

# Eco-morphological Dune Degradation with Dwindling Phyto-resources: A Micro-regional Assessment on Mandermoni Dune Stretch over Midnapore Coast in West Bengal, India

**\*Rabin Das<sup>1</sup> & Harekrishna Manna<sup>2</sup>**

**Assistant Professor, UG & PG Dept. of Geography, Bajkul Milani Mahavidyalaya,  
PurbaMedinipur, West Bengal<sup>1</sup>**

**Research Scholar, Department Of Geography, Midnapore College (Autonomous) Research Centre  
(Science), Midnapore, West Bengal<sup>2</sup>\***

**dasrabin0@gmail.com<sup>1</sup>, harekrishnamanna@gmail.com<sup>2</sup> \*, \*Corresponding Author**

**Abstract - Coastal dunes are configured and characterized by a high ecological diversity, which is the result of a wide set of geomorphological features, environmental heterogeneity, and species variability. The sand dunes have behaved like natural guard walls and natural purifiers at coastline throughout World. This paper reports the study on the morphology and species found within the sand dune (including habit, coastal habitat, morphological features, lowering time, floral biology, and some environmental studies) along the Mandermoni coastal stretch on Bengal coast. If we consider a typical coastal sand dune we can found first embryonic dune, then fore dune, yellow dune, grey dune, and dune slack sequentially from sea to landward. But in my study area, the dune characteristics are not at idealistic fashion since most of the dune section are degraded as the environmental and human cost of nature-human process and response. Not only that, the dune biology and ecology have been disturbed and interrupted influencing vegetation succession, biodiversity, mass productivity and resource potentiality. The paper wants to enlighten and assess the state and status of dune morphology and ecology using geo-ecological methodology along with direct interviews with ethnic groups, native traditional healers and mapping analysis by Arc GIS and Google Earth. This paper draws the suggestion for urgent need to manage the nature gifted dune configuration alongwith its essential ecological set up. Proper planning strategies are needed to recognize that species succession and morphological evolution as the natural dynamics of this environments and conservation strategies need to be flexible enough to have room for these changes and variations.**

**Keywords: Dune morphology, Ecological diversity, Environmental heterogeneity, coastal habitats, Geo-ecological methodology.**

## **I. INTRODUCTION**

Geomorphology is the scientific study of landforms origin, by which various processes acting over the Earth's surface and creating landforms development and landform evolution. Development of coastal dune is one of the important morphological features, and it is characterized by a high ecological diversity, which is the result of a wide set of geomorphological features, environmental heterogeneity, and species variability. The sand dunes have behaved like natural guard walls and natural purifiers at coastline throughout World.

A dune is a sand hill formed by aeolian process [1]. Coastal sand dunes are generally formed in close proximity of beaches where waves promote accumulation of sand and prevailing onshore winds blow this sand inland [6] [13]. The size and character of the coastal sand dune system depends on the combination of physical factors, such as the wind and wave regime, the sand supply from the beach and offshore bars, and biotic controls, such as plant succession and grazing pressure. Dunes sand is usually very well sorted sand of medium to fine size. Dry sand is easily picked up at even moderate wind speeds and moves mainly by saltation across the beach and on to the dunes [3]. These

are abundant in the back beach areas where there is large sand supply and winds are strong and persistent enough to move it to suitable places for accumulation [4]. Large sand supplies are commonly associated with large tidal ranges, which expose extensive sandy beaches during low tide period. Though coastal sand dunes develop in many coasts, these are more common and extensive in areas of strong onshore winds and sufficient supply of medium to fine-grained well-sorted sand suitable for entrapment [5]. Coastal dunes are widespread along humid temperate and arid tropical coasts, but are uncommon in humid tropical coasts. Three main types of coastal sand dunes have been identified by King (1972) [11]. These are transverse dunes, vegetated dunes and parabolic dunes. Some coastal areas have one or more sets of dunes running parallel to the beach [7]. On sandy shorelines, coastal dunes represent the last line of defence against erosion by providing a reservoir of sand for waves to utilise during storms.

As well as limiting the landward intrusion of waves, wind and salt spray, dunes act as a barrier to oceanic inundation and they provide for an important morphological and ecological transition from marine to terrestrial environments [8]. At many locations dunes have been removed, replaced or otherwise adversely affected by human activities. These include grazing, heavy mineral sand mining or sand extraction for construction, uncontrolled pedestrian or vehicular access, installation of protective works such as seawalls, and residential development [9]. Where there is an inadequate dune, properties and facilities near the back of the beach may be subject to inundation from the ocean, to structural damage from wave attack, undermining by foreshore erosion, or to sand drift. The presence of a stable dune system provides a natural defence mechanism against these hazards [10].

While coastal dunes are the focus of this paper, it would be short sighted to develop plans for their protection or rehabilitation at a specific site without some understanding of their place within the broader coastal landscape. Recurring phases of beach erosion and accretion are natural phenomena and a sound understanding of relevant processes is essential if the values of coastal dunes are not to be compromised by future land use [11].

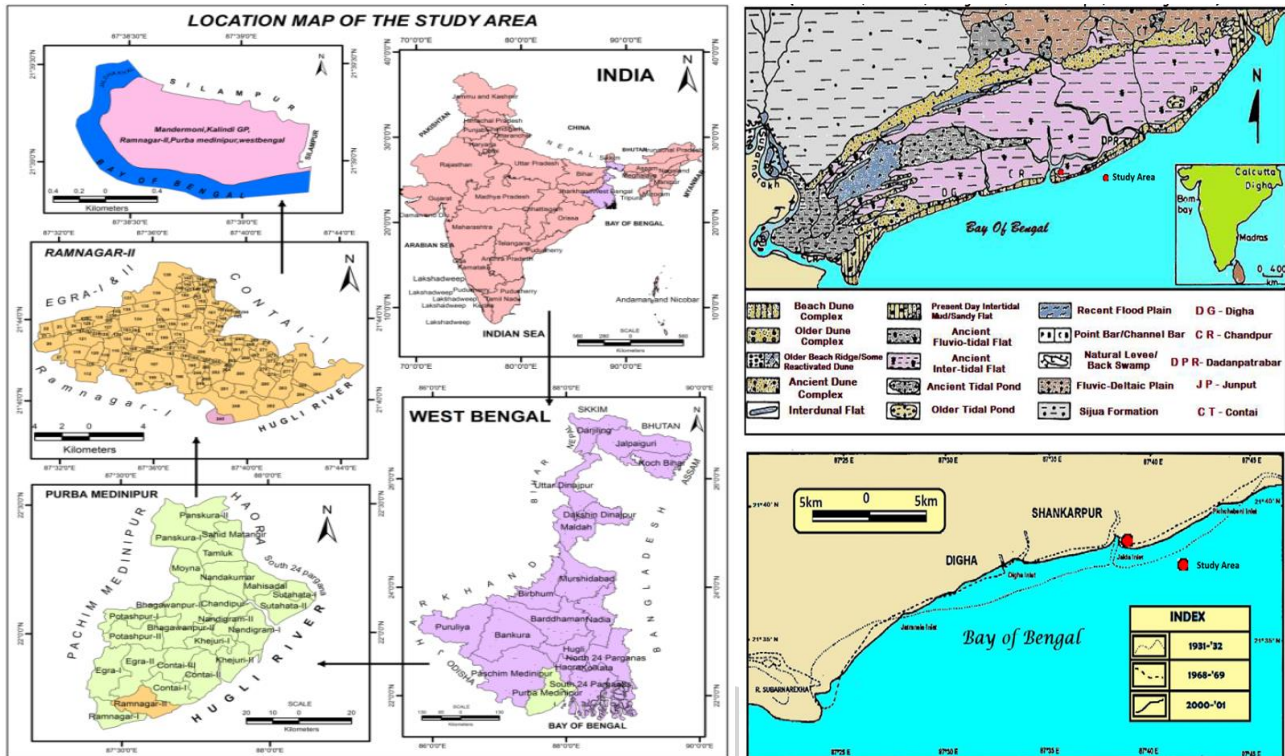
Moreover, while there are some general principles on the role and dynamics of coastal dunes to guide our planning, there are also significant variations in environmental attributes at different geographic scales that need to be

taken into account. It is also important to have some understanding of how the systems have evolved over thousands of years and may change in the future, for example in response to changing atmospheric or wave climates [12].

The Ecological roles and functions of coastal dunes include: essential store of sediments, protecting the land behind them from storm erosion and potential sea level rise; filter for rainwater and groundwater and in some situations, provided aquatic habitats such as dune lakes; protection of islands from storm surges, hurricanes and erosion; trapping of the windblown sand and prevention of sand being blown further inland by the vegetation; habitats for specially adapted plants, birds, and animals - several of which are now rare or endangered; a range of unique landforms and processes which have intrinsic value and are of scientific interest; and nesting sites for sea turtles and birds [13].

Bay of Bengal touches the southernmost part of West Bengal including the districts like Purba Medinipur and both 24 Parganas. Both 24 Parganas are mostly familiar due to largest delta is the existence of the world, and famous Royal Bengal Tiger with typically mangrove forest. But Purba Medinipur coastal sector shows only the Bengal coast with beach, dune, fewer creeks and coastal vegetation. Along the Medinipur coast, there are many important places like Digha, Sankarpur, Tajpur, Mandermoni, Junput, Hilli, Haldia and Geonkuli, which are not known to the Bengal people only but familiar to the people of the nation and foreign countries as the tourism destination. Mandermoni is one of the about the places our Bengal coast. This place is administratively designated as one coastal village of Kalindi GP of Ramnagar-II CDBlock under Contai Sub-division in Purba Medinipur. My study area reflects a fantastic natural scenario with the experience of sand, sea and sun. So it has been popular as the tourist spot like Digha. Hence, the physical and anthropogenic profiles of this place may be described to us. Not only that, with the emerging and developing trend of this tourist place, there is observed the problematic scenario at this time. Here lies the essence of this study. The aim of the present work is to study the geomorphology, flora and hydrogeology of the coastal sand dunes and anthropogenic impacts on sand dune ecology and its phyto-resources over Mandermoni coast of South Bengal. In this perspective, this study aims to generate a baseline data on coastal sand dune vegetation in the Midnapore coast, with special reference to Tajpur-Mandermoni coastline.

## II. LOCATION OF THE STUDY AREA



Map No.-1:- Location map of the study area & Map No.-2:- Geological and Morpho-Dynamic existence of mandermoni over coastal Medinipur

Our study area, Mandermoni mouza is one of the segments of coastal Bengal which is very important because this area shows a fine and fantastic coastal scenario with well anthropogenic set up. Geometrically, it is located in between  $21^{\circ}38'5''N$  –  $21^{\circ}39'30''N$  &  $87^{\circ}38'20''E$ . Geomorphologically, this area is one of the coastal segments over Rasulpur – Pichhaboni river basin having the characteristics of fluvio-coastal landscape over Midnapore coast. Mandermoni is situated at the left arm (eastern site) of extended Pichhaboni River (Jaldha Khal). Having typical fluvio-coastal environment, it is existed on Medinipur Coastal Belt neighbouring with Silampur – Sonamuih - Dadanpatrabad at the left and Taipur – Sankarpur – Digha at right side. Not only that, this area is featured by the green coastal landscape having the geo-conference of excellent co-existence of sea, sand and sun. Administratively, Mandermoni is one of rural mouzas of Kalandi Gram Panchayet of Ramnagar-II CD Block under Contai Sub –Division in Purba Mednipur District of West Bengal.

## III. AIM AND OBJECTIVES

**Aim:** Causality assessment of endangered dune morphology and ecology with its phyto-resources on Mandermoni stretch on coastal midnapore

### Specific Objectives:

- ❖ To estimate the nature and status of dune morphology and ecology in the study area;
- ❖ To find out the phyto-resources existed in sand dune ecosystem;
- ❖ To investigate the driving factors for degrading the dune ecol-morphology with its phyto-resources;
- ❖ To assess the impacts of degrading dune eco-morphology on society and environment.

## IV. METHOD AND METHODOLOGY

Table No.-1: Major Stages, Methods, Tools and Techniques for the Study

Sl. No.	Major Stages	Applicable Methods	Tools & Techniques	Order of Phase
1.	Pre-field Stage	<ul style="list-style-type: none"> <li>• Study Area Selection</li> <li>• Problem Selection</li> <li>• Formulation of Problems</li> <li>• Statement of the Problem</li> <li>• Literature Review</li> <li>• Objectives Formulation</li> <li>• Preparation of Data Collection Tools &amp; Techniques</li> </ul>	<ul style="list-style-type: none"> <li>❖ Offline Literature Review/ Library Research</li> <li>❖ Online Literature Review</li> <li>❖ Sampling Techniques Fixation</li> <li>❖ Survey Schedule/ Questionnaire Making</li> </ul>	Preparatory Phase



				Action Phase	Processing & Implementation Phase
2.	Field Stage	Data Collection	Primary	❖ Different kinds of sampling and Physical Survey regarding the issues & Institutional Survey with Photo Documentation	
			Secondary	❖ Previous Records, Books, Reports, Articles, Journals, Documents from various sources	
3.	Post Field Stage	Data Processing & Analysis	• Data Generation	❖ Theoretical Bases, Data Book Principles, Basic and Advanced Statistical Techniques for bothe Quantitative and Qualitative Data, etc.	
			• Data Organization	❖ MS Excel, SPSS (IBM), R & R Studio Software	
			• Data Compilation	❖ Google Earth, IRS LISS-III, LANDSAT-8 Images	
			• Data Calculation & Presentation	❖ ARC GIS & Q GIS Software	
			Mapping Analysis	❖ Photo Selection, Photo Editing, Photo Arrangement, etc.	
			Photographic Analysis		
Source: Own Techniques to configure method and methodology for easy and smooth study/ research					

Source: Own Techniques to configure method and methodology for easy and smooth study/ research

Table No.-2: Major database, software and sampling techniques used for study

Major Database	Major Software	Major Survey Techniques	Major Sample Techniques
<ul style="list-style-type: none"> <li>Google Earth Image-2010,2015 &amp; 2020</li> <li>LANDSAT-8-2010, 2015 &amp; 2020</li> <li>IRS LISS III-2010, 2015 &amp; 2020</li> <li>Corresponding Mouza Map</li> <li>DEM (SRTM/ ASTER)</li> <li>Bhuvan: Indian Geo-platform of ISRO</li> <li>DSDA Database</li> <li>Database of Ministry of Environment &amp; Forestry, Govt. of West Bengal</li> <li>Census of India, 2001 &amp; 2011 Research based literatures</li> </ul>	<ul style="list-style-type: none"> <li>ARC GIS-10.1</li> <li>Q GIS</li> <li>GPS</li> <li>MS Excell</li> <li>SPSS IBM (22/24)</li> <li>Photoshop 7.0.1</li> </ul>	<ul style="list-style-type: none"> <li>❖ Literature Survey</li> <li>❖ Levelling, Traversing &amp; GPS Tracking</li> <li>❖ Landscape Survey</li> <li>❖ Soil and Vegetation Sampling</li> <li>❖ Perception Survey on Target Group (Structured Questionnaire Method)</li> <li>❖ Institutional Survey (Structured Questionnaire Method)</li> <li>❖ Individual Interview (Formal Method)</li> </ul>	<ul style="list-style-type: none"> <li>❖ Systematic Random Sampling (Eco-morphological Survey)</li> <li>❖ Stratified Random Sampling (Soil &amp; Vegetation Survey)</li> <li>❖ Stratified Random Sampling (Perception Survey for Causal, Impact and Management Assessment/ Study)</li> <li>❖ Purposive Sampling (Phyto-resource Survey)</li> </ul>

Source: Self-made Research Design, 2018-2020

Table-3: Categories of Sample Respondents for Perception Study

Categories of Sample Respondents	% of Respondents	Number of Respondents
Older & Experienced Person (> 55 Yrs.)	46.09	59
Past & Present Researchers	3.13	4
Eminent Academicians & Environmentalists	13.28	17
Relevant Organizational Characters	3.91	5
Common People	33.59	43
Total	100	128

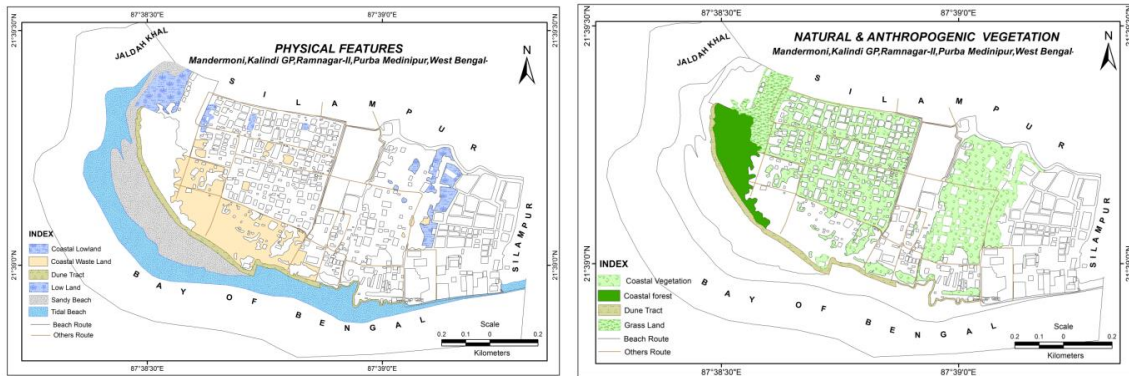
Source: Field Study, 2018-2020

The above data table shows the scenario of sampling for the selection of respondents due to Perception Study. In this study, different kinds of characters have been chosen throughout and outside the study area. Older and experienced persons, local people, relevant academic organizational and official characters, eminent academicians and environmentalists and researchers have been the pivotal or key characters for data collection on the selected topic or issue.

## V. GENERAL STATEMENT OF THE STUDY AREA

### (A) Physical Set up at a glance:

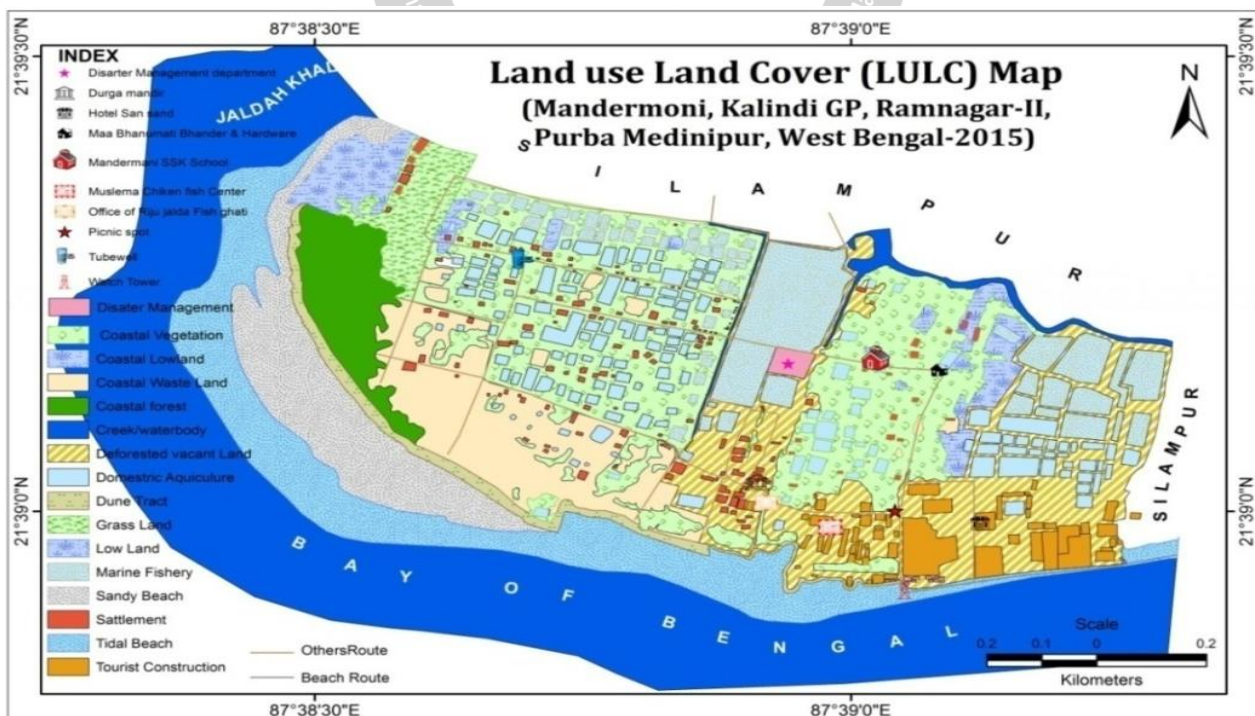
- General Geology:** Geologically, Mandermoni is one costal segment on the recent fluvio-coastal sedimentary and alluvial sub-formation of Quarternary-Holocene Sequence of Bengal Coastal Formation (6000-8000 BP).
- General Topography:** Mandermoni is basically a coastal mouza included of Bengal coastal plain. Average height from mean sea level (MSL) is ranged between 3m-5m on the basis of our levelling survey and GPS survey. The highest altitude is 14.3 m showing the dune elevation as a topographic feature. Geomorphologically, Mandermoni is situated at the mouth of extended pichaboni river (Jaldhakhhal) where it is included of Pichaboni - Rasulpur basin. Major geomorphic features like coastal sand dunes (avg. height 3.5-14.3m), sandy plain/sandy tract, sandy sea beach, eroded dune cliff, coastal low land and wet land, salt pits and salt pans, tidal creeks and inlets, coastal plain, mud track, etc.



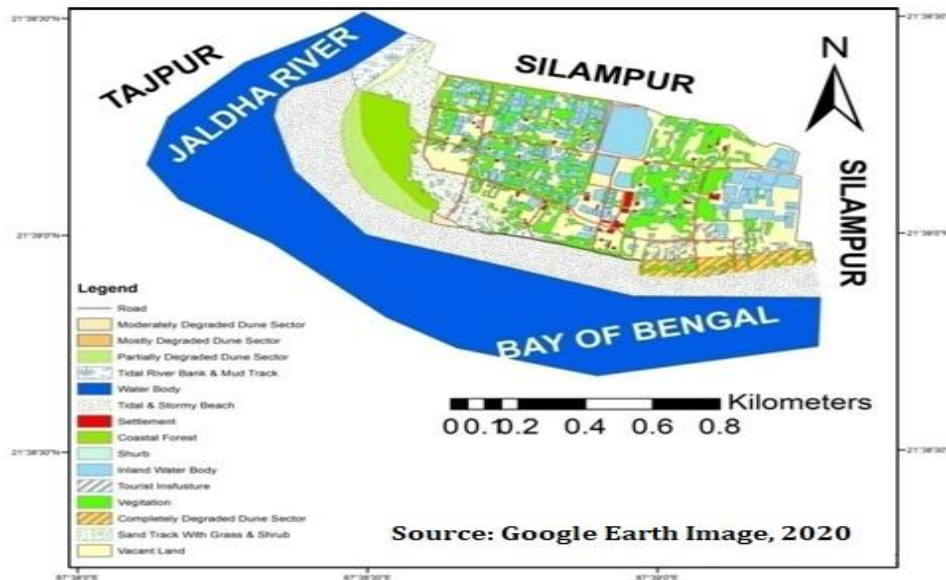
Map No.-3: Physical Features & Map No.-4: Vegetation Cover with Dune Tract in the Study Area

3. **Soil:** Since, the study area is one of the coastal segments over Bengal coast, sandy soil is the basic character here. There are observed sandy tract along the coastal line in front of and at the back side of sand dune. At the internal part of the village, there are observed the typical coastal sandy soil, sandy loam soil, loamy soil. At the forest zone of the village, there is observed the forest soil having thin organic layer and acidic character. At and along the tidal creeks, tidal mud flat, and tidal influenced beach area, there is observed the coastal saline and alkaline sandy soil. Along the tidal part of Jaldha khal, there is observed the salty sticky clay soil / mud soil.
4. **Natural Drainage:** There is existed the twin assemblage of fluvio- coastal drainage networks. Bay of Bengal towards south, Jaldha Khal at the west, some tidal creeks, channels and coastal wastelands at the northern and north eastern part are configured as the distinct drainage system here.
5. **Climate:** The study area is under sub-tropical monsoonal climate of India. It is habituated with typical coastal climate also along with the Rasulpur-Hooghly Estuary system. The hot summer and cold winter with normal to heavy rainfall are typical here like the Bengal Coast. The winter season starts from about the middle of November and continues up to the end of February and summer extends up to May. The south west monsoon season continues up to the end of September. October and the first half of November is the post monsoon. The study area is highly affected by flood in monsoon and continues to be affected in the post monsoon season.
6. **Vegetation:** Typical sub-tropical coastal vegetation is reflected with green line of variable dune vegetation, greenery of coastal forest having charming casurina colony and inward deciduous coastal vegetation adopted with sub-tropical monsoonal and regional coastal climates.

#### (B) Changing Land Use Scenario in the study area:



Map No.-5:- LULC Map of the Study Area, 2015



Map No.-6:- LULC Map of the Study Area, 2020

Table No.-4: LULC of the Study Area throughout the time

Different LULC	2010		2015		2020	
	Area(sq.m)	Area (%)	Area(sq.m)	Area (%)	Area(sq.m)	Area (%)
Tourist Construction	26064	2.41	33482	3.10	69219	6.40
Tidal Beach	144135	13.33	145456	13.45	145856	13.49
Settlement	12456	1.15	14902	1.38	24721	2.29
Sandy Beach	88504	8.18	86504	8.00	84805	7.84
Marine Fishery	79076	7.31	90660	8.38	81096	7.50
Coastal Low Land & Wetland	63195	5.84	45037	4.17	28900	2.67
Grass Land	29438	2.72	27665	2.56	23846	2.21
Cultivation	737	0.07	912	0.08	2124	0.20
Dune Tract	29287	2.71	22618	2.09	13533	1.25
Domestic Aquaculture	70329	6.50	73001	6.75	71654	6.63
Disaster Management	-	-	3354	0.31	3354	0.31
Devegetated Vacant Land	39687	3.67	126563	11.70	131386	12.15
Water Body (without sea)	14478	1.34	11806	1.09	13008	1.20
Coastal Waste Land	98413	9.10	95248	8.81	89046	8.24
Coastal Vegetation (without forest)	296498	27.42	253763	23.47	249875	23.11
Coastal Forest	84598	7.82	42613	3.94	32449	3.00
Beach Shops	390	0.04	577	0.05	276	0.03
Transport & Others	4006	0.37	7124	0.66	16137	1.49
Total	1081285	100.00	1081285	100.00	1062835	100.00

Source: Google Earth, IRS LISS-III and LANDSAT-8 Image Analysis, 2020

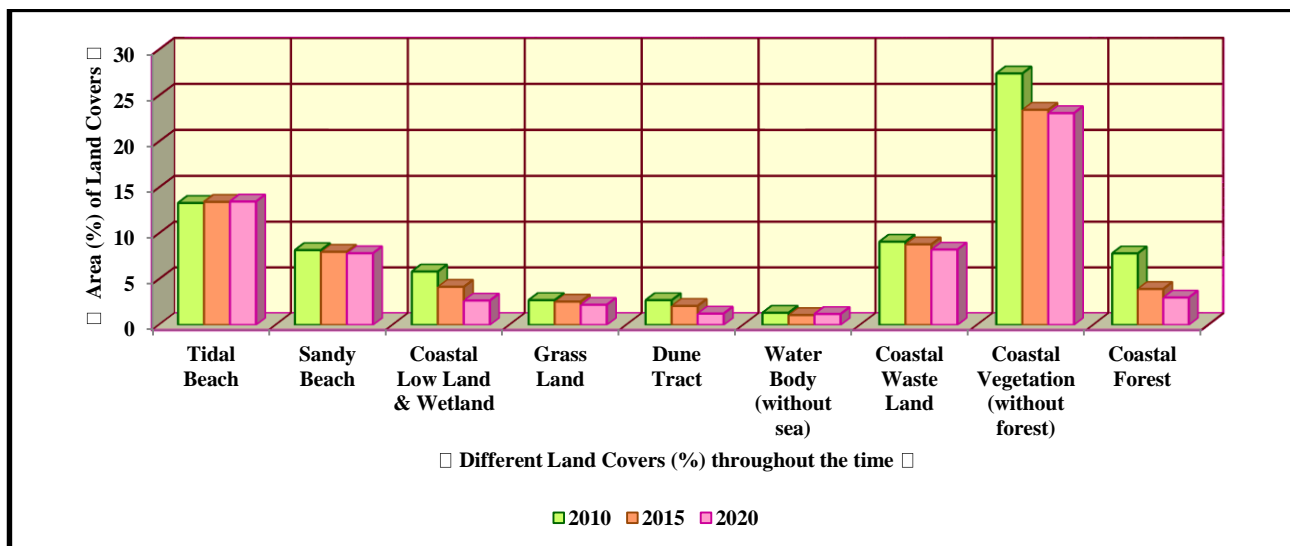


Figure-1: Status of Different Land Covers (%) in the Study Area throughout the Time



Mandermoni this coastal mouza shows a particular land use pattern having the recent tourism development and coastal rurbanization during last 10 years. Changing land use scenario is the recent burning picture here. Before the emergence of tourism development, there was existed a typical coastal rural landscape having sea, sand and green blue scenario. But from the last decade of 20th century, there has been developing the tourism activities with urbanization trend. From the first decade of 21st century, these two processes (tourism and urbanization) are being flourished at quite illiterate. As the result most of the green segment of this area have been enclosed most of the sandy tract and sand dunes have been captured by human being through settlement expansion, tourist construction, commercial development, marine aquaculture etc. Not only that, as a result of unauthorised non-scientific and haphazard interventions of human beings this landscape holistically degraded and pled down from its sweet romantic scenario. Recently, recreational activities have been the major influences to improve the socio-cultural degradation. So, it may be said that changing trend in land uses has brought out problematic face of this coastal village. The changing LULC scenario in table no.-4, figure-1, 2, 3, 4, 5, 6, 7 and 8 reflects declining and degrading scenario of natural signatures of landscape like dune tract, lowland, wetland, grassland, coastal vegetation, coastal forest, etc. in the opposite tone of anthropogenic aspects like increasing settlement, tourism and other construction, fish farming, devegetated land, infrastructural dimension, etc. Map No.-7a., 7b. and 7c show the DEM variation alongwith the altitudinal change in the study area and dune segments have been declined from elevational point of view. Map No.-8a, 8b and 8c and Map No.-9a, 9b and 9c reflect the changing scenario of vegetation and built up area through NDVI and NDBI mapping over time whereas natural vegetation coverage and intensity have been diluted along the dune line and built up land uses have been increased here through the twin processes like rurbanization and tourism development over time.

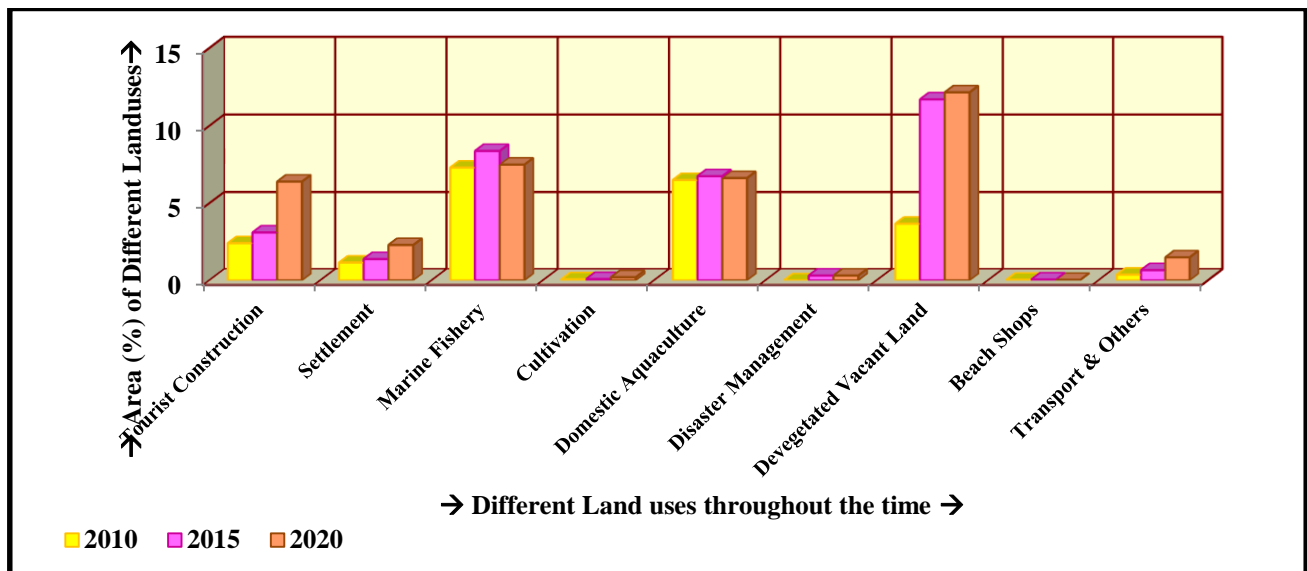


Figure-2: Status of Different Land uses (%) in the Study Area throughout the Time

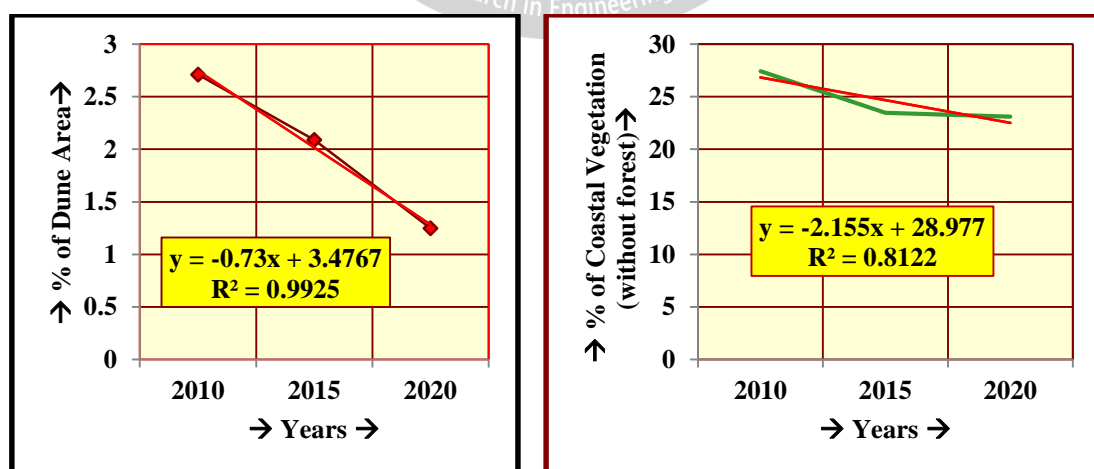


Figure-3: Change in Dune Tract (%) &amp; Figure-4: Change in Coastal Vegetation Cover (%)

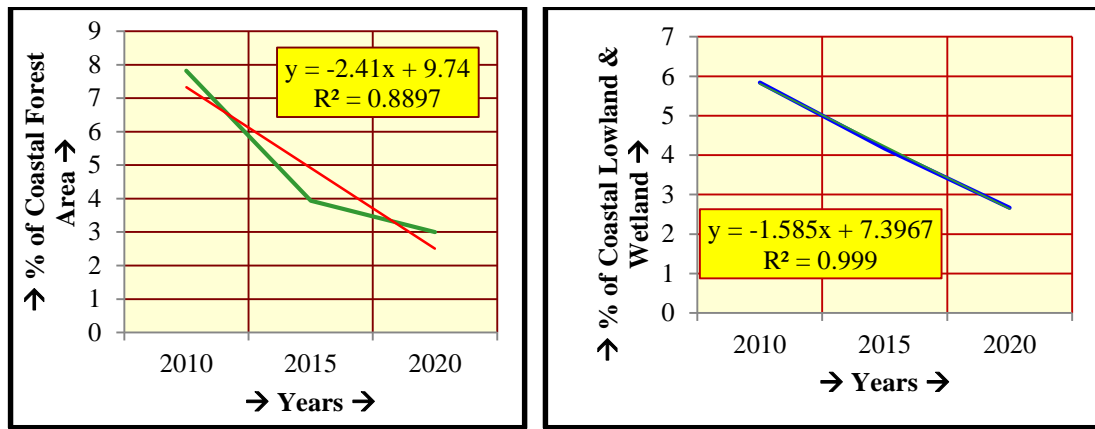


Figure-5: Change in Coastal Forest (%) & Figure-6: Change in Coastal Lowland and Wetland (%)

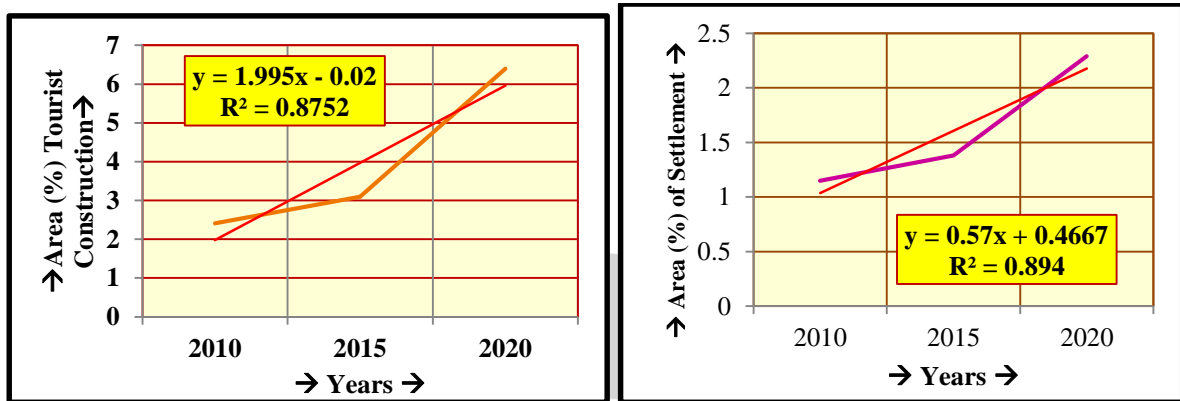
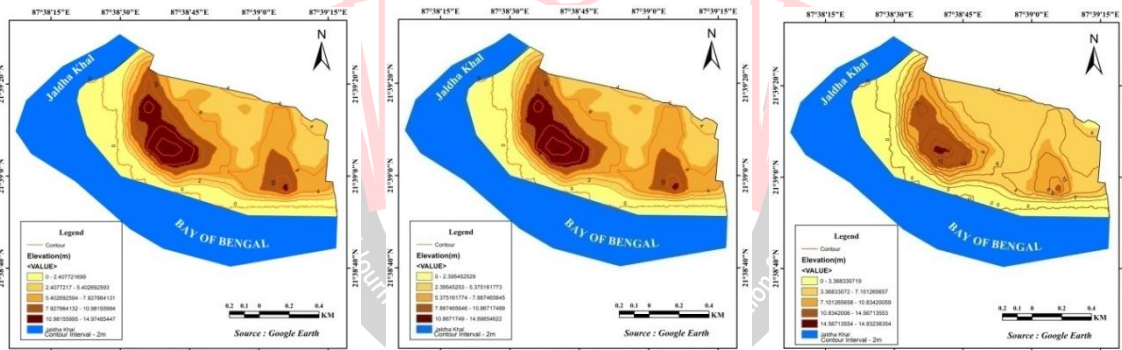
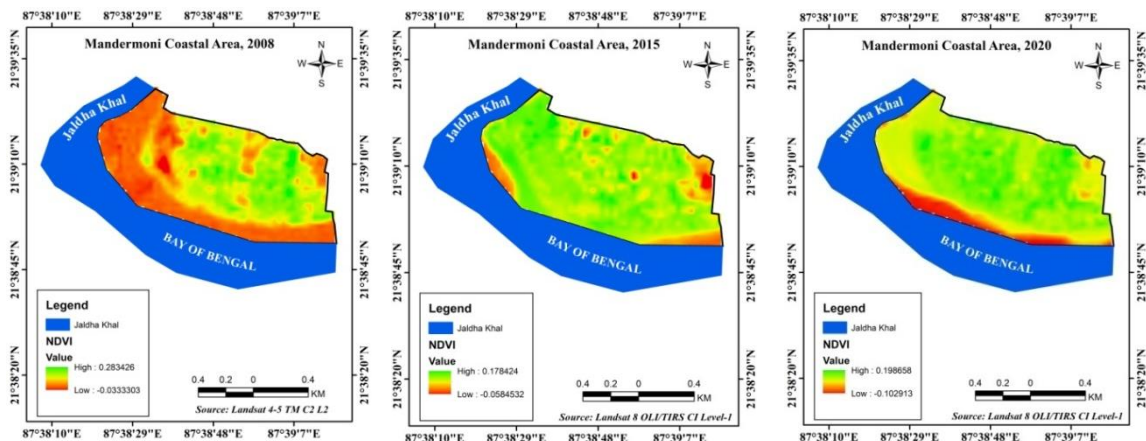


Figure-7: Change in Coastal Tourist Construction (%) & Figure-8: Change in Settlement (%)

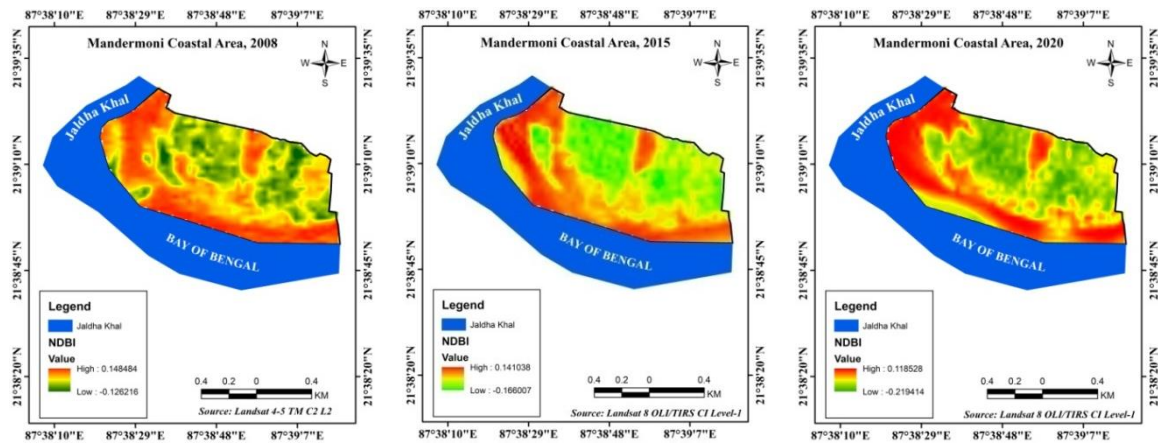


Map No.-7a., 7b. & 7c.: DEM with Contour Configuration in the Study Area, 2008, 2015 & 2020



Map No.-8a., 8b. & 8c.: NDVI in the Study Area, 2008, 2015 & 2020



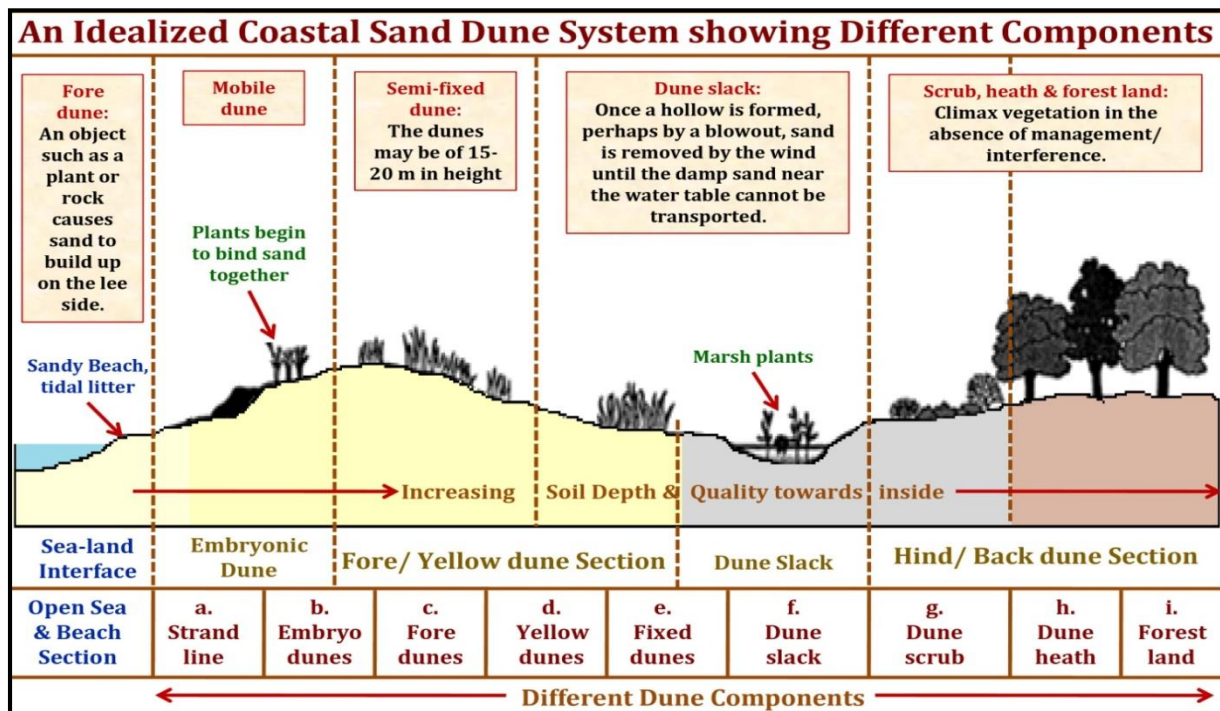


Map No.-9a., 9b. &amp; 9c.: NDBI in the Study Area, 2008, 2015 &amp; 2020

## VI. RESULT AND DISCUSSION

### 6.1 Eco-morphological Assessment of the Dune System in the Study Area:

#### 6.1.1 Geomorphological Processes of Coastal Sand Dune System:



Profile-1: Idealized Coastal Sand Dune System

#### 6.1.2 Biogeographical Processes in Dune Ecology:




Table-5: Interrelated Dune and Vegetation Characteristics with Dune Morphology

Characteristics	Mobile Dunes		Fixed Dunes		Forestlands
	Embryo and Fore Dunes	Yellow Dunes	Grey Dunes	Dune Slack	
Dune Characteristics	<ul style="list-style-type: none"> <li>On shore winds,</li> <li>Seaweeds (humus build up),</li> <li>Sand building up,</li> <li>Transient,</li> <li>Alkaline Sand, etc.</li> </ul>	<ul style="list-style-type: none"> <li>Surface continually blown away and replenished by fresh sand</li> <li>Reduced wind speed</li> <li>Top of dunes above high tide level</li> </ul>	<ul style="list-style-type: none"> <li>Increased humus contents,</li> <li>Surface lichens,</li> <li>Sand no longer accumulating</li> <li>Marram grass not able to compete well</li> </ul>	<ul style="list-style-type: none"> <li>Damp, low lying hollows,</li> <li>High water table in winter,</li> <li>Soil acidic and pH variable</li> </ul>	<ul style="list-style-type: none"> <li>Acid soil and increased organic matter content,</li> <li>Nutrient rich,</li> <li>Shelter developed</li> </ul>
	<ul style="list-style-type: none"> <li>Scattered individuals,</li> <li>Low growing prostrate habitat,</li> <li>Waxy leaves,</li> </ul>	<ul style="list-style-type: none"> <li>Salt intolerant,</li> <li>Thrives on being buried by sand,</li> <li>In rolled leaves,</li> </ul>	<ul style="list-style-type: none"> <li>Many plants now co-exist,</li> <li>Mainly perennial,</li> <li>Stabilizing plants liking increased</li> </ul>	<ul style="list-style-type: none"> <li>Moisture loving plants</li> </ul>	

- ❖ Salt tolerant.
- Underground rhizomes to stabilize sand.
- organic matter content
- species.

Source: Compilation of Sedondary Knowledge base and Field Survey (2018-2020)

### 6.1.3 Interlinkage between Dune Geomorphology and Dune Ecology in the Study Area:

Table-6: Typical Unaffected Sand dune Ecosystem, Succession and Characteristics in the Study Area (Relation among Geomorphological Zonation, Vegetation Zonation and Biogeographical Processes)								
Location/ Types of Dunes	Strand line & Beach Berm	Mobile Dunes			Fixed Dunes			Dune back/ edge
		Embryonic/ Incipient dune (Yellow dune)	Fore dune		Dune slack (Grey)	Back/ Hind dune		
Embryo-Fore dune (Yellow dune)	Yellow-Grey dune		Grey dune	Grey-Brown dune				
Appx. Distance from Sea (m)	0-25	25-70	70-125	125-260	260-435	435 & Inwards (Variable)		
Height (m) from MSL	<4	4-8	8-10	10-15	5-7	10-13		
pH of Surface Soil	9.0-8.5	8.5-8.0	8.0-7.5	7.5-7.0	7.0-6.5	6.5-6.0		6.5-6.0
Soil Depth	Low  High							
Soil Colour	Straw like	Yellowish/ Straw like		Yellow	Grey	Greyish		Greyish-Brownish
Humus (%)	< 0.5	0.5-2.0	1.0-3.5	3.0-5.0		5.0-20		> 35
Calcium Carbonate (%)	12-8	10-8	8-5	5-1		≅1	< 0.1	
Estimated Age (Years)	0-5	0-50	50-100	100-150		150-250	250+	
Stage of Life Cycle	Juvenile	Childhood	Childhood to Young		Young-Mature		Mature	
Vegetation Zone	-	Primary Vegetation Zone		Secondary Vegetation Zone			Tertiary Vegetation Zone	
Stage of Succession	-	Pioneer Stage		Building Stage			Climax Stage	
Colonization & Succession	-	Primary Species	Primary Species	Secondary Species		Secondary Species (Tertiary trend)		Tertiary Species
Nature of Vegetation	-	<ul style="list-style-type: none"><li>Grasses &amp; Creepers</li><li>pioneer colonisers of dunes and are the primary species in the succession process</li><li>Sand and salt tolerant</li><li>Reduces sand and salt spray into hind/ back dunes</li><li>Dry sand trapper and amazing sand holding grasses called Spinifex</li><li>First thin skin of coastal protection called as primary dune</li><li>Plants like Marram Grass and Sea Holly</li></ul>		<ul style="list-style-type: none"><li>Shrubs &amp; Short lived trees Fast growing plants</li><li>Highly adapted</li><li>Prolific re-seeders</li><li>The salt and wind loving pioneers</li><li>Low sand holding shrubs like coastal acacias and banksias</li><li>low natural wall of defense against intense invasion from the sea</li><li>Behind this wall a snug valley, called a swale, nurtures conditions for nutrients to build up and other plants to develop</li></ul>			<ul style="list-style-type: none"><li>Long lived trees</li><li>Permanent</li><li>Highly independent</li><li>Surviving in protection of dunes and secondary species</li><li>highly vegetated sand hill called as secondary dune</li><li>The original dune converted as tertiary dune with biodiversed coastal forest.</li></ul>	
Salt Tolerability	High Salt Tolerance  Low Salt Tolerance							
Diversity of Species	Low  High							
Vegetation Ground Cover	Low  High							
Increase in Nutrients & Organic Contents	Low  High							
Water Holding Capacity	Low  High							
Source: Field Survey, 2018-2020								

Source: Field Survey, 2018-2020

### 6.1.4 The floristic succession found at the coastal part in the Study Area:

Table No.-7: The floristic succession in the study area

Sl. No.	Edaphic status	pH	Vegetation	Floristic elements
1.	Zone under direct tidal influence	7.5 -8.5	No specific vegetation found	No
2.	Semi aerated upper tidal zone	7.5 – 7.8	Sparse elements	<i>Hydrophylaxmaritima</i>
3.	Outer Strand zone (well aerated sandy soil with leached out upper surface)	7.2-7.6	Pioneers species found	<i>Ipomoea pes-caprae</i> , <i>Spinifexsquarossus</i> , <i>Lippiasp.</i> , <i>Hydrophylaxmaritime</i> , <i>spinifexlittoreus</i> ,etc.

4.	Central strand zone	7.0-7.5	Pioneers and associated species found.	<i>Ipomoea pes-caprae</i> , <i>Cyperussp.</i> , <i>Euphorbia sp.</i> , <i>Crotalaria sp.</i> , <i>Tephrosiasp.</i> , <i>Launeasp.</i> , <i>Sesuviumportulacastrum</i> , <i>Vignaltutiola</i> , <i>Crotalaria pallid</i> , <i>Paspalumvaginatum</i> etc.
5.	Inner strand zone (high humus)	6.2-7.0	Mixed ground vegetation with background trees	<i>Casuarinaequasetifolia</i> , <i>Pandanusfascicularis</i> , <i>Phoenix sylvestris</i> , <i>Cocosnucifera</i> , <i>Opuntiamonacantha</i> , <i>Calotropisprocera</i> , <i>Salicomiasp.</i> , etc.

Source: Primary Data (Field Survey, 2018-2020)

### 6.1.5 Major Sand Dune Ecosystem Services in the Study Area:

Table-8: Major Sand Dune Ecosystem Services in the Study Area

Major Sand Dune Ecosystem Services		Sub-services
1. Provisioning Services	Fresh water	Drinking water Irrigation
	Food (e.g. crops, fruit, fish)	
	Fibre and fuel (timber, etc.)	Grass/reeds Timber Breeding stock Biochemicals, natural medicines, pharmaceuticals
	Genetic resources	
	Ornamental resources (e.g. shells, flowers, etc.)	
2. Mineral extraction	Sand extraction	
3. Landscape suitable for industrial use	Fishing, Fish Farming, Fish Frying & Manufacturing	
5. Regulating Services	Air quality regulation	
	Climate regulation (local temperature/ precipitation, GHG sequestration, etc)	
	Water regulation (water storage, recharging and discharging)	
	Natural hazard regulation (i.e. storm protection)	
	Pest regulation	
6. Cultural Services	Disease regulation	
	Erosion regulation	
	Water purification and waste treatment	For drinking water Purification of groundwater
	Pollination	
	Cultural heritage	
7. Supporting Services	Recreation and tourism	
	Aesthetic value	
	Spiritual and religious value	
	Inspiration of art, folklore, architecture, etc.	
	Social relations (e.g. fishing, grazing or cropping communities)	
	Educational resource	
	Soil formation	
	Primary production	
	Nutrient cycling	
	Water recycling	
	Photosynthesis (production of atmospheric oxygen)	

Source: Field Survey (2018-2020)

### 6.1.6 Roles of Dune Vegetation/ Flora in the Dune Morphology at the Study Area:

Table-9: Roles of Dune Vegetation/ Flora in the Study Area

Pretty amazing in controlling the erosion:	<ul style="list-style-type: none"> <li>Reduce wind erosion by decreasing wind speed at ground level.</li> <li>Build up sand dunes, reducing the amount of damage during a storm.</li> <li>Reduce wave erosion.</li> <li>Tolerate a hostile environment of high winds, salt spray, sand blast, covering by sand, sandy soil and little water.</li> <li>Fore dune plants like trap wind-blown sand in the fore dunes.</li> </ul>
Importance of fore dune plants:	<ul style="list-style-type: none"> <li>This sand serves as a reservoir for the beach during periods of wave erosion.</li> <li>In the absence of sand trapping dune vegetation, wind-blown sand from the beach moves inland and is lost to the beach/dune system.</li> <li>Sand remains mobile and loose in the system, so can be moved along the beach in long shore drift currents.</li> <li>Plants here gradually replace the fore dune plants as soil conditions improve and conditions become less harsh (e.g. decreased exposure to salt spray and sand blast).</li> </ul>
Roles of plants behind the fore dune:	<ul style="list-style-type: none"> <li>These plants play a lesser role in dune formation.</li> <li>In severe storms dune plants sometimes get washed away. It's a natural part of the dune formation process. Their remnants are left to re-grow.</li> </ul>
Maintaining the sand budget:	<ul style="list-style-type: none"> <li>Keeping sand dunes healthy means the sand budget needs to be maintained – plants are an important part of this process.</li> </ul>
The natural storm cut and beach recovery processes:	<ul style="list-style-type: none"> <li>Post storm recovery is aided by sand binding plants colonizing the dune scarp, trapping wind-blown sand to repair the dune. Healthy dunes with good vegetation can buffer the effects of storms</li> </ul>

Source: Primary Data (Field Survey, 2018-2020)



### 6.1.7 Dune Phyto-resources and Its Importance in the Study Area:

Selected 46 plant species have been listed in the following table. Most of the plants are natural. Some are manmade. Some manmade plants have become natural like *Acacia moniliformis*, *Anacardium occidentale* & *Casuarinas equisetifolia*. Plants of sand dune have significant role in ecosystem. A prominent plant succession is found on sand dune and sand dune vegetation has a great role to stabilize sand dune. *Cynodon dactylon*, *Indigofera dendroides*, *Ipomoea pes-caprae*, *Lippia nodiflora*, *Evovulus nummlarius* & *glycosmis pentaphylla* are the main sand dune stabilizer. Main business of Digha, Sankarpur, Mandarmoni is hotel marketing. The byproduct of tourism and hotel marketing is pollution, mainly plastic pollution. There are no proper waste management system and drainage system. So it is threat to ecosystem. Illegal housing for hotel business plants are destroying and sand dune are abolishing day by day, this is a great threat to ecosystem to near future. As the plants and sand dune are destroying day by day, a great disaster may be occurred at the time of storm, flood, tsunami etc. *Cynodon dactylon*, *Indigofera dendroides*, *Ipomoea pes-caprae*, *Lippia nodiflora*, *Evovulus nummlarius* & *Glycosmis pentaphylla* are the primary successor on sand dune and *Casuarinas equisetifolia*, *Albizia lebbeck*, *Anacardium occidentale*, *Allophylus cobbe* & *Azadirachta indica* are the secondary successor on sand dune.

**Table-10: List of habituated dune vegetation and their phyto-medicinal uses in the study area**

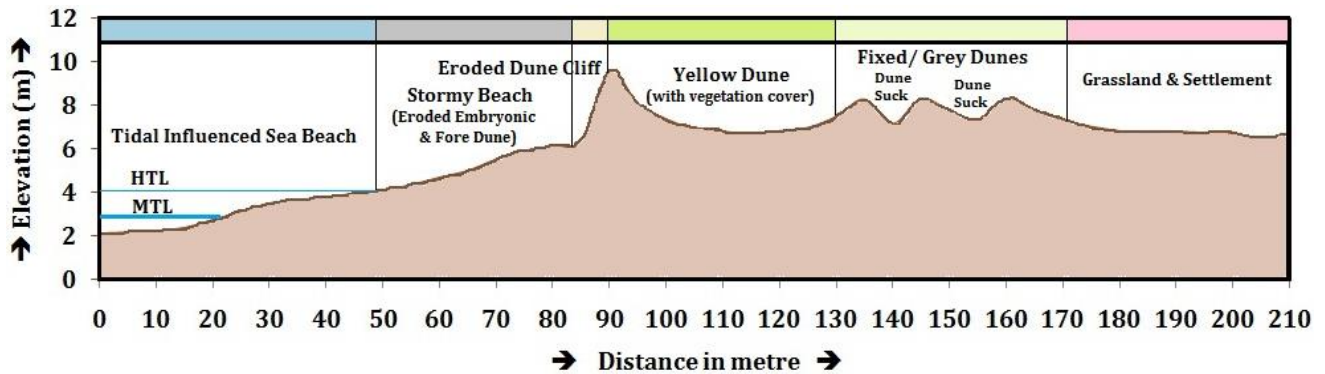
S. N.	Scientific Name	Family	Habitat/ Character	Usable Parts	Nature of Uses
1.	<i>Acalypha indica</i> L.	Euphorbiaceae	On sand dune	Leaves	<ul style="list-style-type: none"> <li>Medicinal uses</li> </ul>
2.	<i>Allophylus cobbe</i> Raeusch	Sapindaceae	Good sand dune stabilizer	Leaves, bark, root and wood	<ul style="list-style-type: none"> <li>Medicinal uses</li> <li>Furniture uses.</li> <li>Cooking fuel uses</li> </ul>
3.	<i>Amaranthus spinosus</i> L.	Amaranthaceae	On sand dune	Seed, flower, root, sap and ash of plant	<ul style="list-style-type: none"> <li>Medicinal uses</li> </ul>
4.	<i>Anacardium occidentale</i> L.	Anacardiaceae	Sand dune stabilizer	Seeds, bark, leaves and fruit	<ul style="list-style-type: none"> <li>Medicinal uses</li> </ul>
5.	<i>Argemone Mexicana</i>	Papaveraceae	common plant on dune along the coastline	Whole plant	<ul style="list-style-type: none"> <li>Medicinal uses</li> <li>Uses as drink like tea</li> <li>Medicinal uses</li> <li>Agri-horticulture uses</li> <li>Uses in land conversion</li> <li>Uses in forestry, farming, fishing and household purpose</li> <li>Uses in making music instrument, toy making, dying, ink and tattoo making</li> <li>Social religious and ceremonial uses, etc.</li> <li>Uses as fodder for livestock,</li> <li>using potential for contaminating seed stocks</li> </ul>
6.	<i>Axonopus compressus</i> (Sw.) P.Beauv	Poaceae	Sand dune grass	Seed, bark, leaves, flower, young twig, root, etc.	<ul style="list-style-type: none"> <li>Sand binder plant species</li> </ul>
7.	<i>Boerhavia diffusa</i>	Nyctaginaceae	common herb on sand dune	Whole plant	<ul style="list-style-type: none"> <li>Medicinal uses</li> </ul>
8.	<i>Bulbostylis barbata</i> Roth.	Cyperaceae	Potent soil binding species.	Whole plant	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
9.	<i>Cassia absus</i> L. (Chaksu)	Fabaceae	Sand dune stabilizer	Whole plant	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
10.	<i>Cassia alata</i> (L.) Roxb.	Fabaceae	Sand dune stabilizer	Mainly leaves	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
11.	<i>Cassia occidentalis</i> L.	Fabaceae	Sand dune stabilizer	Roots, seeds and leaves	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> <li>Wood is used for house posts, rafters and crafts, for fencing.</li> <li>Bark as the medicinal uses</li> <li>Medicinal uses mainly</li> </ul>
12.	<i>Casuarinas equisetifolia</i> L.	Casuarinaceae	Sand dune stabilizer	Wood and bark	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> <li>The leaf and root are widely used as antidandruff</li> </ul>
13.	<i>Catharanthus roseus</i>	Apocynaceae	common sand dune plant/ herb	Leaves mainly	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
14.	<i>Cleome viscosa</i> L.	Cleomaceae	Sand dune stabilizer	Leaves, bark and roots	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
15.	<i>Clerodendrum infortunatum</i> L.	Lamiaceae	Sand dune shrub	Leaf and root	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
16.	<i>Coccinia grandis</i> (L.) Voigt	Cucurbitaceae	Sand dune Climber plant	Fruit mainly	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
17.	<i>Commelina benghalensis</i> L.	Commelinaceae	Sand dune vegetation	Leaf and root	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
18.	<i>Crotalaria pallida</i> Aiton	Fabaceae	Sand dune stabilizer	Leaf and root	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
19.	<i>Croton bonplandianum</i> Baill	Euphorbiaceae	Sand dune stabilizer	Leaf, seed, bark and root	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
20.	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Good sand dune stabilizer	Whole plant	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>

21.	<i>Datura metel</i> L.	Solanaceae	Sand dune shrub	Leaf, flower, seed, bark & root	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
22.	<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	Sand dune vegetation	The whole plant (leaf & root)	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> <li>Plant ash as the medicinal uses</li> <li>The straw is woven into mats for covering food, and also into a coarse cordage.</li> </ul>
23.	<i>Eragrostis ciliaris</i> (L.) R.Br.	Poaceae	Sand dune vegetation	The whole plant	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
24.	<i>Evolvulus nummularius</i> (L.)L.	Convolvulaceae	Good sand dune stabilizer	leaf & root	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
25.	<i>Ficus racemosa</i> L.	Moraceae	Sand dune vegetation	Leaves, bark, fruit and root	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
26.	<i>Glycosmis pentaphylla</i> (Retz.) DC.	Rutaceae	Good sand dune stabilizer	Leaves, bark and root	<ul style="list-style-type: none"> <li>The plant is often used in traditional medicine.</li> <li>It is a good sand binder and protect the coast from erosion</li> </ul>
27.	<i>Hydrophyllax maritima</i> L.f.	Rubiaceae	Good Sand binder species	The whole plant	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
28.	<i>Indigofera dendroides</i> Jacq.	Fabaceae	Good sand dune stabilizer	The whole plant	<ul style="list-style-type: none"> <li>It is a sand binder; leaves and roots are useful as medicine.</li> </ul>
29.	<i>Ipomoea pes-caprae</i> (L.) R.Br.	Convolvulaceae	Good sand dune stabilizer	Leaves and root	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
30.	<i>Jatropha gossypifolia</i> L.	Euphorbiaceae	Sand dune vegetation	Root, bark and leaves	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
31.	<i>Lantana camara</i> L.	Verbenaceae	Good sand dune stabilizer	Root, bark and leaves	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
32.	<i>Lippia nodiflora</i> (L.) Greene	Verbenaceae	Sand dune vegetation	Root, bark and leaves	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> <li>Good sand binder and plant juice is applied for the treatment of Rheumatism.</li> <li>It is used in traditional medicines.</li> </ul>
33.	<i>Launaea sermentosa</i> (Willd.)	Asteraceae	Sand binder species	The whole plant	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
34.	<i>Martynia annua</i> L.	Martyniaceae	Sand dune vegetation	The whole plant	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
35.	<i>Melastoma malabathricum</i> L.	Melastomataceae	Sand dune vegetation	Leaves, shoots, barks, seeds, and roots	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
36.	<i>Mitracarpus hirtus</i> (L.) DC.	Rubiaceae	Sand dune herb	Leaves mainly	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
37.	<i>Mollugo pentaphylla</i> L.	Molluginaceae	Sand dune herb	Leaves and root mainly	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
38.	<i>Ocimum americanum</i> L.	Lamiaceae	Sand dune herb	Leaves mainly	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> <li>Dried plant is burnt as mosquito repellent.</li> </ul>
39.	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	Sand dune herb	The whole plant	<ul style="list-style-type: none"> <li>It is used in traditional medicines.</li> </ul>
40.	<i>Opuntia dillenii</i> (Ker Gawl.) L.D.Benson	Cactaceae	Sand dune herb	Fruits mainly	<ul style="list-style-type: none"> <li>It is used in traditional medicines.</li> <li>This species also a dangerous weed but this species could be used for soil erosion control.</li> </ul>
41.	<i>Panicum repens</i> L.	Poaceae	Sand binder species	The whole plant	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
42.	<i>Pedaliu murex</i> L.	Pedaliaceae	Sand dune vegetation	Fruits, seeds and leaves	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> </ul>
43.	<i>Phyllanthus niruri</i> L.	Phyllanthaceae	Sand dune vegetation	Leaves & roots	<ul style="list-style-type: none"> <li>Medicinal uses mainly</li> <li>A very good sand binder.</li> <li>Young plants are edible after boiling to remove the excess the salt.</li> <li>It is an excellent soil binder.</li> <li>Dried grass is used as fuel.</li> <li>Medicinal uses mainly</li> <li>It is also used to control population of mosquitoes.</li> </ul>
44.	<i>Sesuvium portulacastrum</i> (L.) L.	Aizoaceae	Good dune stabilizer	The whole plant	
45.	<i>Spinifex littoreus</i> (Burm.f.) Merr.	Poaceae	Good dune stabilizing grass	The whole plant	
46.	<i>Vitex negundo</i> L.	Lamiaceae	Sand dune vegetation	Leaves & roots	

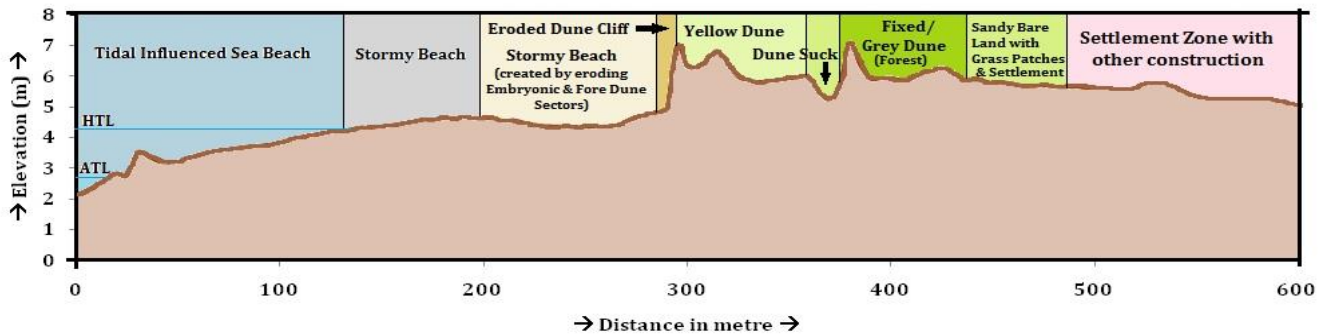
Source: Compilation of Secondary Data [14],[15],[16] and Primary Data (Field Survey, 2018-2020)

## 6.2 Responsible Causes to Eco-morphological Degradation of Dune System in the Study Area:

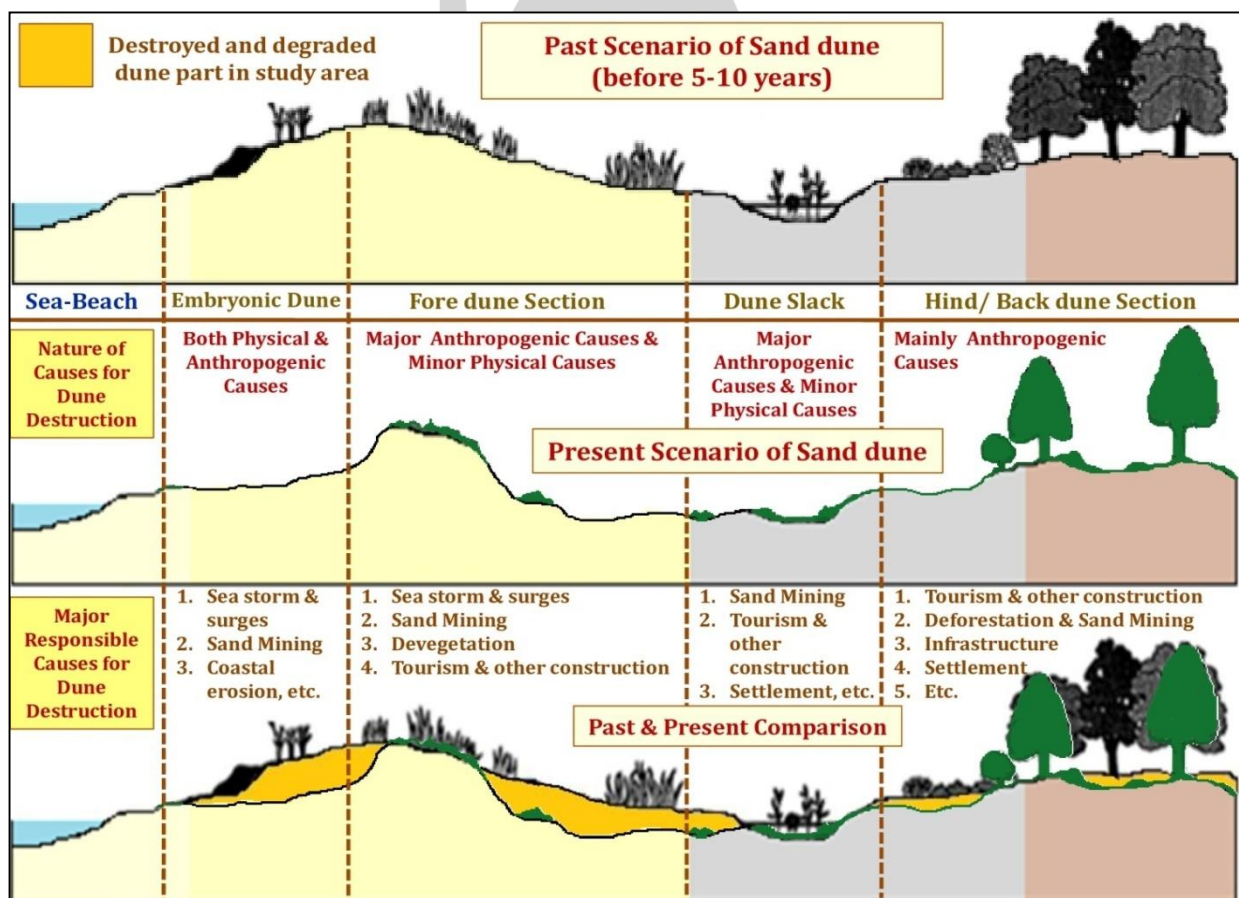
### 6.2.1 State and Status of Dune Degradation in the Study Area:



Profile No.-2: Degraded Dune Cross Section in the Study Area (Source: Field Survey, 2018-2020)



Profile No.-3: Degraded Dune Cross Section in the Study Area (Source: Field Survey, 2018-2020)



Profile No.-4: Comparison of Past and Present Situation of Dune System in Study Area (Source: Field Survey, 2018-'20)

State and status of sand dune degradation in the study area show the deteriorating situation of local coastal environment. Profile No.-2, 3, and 4 reflects the ruining scenario of dune alongwith the dwindling status of dune vegetation. Based on dune landscape survey and data analysis it is seen that embryonic dune is affected by both natural phenomena like sea storm, sea surges, etc. and anthropogenic activities like sand mining whereas foredune, dune slack and hind dune are mostly affected by



human interference like illegal tourism development, settlement and infrastructural development, sand mining, deforestation, etc.

### 6.2.2 Major Forces to Dune Degradation:

Table-11: Major Forces to Dune Degradation

Major Forces to Dune Destruction	Perception (%) on the Magnitude of Causes						Total
	Very High	High	Moderate	Low	Very Low	No Remarks	
Sea Storm & Coastal Hazard	25.56	24.32	18.25	17.89	10.48	3.5	100
Fragile Land use Policy	39.21	28.67	18.65	5.62	3.45	4.4	100
Unrestricted Govt. Rules & Regulation	33.69	29.67	22.17	8.56	4.12	1.79	100
Non-implementation of CRZ Policy	21.32	19.45	20.56	13.31	7.47	17.89	100
Improper Development & Management	25.62	27.32	31.23	7.11	6.34	2.38	100
Influence of Local Politics	30.21	23.78	24.77	9.1	4.1	8.04	100
Impersonality of Local Administration	21.78	29.71	13.25	18.32	7.88	9.06	100
N = 128							Source: Field Study-2018-2020

Table No.-11 reflects the major forces for dune destruction and degradation in the study area. As per perception from different target groups, sea storms and other coastal hazards are the major physical drivers to squeeze the existence of dune feature whereas fragile land use policy including govt. rules and regulation, CRZ policies, improper development, impersonality from local politics and administration, etc. are the key forces for dune degradation. The perception study indicates the severe negligence of the policy maker, planner, politicians and also public towards the existence of this important geo-environmental character.

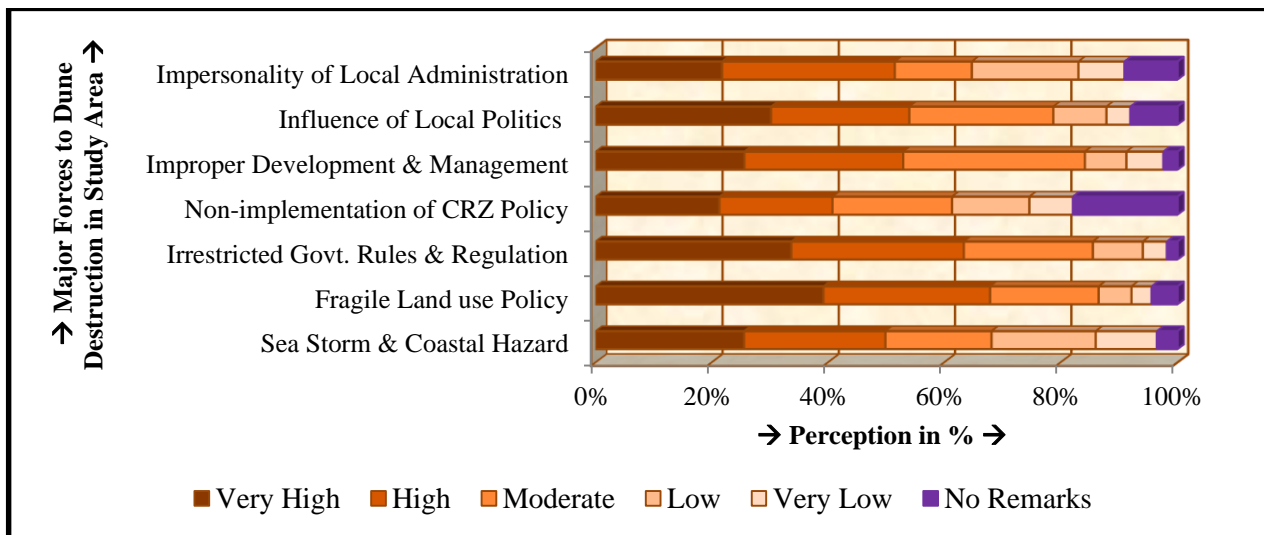
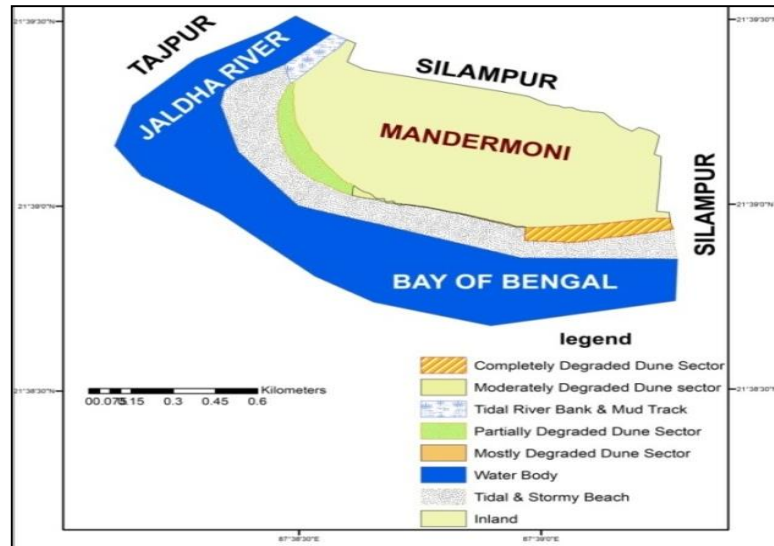


Figure-9: Major Forces to Dune Destruction



Figure-10: Anthropogenic Causes & Sub-causes for Dune Destruction at the Study Area

### 6.2.3 Major Responsible Causes to Dune Degradation in the Study Area:



Map No.-10: Status Map of the Dune Stretch in the Study Area

Table-12: Major Causal Action/ Activities to Dune Destruction

Major Causal Action/ Activities to Dune Destruction	Perception (%) on the Magnitude of Causes						Total
	Very High	High	Moderate	Low	Very Low	No Remarks	
Sea Storm & Flood	21.39	23.55	21.78	13.45	11.67	8.16	100
Coastal Erosion	18.44	24.67	27.23	19.56	7.23	2.87	100
Deep Depression/ Cyclones	17.54	26.76	28.32	18.81	4.64	3.93	100
Tourism Development	34.58	29.87	27.43	3.21	3.35	1.56	100
Settlement Expansion	17.21	19.23	25.79	13.46	16.43	7.88	100
Road Construction	15.75	22.32	29.88	18.32	8.34	5.39	100
Recreational Project	18.54	27.43	28.71	16.75	5.2	3.37	100
Commercial Construction	21.12	24.33	26.78	17.56	7.24	2.97	100
Deforestation	28.65	29.32	26.99	11.32	3.72	0	100
Sand Mining	17.56	27.62	24.76	12.82	9.65	7.59	100
N = 128							Source: Field Study-2018-2020

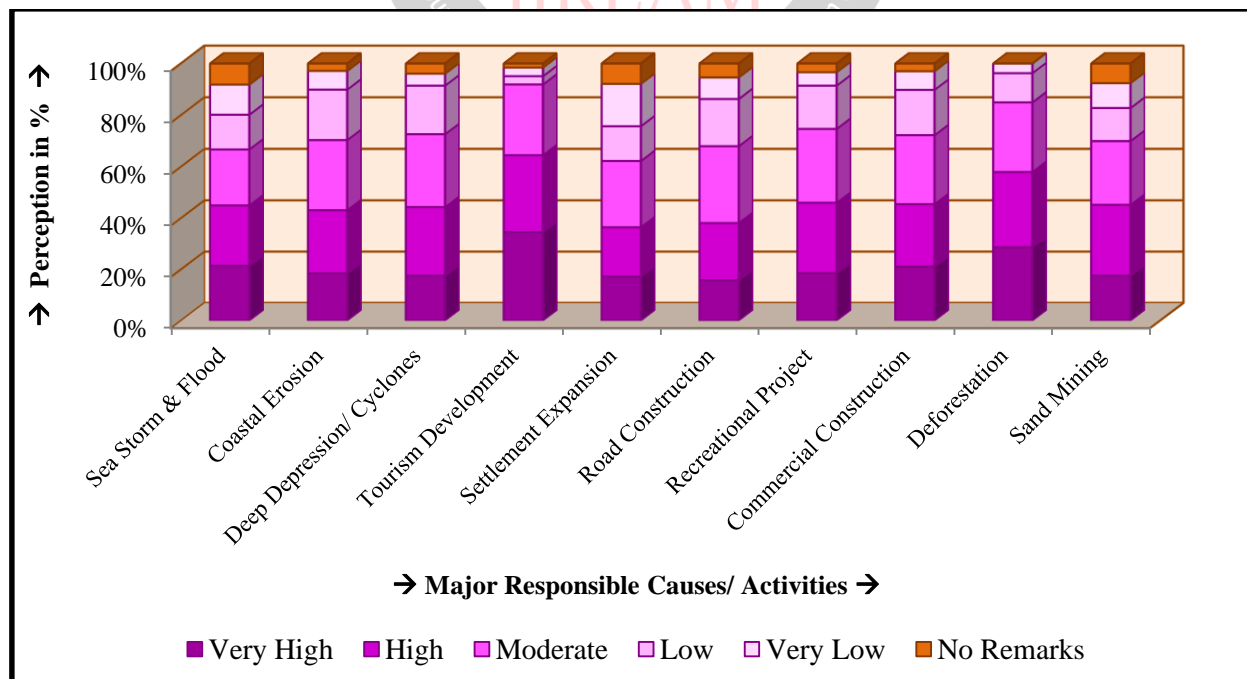


Figure-11: Major Causal Activities for Dune Degradation

The above data (Table No.-12) collected from the field survey through perception study indicates the responsible causal actions or activities due to dune destruction and degradation. Physical processes like sea storm, sea surges, deep depressions, cyclones, coastal erosion, etc. are the reliable characters to dwindle the dune morphology and ecology. On the other hand, human causes are more responsible than that of the physical processes. As per Figure-11, Table-12 and Map No.-10, unscientific tourism development, illegal and haphazard development projects including recreational schemes, road construction, settlement expansion, etc. are the steadfast characters or activities to promote this degradational scenario. Higher magnitude of deforestation and sand mining are also another two important black character due to declination and crisis of the coastal safe guard.

### 6.3 Major Impacts due to Eco-morphological Dune Degradation in the Study Area:

#### 6.3.1 Major Environmental Impacts:

Table No.-13:- Major Environmental Impacts due to Sand dune Degradation

Sl. No.	Major Environmental Impacts	% of Responses on the Magnitude of Impacts						T
		VH	H	M	L	VL	NR	
1.	Declination Dune Species	47.06	30.88	16.18	4.41	0	1.47	100
2.	Decrease in Coastal Biodiversity & Species Diversity	33.82	35.29	17.65	7.35	2.94	2.94	100
3.	Declination of Dune & Coastal Phyto-resources	36.76	25.00	27.94	4.41	4.41	1.47	100
4.	Change in Coastal Morphology	27.94	29.41	26.47	2.94	0.00	10.29	100
5.	Increasing Trend in Coastal Erosion	25.00	33.82	23.53	7.35	2.94	7.35	100
6.	Increase in Coastal Instability	23.53	27.94	39.71	5.88	0.00	2.94	100
7.	Increase in Flood prone Behaviour of Coastal Region	27.94	26.47	26.47	16.18	0.00	2.94	100
8.	Change and Modification of Coastal Ecosystem & Habitat	23.53	30.88	22.06	10.29	8.82	4.41	100
9.	Increase in Ground Water Salinity	20.59	27.94	26.47	16.18	4.41	4.41	100
10.	Increase in Fresh Water Crisis	25.00	30.88	25.00	10.29	4.41	4.41	100
N=128, VH=Very High, V=Very, M=Moderate, L=Low, VL= Very Low, NR= No Response, T=Total								
Source: Compilation of Primary and Secondary Data, 2018-2020								

#### 6.3.2 Major Anthropogenic Impacts:





Table No. – 14: Major Anthropogenic Impacts due to Sand dune Degradation

Sl. No.	Major Anthropogenic Impacts	% of Responses on the Magnitude of Impacts						T
		VH	H	M	L	VL	NR	
1.	Decrease in Phyto-resources	38.24	30.88	19.12	5.88	2.94	2.94	100
2.	Fresh Water Crisis	25.00	30.88	25.00	10.29	4.41	4.41	100
3.	Decrease in Fuel & Furniture Woods	27.94	32.35	22.06	14.71	1.47	1.47	100
4.	Declination of Foods & Fodders to Livestock Farming	22.06	33.82	23.53	11.76	5.88	2.94	100
5.	Decrease in Medicinal Plants	19.12	30.88	22.06	10.29	10.29	7.35	100
6.	Narrowing the Fisherman's Shelters	10.29	23.53	25.00	20.59	11.76	8.82	100
7.	Fragmenting the Resistance/ Natural Guard against Sea Storms/ Surges / Flood, etc.	27.94	26.47	26.47	16.18	0.00	2.94	100
8.	Loosening the Aesthetic Value & Natural Beauty of Coast	30.88	35.29	19.12	10.29	2.94	1.47	100
VH=Very High, V=Very, M=Moderate, L=Low, VL= Very Low, NR= No Response, T=Total								
N=128								
Source: Field Study-2018-2020								

The above data tables (Table No.-13 and 14) reflect the environmental and anthropogenic impacts for dune degradation due to different human interferences mainly. As per survey, most of mentioned impacts in the table have been dignified by higher magnitude of perception which indicates morphological deterioration of dune with its mining ecosystem and dwindling phytoresources.









#### 6.3.3 Major recognized endangered plant species at Mandermoni dune section:

Table No.-15:- List of Plant Status at Mandermoni Dune Section

Sl. No.	Scientific Name	Family	Habitat/ Characters	Picture of dune Species	Global Status as per IUCN Red Book Data List	Regional Status as per IUCN Red Book Data List	Local Status as per IUCN Red Book Data List
1.	<i>Acalypha indica</i> L.	Euphorbiaceae	On sand dune		EN	EN	CR
2.	<i>Allophylus cobbe</i> (L.) Raeusch.	Sapindaceae	Good sand dune stabilizer		NT	VU	EN
3.	<i>Amaranthus spinosus</i> L.	Amaranthaceae	On sand dune		EX	EX	EX
4.	<i>Anacardium occidentale</i> L.	Anacardiaceae	Sand dune stabilizer		LC	VU	EN



5.	<i>Axonopus compressus</i> (Sw.) P.Beauv.	Poaceae	Sand dune grass		NT	VU	VU
6.	<i>Cassia absus</i> L. (Chaksu)	Fabaceae	Sand dune stabilizer		DD	EN	EN
7.	<i>Cassia alata</i> (L.) Roxb.	Fabaceae	Sand dune stabilizer		NT	VU	EN
8.	<i>Casuarinas equisetifolia</i> L.	Casuarinaceae	Sand dune stabilizer		LC	VU	VU
9.	<i>Cleome viscosa</i> L.	Cleomaceae	Sand dune stabilizer		EN	CR	EX
10.	<i>Clerodendrum infortunatum</i> L.	Lamiaceae	Sand dune shrub		NT	VU	EN
11.	<i>Coccinia grandis</i> (L.) Voigt	Cucurbitaceae	Climber plant		LC	NT	NT
12.	<i>Commelina benghalensis</i> L.	Commelinaceae	Sand dune vegetation		LC	CR	CR
13.	<i>Crotalaria pallida</i> Aiton	Fabaceae	Sand dune stabilizer		LC	VU	EN
14.	<i>Croton bonplandianum</i> Baill.	Euphorbiaceae	Sand dune stabilizer		LC	VU	EN
15.	<i>L.</i>	Poaceae	Good sand dune stabilizer		LC	VU	VU
16.	<i>Datura metel</i> L.	Solanaceae	Sand dune shrub		NT	VU	VU
17.	<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	Sand dune vegetation		LC	VU	VU
18.	<i>Eragrostis ciliaris</i> (L.) R.Br.	Poaceae	Sand dune vegetation		LC	VU	VU
19.	<i>Evolvulus nummularius</i> (L.) L.	Convolvulaceae	Good sand dune stabilizer		NT	VU	EN
20.	<i>Ficus racemosa</i> L.	Moraceae	Sand dune vegetation		LC	EN	EX
21.	<i>Glycosmis pentaphylla</i> (Retz.) DC.	Rutaceae	Good sand dune stabilizer		NT	VU	EN
22.	<i>Indigofera dendroides</i> Jacq.	Fabaceae	Good sand dune stabilizer		VU	EN	CR
23.	<i>Ipomoea pes-caprae</i> (L.) R.Br.	Convolvulaceae	Good sand dune stabilizer		EN	CR	EX
24.	<i>Jatropha gossypifolia</i> L.	Euphorbiaceae	Sand dune vegetation		LC	VU	EN
25.	<i>Lantana camara</i> L.	Verbenaceae	Good sand dune stabilizer		VU	VU	EN
26.	<i>Lippia nodiflora</i> (L.) Greene	Verbenaceae	Sand dune vegetation		LC	VU	VU
27.	<i>Martynia annua</i> L.	Martyniaceae	Sand dune vegetation		DD	EN	CR

28.	<i>Melastoma malabathricum</i> L.	Melastomataceae	Sand dune vegetation		NT	VU	EN
29.	<i>Mitracarpus hirtus</i> (L.)DC.	Rubiaceae	Sand dune herb		NT	VU	EN
30.	<i>Mollugo pentaphylla</i> L.	Molluginaceae	Sand dune herb		VU	EN	EN
31.	<i>Ocimum americanum</i> L.	Lamiaceae	Sand dune herb		LC	EN	EN
32.	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	Sand dune herb		LC	VU	EN
33.	<i>Opuntia dillenii</i> (Ker Gawl.) L.D.Benson	Cactaceae	Sand dune herb		DD	VU	VU
34.	<i>Pedaliium murex</i> L.	Pedaliaceae	Sand dune vegetation		DD	VU	VU
35.	<i>Vitex negundo</i> L.	Lamiaceae	Sand dune vegetation		NT	VU	VU

EX = Extinct, EW = Extinct in Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern & Data Deficient = DD

Source: Compilation of Primary, 2018-2020 and Secondary Data [14], [15] and [16]

### 6.3.4 Red Data Book status of risky dune species in the study area:

Table No.-16:-Red Data Book status of selected dune species in the study area

Red List Status of Selected Species	Global Scenario		Regional Scenario		Local Scenario	
	Number of Species	% of Species	Number of Species	% of Species	Number of Species	% of Species
Extinction (EX)	01	2.86	01	2.86	04	11.43
Critically Endangered (CR)	0	0	03	8.57	04	11.43
Endangered (EN)	03	8.57	07	20.00	16	45.71
Vulnerable (VU)	03	8.57	23	65.71	10	28.57
Near Threatened (NT)	10	28.57	01	2.86	01	2.86
Least concern (LC)	14	40.00	0	0	0	0
Data Deficient (DD)	04	11.43	0	0	0	0
Total	35	100.00	35	100.00	35	100.00

Source: Compilation of Primary (Identification method, expertise interviews, target group interviews, perception survey-2018-2020) and Secondary Data (IUCN Red Data Book, South Bengal Medicinal Plant and Medicinal Plant Resources of South West Bengal, Paria, N.D., 2005) [14]

The data prepared from identification method, expertise interviews, target group interviews, perception survey, research based literatures, IUCN Red Data Book verification shows the status of existence of 35-risky sand dune species in the study area. As per analysis (Table-16 and Figure-12), it is seen that where 68.57% of recognized species is under near threatened and least concern status at global scale (as per IUCN Red Data Book), 65.71% and 20% are under vulnerable and endangered status (as per Research literatures on the region) respectively and 11.43%, 11.43%, 45.71% and 28.57% are under extinction, critically endangered, endangered and vulnerable status respectively in the study area (as per field survey). Hence, local scenario of risky dune species is at red alarm due to unscientific, unplanned, haphazard and illegal interferences of inhabitants, enterpreneures and outsiders here.

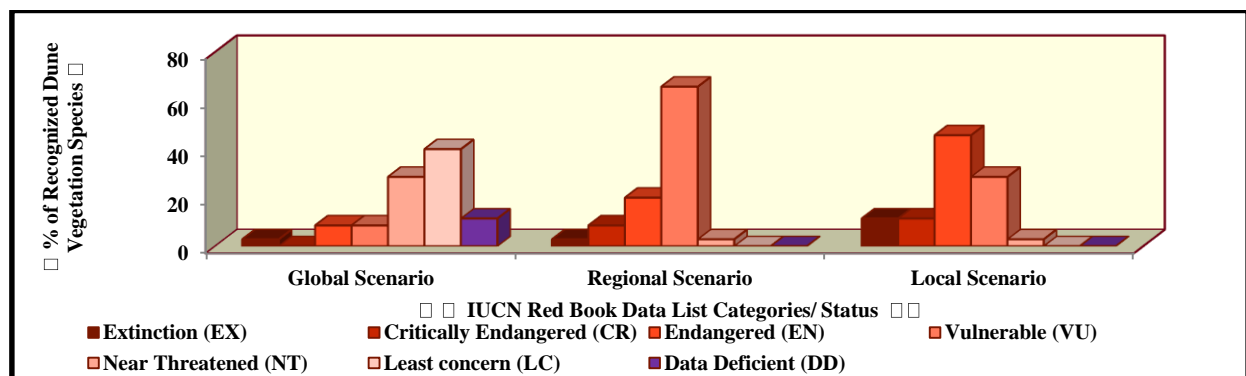


Figure-12: Red Data Book status of recognized endangered dune species in the study area

## 6.4 Management against Eco-morphological Degradation of Dune System in the Study Area:

### 6.4.1 Managerial Efforts from Govt. and NGO's Sites:

In our study area, Mandermoni, for reducing the existed anthropogenic and environmental problems there is not observed more noticeable managerial ways from govt. and non govt. sites. Only for the transport system, there has been implemented one road scheme by Digha-Sankarpur Development Authority (DSDA). Recently to mitigate tourism related accidents and frequent types at this tourist place, there have adopted some administrative plans. There is established a watch tower and a branch of police station at mandermoni coast. Although there are accepted some plans and projects to handle the tourism corruption and accidents, but there is not implemented the CRZ rules and policies to prevent the illegal urban sprawl, tourism development and settlement expansion at the sensitive coastal belt. There are some policies in the bag of govt. as well as administration. But, these are inside the report or book, are not implemented in the reality. There is observed the frequent sounds from the site of some social workers, environmentalist and well wishers of this place. But, those sounds can't touch the heart or core point of govt./ administration and also justice. From day to day, the illegal activities and expansion of tourism infrastructure with huge construction on the soft and sponge like body of this coastal plain have been increasing with the help of the colour of politics and negligence of administration. So it may be said that managerial efforts for this area is not satisfactory level where pollution and degradation of the blue green belt are the banding pictures here.

### 6.4.2 Managerial Gap between Problems, Policy and People:

In our study area, without transport and electricity development and also a small effort to prevent the coastal crime from govt., there is not well observed any good effort to save the environment and its potentiality including coastal sand dune. These are huge gaps among problems, policies, planning, plan makers, protesters and public.

**Table-17: Role of different sites for management of the issue**

Role of Different Sites for Management of the Issue	Perception (%) on the Magnitude of Satisfaction regarding Management						Total
	Over Satisfactory/ Mostly	Satisfactory/ A Lot	Traditional/ Quite a bit	Low/ A little	Very Low/ Not at all	No Remarks	
Role of Govt. & Higher Level Administration	9.12	13.58	18.32	22.35	27.48	9.15	100
Role of Local Administration	4.68	14.64	18.23	37.88	16.78	7.79	100
Role of Local Political Party & Selected Members	11.18	9.85	23.12	26.76	11.43	17.66	100
Role of DSDA	8.75	11.65	24.23	23.56	19.98	11.83	100
Role of NGOs	4.33	7.86	15.56	18.78	32.15	21.32	100
Effort from Individual Level	3.28	4.76	12.22	16.64	27.43	35.67	100

N = 128

Source: Field Study-2018-2020

The data table-17 shows that managerial efforts from different levels are not very good, but from traditional to poor at scale. Roles of Government, administration and public representative are very bad although Coastal Regulation Act, CRZ Policies, Biodiversity Conservation Rules, etc. are remained from the sites of legacy and justice. Developmental efforts have been adopted from the sites of above mentioned characters for the community and regional development of this region. But, nature or natural protection and conservation are not emphasized from the policy and planning which have been implemented already. This perception study reflects the poor status of management for protecting and preserving the sand dune ecology of this area.



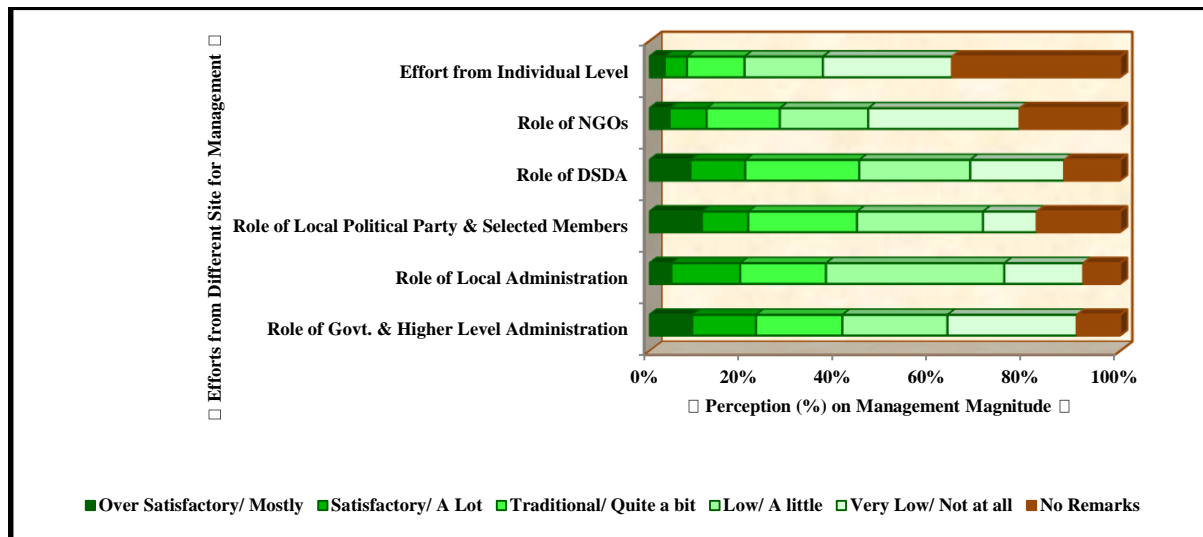


Figure-13: Perception on Management Magnitude for Dune Destruction at the Study Area

#### 6.4.3 Respondent's Proposal to the expected management for dune degradation:

Table No.-18: Respondent's Proposal on the Expected Management for Dune Degradation

Sl. No.	Proposed Managerial Ways as per Respondent's Perception	Number of Respondent	% of Respondent
1.	More active role of Govt. & Administration by rules and regulation	114	89.06
2.	More active role of Biodiversity Board, Dept. of Environment & Forestry, etc.	89	69.53
3.	Strictly restriction on coastal land conversion & land use change maintaining CRZ policy	117	91.41
4.	Strictly restriction on coastal devegetation	107	83.59
5.	Documentation of threatening species & special care on its conservation and protection	83	64.84
6.	Efforts to bring back the species through garden culture & beautification of domestic environment	79	61.72
7.	To make the generation as more knowledgeable about phytoresources & its importance through education and training	92	71.87
8.	Arrangement of workshop, seminar, discussion, awareness programme, etc. on the issue	81	63.28
9.	Root level efforts from domestic to local institutional sectors	79	61.72
10.	Introducing, proper implementing and justifying more projects or schemes relating eco-friendly development in self of environment and ecology	104	81.25
11.	'1' in '10' plantation policy	103	80.47
<b>Total</b>		<b>128</b>	<b>100.0</b>

N=128

Source: Field Study, 2018-2020

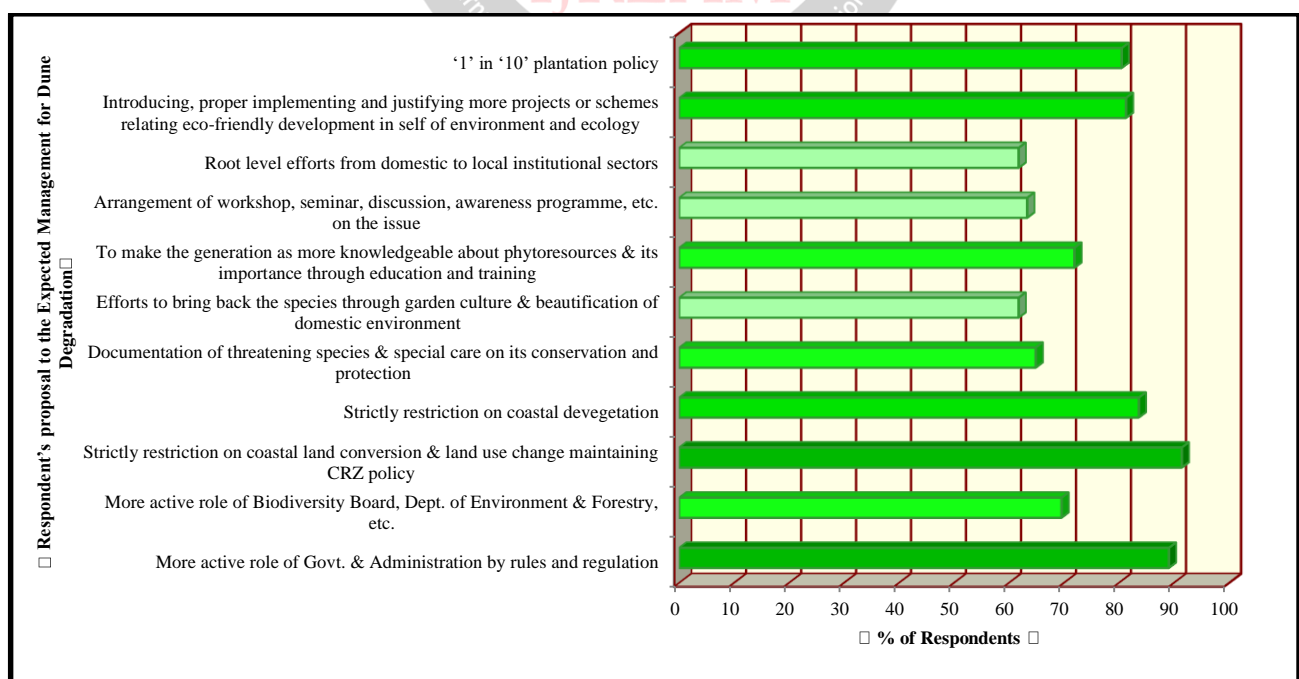


Figure-14: Respondent's Perception on the Expected Management for Dune Degradation

The above data (Table-18 and Figure-14) reflects the managemental ways proposed by the sample respondents in the study areas. This is very interesting that most of the respondents (>50%) have given their proposal for protection and conservation of the medicinal and economic plant species in the study area. About 90% of the respondents are agree for strictly restriction on devegation and about 85 % are fingering towards government and administration for their negligence regarding the issue. About 80% want to maintain '1' in '10' plantation policy for bringing back the species in local environment where each one among ten planted species must be medicinal plant through plantation programme by different characters and sites. According to 73% of the respondents, there should be restricted the land use change and conversion policy strictly. 75% of them emphasize the root level efforts from domestic to local institutional sectors for the management of the issue whereas about 58% and 62% of the respondents opine to arrange the workshop, seminar, discussion, awareness programme, etc. on the issue and to make the generation as more knowledgeable about medicinal plants & its importance through education and training. Efforts to bring back the species through garden culture & beautification of domestic environment may be also the essential managemental way as per perception of about 60% respondents for protecting and conserving the medicinal plant species in the study area.

## VII. RECOMMENDATION

### 7.1 Urgent management practices needed to consider for dune protection:

The sand dune ecosystem should be urgently managed by local groups, local administration, government and other responsible govt. and non-govt. organizations. Although, in more recent times, management of the ecosystem has been brought into a little bit of consideration of the responsible governmental departments; but, it's not sufficient at the minimum scale of management. Hence, there should be needed to take adequate strategies, policies and plans and the following practices should be conducted and implemented as soon as.

- Maintenance of Genetic Diversity (Biodiversity),
- Weighting the Intrinsic Values of the eco-morphology,
- Weighting the Utility Values of the eco-morphology,
- Weighting the Heritage Value of the eco-morphology,
- The need to allow natural change to proceed, etc.

**7.2** On the basis of our micro-regional root level study, we can consider some following recommendations for the comprehensive development and management for the study area:

- taking the rules of CRZ policy seriously to control the free frog movement of tourism construction and settlement expansion in terms of sub-urb process on and along the sensitive CRZs.

- applying the restricted land use policy for this local development.
- taking the proper planning outline for the developmental activities at this coastal belt.
- implementing the scientific way to control and prevent the coastal erosion at this village.
- taking more and more govt. and non-govt. efforts to control and mitigate the coastal pollution and degradation.
- implementing the provided govt. schemes or projects from the eco-developmental point of view.
- providing the proper waste disposal methods, sanitation facilities, lavatory facility, etc. to control the environmental pollution.
- providing the proper education regarding development, environment and ecosystem to make the understanding about mother landscape.
- implementing proper disaster management strategies and policy throughout the time.
- providing the basic infrastructural facilities and services for livelihood development.
- need the positive and constructive rules of politics in case of any developmental and environmental self.
- need the eco-tourism policy to preserve and conserve the local environment and also development to continue the tourism industry at the same rate.

Finally, it may be said that proposals are many, but implementation must be done as one and unique effort from all sites of society and region in the conservation and management of this natural sun-sea-sand green signature and its potentiality.

## VIII. CONCLUSION

Coast line of East Midnapore district is a golden treasury of natural flora. Its natural vegetation carries a distinct character. Sand dunes and sand dune vegetation make its own identification. The sand dune species of costal West Bengal are extremely important resources, which play a vital role in the economic and social life of nearby people. Plant succession on sand dune is tremendous character [14]. Adaptation of various plants is remarkable. Various plants show the xerophytic. Leaf of Casuarinas equisetifolia shows succulent character of xerophytes. Sand dune vegetation is the main protester of storm and flood. Xerophytic plant such as Opuntia dillenii, Spinifex littoreus etc. are found throughout coastal area. But this area is facing a problem due to manmade plastic pollution and destruction of sand dunes. At Mandarmoni the natural vegetation and sand dunes are destroying for hotel business. Conservation and judicious utilization of the costal plant wealth is important

because they have become threatened by over exploitation, clearing of forest for industrialization, rapid urbanization, pisciculture, human settlements, etc. The vegetation cover of old dunes should be protected, as their base sand surfaces are always washed away by river or sea water. These vegetation and dunes are natural protection from natural forces like storm, flood, tsunami etc [15]. As these are destroying, a natural disaster may be occurred. So, immediate steps should be taken by government and local authorities. The different plant species as used by the local costal people throws some light on the economic and medicinal importance of these species. Hence, there is a need for detailed investigations of ethno- botanical knowledge held by the local villagers before such valuable knowledge is lost forever. A rational and sustainable method of utilization can help improving the life of the local people while maintaining ecological balance of costal habitats [11]. There should be needed a deep-heart interdisciplinary study on not only dune ecology, but also over the fragile coastal landscape of this coastal sector including whole of the Bengal coast. Unfortunately, most of the studies relating coastal landscape of our Bengal are implemented for the academic or report based administrative selves. There are a few examples to enlighten that can be treated as the study for the society, development and environment of the green-blue coastal landscape. So, in self of the coastal sustainability, there should be needed to conduct, adopt and also implement the frequent and urgent discussion, meeting, seminars, workshops, training programmes, planning programmes, policy making/ modifying platform, legal justice for coastal sensitiveness and application of EIA method maintaining CRZ Rules and Regulations through the participating, sharing, exchanging and providing the newer ideas, thought, ways, techniques and technologies from different disciplines, sectors, levels and groups of community, society, administration, politics, planners, social workers, environmentalists and other broad thinkers who heartily like and love to do it.

## IX. ACKNOWLEDGEMENTS

Authors would like to acknowledge the contribution of the Post Graduate Department of Geography and Environment Management in Bajkul Milani Mahavidyalaya, PurbaMedinipur, West Bengal for conducting the field study, data collection and its analysis. Authors also like to thanks Digha Sankarpur Development Authority (DSDA) for providing us the valuable information throughout the study. Authors are also very much grateful to three anonymous reviewers for their valuable comments which helped the paper to improve a lot.

**Compliance with ethical standards:** The authors declare no conflicts of interest. The authors also elicit that all ethical standards have been maintained throughout the research.

## REFERENCES

- [1] Bagnold, R. (1954). The Physics of Blown Sand and desert dunes, William Morrow and Co., New York, 265
- [2] Chakraborty, S. K. (2010). Coastal Environment of Midnapore, West Bengal: Potential Threat and Management, Jour. Coast. Env, 1(1), 27-40.  
<http://re.indiaenvironmentportal.org.in/files/coastal%20environment.pdf>
- [3] Corre, J. J. (1991). The Sand Dunes and their vegetation along the Medeterrian coast of France, their likely response to climate change. Landscape Ecology, 6(1&2):65-75
- [4] Das, R. and Dandapath, P. K. (2014). Existence and Experience of PurbaMedinipur Coastal Belt on its Morpho-Dynamic Journey with the Distinctive Geology and Geomorphology, IJSR, Volume 3, Issue 6, pp 1242-1251.  
[https://www.researchgate.net/publication/267776894\\_Existence\\_and\\_Experience\\_of\\_Purba\\_Medinipur\\_Coastal\\_Belt\\_on\\_its\\_MorphoDynamic\\_Journey\\_with\\_the\\_Distinctive\\_Geology\\_and\\_Geomorphology](https://www.researchgate.net/publication/267776894_Existence_and_Experience_of_Purba_Medinipur_Coastal_Belt_on_its_MorphoDynamic_Journey_with_the_Distinctive_Geology_and_Geomorphology)
- [5] Das, R., Das, G. and Pahari, S. (2017). Acute Intervention of Civilized People on the Plant Resources over Midnapore Coast in West Bengal: A Biogeographical Study, International Journal of Research in Economics and Social Sciences (IJRESS) Vol. 7 Issue 5, May- 2017, pp. 193~211, ISSN(o): 2249-7382.  
<http://euroasiapub.org/wp-content/uploads/2017/06/24ESSMay-4926-1.pdf>
- [6] Goldsmith, V. (1978). Coastal dunes. In: Davis, RA (ed), Coastal Sedimentary Environments. Springer Verlag, New York
- [7] Hota, R.N. (2011). Geochemical analysis. CBS Publishers and Distributors, New Delhi. <https://www.amazon.com/Geochemical-Analysis-Hota-R-N/dp/8123919492>
- [8] <http://www.landforms.eu/Lothian/dune%20geomorphology.htm> (2014) <https://issuu.com/ijsrd/docs/ijsrdv4i50252>
- [9] International Research Journal of Earth Sciences (2014). ISSN 2321–2527 Vol. 2(9), 15-21, Int. Res.J. Earth Sci.International Science Congress Association
- [10] King, C.A.M. (1972). Beaches and Coasts, Edward Arnold 2nd edition, London
- [11] Kumar, N. P. and Hota, R. N. (2014). Geomorphological study of Sand Dunes with special reference to their Hydrogeology in Southern Coast of Odisha, India, International Research Journal of Earth Sciences, ISSN 2321-2527, Vol. 2(9), 15-21, October (2014). [https://www.researchgate.net/profile/RabindraHota/publication/281062387\\_Geomorphological\\_study\\_of\\_sand\\_dunes\\_with\\_special\\_reference\\_to\\_their\\_hydrogeology\\_in\\_southern\\_coast\\_of\\_Odisha\\_India/links/55d2ff8b08aec1b0429f1616/Geomorphological-study-of-sand-dunes-with-special-reference-to-their-hydrogeology-in-southern-coast-of-Odisha-India.pdf](https://www.researchgate.net/profile/RabindraHota/publication/281062387_Geomorphological_study_of_sand_dunes_with_special_reference_to_their_hydrogeology_in_southern_coast_of_Odisha_India/links/55d2ff8b08aec1b0429f1616/Geomorphological-study-of-sand-dunes-with-special-reference-to-their-hydrogeology-in-southern-coast-of-Odisha-India.pdf)
- [12] McLachlan I and Brown A. C. (2006). The Ecology of sandy shores, Academic Press, 373
- [13] Paria, N.D. (2005). Medicinal Plant Resources of South West Bengal, Research Wing, Directorate of Forests, Government of West Bengal, in collaboration with Department of Environment, Government of West Bengal.
- [14] Pattanaik, C., Reddy, C. S. and Dhal, N. K. (2008). Phytomedicinal Study of Coastal Sand Dune Species of Orissa, Indian Journal of Traditional Knowledge, Vol. 7(2), pp 263-268.  
[https://www.researchgate.net/publication/258873365\\_Phytomedicinal\\_study\\_of\\_coastal\\_sand\\_dune\\_species\\_of\\_Orissa\\_India](https://www.researchgate.net/publication/258873365_Phytomedicinal_study_of_coastal_sand_dune_species_of_Orissa_India)
- [15] Das R. et al. (2017). Endangered Dune Ecology With Its Risky Phyto-Resources- A Red Alarm To Mandermoni-Tajpur Sector Over Midnapore Coast In West Bengal. Int J Recent Sci Res. 8(6), pp. 17371-17384. <https://recentscientific.com/endangered-dune-ecology-its-risky-phyto-resources-%E2%80%93-red-alarm-mandermoni-tajpur-sector-over-midnapore>