INNOVATIVE ENERGY TECHNOLOGY SYSTEMS AND ENVIRONMENTAL CONCERNS: A SUSTAINABLE APPROACH
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Coastal Development: Neglected Coastal Ecosystems and Increasing Coastal Concerns

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Abstract

Coasts provide one of the most fragile and dynamic coastal ecosystems with a great diversity of flora and fauna, uniquely adapted to tolerate the stressful conditions of coastal environments. Also there is a great scope for economic development through development of various industries and increasing recreational activities. Andhra Pradesh is the second state in India with a longest coastline of 974 km, part of which extending between Visakhapatnam and Kakinada is delineated as AP Petroleum, Chemicals and Petrochemical Investment Region (AP PCPIR), one of the five approved PCPIRs in India. Like any other coastal zone, this stretch is continuously under immense pressure due to natural processes and increasing anthropogenic activities. Construction of artificial structures like seawalls, breakwaters, groynes etc. for the development of port and harbors, laying of pipelines for effluent disposal, seawater intake etc, leads to changes not only in the immediate coastal region undergoing changes but also in the adjacent coastal zones. Coastal ecosystems like mangroves, mudflats, sand dunes located at the extreme edge of coastlines are specially adapted to tolerate the high winds and strong ocean currents and hence, a better solution for the growing coastal concerns especially beach sand erosion. An attempt has been made to study the anthropogenic activities which either directly or indirectly by accelerating the natural processes leads to coastal erosion in the Visakhapatnam- Kakinada Corridor. It also gives an idea to chalk out a better coastal management plan for the protection of a vulnerable coastal zone subjected to drastic changes in the name of development. Whether the sensitive coastal ecosystems and the underprivileged fishing communities occupying the coasts bear any prominence when compared to the developmental activities remains unanswered and attests that environment still remains a meager issue.

1. Introduction

Coast is a unique environment which is endowed with a wide range of habitats like wetlands, mangroves, estuaries, mud flats, sand dunes, coral reefs etc. These coastal habitats are home to some of the endemic and endangered species of flora and fauna. Mangroves are considered to be one of the most productive ecosystems. They maintain ecological balance and provide rich variety of sea foods consumed by humans. They also protect the coast from natural calamities.

Coasts provide scope for development and act as centers of business especially port and port based industries. Due to good employment opportunities, large populations settle and flourish along coasts. Thus coasts accrue economic benefits from coastal fisheries, recreation and industrialization. Coasts have very sensitive ecosystems which can easily be degraded by

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the ruthless developmental activities. The Visakhapatnam- Kakinada coastal corridor is one such coastal zone which is already facing trouble due to natural calamities. The intense coastal erosion problem in the area resulted in the landward movement of the shoreline. Landward movement of shoreline often poses a problem for human activities by threatening roads, buildings and other coastal infrastructure. It may result in changes in coastal habitat also. Sand dunes and salt marshes may shift or even totally disappear. Coastal ecological ‘degradation and pollution have been evidenced in many parts of the world. Based on these, the current study shows the future perspective of the proposed AP PCPIR project.

2. PCPIR

The petroleum, chemicals and petrochemicals sectors in India are well established and have recorded a steady growth over the years. These sectors are major contributors to India’s economic growth and regional development.

Government of India notified the Petroleum, Chemicals and Petrochemical Investment Regions (PCPIR) policy in 2007 to provide a major fillip to the refining, petrochemicals and chemical industries in the country. The Objective of Setting up a PCPIR is to ensure planned development of industrial hubs focused on the petroleum, chemical and petrochemical sectors with an integrated and sustainable approach in order to extract synergies for world class manufacturing, research and development. It is envisaged that the PCPIRs will help in promoting investment in the sector and making India a key hub for both domestic and international markets. A PCPIR would be a specifically delineated investment region with an area of around 250square kilometers planned for the establishment of manufacturing facilities for domestic and export led production of petroleum, chemicals & petrochemicals, along with the associated services and infrastructure. The main features of PCPIR Planned for setting up of manufacturing facilities for domestic and export led production of petroleum, chemicals & petrochemicals, along with the associated services and infrastructure and it may include one or more Special Economic Zones (SEZ), Industrial Parks, Free Trade & Warehousing Zones, Export Oriented Units, or Growth Centers.

2.1 VK-PCPIR/AP PCPIR

VK-PCPIR is one of the six Petroleum Chemical Petrochemical Investment Regions (PCPIRs) Visakhapatnam - Kakinada PCPIR is seen to be a CATALYST, to position Andhra Pradesh as having the LARGEST PETROCHEMICAL HUB of INDIA, VK-PCPIR SDA Area spreads over an area of 640 sq.km encompassing 97 revenue villages across parts of 10 Mandalas of Visakhapatnam and East Godavari.

These Coastal corridors from Vishakhapatnam to Kakinada strategically located to serve global and domestic markets between two industrialized regions named Vishakhapatnam north and Kakinada in south abuts Krishna- Godavari natural gas basin shown in Fig. 1.The project area is well connected by all possible modes of transport including road, rail, air and sea ports. It is on the 'Golden Quadrilateral' with the NH-16 connecting it to Kolkata in the North and Chennai in the South. The Chennai - Howrah main line of Indian railways traverses close to the VK-PCPIR with rail sidings to Visakhapatnam Port, Gangavarm Port, Kakinada Port, NTPC and Visakhapatnam Steel Plant. PCPIR attains a special significance in terms of its proximity to urban centers, including Visakhapatnam, Anakapalle, Yelamanchili, Parawada, Tuni, Pithapuram, Samalkota and Kakinada.

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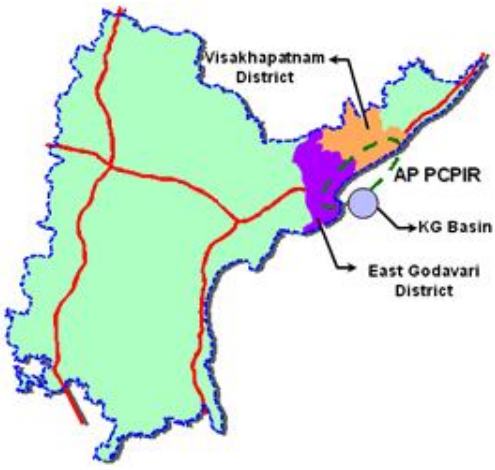

Fig. 1: PCPIR in Andhra Pradesh.

3. Observations

The current study is done on an area extending from Visakhapatnam to Kakinada coastal zone where the AP PCPIR project is proposed. The coast along this stretch possesses coastal vegetation like mangroves, sand dune vegetation etc. small patches of mangroves were found at Visakhapatnam, Pudimadaka and Rambilli. Casaurina plantations were also found along the coast. At the south of Kakinada bay, Coringa mangrove reserve forest is situated which is the second largest mangrove forest in India, next to Sundarbans. Towards north of Kakinada Bay, along the small coastal villages, patches of *Pandanus* species were found growing on the crests of sand dunes. All these coastal ecosystems are under stress due to human activities like port development and expansion, release of industrial and sewage effluents and dredging activities. In order to provide transportation facility and connecting the ends for the proposed PCPIR project a road has been laid. On the landward side of the road continuous patches of *Pandanus* species were observed. Beach along this coast is very narrow and the waves continuously hit the road often damaging it which requires frequent maintenance. Beach erosion problem is found to be severe along the coast both at the north of Kakinada Bay and Visakhapatnam. The coastal communities which are dominated by fishermen are at great risk as the shoreline is moving landward and their houses are washed away by cyclonic storms and sea surges. Protective measures taken so far are not of much help. Such a sensitive and vulnerable coastal zone has been chosen for development in the name of petroleum, chemical and petrochemical investment region.

4. Discussions

Coasts are naturally equipped with barriers which protect the coasts as well as maintain the coastal ecological processes, on the other hand give a scenic beauty which attracts millions of people for recreation. These coastal barriers are the coastal ecosystems like mangroves, mud flats, sand dunes, swamps etc. They possess a great diversity of flora which is adapted to tolerate the stressful conditions in the coastal environments like anoxic conditions, unstable and soft soils, high winds, strong waves and ocean currents especially during cyclones and even tsunami. These occasionally occurring natural disasters may devastate the small coastal villages, damaging their property and leaving the already deprived coastal communities in a much poor state. The coastal ecosystems which are located at the extreme edge of coastlines

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have flora with well modified root system which provides strength and support to the plant to sustain in harsh environmental conditions. With their typical morphological and physiological characteristics, they can reduce the damage inflicted by tsunamis. Their efficiency as coastal shields is determined by various factors like state of vegetation cover (dense, open, no trees), species composition, and signs of cryptic degradation. Hence scientific investigations so far have addressed the role of mangrove forests in tsunami protection. This however is also applicable to the role of mangroves in protection against a wide range of natural issues like cyclones, daily tidal action, waves during full moon and new moon, sea- level rise induced by climate change and heavy rains. This is attested by the fact that the hydraulic resistance of mangroves varies for tidal flows and wind induced waves and hence the protective capacity of mangroves varies according to the time scale of waves. The post – tsunami studies conducted in Sri Lanka strongly suggest the maintenance and restoration of coastal wetlands, forests or sand dunes along vulnerable tropical coastlines. Such a strategy would not only provide protection against major natural disasters but also prevents coastal erosion [3].

Part of the coastline from Visakhapatnam to Kakinada is narrow and vulnerable to beach sand erosion. During visits to this coastal stretch *Pandanus* species was observed on the landward side of the road laid at the beach. *Pandanus* species grow on a wide variety of coastal soils, including sandy and rocky beaches. They are adapted to shallow, saline, sodic, and nutrient poor soils. They also grow well even in waterlogged soils. They have a well developed root system which helps to bind sand and prevent wind erosion. They also function as wind breaks. They have a capacity to regenerate rapidly from seed in fallen fruit segment. Since this species is tolerant to salt spray, sand blasting, exposure to strong winds and regenerate rapidly, they can be part of multispecies biosheild for coastal area protection [4]. The presence of *Pandanus* species in the studied area depicts that a good stretch of this vegetation was cleared for laying the road. If the earlier status of this coastal stretch would have been retained, the severity of coastal erosion may be less and naturally encountered by the existing vegetation.

Coastal ecosystems face a continuous threat due to urban expansion, industrial development, port development and expansion activities, dumping of sewage and industrial effluents, conversion into aquaculture ponds and tourism. Degradation of mangrove ecosystem due to developmental activities has been observed along the Visakhapatnam – Kakinada coastline. Venkanna et al. (1989), Venkateswarulu et al. (1972) and Swain et al. have reported the presence of a small patch of mangroves distributed in an area of 55 ha at Visakhapatnam Port inner harbor [8,9,10]. Subhashini et al. have given a detailed account on various anthropogenic activities like port expansion, industrialization; dumping site for industrial effluents, dredging activities etc which shows a complete disregard for mangroves. On the other hand, The Forest Survey of India has never mentioned about the mangrove cover occurring in Visakhapatnam in any of its reports. In consequence no extensive studies have been carried out in this area and a regular abuse by human activities has reduced its distribution to mere 30 hectares in 2014 [7].

Similarly the Coringa mangrove forests at the Kakinada Bay is also under pressure due to aquaculture practices, clear felling of trees for collection of firewood, and conversion to mud flats. As it is the second largest mangrove forest in India, studies have been conducted to collect information like topography, land use, land cover, density of forests etc by using remote sensing and GIS technology [2]. Much research activity is taking place on these mangroves providing scope for their conservation and restoration.

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Post- tsunami the importance of mangroves has increased and hence strategies for their protection have also come up. But these conservation and restoration measures have been implemented only for mangrove forests spread over vast stretches. Other coastal ecosystems like sand dunes which are very important to prevent beach erosion have not gained much prominence. Though the efficiency of mangroves in protecting the coasts from tsunami has been proved, they cannot protect the entire coastline from such disasters as they can establish themselves under certain specific conditions only which are not available throughout the coast. The satellite data collected regarding the vegetation cover, density, composition etc for the preparation of EIA report does not include these small patches. Alteration or complete destruction of these neglected coastal ecosystems expose the small villages to the regular phenomena of beach erosion, occasional cyclones and sea- level rise making them vulnerable.

Coastal erosion has been one of the major environmental concerns in many parts of the world. Especially sandy beaches are at greater risk. Sandy beaches have loose sand and have no strength to resist wave action. The coast along Visakhapatnam – Kakinada is largely a sandy beach system with sandy barrier system at a few places. Erosion and deposition at the coast is a continuous natural process. The phenomenon of coastal erosion is accelerated due to natural processes and human activities. Climate change, one of the major environmental issues resulting in sea level rise is also expected to increase the rate of coastal erosion. Earlier studies have identified various reasons for coastal erosion in various parts of the current study area. The factors responsible for coastal erosion vary depending on the geomorphological conditions.

Erosion at the northeastern end of the Godavari delta coast at Uppada village is attributed to the growth of 21 km sand spit which prevents the sediment flow along the main coast and utilizes sediment for the growth of spit. Other studies have reported that the sediment supply from Godavari river has reduced drastically due to construction of dams. Reduced accretion of the riverine sediments leads to continuous subsidence, thereby relative sea level rise causing erosion [5]. On the other hand, studies conducted by Vijayam et al. at Visakhapatnam beach revealed the construction of breakwaters at the entrance of the harbour channel has altered the sand movement pattern depositing much of it in the shadow region behind the break waters leading to beach erosion [11]. The above mentioned factors aggravate the issue of coastal erosion caused by the climate change. Hence coastal erosion has become a challenge as it will keep pace with climate change.

To prevent beach erosion caused by either natural or anthropogenic activities, hard and soft engineering techniques are in use. Hard engineering techniques include construction of seawalls, breakwaters, and groynes. Construction of seawalls adversely affects the beaches by excessive deepening in front and erosion on the downdrift side causing larger waves which damage the seawalls. Similar effects have been reported in case of breakwaters also which causes accumulation on the updrift and erosion on the downdrift side [6]. Though there are negative impacts of such physical structures, they have been successful in controlling erosion in many parts of the world. For instance detached breakwaters constructed at the Mediterranean sea have been successful in increasing the width of the beach and controlling erosion [1]. Hence taking into account the geographical conditions appropriate structures should be planned to suite the location. Soft engineering techniques include building up beach with sand and gravel. Though these measures protect the immediate coasts for which they are meant, but pose risk to other coasts which are not protected.

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Visakhapatnam- Kakinada PCPIR positions AP as one of the largest Petrochemical Hub of India. This region is meant for the establishment of manufacturing facilities for domestic and export led production of petroleum, chemicals & petrochemicals, along with the associated services and infrastructure. This project includes Special Economic Zones (SEZ), Industrial Parks, Trade & Warehousing Zones, and Export Oriented Units. This clearly shows that the coastal stretch from Visakhapatnam to Kakinada will face immense pressure due to industrial effluents. Industrial effluents include different types of organic and inorganic chemicals, heavy metals, hydro carbons etc. which may get accumulated in the marine flora and fauna causing threat to the ecological processes and disrupting the entire habitat. Some of the chemicals present in the effluents which appear to be harmless may also react under environmental conditions forming more complex and poisonous chemicals posing threat to the marine life. This is evident in Japan where the industrial effluents including Mercury was left in the Minimata Bay where it turned into methyl mercury and accumulated in the fishes. Consumption of such polluted fish lead to a disease which was named as Minimata disease. Petroleum and Petrochemical based industries release effluents containing hydrocarbons, low molecular weight aromatic compounds, grease, acidic waste water containing hydrogen sulphide, alkaline waste water containing sodium sulphate, sodium hydrogen sulphide from various processes. Apart from this, accidental discharges of petroleum, oil spills and leaks during transportation or exploration are an important cause of pollution along shorelines. Their impact on the delicate marine ecosystems may be devastating. Oil once spilled spreads very rapidly on the surface of water. The wave action in sea accelerates the rate of spread. Oil gets coated on the bodies of marine organisms and kills them. Any attempt made to clean the spilled oil may pose even more threat to the marine life. Such spilled oils washed to the shores spoils the beauty of the beaches and reduces the scope for recreational activities. Coastal vegetation especially mangroves tend to accumulate heavy or trace metals. Elevated concentrations of fluoride, copper, zinc etc in the plant body impairs growth and development of some of these species. This has been observed in the mangrove patch in Visakhapatnam which receive a cocktail of effluents from petroleum and chemical industries. Industrial effluents cause over nourishment of water leading to hypoxia in coastal areas creating dead zones. Many a times massive fish kills are observed. One such instance was observed in Visakhapatnam as well. Dead and contaminated fish is also sold in the market increasing the risk to human health. Excessive industrial development puts great pressure on the fishery resource. The coastal zones where a large population of fishing community resides will lose their traditional occupation and homes and have to relocate which crops up resettlement and rehabilitation problems. So far the government has not been much successful in encountering such issues in case of major dam construction projects. The people residing in these areas have to start their lives afresh in a new place which gives them a setback in the process of development. This gives us a glance of the impact of the proposed PCPIR on the coastal ecosystems.

5. Conclusions

The coast extending from Visakhapatnam to Kakinada is facing severe beach erosion problems. This stretch has small patches of coastal vegetation, much of which has been already destroyed due to construction of road for providing transport facility which is continuously been damaged by the strong wave action. In the current situation, laying of a road at such a location which obstructs the waves is neither economical nor environmentally

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safe. Further in order to reduce the damage caused by strong winds and waves, the extent on land to which the waves move should not be used for any construction purposes. As it is noticed that there is some sandy vegetation which acts as wind breaks and barrier to waves, it is suggested that such vegetation should be maintained to increase the chances of natural regeneration and the degraded areas should be restored. Such a restoration program would be successful rather than using other varieties of trees which are not native to the area. Hence restoration of coasts with coastal vegetation is a cheaper solution and protects the coasts from erosion even in future efficiently.

Hard engineering techniques and soft engineering are highly expensive and not suitable to all types of coasts. Hence these measures if used should be carefully analyzed not to cause any damage to the coastal ecological processes.

The current study suggests that appropriate measures should be taken for coastal zone management giving prominence to the small coastal ecosystems spread along the coast. As both economic and industrial developments are much needed, any developmental activity proposed in this area should be planned in such a manner that it does not alter the environment. Industrial development especially the petroleum and petrochemical based industries along the Visakhapatnam Kakinada coastal zone will have irreversible impact on the coastal environment and the lives of the coastal communities. The resulting marine pollution and ecological destruction can not be ruled out. The VK – PCPIR project is supposed bring a good economical growth but this economical growth must be compared to the environmental costs the project has raised and will rise in future. Thus the developmental activities are forcing some of the very sensitive ecosystems to perish from the earth.

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