estuaries and patches of the mangroves along it. Beaches of the Maharashtra coast are small, crescent shaped and flanked by promontories. Long and linear beaches are observed along with mudflats near the estuaries and bay. Mangroves are mainly observed along the intertidal region of estuaries and creeks.

Shoreline change analysis is carried out along 724 km of the Maharashtra coast. The change analysis have avoided the coastal segments at major ports and harbours. Around 81% of the Maharashtra coast is stable in nature and accounts to about 589 km. Erosion is estimated along 75 km and accretion along 60 km. Figure 1 shows the statistics of shoreline change. Due to the deposition of sediments Maharashtra is estimated to have gained an area of 210 ha of land while due to erosion the state have lost an area of 105 ha. Details of erosion/accretion status at each SOI grid is given in Table 1. The shoreline of Maharashtra is divided into four sectors and the analysis has been carried out. The northern sector comprises of Palghar, Thane, Mumbai Suburban and Mumbai city. The second sector is of the shoreline at Raigarh District, the third sector is along the Ratnagiri District and the southern sector covers the shoreline of the Sindhudurg District.

The northern sector of Maharashtra coast is fringed with vast tidal mudflats and interleaving river/creek systems. The percentage of shoreline under erosion along the northern sector is more compared to the other regions, where 17% (33 km) of the coast is eroding, while along 12 km the shoreline is accreting. The changes are mainly observed along the mouth of streams or creeks. Plate (1) show the shoreline to the north of Vadrai (47A10NE). Major eroding

shoreline in the sector are located to the norther part, specifically at Bordi - Gholvad (46D12SE), south of Ucheli creek to Nandgaon (47A09SE) and Bhugaon (47A15NW).

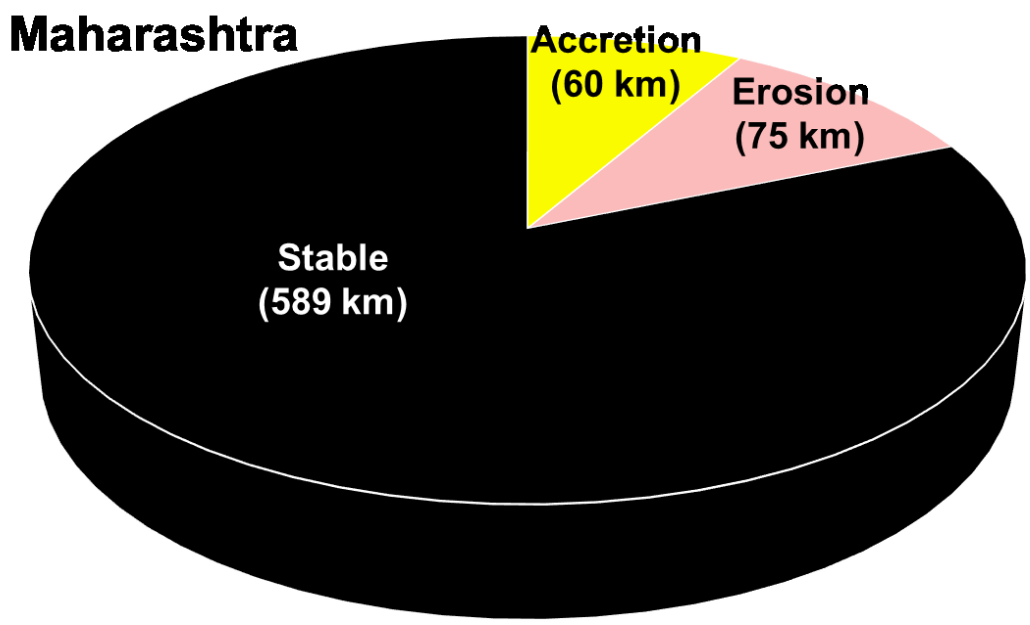

Figure 1: Shoreline change status of Maharashtra

In Raigad District, 11 km of the shoreline is eroding and accretion is along 16 km. A long stretch of coastline of around 112 km is observed to be in stable condition. The coastal region at Raigad is rocky cliff and headlands which forms stable shoreline, restricting the changes only along its pocket beaches and spits. Major coastal erosion at Raigad Districts are along Korlai-ABorli (47B14SE), Adhi (47B15NE), Velas (47B16NE) and Shrivardhan (47F04SW). A long coastal stretch at Revdanda (47B14SE) is observed to be accreting.

Around 22 km of the shoreline is estimated to be eroding along the Ratnagiri Distrtict. Accretion is along 17 km, while 216 km of the coast is stable. Major changes in the shoreline is observed to the mouth of river/stream and creeks, while the rest of the coast remains more or less stable in nature.

Plate 2 shows the changes along the mouth of Mirya (47G08SW) and Plate 3 shows the coastal erosion at Ratnagiri (47H05NW). Other major coastal erosions at Ratnagiri District are observed at Utambar (47G01NW), Hornal (47G01SW), Murud (47G01SW), Kolthare (47G02NE), Velaneshwar (47G03NE), Bhandiwada (47G04NE), Malgund (47G08NW), Prandavane (47G08SW) and Mirya (47G08SW).

Along Sindhudurg District, only 9 km of the coast is under erosion, while 15 km of the coast is accreting and 113 km is observed to be under stable condition. Likewise, the Raigad and Ratnagiri Districts,

Sindhudurg also have coastal area with rocky cliffs that make the coast stable and shoreline changes is observed along confined areas of pocket beaches and spits near the river/creek mouths. Eroding coasts along the Sindhudurg District is observed at Padvane (47H07NW), and Walagar (48E09SE).

Table 1: Mapsheet-wise results of shoreline changes for 2004-06 and 2014-16 time-frame for Maharashtra coast

Serial No.	Map Sheet No.	Erosion Area (in ha)	Erosion Length (in km)	Accretion Area (in ha)	Accretion length (in km)	Stable Length (in km)	Total Length (in km)
1	46D12NE	0.21	0.27	0.00	0.00	0.94	1.21
2	46D12SE	4.73	6.16	1.71	1.42	8.60	16.18
3	47A09NE	2.31	2.93	0.56	0.57	16.35	19.85
4	47A09SE	8.03	6.73	1.10	1.18	11.54	19.45
5	47A10NE	3.97	2.43	3.02	1.29	11.61	15.33
6	47A10SE	3.44	2.98	0.23	0.20	13.85	17.03
7	47A14SW	0.23	0.30	3.46	1.74	0.00	2.04
8	47A11NE	0.00	0.00	0.58	0.33	2.30	2.63
9	47A15NW	2.83	2.65	7.05	1.59	5.97	10.21
10	47A15SW	16.50	4.96	4.46	1.65	11.23	17.84
11	47A16NW	2.34	2.64	4.53	1.70	18.44	22.78
12	47A16SW	1.50	1.38	0.61	0.20	20.05	21.63
13	47B13NW	0.00	0.00	0.00	0.00	26.69	26.69
14	47B13SW	1.31	1.30	0.16	0.29	5.21	6.8
15	47B14NW	0.33	0.43	2.32	1.01	12.40	13.84
16	47B14NE	1.17	0.67	1.16	0.74	1.04	2.45
17	47B14SE	3.11	3.05	6.18	4.34	9.87	17.26
18	47B15NE	0.68	0.93	0.92	1.17	16.35	18.45
19	47B15SE	0.42	0.20	125.36	6.40	27.23	33.83
20	47B16NE	1.76	1.46	2.77	1.41	19.27	22.14
21	47B16SE	0.31	0.18	0.48	0.27	10.27	10.72
22	47F04SW	3.35	2.07	1.87	1.01	7.35	10.43
23	47G01NW	5.03	3.01	1.59	1.52	14.23	18.76
24	47G01SW	3.22	3.28	1.34	0.51	13.54	17.33
25	47G02NE	0.94	1.29	0.68	0.44	10.39	12.12
26	47G02NW	0.00	0.00	0.49	0.46	5.65	6.11
27	47G02SE	7.36	2.19	6.03	1.71	16.38	20.28
28	47G03NE	0.80	1.19	0.82	0.75	21.76	23.7
29	47G03SE	1.20	0.92	6.19	3.66	25.13	29.71
30	47G04NE	0.45	0.73	1.08	0.54	10.66	11.93
31	47G08NW	0.77	1.18	0.30	0.46	6.89	8.53
32	47G08SW	10.39	6.69	1.20	0.67	17.83	25.19
33	47H05NW	3.39	1.68	1.33	1.87	22.55	26.1
34	47H05SW	0.00	0.00	0.32	0.44	18.94	19.38
35	47H06NW	1.56	0.69	2.34	2.29	18.48	21.46
36	47H06SW	0.00	0.00	2.43	1.93	29.33	31.26
37	47H07NW	1.05	0.98	0.73	0.41	16.40	17.79
38	47H07SE	3.29	2.39	0.74	1.05	11.93	15.37
39	47H07SW	0.00	0.00	0.23	0.27	1.98	2.25
40	47H08NE	0.83	0.80	5.12	4.83	10.00	15.63
41	47H08SE	1.96	1.13	3.67	3.08	15.77	19.98
42	48E05NE	0.00	0.00	0.00	0.00	3.54	3.54
43	48E09NW	1.01	0.58	2.05	2.75	18.17	21.5
44	48E09SE	2.13	2.02	2.41	1.84	10.47	14.33
45	48E09SW	0.47	0.32	0.32	0.28	4.16	4.76
46	48E10NE	0.37	0.37	0.00	0.00	7.90	8.27
	Total	**104.8**	**75.1**	**210.0**	**60.2**	**588.6**	**724.07**

Goa

Goa is the smallest maritime state of India located between 15°44’30” and 14°53’30” N latitude, and 73°45’ and 74°26’E longitude, along the Central West Coast of India. Goa is known for its beaches and its shoreline stretches to about 155 km in length (excluding the river/creek mouth). The coastal plains of Goa consist of sandy beaches, sea cliffs, promontories, estuaries, spits, sand dunes, wave cut platforms, wooded or bare hill slopes which are dissected by rivers such as the Terekhol, the Chapora, the Mandovi and the Zuari. Goa has long, linear and wide beaches in the north and rocky cliffs along the southern coast. Beaches occur along Harmal, near Mandre, Morji, Chapora, Kalangute in the north and Bogmalo, Agonda, Palolen, Talpona in the south. The Mandovi river drains into the Aguada Bay, while the Zuari into the Marmagao Bay.

Estimation of shoreline change is carried out along 146 km of coastal stretch of Goa state. The coast of Goa is observed to have a long stable shoreline of around 117 km. Erosion is along 22 km of the coastal region, while accretion is observed merely along 7 km. Figure 2 shows the statistics of shoreline change for Goa. Area of erosion is around 29 ha for the entire Goa coast and the area that have accreted is about 14 ha. Details of erosion/accretion status at each SOI grid is given in Table 2. Shoreline change analysis is carried out for Goa by dividing the entire coast into two sector based on the district boundary between North Goa and South Goa.

North Goa district is observed to have severe erosion, where the erosion is along 16 km and accretion is observed along 4 km of its coast. 23 km of the coast at North Goa district is stable in nature. Goa is famous for its beaches and in the North Goa; several stretches of famous beaches are under erosion. Erosion is observed along the coast at Keri and Harmal (48E10NE), Morji (48E10NE and 48E10SE) and Anjuna (48E10SE). Changes are observed to the river mouth, where the long northern spits have eroded near Harmal (48E10NE).

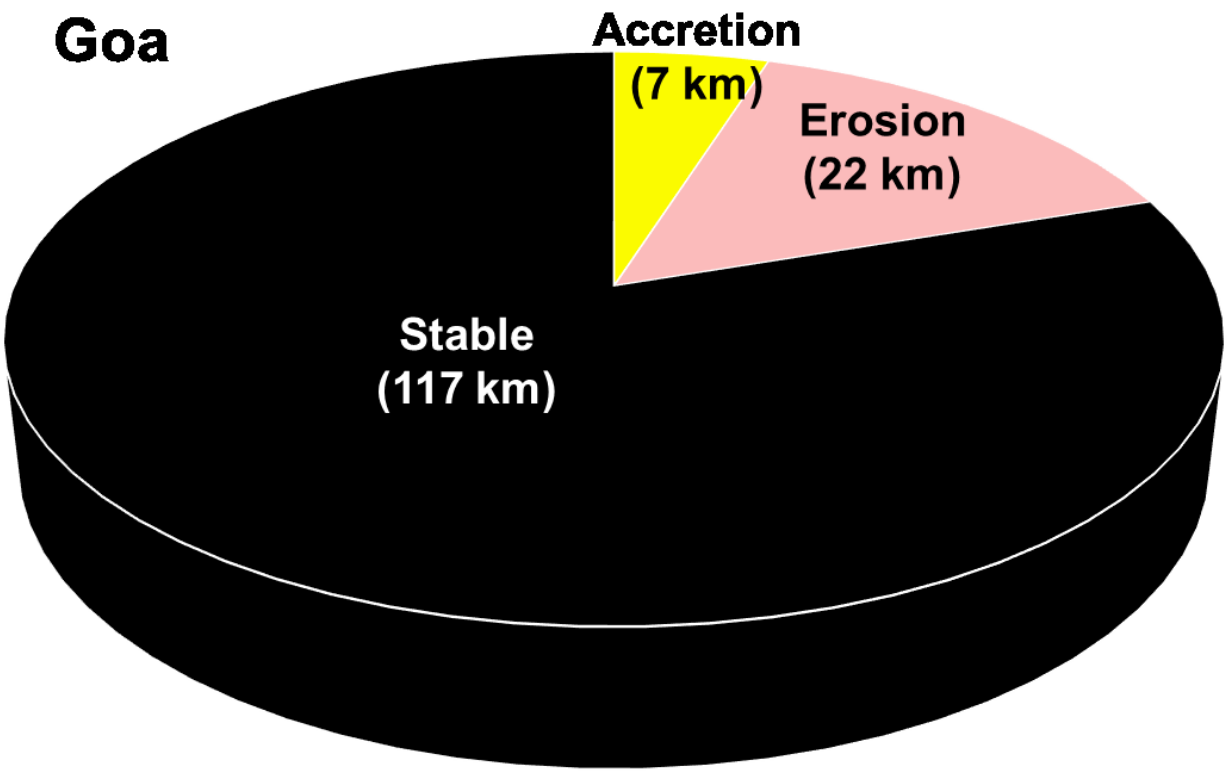

Figure 2: Shoreline change status of Goa

Beaches of the South Goa District is mostly stable in nature, where the total length of stable coast is around 94 km. About 6 km of coast at South Goa is under erosion and 3 km of the coast is being accreted. The coast at South Goa is mainly rocky cliffs and rocky headlands, where sandy beaches are observed between the headlands forming pocket beaches and along the spits of river or streams. Plate (13) shows the erosion along Palolem beach (48I04SW). Coastal erosion is observed to the south of Talpona (48J01NW).

Table 2: Mapsheet-wise results of shoreline changes for 2004-06 and 2014-16 time-frame for Goa coast

Serial No.	Map Sheet No.	Erosion Area (in ha)	Erosion Length (in km)	Accretion Area (in ha)	Accretion length (in km)	Stable Length (in km)	Total Length (in km)
1	48E10NE	7.96	6.48	1.12	0.54	5.00	12.02
2	48E10SE	3.94	3.14	3.83	1.35	5.51	10
3	48E14SW	8.74	5.46	0.00	0.00	1.54	7
4	48E15NW	2.29	1.39	4.95	2.53	17.84	21.76
5	48E15SW	0.00	0.00	0.23	0.18	8.32	8.5
6	48E15SE	1.54	1.29	0.58	0.34	12.57	14.2
7	48E16NE	0.34	0.21	2.62	1.92	13.78	15.91
8	48E16SE	0.18	0.14	0.00	0.00	27.27	27.41
9	48I04SW	1.62	1.58	0.12	0.09	4.6	6.27
10	48J01NW	2.17	2.01	0.15	0.18	20.30	22.49
	Total	**28.8**	**21.7**	**13.6**	**7.1**	**116.7**	**145.5**

5. END USE

Coastal management plans require a proper understanding of the coastal processes and coastal dynamics to achieve a sustainable development along the coastal region. The inventory of shoreline change is the pre-requisite in understanding the dynamics of the coastal region. As the Indian coastal regions are modified by mounting development activities, an improper management at times shall lead to severe coastal erosion. Planning measures for sustainable development along the coastal region require a systematic inventory of shoreline changes occurring along the entire Indian coast on 1: 25,000 scale.

The Atlas can be used as a reference material for obtaining information on status of shoreline changes during 2004-06 and 2014-16 time-frames along entire Indian coastline. Areas under coastal erosion and status of coastal protection measures taken up by respective maritime State and Union Territory are depicted and can be used for planning coastal protection measures.

The Atlas is extremely useful to Coastal Management Directorate, Central Water Commission for providing guidance towards coastal protection works in maritime states of India.

All the State Public Works Departments, Ports and Harbour Authorities, Coastal Regulation Zone Authorities shall be able to have better management of the shorelines in respective states.

ACKNOWLEDGEMENTS

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We express special thanks to the Chairman and Members of Coastal Protection and Development Advisory Committee (CPDAC) for necessary support. We express deep gratefulness to the Director, Coastal Management Directorate, Central Water Commission, Ministry of Water Resources for his full support for this work and in organizing collection of coastal protection measures data from all the maritime States and U.T. of India.

We are highly grateful to the quality check team Shri T.V.R Murthy, Shri J.G Patel, Shri R.J Bhanderi, Shri B.P Rathore and Shri Manish Parmar for meticulously checking the shoreline change database and giving invaluable suggestion towards improving the same. We express our sincere gratitude to Ms. Savita Kumari and Ms. Anupama Sahoo for helping us in the map composition and database management.

Project team
Shoreline Change Atlas

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SHORELINE CHANGE MAPS

COMPLETE LEGEND TO SHORELINE CHANGE MAPS

EROSION

ACCRETION

HIGH-TIDE LINE 2014-16

HIGH-TIDE LINE 2004-06

STABLE

ROAD

RAILWAY

SEA WALL

GROYNES

BREAKWATER

JETTY

STATE BOUNDARY

PORT/HARBOUR

HABITATION

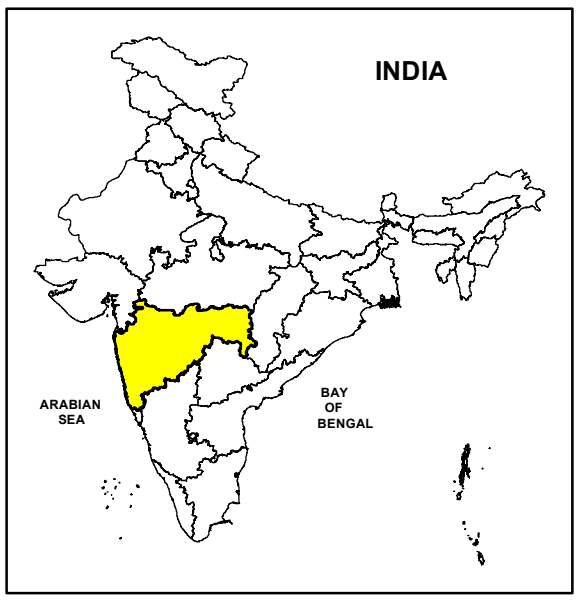
SHORELINE CHANGE MAPS

MAHARASHTRA

INDEX MAP OF MAHARASHTRA

46D12SE
47A09NE
47A09SE
47A10NE
47A10SE 47A14SW
47A11NE 47A15NW
47A15SW
47A16NW
47A16SW
47B13NW 47B13NE
MUMBAI
47B13SW 47B13SE
47B14NW 47B14NE
47B14SE
47B15NE
47B15SE
47B16NE
47B16SE 47F04SW
47G01NW
47G01SW 47G01SE
47G02NW 47G02NE
47G02SE
47G03NE
47G03SE
47G04NE 47G08NW
RATNAGIRI
47G08SW
47H05NW
47H05SW
47H06NW
47H06SW
47H07NW
47H07SW 47H07SE
47H08NE
47H08SE
MALVAN
48E05NE 48E09NW
48E09SW 48E09SE
48E10NE

ARABIAN SEA

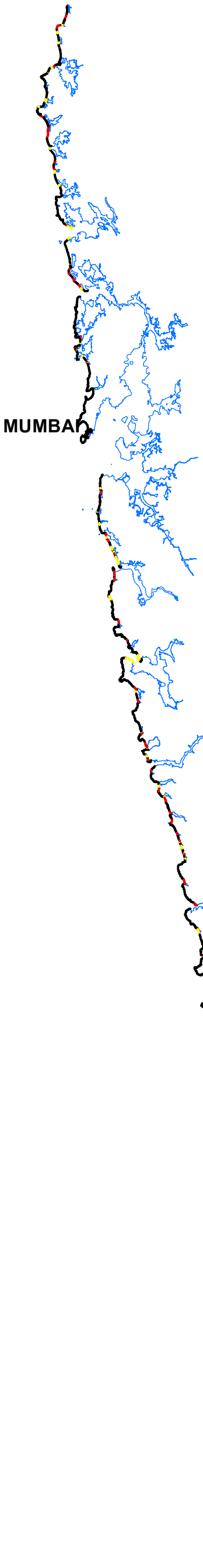


N

0 250 500

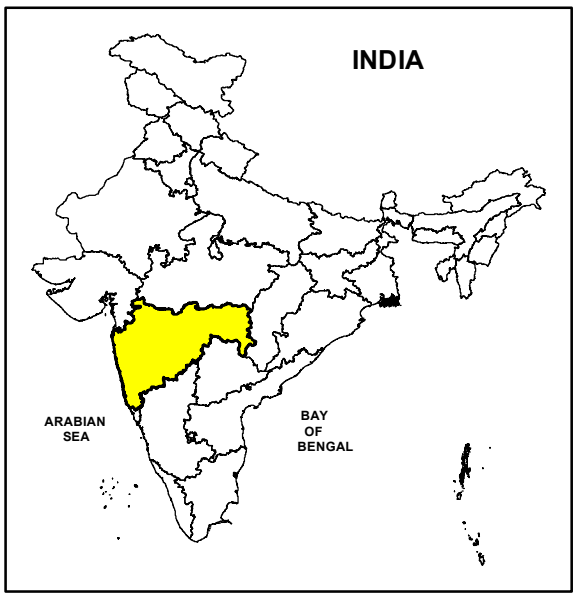
KM

SHORELINE CHANGES OF MAHARASHTRA



ARABIAN

SEA



N

0 250 500

KM

LEGEND

- ACCRETION LENGTH
- EROSION LENGTH
- STABLE LENGTH
- HIGH-TIDE LINE 2014-16

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

PALGHAR DISTRICT

MAHARASHTRA

SHEET NO. 46D12NE

Legend

- EROSION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- STATE BOUNDARY
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	46D11SE	46D15SW
SEA	46D12NE	46D16NW
SEA	46D12SE	46D16SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

PALGHAR DISTRICT

MAHARASHTRA

SHEET NO. 46D12SE

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- HABITATION

N
W E
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0 2 km

INDEX TO SHEETS

SEA	46D12NE	46D16NW
SEA	46D12SE	46D16SW
SEA	47A09NE	47A13NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

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PALGHAR DISTRICT

MAHARASHTRA

SHEET NO. 47A09NE

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- HABITATION

N
W E
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0 2 km

INDEX TO SHEETS

SEA	46D12SE	46D16SW
SEA	47A09NE	47A13NW
SEA	47A09SE	47A13SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

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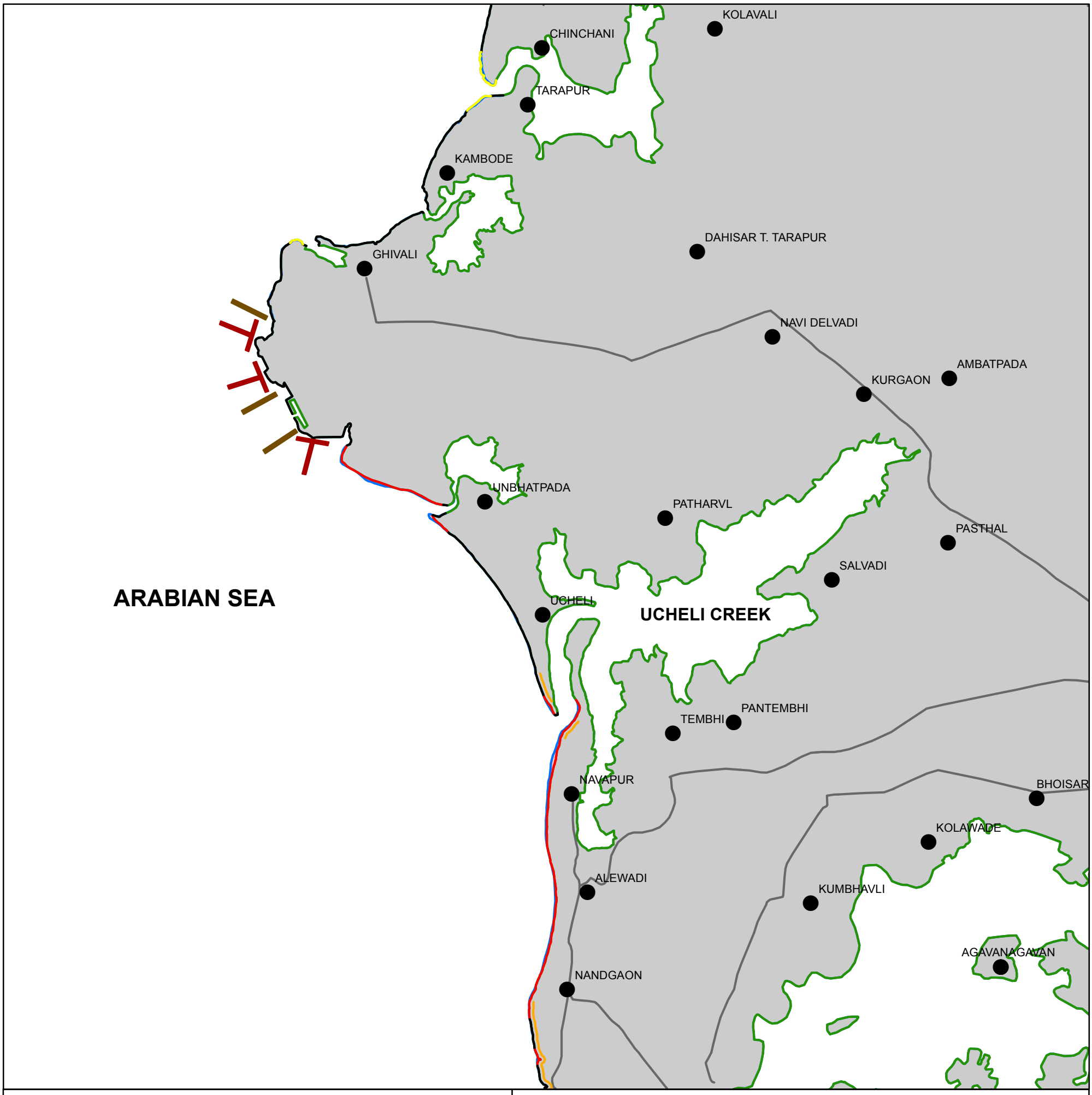
PALGHAR DISTRICT

MAHARASHTRA

SHEET NO. 47A09SE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47A09NE	47A13NW
SEA	47A09SE	47A13SW
SEA	47A10NE	47A14NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

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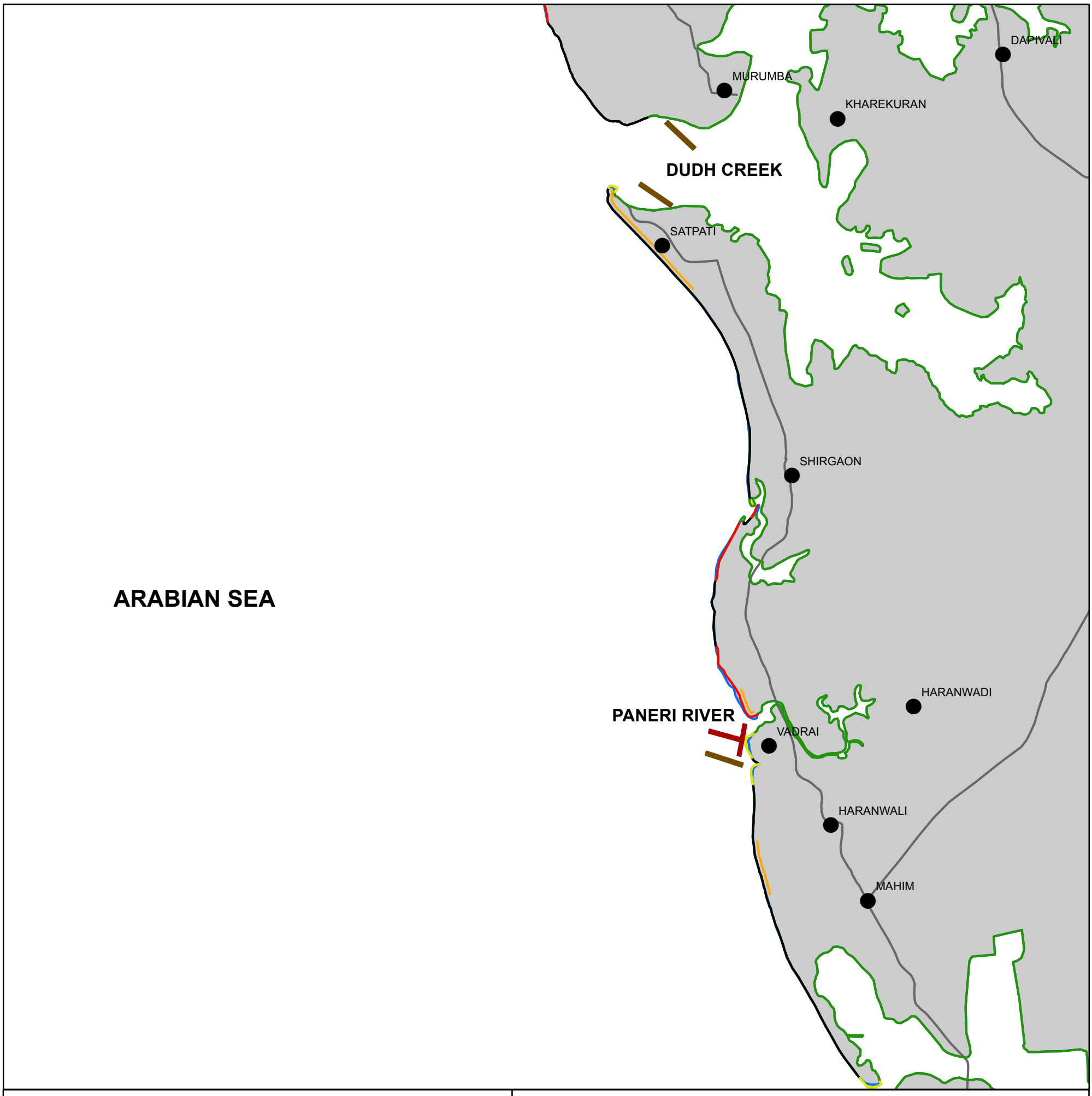
PALGHAR DISTRICT

MAHARASHTRA

SHEET NO. 47A10NE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47A09SE	47A13SW
SEA	47A10NE	47A14NW
SEA	47A10SE	47A14SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

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PALGHAR DISTRICT

MAHARASHTRA

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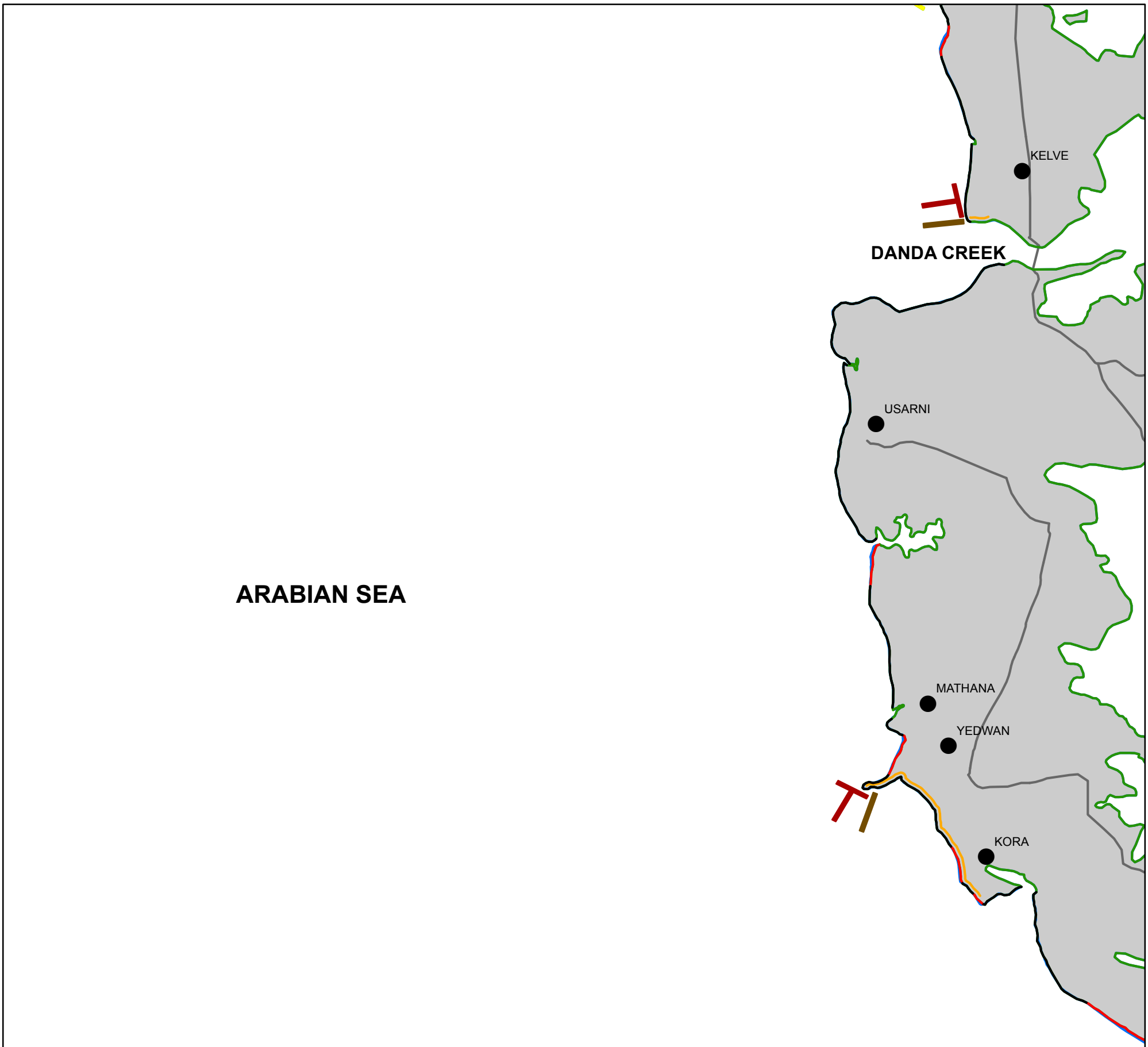

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47A10NE	47A14NW
SEA	47A10SE	47A14SW
SEA	47A11NE	47A15NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

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PALGHAR DISTRICT

MAHARASHTRA

SHEET NO. 47A14SW

ROTHA
MAKUNSAR
TIGRAH
KAPASE
TANDALWADI
SAPHALE
UCHAVALI
CHATALE
MANDA
VITHAL WADI
SARAVALI
KANDARWAN
KANDRE BHURE
VAKDI PADA
CHIKHALPADA
KHARDI PADA
SARVAR
TEMBHI KHODAVE
PHANASPADA
DOLIVPADA
DATVIRA
KASRAL PADA

VAITARNA RIVER

ARABIAN SEA

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- ROAD
- RAILWAY
- JETTY
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47A10NE	47A14NW	47A14NE
47A10SE	47A14SW	47A14SE
47A11NE	47A15NW	47A15NE

INDIA

MAHARASHTRA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

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PALGHAR DISTRICT

MAHARASHTRA

SHEET NO. 47A11NE

Legend

- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47A10SE	47A14SW
SEA	47A11NE	47A15NW
SEA	SEA	47A15SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
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AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

PALGHAR DISTRICT

MAHARASHTRA

SHEET NO. 47A15NW

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47A10SE	47A14SW	47A14SE
47A11NE	47A15NW	47A15NE
SEA	47A15SW	47A15SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

PALGHAR/THANE/
MUMBAI SUBURBAN DISTRICT

MAHARASHTRA

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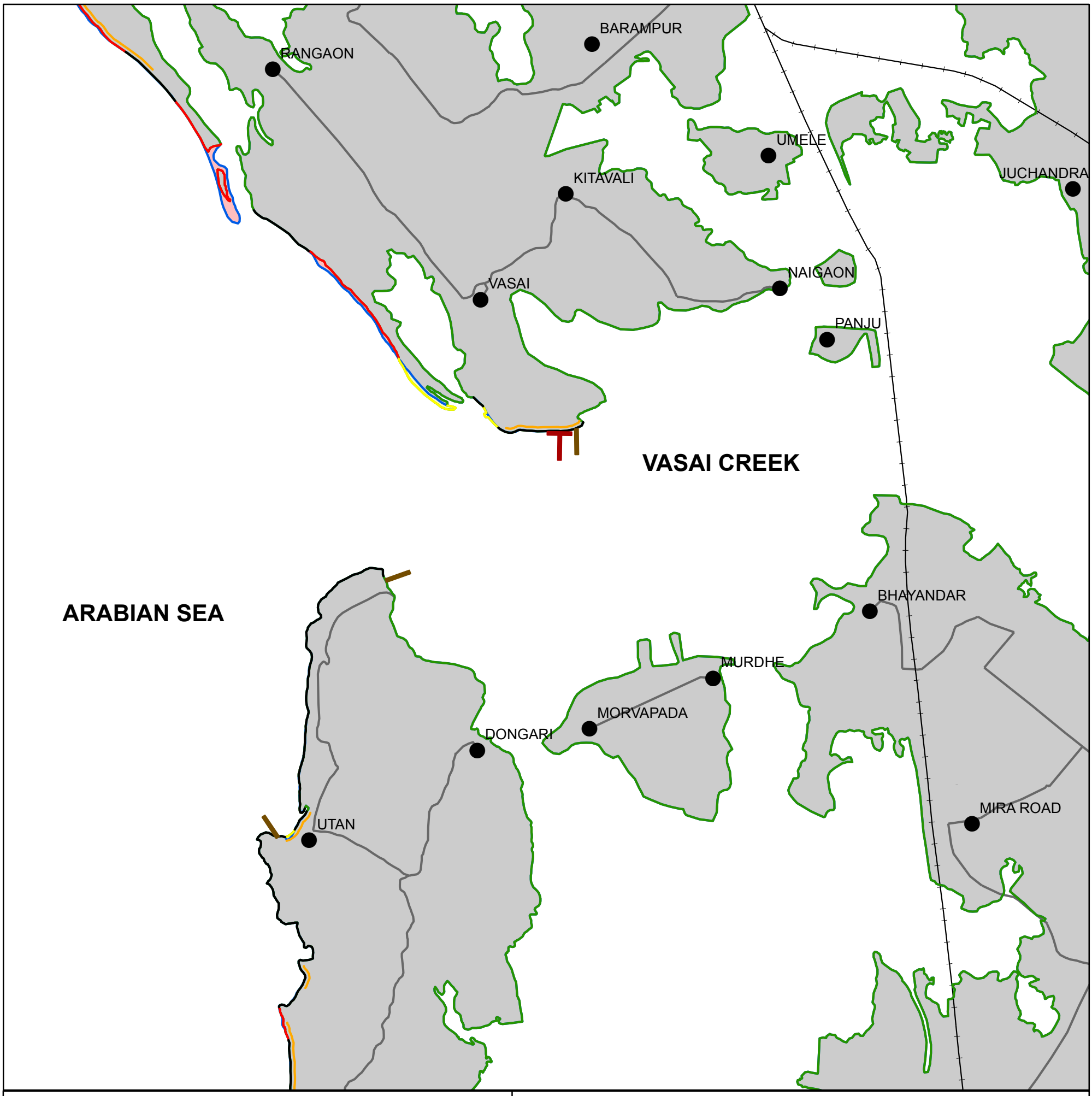
SHEET NO. 47A15SW



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2

Scale in Kilometer

INDEX TO SHEETS

47A11NE	47A15NW	47A15NE
SEA		47A15SE
SEA	47A16NW	47A16NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

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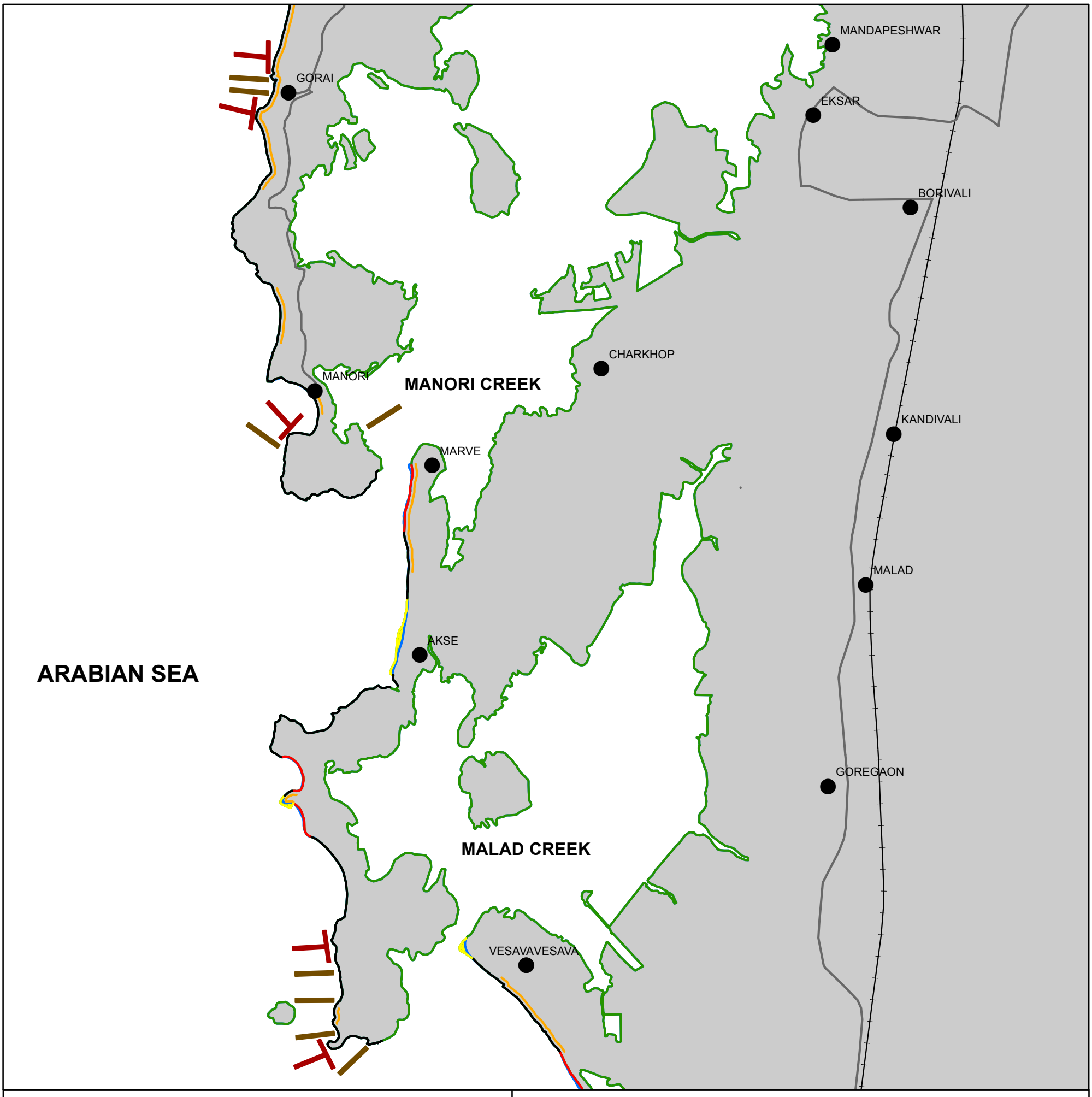
MUMBAI SUBURBAN DISTRICT **MAHARASHTRA** SHEET NO. 47A16NW



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47A15SW	47A15SE
SEA	47A16NW	47A16NE
SEA	47A16SW	47A16SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

MUMBAI SUBURBAN/
MUMBAI CITY

MAHARASHTRA

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SHEET NO. 47A16SW

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47A16NW	47A16NE
SEA	47A16SW	47A16SE
SEA	47B13NW	47B13NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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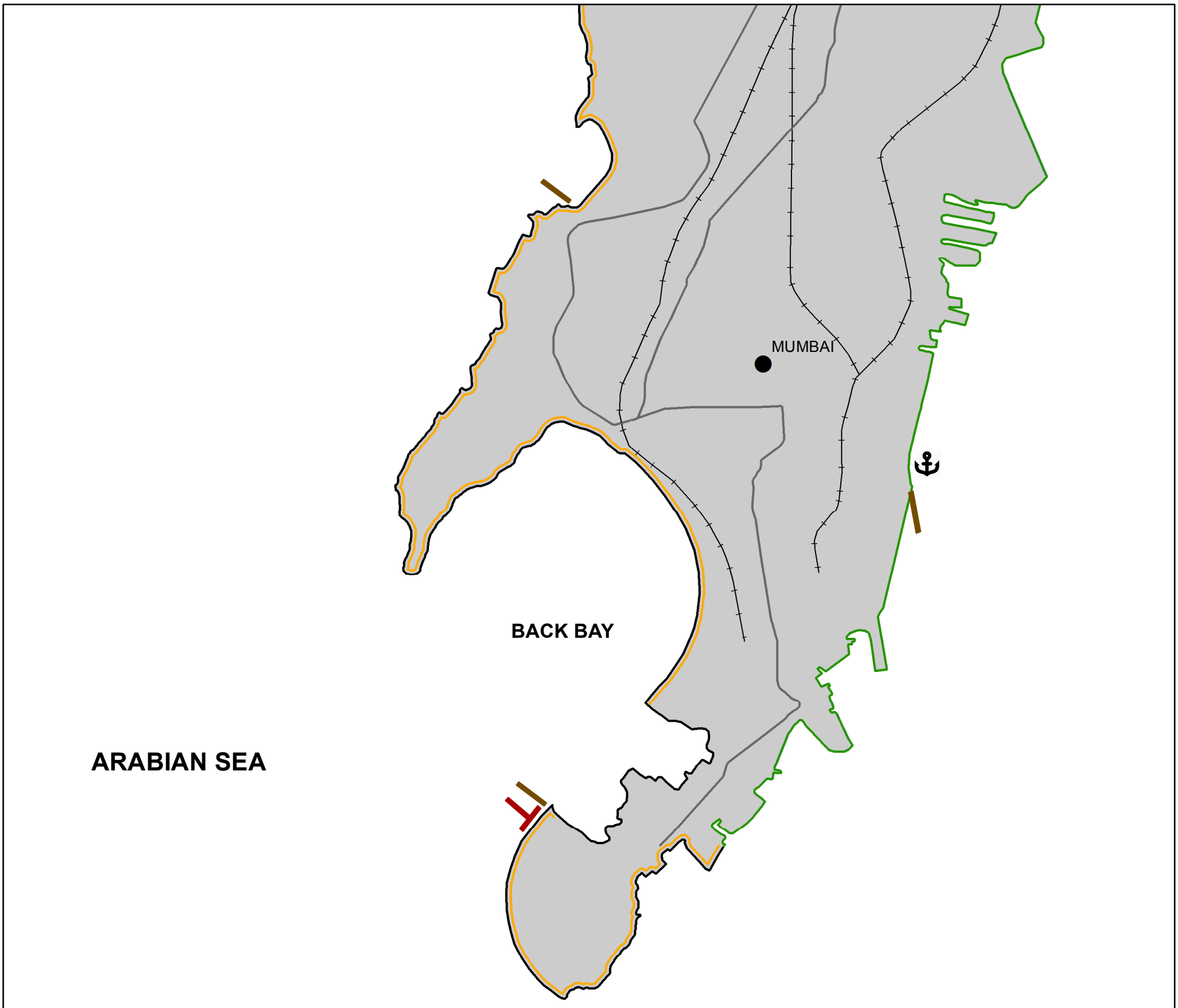
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

MUMBAI CITY

MAHARASHTRA

SHEET NO. 47B13NW



Legend

- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- BREAKWATER
- PORT/HARBOUR
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47A16SW	47A16SE
SEA	47B13NW	47B13NE
SEA	47B13SW	47B13SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

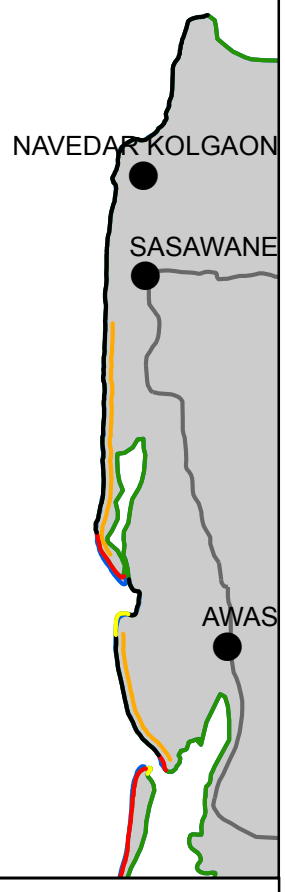
FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47B13SW

ARABIAN SEA



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47B13NW	47B13NE
SEA	47B13SW	47B13SE
SEA	47B14NW	47B14NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
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SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47B14NW

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47B13SW	47B13SE
SEA	47B14NW	47B14NE
SEA	SEA	47B14SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

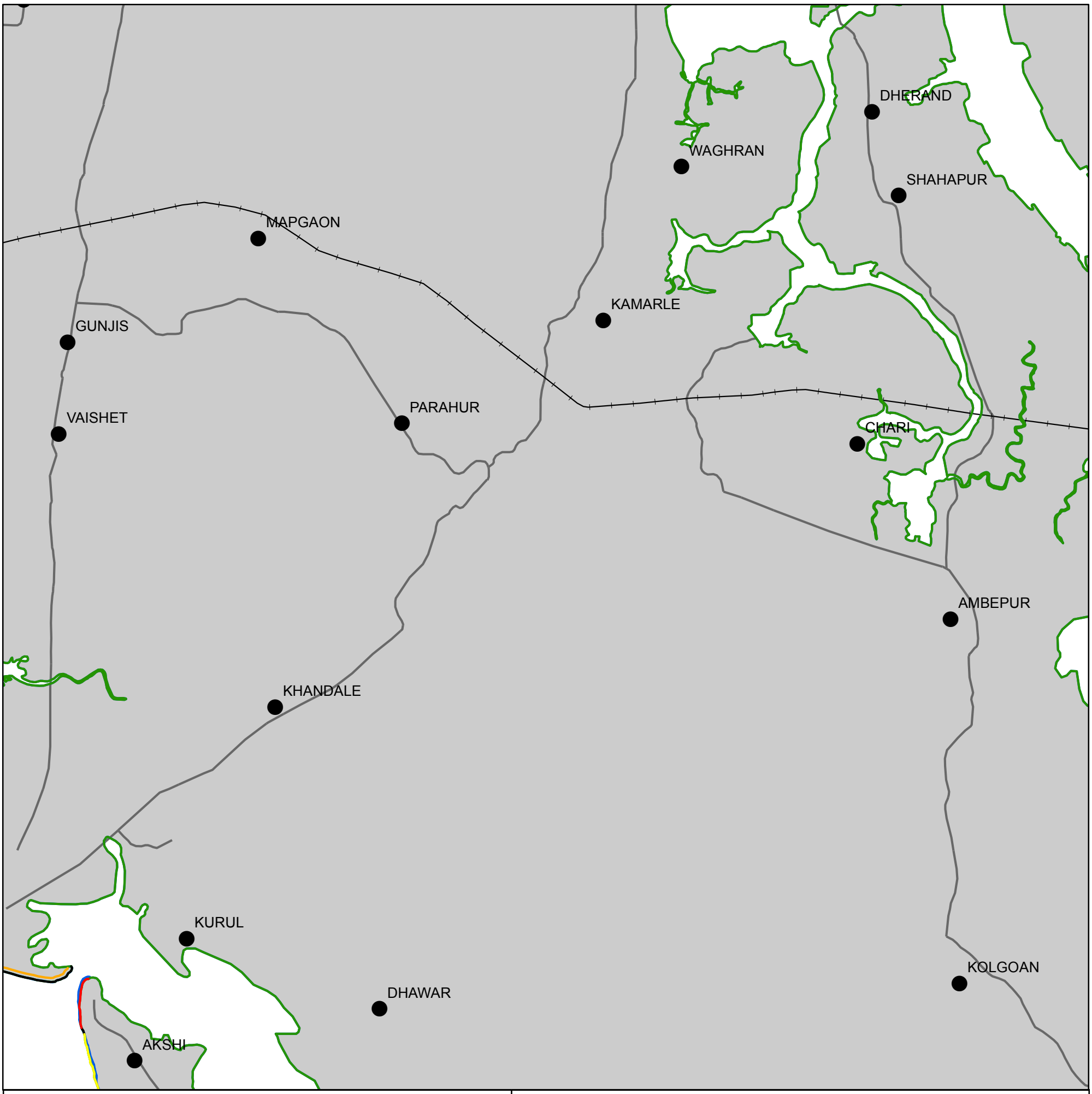
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47B14NE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- HABITATION

N
W E
S

0 2 km

47B13SW	47B13SE	47F01SW
47B14NW	47B14NE	47F02NW
SEA	47B14SE	47F02SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
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SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47B14SE

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47B14NW	47B14NE	47F02NW
SEA	47B14SE	47F02SW
SEA	47B15NE	47F03NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

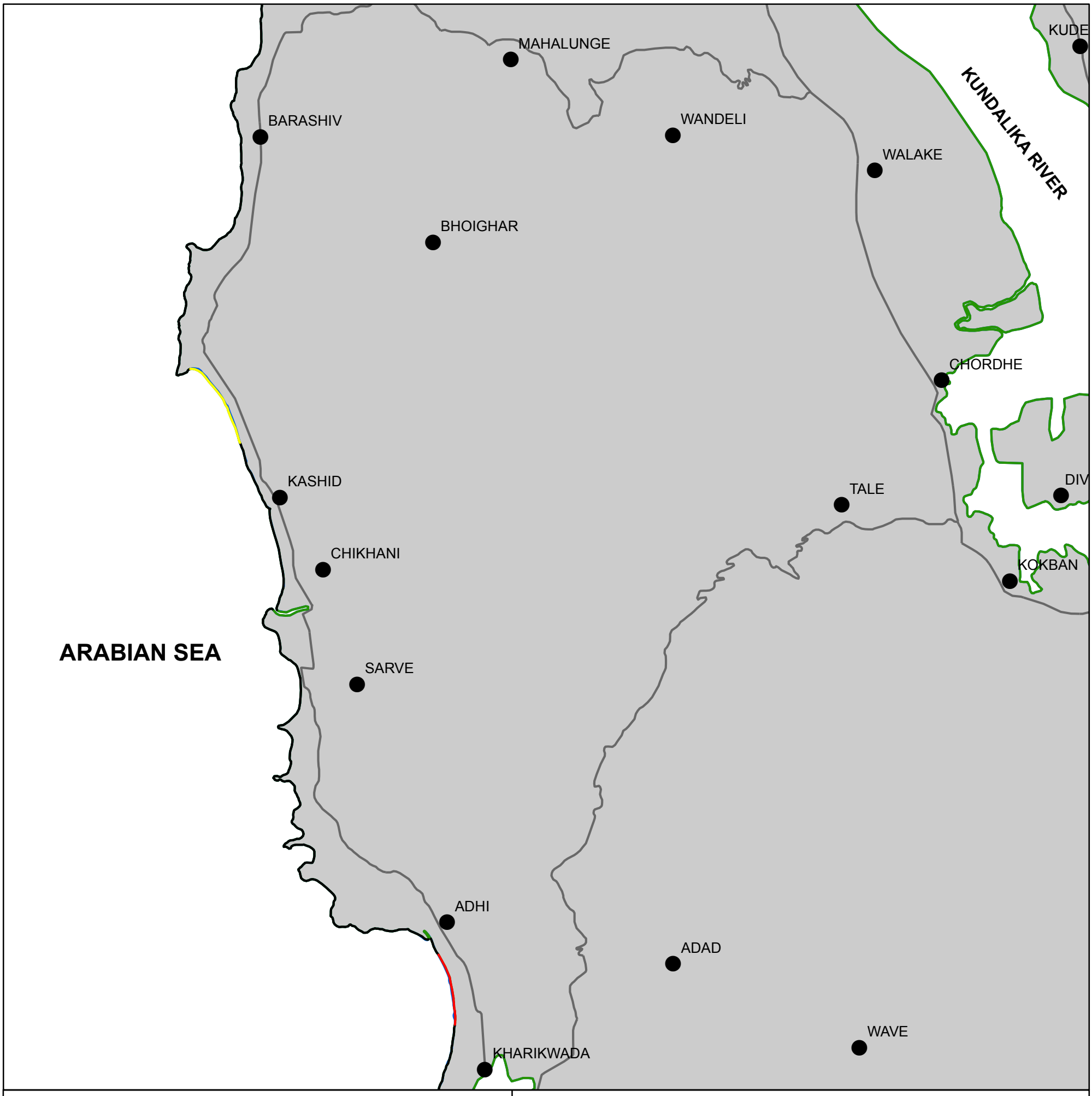
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47B15NE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47B14SE	47F02SW
SEA	47B15NE	47F03NW
SEA	47B15SE	47F03SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

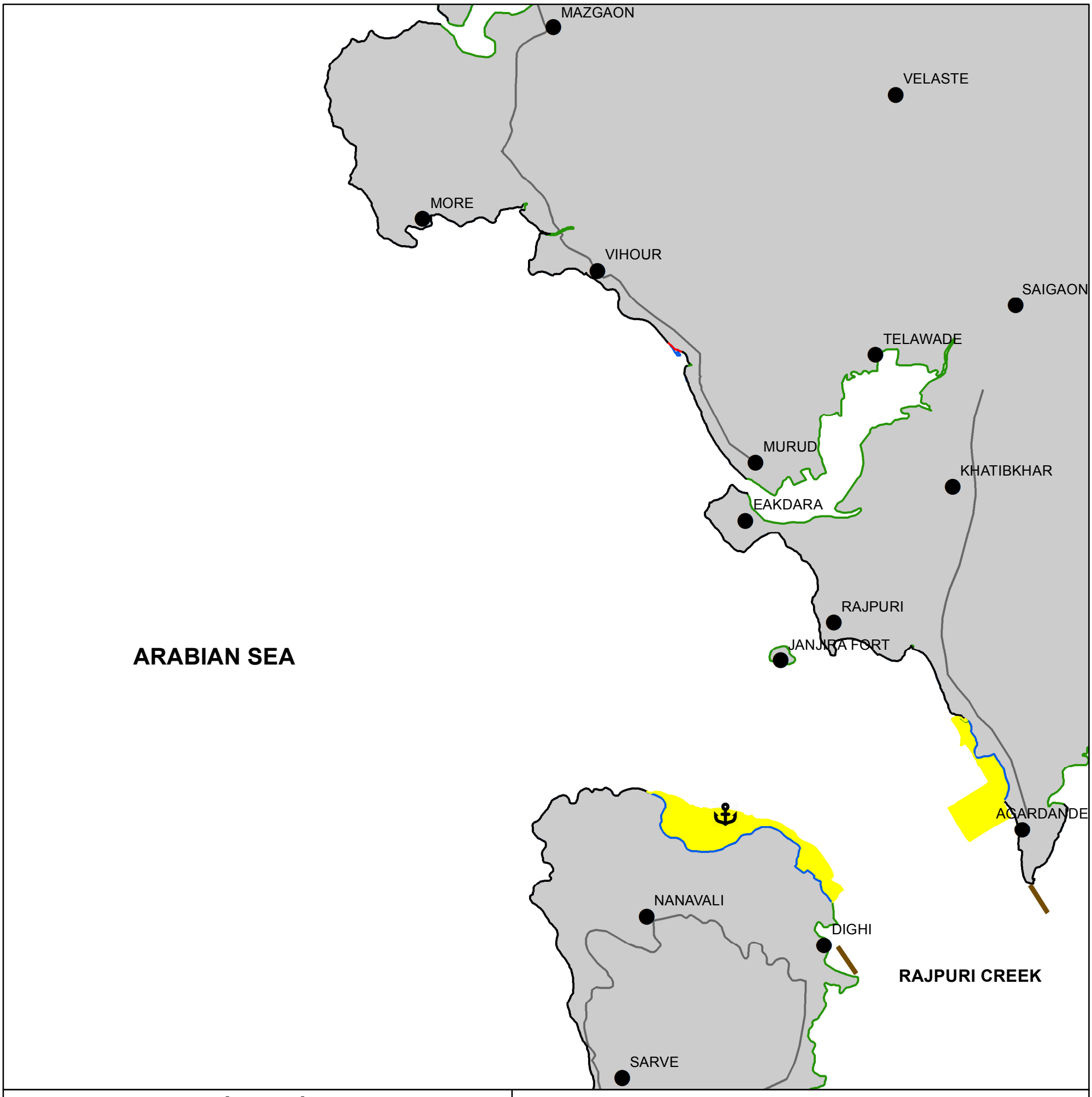
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47B15SE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- JETTY
- PORT/HARBOUR
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47B15NE	47F03NW
SEA	47B15SE	47F03SW
SEA	47B16NE	47F04NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
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AND CENTRAL WATER COMMISSION, NEW DELHI

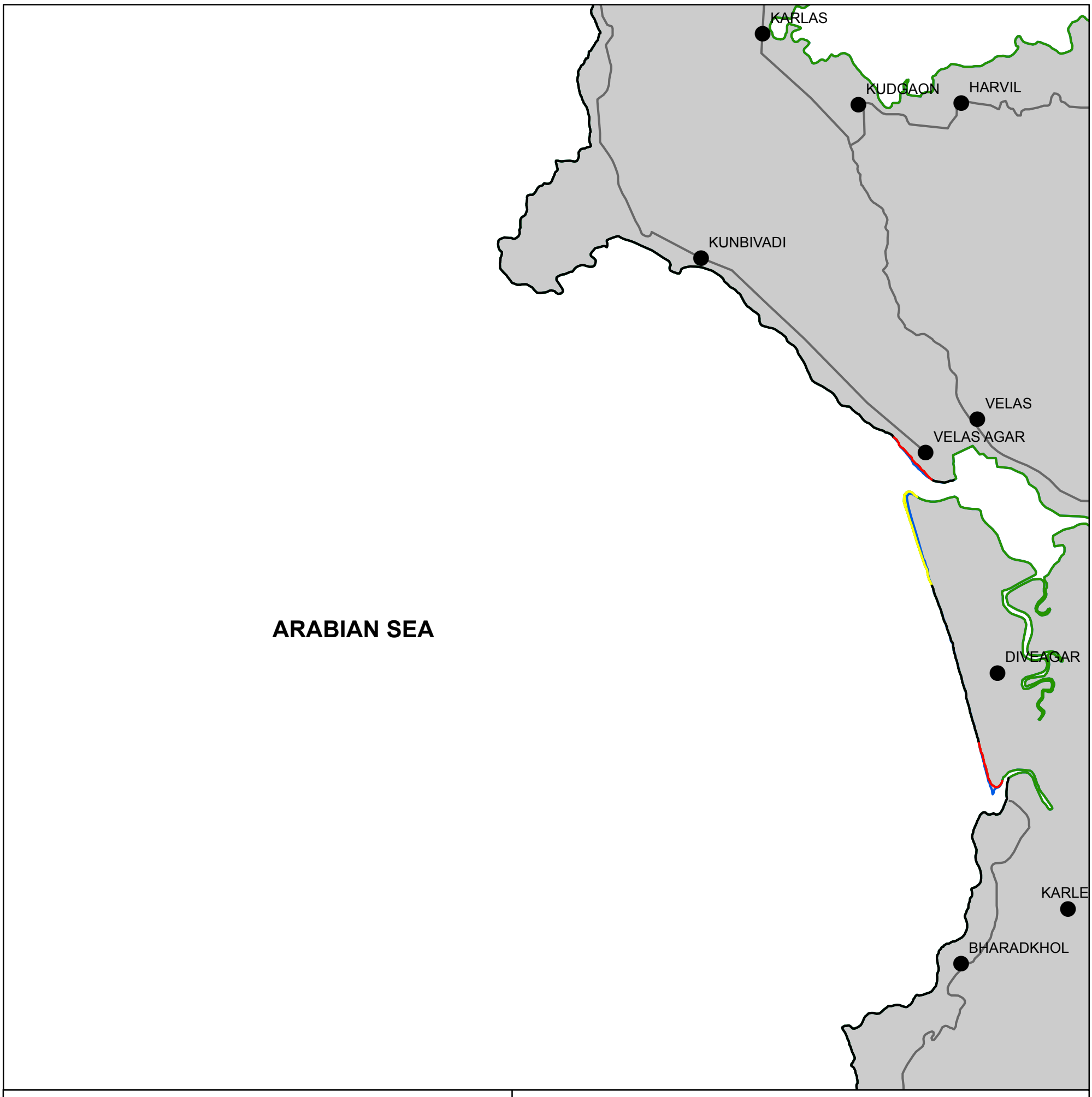
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47B16NE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47B15SE	47F03SW
SEA	47B16NE	47F04NW
SEA	47B16SE	47F04SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

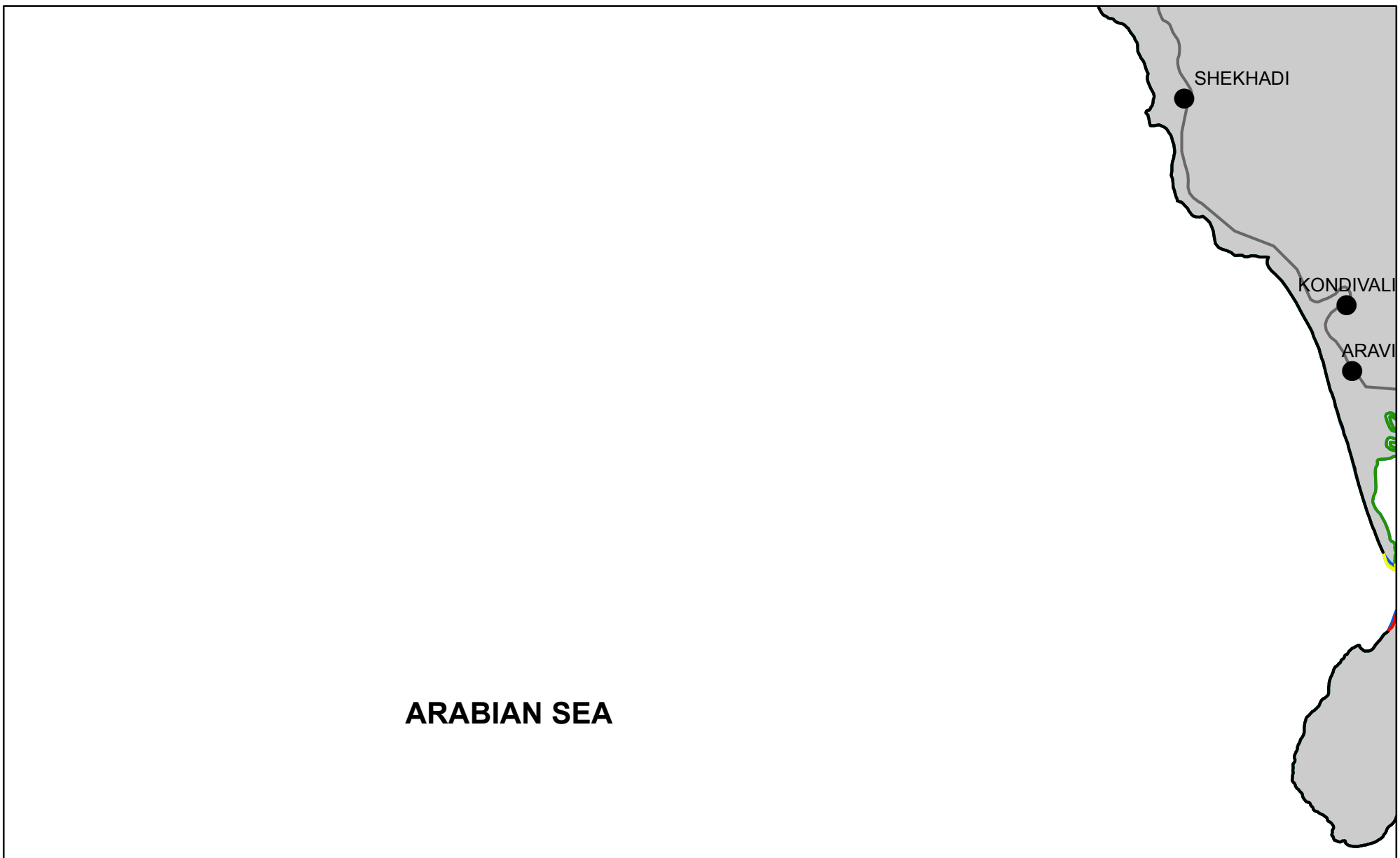
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47B16SE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- ROAD
- STABLE
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47B16NE	47F04NW
SEA	47B16SE	47F04SW
SEA	SEA	47G01NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
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AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47F04SW

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47B16NE	47F04NW	47F04NE
47B16SE	47F04SW	47F04SE
SEA	47G01NW	47G01NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI/RAIGAD DISTRICT **MAHARASHTRA** SHEET NO. 47G01NW

DEVGHAR
BAGMANDALE
ADI MAHAKHADI
KARIVANE
SAVITRI RIVER
BANKOT
SIPHOLE
UMROLI
KENGVAL
VELAS
RANAVALI
AMBAVALI
SAKHAR
RAWTOLI
KELASHI
ASGAON
ROWALE
UTAMBAR
AMBAVALI
MALVI
PADALE

ARABIAN SEA

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- JETTY
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47B16SE	47F04SW	47F04SE
SEA	47G01NW	47G01NE
SEA	47G01SW	47G01SE

INDIA

MAHARASHTRA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

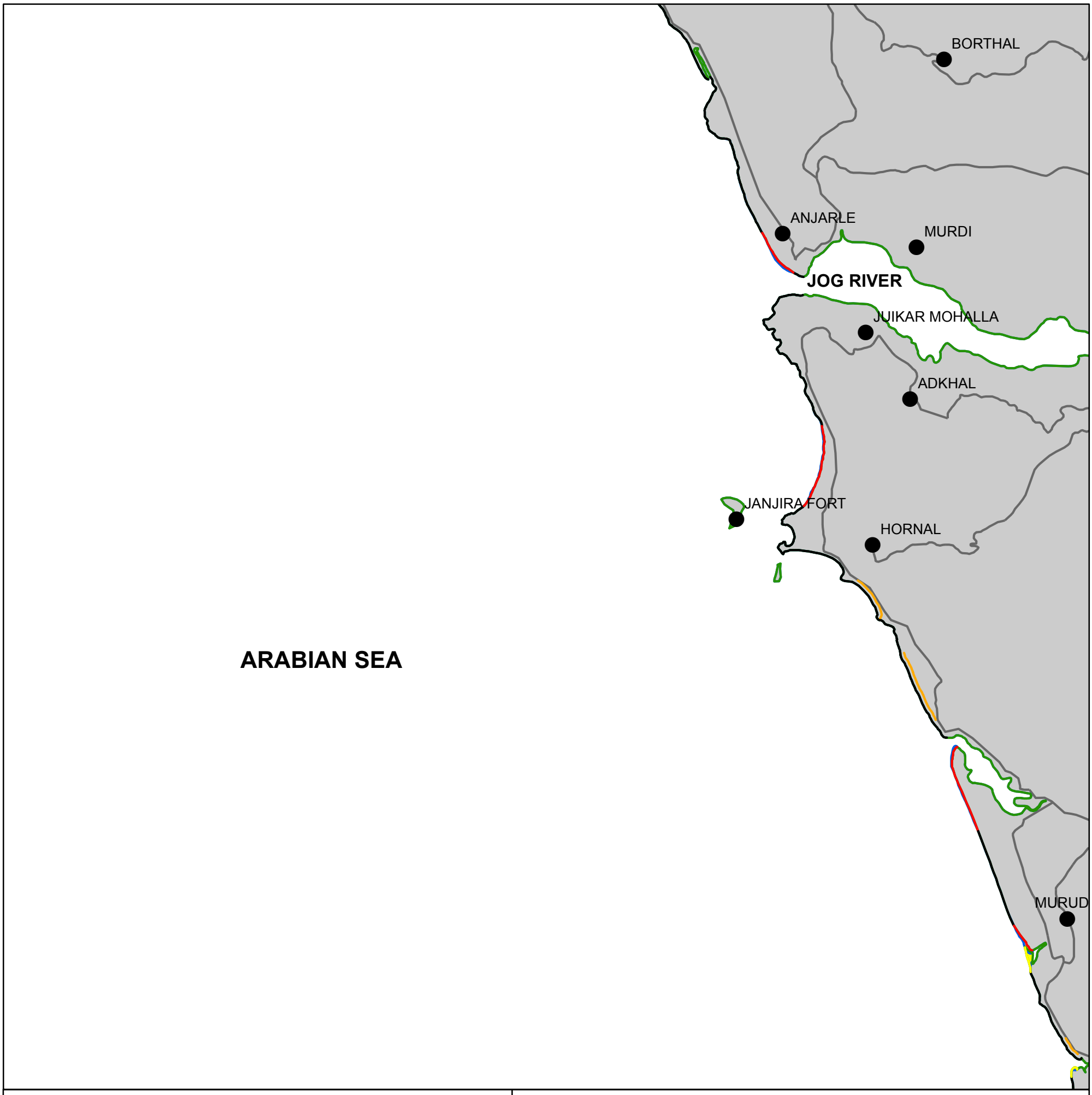
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G01SW



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47G01NW	47G01NE
SEA	47G01SW	47G01SE
SEA	47G02NW	47G02NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G02NW

ARABIAN SEA

Legend

- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47G01SW	47G01SE
SEA	47G02NW	47G02NE
SEA	SEA	47G02SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

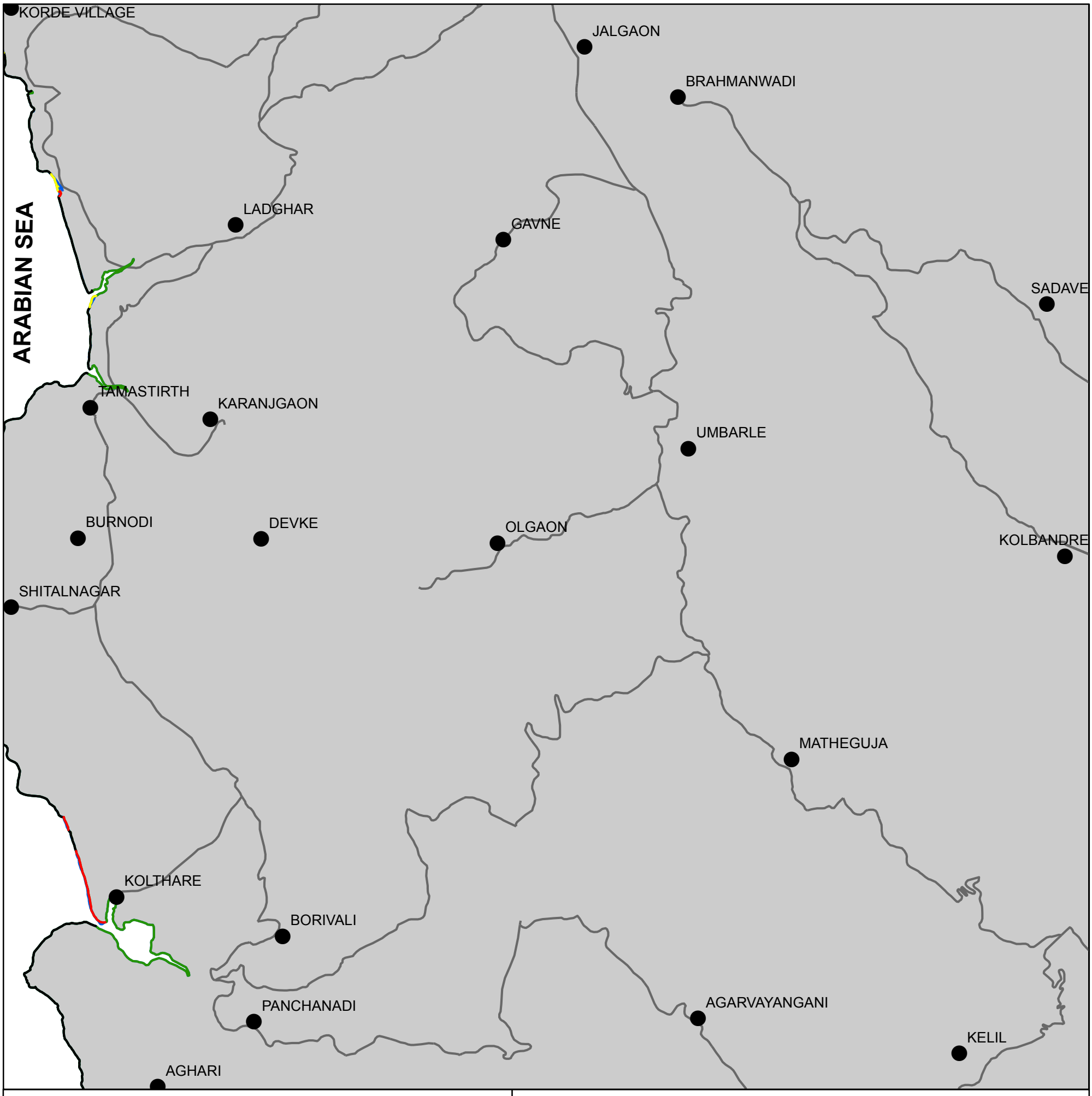
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G02NE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47G01SW	47G01SE	47G05SW
47G02NW	47G02NE	47G06NW
SEA	47G02SE	47G06SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G02SE

VANDOSH TARF PANCHAN

VARCHA

USGAON

PANDERI

NAVASE WADI

DABHOL

VASHISTI RIVER

UMBAR GHAR

TETALE

KULVANDI

PARDALEWADI

ANJANWEL

SAKHARI BK.

KHAMSHET

KHAKAMWADI

ARABIAN SEA

PALPENE

BHANDARWADI

PIMPALWADI

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- JETTY
- HABITATION

N

W E

S

0 2 km

INDEX TO SHEETS

47G02NW	47G02NE	47G06NW
SEA	47G02SE	47G06SW
SEA	47G03NE	47G07NW

INDIA

MAHARASHTRA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

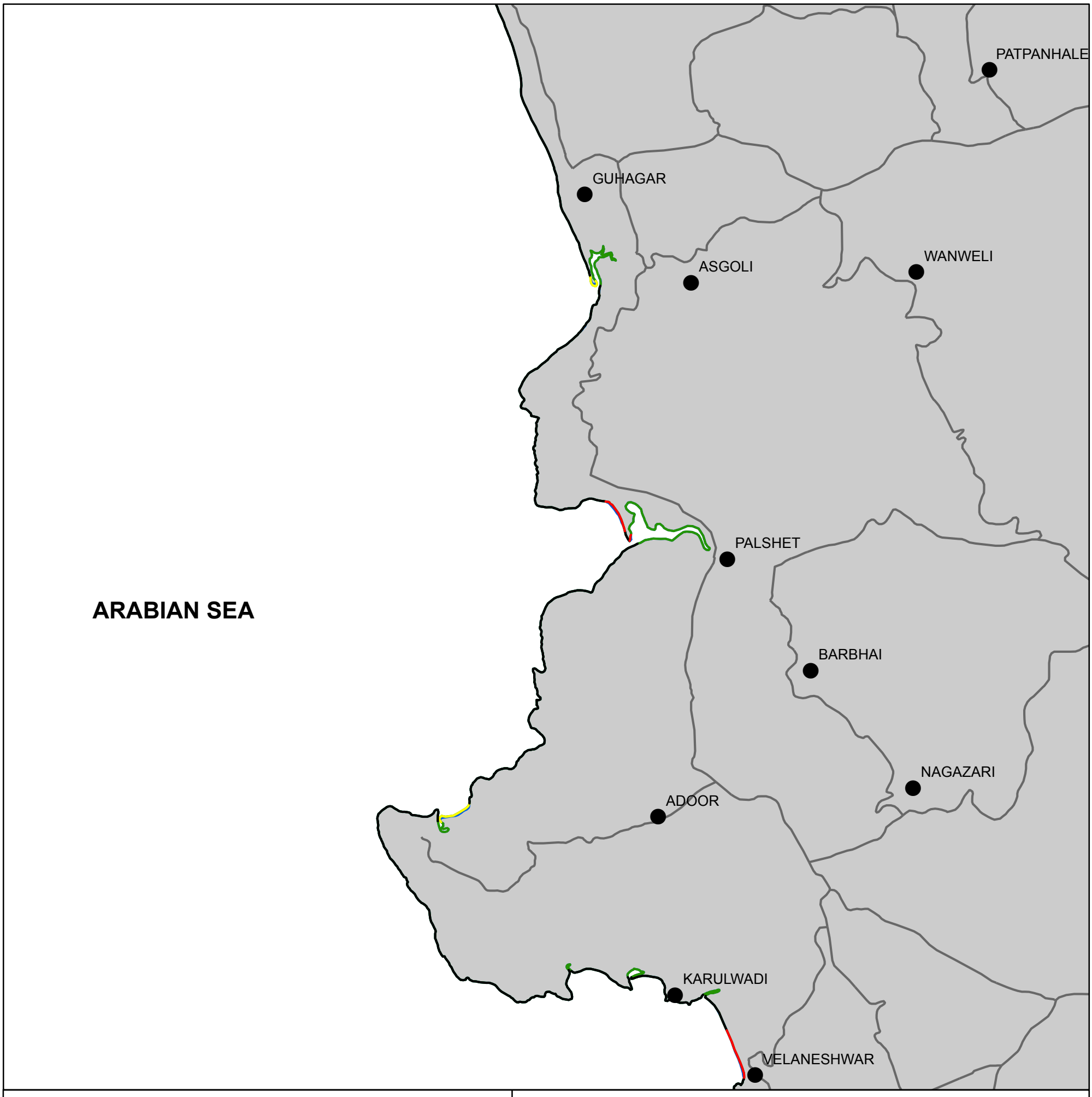
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G03NE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47G02SE	47G06SW
SEA	47G03NE	47G07NW
SEA	47G03SE	47G07SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

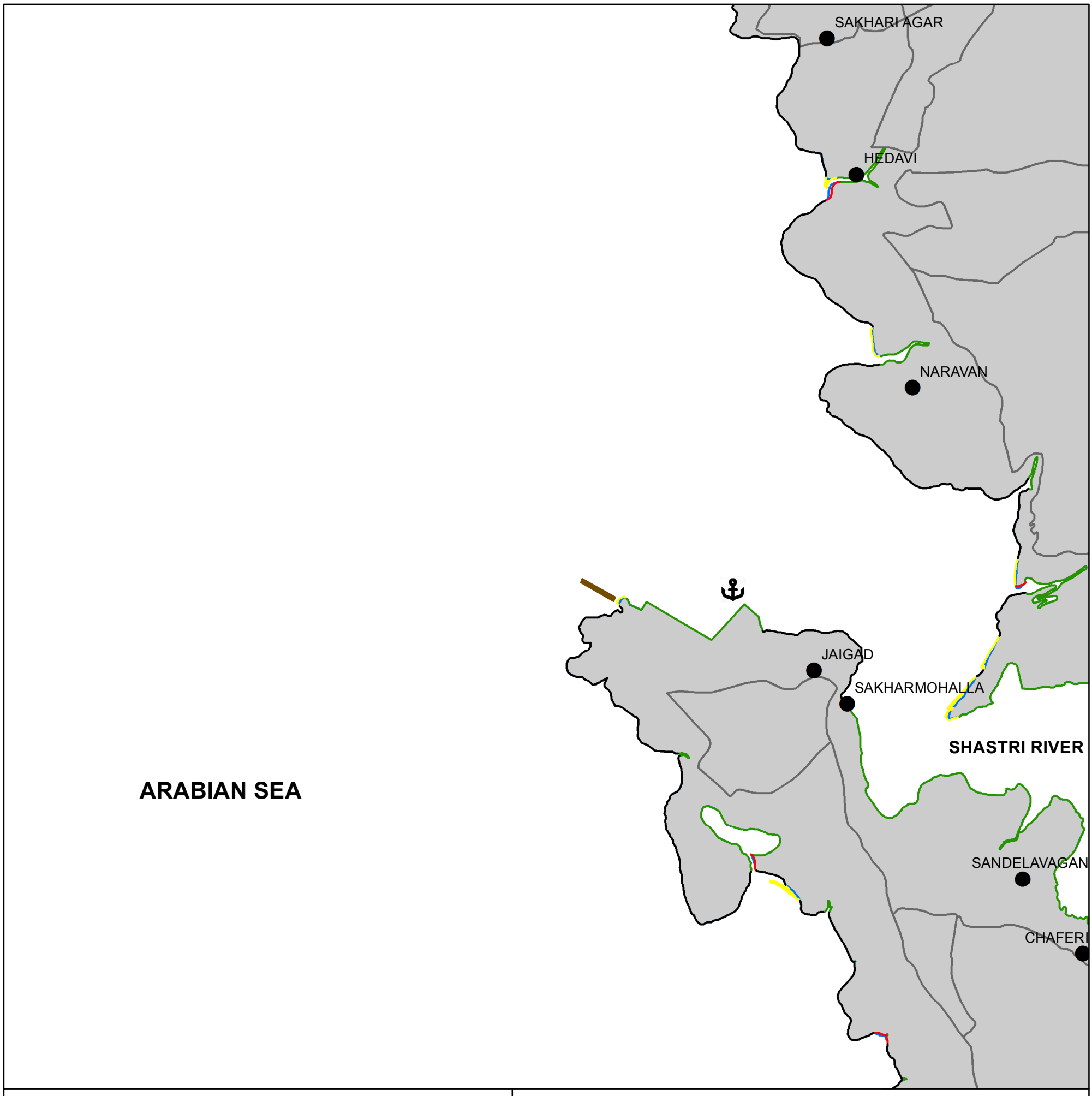
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G03SE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- JETTY
- PORT/HARBOUR
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47G03NE	47G07NW
SEA	47G03SE	47G07SW
SEA	47G04NE	47G08NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

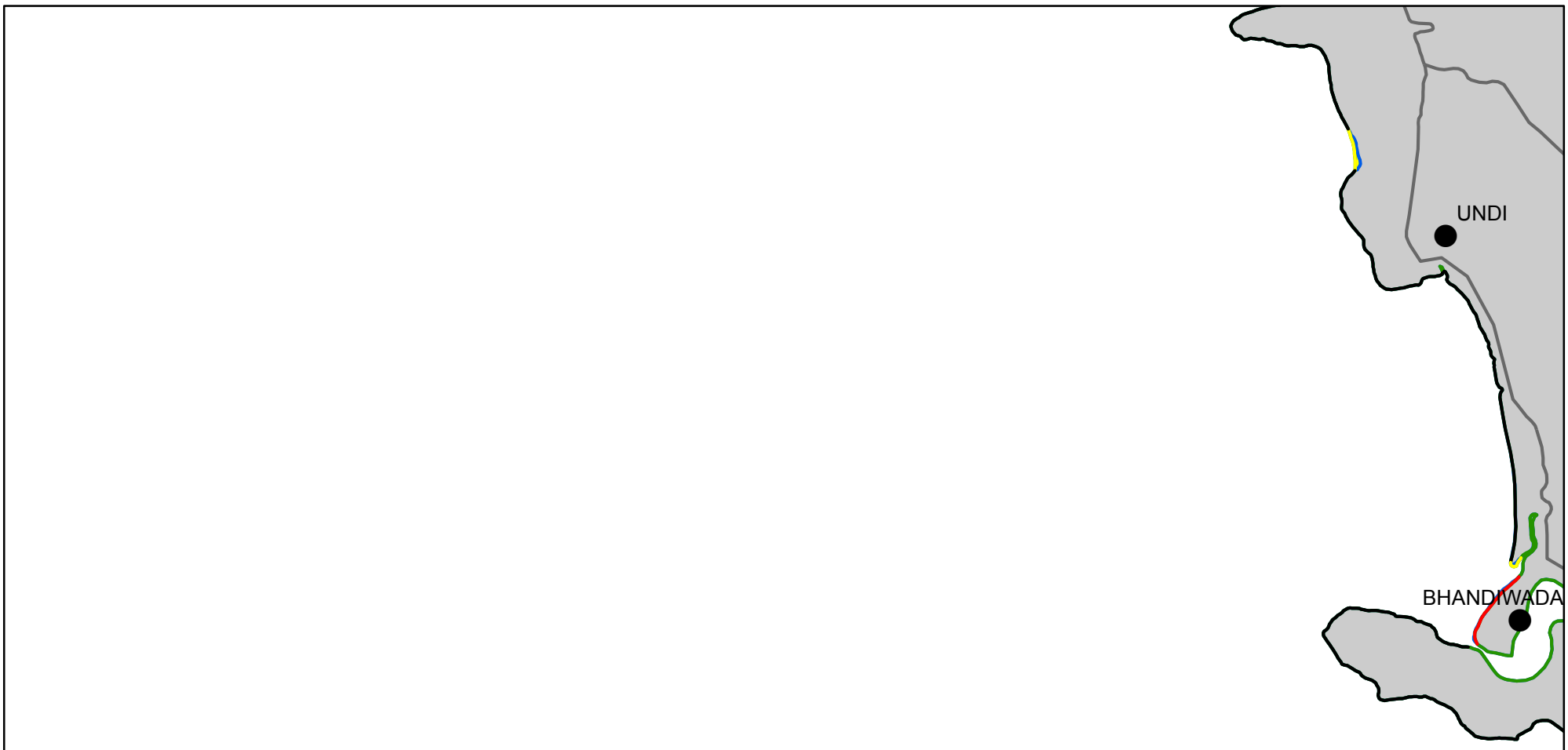
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G04NE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47G03SE	47G07SW
SEA	47G04NE	47G08NW
SEA	SEA	47G08SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G08NW

KOLAVALI

SHASTRI RIVER

REWALWADI

KESAPURI

MALGUND

GANAPATIPULE

DHAMANSO

ARABIAN SEA

BHANDARPULE

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N

W E

S

0 2 km

INDEX TO SHEETS

47G03SE	47G07SW	47G07SE
47G04NE	47G08NW	47G08NE
SEA	47G08SW	47G08SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47G08SW

NEWARE
KOTAVADE
JAMBHARUN
UMBARWADI (N.V.)
MADHALIWADI (N.V.)
SADYE
BHOLEWADI
BASANI
PRANDAVANE
ARABIAN SEA
SAKHARTAR
PHANASAVALE
MAJGAON
SADAMIRYA
MAHIM BAY
ADI WADI
SHIRGAON
MIRYA
JAKIMIRYA
MUSALMANWADI (N.V.)

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47G08NW	47G08NE
SEA	47G08SW	47G08SE
SEA	47H05NW	47H05NE

INDIA

MAHARASHTRA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

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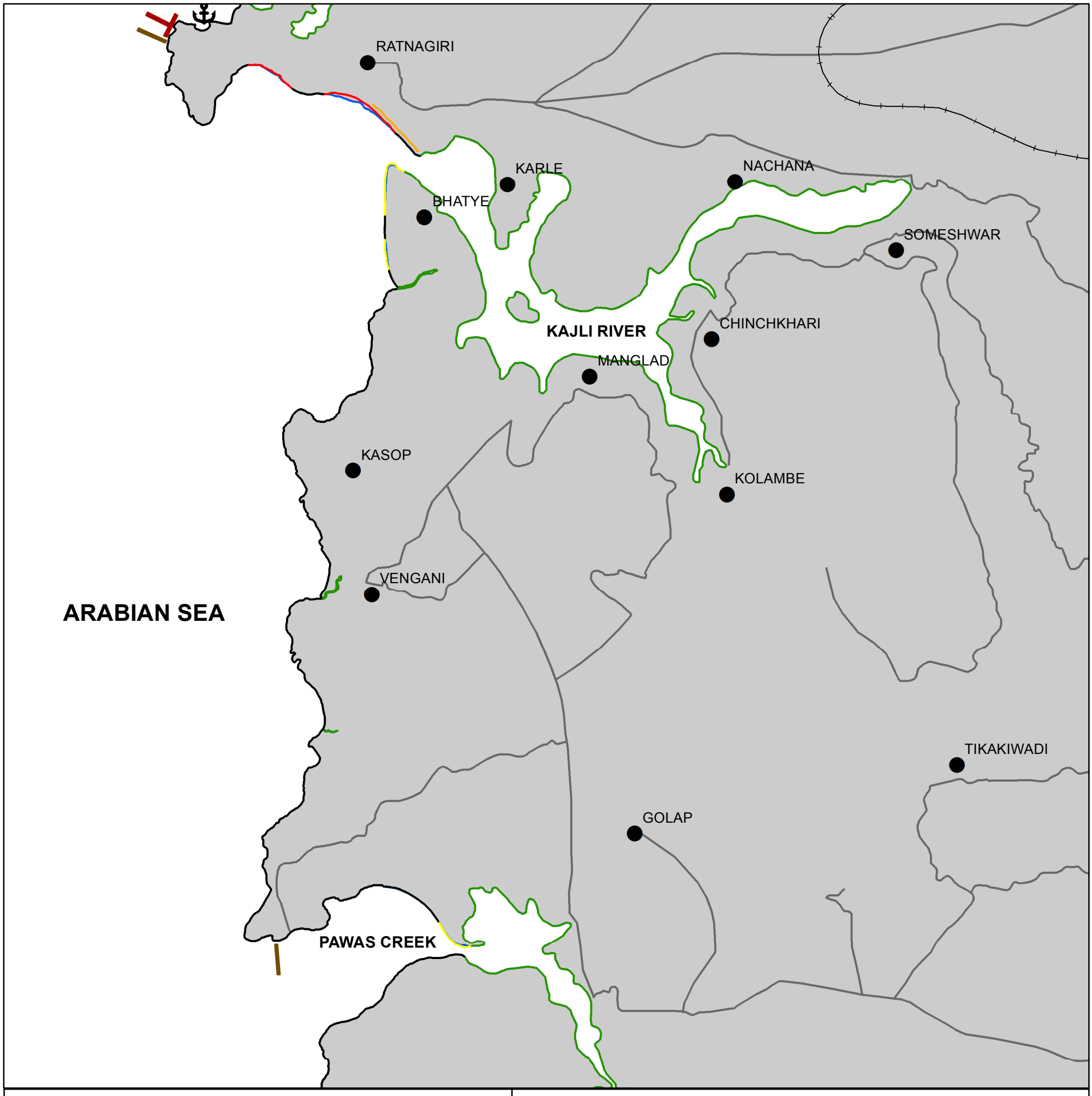
RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47H05NW



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- BREAKWATER
- PORT/HARBOUR
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47G08SW	47G08SE
SEA	47H05NW	47H05NE
SEA	47H05SW	47H05SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

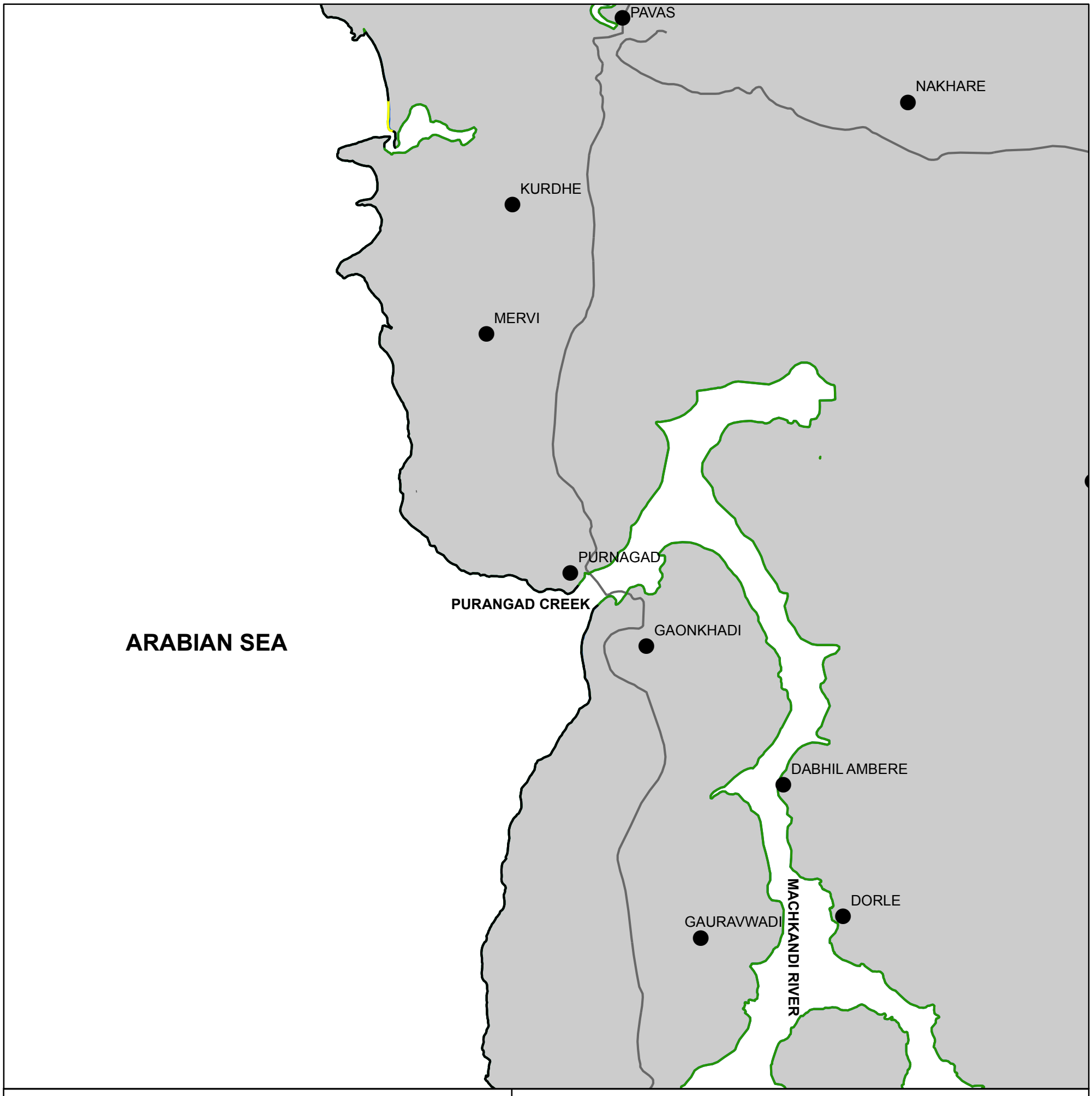
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47H05SW



Legend

- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47H05NW	47H05NE
SEA	47H05SW	47H05SE
SEA	47H06NW	47H06NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

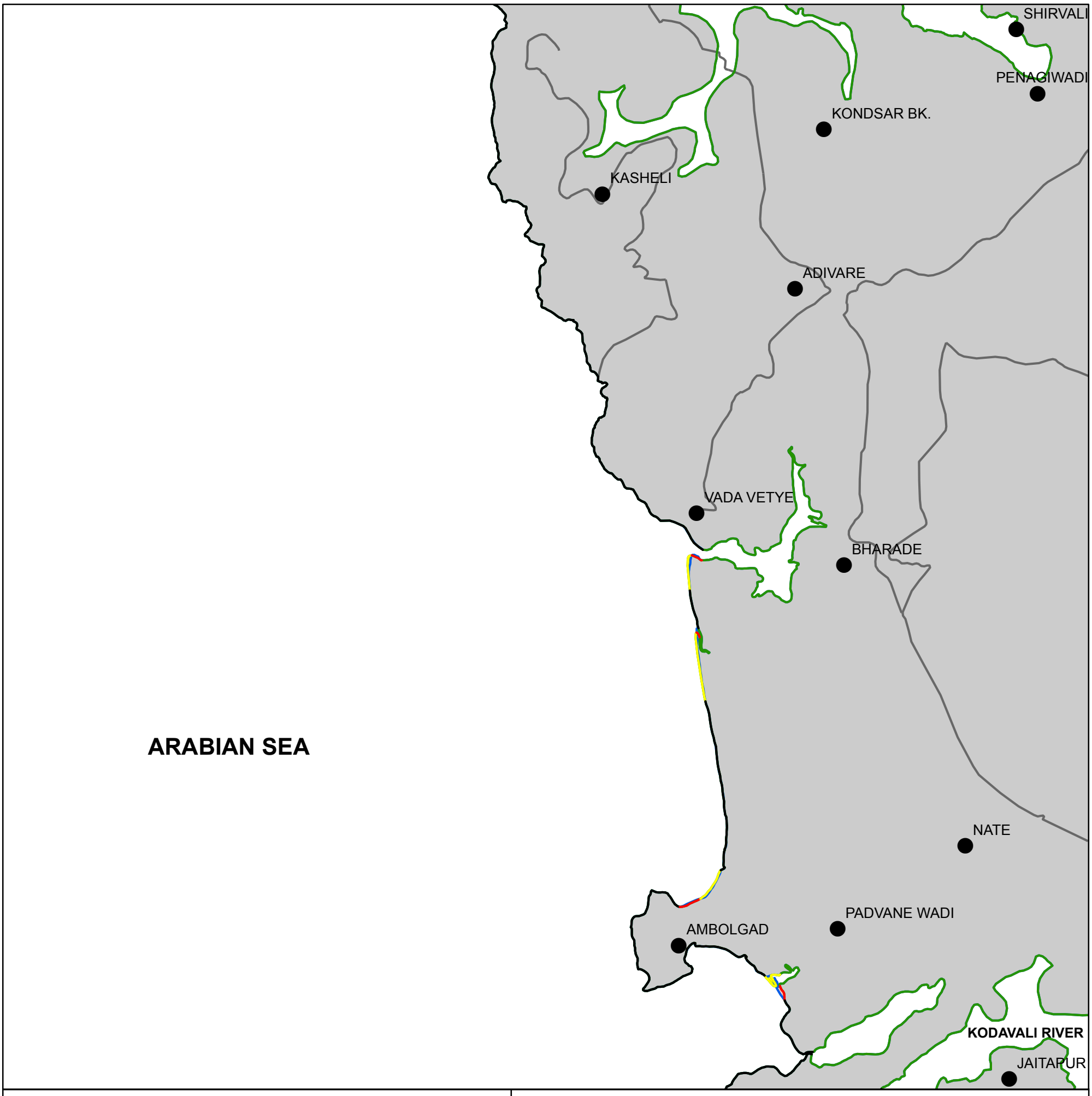
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI DISTRICT

MAHARASHTRA

SHEET NO. 47H06NW



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47H05SW	47H05SE
SEA	47H06NW	47H06NE
SEA	47H06SW	47H06SE

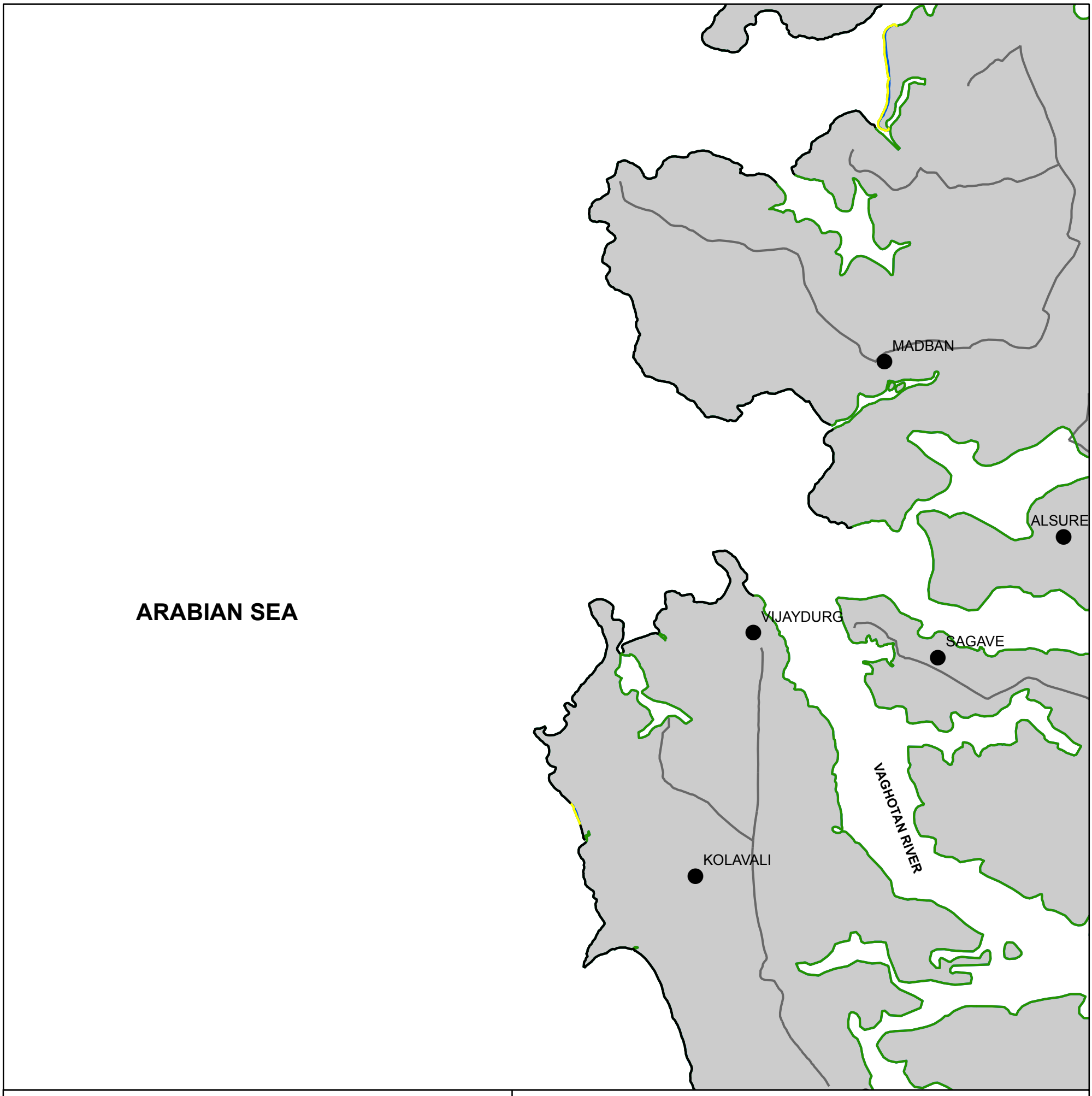
DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RATNAGIRI/SINDHUDURG DISTRICTS **MAHARASHTRA** SHEET NO. 47H06SW



Legend

- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47H06NW	47H06NE
SEA	47H06SW	47H06SE
SEA	47H07NW	47H07NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

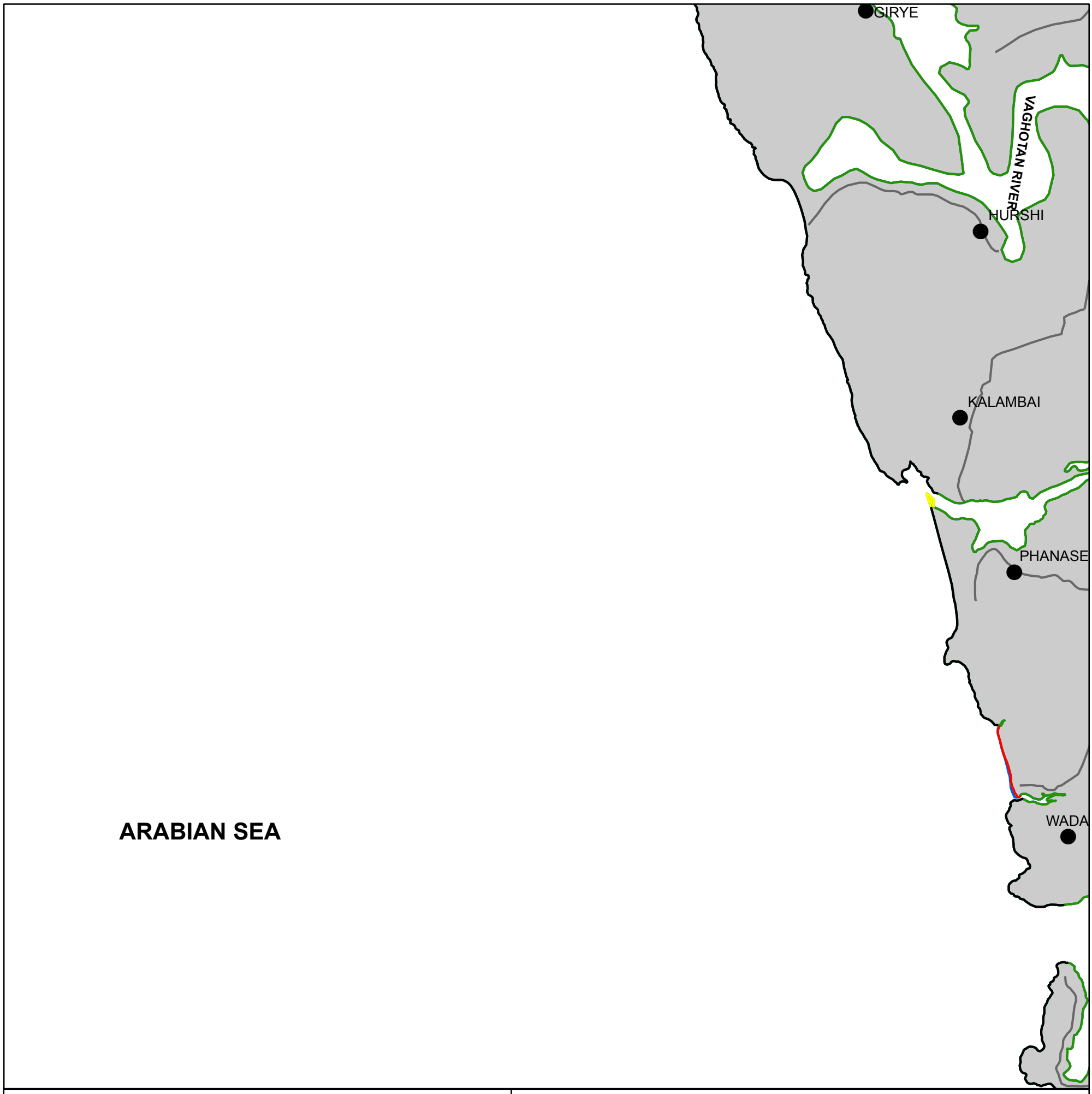
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT

MAHARASHTRA

SHEET NO. 47H07NW



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47H06SW	47H06SE
SEA	47H07NW	47H07NE
SEA	47H07SW	47H07SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

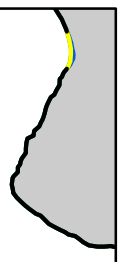
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT

MAHARASHTRA

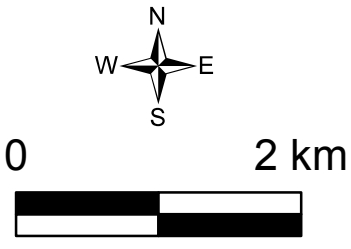
SHEET NO. 47H07SW



ARABIAN SEA

Legend

- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE



INDEX TO SHEETS

SEA	47H07NW	47H07NE
SEA	47H07SW	47H07SE
SEA	SEA	47H08NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT

MAHARASHTRA

SHEET NO. 47H07SE

DEVGAD
WARERI
ELAYE
LINGDAL
KUNKESHWAR
KATVAN
KOT KAMATE
DAHIBAV
NARINGRE
MITHBAV
ARABIAN SEA
MORVE
HINDALE
SADEWADI

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47H07NW	47H07NE	47H11NW
SEA	47H07SE	47H11SW
SEA	47H08NE	47H12NW

INDIA

MAHARASHTRA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT

MAHARASHTRA

SHEET NO. 47H08NE

MUNAKE
POYARE
PARWADI
CHINDAR
ACHARE
WARCHI CHAVADI
BHATWADI CHINDAR
PIRWADI
ACHRA CREEK
SADEWADI
WAYANGANI
HADI
TONDVALI

ARABIAN SEA

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47H07SW	47H07SE	47H11SW
SEA	47H08NE	47H12NW
SEA	47H08SE	47H12SW

INDIA

MAHARASHTRA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

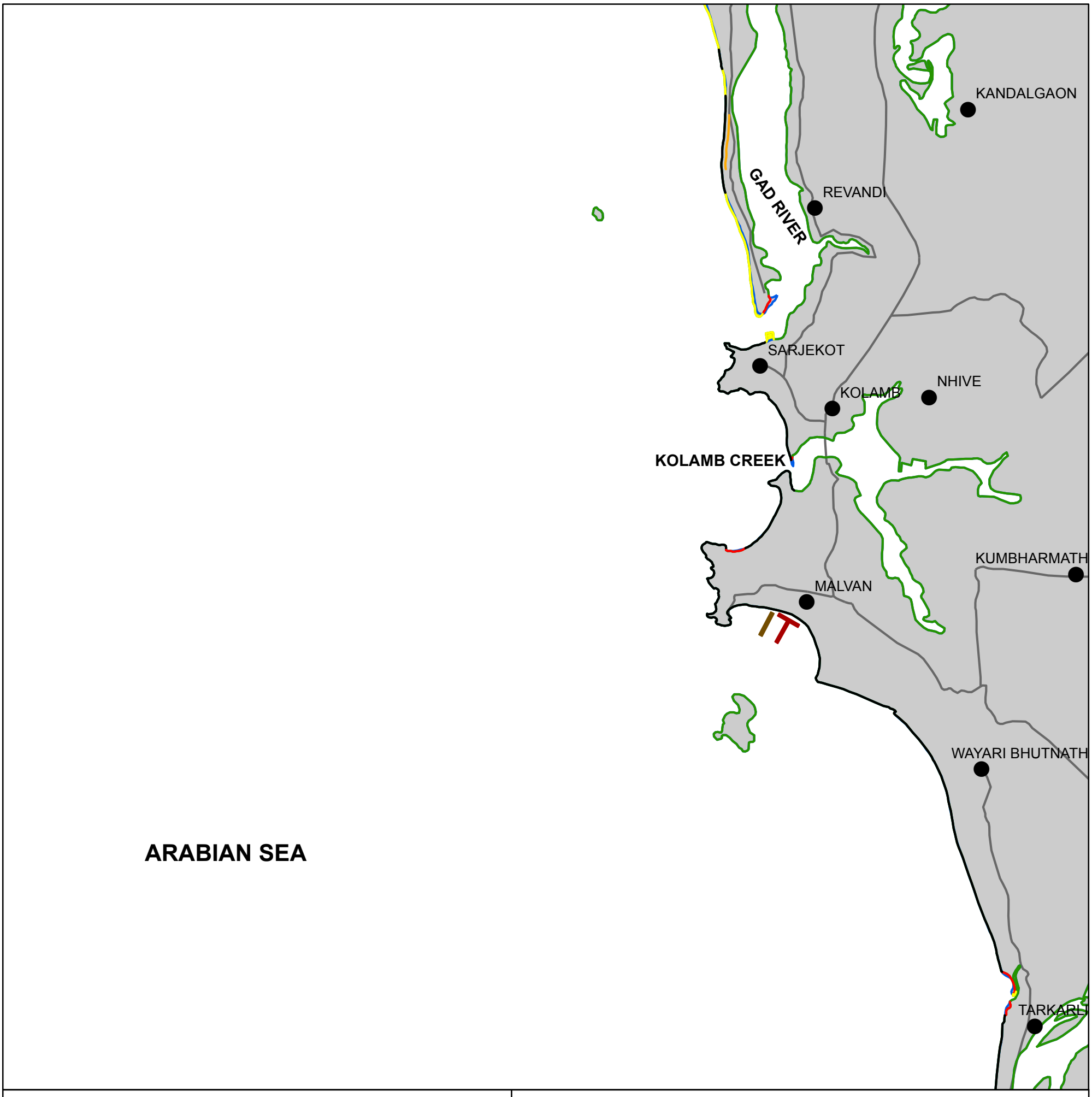
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

RAIGAD DISTRICT

MAHARASHTRA

SHEET NO. 47H08SE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- JETTY
- BREAKWATER
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47H08NE	47H12NW
SEA	47H08SE	47H12SW
SEA	48E05NE	48E09NW

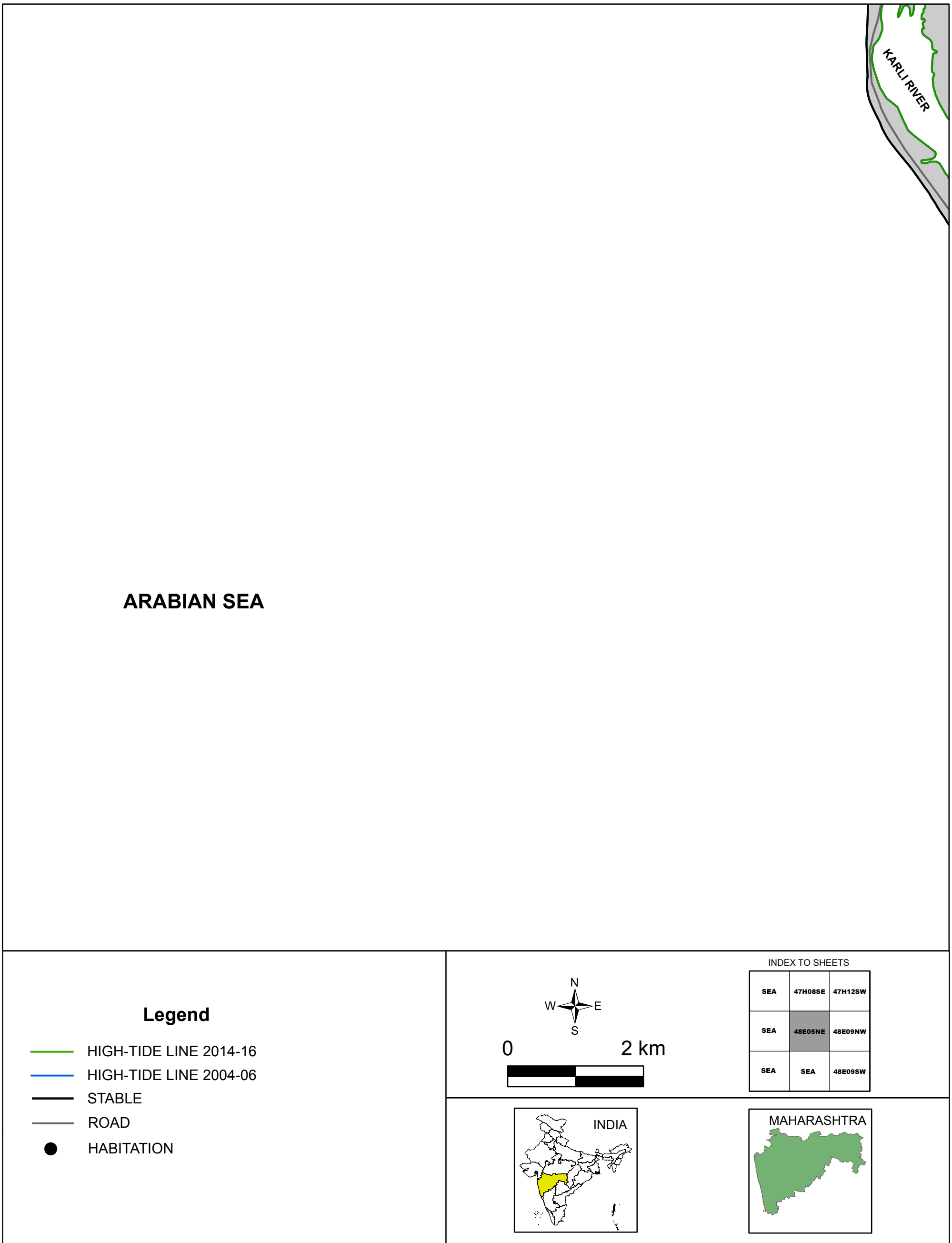
DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT **MAHARASHTRA** SHEET NO. 48E05NE



Legend

- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	47H08SE	47H12SW
SEA	48E05NE	48E09NW
SEA	SEA	48E09SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT

MAHARASHTRA

SHEET NO. 48E09NW

PARULE
KARLI RIVER
DEVBAG
MIHAPAN
KOCHARE
BHOGAVE
SHRIRAMWADI
MEDHA
MALAI
MUNGI
KELUS
KALAVI
ARABIAN SEA

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

47H08SE	47H12SW	47H12SE
SEA	48E09NW	48E09NE
SEA	SEA	48E09SE

INDIA

MAHARASHTRA

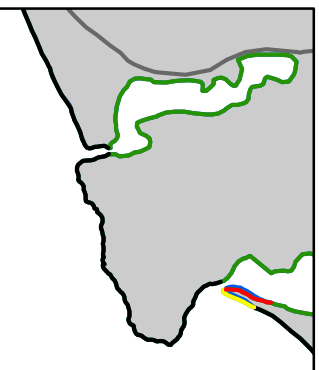
DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT **MAHARASHTRA** SHEET NO. 48E09SW



ARABIAN SEA

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD

N
W E
S

0 2 km

INDEX TO SHEETS

48E05NE	48E09NW	48E09NE
SEA	48E09SW	48E09SE
SEA	SEA	48E10NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT

MAHARASHTRA

SHEET NO. 48E09SE

VENGURLA
NAVABAG
BHENDMALA
PADATAL
UBHADANDA
MUTH
ANASUR
WADAKHOL
MALEWAD
MOCHEMAD
SONASURE
TEMBH
BAGAYAT
AJGAON
SHIRODA

ARABIAN SEA

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

48E09NW	48E09NE	48E13NW
48E09SW	48E09SE	48E13SW
SEA	48E10NE	48E14NW

INDIA

MAHARASHTRA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SINDHUDURG DISTRICT

MAHARASHTRA

SHEET NO. 48E10NE

Legend

- EROSION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- JETTY
- STATE BOUNDARY
- PORT/HARBOUR
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

48E09SW	48E09SE	48E13SW
SEA	48E10NE	48E14NW
SEA	SEA	48E14SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAPS

GOA

INDEX MAP OF GOA

48E10NE

48E10SE

48E14SW

48E15NW

48E15SW

48E15SE

48E16NE

48E16SE

48I04SW

48J01NW

CHAPORA

PANAJI

DABOLIM

MADGAON

ARABIAN SEA

N

0 25 50

KM

SHORELINE CHANGES OF GOA

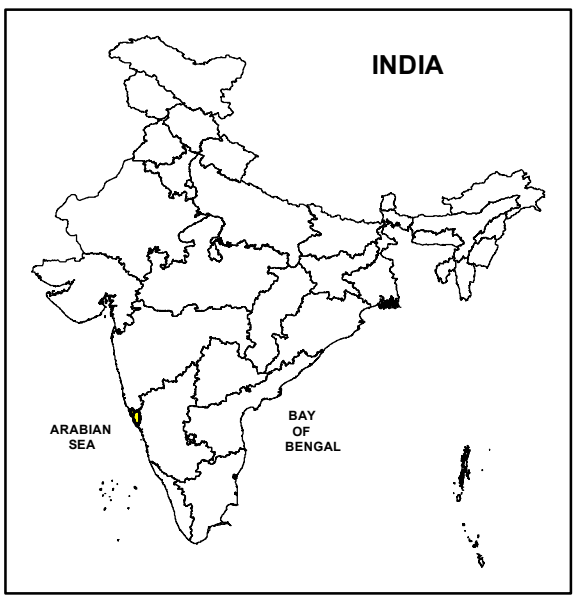
ARABIAN SEA

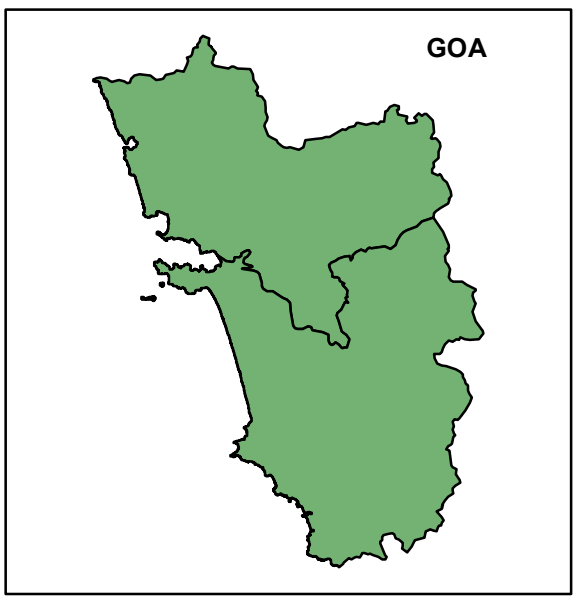
CHAPORA

PANAJI

DABOLIM

MADGAON





LEGEND

- ACCRETION LENGTH
- EROSION LENGTH
- STABLE LENGTH
- HIGH-TIDE LINE 2014-16

N

0 25 50

KM

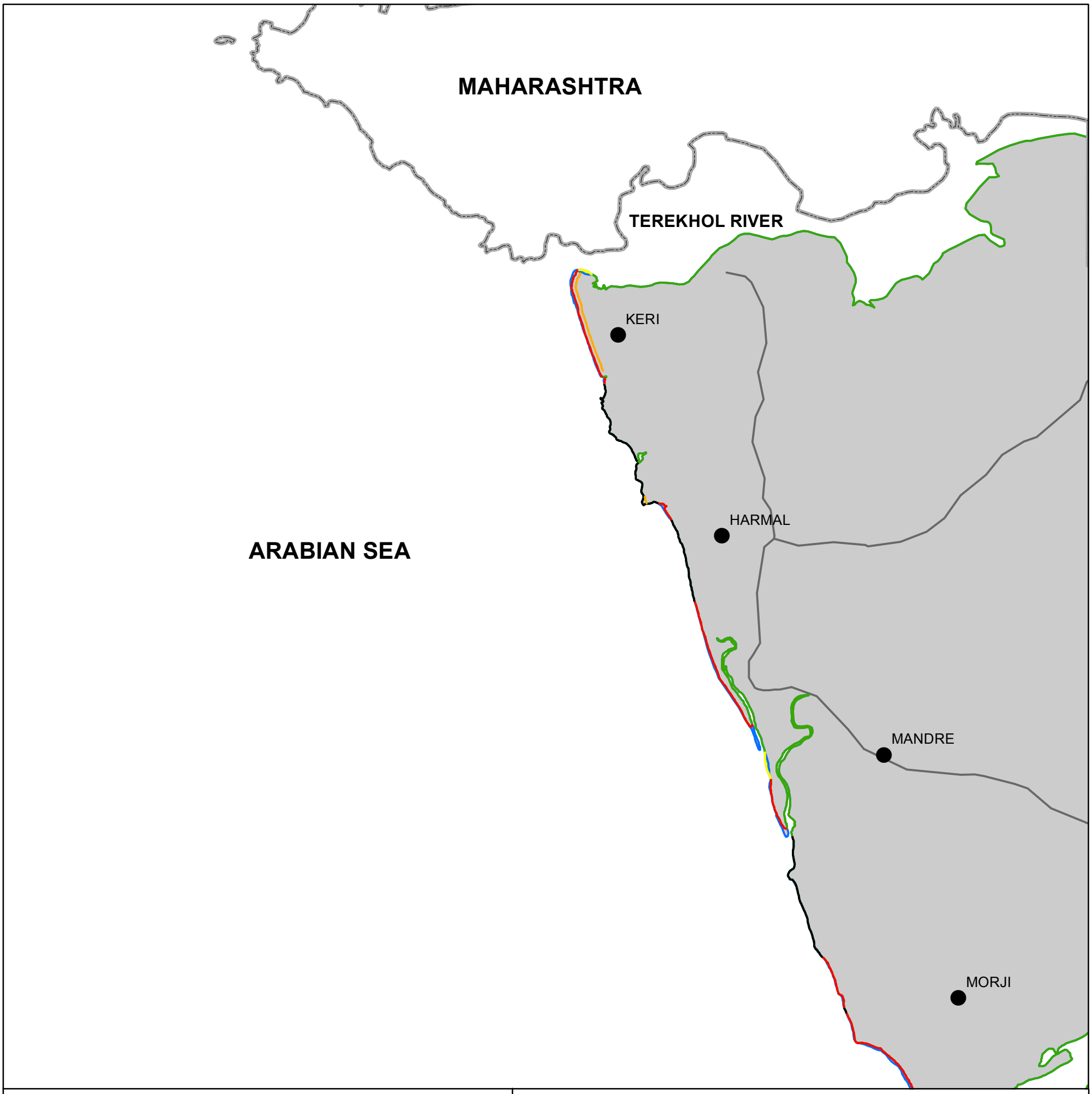
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

NORTH GOA DISTRICT

GOA

SHEET NO. 48E10NE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- STATE BOUNDARY
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	48E09SE	48E13SW
SEA	48E10NE	48E14NW
SEA	48E10SE	48E14SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

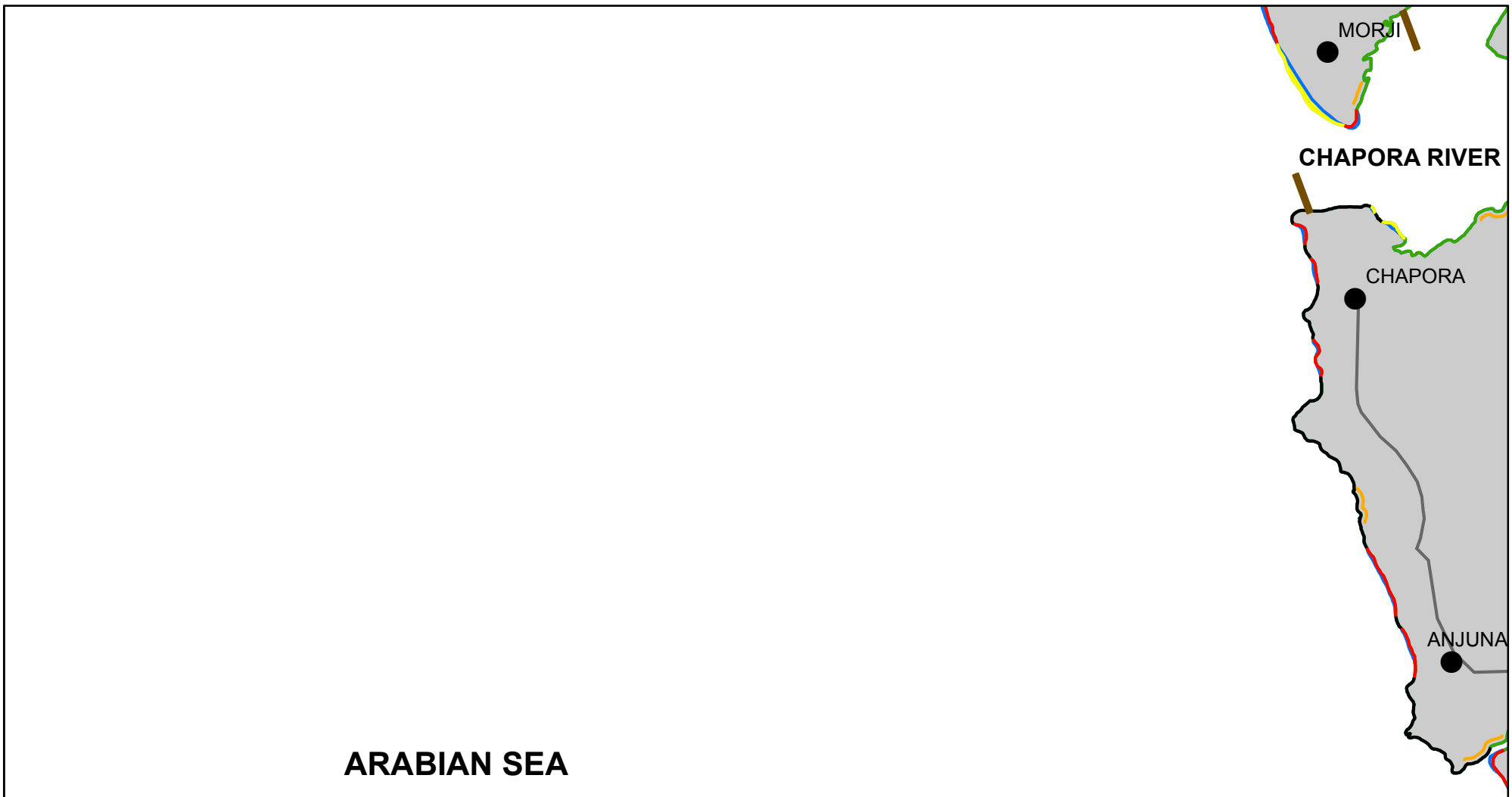
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

NORTH GOA DISTRICT

GOA

SHEET NO. 48E10SE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- JETTY
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	48E10NE	48E14NW
SEA	48E10SE	48E14SW
SEA	SEA	48E15NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

NORTH GOA DISTRICT

GOA

SHEET NO. 48E14SW

ARPORA

KALANGUT

NERUL

VEREM

Legend

- EROSION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- SEA WALL
- JETTY
- PORT/HARBOUR
- HABITATION

N
W E
S

0 1.9 km

INDEX TO SHEETS

48E10NE	48E14NW	48E14NE
48E10SE	48E14SW	48E14SE
SEA	48E15NW	48E15NE

INDIA

GOA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

NORTH GOA/SOUTH GOA DISTRICT **GOA**

SHEET NO. 48E15NW

SHINKEN
MANDAVI RIVER
PANAJI
AGUADA BAY
KARANJNALEN
DON PAOL
MORGADU
MARMAGAO BAY
ZUVARI RIVER
JASIARU ISLAND
CHIKALIN
BOBDAN
VASCO DA GAMA
DABOLIN
ARABIAN SEA
DABOLIMRS
DABOLIM AERODROME
PIKENE ISLAND

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- JETTY
- BREAKWATER
- PORT/HARBOUR
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

48E10SE	48E14SW	48E14SE
SEA	48E15NW	48E15NE
SEA	48E15SW	48E15SE

INDIA

GOA

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

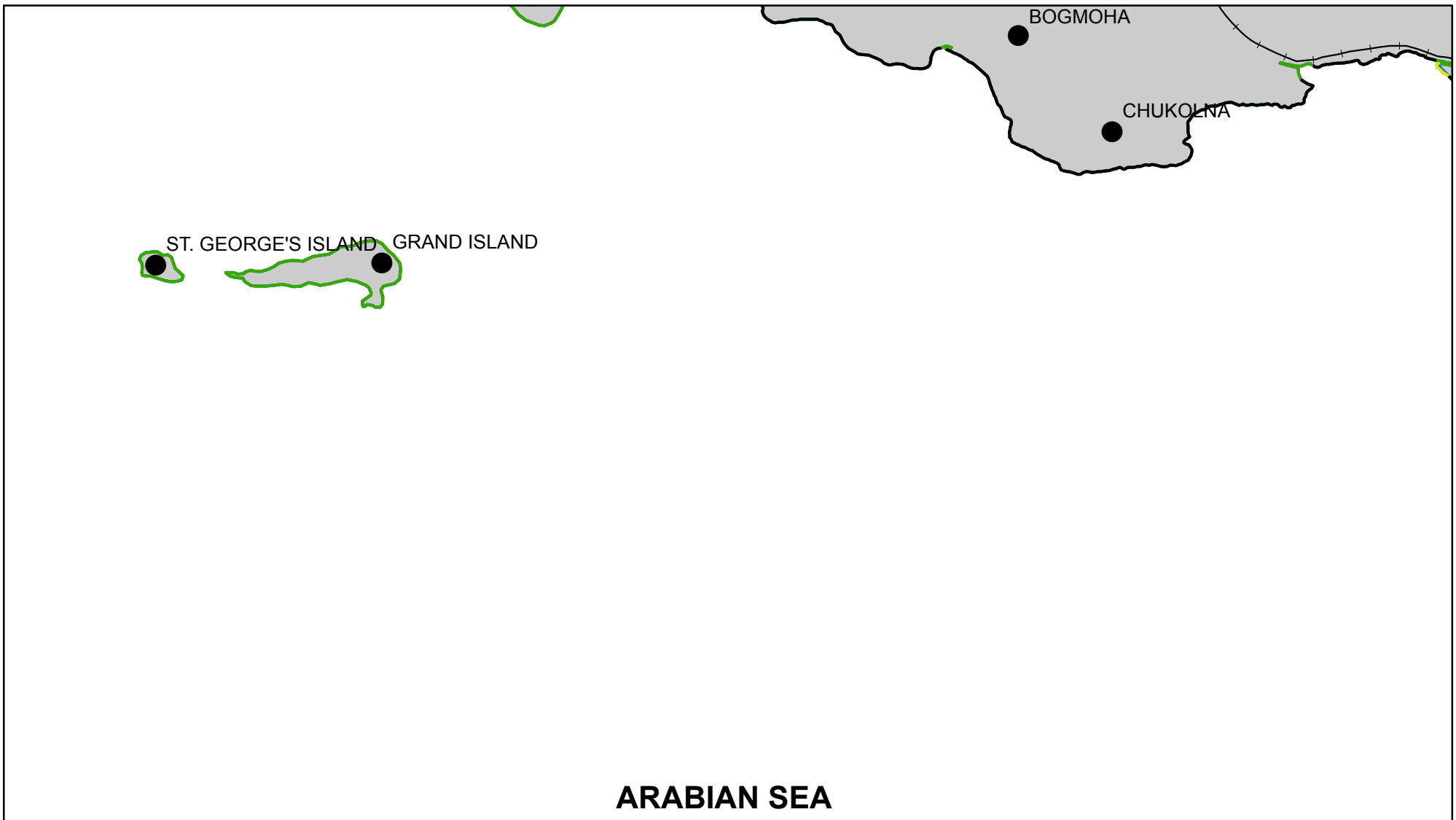
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SOUTH GOA DISTRICT

GOA

SHEET NO. 48E15SW



Legend

- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- RAILWAY
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	48E15NW	48E15NE
SEA	48E15SW	48E15SE
SEA	SEA	48E16NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
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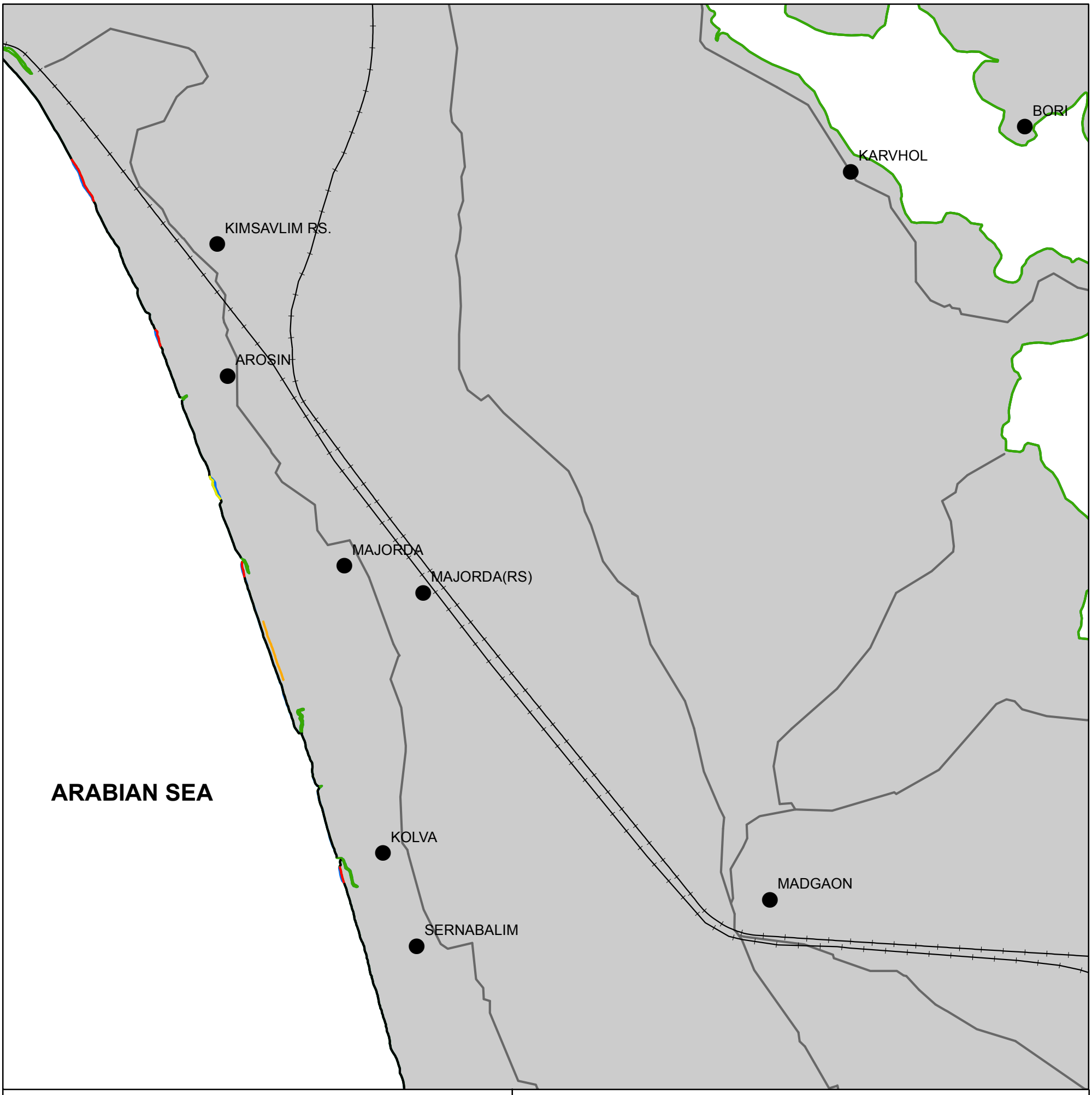
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SOUTH GOA DISTRICT

GOA

SHEET NO. 48E15SE



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

48E15NW	48E15NE	48I03NW
48E15SW	48E15SE	48I03SW
SEA	48E16NE	48I04NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SOUTH GOA DISTRICT

GOA

SHEET NO. 48E16NE

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

48E15SW	48E15SE	48I03SW
SEA	48E16NE	48I04NW
SEA	48E16SE	48I04SW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

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SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SOUTH GOA DISTRICT

GOA

SHEET NO. 48E16SE

KANAGINI

NUVEN

CAPE RAMA

BETUL

PARVEN

AGONDA

ARABIAN SEA

Legend

- EROSION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

SEA	48E16NE	48I04NW
SEA	48E16SE	48I04SW
SEA	SEA	48J01NW

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
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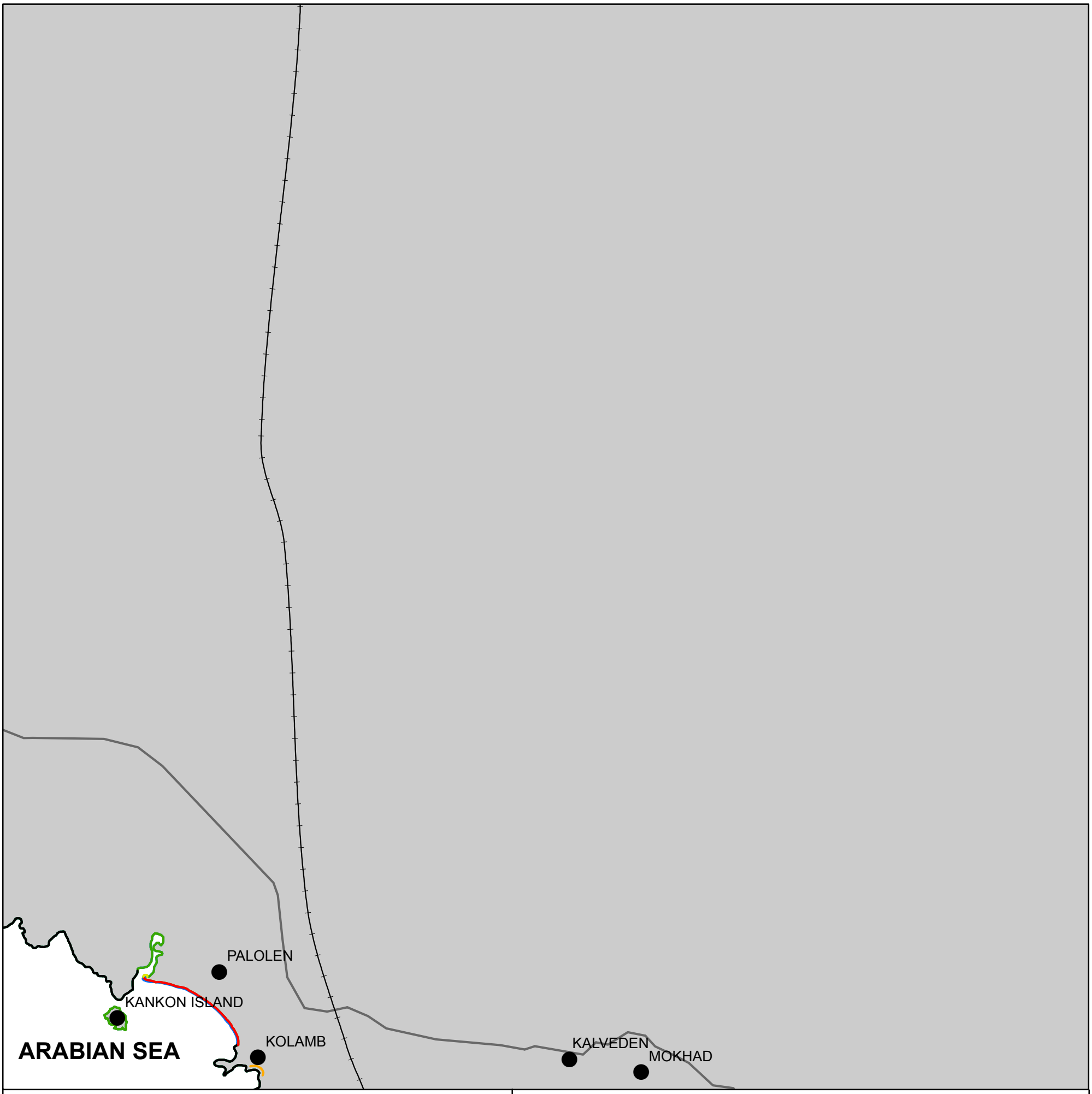
SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SOUTH GOA DISTRICT

GOA

SHEET NO. 48I04SW



Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

48E16NE	48I04NW	48I04NE
48E16SE	48I04SW	48I04SE
SEA	48J01NW	48J01NE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
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AND CENTRAL WATER COMMISSION, NEW DELHI

SHORELINE CHANGE MAP

FOR OFFICIAL USE ONLY

SOUTH GOA DISTRICT

GOA

SHEET NO. 48J01NW

Legend

- EROSION
- ACCRETION
- HIGH-TIDE LINE 2014-16
- HIGH-TIDE LINE 2004-06
- STABLE
- ROAD
- RAILWAY
- SEA WALL
- STATE BOUNDARY
- HABITATION

N
W E
S

0 2 km

INDEX TO SHEETS

48E16SE	48I04SW	48I04SE
SEA	48J01NW	48J01NE
SEA	48J01SW	48J01SE

DATA SOURCE:
IRS LISS4 IMAGES OF 2004-06 & 2014-16

PREPARED BY:
SPACE APPLICATIONS CENTRE, ISRO, AHMEDABAD
AND CENTRAL WATER COMMISSION, NEW DELHI

HOT SPOTS OF SHORELINE CHANGE

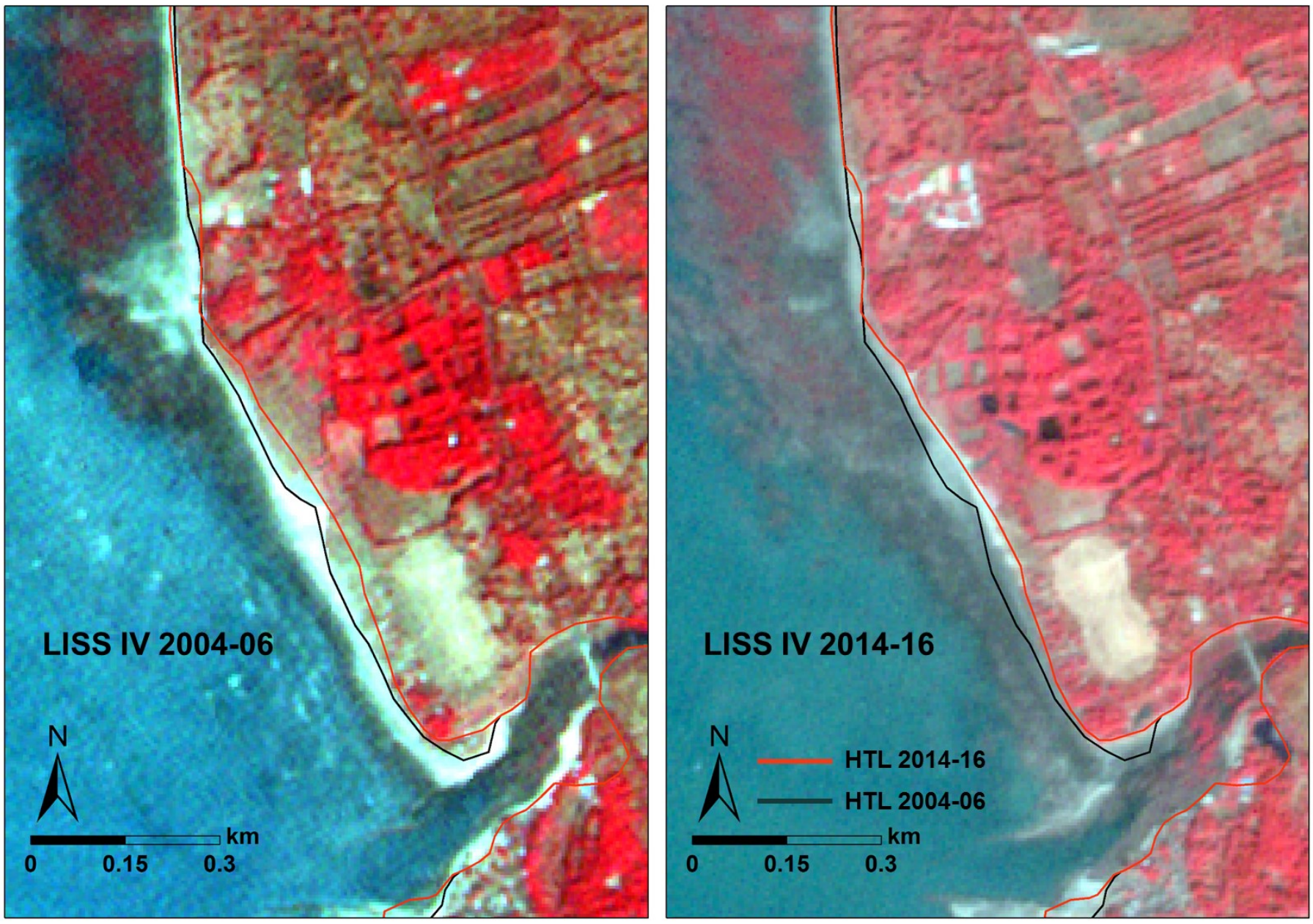

Plate 1: Coastal erosion to the north of Vadrai (47A10NE) marked on LISS IV images of IRS P6 and Resourcesat-2

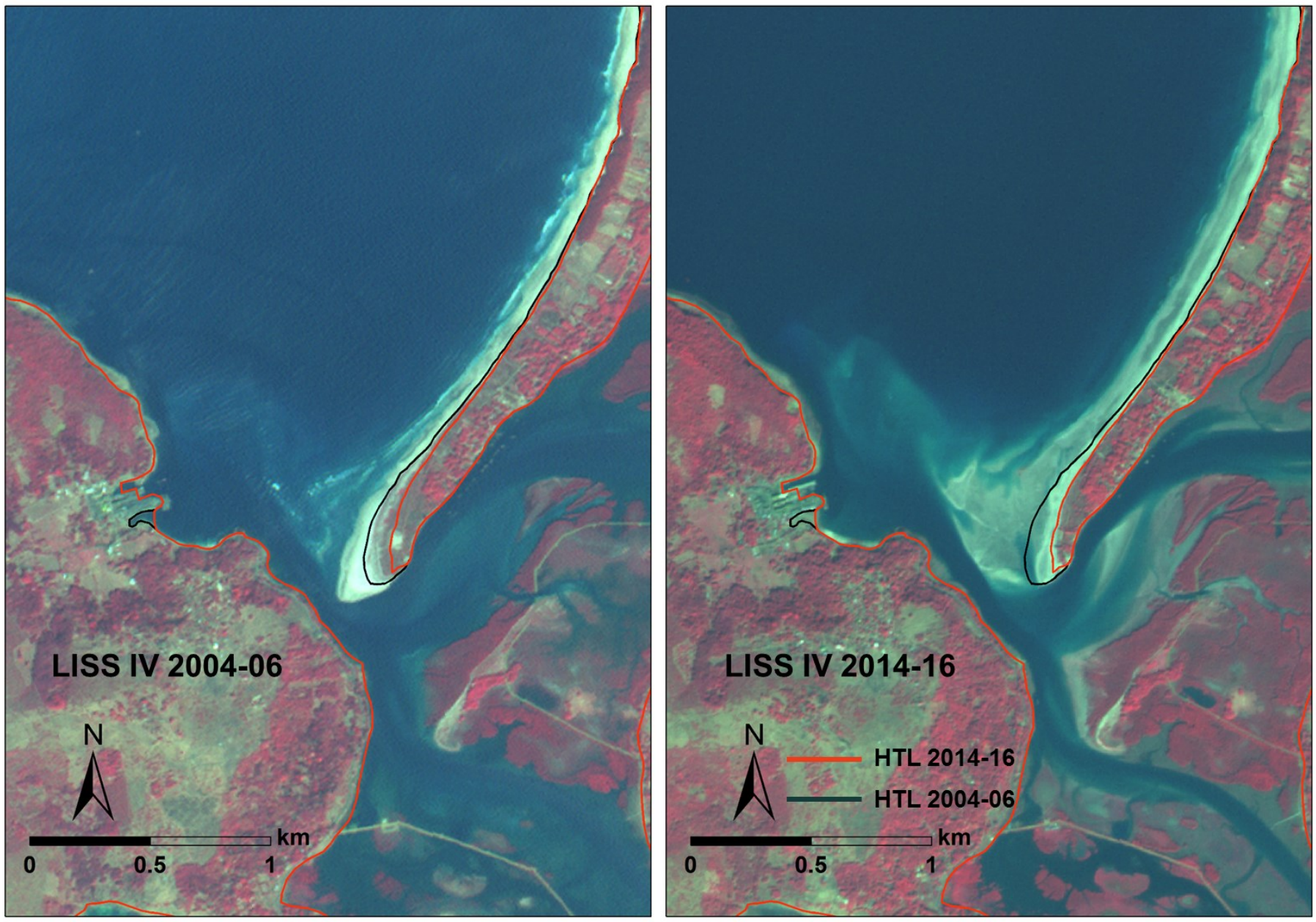

Plate 2: Costal erosion to the spit north of Mirya (47G08SW) marked on LISS IV images of IRS P6 and Resourcesat-2

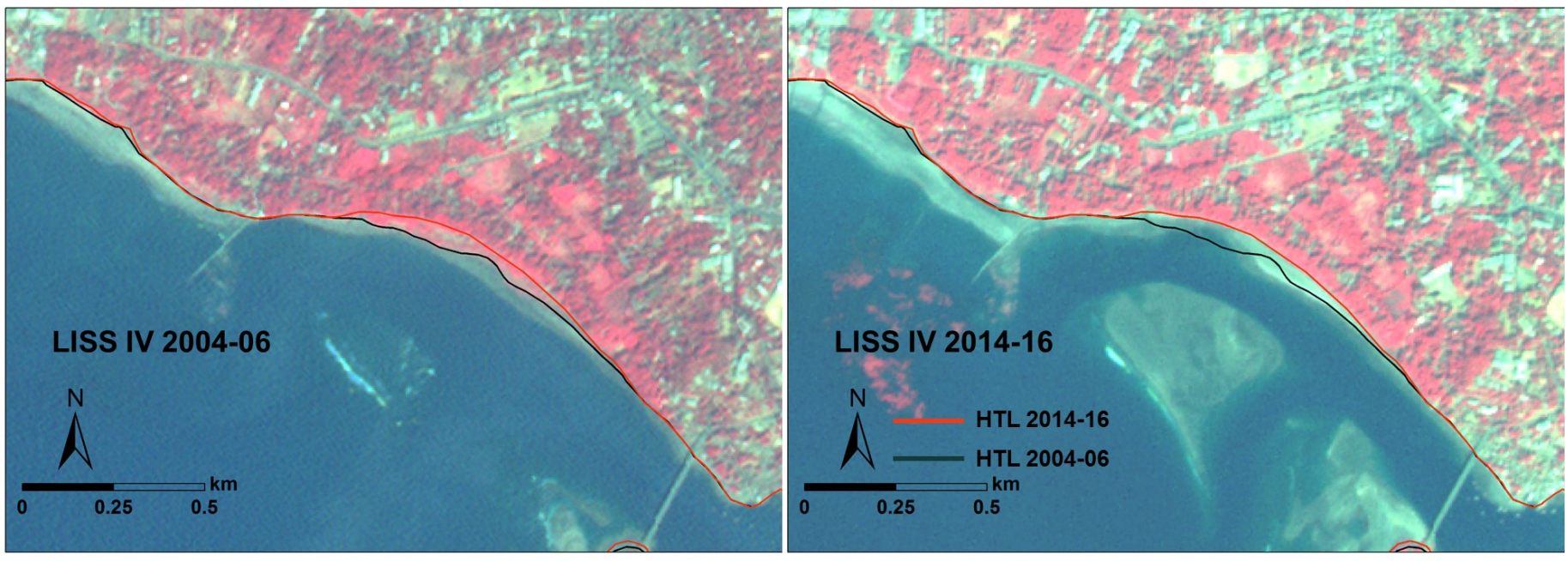

Plate 3: Coastal erosion at Ratnagiri (47H05NW) marked on LISS IV images of IRS P6 and Resourcesat-2

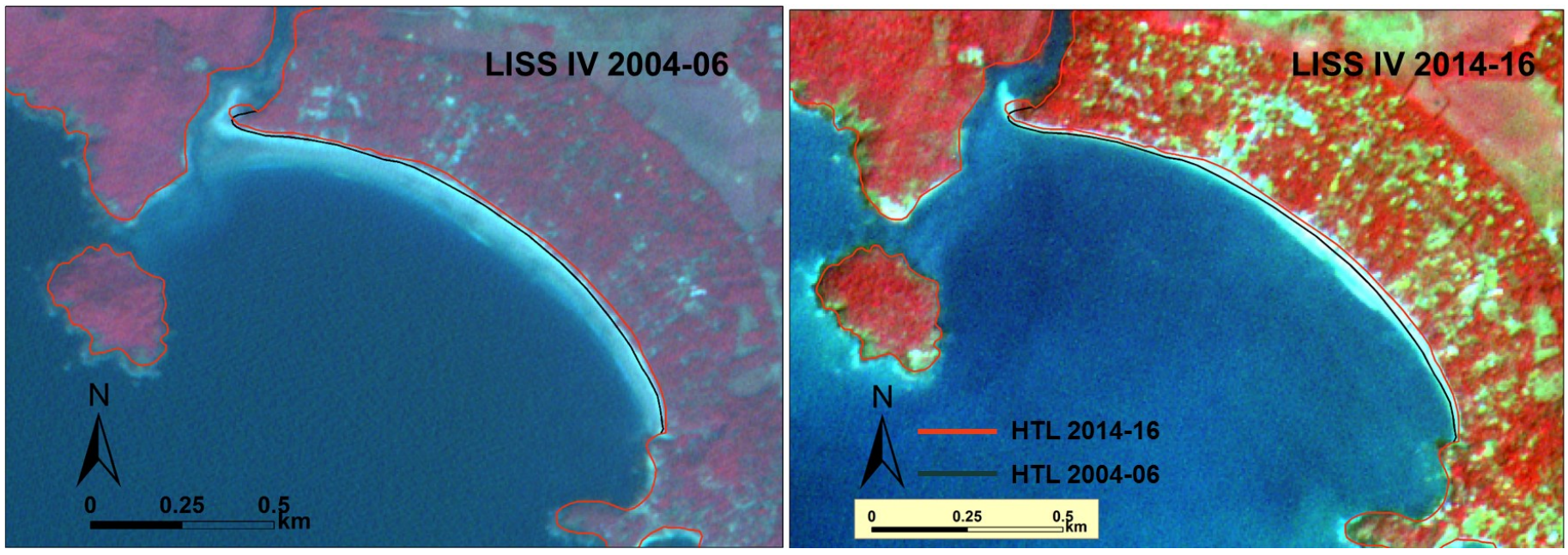

Plate 4: Erosion at Palolem beach (48I04SW) marked on LISS IV images of IRS P6 and Resourcesat-2

LIST OF SATELLITE DATA USED

Table No. 3: Satellite data used for Maharashtra Coast (2004-06 time-frame)

S. no.	Map sheet no.	Satellite	Sensor	Orbit	Scene	Date
1	46D12NE	IRS-P6	LISS IV	10629	62, 63	03-11-2005
2	46D12SE	IRS-P6	LISS IV	10629	63	03-11-2005
3	47A09NE	IRS-P6	LISS IV	10629	63,64	03-11-2005
4	47A09SE	IRS-P6	LISS IV	10629	63,64	03-11-2005
5	47A10NE	IRS-P6	LISS IV	12462	110, 111	12-03-2006
6	47A10SE	IRS-P6	LISS IV	12462	111, 112	12-03-2006
7	47A13NW	IRS-P6	LISS IV	12462	109, 110	12-03-2006
8	47A13SW	IRS-P6	LISS IV	12462	110	12-03-2006
9	47A16NE	IRS-P6	LISS IV	10757	2	12-11-2005
10	47A16NW	IRS-P6	LISS IV	10345	2	14-10-2005
11	47A16SW	IRS-P6	LISS IV	10757	2	12-11-2005
12	47B13NE	IRS-P6	LISS IV	8512	91	07-06-2005
13	47B13NW	IRS-P6	LISS IV	8512	91	07-06-2005
14	47B14NE	IRS-P6	LISS IV	6466	26	14-01-2005
15	47B14NW	IRS-P6	LISS IV	8512	92	07-06-2005
16	47B14SE	IRS-P6	LISS IV	6466	26,27	14-01-2005
17	47B16SE	IRS-P6	LISS IV	6878	96	12-02-2005
18	47E04NW	IRS-P6	LISS IV	8512	89,90	07-06-2005
19	47F01SE	IRS-P6	LISS IV	6878	92,93	12-02-2005
20	47F02SE	IRS-P6	LISS IV	6878	93,94	12-02-2005
21	47F02SW	IRS-P6	LISS IV	6466, 6878	26,27,94	14-01-2005,12-02-2005
22	47F03NW	IRS-P6	LISS IV	6878	94, 95	12-02-2005
23	47F03SW	IRS-P6	LISS IV	8029	92	04-05-2005
24	47F04NW	IRS-P6	LISS IV	6878	96	12-02-2005
25	47F04SW	IRS-P6	LISS IV	6878	96	12-02-2005
26	47F04SE	IRS-P6	LISS IV	7972, 8029	97,93	30-04-2005,04-05-2005
27	47F08NW	IRS-P6	LISS IV	7972	96	30-04-2005
28	47F08SE	IRS-P6	LISS IV	11851	101	28-01-2006
29	47F08SW	IRS-P6	LISS IV	7972	96, 97	30-04-2005
30	47G01NE	IRS-P6	LISS IV	7972	97, 98	30-04-2005
31	47G01NW	IRS-P6	LISS IV	6878	96, 97	12-02-2005
32	47G01SE	IRS-P6	LISS IV	7972	98	30-04-2005
33	47G01SW	IRS-P6	LISS IV	7972, 8029	98,94	30-04-2005,04-05-2005
34	47G02NE	IRS-P6	LISS IV	7972	98,99	30-04-2005
35	47G02SE	IRS-P6	LISS IV	7972	98,99	30-04-2005
36	47G02NW	IRS-P6	LISS IV	7972	98,99	30-04-2005
37	47G03NE	IRS-P6	LISS IV	7972	99,100	30-04-2005
38	47G03SE	IRS-P6	LISS IV	10558	103, 104	29-10-2005
39	47G04NE	IRS-P6	LISS IV	11851	105	28-01-2006
40	47G06NE	IRS-P6	LISS IV	11851	102, 103	28-01-2006

41	47G06NW	IRS-P6	LISS IV	7972, 11851	98,103	30-04-2005,28-01-2006
42	47G06SE	IRS-P6	LISS IV	11851	103,104,97	28-01-2006,19-01-2005
43	47G06SW	IRS-P6	LISS IV	11851	102, 103	28-01-2006
44	47G07SW	IRS-P6	LISS IV	11851	104, 105	28-01-2006
45	47G08NE	IRS-P6	LISS IV	6537	99	19-01-2005
46	47G08NW	IRS-P6	LISS IV	11851	105	28-01-2006
47	47G08SE	IRS-P6	LISS IV	6537	99,100	19-01-2005
48	47G08SW	IRS-P6	LISS IV	12263	124	26-02-2006
49	47G10SW	IRS-P6	LISS IV	6537	97	19-01-2005
50	47G12NW	IRS-P6	LISS IV	6537	98,99	19-01-2005
51	47H05NW	IRS-P6	LISS IV	6537	100	19-01-2005
52	47H05NE	IRS-P6	LISS IV	6537	100	19-01-2005
53	47H05SW	IRS-P6	LISS IV	6537	100, 101	19-01-2005
54	47H06NE	IRS-P6	LISS IV	6537	100, 101	19-01-2005
55	47H06NW	IRS-P6	LISS IV	6537	101	19-01-2005
56	47H06SW	IRS-P6	LISS IV	6537	101, 102	19-01-2005
57	47H06SE	IRS-P6	LISS IV	6537	101, 102	19-01-2005
58	47H07NE	IRS-P6	LISS IV	6537	102	19-01-2005
59	47H07NW	IRS-P6	LISS IV	6537	102	19-01-2005
60	47H07SW	IRS-P6	LISS IV	6537	102, 103	19-01-2005
61	47H08NE	IRS-P6	LISS IV	7759	28,29	15-04-2005
62	47H08SE	IRS-P6	LISS IV	7759	28,29	15-04-2005
63	47H11NW	IRS-P6	LISS IV	7759	27	15-04-2005
64	47H12NW	IRS-P6	LISS IV	7759	28	15-04-2005
65	47H12SE	IRS-P6	LISS IV	6665	99	28-01-2005
66	47H12SW	IRS-P6	LISS IV	6665, 7759	99,29	28-01-2005,15-04-2005
67	48E05NE	IRS-P6	LISS IV	7759	29, 30	15-04-2005
68	48E09NW	IRS-P6	LISS IV	7759	29	15-04-2005
69	48E09SE	IRS-P6	LISS IV	6665, 11723	100, 117	28-01-2005,19-01-2006
70	48E09SW	IRS-P6	LISS IV	6665	100	28-01-2005
71	48E10NE	IRS-P6	LISS IV	11723	117, 118	19-01-2006

Table No. 4: Satellite data used for Maharashtra Coast (2014-16 time-frame)

S. No.	Map Sheet No.	Satellite	Sensor	Path	Row	Subscene	Date
1	46D16SE	IRS-R2	L4FX	94	58	C	03-Jan-14
2	47A09NE	IRS-R2	L4FX	94	58	C	03-Jan-14
3	47A09SE	IRS-R2	L4FX	94	58	C	03-Jan-14
4	47A10NE	IRS-R2	L4FX	94	58	C	03-Jan-14
5	47A10SE	IRS-R2	L4FX	94	58	C	03-Jan-14
6	47A14SW	IRS-R2	L4FX	94	58	C	03-Jan-14
7	47A11NE	IRS-R2	L4FX	94	58	C	03-Jan-14
8	47A15NW	IRS-R2	L4FX	94	58	C	03-Jan-14

9	47A15SW	IRS-R2	L4FX	94	58	C	03-Jan-14
10	47A16NW	IRS-R2	L4FX	94,94	58,58	C,C	03-01-2014,16-Nov-2015
11	47A16SW	IRS-R2	L4FX	94,94	58,58	C,C	03-01-2014,16-Nov-2015
12	47B13NW	IRS-R2	L4FX	94	59	C	16-Nov-15
13	47B13NE	IRS-R2	L4FX	94	59	D	27-Jan-14
14	47B13SW	IRS-R2	L4FX	94	59	D	27-Jan-14
15	47B13SE	IRS-R2	L4FX	94	59	D	27-Jan-14
16	47B14NW	IRS-R2	L4FX	94	59	D	27-Jan-14
17	47B14NE	IRS-R2	L4FX	94	59	D	27-Jan-14
18	47B14SE	IRS-R2	L4FX	94	59	D	27-Jan-14
19	47B15NE	IRS-R2	L4FX	94	60	B	16-Mar-14
20	47B15SE	IRS-R2	L4FX	94	60	B	16-Mar-14
21	47B16NE	IRS-R2	L4FX	94	60	B	16-Mar-14
22	47B16SE	IRS-R2	L4FX	94	60	B	16-Mar-14
23	47F04SW	IRS-R2	L4FX	94	60	B	16-Mar-14
24	47G01NW	IRS-R2	L4FX	94	60	B	16-Mar-14
25	47G01SW	IRS-R2	L4FX	94	60	B	16-Mar-14
26	47G01SE	IRS-R2	L4FX	95	60	C	08-Jan-14
27	47G02NW	IRS-R2	L4FX	95	60	C	08-Jan-14
28	47G02NE	IRS-R2	L4FX	95	60	C	08-Jan-14
29	47G02SE	IRS-R2	L4FX	95	60	C	08-Jan-14
30	47G03NE	IRS-R2	L4FX	95,95	60,61	C,A	08-01-2014, 08-JAN-2014
31	47G03SE	IRS-R2	L4FX	95	61	A	08-Jan-14
32	47G04NE	IRS-R2	L4FX	95	61	A	08-Jan-14
33	47G08NW	IRS-R2	L4FX	95	61	A	08-Jan-14
34	47G08SW	IRS-R2	L4FX	95	61	A	08-Jan-14
35	47H05NW	IRS-R2	L4FX	95	61	A	08-Jan-14
36	47H05SW	IRS-R2	L4FX	95,95	61,61	A,C	08-01-2014, 08-JAN-2014
37	47H06NW	IRS-R2	L4FX	95,95	61,61	A,C	08-01-2014, 08-JAN-2014
38	47H06SW	IRS-R2	L4FX	95,95	61,61	A,C	08-01-2014, 08-JAN-2014
39	47H07NW	IRS-R2	L4FX	95,95	61,61	A,C	08-01-2014, 08-JAN-2014
40	47H07SW	IRS-R2	L4FX	95	61	D	01-Feb-14
41	47H07SE	IRS-R2	L4FX	95	61	D	01-Feb-14
42	47H08NE	IRS-R2	L4FX	95	61	D	01-Feb-14
43	47H08SE	IRS-R2	L4FX	95,95	61,62	D,B	01-02-2014, 01-FEB-2014
44	48E05NE	IRS-R2	L4FX	95	62	B	01-Feb-14
45	48E09NW	IRS-R2	L4FX	95	62	B	01-Feb-14
46	48E09SW	IRS-R2	L4FX	95	62	B	01-Feb-14
47	48E09SE	IRS-R2	L4FX	95	62	B	01-Feb-14
48	48E10NE	IRS-R2	L4FX	95	62	B	01-Feb-14

Table No. 5: Satellite data used for Goa Coast (2004-06 time-frame)

S. no.	Map sheet no.	Satellite	Sensor	Orbit	Scene	Date
1	48E10NE	IRS-P6	LISS IV	11723	117/118	19-01-2006
2	48E10SE	IRS-P6	LISS IV	11723	117/118	19-01-2006
3	48E14NW	IRS-P6	LISS IV	11723/7418	117/118/104	19-01-06/22-03-05
4	48E13SW	IRS-P6	LISS IV	11723	116/117	19-01-2006
5	48E14SE	IRS-P6	LISS IV	11723/6608	118/037/038	19-01-06/24-01-05
6	48E14SW	IRS-P6	LISS IV	11723/6608	118/037/038	19-01-06/24-01-05
7	48E14NE	IRS-P6	LISS IV	6608	037/038	24-01-2005
8	48E15NW	IRS-P6	LISS IV	11723/6608	118/119/039	19-01-06/24-01-05
9	48E15NE	IRS-P6	LISS IV	6608	038/039	24-01-2005
10	48I03NW	IRS-P6	LISS IV	11581	122	09-01-2006
11	48I03SW	IRS-P6	LISS IV	11581	122/123	09-01-2006
12	48I02SW	IRS-P6	LISS IV	11581/6608	121/122/038	09-01-06,24-01-05
13	48E15SW	IRS-P6	LISS IV	11723/6608	119/039/040	19-01-06,24-01-05
14	48E15SE	IRS-P6	LISS IV	6608	039/040	24-01-2005
15	48I04SW	IRS-P6	LISS IV	11581	123/124	09-01-2006
16	48I04NW	IRS-P6	LISS IV	11581	123	09-01-06/15-05-05
17	48I04NE	IRS-P6	LISS IV	11581/8185	123/058	09-01-06/15-05-05
18	48E16NE	IRS-P6	LISS IV	6608	039/040	24-01-2005
19	48E16SE	IRS-P6	LISS IV	6608	039/040	24-01-2005
20	48J01NW	IRS-P6	LISS IV	11581	124/125	09-01-2006

Table No. 6: Satellite data used for Goa Coast (2014-16 time-frame)

S. No.	Map Sheet No.	Satellite	Sensor	Path	Row	Subscene	Date
1	48E10NE	IRS-R2	L4FX	96,96	62,62	A,C	17-Oct-2016, 21-Mar-2015
2	48E10SE	IRS-R2	L4FX	96,96	62,62	A,C	17-Oct-2016, 21-Mar-2015
3	48E14SW	IRS-R2	L4FX	96,96	62,62	A,C	17-Oct-2016, 21-Mar-2015
4	48E15NW	IRS-R2	L4FX	96	62	C	21-Mar-15
5	48E15SW	IRS-R2	L4FX	96	62	C	21-Mar-15
6	48E15SE	IRS-R2	L4FX	96	62	C	21-Mar-15
7	48E16NE	IRS-R2	L4FX	96	62	C	21-Mar-15
8	48E16SE	IRS-R2	L4FX	96	62	C	21-Mar-15
9	48I04SW	IRS-R2	L4FX	96	62	C	21-Mar-15
10	48J01NW	IRS-R2	L4FX	96	63	B	08-Jan-15