The Coastal Protection Measures and Techniques for Shoreline of Visakhapatnam

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Abstract

Globally, most coastlines' rapid erosion is seen as a serious issue. Anthropogenic activities and/or coastal hydrodynamics are the major culprits. Along with difficulties related to pollution, accretion, sedimentation, and climate change, the coastal zone also experiences these issues Climate change will accelerate sea level rise, saltwater incursions, and storm surges. To safeguard homes, infrastructure, and cultivated land, significant effort has been made to mitigate coastal erosion issues and restore coastal capacity. Different kinds of hard structures were used to solve these issues, but the majority of these solutions had limited success since they failed to consider the complete ecological situation. This encouraged the coastal engineers to consider new designs for environmentally friendly constructions that would better fit the surrounding ecosystem. This report reviews global protection measures and categorizes them primarily into four groups: hard, soft, combination, and novel approaches. Each type's use and negative effects are briefly described. It is obvious that using soft engineering, eco-engineering approaches, or a mix of these to improve the ecological condition is the preferred strategy. This article's aim is to suggest practical remedies for this problematic situation in Visakhapatnam by examining reviews and a few global case studies.

Keywords: Breakwaters, Geotextile, Ecological Engineering.

Introduction

The First-largest city in Andhra Pradesh is located within the Seventh-largest district in the state, Visakhapatnam. The district of Visakhapatnam area is around 11,161 SqKm (census 2011) Because Visakhapatnam is a significant port city on India's east coast, numerous tertiary industries are drawn to develop nearby. The heart of Andhra Pradesh's industry and education is located in the district of Visakhapatnam. The Eastern Naval Command is headquartered in Vizag. In addition to Visakhapatnam, Gangavaram Port functions as a gateway for advancing the district's steel, fertilizer, and petroleum industries. It serves as a center for the shipment of iron ore and other minerals to other nations via marine channels. The district was located between the northern latitudes of 17°15′ and 18°32'N and the eastern longitudes of 81°06′ and 83°31'E. The shoreline stretches over 135 kilometers. The Vishakhapatnam area features a headland bay and a few little beaches. The district's economy and that of the state of Andhra Pradesh is heavily dependent on fishing. For the export of seafood and for the fishing sector, the area possesses one of the biggest harbors in the nation. Many of the fishermen in the area rely on fishing for their living. In addition to meeting the requirements of the 1.16 lakh fisherman, the ice manufacturers in and around Fishing Harbor also offer jobs for fishermen

Objectives

1. Identify and analyse coastal protection measures and techniques for mitigating erosion and flooding.
2. Assess the effectiveness of the identified measures and techniques in mitigating erosion and flooding.
3. Develop a comprehensive strategy for implementing effective and sustainable coastal protection measures and techniques.

Coastal protection and measures:

There are several techniques for defending the shoreline and coast from the effects of waves, currents, storm surges, and flooding. There are two sorts of preventative strategies for avoiding coastal erosion: non-structural and structural. Hard structures and soft structures are two sorts of structures. Land use regulations, the introduction of warning lines like the coastal setback line and coastal construction control line to defend the shoreline from illegal development, and the ban on excessive sand extraction and reclamation are examples of nonstructural remedies.

Hard Engineering:

Hard-engineered structures are meant to decrease or prevent coastal erosion and retreat. They succeed at local sizes. Nevertheless, hard-engineered buildings restrict the dispersion of the sand to the coast. Further concerns occur in that hard structures can limit the recreational use of beaches and be costly to develop and maintain. These costs and advantages need to be weighed. There are various sorts of hard structures such;

Seawalls:

A sea wall is a manmade barrier that is created along to the coastline to protect the shoreline and the land that is beyond it. The primary objective of many sea walls is to protect the beach from erosion, but they may also be used to safeguard human settlements and recreational areas from the detrimental influence of waves, tides, and tsunamis.

Large seawall located at Christiansted National Historic Site, Virgin Islands (National Park Service)

Advantages of Seawalls:

- Prevent coastal erosion.
- They may be utilized to create renewable energy.
- Small footprint.
- Very versatile.
- Add value to coastal regions.
- Last an extremely long time.

Disadvantages of Seawalls:

- High cost of construction and upkeep
- Disturbs marine and coastal environments
- Restricts sediment flow.
- They can be overtopped if they are too low.
- Disrupt the natural line of the coast.
- Can hinder accessibility

Revetments:

A revetment is just like a seawall, a coastal parallel structure. The key distinction is that it is more sloped than a seawall. A revetment has a distinct slope, while a seawall is often almost vertical, the surface of a revetment might be either smooth or rough and the height of a revetment does not necessarily fill the total height difference between the beach and the mainland.

Revetment near the ferry dock at Jean Lafitte National Historical Park and Preserve, Louisiana. (National Park Service)

Advantages of Revetments:

- Reduce the force of the wave without generating reflection scour
- Longshore drift not hindered
- Cheap

Disadvantages of Revetments:

- Limited lifespan
- Limited usefulness in storm situations.
- Reduce the recreational value of beach.
- Unsightly
- Ongoing maintenance expenses.

Bulkhead:

Bulkheads are generally erected in the form of a vertical wall made of concrete, stone, steel, or timber. The concrete, steel, or timber walls can be stacked and anchored walls, whilst the concrete and stone walls can also be constructed as gravity walls. The function of a bulkhead is to maintain or prevent the sliding of land at the transition between the land, filled or natural, and the sea. Bulkheads are only appropriate for low-energy sheltered sites where strong waves are not anticipated.

Advantages of Bulkheads:

- Effective Coastal Protection
- Long Lifespan up to 50 years
- Customizable as per site circumstance
- Low Environmental effect when compared to other forms of coastal protection measures such as seawalls.

Disadvantages of Bulkhead:

- Expensive Installation and Maintenance
- Inadequate Effectiveness
- Habitat Degradation
- Reduced Recreational Value

Dikes:

Sea dikes are onshore constructions aiming to safeguard low-lying areas against floods. Sea dikes are normally created as a mound of fine materials like sand and clay with a gradual seaward slope in order to reduce the wave run-up and the erodible impact of the waves. The dike's surface is fortified with grass, asphalt, stones, or slabs of concrete.

The German Island of Pell worm

Advantages of Dikes:

- They frequently constitute the cheapest hard defense when the value of coastal land is minimal, and lessen wave loadings on the structure compared to vertical structures
- Dikes give a high degree of protection against floods in low-lying coastal areas.
- The sloping seaward border of a dike leads to higher wave energy dissipation and decreased wave loadings on the structure compared to vertical structures
- The waves have lost energy; they are less capable to cause harmful impacts like erosion of the beach.

Disadvantages of Dikes:

- Dikes require substantial volumes in order to resist strong water pressures on their seaward faces. They require a lot of expensive building supplies, including sand, clay, and asphalt, during construction because of this.
- Dike building necessitates a sizeable amount of land due to the dikes' enormous footprints caused by the shallow slopes used to promote wave energy dispersion. This can boost dike building costs if coastal land is valuable.
- The considerable space needed for sea dikes is one hurdle to implementation.

Groynes:

Groynes are straight structures perpendicular to the shoreline. They act by stopping the littoral drift; thus, they capture or keep sand on their upstream side. Groynes can have special shapes; they can be emerged, sloped, or buried, and they can be solitary or in clusters, the so-called groyne fields. Types of groynes are wooden groynes, sheet-pile groynes, concrete groynes , and rubble-mound groynes composed of concrete blocks or stones and sand-filled bag groynes.

Wooden groynes on Hornsea beach

Advantages of groynes:

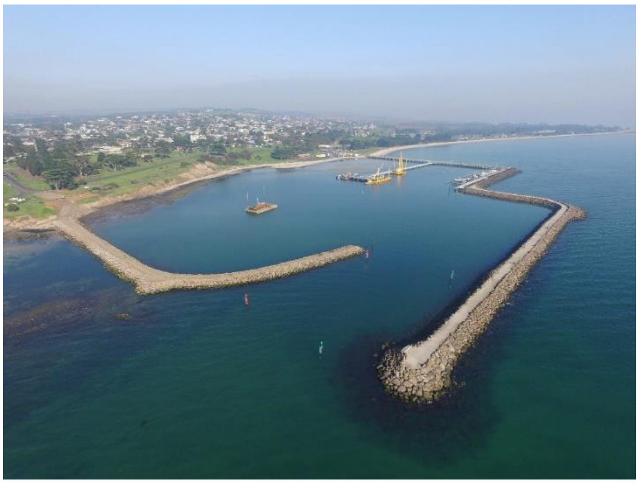
- Building up the beach, providing a bigger beach, providing calm water, and increases tourists.
- Navigation improvements.
- To develop and maintain sandbars.
- Groynes can be employed if there is fear that drainage systems could lead to floods outside of a facility.
- It can also be employed if there is concern that the natural movement of beach sediment may cause debris to build in high-traffic areas.
- It decreases coastal erosion during storms and hurricanes.

Disadvantages of groynes:

- It harms marine species like sea turtles and whales since garbage may build on a groynes structure.
- In places with strong wave energy, re-breakout of beach erosion may occur during the construction of groynes, and extreme weather events such as stroms can cause too much breakage of groynes.
- The downsides are; needs maintenance, acceptable with medium waves, but strong waves still get to the cliff face, and contributes to quicker cliff erosion along the coast by depriving it of potential beach material.
- They are expensive to construct.

Breakwaters:

There are two different kinds of breakwaters; the first is a detached breakwater, which is a straight shore-parallel construction that is frequently built as a wreckage-mound construction having a relatively low peak level that allows for significant overtopping during storms at high tide. The low-crested structures are less conspicuous and help encourage a more even distribution of littoral material throughout the shoreline. Submerged detachable breakwaters are employed in certain circumstances because they do not impair the view, but they do offer a severe unseen threat to boats and swimmers. This decrease of transit leads in entrapment of sand in the lee zone and some distance upstream. The second form is the breakwater that is attached to the coast, i.e., it is extending from the shoreline in the offshore direction. This type of structure issued to protect harbors and navigation channels from wave movement to create a quiet location for ships and may be for swimming.



Port Arlington Harbor

Advantages of breakwaters:

- Although breakwaters aren't in a halt wave that are high due of storms, they will prevent most average waves reaching the coast at their full power.
- They Don't Interfere with Water Flow.
- Even if fast-moving waves or enormous waves can't be totally stopped by the breakwaters that have been erected, they will still provide a natural harbour that is safer than the open water.

Disadvantages of breakwaters:

- They Won't Offer Emergency Protection
- They Can Be Expensive to Build
- They May Present the Long-Term Ecological Hazard

Jetties:

A jetty is any of a range of buildings used in river, dock, and marine works that are often carried out in pairs from river banks, Orin continuation of river channels at their outlets into deepwater. Jetties are used for stabilisation of navigation channels at river mouths and tidal inlets, and are in most cases constructed as rubble-mound structures except that the outer half must be armoured on both sides.

Gulf of Mexico in Sabine Pass, Texas

Advantages of jetties:

- Widen the beach.
- Storm damage mitigation.
- Protects the base of cliffs, land and structures against erosion. They can avoid coastal flooding in particular regions.

Disadvantages of jetties:

• They impede the natural flow of water and sand in an attempt to reduce erosion with related repercussions.

• There will be build-up of sand and silt behind the jetty. This accumulation counteracts the erosion and provides extra sand for the beaches behind the jetty.

Soft Engineering:

Increasing understanding of the negative side-effects of hard constructions on erosion and sedimentation patterns has led to greater appreciation of the benefits of soft protection and the adaptive techniques of retreat and accommodating

Beach Fills and Beach nourishment:

Beach nourishment needs the replenishment of sand to an eroding beach. Sand is imported and scattered to improve beach breadth and height. It is utilized globally as a sort of soft engineering to safeguard coastal development from the hazards of uncontrolled erosion. It serves to sustain the value of coastal investments and keep the value of beach amenities to tourism and recreation. It permits the sand to change continually in response to shifting waves and water levels.

Beach nourishment going on at Hayling Island

Advantages of beach fill:

- reducing the detrimental impacts of coastal erosion by providing additional sediment which satisfies erosional forces,
- Beach replenishment, which is reversible and results in the redistribution of sediment through longshore drift, is a versatile coastal management strategy.
- beach nourishment is likely to positively impact adjacent areas which were not directly nourished.
- Widens the beach.
- Protects structures behind beach.
- Protects against storms.
- Increases land value of surrounding homes.
- Promotes economic growth through tourism and leisure.
- Increases habitat.
- The only practical, ecologically beneficial method of dealing with erosional pressure.
- Encourages plant growth to assist stabilize tidal flats.

Disadvantages of Beach fills:

- The downside; nourishment is not a permanent solution to shoreline erosion, frequent re-nourishments will be needed to sustain a plan, and efficacy.
- Sediment deposition can cause a range of detrimental environmental impacts, including the immediate burial of animals and species live on the shore.
- Storms or a shortage of up-drift sand sources might cause newly added sand to disintegrate.
- Expensive and needs to be applied frequently.
- Access restrictions during meals.
- Exterminate aquatic life.
- Difficulty sourcing adequate materials.

Dredging & Sand Bypassing

Sand bypassing is the hydraulic or mechanical transportation of sand, a from a region of accretion to a down drift area of erosion, past a barrier to natural sand transport such as large-scale harbour or jetty facilities. The hydraulic movement may encompass natural movement as well as movement created by man. Bypassing frequently takes place using two basic mechanisms.

First, pipe may be pumping equipment could be erected that moves sand from the updrift side of the littoral barrier, and dumps it as a slurry of sand and water on the downdrift side. The second approach involves the dredging or extraction of sand from the updrift side, utilising dredges or heavy gear and the placement of this material on the downdrift side by the dredge

Dredging

Advantages of Dredging:

- Dredging can swiftly replace deteriorated beaches and restore the beach profile.
- Dredging can be a low-cost technique to keep navigation channels open and safeguard harbours and ports from sedimentation.
- Dredging can supply a consistent supply of sand for beach nourishment projects.

Disadvantages of Dredging:

- Dredging can disturb marine ecosystems and destroy or harm benthic habitats.
- Dredging has the potential to discharge toxins and pollutants that have collected in sediments.
- Dredging may be costly, especially if the sediments must be moved and disposed of in a separate place.

Advantages of Sand bypassing:

- Sand bypassing can offer a constant supply of sand to rebuild beaches while also preserving the natural sediment transport mechanism.
- Sand bypassing can help to limit erosion and the creation of sandbars and shoals, which can obstruct shipping.
- In regions where natural sediment movement has been disturbed, sand bypassing can be a cost-effective solution to mitigate coastal erosion.

Disadvantages of sand bypassing:

- Sand bypassing needs continual maintenance and monitoring to guarantee optimal system operation.
- Sand bypassing has the potential to disrupt natural sediment transport patterns, affecting downstream beaches and ecosystems.
- Sand bypassing can be expensive to build and operate, especially in regions with wide tidal ranges or strong currents.

Sand dunes stabilization:

Sand dunes are naturally wind-formed sand formations forming a store of sediment in the zone just landward of frequent high tides. Dune/sand stabilisation includes applying structural controls and natural vegetation to stabilise, build, or rebuild dunes. Plants may be exploited to help dune growth by catching and stabilising blowing sand. Dunes offer habitat for highly specialised plants and animals, including unusual and endangered species. They may defend coastlines from erosion and recruit sand to deteriorated beaches. The detrimental consequences of these technologies are practically minimal and their prices are cheap compared with the hard structures. Sand dune stabilisation commonly is employed in tandem with beach nourishment. Sand dune stabilisation has many of the same issues as beach nourishment. Additionally, it inhibits the expansion in the beach region, as the dunes demand vast quantities of land on which to create.

Dune stabilization- North Cronulla Beach

Advantages of Sand dune stabilization:

- Effective in reducing coastal erosion: By preventing wind and water from carrying sand away from the beach, sand dune stabilisation can be an effective technique to lessen coastal erosion.
- Low cost: Sand dune stabilisation is less expensive than other coastal protection techniques such as seawalls and revetments.
- Environmentally friendly: Sand dune stabilisation is an environmentally benign approach of coastal protection because it does not employ concrete or other potentially harmful materials.
- Provides wildlife habitat: Sand dunes may provide home for a wide range of plant and animal species, some of which are endangered.

Disadvantages of Sand dune stabilization:

- Time-consuming: Because vegetation takes time to establish and stabilise the sand, sand dune stabilisation treatments might take years to be successful.
- Storm-prone: Sand dunes are susceptible to storms and high tides, which can cause erosion and damage stabilisation measures.
- Inadequate protection during major weather events: Sand dunes may not provide appropriate protection during extreme weather events such as hurricanes or typhoons.
- Maintenance requirements: To be effective as a coastal protection strategy, sand dunes must be maintained on a continuous basis, including replacing vegetation.

Mangrove forest

Mangrove forests can offer a variety of benefits as a method of coastal protection. There are certain disadvantages to think about, though. Here are some of the benefits and drawbacks of adopting mangrove forests as a coastline protection measure:

Palm Beach County, Florida

Advantages of Mangrove Forest:

- Wave attenuation: Mangrove trees have the ability to attenuate wave energy and safeguard coastal regions from erosion and flooding.
- Soil stabilisation: Mangroves have deep roots that help anchor soil and prevent coastal erosion.
- Biodiversity: Mangrove forests support a wide range of animals, including fish, crabs, and birds.
- Carbon storage: Mangrove trees can store enormous amounts of carbon, aiding in climate change mitigation.
- Local livelihoods: Mangrove forests may supply valuable resources to local populations, including timber, seafood, and medicinal plants.

Disadvantages of Mangrove Forest:

- Inadequate effectiveness: Mangrove forests may be unable to endure powerful storms or high-energy waves.
- Slow growth: Because mangrove forests take a long time to form and flourish, they may be ineffective in the short term.
- Land use conflicts: Mangrove forests may compete with other land uses, such as aquaculture or tourism, and may be converted or degraded.
- Saltwater intrusion: Mangrove forests can have an impact on freshwater resources by limiting input and boosting saltwater intrusion.
- care costs: To maintain its efficacy as a coastal protection strategy, mangrove forests require constant care such as trimming and the removal of dead wood.

Combinations of Options:

Combining hard and soft solutions is often important to increase the effectiveness of the alternatives and produce an environmentally and economically appropriate coastal protection system. Hard solutions are known for:

- produce erosion and superfluous accretion;
- be expensive and frequently further worsen the situation; and
- spoil the visual aspect of the beaches or coasts they intend to protect, thereby diminishing its economic worth, especially for tourism purposes.

Meanwhile, various soft solutions can:

- require time to become effective (not instant or quick-fix remedies), which causes unfavourable public response; and
- be successful solutions only in medium- to long-term perspectives (five to ten years).

A planned retreat where the shoreline is left to erode can be expensive, unneeded and often impossible, especially in highly changed ecosystems such as tourism zones and seaside communities. The most popular strategy involves combining beach nourishment with artificial headlands/groynes, revegetation, temporary offshore breakwaters/artificial reefs that serve as interim hard structures, in order to maximise the long-term positive impact of soft solutions.

Perched Beaches

Is the installation of a low retaining sill to collect sand and to elevate the beach beyond its natural level. Perched beaches feature many of the same attributes as natural beaches, and the submerged sill does not impede on the view of the waterfront. Perched beaches are effective erosion management solutions if a beach is sought and sand loss is too rapid for practical or inexpensive restoration. They can also be utilised to build a new beach for enjoyment and shore protection

Bugibba perched beach, Malta

Advantages of Perched beaches:

- Protection: Because perched beaches are frequently higher up than other beaches, they can provide natural protection from large waves and storm surges.
- Scenic Beauty: Perched beaches can provide spectacular views of the ocean, shoreline, and adjacent places.
- Accessibility: Because perched beaches are frequently higher up, they are more accessible to those with mobility challenges because they do not need a steep slope to the ocean.

Disadvantages of Perched Beaches:

- Limited Space: Because perched beaches are tiny in area, they may not be able to accommodate huge people or offer a variety of leisure activities.
- Erosion: Because perched beaches are higher above sea level, they are more prone to erosion. As a result, they may be more vulnerable to hurricanes, tides, and other natural disasters.
- Minimal Vegetation: Because perched beaches have minimal vegetation, the area's capacity to sustain a varied range of wildlife and plant species is reduced. This may also contribute to increased soil erosion.
- Inaccessibility: Perched beaches may be inaccessible in some situations due to their position or a lack of infrastructure, making them difficult to reach for some guests.

Artificial Headlands

Artificial headlands are rock constructions created along the toe of eroding dunes to safeguard critical spots, allowing natural processes to proceed along the entire frontage, thereby trapping coastal drift and producing a solid embayed beach. This is substantially cheaper than securing a complete frontage and can give temporary or long term protection to individual assets at risk. Temporary headlands can be made of gabions or sand bags, although life expectancy will generally be between 1 and 5 years.

Advantages of Artificial Headlands:

- Erosion protection: By limiting the force of waves hitting the coastline, artificial headlands can serve to protect the shoreline from erosion caused by the sea.
- Habitat creation: Artificial headlands can help marine life and seabirds by creating new habitats.
- Recreation: Artificial headlands can be used for recreational purposes like as fishing or bird viewing.

Disadvantages of Artificial Headlands:

- Cost: Creating artificial headlands can be costly.
- Environmental impact: Artificial headlands can harm the environment by changing natural water flow and damaging maritime ecosystems.
- Maintenance: Artificial headlands require continual maintenance, which may be expensive and time-consuming.

- Unforeseen effects: The creation of artificial headlands may result in unforeseen consequences such as changes in beach morphology or repercussions on surrounding coastal communities.

New techniques for erosion control:

More recent advances have utilised advancements in certain areas of engineering connected with erosion management. Some of these strategies are as follow:

Geotextile structures

Geotextile systems employ a high-strength synthetic cloth as a form for casting big units by filling with sand or cement. Geotextile systems might be bags, beds, tubes, containers, and inclined curtains. All of which may be filled with sand or mortar. Geotextile bags or tubes are already gaining significant recognition in coastal protection. They have been utilised as nearshore breakwaters (placed parallel to shore), as groynes (placed perpendicular to beach) and even as revetments. Nearshore, low geotextile breakwaters are created to a height adequate enough to preclude storm waves from reaching the coast but enable smaller waves to penetrate. In addition, layered sacks are excellent as temporary emergency protective measures. On the other hand, they are confined to low-energy locations, have a very short service life compared to other revetments, and often have an unsightly look. Installing structures of this sort is quick and less costly than hefty constructions. They do not damage the littoral ecosystem too much

Geotextile tube at Harbour, Kaohsiung, Taiwan

Advantages of Geotextile structure:

- Simple installation: Geotextile structures may be simply placed without the need for heavy equipment or specialised expertise, which can save construction costs and accelerate implementation.
- Durability: Geotextile constructions withstand erosion, UV radiation, and other environmental variables. They are also resistant to heavy water pressure and wave action.
- Ecologically friendly: Because geotextile constructions produce no dangerous compounds or pollutants, they are ecologically beneficial.
- Versatility: Geotextile constructions may be employed in a variety of settings, such as shorelines, beaches, and riverbanks.

Disadvantages of Geotextile structure:

- Limited protection: Geotextile constructions are only capable of providing limited protection against extreme weather events such as hurricanes and tsunamis.
- Cost: Geotextile constructions may be expensive to install, as well as expensive to maintain and replace.
- Aesthetic concerns: Geotextile constructions may not be visually pleasing and may not blend in with their surroundings.
- Damage potential: Marine life and detritus can damage geotextile constructions, compromising their performance and necessitating repairs.

Beach drainage system:

The Beach drainage is classified among soft coastal protection technologies, able to preserve sandy beaches from erosion with a minimum impact on the environment. It is composed of one or more drains installed parallel to the coastline, under the emergent beach face, intended at improving seawater penetration into the beach. The pipes are linked with blind pipes with a well, from whence the water is pumped out and then delivered back to the sea or to another destination. The method produces a water table lowering and, subsequently, an increase in the thickness of the unsaturated zone. The relatively low water table improves up-rush fluxes infiltration, permitting sediment deposition on the beach face and reducing sea-ward sediment transfer. Yet, drainage performance in recovering eroding beaches is not well characterized. For this reason, it may be viewed as an auxiliary system for defensive works management, such as beach nourishment in order to enhance its lifetime.

Advantages of a beach drainage system:

- low environmental effect of the operating system compared with nutrition or existing hard engineering solutions,
- provide a buffer zone from storm events and seasonal erosion and improved recovery time to pre-storm equilibrium following storm events,
- protect of coastal fresh water environments from sea over-topping and seepage contamination,
- better 'natural character' outcomes than hard engineering or nourishment

Disadvantages of beach drainage system:

- Confined to particular types of beaches. Also, silt under the shoreline must be thick and porous (between 0.1 and 0.5 mm) to allow pipes to be laid and avoid clogging. Furthermore, a very modest slope is recommended from 1/10 to 1/50).
- Moreover, draining weakens one erosion process and does not address the sedimentary shortage problem; so it is better suited to bay head beaches (that make up a sedimentary compartment themselves

Eco-Engineering:

Ecological engineering mixes engineering concepts with ecological and geomorphologic processes to develop new ecosystems or repair systems that have undergone degradation or been destroyed. For example, improving fore dune vegetation enhances sand accretion rates and dune elevation, which provide a bigger barrier against rising waves. Ecological engineering can be employed alongside the other adaption option. Pre-existing hard-engineered adaption choices can be modified with design characteristics, such as holes and caverns that offer habitat. Ecosystem engineering employs pioneer species to re-engineer the environment or develop a habitat suited to attract additional species establishing an ecosystem. For example, dune vegetation is often employed in the restoration of coastal dune systems as it stabilises sandy beaches and absorbs windblown sand building dunes. Pioneer species can restart successional processes and prepare the new habitat for succeeding colonists. For example, dune plants prevent wind and wave erosion and shield less tolerant plants from salt spray and storm damage.

Bio-technical ideas:

The notion of bio-technical is centred on developing coastal restoration goods. Bio-technical structures are soft measures that both replicate natural coastal structures and assist the growth of marine plants. For instance, artificial seagrass systems, when securely connected to the bottom, have a key role in boosting fish habitats and lowering the velocity of the water current. Similar to artificial sea grass habitats, Artificial mangrove roots is another intriguing form of bio-technical construction. Based on the natural properties of the mangroves and their role as an efficient wave breaker, manmade structures give protection to the coastal developments in an event of storm surges, and also preserve young mangrove seedlings from being swept away due to wave action.

Artificial Sea grass

Many efforts at constructing artificial seaweed mats in the nearshore zone in an effort to minimise wave energy through the mechanism of frictional drag were accessed. The most effective testing have been in locations with extremely low wave conditions, low tide range and rather steady tidal current flows, where some sedimentation was discovered to take place. On open coast sites there have been considerable challenges with the installation of the devices and the synthetic seaweed fronds have showed very limited endurance even under minor wave attack. The synthetic seaweed has tended to flatten under wave movement, hence having negligible influence upon waves reaching the coast. Field testing in the United Kingdom have proved unsuccessful and the studies were abandoned in all cases, due to the material being pulled away from the anchoring points. As it functions as a drag barrier against frequently powerful currents, much of the effectiveness of artificial grass systems are based on solid anchoring to the sea bed. Concrete block bases are widely utilised as the anchoring method (Ismail 2005). There are various experimental research undertaken to examine the influence of sea grass on the wave dumping and velocities.

Advantages of Artificial Seagrass:

- Low care: Artificial Sea grass takes very little care, unlike actual sea grass, which requires regular pruning, fertiliser, and other types of upkeep.
- Durable: Artificial Sea grass is more durable and long-lasting than genuine sea grass. It is not subject to damage from storms, erosion, or other environmental causes.
- Cost-effective: Artificial Sea grass is more cost-effective in the long term since it does not require frequent maintenance or replacement.
- Environmentally friendly: Artificial Sea grass may be created from recyclable materials, which lessens the environmental effect of harvesting genuine sea grass.
- Versatile: Artificial Sea grass may be utilised in a number of situations, including aquariums, swimming pools, and landscaping projects.

Disadvantages of Artificial Seagrass:

- Lack of Biodiversity: Artificial Sea grass does not support the same amount of biodiversity as real sea grass. It does not provide a home for marine life, and it does not contribute to the food chain in the same manner that natural sea grass does.
- Aesthetics: While fake sea grass can be created to seem like natural sea grass, it does not have the same visual appeal as the genuine thing.
- Limited Functionality: Artificial Sea grass does not have the same ecological roles as genuine sea grass. It does not contribute to water quality, sediment stability, or coastline protection in the same manner that native sea grass does.
- care: While artificial sea grass requires less care than actual sea grass, it still requires some upkeep. It may need to be cleaned occasionally to eliminate dirt and avoid algae development.
- Environmental Impact: The manufacture and disposal of artificial sea grass might have an environmental impact. The materials used to produce it may emit hazardous compounds into the environment, and it may not be biodegradable, resulting to long-term environmental damage.

Artificial reefs

Artificial reefs limit the wave energy discharged on the beaches behind them; it can be set on offshore or shoreline. They slow down the long-shore drift and encourage foreshore vegetation, thereby minimising erosion. They respond in the same way as submerged breakwaters, and are commonly formed up of coils or bags of geotextile, although alternative materials that may be utilised include sand, big stones, concrete or pit run material. Low crested and submerged constructions like detached breakwaters and artificial reefs are becoming highly typical coastal defence methods employed alone or in conjunction with artificial sand replenishing. The main objective is to lower the hydraulic loading to a specified level allowing for a dynamic balance of the coastline. To attain this purpose, they are constructed to allow the passage of a particular amount of wave energy across the structure in terms of overtopping and transmission through the porous structure (emerging breakwaters) or wave breaking and energy dissipation on shallow crest (submerged structures). Due to aesthetical criteria low, freeboards are generally selected (freeboard around SWL or below). However, in tidal environment and frequent storm surges they become less effective when constructed as a narrow crested buildings. That is also the reason that broad-crested underwater breakwaters (called sometimes, artificial reefs) became popular, notably in Japan. However, broadcrested buildings are substantially more expensive and them

use should be supported by a good cost-benefit study. On the other hand the development of alternative materials and technologies, for example, the use of sand-filled geo-tubes as a core of such structures, can cut significantly the cost. The relatively recent novel coastal strategy is to deploy artificial reef structures termed Reef Balls as submerged breakwaters, offering both wave attenuation for shoreline erosion mitigation, and artificial reef structures for habitat improvement. Reef Balls are mound-shaped concrete artificial reef modules that simulate genuine coral heads. The modules feature holes of several different sizes in them to provide habitat for many sorts of aquatic creatures. They are built to be simple to construct and deploy and are unusual in that they can be floated to their drop point behind any boat by employing an internal, inflatable bladder. Stability requirements for these units were defined based on analytical and experimental tests.

Advantages:

- Habitat creation: Artificial reefs provide a home for a variety of marine animals, including fish, shellfish, and corals, that would not otherwise be available.
- Fisheries enhancement: Artificial reefs can boost fish populations, improving recreational and commercial fishing possibilities.
- Dive opportunities: Artificial reefs can attract scuba divers and snorkelers, boosting local tourism.
- Erosion control: By functioning as breakwaters and minimising the impact of waves on shorelines, artificial reefs can assist prevent erosion.

Disadvantages:

- Environmental impact: The construction of artificial reefs can disrupt the natural environment by displacing existing marine life and introducing invasive species.
- Cost: The creation and upkeep of artificial reefs can be costly, making them unaffordable for some communities.
- Maintenance requirements: Artificial reefs require routine maintenance to guarantee structural integrity and to keep them from becoming navigational hazards.
- Limited lifetime: Artificial reefs have a limited lifespan and can disintegrate over time, posing environmental risks such as harmful material discharge.

To summarise, artificial reefs can help marine life and the surrounding community, but they can also have negative consequences that must be addressed before they are built. Careful planning, monitoring, and maintenance can reduce the negative consequences of artificial reefs while maximising their advantages.

Artificial mangroves:

Mangrove systems limit the force of waves and hence prevent the shoreline from erosion. The decrease of waves rises with the density of vegetation and the depth of water. This has been proved in Vietnam. It is demonstrated the tall mangrove forests; the rate of wave reduction per 100 m is as great as 20 %. Another experiment has demonstrated that mangroves create 'live seawalls', and are extremely cost effective as compared to the concrete seawall and other structures for the prevention of coastal erosion. Another purpose of these kind is to capture sediment and therefore functioning as sinks for the suspended sediments. The mangrove trees serve as land expanders by capturing silt through their extensive aerial root systems. Experimentally, the impact of strength, form and configuration (or arrangement) of a 'engineered' mangrove root-system is now being examined by local researchers to understand how they interact with waves. Numerically, explored the dispersion effects of wave propagation across mangrove models in shallow water situations. displays the natural and artificial mangrove. Though the limitations based on morphological, hydrodynamic and water quality conditions, to real combination between traditional engineering and ecological engineering is revealed, the inclusion of ecological engineering in coastal protection is shown to be a promising approach to integrate multiple functions in areas where demands for space are becoming more urgent every day. Full-scale field operations are probably the only method to assess the success of eco-based strategies. However, when coastal projects are executed, tried and proved approaches are often favoured over novel innovations until adequate proof of performance at pilot locations has been confirmed. Without significant scale field studies, bio-technical systems may be constrained to be employed as supplemental protection strategies.

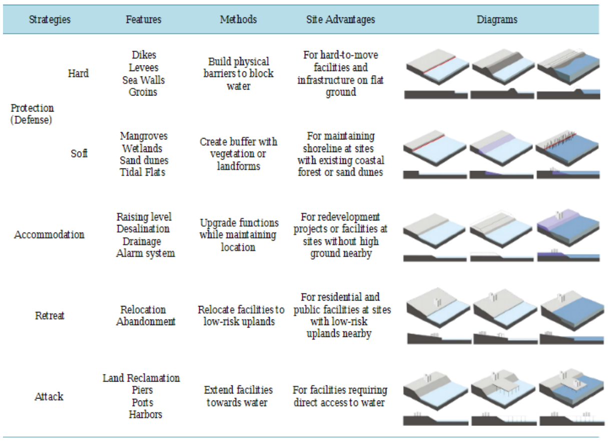
Advantages of Artificial mangrove:

- Provides a cost-effective alternative to natural mangrove restoration in regions where natural mangroves cannot survive owing to environmental conditions such as salinity, tidal fluctuations, and soil characteristics.
- Can be constructed to fit individual site circumstances, enabling for customisation to address specific demands such as erosion control or coastline protection.
- Provides habitat for fish and other aquatic species, helping to sustain local biodiversity.
- Can help alleviate the consequences of climate change by sequestering carbon dioxide and minimising the repercussions of storm surges and sea level rise.
- May be more robust to natural calamities such as hurricanes and typhoons compared to natural mangrove forests.

Disadvantages of Artificial mangroves:

- May not provide the same amount of ecological functions as natural mangrove forests, such as water filtering and nutrient cycling.
- The long-term viability and usefulness of artificial mangroves are questionable and may require regular care and replacement.
- May not be able to support the same amount of richness as natural mangrove forests owing to the absence of some species that rely on natural mangrove environments.
- May not have the same cultural and social value as natural mangrove forests, which can be essential for indigenous people and local inhabitants.

- May have unforeseen ecological repercussions, such as changes to water flow and sedimentation patterns, which can damage neighbouring ecosystems.



Strategies		Features	Methods	Site Advantages	Diagrams
Protection (Defense)	Hard	Dikes Levees Sea Walls Groins	Build physical barriers to block water	For hard-to-move facilities and infrastructure on flat ground	
	Soft	Mangroves Wetlands Sand dunes Tidal Flats	Create buffer with vegetation or landforms	For maintaining shoreline at sites with existing coastal forest or sand dunes	
Accommodation		Raising level Desalination Drainage Alarm system	Upgrade functions while maintaining location	For redevelopment projects or facilities at sites without high ground nearby	
Retreat		Relocation Abandonment	Relocate facilities to low-risk uplands	For residential and public facilities at sites with low-risk uplands nearby	
Attack		Land Reclamation Piers Ports Harbors	Extend facilities towards water	For facilities requiring direct access to water	

Potential adaptation responses

In order to address the potential risks of climate change to existing assets and people, some form of protection is required for coastal environments, such as cities, ports, deltas, and agriculture areas. Although there is a strong "commitment to sea level rise and a commitment to adaptation," adaptation is still required since climate changes and their impacts are now unavoidable, especially for coastal communities. Coastal protection to sea-level rise is often a costly, but a straightforward way to Despite having relatively limited ability for adaptation, research on the global and regional scale have shown that developing country adaptation to climate change is a crucial and urgent need. However, limitations both in human capacity and financial resources make adaptation difficult for the poorer nations such as Tanzania for example. The following are examples of general adaption strategies:

1. (Planned) Retreat - By relocating away from the coast via suitable development management, land use planning, set-back zones, etc., the effects of sea-level rise are permitted to occur and human consequences are minimised. Managed retreat has been used as an alternative to building and maintaining hard-engineered structures in a number of nations, including Australia and the United Kingdom. However, to date, it has primarily been used in areas such as agricultural land, where the minimum economic impact is expected.

2. Accommodation - Human use of the coastal zone is adjusted to the hazard via early warning as well as evacuation systems, expanding risk-based danger insurance, increasing flood resilience (e.g., raising houses on pilings), etc.

3. **Protection** – 3. Protection - the effects of sea-level rise are reduced by hard or soft engineering measures, such as the construction of dikes, which lessen human consequences in the coastal zone that would otherwise be felt. However, even in the richest and most sophisticated nations, like The Netherlands, there is always a residual risk, making perfect protection impossible. The choice and use of these adaptation strategies with the objective of protecting the human use of the coastal zone would generally depend on the nature characteristics of the coastal zone and the type and extent of impacts. For example, unlike the first option (protection), the two adaptation solutions (accommodation and retreat) lessen or completely eliminate the issue of "coastal squeeze," which is caused by permanent coastal defences and increasing sea levels and prevents coastal ecosystems from migrating inland. However, soft protection measures (such as beach/shore nourishment and sediment re-cycling) can minimize this problem. It is also important to identify the benefits of applying adaptation strategies for example dikes can be combined with building codes/flood-wise buildings and flood warning and evacuation systems,

and quite different adaptation strategies might be applied in a city versus a rural area. Responsibility for local shoreline management alternatives may rest with a specific property owner or the entire community. In addition, there are three major constraints on what an individual can do in terms of coastal management. These constraints include: Local and state rules and regulations including building standards that pertain to land use and development in shoreline areas.

Case Studies:

Coastal protection measures around the globe differ widely depending on the location, the type of shoreline, and the degree of development of the region as a whole. In general, coastal towns that are more developed and affluent likely to have greater and sophisticated coastal protection measures in place. Below are some examples of coastal protection measures across the world:

Japan

Japan is a country that is very prone to natural calamities, including typhoons, tsunamis, and earthquakes. As a result, there are numerous coastal protection measures that have been adopted to defend against these catastrophes. Here are some of the existing coastal protection measures in Japan:

1. **Seawalls:** Japan has erected extensive seawalls along its coastline to defend against tsunamis and storm surges. These seawalls are frequently composed of reinforced concrete and are meant to be high enough to avoid floods.
2. **Breakwaters:** Breakwaters are offshore constructions that are meant to protect coastal regions from waves and currents. Japan has erected several breakwaters along its coast to safeguard ports and other coastal infrastructure.
3. **Mangrove forests:** Mangrove forests are thick, salt-tolerant woods that occur along tropical and subtropical coastlines. Japan has planted extensive mangrove forests along its shore to defend against erosion and storm surges.
4. **Beach nutrition:** Beach nourishment is the practise of adding sand to deteriorating beaches to improve their width and height. Japan has utilised this technology to preserve beaches from erosion and to construct bigger beaches that can absorb the force of waves and storms.
5. **Tsunami evacuation structures:** Japan has erected several tsunami evacuation shelters in coastal locations. These structures are built to resist tsunamis and provide a safe spot for people to refuge during a crisis.
6. **Coastal vegetation:** Planting vegetation such as trees and bushes on coastal regions can assist to lessen the impact of wind and waves on the coastline, and also prevent erosion. Japan has launched many schemes to stimulate the planting of coastal plants.

Overall, Japan has undertaken a range of measures to safeguard its coastline from natural catastrophes and continues to study and develop new technologies to improve coastal protection.

Positives:

1. **Minimised damage:** Coastal protection measures have minimized the damage caused by natural disasters in Japan. For example, the development of seawalls has lessened the impact of tsunamis and storm surges on coastal towns.
2. **Enhanced safety:** These measures have boosted the safety of individuals living in coastal regions by safeguarding them from the effects of natural catastrophes.
3. **Improved economic stability:** Coastal protection measures have averted or decreased the damage to infrastructure and companies located in coastal areas, therefore ensuring economic stability in these regions.

4. **Increase in tourism:** Some coastal protection measures have been developed to improve the attractiveness of coastal regions, such as the creation of breakwaters or artificial reefs. This has drawn tourists to these locations, therefore strengthening the local economy.

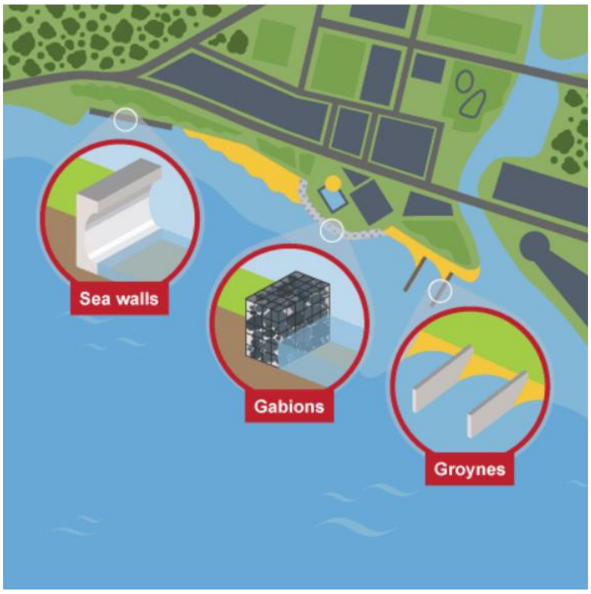
Negatives:

1. **Environmental impact:** Some coastal protection methods, such as seawalls and breakwaters, can have negative environmental implications. They can change the normal coastal processes and affect the environment, leading to habitat loss and diminished biodiversity.
2. **High cost:** Coastal protection systems can be expensive to develop and maintain. This can impose a burden on public resources, and may also result in greater taxes or fees for inhabitants and companies located in the protected regions.
3. **Unattractive appearance:** Some coastal protection measures, such as seawalls, can be unattractive and can significantly impair the visual attractiveness of the shoreline. This may dissuade tourists and result in diminished economic activity in certain places.
4. **False feeling of security:** Coastal protection measures may provide a false sense of security among those living in coastal areas. This can lead to complacency and a lack of readiness for natural disasters, which can be deadly.

Newcastle, Co Down

Newcastle is a modest sea side resort village in County Down, Northern Ireland. It is known for its pristine coastline, forests and mountains.

The tourist resort of Newcastle, Co Down has long been under attack from the sea and has regularly caused inundation along the main street.



Newcastle's coastal management techniques

Groynes: The beach was continuously being eroded away and the debris was being transferred down the shore, therefore the municipality took action to preserve it. There were constructed several wooden groynes.

Positives

- Easy to construct into the coastline.
- Relatively affordable.
- Helps to capture the sand as it is transported along the shore by longshore drift.

Negatives

- As the groynes serve to build up a beach in one location, there will be another place along the coastline that is now not receiving any sand.
- Every 10 to 15 years, wooden groynes need to be replaced and require continual upkeep.
- Some people do not like the appearance of the groynes and people who like to walk along the shoreline don’t like having to climb up over these barriers.

Gabions: Many gabions were installed along the coast to halt the erosion of the sand dunes and the shore in front of it. Some of the gabions survived for 10 years but many had to be replaced on an annual basis.

Positives

- Gabions are just metal enclosures that are filled with pebbles and are very inexpensive.
- As the waves hit the stacked rock cages, the energy of the waves is absorbed by the spaces between the boulders. This implies that there is no longer any energy available to drive erosion.
- Can be used very rapidly to create a temporary or a more permanent solution.

Negatives

- The rock enclosures can often fracture due to the energy caused by winter storms. They need to be restored and replaced frequently.
- The enclosures are unappealing. Pollution and debris can build up which provides a breeding ground for rodents.

Seawall: In 2007 a new Newcastle promenade development was completed that elevated the sea wall by 1m and provided a new curved wall that would continue to safeguard the seafront landscape.

Positives

- Protects the land and when constructed high enough will also prevent coastal inundation.
- The sea wall's curvature will guarantee that wave energy is reflected back into the water.
- Sea barriers can also help mould the landscape and provide walkways and urban architecture

Negatives

- The enhancements in 2007 cost over £4 million for a relatively brief section of wall.
- They require deep foundations, which means extensive building will be required. This could disturb animals' natural habitats.
- As they reflect the wave energy back, this can cause coastal erosion either further along the coast or back in the sea where the waves inevitably land.
- Frequently need to be replaced every 25 years.

Swakopmund:

Swakopmund is a city on the coast of western Namibia,

The Swakopmund Jetty:

Jetties are frequently visited by tourists. Typically, they offer secure access to coastal regions. The iron Swakopmund jetty in Namibia, an African nation, was built in 1905 to prevent the harbour from accumulating too much silt or sediment. This jetty was refurbished in 2006 and is well-liked by tourists due to the view of Namibia's coastline it provides. Here are some benefits and negatives of the Swakopmund Jetty:

Positives:

1. **Historical significance:** The Swakopmund Jetty has a rich history and is a significant landmark in Namibia, making it a popular tourist destination.
2. **Scenic views:** The jetty offers amazing views of the ocean and the town, making it a perfect site to shoot photographs or simply enjoy the scenery.

3. **Fishing:** The jetty is a popular fishing place for residents and tourists alike, with a diversity of fish species present in the vicinity.
4. **Activities:** Visitors may enjoy activities such as fishing, sightseeing, and photography.

Negatives:

1. **Safety concerns:** The jetty may be dangerous, particularly during severe weather conditions, and there have been incidences of individuals being washed off the jetty and drowning.
2. **Repair issues:** The jetty is ancient and requires regular repair to ensure it stays safe for guests. However, there have been allegations of poor maintenance and repairs.
3. **Congested:** The jetty may get congested during peak tourist season, which might make it difficult to enjoy the area completely.
4. **Limited access:** The jetty is only accessible at specific periods of the day, as it is cut off during high tide. This might be problematic for guests who wish to experience the region at their own time.

Philippines:

Being an archipelago, the Philippines is susceptible to coastal risks such as storm surges, coastal erosion, and sea level rise. The Philippine government and a number of organizations have put different coastline protection measures into place to counter these dangers.

Mangrove restoration:

In order to create natural barriers against storm surges and erosion at the coast, mangrove regeneration involves establishing and rebuilding forests of mangroves along the coast.

Positives:

- Mangroves offer storm and erosion protection naturally.
- Additionally, they promote marine biodiversity and give coastal residents options for a living.

Negatives:

- Reforestation of mangroves may be costly and time-consuming.
- Mangrove forest commercial development and illegal logging are still issues.

Beach Nourishment:

Beach nourishment is the process of widening and strengthening deteriorating coastlines by introducing sand or sediment.

Positives:

- A quick and rather inexpensive approach of protecting the coast is beach nourishment.
- It may enhance a beach's beauty, drawing visitors and boosting the local economy.

Negatives:

- Large storm surges and sea level rise can make beach nourishment ineffective.
- Additionally, it may harm marine ecosystems by suffocating coral reefs.

Seawalls:
Building a seawall along the shore will stop erosion and stop waves from damaging the land.
Positives:
- Effective defence against storm surges and coastal erosion may be found in seawalls.
- Additionally, they are reasonably priced in comparison to other technical solutions.

Negatives:
- On nearby coasts, seawalls may contribute to beach erosion.
- Additionally, they could damage marine ecosystems and destroy habitat.

Artificial reefs:
Making artificial reefs will encourage the development of coral and marine life.
Positives:
- Coastlines can be shielded from storm surges and waves by artificial reefs.
- They also assist fisheries and advance biodiversity by providing habitat for marine species.

Negatives:
- Artificial reef installation and upkeep can be costly.
- They could be susceptible to harm from both natural disasters and human activity.

Each coastal protection method has both benefits and drawbacks overall. The best strategy is frequently a mix of these actions, each suited to the unique coastal circumstances. Additionally, local communities may contribute to the sustainability and efficacy of coastal preservation initiatives.
Alabama:
Living breakwaters are coastal constructions intended to lessen the effects of waves and coastline erosion. The traditional construction of these structures consists of a number of substantial rocks or concrete blocks that are positioned offshore to form a barrier that breaks up oncoming waves, lessening their force and defending the beach behind them.

A particular variety of living breakwater, known as an Alabama living breakwater, is frequently utilised in the Gulf of Mexico, notably along the Alabama coast. These breakwaters are made to resemble natural reefs and act as a refuge for marine life, which may help the ecology and the local economy in its own right.
Positives:
- Erosion control: Living breakwaters assist in lessening the effects of waves and erosion on shorelines, safeguarding nearby infrastructure and property.

- home creation: By creating a home for marine life, living breakwaters can aid in boosting biodiversity and the expansion of fish populations, both of which are advantageous to the environment and the local fishing sector.
- Recreation: Living breakwaters can serve as a location for outdoor pursuits including diving, snorkelling, and fishing, which can boost the regional tourist sector.

Negatives:

- Cost: Building living breakwaters may be costly, and they need to be maintained constantly to be functional.
- Natural currents disruption: Living breakwaters have the potential to alter water flow and currents, which may have unforeseen effects on the environment.
- Potential effects on surrounding beaches: In certain situations, living breakwaters can modify the way sediment is transported and result in changes to the area's beaches, which can be harmful to the community's ecological and economic.

Overall, living breakwaters in Alabama may be very beneficial for habitat formation, erosion control, and enjoyment, but they must be properly planned and maintained to reduce any possible harm to the ecology and neighboring populations.

Egypt:

Seawalls

Examples of how this construction has been used in the past to safeguard the Egyptian shore include the ancient Burg El Burullus seawall, the old Mohamed Ali seawall in Abu Quir Bay, and the old barrier west of the Damietta Nile estuary. Mohamed Ali seawall is the oldest seawall in the country which was constructed to protect the low-lying industrial district of Alexandria (some of it up to 3 m below sea level). However, prior to its alterations to slope the face, which alleviated the situation, substantial erosion was found in front of this wall.

Revetments

East and west of the Rosetta Estuary, on the eastern shore of Burg El Burullus, and east of the Damietta Nile Estuary, as well as for the safety of the sea route west of Port-Said are all common locations in Egypt for this type of building. When there are no needed beach in front of them, these buildings are employed instead to speed up the rate of erosion in front of them in order to move the erosion issue to the downdrift regions.

Breakwaters

Egypt's northwestern coast, where Marabella and the 6th of October resort community are located, and the delta coast, where Baltim, Damietta, and El Gamil are located, also utilise this kind extensively. The second kind is a breakwater that extends from the coast in an offshore direction while still being connected to the shoreline. This type of structure is used to protect harbours and navigation channels from wave action to create a calm area for ships and may before swimming. In Egypt, this type is used in SidiKerair port, SidiKerair coastal resort, and Edku LNG harbor. All of these structures cause sedimentation and erosion problems in the updraft and downdrift zones respectively.

Groins

The middle of Marina El-Alamien, El Mandara Beach, both east and west of Rosetta Protection Works, the east Baltim Sea Resort, and the western as well as eastern sides of El Arish Port are some locations along the Egyptian coast where this structure has been used. Typical shoreline changes are seen around these locations.

Jetties

On both sides of the manmade lagoon inlets of the El Alamien marina centre, the Maadia outflow, the Burullus lake outlet, the Damietta Nile estuary, and the El-Bardawil Lake outlets, they have been extensively utilized in Egypt. These jetties have substantial degradation on their eastern edges and sand accumulation on their western side. It is obvious that the conventional coastal constructions employed along Egypt's coastlines have an adverse impact on the natural environment and are viewed as a burden on the national economy. Hard defenses are often ineffective since they transfer the issue from one side to the other and impede the natural process in Egypt.

Seawall and groynes at Rosetta Promontroy as an exampleCase study on coastal protection measures (Mediterranean region, Egypt)

Example of seawall, and groins at Rosetta promontory

Soft protection measures

Sand Fills

Between 1986 and 1995, six successful sand replenishment operations were carried out along the Alexandria coast. Many of those beaches are still in good condition.

Using sand bypass or dredging

The Edku LNG harbour and navigation canal, Rosetta estuary outlet, Damietta harbour navigation canal, and El Manzala lake outflows are some of the locations along the Egyptian coast where dredging work are being carried out. Regardless of the harsh approach, the soft strategy may be the most effective one.

Visakhapatnam coastal protection measures

Existing coastal measures:

Erosion in Visakhapatnam beach was triggered due to the construction of outer harbour breakwaters. The 30 km long coastal route from Visakhapatnam to Bheemunipatnam, is under the threat of erosion. About four decades ago, the ocean lashed the beach road and rocks were thrown along the shore as an emergency measure to stop the rising seawater and to defend the beach. The largest erosion was noticed along the beach near the Submarine Museum and at the area opposite INS Kalinga, near Bheemunipatnam. It is recently reported that comparable extreme erosion is taking place at identical spot at Visakhapatnam.

The Visakhapatnam coastline area has developed numerous coastal protection measures to preserve against natural catastrophes and human activity. Some of the present coastline protection measures in Visakhapatnam are:

- **Beach nourishment** includes adding sand to the beach to rebuild degraded shorelines and avoid coastal erosion. The Visakhapatnam Beach nourishment project was launched in 2017 and has been effective in safeguarding the shoreline.
- **Mangrove conservation:** Mangroves are crucial coastal ecosystems that provide natural protection from tidal surges, hurricanes, and tsunamis. The Visakhapatnam district government has developed various mangrove conservation programmes to conserve and enhance these crucial ecosystems.
- **Seawall construction**: Seawalls are barriers created along the shoreline to guard against wave erosion and storm surges. The Visakhapatnam Port Trust has constructed a seawall along the northern part of the city's coastline to protect against high tidal waves.
- **Stormwater drainage systems:** Proper stormwater drainage systems can help prevent flooding and reduce the risk of damage caused by natural disasters. The Visakhapatnam Municipal Corporation has implemented several drainage systems to mitigate the impact of floods and heavy rainfall.
- **Coastal regulatory zone (CRZ) laws:** The Indian government has enacted CRZ rules that restrict coastal development activities in the nation. The Visakhapatnam district government implements these policies to manage and monitor the region's urbanisation and tourism activities.
- **Tsunami warning systems:** The Indian National Centre for Ocean Information Services has erected various tsunami warning systems along the Visakhapatnam coast to offer early warning and evacuation in the event of a tsunami.

These coastal protection techniques have helped defend the Visakhapatnam coastal area against natural calamities and anthropogenic activity. However, there is a need for constant monitoring and enhancement of these strategies to maximise their efficacy and sustainability.

Google Maps show breakwaters and jetties along the Visakhapatnam district coastline.

Ongoing Projects on Visakhapatnam Coastline:

Planting coconut trees:

Greater Visakhapatnam Municipal Corporation (GVMC) is planting 200 15-year-old coconut palms at the Sagarnagar beach's offshore sandy region as part of the Andhra Pradesh government's efforts to promote tourism.

"The move, taken up with combined efforts of Sunray resorts and GVMC, is meant to beautify and also to give shade for guests that visit the beach throughout the summer. planted in the sand had developed to a fair size after the planting push by GVMC. Which was truly a tourists attraction spot at the beach. Apart from the aesthetics the coconut trees also give shade to the passers-by, coming here for a morning walk, and to the visitors that visit the beach during the day time.

Dredging and beach nourishment:

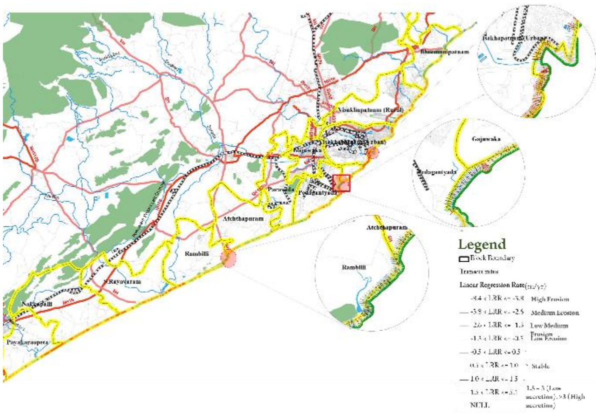
The Dredging Corporation of India Limited has been given the yearly Maintenance Dredging contract by the Visakhapatnam Port Authority (VPA). The project will cost approximately 57.0 CR INR for three years and will include dredging at the New Sand Trap (NST), its methods, and other areas of the VPA. It will also include pumping the material that was dredged to the shore for beach nourishment.

The Visakhapatnam dredging and nourishment of beaches work has officially started under the supervision of Dredging Corporation of India (DCI). The operation entails dredging the equivalent of 0.2 million cubic metres of sands over the course of 30 days and dumping it on nearby beaches.

The Rama Krishna Beach has been regularly replenished by the Visakhapatnam Port Authority with sand from the sand trap at the outer port in an effort to halt erosion.

Due to littoral drift, the wind blows in northward for 8 to 9 months out of the year, with waves coming in from the southwest. Because of the northeast monsoon waves, there is a southern littoral drift lasting three to four months. When man-made structures obstruct the free-sand flow, this variation in littoral drift causes beach instability..

Rate of change of shoreline of Visakhapatnam district:



- By the analysis done by using the Digital Shoreline Analysis System, we can understand the high rate of erosion can be seen at Payakaraopeta, Nakkapalli, Rambilli, Visakhapatnam urban, Bheemuipatnam.
- High amount of erosion can be in Visakhapatnam urban.

Suitable Coastal Protection measures of Visakhapatnam:

The coast of Visakhapatnam is prone to natural calamities including as cyclones, storm surges, and erosion. To safeguard the coastline from these threats, numerous coastal protection strategies and procedures can be applied. Some of the relevant coastal protection methods and strategies for the coast of Visakhapatnam are:

Beach nourishment: Beach nourishment is the process of adding silt to a beach to expand its breadth and height. This approach may be used to restore deteriorated beaches along the coast of Visakhapatnam. By adding sand to the beach, the waves will have less influence on the shoreline, minimizing erosion. In Visakhapatnam, beach nourishment is going on only in municipal areas. As the erosion can be seen in most of the places like Payakaroapeta, Nakkapalli, and Rambilli etc, beach nourishment should be done along these places as well.

Dune restoration: Dunes are natural barriers that protect the shoreline from storms and erosion. Dune restoration comprises the planting of plants and the placement of sand fences to assist restore and enhance natural dunes. This approach may be used to rebuild eroded dunes along the coast of Visakhapatnam.

Breakwaters: Breakwaters are offshore structures designed to lessen the force of oncoming waves, safeguarding the shoreline from wave action and erosion. Breakwaters can be used to defend harbors, marinas, and other coastal facilities along the coast of Visakhapatnam.

Combined techniques: breakwaters can be turned into artificial reefs which helps to break the waves and also develop marine life. The jetties which are present along the coast can develop as the best tourist spots. Include ecological engineering techniques with every structure which replenishes marine life.

Geotextile: Maximum 70% of area is in medium erosion and low erosion state. So, geotextile structures can be used along with other protective measures

Mangrove plantation: Mangroves are a form of vegetation that thrives in intertidal zones and estuaries. They are great natural barriers against storm surges, tidal waves and coastal erosion. Mangroves might be planted along the coast of Visakhapatnam to safeguard sensitive regions from coastal risks.

Artificial mangroves: India has also been using artificial mangroves to protect its coastlines. The country has planted over 50,000 hectares of artificial mangroves along its coastlines to reduce the impact of coastal erosion and storm surges. It could be adopted in Visakhapatnam district as well.

These are some of the acceptable coastal protection methods and strategies that may be used along the coast of Visakhapatnam to safeguard the shoreline from natural catastrophes and promote sustainable coastal development.

Challenges: The execution of coastal protection measures is not without problems. One of the biggest issues is the high cost of building and maintenance of hard barriers such as seawalls and dams. In addition, the development of large structures can potentially have severe repercussions on the environment and the nearby community. Soft interventions like as beach nourishment and dune restoration can also be tough to undertake, especially in places with limited sand supplies.

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