Andhra Pradesh Coastal Zone Management Authority (APCZMA)
Andhra Pradesh
Ministry of Environment Forests & Climate Change
Government of India
D.No.33-26-14 D/2, Near Sunrise Hospital, Pushpa Hotel Centre,
Chalamavari Street, Kasturibaipet, Vijayawada-520010

सत्यमेव जयते

Letter No. OA No.04/APCZMA/Legal/2013   **Date: 04.2022**

To
The Registrar,
Hon'ble NGT, SZ, Chennai.

Sir,

Sub :   CRZ – APCZMA – Hon'ble NGT, SZ, Chennai dated 15.12.2021 in O.A No.
04 of 2013 (SZ) with appeal No. 18 of 2017 (SZ) – Submission of detail
report regarding the action plan to protect the coastal shoreline – Proposals
received from Institutions – Finalisation of proposals - Reg.

Ref :   1)   Hon'ble NGT, SZ dated 15.12.2021 in O.A No. 04 of 2013 (SZ) with
appeal No. 18 of 2017 (SZ).
2)   Directions of the Hon'ble NGT (SZ) during the meeting held on
02.02.2022 on O.A.No.4 of 2013 with appeal No.18 of 2017.
3)   Letter   No.   OA   No.04/APCZMA/Legal/2013–1397,   dated
25.03.2022.

***

It is to submit that, vide reference 2nd cited, the Hon'ble NGT (SZ) directed the
Government to submit the proposal on Shoreline Management Plan to protect marine
ecology and also to protect the Coastal shoreline, by end of February 2022.

In this regard, the APCZMA has addressed letters to NCSCM, Chennai; IRS, Chennai;
CSIR-NIO, Visakhapatnam and Andhra University, Visakhapatnam requesting them to
submit their proposals on preparation of the Shoreline Management Plan for the coast of
Andhra Pradesh.

M/s. NCSCM, Chennai and the M/s. Andhra University, Visakhapatnam submitted
their proposals to APCZMA. The proposals are under scrutiny by the APCZMA for
finalization of the Institutions for preparation of the report. The details of the study

1

- These shoreline change rate have been categorized into eight classes as erosion (high, medium and low erosion) and accretion (high, medium and low accretion), stable and artificial coast.

- <u>Output of the proposal</u>:
  Finally shoreline change maps are in 1:25000 Scale will be prepared along with the report. Preparation of Land Use/ Land Cover map, map showing vulnerable zones of Coastal erosion/accretion along the entire coastline of Andhra Pradesh. The estimated time for preparation of the report and maps is 5 months.
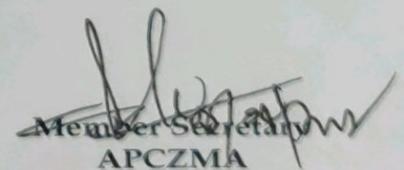
Phase 2: Engineering and other soft proposals for Shoreline Management

- After the monitoring shoreline changes that resulted from coastal erosion, the causes of erosion will be studied case wise in the vulnerable zones as said earlier through the appropriate methods that are essential for understanding of coastal dynamics towards giving control/remedial measures. The objectives of the studies will be (i) to conduct suitable studies on causes of coastal erosion in the most vulnerable zones of the AP coast identified in the phase 1 study; (ii) to suggest structural/non-structural remedial measures to check the erosion in the above zones.

The proposals are being scrutinized by the Expert Members of the APCZMA for analyzing the methodology, data requirement/ acquisitions, field surveys, data interpretation and the required output for suggesting suitable engineering and other soft proposals for the shoreline management of the identified vulnerable areas along the coast of Andhra Pradesh. Further, the data from the implementing agencies and the stakeholder departments actively involved in the protection of shoreline is being collected to supplement the proposals being contemplated.

Also, the APCZMA earlier addressed a letter to the Hon'ble NGT (SZ) vide reference 3rd cited, requesting to permit further 8 weeks time to submit the draft report.

In view of the above, and the progress made by the APCZMA for preparation of the shoreline management plans may be considered and time may be permitted.

Member Secretary
APCZMA

proposed by the agencies are as below:

Phase 1: Identification of vulnerable areas

- The State of Andhra Pradesh is situated on the southeast coast of Indian Peninsula and covers an area of about 160,205 km² and a coastline of length 974Km, the second largest in the country. The proposal is to first study the Shoreline changes along the entire coast of Andhra Pradesh, which will be estimated using satellite images for the years 2001-2021.

- The study proposed list of data sources that would be used for mapping Shoreline change based on multi-temporal and multi-spectral images and other satellite images such as LISS IV images; Cartosat images; WorldView/GeoEye/QuickBird images; SoI Aerial Photos; Sentinel images.

- The principle involves extraction of past and current shoreline positions from various data sources, geo-referencing and removing distortions from satellite images. These geo-rectified images will be transformed to Universal Transverse Mercator (UTM 42N) projection in the World Geodetic System Datum of 1984 (WGS 84) prior to shoreline extraction.

  In general, shoreline is extracted using proxies or shoreline reference features (i.e. shoreline positions) which includes high water line, wet/dry line, vegetation line, cliff base and artificial structures. The multiple shorelines extracted from satellite images will be used to calculate shoreline change rates using Digital Shoreline Analysis System (DSAS) model developed by United States Geological Survey (USGS) in an ArcGIS environment.

  To calculate the rate of change, statistical baseline will be constructed on the landward side at a distance of 50m adjacent to series of shoreline positions. After these shoreline settings, DSAS model will be used to generate orthogonal transects to the baseline at 200 m spacing interval along the study area/ coast. Subsequently, for calculation of shoreline change rate, minimum three shorelines will be considered at each transect. And the model computes change rates using several statistical methods such as i) end point rate, ii) linear regression rate, iii) jackknife, iv) average of rate, v) net shoreline movement and vi) shoreline change envelope.

- In the present study, Linear Regression Rate (LRR) will be used for expressing the rate of change. The Linear regression rate is the slope of the line. For the estimation of the LRR, erosional trends (landward movement of the shoreline) will be presented as negative values and accretional trends (seaward movement of the shoreline) as positive values. Because of the inconsistency of shoreline positions due to changing inlet or river mouth dynamics, at coastal structures such as ports, seawalls, breakwaters, groynes etc., these shoreline positions will be removed to achieve unavoidable significant change rates.

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Letter No. OA No.04/APCZMA/Legal/2013   **09/04/2022**

To
The Registrar,
Hon'ble NGT, SZ, Chennai.

Sir,

Sub : CRZ – APCZMA – Hon'ble NGT, SZ, Chennai dated 15.12.2021 in O.A No. 04 of 2013 (SZ) with appeal No. 18 of 2017 (SZ) – Submission of detail report regarding the action plan to protect the coastal shoreline – Proposals received from Institutions – Finalisation of proposals - Reg.

Ref :   1. Hon'ble NGT, SZ dated 15.12.2021 in O.A No. 04 of 2013 (SZ) with appeal No. 18 of 2017 (SZ).
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3. Letter No. OA No.04/APCZMA/Legal/2013–1397, dated 25.03.2022.

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In this regard, the APCZMA has addressed letters to NCSCM, Chennai; IRS, Chennai; CSIR-NIO, Visakhapatnam and Andhra University, Visakhapatnam requesting them to submit their proposals on preparation of the Shoreline Management Plan for the coast of Andhra Pradesh.

M/s. NCSCM, Chennai and the M/s. Andhra University, Visakhapatnam submitted their proposals to APCZMA. The proposals are under scrutiny by the APCZMA for finalization of the Institutions for preparation of the report. The details of the study proposed by the agencies are as below:

Phase 1: Identification of vulnerable areas

- The State of Andhra Pradesh is situated on the southeast coast of

Indian Peninsula and covers an area of about 160,205 km^2 and a coastline of length 974Km, the second largest in the country. The proposal is to first study the Shoreline changes along the entire coast of Andhra Pradesh, which will be estimated using satellite images for the years 2001-2021.

- The study proposed list of data sources that would be used for mapping Shoreline change based on multi-temporal and multi-spectral images and other satellite images such as LISS IV images; Cartosat images; WorldView/GeoEye/QuickBird images; SoI Aerial Photos; Sentinel images.

- The principle involves extraction of past and current shoreline positions from various data sources, geo-referencing and removing distortions from satellite images. These geo-rectified images will be transformed to Universal Transverse Mercator (UTM 42N) projection in the World Geodetic System Datum of 1984 (WGS 84) prior to shoreline extraction.

   In general, shoreline is extracted using proxies or shoreline reference features (i.e. shoreline positions) which includes high water line, wet/dry line, vegetation line, cliff base and artificial structures. The multiple shorelines extracted from satellite images will be used to calculate shoreline change rates using Digital Shoreline Analysis System (DSAS) model developed by United States Geological Survey (USGS) in an ArcGIS environment.

   To calculate the rate of change, statistical baseline will be constructed on the landward side at a distance of 50m adjacent to series of shoreline positions. After these shoreline settings, DSAS model will be used to generate orthogonal transects to the baseline at 200 m spacing interval along the study area/ coast. Subsequently, for calculation of shoreline change rate, minimum three shorelines will be considered at each transect. And the model computes change rates using several statistical methods such as i) end point rate, ii) linear regression rate, iii) jackknife, iv) average of rate, v) net shoreline movement and vi) shoreline change envelope.

- In the present study, Linear Regression Rate (LRR) will be used for expressing the rate of change. The Linear regression rate is the slope of the line. For the estimation of the LRR, erosional trends (landward movement of the shoreline) will be presented as negative values and accretional trends (seaward movement of the shoreline) as positive values. Because of the inconsistency of shoreline positions due to changing inlet or river mouth dynamics, at coastal structures such as ports, seawalls, breakwaters, groynes etc., these shoreline positions will be removed to achieve unavoidable significant change rates.

- These shoreline change rate have been categorized into eight

classes as erosion (high, medium and low erosion) and accretion (high, medium and low accretion), stable and artificial coast.

- <u>Output of the proposal</u>:
Finally shoreline change maps are in 1:25000 Scale will be prepared along with the report. Preparation of Land Use/ Land Cover map, map showing vulnerable zones of Coastal erosion/accretion along the entire coastline of Andhra Pradesh. The estimated time for preparation of the report and maps is 5 months.

Phase 2: Engineering and other soft proposals for Shoreline Management

- After the monitoring shoreline changes that resulted from coastal erosion, the causes of erosion will be studied case wise in the vulnerable zones as said earlier through the appropriate methods that are essential for understanding of coastal dynamics towards giving control/remedial measures. The objectives of the studies will be (i) to conduct suitable studies on causes of coastal erosion in the most vulnerable zones of the AP coast identified in the phase 1 study; (ii) to suggest structural/non-structural remedial measures to check the erosion in the above zones.

The proposals are being scrutinized by the Expert Members of the APCZMA for analyzing the methodology, data requirement/ acquisitions, field surveys, data interpretation and the required output for suggesting suitable engineering and other soft proposals for the shoreline management of the identified vulnerable areas along the coast of Andhra Pradesh. Further, the data from the implementing agencies and the stakeholder departments actively involved in the protection of shoreline is being collected to supplement the proposals being contemplated.

Also, the APCZMA earlier addressed a letter to the Hon'ble NGT (SZ) vide reference 3rd cited, requesting to permit further 8 weeks time to submit the draft report.

In view of the above, and the progress made by the APCZMA for preparation of the shoreline management plans may be considered and time may be permitted.

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Vijay Kumar Gsrkr Ias
Member Secretary
APCZMA

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PROJECT PROPOSAL FOR IDENTIFICATION OF VULNERABLE ZONES OF EROSION AS INPUT TO SHORELINE MANAGEMENT PLANNING FOR AP COASTLINE.

Introduction:

With reference to the letter No. OA No.04/APCZMA/ Legal/2013/341 dated 22.02.2022 from the Member Secretary, APCZMA addressed to the Head, Geo-Engineering, AUCE, Visakhapatnam, we are happy to inform you that we are willing to take up the proposed studies to serve as input to the planning of shoreline management plan for protecting AP Coast of 972 km.

The above study will be carried out in different phases starting with the identification of the vulnerable zones of coastal erosion in the first phase. The critical vulnerable zones will be taken up in the second phase case wise towards investigating the causes of erosion and suggesting erosion control measures.

PHASE 1 STUDIES

OBJECTIVES:

- To prepare Shoreline map of Andhra Pradesh at 1:25000 scale
- To prepare Land use/ Land cover maps using temporal satellite data & detect LULC changes over the past 20 years or more along the coastline within 500m from the coast
- To identify vulnerable zones of coastal erosion along the AP coast.

DATA REQUIRED:

- Survey of India Maps, Village and Mandal Maps for the Andhra Pradesh Coastline of suitable scale
- Temporal Multispectral and High Resolution satellite data (pre and post monsoon) of AP coast for the past 20 or more years.
- Field visits for ground truth data.
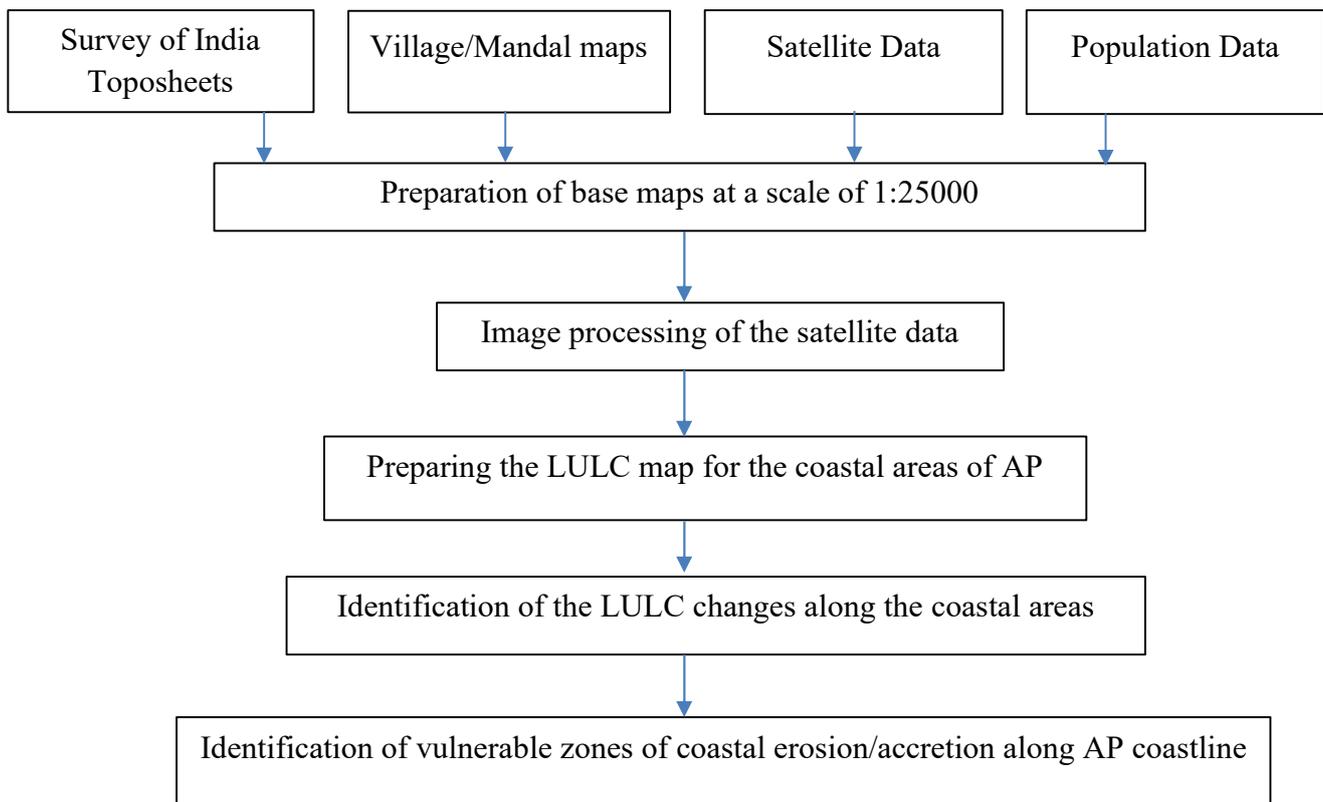
METHODOLOGY:

Shorelines are subjected to change due to coastal processes, which are controlled by wave characteristics and the near-shore circulation, sediment characteristics, beach form.

From the coastal vulnerability point of view accretion will be considered as less vulnerable whereas erosion will be considered as more vulnerable because of the loss of private property and natural habitats such as beaches, dunes and marshes. It also reduces the distance between population and ocean.

The stages involved in this procedure are given in the flowchart below.

The study of long term and short-term shoreline changes along AP coast will be done using land use/ land cover changes obtained from temporal remote sensing data of appropriate spatial and spectral resolution. The primary technique used to monitor coasts for vulnerability assessments is spatial data with Geographic Information System (GIS). Coastal Vulnerability Index (CVI) methods for physical assessments will be applied. Wherever necessary a certain amount of field data will be collected for the evaluation, due to limitations in the available spatial and temporal satellite data resolution.

According to Indian Coastal Zone (CRZ) regulations, the buffer zones, also known as active zones, usually cover a region of 500 m from the shoreline; these zones will be focused on coastal vulnerability studies. However, for critical coastal areas beyond 500m from the shoreline will also be considered as vulnerable areas for assessment studies.

Survey of India Toposheets	Village/Mandal maps	Satellite Data	Population Data

↓ ↓ ↓ ↓

Preparation of base maps at a scale of 1:25000

↓

Image processing of the satellite data

↓

Preparing the LULC map for the coastal areas of AP

↓

Identification of the LULC changes along the coastal areas

↓

Identification of vulnerable zones of coastal erosion/accretion along AP coastline

**Figure 1: Flow chart representing the stages involved in Phase-1 studies**

OUTPUT of the Phase 1 project:

1. Land Use/ Land Cover (LULC) map preparation for the buffer zone at a scale of 1:25000 scale.
2. Map representing the vulnerable zones of coastal erosion/accretion along the Andhra Pradesh coastline.

TIME required to finish Phase 1: One month from the date of receipt of work order.

Sample output maps expected from the Phase-1 study are shown as following.
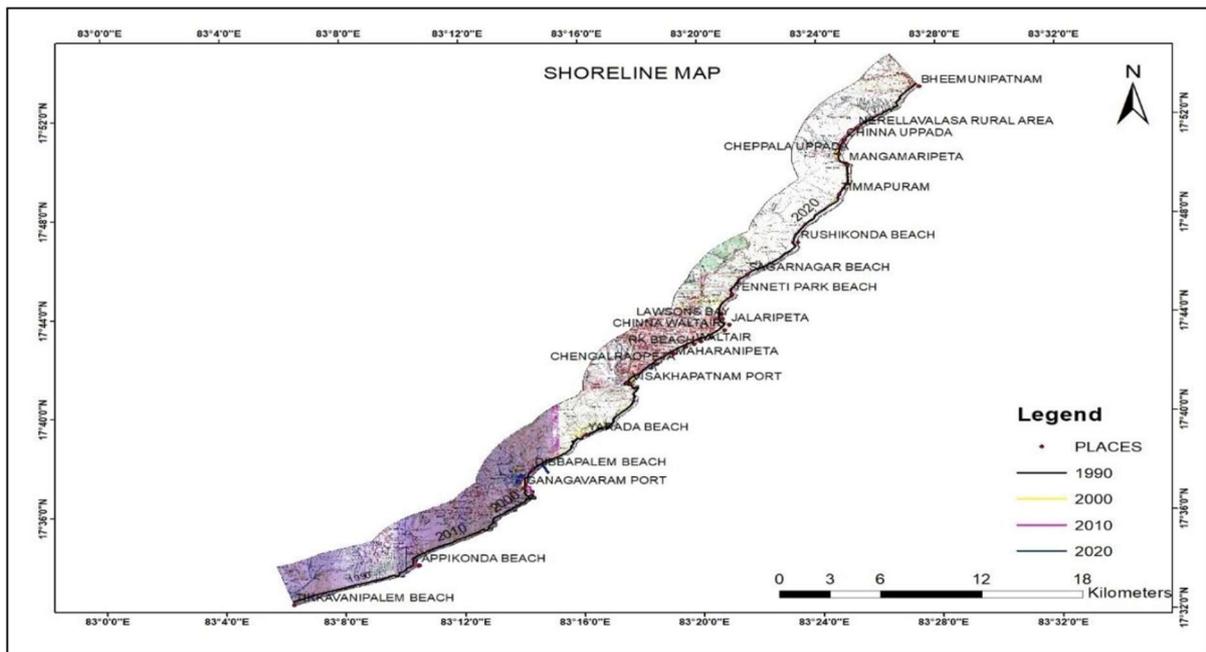
SOME MAPS FROM EARLIER STUDIES DONE IN THE DEPARTMENT
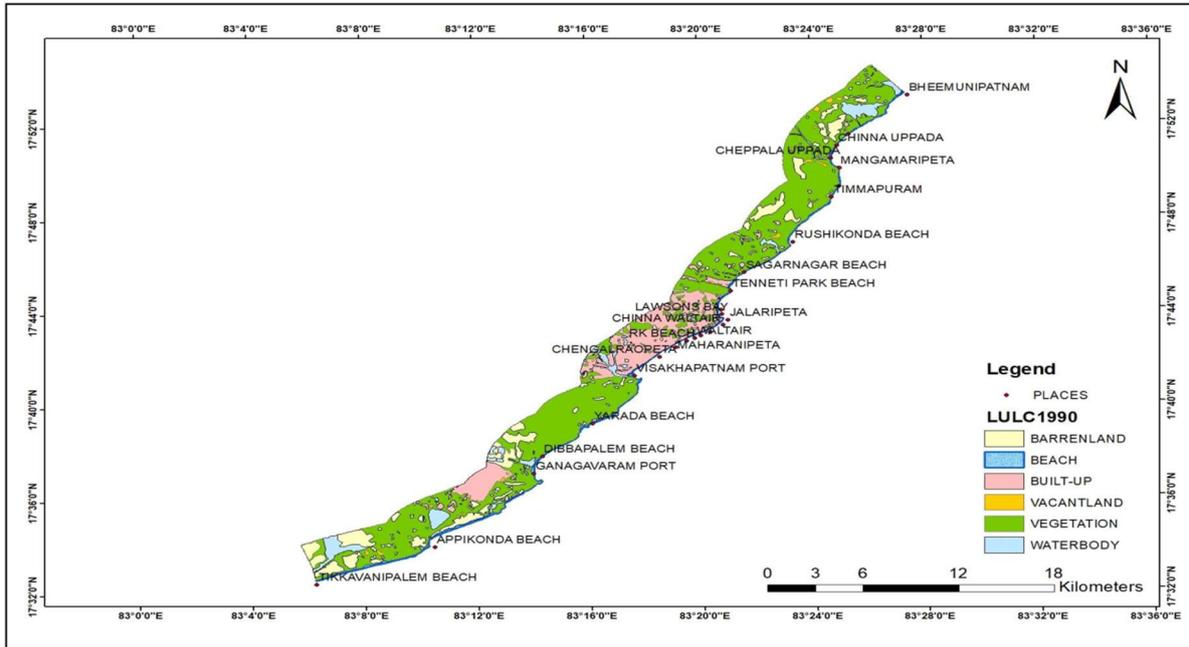
Figure 2: LULC – 1990 map of Visakhapatnam Coast for a buffer zone of 500m
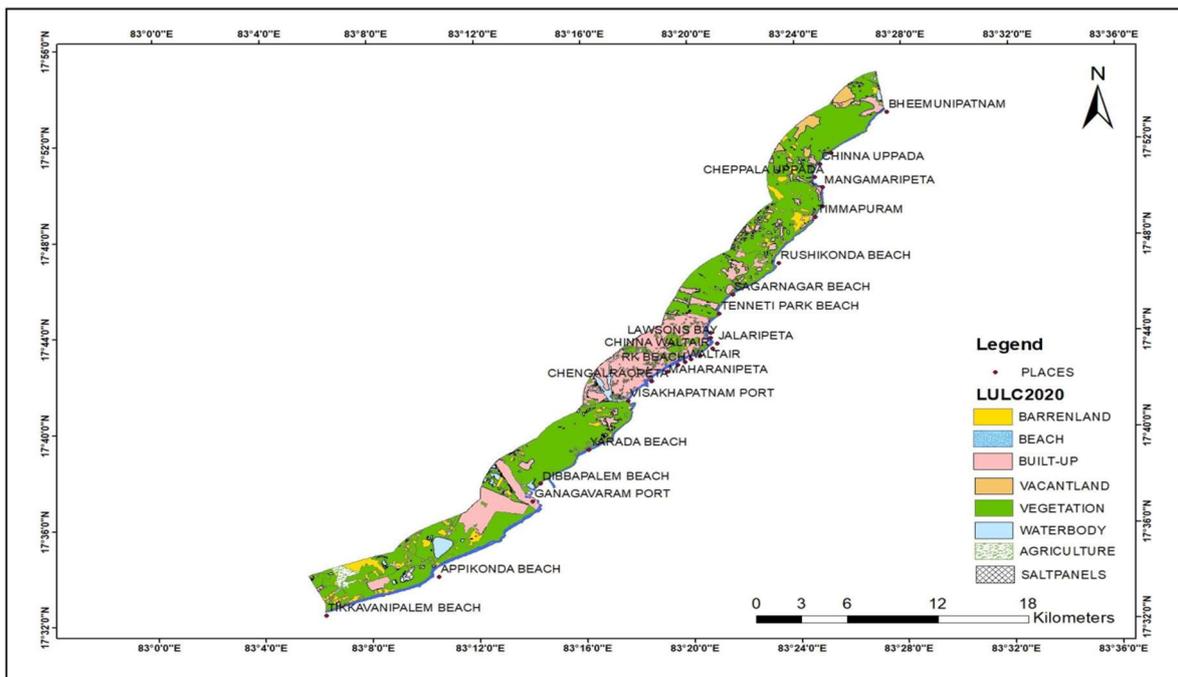
Figure 3: LULC – 2020 map of Visakhapatnam Coast for a buffer zone of 500m

Figure 4: Shoreline changes map of Visakhapatnam during 1990-2020

PHASE 2 STUDIES

After monitoring shoreline changes that resulted from coastal erosion, the causes of erosion will be studied case wise in the vulnerable zones as said earlier through the appropriate methods that are essential for understanding of coastal dynamics towards giving control/ remedial measures.

OBJECTIVES: The objectives of the phase 2 studies will be,

- To conduct suitable studies on causes of coastal erosion in the most vulnerable zones of the AP coast identified in the phase 1 study.
- To collect data and develop model involving coastal hydraulics to arrive at a solution for controlling the erosion for each vulnerable zone separately.
- To suggest structural/ non-structural remedial measures to check the erosion in the above zones.

OUTPUT of the Phase 2 project:

Design and Drawings of Structural/ non-structural remedial measures to check the erosion in the above zones. The proposals does not include Quantity/ Cost Estimates.

TIME required to finish Phase 2: Depends on the cause of erosion and magnitude of the work components involved. However, at this stage it can be assumed as 3 months.

Prof. Vazeer Mahammood, HOD
Dept. Geo-Engineering, AUCE, Visakhapatnam-3

10

DEPARTMENT OF GEOENGINEERING & RDT
ANDHRA UNIVERSITY COLLEGE OF ENGINEERING
VISAKHAPATNAM – 530 003

Prof. Vazeer Mahammood,
M.E (Hydraulics, Coastal & Harbour Engg), M.Tech (RS&GIS/WRE-CSSTEAP,UN))., M.E. (Structures) Ph.D.
Head of the Department
head.geo@andhrauniversity.edu.in
vazir81c158@gmail.com   Mobile: 99853 69669

Dt.04.04.2022

To
The Member Secretary,
APCZMA, AP, D.No.33-26-14 D/2, Chalamavari st, Kasturibaipet
Vijayawada - 520010

Sir,

      Sub: Consultancy Proposals for studies on AP shoreline changes – APCZMA-CRZ-reg.
      Ref: Your Lr. No. OA No.04/APCZMA/Legal/2013/1341 dt.22.02.2022 and
          File No. APPCB-11033/135/2021-TECH SEC-APPCB

      With reference to your cited above in the reference, we are happy to inform you that we are willing to take up the proposed studies on shoreline changes along AP coast to serve as input to the planning of shoreline management plan for protecting AP Coast of 972 km length.

      The above study will be carried out in different phases starting with the identification of the vulnerable zones of coastal erosion in the first phase. The critical vulnerable zones will be taken up in the second phase case wise (in sub phases) towards investigating the causes of erosion and suggesting erosion control measures. The methodology and deliverables are discussed in the enclosed document. The budgetary requirement and time required for the completion of the project is one month and three months (tentatively) for Phase 1 and Phase 2 respectively.

S.No.	Item	Time required	Rate (Rs.)	Amount (Rs.)
1	Phase 1 studies to prepare • Shoreline map of AP at 1:25000 scale, • LU/LC maps using temporal satellite data & detect LULC changes over the past 20 years or more along the coastline within 500m from the coast and • Identification of vulnerable zones of coastal erosion along the AP coast.	1 month	LS	20,00,000/-
2	Phase 2 studies to • understand causes of coastal erosion in the most vulnerable zones of the AP coast identified in the phase 1 study, • develop model involving coastal hydraulics to arrive at a solution for controlling the erosion for each vulnerable zone separately and • suggest structural/ non-structural remedial measures to check the erosion in the above zones.	3 months (tentatively)	LS	20,00,000/-
	Sub Total			40,00,000/-
3	GST @18%			7,20,000/-
	Grand Total			47,20,000/-

.

(Rupees forty seven lakhs and twenty thousand only)

Terms and Conditions:
1. 50% payment has to be done along with the work order.
2. The necessary inputs if any will be supplied by your office and the entry permissions wherever required during the field study and permissions for restricted data if any will be arranged by your office. Further the physical access to the critical areas for collecting field data in difficult terrains or in waters will be arrange by your office.

Bank Details:
Director, Centre for Industrial and Scientific Consultancy (CISC), Andhra University.
Current A/C No. **35843070000040,** IFSC Code: **CNRB0013582,** CANARA Bank**,** SDE Branch, A.U Campus, Visakhapatnam- 530 003. **MICR Code:530015033**

Thanking you,

Best regards,

Yours sincerely,

(VAZEER MAHAMMOOD)

NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT

Ministry of Environment, Forest & Climate Change, Government of India

No. NCSCM/CZMA/AP /22- 0072/EDC   dated 14 /03/2022

TO

The Member Secretary,

AP Coastal Zone Management Authority (APCZMA),

Office of the AP Pollution Control Board,

D. No. 33-26-14, D/2, Near Sunrise Hospital,

Chalamalavari Street, Kasturibaipet,

Vijayawada – 520010, Andhra Pradesh.

SUB: SHORELINE CHANGE MAPPING OF ANDHRA PRADESH COAST- REG.
Ref: Your letter No. OA No. 04/APCZMA/Legal/2013-1129 dated 16/12/2021

Please refer to your letter cited above. The proposal for providing Shoreline change database covering the last 20 years (2001 to 2021), for the entire Andhra Pradesh mainland coast (excluding banks of rivers/creeks/backwaters, Ports) is given below along with details of the work including the work schedule, deliverables and the cost.

1. Approach:
- Extraction of shorelines from Satellite images/Aerial orthophotos of selected periodic /historic images from the year 2001 to 2021.
- Mapping of offshore and onshore structures.
- Mapping of Ports, harbours, Fish Landing Centres.
- Mapping of all Geomorphological features.
- Linear Regression Modelling using Digital Shoreline System Analysis (DSAS) system.
- Shoreline change analysis.
- Creation of database, maps and reports.

Details are given in Annex-1.

2. Deliverables:
- Draft Shoreline change maps on 1:25,000 scale (pdf copies) for review and approval of Department of Environment.
- Final Shoreline change maps on 1:25,000 scale.
- Report.

- Final Shoreline change digital database of Andhra Pradesh containing Erosion categories and other layers.

3. Schedule of work / Total duration: 5 months from the date of receipt of advance payment.

4. Cost Estimates:

- Cost of shoreline change mapping of Andhra Pradesh: Rs 55,09,420/= (Rupees fifty-five lakh nine thousand four hundred twenty only, inclusive of 18% GST).

- Tax Invoice with Bank details will be sent to you, on receipt of work order from your office. Taxes are subject to change as per change in the law and the contract price will be adjusted (plus/minus) accordingly due to the impact of such changes in taxes.

- The amount is to be remitted by Demand Draft drawn on a scheduled Bank in favour of Director, NCSCM, payable at Chennai or by RTGS / NEFT.

5. The work will be taken – up, on receipt of 100% advance payment of the amount of Rs 55,09,420/= (Rupees fifty-five lakh nine thousand four hundred twenty only, inclusive of 18% GST). mentioned above.

6. With reference to the request by the APCZMA, to prepare a Shoreline Management Plan for Andhra Pradesh, NCSCM proposes to first study the shoreline changes along the entire coast of Andhra Pradesh, which will be estimated using satellite images for the years 2001-2021. The Shoreline Management Plan will be prepared based on the outcomes of the present study.

(Dr. R. Ramesh)   14/3/2022
Director, NCSCM.

Encl: Annex-1.

Copy to: Manager, Finance, NCSCM.

Anna University Campus, Chennai 600 025. India
Phone (+91) 44 22200600 Fax (+91) 44 22200700

www.ncscm.res.in

NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT

Ministry of Environment, Forest & Climate Change, Government of India

<u>Annex-1</u>

SHORELINE CHANGE STUDY (FOR THE PERIOD 2001 – 2021) FOR ANDHRA PRADESH

INTRODUCTION

Andhra Pradesh is situated on the southeast coast of Indian Peninsula and covers an area of about 160,205 km² and a coastline of length ~1008 km, the second longest in the country. The Member Secretary, AP Coastal Zone Management Authority (APCZMA), Government of Andhra Pradesh has requested NCSCM to prepare the Shoreline Management Plan for entire coast of Andhra Pradesh. To this end, NCSCM proposes to first study the shoreline changes along the entire coast of Andhra Pradesh, which will be estimated using satellite images for the years 2001-2021. The Shoreline Management Plan will be prepared based on the outcomes of the present study.

DATA USED AND METHODOLOGY

The study proposed list of data sources that will be used for mapping shoreline change based on multi-temporal and multi-spectral images shown in Table 1. Other satellite images will also be selected, as required, to suit the dates of dumping. The resolutions indicated are subject to availability of images for procurement from NRSC, Hyderabad.

Table 1: Data source for extraction of shoreline

Sl. No.	Year	Satellite Image
1.	2001	LISS IV images
2.	2005	Cartosat & LISS IV images
3.	2009	WorldView/GeoEye/QuickBird images
4.	2011	Sol Aerial Photos
5.	2016	LISS IV images
6.	2019	WorldView/Sentinel images
7.	2021	Sentinel images

The following figure 1 describes the flow diagram of shoreline change analysis.

Anna University Campus, Chennai 600 025. India
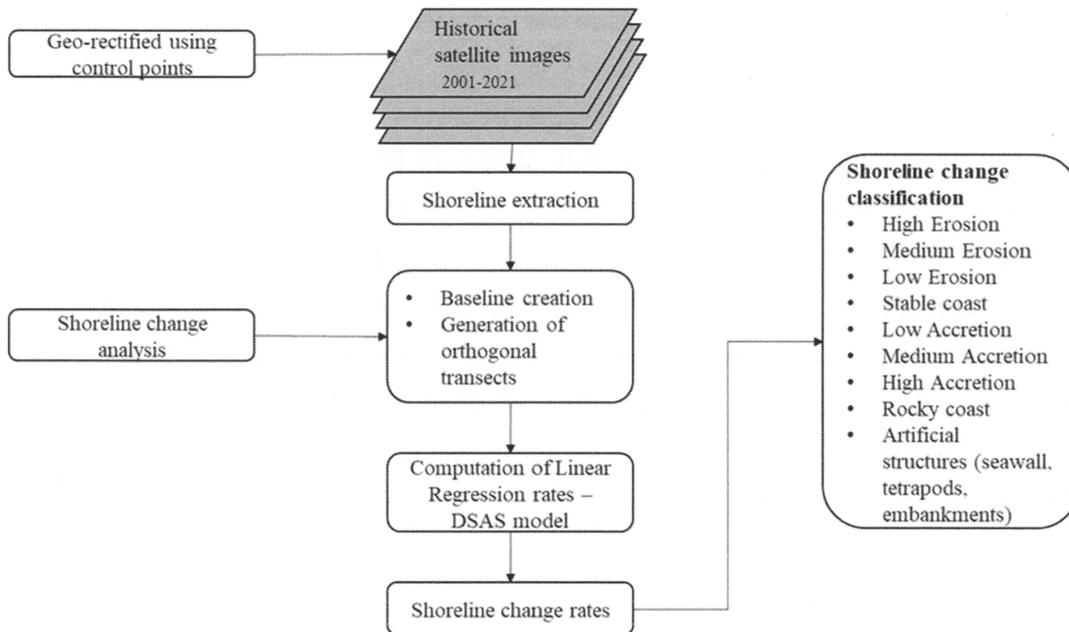Phone (+91) 44 22200600 Fax (+91) 44 22200700

www.ncscm.res.in

Figure 1. Workflow diagram for Shoreline change rate analysis

The principle of extraction of past and current shoreline positions from various data sources involves geo-referencing and removing distortions from satellite images. These geo-rectified images will be transformed to Universal Transverse Mercator (UTM 42N) projection in the World Geodetic System Datum of 1984 (WGS 84) prior to shoreline extraction. In general, shoreline is extracted using proxies or shoreline reference features (i.e shoreline positions) which includes high water line, wet/dry line, vegetation line, cliff base and artificial structures. In order to map this, spectral bands blue, green and NIR will be used and enhanced using image processing techniques (Standard deviation, Contrast stretching, Mininum-Maximum, etc). Thus, multiple shorelines extracted from satellite images will be used to calculate shoreline change rates using Digital Shoreline Analysis System (DSAS) model developed by United States Geological Survey (USGS) in an ArcGIS environment. To calculate the rate of change, statistical baselines is to be constructed on the landward side at a distance of ~50 m adjacent to the

series of shoreline positions. After these shoreline settings, DSAS model will be used to generate orthogonal transects to the baseline at 200 m spacing interval along the study area / coast. Subsequently, for calculation of shoreline change rate minimum three shorelines is required at each transect. And the model computes change rates using several statistical methods such as i) end point rate, ii) linear regression rate, iii) jackknife, iv) average of rate, v) net shoreline movement and vi) shoreline change envelope within the ArcGIS environment.

In the present study, Linear Regression Rate (LRR) will be used for expressing the rate of change since it includes all the available time-series shorelines. A linear regression rate-of-change statistic can be determined by fitting a least-squares linear regression line to all shoreline points for a transect (fig. 2). The regression line is placed so that the sum of the squared residuals (determined by squaring the offset distance of each data point from the regression line and adding the squared residuals together) is minimized. The linear regression rate is the slope of the line. For the estimation of the LRR, erosional trends (landward movement of the shoreline) will be presented as negative values and accretional trends (seaward movement of the shoreline) as positive values. Because of the inconsistency of shoreline positions due to changing inlet or river mouth dynamics, at coastal structures such as ports, seawalls, breakwaters, groynes etc., these shoreline positions will be removed to achieve unavoidable significant change rates.

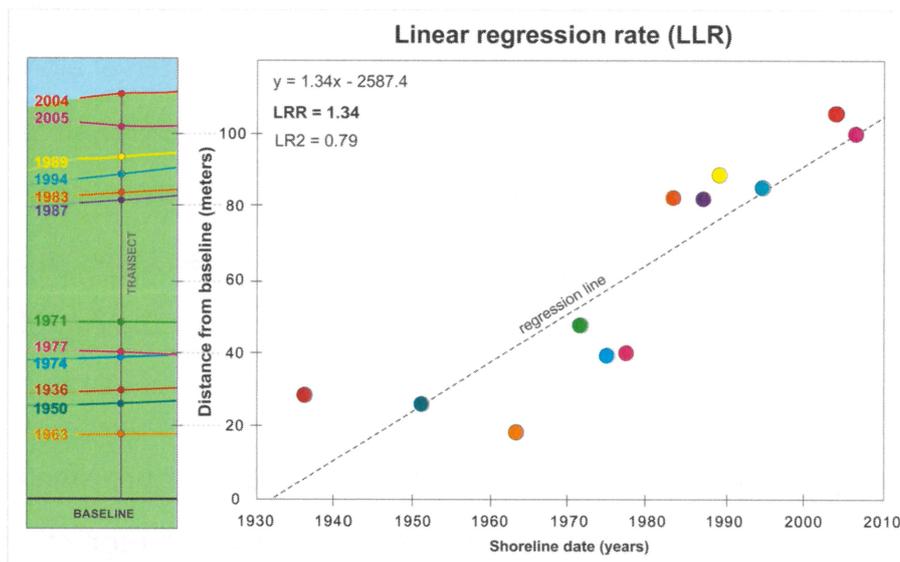Figure 2.   Graphical

representation of Linear Regression Rate

(Source: Himmelstoss et al., 2018)

These shoreline change rates have been categorized into eight classes as erosion (high, medium and low erosion) and accretion (high, medium and low accretion), stable and artificial coast as shown in **Table 2.**

Table 2: Classification of Shoreline Change Rates

Categories	Rate of Erosion/Accretion (m/yr)
High Erosion	>= -5
Medium Erosion	-2 to -5
Low Erosion	-0.5 to -2
Stable Coast	-0.5 to 0.5
Low Accretion	0.5 to 2
Medium Accretion	2 to 5
High Accretion	>= 5

NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT
Ministry of Environment, Forest & Climate Change, Government of India

Artificial coast	*Presence of boulders, tetrapods, and other shore protection structures along the coast*

DELIVERABLES

The outcome of the study will be stored in ArcGIS Geodatabase format and the output will be represented in map with zones of erosion and accretion on 1:25,000 scale.

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