**GEO 404B.2: Coastal Issues and Management**

**1. Coral Bleaching: Impact of Global Warming, Coastal eutrophication and habitat conservation (Coastal lagoons, other coastal wetlands)**

**2. Coastal tourism and environment conflicts (Beaches and barrier coasts, mangrove dominated coasts, coral coasts, environmental regulations)**

**3. Application of Remote Sensing and GIS techniques in coastal management (Geomorphological mapping, coastal cell circulation systems, environmental zoning approach, identification and diversity of coastal habitats)**

**4. Managing coastal change: Assessment of coastal vulnerability, ecosystem valuation of coast, integrated coastal zone management, coastal regulations); Coastal engineering: Developments in hard structure designs, developments in soft structure designs, new dredging techniques and procedures.**

**5. Coastal urbanization and population pressures, Coastal resource management.**

**GEO 404B.2: Coastal Issues and Management**

**1. Coral Bleaching: Impact of Global Warming**

Coral bleaching, whitening of coral that results from the loss of a coral’s symbiotic algae (zooxanthellae) or the degradation of the algae’s photosynthetic pigment. Bleaching is associated with the devastation of coral reefs, which are home to approximately 25 percent of all marine species.

 When corals are stressed by changes in conditions such as temperature, light, or nutrients, they expel the symbiotic algae living in their tissues, causing them to turn completely white. Warmer water temperatures can result in coral bleaching. When water is too warm, corals will expel the algae (*zooxanthellae*) living in their tissues causing the coral to turn completely white. This is called coral bleaching. When a coral bleaches, it is not dead. Corals can survive a bleaching event, but they are under more stress and are subject to mortality.

Coral bleaching has a variety of causes. It may result from increases in seawater temperature, particularly when associated with elevated levels of solar irradiance (e.g., ultraviolet radiation), or it may be caused by changes in seawater chemistry (e.g., due to ocean acidification or pollution), increased levels of sediment in seawater, or a coral’s exposure to sodium cyanide (a chemical used in the capture of coral reef fish). Under such conditions the zooxanthellae may lose substantial amounts of their photosynthetic pigmentation, which decreases rates of photosynthesis and produces bleaching. In addition, studies have found that the chemicals in sunscreens and other personal care products can accumulate in areas with significant marine tourism and recreational use by humans and can promote viral infections in hard corals that lead to bleaching. Exposure to increased temperatures and solar irradiance also causes zooxanthellae to manufacture abnormally large quantities of reactive oxygen species (molecules that contain oxygen and at least one unpaired electron), which are toxic to both the algae and their coral symbionts. These changes ultimately cause a breakdown of the symbiotic relationship, characterized by the physical separation of the zooxanthellae from their coral hosts. If zooxanthellae do not recolonize the coral within a few months of leaving, their absence can result in the death of individual corals as well as the coral colony to which they belong. Given that both ocean acidification and increasing ocean temperatures are associated with global warming, anthropogenic climate change is a major existential threat to coral reefs worldwide.

Because coral colonies serve as the foundations of coral reef ecosystems, their decline may translate into a loss of habitat for numerous plant and animal species that depend on them. Without living space and food sources, populations of reef-dependent fishes and other forms of marine life can drop precipitously. There is concern that widespread coral bleaching may cause some species to become extinct locally. In such cases, the affected coral ecosystems may not be able to recover fully from the disturbance, because critical parts of the ecosystem would no longer be present. Degraded coral ecosystems are also vulnerable to invasive species, such as seaweed and other types of algae, which have the potential to bring about significant and long-lasting structural changes to affected reefs.

*Coral reefs and climate change*

Increased greenhouse gases from human activities result in climate change and ocean acidification. Climate change = ocean change. The world's ocean is a massive sink that absorbs carbon dioxide (CO2). Although this has slowed global warming, it is also changing ocean chemistry.

* Coral reefs harbour the highest biodiversity of any ecosystem globally and directly support over 500 million people worldwide, mostly in poor countries.
* They are among the most threatened ecosystems on Earth, largely due to unprecedented global warming and climate changes, combined with growing local pressures.
* Over the last three years, reefs around the world have suffered from mass coral bleaching events as a result of the increase in global surface temperature caused by anthropogenic greenhouse gas emissions.
* According to UNESCO, the coral reefs in all 29 reef-containing World Heritage sites would cease to exist by the end of this century if we continue to emit greenhouse gases under a business-as-usual scenario.
* Limiting global average temperature to well below 2°C above pre-industrial levels in line with the Paris Agreement provides the only chance for the survival of coral reefs globally.

*Climate change dramatically affects coral reef ecosystems*

Contributing factors that increase greenhouse gases in the atmosphere include burning fossil fuels for heat and energy, producing some industrial products, raising livestock, fertilizing crops, and deforestation. Climate change leads to:

* A warming ocean: causes thermal stress that contributes to coral bleaching and infectious disease.
* Sea level rise: may lead to increases in sedimentation for reefs located near land-based sources of sediment. Sedimentation runoff can lead to the smothering of coral.
* Changes in storm patterns: leads to stronger and more frequent storms that can cause the destruction of coral reefs.
* Changes in precipitation: increased runoff of freshwater, sediment, and land-based pollutants contribute to algal blooms and cause murky water conditions that reduce light.
* Altered ocean currents: leads to changes in connectivity and temperature regimes that contribute to lack of food for corals and hampers dispersal of coral larvae.
* Ocean acidification (a result of increased CO2): causes a reduction in pH levels which decreases coral growth and structural integrity.

**Coastal eutrophication and habitat conservation (Coastal lagoons, other coastal wetlands)**

Harmful algal blooms, dead zones, and fish kills are the results of a process called eutrophication—which begins with the increased load of nutrients to estuaries and coastal waters.

Eutrophication is a big word that describes a big problem in the nation's estuaries. Harmful algal blooms, dead zones, and fish kills are the results of a process called eutrophication—which begins with the increased load of nutrients to estuaries and coastal waters.

Sixty-five percent of the estuaries and coastal waters in the contiguous U.S. that have been studied by researchers are moderately to severely degraded by excessive nutrient inputs. Excessive nutrients lead to algal blooms and low-oxygen (hypoxic) waters that can kill fish and seagrass and reduce essential fish habitats. Many of these estuaries also support bivalve mollusk populations (e.g., oysters, clams, scallops), which naturally reduce nutrients through their filter-feeding activities.

The primary culprits in eutrophication appear to be excess nitrogen and phosphorus—from sources including fertilizer runoff and septic system effluent to atmospheric fallout from burning fossil fuels—which enter waterbodies and fuel the overgrowth of algae, which, in turn, reduces water quality and degrades estuarine and coastal ecosystems.

Eutrophication can also produce carbon dioxide, which lowers the PH of seawater (ocean acidification). This slows the growth of fish and shellfish, may prevent shell formation in bivalve mollusks, and reduces the catch of commercial and recreational fisheries, leading to smaller harvests and more expensive seafood.

In recent years, NOAA's National Centers for Coastal Ocean Science (NCCOS), in collaboration with NOAA's Northeast Fisheries Science Center, has enlisted estuaries' indigenous residents, namely, bivalve mollusks, to help slow and, in some cases, reverse the process of eutrophication, since they efficiently remove nutrients from the water as they feed on phytoplankton and detritus.

A groundbreaking modeling project in Long Island Sound showed that the oyster aquaculture industry in Connecticut provides $8.5 – $23 million annually in nutrient reduction benefits. The project also showed that reasonable expansion of oyster aquaculture could provide as much nutrient reduction as the comparable investment of $470 million in traditional nutrient-reduction measures, such as wastewater treatment improvements and agricultural best management practices.

The NOAA scientists used aquaculture modeling tools to demonstrate that shellfish aquaculture compares favorably to existing nutrient management strategies in terms of efficiency of nutrient removal and implementation cost. Documenting the water quality benefits provided by shellfish aquaculture has increased both communities' and regulators' acceptance of shellfish farming, not only in Connecticut but across the nation. In Chesapeake Bay, for example, nutrient removal policies include the harvesting of oyster tissue as an approved method, and in Mashpee Bay, Massachusetts, cultivation and harvest of oysters and clams are parts of the official nutrient management plan.

*Effects of Eutrophication*

The different processes and possible effects of coastal eutrophication on the marine ecosystem are well documented.

* Toxic algal blooms
* Reduced depth distribution of submerged aquatic vegetation
* Increased growth of nuisance macroalgae
* Increased sedimentation
* Increased oxygen consumption
* Oxygen depletion in lower water layers
* Sometimes dead benthic animals and fish.

Eutrophication causes structural changes throughout the marine ecosystem and reduces ecosystem resilience. Eutrophication issues are often divided into three groups:

* Causative factors: inputs, elevated nutrient concentrations, Redfield ratio changes
* Direct effects on primary producers - phytoplankton and submerged aquatic vegetation
* Indirect effects (secondary effects) related to zooplankton, fish and ínvertebrate benthic fauna (animals living on and in the seabed).

The following responses to increased nutrient inputs are observed in the Baltic Sea:

Increased phytoplankton primary production, which increases biomass, which decreases light penetration through the water column. Reduced light penetration reduces the depth at which macroalgae and seagrasses can grow.

Increased nutrient inputs generally entail a change in ratio between dissolved nitrogen and phosphorus in the water, the DIN:DIP ratio. Optimal is 16:1 – called the Redfield ratio. A significantly lower ratio can cause nitrogen limitation, whereas a higher ratio can lead to phosphorus limitation of phytoplankton primary production. Species that are less sensitive for their growth to the optimal DIN:DIP ratio outcompete more sensitive species.

A gradual change of (pelagic ecosystems) towards:

* Increased planktonic primary production compared to benthic production
* Dominance of microbial food webs over linear planktonic food chains
* Dominance of non-siliceous phytoplankton species over diatom species
* Dominance of gelatinous zooplankton (jellyfish) over crustacean zooplankton

**Habitat conservation**

Habitat conservation for wild species is one of the most important issues facing the environment today — both in the ocean and on land. As human populations increase, land use increases, and wild species have smaller spaces to call home. More than half of Earth’s terrestrial surface has been altered due to human activity, resulting in drastic deforestation, erosion and loss of topsoil, biodiversity loss, and extinction. Species cannot survive outside of their natural habitat without human intervention, such as the habitats found in a zoo or aquarium, for example. Preserving habitats is essential to preserving biodiversity. Migratory species are particularly vulnerable to habitat destruction because they tend to inhabit more than one natural habitat. This creates the need to not only preserve the two habitats for migratory species, but also their migratory route. Altering a natural habitat even slightly can result in a domino effect that harms the entire ecosystem.

Habitat destruction is a huge problem in the marine environment. Habitats are destroyed by:

* Destructive fishing activity: bottom trawling and dynamiting coral reefs destroy entire ecosystems.
* Coastal development: habitats are destroyed when marshes are dredged for real estate development. Soil runoff and erosion result in excess nutrients from fertilizers and domestic sewage, which then leads to harmful algae blooms that block sunlight and deplete the water of oxygen. It also causes silt to build-up on coral reefs, which blocks sunlight necessary for coral to grow.
* Pollution: development near coastal waters contaminates the Ocean with toxic substances, such as industrial chemicals, pesticides, and motor oil.
* Dredging ship channels: Removes accumulated sediment and pollutants, re-suspending them into the water. Dredging can also destroy sea grass beds and other habitats that provide food, shelter, and breeding grounds. The dredged material must be disposed of, and is often dumped into salt marshes, damaging very productive marine habitats in the process.

*Solutions*

* Marine Protected Areas (MPAs): marine sites such as sanctuaries, fisheries management areas, state conservation areas, and wildlife refuges established to protect habitats, endangered species, and to restore the health of marine ecosystems in areas jeopardized by habitat and species loss. Examples: NOAA National Marine Sanctuaries: USA
* Marine Reserves: marine sites that provide a higher degree of ecosystem protection by prohibiting fishing, mineral extraction, and other habitat-altering activities. Marine Reserves are far more effective than MPAs, but unfortunately, they are not as common. Example: Marine Reserves in New Zealand
* Land use and development regulation: An integrated approach to land use and management based on scientific knowledge is needed to protect coastal areas. Policy makers need to be informed on the impact coastal development is having on marine habitats through accessible and evidence-based information.
* Monitoring and reporting: some conservation efforts are empowering the citizens with the responsibility for monitoring water quality in their coastal communities through sampling and testing, photographing fouled areas, and providing information to local policy makers for action.
* Zoning: related to integrated land use and development management, zoning coastal areas into MPAs, Marine Reserves, approved fishing areas, with varying levels of use has the potential to slow some of the habitat degradation caused by development. The Great Barrier Reef is managed in this way. Through cooperation among local, state, and national governments, this approach may provide a viable solution to all stakeholders from tourists, to the fishing industry, to conservation efforts, etc.

Although habitat destruction has been increasing for many years, the protection of marine habitats has only recently become an issue of critical importance to conservation efforts, local and national governments, and international marine conservation groups. The Ocean’s invulnerability to human activity is now being realized as a myth. Coastal regions are still experiencing intense pressure by exploding coastal populations; however, there are solutions at hand to prevent further damage from occurring.

**Coastal lagoons**

Coastal lagoons are estuarine basins where freshwater inflows are trapped behind coastal dune systems, sand spits, or barrier islands which impede exchange with the ocean. They are most frequent in regions where freshwater inflows to the coast are small or seasonal, so that exchange with the ocean may not occur for months or years at a time. Many occupy shallow drowned valleys formed when the sea level was lower during the last ice age and subsequently flooded by postglacial sea level rise. The tidal range is usually small. Accordingly, coastal lagoons are frequently found in warm temperate, dry subtropical, or Mediterranean regions along moderately sheltered coasts. Lagoons are infrequent in wetter temperate and tropical regions where freshwater inflows are sufficient to scour out river mouths and keep them open. Here estuaries are dominated by salt marshes in temperate and mangroves in tropical climes. A particularly good example is the series of coastal habitats on the southern and eastern coastline of Australia which change from open temperate estuaries and salt marshes in the wetter southern regions of Tasmania, through a series of coastal lagoons of varying sizes and ecologies along the south and east coasts, to open subtropical and tropical estuaries, reefs, and mangroves in the warmer and wetter north. A similar, although inverted, sequence can be seen running south along the east coasts of Canada, and the northeastern, central, and southeastern coasts of the USA. The resulting lagoons have varying water residence times, depending on volume, climate, freshwater inflow volumes, and the tidal prism.

*Biodiversity of coastal lagoons*

Coastal lagoons support a rich specific biodiversity, so we can find different groups of organisms, like plants, animals or microbes. They act as spawning grounds for marine fish and invertebrates, and behave as resting areas for many species of migratory birds.

Macrophytes can grow almost everywhere in the basin, due to its shallowness and the transparency of the water, except in more unstable or seasonally dry areas. Only nutrients determine the vegetation growth and the turbidity of the water by phytoplankton in cases of overconcentration. Lagoon vegetation constitutes a particular habitat for many species, especially birds and invertebrates, and is the substrate on which periphytic communities develop. They provide refuge, food and substrate for aquatic organisms. Moreover, macrophytes create a micro climate with softened temperatures during the hot summer, produce oxygen and retain the upper horizon of the sediment helping to control the turbidity. In coastal lagoons the helophytes usually cover a more or less wide stretch in the shallowest areas, acting as a buffer zone for impacts on the open water. Submerged macrophytes can reduce eutrophication by stabilizing clear water states or outcompeting phytoplankton for nutrients and light. But they can have a negative contribution to the productivity in most shallow lakes, because they influence water exchange with the offshore area, reducing water movement and increasing sedimentation rates.

The microbial community is composed of common heterotrophic taxa of natural waters, the presence of coliforms in habitats suffering from human impact being of special interest. The bacterial community is basic in the energy flows, because it decomposes and remineralizates organic matter. The hydrology of the lagoon (freshwater or marine inputs) greatly influences the bacterial composition. Changes in the ecosystem functioning can change the composition of the bacterial assemblages as an answer to the stress factor.

Phytoplankton in coastal lagoons is rich and diverse, and as primary producers are important parts of the food web in freshwater environments. Phytoplankton is usually composed of diatoms, dinoflagellates, chlorophytes, cryptophytes and other microflagellates. In the coastal lagoons it is often responsible for the eutrophication phenomenon, with dominance of phytoplankton over other groups of organisms.

Zooplankton consists of heterotrophs that live suspended in the water column, and includes protists (flagellates and ciliates) and micro animals, mainly rotifers and microcrustaceans (cladocerans, copepods and ostracods). Overall, the plankton is consumed by fish, macroinvertebrates and some waterfowl, especially in brackish systems.

Benthos comprise the set of mobile or sessile aquatic organisms living in or on the substrate. They are very important in the recycling of the organic matter, facilitating the activity of the bacterial decomposers. With regard to photosynthetic organisms, besides being part of the plankton communities of microalgae (phytoplankton), many microscopic primary producers can grow attached to solid substrates, on rocks (epilithon), on the sediment (episammon) or on the vegetation (periphyton).

Zoobenthos are macroinvertebrates that live on the bottom (benthos)of water bodies, and on some macrophytes. In addition to the larvae of numerous species of insects (especially flies, dragonflies, beetles and bugs), zoobenthos includes flatworms, annelids, molluscs and crustaceans. In lentic ecosystems, zoobenthos is very important compared with the pelagic communities of animals, particularly in shallow systems and coastal areas. Surface area, water salinity, and outlet width and length, can actually be considered the key limiting, dimensions defining the environmental niche space for benthic macroinvertebrates in lagoon ecosystems.

Fish are the main organisms of nekton, i. e. all the organisms that actively swim in the water. In coastal lagoons, the presence of fish is common and is related to the salinity of the system and its opening to the sea. Lentic ecosystems are an ideal habitat for waterfowl and amphibians. Nowadays amphibians are in decline worldwide, partly due to the decline of aquatic ecosystems where they live, largely coastal lagoons. On the other hand, waterfowl are important consumers in lagoons, but can also be sources of nutrients with a negative effect on eutrophication. Besides birds, amphibians and fishes, other vertebrates such as certain species of reptiles and mammals are typical of these ecosystems, although the diversity of these animals is more limited and only a few species are related to coastal lagoons.

*Hazards and conservation management*

Modification of extensive natural areas by human action, such as desiccation, urbanization, hydrologic modification and isolation of areas previously connected, has led to a reduction or disappearance of large areas of wetlands and coastal lagoons. Increasing of tourism pressure and the use of these ecosystems for different human activities such as aquaculture or fisheries has induced internal perturbations such as pollution or removal of indigenous species.

In coastal lagoons, species distribution is affected by heterogeneity of the environmental variable, such as water depth, hydrodynamic conditions, sediment characteristics, as well as by sources of anthropogenic disturbance that could interact with natural heterogeneity affecting patterns of species distribution, species diversity and ecosystem functioning. Sometimes it is difficult to distinguish between natural heterogeneity and human disturbance.

Healthy lagoons produce food for birds and fish, and provide for several human extractive activities and significant food resources (aquaculture, fishing, hunting, etc.). However, an increase in primary production by external inputs of nutrients, mainly anthropogenic, stresses the ecosystem favouring opportunistic species and reducing diversity. Unfortunately, coastal areas are highly impacted by eutrophication.

These systems are very sensitive to potential climate change due to their dependence on continental and marine inputs. Recent climate changes are beginning to have effects on these environments. According to the Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (2007), many observed changes in freshwater biological systems are associated with rising water temperatures, as well as related changes in salinity, oxygen levels and circulation. Sea level rise and human development are together contributing to losses of coastal wetlands and increasing damage from coastal flooding in many areas. Climate change is likely to reduce flooded areas and increase eutrophication, increasing helophytes populations and grasslands and reducing submerged macrophytes.

One of the major consequences of the climate change is the spread of exotic species worldwide, affecting the ecological functions of an ecosystem and causing a loss of indigenous biodiversity.

It will also affect the biogeochemical cycles of coastal lagoons, especially in peaty environments, characterized by low concentrations of nutrients and organic matter accumulation. In this sense, the relative sedimentation ratio is extremely important in the assessment of lagoon behaviour under climate change scenarios, particularly regarding the prospects for accelerated sea level rise. Research into sedimentation rates is essential to formulating management plans for lagoons under present conditions of sea level rise, as it is to making an informed assessment of the hazards that might be posed by climate change.

**2. Coastal tourism and environment conflicts (Beaches and barrier coasts, mangrove dominated coasts, coral coasts, environmental regulations)**

**Coastal tourism and environment conflicts**

Tourism is environmentally dependent. The unique character of coastal areas gives rise to a distinctive tourist development. Although accounts on the impacts of coastal tourism can be found in works relating to tourism in general, there are few works specifically on coastal tourism. This present volume focuses on the physical environment of coastal tourism, particularly the geomorphological aspects. The papers deal with basic aspects of the coastal environment for tourism, methodologies for assessing the coastal environment for tourism and empirical studies of various types of coastal environment with tourism development. The resulting generalisations are expected to be applied elsewhere.

Since the 1992 Earth Summit in Rio de Janeiro, there is increasing awareness of the importance of sustainable forms of tourism. Although tourism, one of the world largest industries, was not the subject of a chapter in Agenda 21, the Programme for the further implementation of Agenda 21, adopted by the General Assembly at its nineteenth special session in 1997, included sustainable tourism as one of its sectoral themes. Furthermore in 1996, The World Tourism Organization jointly with the tourism private sector issued an Agenda 21 for the Travel and Tourism Industry, with 19 specific areas of action recommended to governments and private operators towards sustainability in tourism.

Coastal areas are transitional areas between the land and sea characterized by a very high biodiversity and they include some of the richest and most fragile ecosystems on earth, like mangroves and coral reefs. At the same time, coasts are under very high population pressure due to rapid urbanization processes. More than half of today’s world population live in coastal areas (within 60 km from the sea) and this number is on the rise.

Additionally, among all different parts of the planet, coastal areas are those which are most visited by tourists and in many coastal areas tourism presents the most important economic activity. In the Mediterranean region for example, tourism is the first economic activity for islands like Cyprus, Malta, the Balearic Islands and Sicily.

Forecast studies carried out by WTO estimate that international tourist arrivals to the Mediterranean coast will amount to 270 millions in 2010 and to 346 millions in 2020 (in 2000 around 200 million foreign visitors per year).

*Main sources of impact*

* Residence in the coastal zone
* Fisheries and aquaculture
* Shipping
* Tourism
* Land-use practices (Agriculture, Industrial development)
* Climate change

*Resulting problems*

* Loss of marine resources due to destruction of coral reefs, overfishing
* Pollution of marine and freshwater resources
* Soil degradation and loss of land resources (e.g. desertification and salinification due to excessive water use, overuse of fertilizers, erosion)
* Air pollution
* Loss of cultural resources, social disruption
* Loss of public access
* Natural hazards and sea level rise
* Climate change

*How does tourism damage coastal environment*

Massive influxes of tourists, often to a relatively small area, have a huge impact. They add to the pollution, waste, and water needs of the local population, putting local infrastructure and habitats under enormous pressure. For example, 85% of the 1.8 million people who visit Australia's Great Barrier Reef are concentrated in two small areas, Cairns and the Whitsunday Islands, which together have a human population of just 130,000 or so.

Tourist infrastructure

In many areas, massive new tourist developments have been built - including airports, marinas, resorts, and golf courses. Overdevelopment for tourism has the same problems as other coastal developments, but often has a greater impact as the tourist developments are located at or near fragile marine ecosystems. For example:

* Mangrove forests and seagrass meadows have been removed to create open beaches
* Tourist developments such as piers and other structures have been built directly on top of coral reefs
* Nesting sites for endangered marine turtles have been destroyed and disturbed by large numbers of tourists on the beaches

Careless resorts, operators, and tourists

The damage doesn't end with the construction of tourist infrastructure. Some tourist resorts empty their sewage and other wastes directly into water surrounding coral reefs and other sensitive marine habitats. Recreational activities also have a huge impact. For example, careless boating, diving, snorkeling, and fishing have substantially damaged coral reefs in many parts of the world, through people touching reefs, stirring up sediment, and dropping anchors. Marine animals such as whale sharks, seals, dugongs, dolphins, whales, and birds are also disturbed by increased numbers of boats, and by people approaching too closely. Tourism can also add to the consumption of seafood in an area, putting pressure on local fish populations and sometimes contributing to overfishing. Collection of corals, shells, and other marine souvenirs - either by individual tourists, or local people who then sell the souvenirs to tourists - also has a detrimental effect on the local environment.

Cruise ships: Floating towns

The increased popularity of cruise ships has also adversely affected the marine environment. Carrying up to 4,000 passengers and crew, these enormous floating towns are a major source of marine pollution through the dumping of garbage and untreated sewage at sea, and the release of other shipping-related pollutants.

The case of cruise ship tourism

A development that has turned out to be a severe problem for many coastal areas in the last decade is the increase in cruise ship tourism. The cruise ship business is the segment that has grown most rapidly during the last decade. While world international tourist arrivals in the period 1990 – 1999 grew at an accumulative annual rate of 4.2%, that of cruises did by 7.7%. In 1990 there were 4.5 million international cruise arrivals which had increased to a number of 8.7 million in 1999. Particularly for many islands in the Caribbean, cruise tourism is an important market segment. In the period from 1990 to 1999 there was an increase from 13.71 million international tourist arrivals to 20.32 million (CTO). Meanwhile the number of cruise passengers increased from 7.75 million to 12.14 million in the same period. This means that in 1999 almost 2/3 of all arrivals to the Caribbean were cruise passengers.

*Problems*

* Discharge of sewage in marinas and nearshore coastal areas.
* The lack of adequate port reception facilities for solid waste, especially in many small islands, as well as the frequent lack of garbage storing facilities on board can result in solid wastes being disposed of at sea, and being transported by wind and currents to shore often in locations distant from the original source of the material.
* “Tar balls” on beaches indicate that oil tankers and other ships dump their oil and garbage overboard (despite laws against such practice), while pollution off Florida and in the Gulf of Mexico is causing serious concern.
* Land-based activities such as port development and the dredging that inevitably accompanies it in order to receive cruise ships with sometimes more than 3000 passengers can significantly degrade coral reefs through the build up of sediment. Furthermore, sand mining at the beaches leads to coastal erosion.
* In the Cayman Islands damage has been done by cruise ships dropping anchor on the reefs. Scientists have acknowledged that more than 300 acres of coral reef have already been lost to cruise ship anchors in the harbour at George Town, the capital of Grand Cayman.
* The potential socio-cultural stress produced by cruise tourism needs to be mentioned as well, since it means that during very short periods there is high influx of people, sometimes more than the local inhabitants of small islands, demanding food, energy,water, etc. and possibly overrunning local communities.

*Impacts*

Environmental impacts

Tourism can create great pressure on local resources such as energy, food, land and water that may already be in short supply. According to the Third Assessment of Europe’s environment, the direct local impacts of tourism on people and the environment at destinations are strongly affected by concentration in space and time (seasonality).

They result from:

* The intensive use of water and land by tourism and leisure facilities.
* The delivery and use of energy.
* Changes in the landscape coming from the construction of infrastructure, buildings and facilities.
* Air pollution and waste.
* The compaction and sealing of soils (damage and destruction of vegetation).
* The disturbance of fauna and local people (for example, by noise).

Impacts on biodiversity

Tourism can cause loss of biodiversity in many ways, e.g. by competing with wildlife for habitat and natural resources. More specifically, negative impacts on biodiversity can be caused by various factors.

Socio-cultural impacts

Change of local identity and values:

Commercialization of local culture: Tourism can turn local culture into commodities when religious traditions, local customs and festivals are reduced to conform to tourist expectations and resulting in what has been called "reconstructed ethnicity".

Standardization: Destinations risk standardization in the process of tourists desires and satisfaction: while landscape, accommodation, food and drinks, etc., must meet the tourists expectation for the new and unfamiliar situation. They must at the same time not be too new or strange because few tourists are actually looking for completely new things.This factor damages the variation and beauty of diverse cultures.

Adaptation to tourist demands: Tourists want to collect souvenirs, arts, crafts, cultural manifestations. In many tourist destinations, craftsmen have responded to the growing demand and have made changes in the design of their products to make them more attractive to the new customers. Cultural erosion may occur in the process of commercializing cultural traditions.

Cultural clashes may arise through:

Economic inequality - between locals and tourists who are spending more than they usually do at home.

Irritation due to tourist behaviour - Tourists often, out of ignorance or carelessness, fail to respect local customs and moral values.

Job level friction - due to a lack of professional training, many low-paid tourism-jobs go to local people while higher-paying and more prestigious managerial jobs go to foreigners or "urbanized" nationals.

*Sustainable Tourism Strategy*

Analysis of status-quo

* Development of previous tourism management or related strategies for the specific area (What can be used? Has it been implemented? Which lessons are to be learnt?)
* A stakeholder analysis (Who has an interest in sustainable tourism development? Who are the main actors?)
* Facts and figures of the local educational system, economical and social structure
* Anecdotal and traditional knowledge

Methods for collecting this information:

Interviews with stakeholders

Questionnaires distributed and collected by e-mail, fax or personally in oder to compile standardised data and perform a statistical analysis

Invitation to focus group meetings (e.g. meetings on environmental education, biodiversity management, good governance and fisheries)

Literature search in the local library and the internet

*Strategy development*

A Sustainable Tourism Strategy is based on the information collected . It defines the priority issues, the stakeholder community, the potential objectives and a set of methodologies to reach these objectives. These include:

* Conservation of specific coastal landscapes or habitats that make the area attractive or are protected under nature conservation legislation
* Development of regionally specific sectors of the economy that can be interlinked with the tourism sector (e.g. production of food specialities and handicrafts)
* Maximising local revenues from tourism investments
* Enabling self-determined cultural development in the region, etc.

*Action plan*

The Action Plan describes the steps needed to implement the strategy and addressing a number of practical questions such as: which organizations will take up which activities, over what time frame, by what means and with which resources? As the actions have to be considered on the basis of regional circumstances, there is no standard action plan for all. However, Action Plans usually include measures in the following fields:

* Administration: e.g. promotion of co-operation between sectors and of cross-sectorial development models; involving local people in drafting tourism policy and decisions
* Socio-economical sector: e.g. promoting local purchasing of food and building material; setting up networks of local producers for better marketing; development of new products to meet the needs of tourists, etc.
* Environment: e.g. improving control and enforcement of environmental standards (noise, drinking water, bathing water, waste-water treatment, etc.); identification and protection of endangered habitats; creation of buffer zones around sensitive natural areas; prohibition of environmentally harmful sports in jeopardised regions; strict application of Environmental Impact Assessment (EIA) and Strategic Environmental Assessment procedures on all tourism related projects and programs.
* Knowledge: training people involved in coastal tourism about the value of historical heritage; environmental management; training protected area management staff in nature interpretation; raising environmental awareness among the local population; introducing a visitors information programme (including environmental information).

During the last century, beaches have completely reversed their role: they have become the driving force behind the economic welfare instead of just being an inhospitable place. However, the demographic pressure and the overuse of the territory related to those factors, in the hinterland (dams in the rivers, farming and tourism) as well as in the proper beach (sewage discharge, dry goods extraction and crops) have caused a general decrease in the contribution of sediments to the beaches with a continental or a marine origin. It is hard to find a unique solution for all those problems. However, it should be absolutely essential to follow these points:

First, an Integrated Coastal Zone Management

Second, a better dissemination of the existing information should be achieved. For that purpose, a better coordination of the existing governmental bodies that deal with coastal management is necessary.

Third, an improvement of the environmental education is essential for a sustainable development of the coast.

**3. Application of Remote Sensing and GIS techniques in coastal management (Geomorphological mapping, coastal cell circulation systems, environmental zoning approach, identification and diversity of coastal habitats)**

Given the diversity of tasks facing the coastal manager and also the range of data processing functions that may exist in a typical GIS, there is a multiplicity of potential application areas for coastal GIS technology. However, from this plethora of applications, a few generic areas are as follows:

Coastal resource survey and management: Continuing expansion of human population increases pressure on the shore for living space, leisure and recreation, and a host of the purposes. At the same time, the oceans and coastal waters of the world are also important hunting grounds for a wide range of economic resources, of value to society. As these resources gradually depleted, there is a corresponding increase in the need to explore conservation measures on remaining sticks. GIS has considerable potential to assist in these tasks. Few examples are as follows:

* Within the leisure and recreation sectors, GIS has been used to assist in the development of new or improved infrastructure including development of new shore-based facilities such as marinas, and the management of recreation activities in the areas of fragile coastal dune systems.
* In the fishing and aquaculture industries, GIS may be used to find optimal locations for fish-farms, through the analysis of salinity, bathymetry, shelter, land uses, proximity to other facilities, etc.
* GIS is also a major technology within the mining and oil exploration industries, where it is harnessed to assist in the discovery, assessment and exploration of new mineral wealth.

Coastal change monitoring and analysis: The coastal zone is highly dynamic, and the scientist or manager increasing requires access to technologies that can represent these dynamics, particularly to evaluate and deal appropriately with changes in the geometry or the or the shore. Two main divisions of coastal change analysis may be recognised, namely monitoring and simulation modeling respectively

In monitoring studies, the primary objective is to record what aspects of the coast are changing, and where and why these changes are taking place. Monitoring at its simplest involves recording what is present at one baseline instance in time, and then comparing this pattern with that of subsequent stages.

GIS has been applied at the coast in order to keep track of a wide range of natural and human-induced changes, including:

* Changes in the extent and ecology of wetlands
* Analysis of erosion and shoreline changes
* Assessment of potential and actual flood hazard and damage.
* The silting up of harbours and the effectiveness and impacts of mitigation efforts such as dredging.
* Monitoring the changes of land use in the coastal hinterlands, in particular the growing urbanisation of the coastal fringe; and
* Monitoring the behaviour of oil spillages in coastal environments.

Modelling coastal process: While monitoring can help identify and evaluate changes that are taking place at the shore, effective management of the coastal zone occasionally requires intervention and manipulation of the processes, controls, feedback and interrelationships at work along, within and across the shore, in order to arrive at more desirable ends. Modeling and simulation of coastal phenomena are extremely valuable techniques for assessing the effectiveness and likely impacts of such intervention.

Traditional modeling of coastal phenomena has mostly relied on experiments with wave tanks and other large physical models. However, it is becoming increasingly common to us computer-based simulation modeling techniques wherever appropriate. Amongst other benefits, computerised simulation has the potential to overcome scale limitations that may be present in a physical model; may avoid the need for physical destruction or alteration of materials under study; can provide greater degree of control over the temporal aspects of the simulation (including compression of long time periods into more manageable extent, temporary halting or even reversal of the model to examine specific aspects in greater detail; etc.); and may be much cheaper and more manageable than construction of a physical model. Furthermore, development of a successful computer simulation depends on the creation of a robust data model for representing the system variables within the GIS, and this in turn requires a meaningful conceptualisation of the phenomena under study. Thus, the process of setting up the simulation can, itself, promote greater awareness of the constituent and relationships at work within the coastal system.

A number of examples are documented in the literature, describing the use of GIS technology for modeling processes and events within the coastal zone. Typical applications include the use of GIS for assessing the threat of sea level rise on the coast of Maine, and the likely responses of coastal sand dunes to such rise. Modeling of oil spills with a view to minimising their environmental impacts, modelling possible impacts of dredge spoil dumping, modeling for multiple use of estuarine waters, and assessment of possible sites for aquaculture development.

GIS for coastal decision-making and policy formulation: By combining rapid data retrieval with analytical and modeling functions, GIS has the ability to respond rapidly and flexibly to ad hoc ‘what if type questions’. Thus, a well-designed coastal zone information system could be significant as a decision-support tool, to aid development of integrated and sustainable coastal management strategies.

**4. Managing coastal change**

India’s coastal zone is endowed with abundant coastal and marine ecosystems that include a wide range of mangroves, coral reefs, sea grasses, salt marshes, mud flats, estuaries, lagoons, and unique marine and coastal flora and fauna. The Sundarbans – shared between India and Bangladesh – are the largest contiguous mangroves in the world. India also has major stocks of corals, fish, marine mammals, reptiles and turtles, sea grass meadows, and abundant sea weeds. Coastal fishing employs a million people full time, and the post-harvest fisheries employ another 1.2 million.

However, in spite of their ecological richness and contribution to the national economy, India’s coastal and marine areas have not received adequate protection and are under stress. About 34% of India’s mangroves were destroyed during 1950-2000 (although substantial restoration and conservation has taken place over the past 10 years); almost all coral areas are threatened; marine fish stocks are declining; and several species of ornamental fish and sea cucumbers are fast disappearing. Such rapid depletion and degradation, unless arrested, will impact the livelihood, health and well being of the coastal population, affecting in turn prospects for India’s sustained economic growth.

India’s coastal and marine environments are threatened by the lack of integrated development planning, especially given the large concentration of towns, petrochemical complexes and industries along India’s coasts. Only 9% of wastewater from India’s coastal towns is treated before entering coastal waters, adding to their already heavy chemical burden from the huge volumes of agricultural run-off that routinely flow into them. In addition, large numbers of coastal people remain dependent on natural resources for their livelihoods, in the absence of alternative livelihood opportunities. However, the returns from traditional fishing are diminishing due to environmental degradation and over-exploitation. Risks from climate change will only accentuate these challenges.

Resources for the conservation of these sensitive coastal and marine ecosystems remain scarce, and the capacity, skills, and knowledge for managing them in a sustainable manner remain inadequate.

*The project*

To reverse this trend, India began implementing a number of measures in 2005. The most important of these initiatives is the World Bank-financed Integrated Coastal Zone Management (ICZM) Project (2010-15). The project – a part of the national coastal zone management program – seeks to balance the diverse needs of development with the protection of vulnerable ecosystems. The ICZM project ($286 million, aimed to directly benefit 1.1 million people) is the Bank’s largest in the Blue Agenda and one of its largest ever to finance knowledge generation and capacity building.

The project’s multi-sectoral and integrated approach represents a paradigm shift from the traditional sector-wise management of coastal resources where numerous institutional, legal, economic and planning frameworks worked in isolation, at times with conflicting aims and outputs. The project puts equal emphasis on conservation of coastal and marine resources, pollution management, and improving livelihood opportunities for coastal communities.

At national and state levels

The project is working at the national level and in three states: Gujarat, Odisha, and West Bengal. At the national level, the project is working to expand the knowledge base and build institutional capacity for the integrated management of coastal zones. This will include the mapping, delineation and demarcation of hazard lines and ecologically sensitive areas along the mainland coast of India, in addition to setting up a new National Center for Sustainable Coastal Management.

Investments in the three coastal states – which were chosen for their varying levels of development and their unique set of challenges – will pilot ICZM approaches with a view to replicating them in all the coastal states in future.

In the three states, complementary pilot investments will be carried in small coastal stretches (on 3% of India’s coastline) to support capacity building. Each of these pilots was selected on the basis of wide stakeholder consultations.

**Assessment of coastal vulnerability**

Coastal environments are particularly vulnerable to the effects of disasters; partly due to denser urbanization and human populations and related economic activities such as agriculture, aquaculture, tourism, industries, trades and transportation in these locations. Coastal areas tend to be relatively highly urbanized with higher concentrations of human populations. Approximately 40% of the global human population lives within 60 km of the coast and more than 25% of the human population in India lies within 50 km of the coast. Natural processes, particularly those affected by climate change, combined with human activities, are becoming significant factors for coastal vulnerabilities. Risks at coastal regions in India are rapidly increasing; major threats for vulnerability are mean sea level rise, extreme events like flash floods, and cyclone induced storm surges. Increased green-house gas emissions, predominantly from human activities, are predicted to expedite climate change and sea level rises that are already making coastal zones vulnerable in the 21st century. Warming oceans lead to sea level rises, which in turn provide a source of thermal expansion of sea water, contributing further to intensified and more frequent cyclone-induced storm surges addressed the potential climate change impacts owing to drought, floods and cyclone events with more intensity and asserted that India has very high risk levels (class 9 among risk class 0–10). As a result of the changes related to climate change, there are significant challenges for assessing coastal vulnerability and subsequent adaptation and mitigation strategies. Systematic coastal vulnerability assessments are essential for managing coastal threats. According to Indian Coastal Zone (CRZ) regulations, the buffer zones, also known as active zones, usually cover a region of 500 m from the shoreline; these zones are more usually focused on coastal vulnerability studies. However, coastal areas up to 100 km perpendicular from the shoreline should be considered as vulnerable areas for assessment studies. Coastal vulnerability resistance developments and strategies done to date are limited; they are only applicable to the coastal buffer zone (yet the effects of disasters impact on areas beyond this zone) and mostly concern coastal geomorphology issues but do not pertain to other extreme events such as cyclones and inundation.

Comprised of different geological, ecological, biological, urban and socio-economic features, the Indian coast is subject to varying degrees of exposure to multiple hazards. In the current scenario, the environmental stresses on coastal zones are increasing significantly in terms of social, physical and economic variables. Social parameters such as population density, drinking water demands owing to over-pumping of fresh-water, communication networks, roads with transportation, drainage, infrastructure, agriculture, aquaculture and industrialization are the prime factors that are providing harmful feedback loops to existing coastal vulnerability. Physical parameters such as sea level rise, slope, cyclones and storm surges are the natural contributing factors (or hazards) for increasing vulnerabilities along the coast. Sand mining is another crucial parameter in terms of coastal vulnerability along this coast. The increasing levels of sand mining along CAP will further result in ecosystem damage in terms of habitat, erosion, riverine system changes, and increased destruction due to extreme events. Therefore, coastal vulnerability assessment techniques require a multi-hazard assessment methodology dependent upon the location at a regional level integrated with global level parameters.

The primary technique used to monitor coasts for vulnerability assessments is spatial data with Geographic Information System (GIS). The method for gathering spatial GIS data is satellite imagery; this is due to its relative accessibility, economic affordability, and regular repetitive coverage. GIS-based spatial data is used in a number of different analytical methodologies, which include ‘Decision Support Systems’ (DSS) and index based techniques. DSS approaches include ‘Community Vulnerability Assessment Tool’ (CVAT), DINAS-coast, Dynamic Interactive Vulnerability Assessment (DIVA), Digital Shoreline Assessment System (DSAS) and vulnerability assessment. Index-based techniques such as the Coastal Vulnerability Index (CVI) are also used widely across the world ‘Integrated Valuation of Ecosystem Services and Tradeoffs’ (InVEST) is an open source software model that has a wide range of models to analyze a range of coastal vulnerabilities, including social, geographical, biological and economic factors.

**Ecosystem valuation of coast**

Ecosystem valuation is an economic process which assigns a value (either monetary, biophysical, or other) to an ecosystem and/or its ecosystem services. By quantifying, for example, the human welfare benefits of a forest to reduce flooding and erosion while sequestering carbon, providing habitat for endangered species, and absorbing harmful chemicals, such monetization ideally provides a tool for policy-makers and conservationists to evaluate management impacts and compare a cost-benefit analysis of potential policies. However, such valuations are estimates, and involve the inherent quantitative uncertainty and philosophical debate of evaluating a range non-market costs and benefits.

*Values provided by coastal and marine ecosystem services*

|  |  |
| --- | --- |
| **Use Values** | **Non-Use Values** |
| **Direct Values** | **Indirect Values** | **Existence and Bequest Values** |
| Food, fiber and raw materials provision | Flood control | Cultural heritage and spiritual benefits |
| Transport | Storm protection, wave attenuation | Resources for future generations |
| Water supply | CC impacts mitigation | Biodiversity |
| Recreation and tourism | Contaminant storage, detoxification |  |
| Wild resources | Shoreline stabilization/erosion control |  |
| Genetic material | Nursery and habitat for fishes and other marine species |  |
| Educational opportunity | Nutrient retention and cycling |  |
| Aesthetic | Regulation of water flow, water filtration |  |
| Art | Source of food for sea organisms |  |
|  | Climate regulation, primary productivity as Oxygen production and CO2 absorption, Carbon sequestration etc. |  |

*Coastal ecosystems and their attributed use-value services*

|  |  |  |
| --- | --- | --- |
| **Coastal Ecosystem** | **Direct Use Value**  | **Indirect Use Value** |
| **Mangrove forests** | Raw material (wood production), aesthetic, educational opportunities, artistic value | CC impact mitigation, storm protection and wave attenuation, shoreline stabilization and erosion control, flood control, nursery and habitat for fishes and other marine species, regulation of water flow and filtration, carbon sequestration, oxygen production and CO2 absorption, contaminant storage and detoxification |
| **Coral reefs** | Aesthetic, recreation and tourism (snorkeling), educational opportunities, artistic value, raw material for building, jewelry and aquarium trade | Nursery and habitat for fishes and other marine species, wave attenuation and shoreline stabilization, nitrogen fixation |
| **Sea-grass beds** | Aesthetic, contribution to recreation andtourism (snorkeling) | Nursery and habitat for fishes and other marine species, source of food for sea organisms, shoreline stabilization and erosion control, primary productivity as oxygen production and CO2 absorption, water filtration |
| **Beach and dune systems** | Recreation and tourism, fiber and raw material (wood source) provided by the dune vegetation, aesthetic value, artistic value | Flood control, erosion control, nursery for some marine species (turtles) |
| **Pelagic systems** | Food source, aesthetic value, tourism services, artistic value | Source of food for sea organisms, nursery and habitat for fishes and other marine species |

In principle, economic valuation of ecosystem services is based on “people preference” and their choices. Therefore, it is quantified by the highest monetary value that a person is willing to pay in order to obtain the benefit of that particular service. The “willingness to accept” approach determines how much someone is willing to give up for a change in obtaining a certain ecosystem good or service [3]. Thus, the key outcome of valuation studies is to illustrate the importance of a healthy ecosystem for socio-economic prosperity and to monetize the gains that one may achieve or lose due to a change in ecosystem services [28].

The value of ecosystem services can be measured in three different forms: (1) Total economic value (TEV) that refers to the value of a particular ecosystem service over the entire area covered by an ecosystem during a defined time period; (2) average value of an ecosystem service per unit, which is often indicated for a unit of area or time; (3) marginal value which is the additional value gained or lost by an incremental change in a provision of a particular service.

The valuation starts from estimating a TEV of an ecosystem, which is in fact a sum of consumer surplus and producer surplus. This is done by applying different valuation techniques. For example, in the case of tourism, producer surplus is the direct or indirect benefit from the local ecosystems for the tourism sector by considering the revenue made from tourists minus the costs of providing these services to them. In addition, consumer surplus conveys the maximum amount that tourists are willing to pay for visiting the specific recreational area.

*Valuation methods and their attributed coastal ecosystem services and goods*

|  |  |  |
| --- | --- | --- |
| Valuation Method | Description | Coastal Ecosystem Services and Goods |
| Revealed preferencemethods (use-value) | Production-based (net factor income) | Often used to value the ecosystem services that contribute to the production of commercially marketed goods | Regulating services such as oxygen production, CO2 absorption, nitrogen fixation and carbon storage, providing fish nurseries, water purification, coastal protection |
| Hedonic pricing | Commonly used to value the environmental services contributing to amenities. Property’s price often represents the amenity value of ecosystems | Tourism and recreation, aesthetic, improving air quality |
| Travel cost | Basically considers the travel costs paid by tourists and visitors to the environmental value of a recreation site | Tourism and recreation,recreational fishery andwater sports |
| Damage avoided cost, replacement cost | Based on either the cost that people are willing to pay to avoid damages or lost services, the cost of replacing services or the cost paid for substitute services providing the same functions and benefits | Buffering CC impacts such as wave attenuation, providing coastal protection against stormsand erosion, flood impactreduction, water purification, carbon storage |
| Stated preferencemethods (both use and non-use value) | Contingent valuation (CVM) | The most applied method for both use and non-use values, based on surveys asking people their willingness to pay (WTP) to obtain an ecosystem service | Tourism and recreation,recreational fishery and water sports, aesthetic value, cultural and spiritual value, art value, educational value |
| Contingent choice (CCM) | WTP is stated based on choices between different hypotheticalscenarios of ecosystem conditions |
| Market price | Often used for the ecosystem products that are explicitly traded in the market | Fiber, wood and sea foodprovision, raw material for building, and aquarium |
| Benefit transfer | It transfers available data from previous valuation studies for a similar application | Mostly applied for gross value of coastal ecosystems associated with recreation |

**Integrated coastal zone management**

Integrated Coastal Zone Management (ICZM) is a resource management system following an integrative, holistic approach and an interactive planning process in addressing the complex management issues in the coastal area.

This concept was borne in 1992 during the Earth Summit of Rio de Janeiro. The policy regarding ICZM is set out in the proceedings of the summit within Agenda 21, Chapter 17. The European Commission defines ICZM as “a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones. It covers the full cycle of information collection, planning (in its broadest sense), decision making, management and monitoring of implementation. ICZM uses the informed participation and cooperation of all stakeholders to assess the societal goals in a given coastal area, and to take actions towards meeting these objectives. ICZM seeks, over the long-term, to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics. 'Integrated' in ICZM refers to the integration of objectives and also to the integration of the many instruments needed to meet these objectives. It means integration of all relevant policy areas, sectors, and levels of administration. It means integration of the terrestrial and marine components of the target territory, in both time and space”.

*The specific character of coastal zones*

A well-informed science-based coastal zone management strategy embedded in an adequate social, institutional and legal framework, can prevent many future coastal problems. This is now usually called ICZM, Integrated Coastal Zone Management. As far as the technical aspects are concerned, experienced coastal authorities are capable to overview most of the coastal engineering issues associated with the future developments of the coastal zone. However, ICZM requires a broader view of coastal issues. ICZM is a governance process for the coastal zone, which differs from usual territorial governance processes due to its specific characteristics:

The coastal zone has no fixed administrative boundary; it is defined by the environmental (physical, ecological) interaction processes between the land environment and the marine environment.

The coastal zone has no dedicated government; coastal zone governance is an interplay of several local, regional and national institutions with different mandates and responsibilities.

The coastal zone environment (the physical and ecological state) is highly dynamic due to the interaction processes between the land environment and the marine environment.

Settlements in low-lying coastal zones are very vulnerable to extreme climatic events and to the impact climate change (sea level rise, in particular).

Because of these particular characteristics many studies and experiments have been carried out for defining a coherent ICZM governance process for coastal zones. Studies and experiments for developing and implementing ICZM are listed in the category Integrated Coastal Zone Management.

*Why it is difficult to put ICZM into practice*

The problems with which coastal zones are confronted often have an insidious character, think, for example, of urban or touristic development, decline of biodiversity or climate change and sea level rise. When problems are perceived as urgent the situation is often already irreversibly deteriorated. Who feels responsible for a well-balanced future-proof development of the coastal zone? At national level, different interests are represented by different sectoral authorities. Local government is often the only body responsible for weighing and integrating different interests. But the means to do this are limited, because often the situation is that:

* local authorities can be overruled by sectoral authorities on a higher governance level (region, state);
* local authorities have little or no staff with profound knowledge of the complex interactions that take place in the coastal zone;
* local authorities have limited financial resources for monitoring and assessment of the state of the coast and for restoration measures;
* local authorities have limited (man)power to enforce regulations;
* The local interests that local authorities represent are often short-term interests.

These limitations can be overcome, at least in part, by delegating more powers to local authorities and by promoting public participation and involvement of civil society organizations (NGOs) in coastal policy processes.

Other impediments to implementing ICZM are:

* Lack of public awareness: “People tend to underestimate risks of natural hazards”
* Low political priority: “There are more urgent issues to be addressed”
* Lack of institutional cooperation: “ICZM trespasses our field of competence”
* Lack of funding: “ICZM investments do not yield short-term visible benefits”
* Lack of monitoring: “No information excuse for inaction”
* Lack of experts: “Experts do not understand politics and vice versa”

*ICZM implementation*

The natural and social characteristics of different parts of the coastal zone can be highly diverse. Coastal zone policy can therefore be determined only partly at the national level. The primary focus at the national level is to establish a legal, institutional and administrative framework for integrated coastal zone management. Of crucial importance is the institutional embedding of the ICZM process. The institutional framework must provide the mandate and resources for the local implementation of ICZM. Implementation of ICZM requires that sufficient powers be delegated to local authorities. This can be a problem in countries with a strongly centralized governance culture.

The coastal zone is constantly evolving through natural and socio-economic processes. ICZM should therefore not consist of a one-time static plan or as a series of ad hoc actions, but must be shaped as a continuous process that goes through a fixed cycle according to the schedule:

Plan development => Implementation => Monitoring => Evaluation => Plan revision => Implementation => Monitoring => Evaluation, etc.

This cycle is implemented at both local and national level:

At local level, detailed concrete plans are developed and carried out (after endorsement at the national level) in consultation with all local and national stakeholders;

At national level, national objectives and targets are defined, local plans are integrated in a national strategy and mandate and resources are allocated for implementation.

The cycle period should be adjusted to the rate at which developments take place in the coastal zone. A cycle of one year may be too short; a cycle of 5 years or 10 years can be more appropriate. The cycle period at the local level may be shorter than at the national level.

Monitoring and evaluation are essential process steps to determine which progress has been realized in the implementation of the ICZM plan. This is only possible if measurable indicators and quantitative targets have been defined for this purpose. Defining indicators and targets is a major component of the ICZM plan process. Various examples of ICZM indicators have been described in the literature. Successful implementation of ICZM is highly dependent on the definition and monitoring of adequate indicators and targets.

* *Major objectives of ICZM are related to:*
* Protecting people and assets at risk
* Enhancing sustainability and ecosystem services
* Economic development of the coastal zone
* Creating awareness of coastal zone vulnerability and risks
* Good governance

Actions for the implementation of Integrated Coastal Zone Management

|  |  |  |
| --- | --- | --- |
| **General objective** | **Specific objective** | **Actions** |
| **Protecting people and assets** | **Flood risk reduction** | Shoreline management plan and implementationEstablishment of flood and erosion risk mapsSetback lines for hard constructionsBan on urban sprawl along the coastUrban drainage systemFlood refuge placesBuilding standards in the coastal zone (incl. geotechnical aspects of soft subsiding soils)Planning of critical infrastructure (road, rail, electricity, pipelines, etc.) |
| **Emergency rescue** | Early warning system and organizationRegulations for emergency evacuationRescue organization and equipment |
| **Flood prevention** | Soft measures:Fences or vegetation to stimulate dune growthSand nourishment of the dune belt |
| Hard measures:[Seawall](http://www.coastalwiki.org/wiki/Seawalls_and_revetments) ([stone, concrete blocks](http://www.coastalwiki.org/wiki/Revetments), geocontainers), dike, bulkhead |
| **Erosion mitigation** | Soft measures:Sand nourishment of the beach or the foreshoreShore vegetationBeach drainage |
| Hard measures:Shore parallel: Offshore breakwater (concrete, stone, geotube)Shore perpendicular: Groynes, jetties, artificial headlandsPerched beach |
| **Enhancing sustainability and ecosystem services** | **Natural protection** | Structural measures:Vegetated foreland in front of coastal defences (planting mangroves, extension of marshland by sediment trapping or by artificial nourishment)Natural offshore reefCoastal wetland restoration and creation, managed retreat |
| Planning:Ecosystem-based long-term development planning of estuaries and delta systemsProtection of biodiversity, designation of coastal and marine protected areas |
| **Sediment management** | Sand by-pass systemsPlanning and management of river damsUse of clean dredging material for coastal nourishment and coastal protection works |
| **Limitation of soil subsidence** | Regulations for groundwater extraction and drainage and for extraction of mineralsGroundwater management and alternative water supply (incl. recharge of aquifers) |
| **Climate change adaptation (CCA)** | Climate projections and socio-economic scenarios for the futureRegular evaluation of ICZM policies and regulationsRegular revision of design standards and corresponding assessment of protection worksAssessment of coastal development projects towards climate resilience (CCA Impact Assessment) |
| **Economic development** | **Land-use (housing, agriculture, fisheries)** | Ban on urban development in sensitive zonesCoastal zone water management plan and implementation (water availability, water quality and limitation of salt intrusion) |
| **Tourism** | Attractive landscape and cultural heritageAccess road planning (walk, bicycle lanes) |
| **Port and industry** | Ban on industrial development in sensitive zonesRegulations for dredged material regarding disposal / treatment / re-useEnvironmental Impact Assessment and nature compensation for port/industrial development |
| **Awareness raising** | **Public information and consultation** | Dissemination of local of risk mapsStakeholder analysis and involvementPublic participation in coastal zone management |
| **Financial instruments** | Coastal risk insuranceCoastal zone management tax for landownersPayment for ecosystem services |
| **Governance** | **ICZM policy cycle** | Planning-monitoring-assessment cycle implemented at decision-making levelsStructural funds for monitoring and implementation of ICZM |
| **Legal/institutional framework** | Clear responsibilities endorsed by all concerned administrationsAdequate and enforced laws and regulations |
| **Knowledge base** | Monitoring and assessment organizationData sharingCapacity building of ICZM staffExchange of knowledge and good practices among similar coastal zones |

**Coastal regulations**

The coastal areas of seas, bays, creeks, rivers, and backwaters which get influenced by tides up to 500 m from the high tide line (HTL) and the land between the low tide line (LTL) and the high tide line have been declared as coastal regulation zone (CRZ) in 1991.

The coastal regulation zones have been declared by the Ministry of Environment, Forest and Climate change under the Environment Protection Act 1986.

While the CRZ Rules are made by the Union environment ministry, implementation is to be ensured by state governments through their Coastal Zone Management Authorities.

HTL and LTL

* High Tide Line: HTL means the line on the land up to which the highest water line reaches during the spring tide.
* Low Tide Line: Similarly, it means the line on the land up to which the lowest water line reaches during the spring tide.
* Spring tides: The position of both the sun and the moon in relation to the earth has direct bearing on tide height. When the sun, the moon and the earth are in a straight line, the height of the tide will be higher. These are called spring tides and they occur twice a month, one on full moon period and another during new moon period.

*Importance of Regulation of Coastal Zones*

* Protection of ecologically Sensitive Areas like mangroves, coral reefs which act as a shield against tsunami and cyclone
* Improving the lives of coastal communities like fishing communities
* Resilient measures for mitigating impacts of Climate Change and high-intensity Cyclones
* To balance development with conservation of the coastal environment

*Timeline of CRZ regulations*

In India, the Coastal Regulation Zone (CRZ) Rules govern human and industrial activity close to the coastline, in order to protect the fragile ecosystems near the sea.

They restrict certain kinds of activities — like large constructions, setting up of new industries, storage or disposal of hazardous material, mining, reclamation and bunding — within a certain distance from the coastline.

Coastal Regulation Zone (CRZ) notification was first issued in 1991 by Ministry of Environment, Forest and Climate Change (MoEFCC) under Environment (Protection) Act, 1986 with the mandate to take measures to protect and conserve our coastal environment.

*Shortcomings of CRZ 1991:*

* Uniform regulations for the entire Indian coastline without taking into account the diversity in terms of biodiversity, demographic patterns, natural resources, etc.
* Laid no clear procedure for obtaining CRZ clearance.
* Post clearance monitoring and enforcement mechanism was not laid out.
* Measures/rules to check pollution emanating from land-based activities were not included.
* Caused hardships to traditional communities living in ecologically sensitive coastal stretches (fishermen, slum dwellers, etc.).

Several amendments were made in the CRZ 1991 notification which was consolidated and issued in the CRZ 2011 notification. The CRZ 2011 notification took into account the issues of CRZ 1991.

*Objectives of CRZ 2011:*

* To conserve and protect coastal stretches;
* To ensure livelihood security to the fishing & local communities living in the coastal areas;
* To promote development in a sustainable manner based on scientific principles, taking into account natural hazards and sea-level rise.

In December 2018, Union cabinet approved the Coastal Regulation Zone (CRZ) Notification, 2018.

CRZ 2018 notification is based on recommendation of Shailesh Nayak committee constituted by the MoEFCC in June 2014 for comprehensive evaluation of provisions under CRZ 2011 notification as demanded by various coastal States/UTs along with other stakeholders

*Classifications of Coastal Zones under CRZ Notification 2011*

CRZ-I (ecologically sensitive areas like mangroves, coral reefs, biosphere reserves etc.).

* No new construction shall be permitted in CRZ-I except
* Projects relating to the Department of Atomic Energy;
* Construction of trans-harbour sea link and roads without affecting the tidal flow of water, between LTL and HTL. Etc.
* Between Low Tide Line and High Tide Line in areas which are not ecologically sensitive, the following may be permitted;
* Exploration and extraction of natural gas;
* Construction of basic amenities like schools, roads, etc. for traditional inhabitants living within the biosphere reserves;
* Salt harvesting by solar evaporation of seawater;
* Desalination plants;
* Storage of non-hazardous cargo such as edible oil, fertilizers within notified ports;

CRZ-II (Areas which are developed up to the shoreline and falling within the municipal limits; includes built-up area – villages and towns are that are already well established),

* Buildings are permissible on the landward side of the hazardous line.
* Other activities such as desalination plants are also permissible.
* Some construction is permitted only as per guidelines specified by the notification.

CRZ-III: Areas that are relatively undisturbed and do not fall under either in Category I or II and also include rural and urban areas that are not substantially developed.

* Between 0-200 metres from HTL is a No Development Zone where no construction shall be permitted.
* Only certain activities relating to agriculture, forestry, projects of Department of Atomic Energy, mining of rare minerals, salt manufacture, regasification of petroleum products, non-conventional energy sources and certain public facilities may be permitted in this zone.
* Between 200-500 metres of HTL, those permitted in 0-200 metres zone, construction of houses for local communities and tourism projects are permissible.

CRZ-IV: The aquatic area from low tide line up to territorial limits is classified as CRZ-IV including the area of the tidal influenced water body.

* There is no restriction on the traditional fishing undertaken by local communities.
* No untreated sewage or solid waste shall be let off or dumped in these areas.

A separate draft Island Protection Zone Notification has been issued for protection of the islands of Andaman & Nicobar and Lakshadweep under Environment (Protection) Act, 1986.

*Procedure for Clearances under CRZ 2011*

A specific procedure has been provided in the 2011 Notification for obtaining project clearance.

* Rapid Environment Impact Assessment (EIA) Report;
* Disaster Management Report and Risk Management Report;
* CRZ map indicating HTL and LTL demarcated;
* No Objection Certificate from the concerned Pollution Control Boards;
* The clearance accorded to the projects shall be valid for a period of five years.

Ecologically sensitive areas (ESA) given Special Dispensations under CRZ 2011

* Sunderbans, Gulf of Khambat and Gulf of Kutch, Malvan, Achra-Ratnagiri in Maharashtra, Karwar and Coondapur in Karnataka, Vembanad in Kerala, Bhaitarkanika in Orissa, Coringa in East Godavari and Krishna in Andhra Pradesh would be declared as Critical Vulnerable Coastal Areas (CVCA) and the integrated management plan would be prepared for each of these areas in consultation with the local communities.
* Beaches such as Mandrem, Morjim, Galgiba and Agonda in Goa have been designated as turtle nesting sites and protected under the Wildlife Protection Act, 1972.
* No developmental activities shall be permitted in these areas.

*Shailesh Nayak Committee Report on Coastal Regulation Zone*

* Shailesh Nayak committee was constituted in June 2014, and it submitted its report in January 2015.
* The committee recommended relaxation on the terms set up by the CRZ 2011 notification. The major objective behind the recommendations was to boost tourism, port construction and real estate.
* The committee suggested diluting the regulatory powers of the Central Government in the coastal areas. Except for those activities which require environmental clearances all other activity should fall under the ambit of state and local planning bodies.
* Based on the recommendations of Shailesh Nayak committee, the suggestions were given by the coastal states and union territories, and the CRZ 2018 notifications were issued.

**Coastal engineering**

Coastal engineering is the branch of civil engineering which involves the sciences of coastal geology and oceanography. The coastal engineer’s main tasks include the protection and management of coastlines. They play an essential role and are crucial for the stability and the development of our coastal environment.

A coastal engineer addresses the entire natural and human-made changes in the coastal region. Let’s discuss why this division of civil engineering is essential. Following are some of the reasons which talk about the significance of coastal engineering:

1. To control erosion

Coastal engineers strive to prevent the damage and destruction caused by waves and erosion. Breakwater, seawalls, and revetments are some of the structures constructed by coastal engineers to control erosion. Knowledge about this may help in preventing destructive erosion. Coastal erosion is one of the major problems in coastal cities and areas.

2. Affects the economy

Coastal engineers contribute a lot to the economy by protecting the coastlines. If the coasts are not protected or managed, it may negatively impact the growth of the country. A large amount of income is generated from the coastal sectors in the form of tourism, imports, and exports. This may affect job opportunities in the country. If the coastal areas are not managed, the total employment from this sector will decrease which will impact the economy of the country.

3. Flood control

The study of coastal engineering will help them to provide defenses that can help to reduce the effects of the lousy weather and control floods in the area. It also preserves the coastal residential areas and prevents them from the damage and dangers of flooding.

4. For the functioning of coastal cities

Coastal cities are great habitats as well as centers of economic growth. They are an important part of the ecosystem and are essential for human activities such as tourism, fishing, and transportation. Coastal management and engineering are vital as they will help the engineers understand the different demographics of these areas and how to work for the development of these coastal lands.

5. Harbors

Coastal engineers construct and build artificial ports. They work for the event, safety and increase the connectivity to the coastal areas. Coastal engineers understand their field and can create an artificial harbor where no natural harbor exists. They are contributing to the safety as well as the development of a coastal region or a city. They also develop and maintain ports.

6. Dredging Operations

Coastal engineers are responsible for conducting dredging operations to retain a secure route for the transportation of vessels into or away from waterways and harbors. The functions and responsibilities of coastal engineering are crucial to the protection of our coastal environment and the operation of our commercial shipping industry.

7. Marine ecosystem

Coastal engineering is essential for the marine ecosystem. Coastal engineers design inlets and channels that can improve the quality of the water and prevent the loss of habitat. They are responsible for maintaining the ecosystem in the marine land.

**Developments in hard structure designs**

Coastal structures are frequently constructed to prevent erosion of coastal landscapes and infrastructure and mitigate the risks to the populations and economic activities dependent on the coastal zone. Coastal structures, sometimes referred to as “hard” structures, are usually built using materials (at least for certain coasts and beaches) that do not form naturally, such as of concrete, large armor stone, steel, or timber, are relatively permanent (typical 50-yr design life), and are spatially-fixed within an otherwise dynamic coastal zone. The most important hard structure types are dikes (levees), seawalls, breakwaters, groins, and jetties.

*Disadvantages of Hard Structures*

While hard coastal structures can be the most effective option for flood protection and/or mitigation, or for stabilizing a shoreline at a fixed position, there is a price to pay. Hard structures partially hinder the recreational use of the coastal zone and can cause adverse ecological effects within the coastal zone. For example, when seawalls are constructed on eroding beaches, the erosion continues so that the beach in front of the seawall can become very narrow or disappear completely. And while groins and jetties trap sediment on the updrift side resulting in shoreline accretion, there is corresponding shoreline erosion on the downdrift side due to the interruption in longshore transport. Some of the disadvantages of hard structures include:

* Visual impacts
* Horizontal and vertical access restrictions
* Loss of sand supply to beach from armoring backshore
* Placement losses with construction of revetment or seawall
* Passive erosion
* Active erosion

**Developments in soft structure designs**

It is the stabilization of the shoreline using environmentally friendly techniques used to protect property and uses from shoreline erosion. The main objective of soft shoreline stabilization is to achieve a balance between the need for protection against erosion while maintaining and enhancing shoreline functions.

Contrary to shorelines that are completely hardened with structures (described earlier), soft stabilization methods seek to incorporate key features into the design that either maintain or enhance functions of the shoreline, or those that allow natural processes to continue. But, natural processes, such as the movement of sand along a beach or barrier island or sediment moving along cliff coasts, headlands, etc., can vary widely between sites, making soft stabilization methods quite variant as well. Soft stabilization methods are highly dependent on local environments, and processes governing sediment pathways in each system. As such, additional planning for these methods may be required because of differences in coastal geomorphology, physical processes governing sediment transport, and because local ordinances vary across state boundaries.

As our understanding of the effects of hard stabilization methods increases, many traditional coastal engineering practices are slowly being phased out, especially where soft stabilization methods can replace or restore the ecological function, establish energy continuity, and offer sufficient protection. But, soft shoreline stabilization is a complex topic. Many federal and state agencies, including the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center, have been working for many years to implement programs to facilitate such protection practices with a fair amount of success. However, we still have a lot to learn before we can completely abandon hard structures. This is especially true if relocating communities that are at immediate risk is not possible (recall concepts in coastal vulnerability, exposure, and rising seas, from previous modules).

*Principles and Objectives of Soft Shoreline Stabilization*

Protection or mitigation of shorelines using soft approaches has some simple objectives and three basic principles.

The first principle is, try to imitate nature. Within each geomorphic environment, sediment characteristics, shoreline slope, and terrestrial and submerged habitat will be specific, hence using native plants and sediments that have already been exposed and shaped by forces within the specific coastal zone are critical to the success of soft mitigation methods. Plants help retain the soil matrix with their roots, and often offer good protection to erosion. On the other hand, if an area is subjected to higher energy conditions where vegetation is not naturally found, such as a beach, trying to steady the shoreline using vegetation along the high energy environment of the beach might not be a good idea. The fast moving water and energy resulting for tidal currents and breaking waves will uproot the plants and quickly render the plants ineffective.

The second principle is, maintain gentle slopes. Unless we are in rocky coasts or regions with bedrock exposure, natural slopes where sediment is stable under gravity (less than the angle of repose) are relatively gentle. Maintaining gentle slope allows for gradual dissipation of wave energy across a longer distance, hence the energy acting on each unit area is much lower compared to a vertical wall.

The third principle is, employ combined or mixed material approaches. Along many shorelines, we see a variety of terrestrial plants, various sediment sizes ranging from mud to sand or gravel, and shorelines are often lined with trees and other plants, and slopes can vary widely. Therefore, using a combination of approaches that imitates nearby natural shorelines is the best recipe for successful implementation of soft approaches.

Methods of protection also often involve integrated approaches that include a combination of soft and non-traditional hard structure approaches.

*Examples of Soft Shoreline Stabilization*

There are many methods of soft shoreline stabilization with complex construction methodologies and materials. Here we will list a few examples for illustrative purposes in order to introduce the concept, and examine case studies that demonstrate how these methods work.

**Soil Bio-engineering:** Stream and riverbank protection efforts in populated areas are expected to address issues such as habitat, aesthetics, and water quality, as much as they address needs such as flood control and erosion protection. Therefore, integrated streambank protection designs that include vegetation are likely to satisfy these multiple objectives. Soil bioengineering is a method routinely used to address erosion and can be achieved in many ways across different systems. These systems utilize hybrid approaches that use geotextile fabrics and/or vegetation and can provide sound streambank protection while maximizing ecological and water quality benefits. These methods are used in place of riprap, concrete, or other inert structures alone. The Jacques-Cartier Park case study describes soil bioengineering systems that have been used to meet specific aquatic and riparian habitat objectives, and the procedures developed for this project are considered or have been used elsewhere where environmental concerns are placed high on the priority list, such as Alaska and the Ottawa River in Canada, which divides the Provinces of Ontario and Quebec.

Soil bioengineering methods have a common geotechnical benefit of providing root reinforcement in the soil and can help modify drainage patterns of the soil, help stabilize soils at steeper angles if desired, help keep grasses and bushy vegetation in place resisting erosion, and support woody debris or other types of vegetation. The species of woody vegetation selected for inclusion in soil bioengineering systems can have a significant effect on the habitat benefits. While various species of willow are the most common woody plants used in soil bioengineering because of their excellent rooting ability, good overhanging cover and shade for streams, good nesting habitat for some species of birds, and some cover for mammals, it is not noted as an excellent food source for land animals, nor it is suitable for saline systems, and may have limited applications in coastal settings.

**Geotubes / Geotextiles:** Geotextiles or geosynthetics have become very popular methods for several streambank stabilization projects, dune stabilization, and generally when earthen stability is required. A geotextile material that can be chosen varies in thickness and porosity and will depend largely on soil properties or whether it is necessary to improve a soil property – for instance, to increase surface soil strength, increase erosion resistance, or stabilize weak soils on steep slopes. For the case study in Grand Isle, LA, the objective was to protect the island from storm waves and storm surge, a function that is typical of a dune system. However, the island is highly exposed to Gulf of Mexico storm waves that frequently overwash and erode the dune system, with increasing dune rebuilding costs after each storm. To protect against this erosion, coastal engineers employed geotubes, which were filled with native material excavated from the existing storm-damaged dune system. Once put in place, the tubes were covered with a top layer of sand and were vegetated for added soil stability. Over time, wind-blown sand from the beach system accumulates at the seaward side of the dune system and organizes into smaller dunes, where additional vegetation growth takes place and provides additional protection from waves and storm surges approaching the island.

Similar shructure had been constructed in the Shankarpur coastal rejoin of West Bengal, but it was entirely devastated within two years.

**Dunes:** Sand dunes are common features in coastal zones and desert environments. Along the coast, dunes can protect beaches from erosion during storms and supply sand to a beach that is eroding. Dunes also provide habitat for highly specialized plants and animals, including rare and endangered species. Because of threats by both intentional and unintentional human activity and because of the benefits they offer, such as storm protection and sediment cycling between dune and beach environment, many countries such as the Netherlands, United Kingdom, and the United States employ dune protection programs. These include stabilization programs and restoration efforts centered on building or re-building dunes. Protection, stabilization, and restoration methods utilize measures to reduce the transport of sand by wind and water, such as planting vegetation, constructing sand fences, and selecting access areas that avoid damage to dunes and dune vegetation from foot traffic.

It is important to consider dune structure when planting dune vegetation. Dunes are composed of the foredune (the part that faces the ocean), the sand plain (the dune crest or top) and the backdune (the side facing away from the ocean). The micro-environments of these dune components limit the types of plants that can thrive on them. For instance, foredune plants need to be tolerant to salt spray, strong winds, and some burial by wind-blown sand from the berm and beach environment, while sand plain and backdune plants can be less tolerant of these stresses because they are typically protected from salt spray and sand burial.

Managing coastal dunes for use as part of a flood protection and mitigation strategy involves an integrated management approach or plan, which follows closely on some of the principles we introduced for soft shoreline engineering. These are to:

* restore and preserve natural processes (that is, work with nature);
* create conditions and opportunities for establishing future natural processes (that is, maintain mass and energy flow);
* prevent land use practices that hinder any of the above.

In the Cape Cod area of Massachusetts, erosion caused by winter storms, in particular, results in loss of beach area. And one solution put into practice to address this issue is dune restoration using sand fencing to trap sand and build new dunes. This technique, in concert with planting suitable beach grass species to hold the sand in place, can be a very effective method.

*Advantages and Disadvantages of Soft Shoreline Stabilization*

Alternative soft stabilization approaches can offer many benefits over typical hard stabilization structures. Often these approaches are referred to as living shorelines because they offer added ecological benefits. Some of the benefits of soft stabilization approaches include:

* maintaining natural shoreline dynamics and healthy sand movement across a coastal cell;
* trapping sand to rebuild eroded shorelines or maintain current shoreline form;
* providing or enhancing important shoreline habitat;
* reducing wave energy impacts at or seaward of the shoreline;
* absorbing storm surge and flood waters;
* filtering nutrients and other pollutants from the water;
* maintaining beach and intertidal areas that offer public access opportunities for wading, fishing, and walking;
* reducing the costs of stabilization from bulkheads, rip rap, and other hard structural approaches;
* creating a carbon sink and thereby helping mitigate climate change.

While there are many benefits associated with living shorelines, they are not appropriate for all geomorphic environments. Drawbacks for living shorelines include:

* not being appropriate for high energy environments;
* not being as effective where much of the shoreline is already hardened;
* being more difficult to design and install than more traditional hard structural approaches;
* having limited information available on the effectiveness of living shorelines for different types of shorelines, energy regimes, and storm conditions.

**New dredging techniques and procedures**

Dredging is the removal of sediments and debris from the bottom of lakes, rivers, harbors, and other water bodies. It is a routine necessity in waterways around the world because sedimentation—the natural process of sand and silt washing downstream—gradually fills channels and harbors.

Dredging often is focused on maintaining or increasing the depth of navigation channels, anchorages, or berthing areas to ensure the safe passage of boats and ships. Vessels require a certain amount of water in order to float and not touch bottom. This water depth continues to increase over time as larger and larger ships are deployed. Since massive ships carry the bulk of the goods imported into the country, dredging plays a vital role in the nation's economy.

Dredging is also performed to reduce the exposure of fish, wildlife, and people to contaminants and to prevent the spread of contaminants to other areas of the water body. This environmental dredging is often necessary because sediments in and around cities and industrial areas are frequently contaminated with a variety of pollutants. These pollutants are introduced to waterways from point sources such as sewer overflows, municipal and industrial discharges, and spills; or may be introduced from nonpoint sources such as surface runoff and atmospheric deposition. NOAA's Office of Response and Restoration plays a major role in protecting and restoring marine natural resources when environmental damage occurs.

*Purposes of dredging*

**Capital dredging**: dredging carried out to create a new harbour, berth or waterway, or to deepen existing facilities in order to allow larger ships access. Because capital works usually involve hard material or high-volume works, the work is usually done using a cutter suction dredge or large trailing suction hopper dredge; but for rock works, drilling and blasting along with mechanical excavation may be used.

**Land reclamation**: dredging to mine sand, clay or rock from the seabed and using it to construct new land elsewhere. This is typically performed by a cutter-suction dredge or trailing suction hopper dredge. The material may also be used for flood or erosion control.

**Maintenance**: dredging to deepen or maintain navigable waterways or channels which are threatened to become silted with the passage of time, due to sedimented sand and mud, possibly making them too shallow for navigation. This is often carried out with a trailing suction hopper dredge. Most dredging is for this purpose, and it may also be done to maintain the holding capacity of reservoirs or lakes.

**Harvesting materials**: dredging sediment for elements like gold, diamonds or other valuable trace substances. Hobbyists examine their dredged matter to pick out items of potential value, similar to the hobby of metal detecting.

**Fishing dredging** is a technique for catching certain species of edible clams and crabs. In Louisiana and other American states, with salt water estuaries that can sustain bottom oyster beds, oysters are raised and harvested. A heavy rectangular metal scoop is towed astern of a moving boat with a chain bridle attached to a cable. This drags along the bottom scooping up oysters. It is periodically winched aboard and the catch is sorted and bagged for shipment.

**Preparatory:** dredging work and excavation for future bridges, piers or docks or wharves, This is often to build the foundations.

**Winning construction materials**: dredging sand and gravels from offshore licensed areas for use in construction industry, principally for use in concrete. This very specialist industry is focused in NW Europe, it uses specialized trailing suction hopper dredgers self discharging the dry cargo ashore. Land based old river beddings can be processed in this manner too.

**Contaminant remediation**: to reclaim areas affected by chemical spills, storm water surges (with urban runoff), and other soil contaminations, including silt from sewage sludge and from decayed matter, like wilted plants. Disposal becomes a proportionally large factor in these operations.

**Flood prevention**: dredging increases the channel depth and therefore increase a channel's capacity for carrying water.

**Beach nourishment**: this is mining sand offshore and placing on a beach to replace sand eroded by storms or wave action. This enhances the recreational and protective function of the beach, which are also eroded by human activity. This is typically performed by a cutter-suction dredge or trailing suction hopper dredge.

**Peat extraction**: dredging poles or dredge hauls were used on the back of small boats to manually dredge the beds of peat-moor waterways. The extracted peat was used as a fuel. This tradition is now more or less obsolete. The tools are now significantly changed.[citation needed]

**Removing rubbish and debris**: often done in combination with maintenance dredging, this process removes non-natural matter from the bottoms of rivers and canals and harbours. Law enforcement agencies sometimes need to use a 'drag' to recover evidence or corpses from beneath the water.

**Anti-eutrophication**: A kind of contaminant remediation, dredging is an expensive option for the remediation of eutrophied (or de-oxygenated) water bodies; one of the causes is like mentioned above, sewage sludge. However, as artificially elevated phosphorus levels in the sediment aggravate the eutrophication process, controlled sediment removal is occasionally the only option for the reclamation of still waters.

**Seabed mining**: is a possible future use, recovering natural metal ore nodules from the sea's deepest troughs.

*Types of dredgers*

**A. Suction dredgers**: These operate by sucking through a long tube like some vacuum cleaners but on a larger scale. A plain suction dredger has no tool at the end of the suction pipe to disturb the material. This is often the most commonly used form of dredging.

*Trailing suction*: A trailing suction hopper dredger (TSHD) trails its suction pipe when working. The pipe, which is fitted with a dredge drag head, loads the dredge spoil into one or more hoppers in the vessel. When the hoppers are full, the TSHD sails to a disposal area and either dumps the material through doors in the hull or pumps the material out of the hoppers. Some dredges also self-offload using drag buckets and conveyors.

The largest trailing suction hopper dredgers in the world are currently Jan De Nul's Cristobal Colon (launched 4 July 2008) and her sister ship Leiv Eriksson (launched 4 September 2009). Main design specs for the Cristobal Colon and the Leiv Eriksson are: 46,000 cubic metre hopper and a design dredging depth of 155 m. Next largest is HAM 318 (Van Oord) with its 37,293 cubic metre hopper and a maximum dredging depth of 101 m.

*Cutter-suction*: A cutter-suction dredger's (CSD) suction tube has a cutting mechanism at the suction inlet. The cutting mechanism loosens the bed material and transports it to the suction mouth. The dredged material is usually sucked up by a wear-resistant centrifugal pump and discharged either through a pipe line or to a barge. Cutter-suction dredgers are most often used in geological areas consisting of hard surface materials (for example gravel deposits or surface bedrock) where a standard suction dredger would be ineffective. They can, if sufficiently powerful, be used instead of underwater blasting.

As of 2018, the most powerful cutter-suction dredger in the world is DEME's Spartacus, which is scheduled to enter service in 2019.

*Auger suction*: The auger dredge system functions like a cutter suction dredger, but the cutting tool is a rotating Archimedean screw set at right angles to the suction pipe. The first widely used auger dredges were designed in the 1980s. In 1996, IMS Dredges introduced a self-propelled version operates without anchors or cables. They were primarily used for sludge removal applications from waste water treatment plants; since then they have been used river maintenance and sand mining.

The turbidity shroud on auger dredge systems creates a strong suction vacuum, causing much less turbidity than conical (basket) type cutterheads and so they are preferred for environmental applications. This and the ability to convey material to the pump faster makes auger dredge systems more productive than similar sized conical (basket) type cutterhead dredges.

*Jet-lift*: These use the Venturi effect of a concentrated high-speed stream of water to pull the nearby water, together with bed material, into a pipe.

*Air-lift*: An airlift is a type of small suction dredge. It is sometimes used like other dredges. At other times, an airlift is handheld underwater by a diver. It works by blowing air into the pipe, and that air, being lighter than water, rises inside the pipe, dragging water with it.

**B. Mechanical dredgers**: Some bucket dredgers and grab dredgers are powerful enough to rip out coral to make a shipping channel through coral reefs.

*Bucket dredgers:* A bucket dredger is equipped with a bucket dredge, which is a device that picks up sediment by mechanical means, often with many circulating buckets attached to a wheel or chain.

*Grab dredgers:* Grab (clamshell) dredging in process in Port Canaveral, Florida. A grab dredger picks up seabed material with a clam shell bucket, which hangs from an onboard crane or a crane barge, or is carried by a hydraulic arm, or is mounted like on a dragline. This technique is often used in excavation of bay mud. Most of these dredges are crane barges with spuds, steel piles that can be lowered and raised to position the dredge.

*Backhoe/dipper dredgers*: A backhoe/dipper dredger has a backhoe like on some excavators. A crude but usable backhoe dredger can be made by mounting a land-type backhoe excavator on a pontoon. The six largest backhoe dredgers in the world are currently the Vitruvius, the Mimar Sinan, Postnik Yakovlev (Jan De Nul), the Samson (DEME), the Simson and the Goliath (Van Oord). They featured barge-mounted excavators. Small backhoe dredgers can be track-mounted and work from the bank of ditches. A backhoe dredger is equipped with a half-open shell. The shell is filled moving towards the machine. Usually dredged material is loaded in barges. This machine is mainly used in harbours and other shallow water.

*Bed leveler*: Steam dredger Bertha, built 1844, on a demonstration run in 1982. This is a bar or blade which is pulled over the seabed behind any suitable ship or boat. It has an effect similar to that of a bulldozer on land. The chain-operated steam dredger Bertha, built in 1844 to a design by Brunel and now the oldest operational steam vessel in Britain, was of this type.

*Krabbelaar*: This is an early type of dredger which was formerly used in shallow water in the Netherlands. It was a flat-bottomed boat with spikes sticking out of its bottom. As tide current pulled the boat, the spikes scraped seabed material loose, and the tide current washed the material away, hopefully to deeper water. Krabbelaar is the Dutch word for "scratcher".

*Water injection*: A water injection dredger uses a small jet to inject water under low pressure (to prevent the sediment from exploding into the surrounding waters) into the seabed to bring the sediment in suspension, which then becomes a turbidity current, which flows away down slope, is moved by a second burst of water from the WID or is carried away in natural currents. Water injection results in a lot of sediment in the water which makes measurement with most hydrographic equipment (for instance: singlebeam echosounders) difficult.

*Pneumatic*: These dredgers use a chamber with inlets, out of which the water is pumped with the inlets closed. It is usually suspended from a crane on land or from a small pontoon or barge. Its effectiveness depends on depth pressure.

*Snagboat*: A snagboat is designed to remove big debris such as dead trees and parts of trees from North America waterways.

*Amphibious*: Some of these are any of the above types of dredger, which can operate normally, or by extending legs, also known as spuds, so it stands on the seabed with its hull out of the water. Some forms can go on land. Some of these are land-type backhoe excavators whose wheels are on long hinged legs so it can drive into shallow water and keep its cab out of water. Some of these may not have a floatable hull and, if so, cannot work in deep water. Oliver Evans (1755–1819) in 1804 invented the Oruktor Amphibolos, an amphibious dredger which was America's first steam-powered road vehicle.

*Submersible*: These are usually used to recover useful materials from the seabed. Many of them travel on continuous track. A unique variant is intended to walk on legs on the seabed.

*Fishing*: Fishing dredges are used to collect various species of clams, scallops, oysters or mussels from the seabed. Some dredges are also designed to catch crabs, sea urchins, sea cucumbers, and conch. These dredges have the form of a scoop made of chain mesh, and are towed by a fishing boat. Clam-specific dredges can utilize hydraulic injection to target deeper into the sand. Dredging can be destructive to the seabed and some scallop dredging has been replaced by collecting via scuba diving.

*Environmental impacts*

Dredging can create disturbance to aquatic ecosystems, often with adverse impacts. In addition, dredge spoils may contain toxic chemicals that may have an adverse effect on the disposal area; furthermore, the process of dredging often dislodges chemicals residing in benthic substrates and injects them into the water column.

The activity of dredging can create the following principal impacts to the environment:

* Release of toxic chemicals (including heavy metals and PCB) from bottom sediments into the water column.
* Collection of heavy metals lead left by fishing, bullets, 98% mercury reclaimed [natural occurring and left over from gold rush era.
* Short term increases in turbidity, which can affect aquatic species metabolism and interfere with spawning. Suction dredging activity is allowed only during non-spawing time frames set by fish and game (in-water work periods).
* Secondary impacts to marsh productivity from sedimentation.
* Tertiary impacts to avifauna which may prey upon contaminated aquatic organisms.
* Secondary impacts to aquatic and benthic organisms' metabolism and mortality.
* Possible contamination of dredge spoils sites.
* Changes to the topography by the creation of "spoil islands" from the accumulated spoil.
* Releases toxic compound Tributyltin, a popular biocide used in anti-fouling paint banned in 2008, back into the water.

The nature of dredging operations and possible environmental impacts cause the industry to be closely regulated and a requirement for comprehensive regional environmental impact assessments with continuous monitoring. The U.S. Clean Water Act requires that any discharge of dredged or fill materials into "waters of the United States," including wetlands, is forbidden unless authorized by a permit issued by the Army Corps of Engineers. As a result of the potential impacts to the environment, dredging is restricted to licensed areas only with vessel activity monitored closely using automatic GPS systems.

**5. Coastal urbanization and population pressures**

The urbanization of coastal zones has divided them into two main categories: Coastal areas characterized by high density of land uses and those with low building and population density. Their main difference lies in their economic performance. A new urban sprawl is normally developed, spatially following in a linear direction from the coast. This phenomenon is a direct effect of the improvement of transport systems, the increase of living standards and the importance of tourist activities and has led to negative effects on coastal biodiversity, a steady increase on demands for water resources and an increase of waste production and pollution. Urban sprawl has also negatively affected the urban coast’s quality of life, creating a population density that leads to problems concerning employment and exploitation of natural resources.

Main characteristics of coastal urbanization include:

* Tourist services
* A street pattern related to the landform and the surrounding natural features
* A direct relationship to the foreshore and a wide choice of uses associated with the coastal edge
* An extensive range of edge conditions, such as parks, beaches and waterfront promenades
* A range of smaller suburbs and suburban centers surrounding the city centre
* A full range of residential building types
* A full range of building heights from low scale to tall

Coastal Management and Urban Planning

Coastal management and urban planning seem to act in different contexts without a common ground for an integrated perspective of coastal cities. In particular, urban planning often ignores environmental issues that characterize a coastal ecosystem, creating land use conflicts and environmental aggravations. It is essential for an urban coast to offer a good quality environment for the users avoiding issues such as:

* Destroying the quality of coastal resources that offer the city its distinct characteristics
* Impacts on water quality
* Decrease of opportunities for new urban infrastructure
* Degraded public spaces
* Privatization of open spaces and foreshores
* Lack of planning integration

Cities in coastal areas require a special interest as they constitute important growth poles and gates to the hinterland as well as centers of economic growth involving human activities such as tourism, transport and fishing and sensitive environments and ecosystems.

The problems that coastal cities have to face might appear similar to the ones that most cities are also trying to overcome. The elements that make coastal cities different are:

The complexity of the activities that constitute a coastal city coming from the hinterland, creating (most often) conflicts and influencing their economy in a local and supra local level

The planning issues of coastal cities that involve a more integrated approach between urban planning and environmental management (coastal management).

Best practices

By including coastal zone issues in the city’s development plans, an integrated approach could be generated taking into account all the essential matters for the achievement of effective policies for both coastal/marine and urban activities. For example, the joint UN-HABITAT/UNEP Sustainable Cities Programme (SCP) provides support to many coastal cities worldwide in their efforts to integrate coastal management into city development strategies.

Best practices for coastal cities

* Protecting the most attractive quality elements of a coastal city
* Optimizing the efficient land use to minimize impacts on the surrounding urban and natural environment
* Maintaining the natural geography of the coast
* Maintaining the coast in connection to the inland (perhaps the city centre)-(best access to the coast, quality of streets etc.)
* Protecting coastal waters through modern ecological methods
* Providing sustainable transport systems
* Regulations governing the industrial, municipal and agricultural pollution
* Preserving the historic and cultural resources through the process of waterfront/urban regeneration
* Planning for the waterfront considering it as a part of a coastal (eco)system
* Optimizing coastal cities as a separate entity of the region that requires a more complex approach, including environmental policies/aspects

Coastal Cities Challenges

* Increase in population. Sixty percent of the world’s population already lives in coastal areas, while 65 percent of cities with populations above 2.5 million are located along the world coasts
* Seaward widening of the waterfront. Recent experience has proved that even artificial islands hosting human activities can be built out of nothing
* Changes in waterfronts (regeneration) could lead to upgrading ports and coastal areas and reduce or enlarge the range of economic inter-regional and international relationships of the city port
* Confrontation of service issues (e.g. transportation)
* Predictions about natural risks
* Urban sprawl control/restrictions
* Integration of urban planning with the concept of Sustainable Development
* Integration of urban planning with Integrated Coastal Zone Management (ICZM)
* Co-operation between private and public sector
* Protection of ‘hot spots’
* Protection of coastal resources
* Innovative approaches to existing policy areas

India's population along low- elevation coastlines is expected to witness a three-fold rise in the coming decades, says a new report on how climate change will bring devastating consequences to nations in Asia and Pacific.

According to the report, the projected population in Low-Elevation Coastal Zones (LECZ) in 2000 is 63.9 million.

This is, however, projected to increase to 216.4 million by 2060, the report by the Asian Development Bank (ADB) and the Potsdam Institute for Climate Impact Research (PIK) claims.

Under a business-as-usual scenario, a six degree Celsius temperature increase is projected over the Asian land mass by the end of the century.

Some countries in the region could experience significantly hotter climates, with temperature increases in Tajikistan, Afghanistan, Pakistan, and the northwest part of the People's Republic of China (PRC) projected to reach eight degree Celsius, it says.

The report titled 'A Region at Risk: The Human Dimensions of Climate Change in Asia and the Pacific' says that more intense typhoons and tropical cyclones are expected to hit Asia and the Pacific with rising global mean temperatures.

Under a business-as-usual scenario, annual precipitation is expected to increase by up to 50 per cent over most land areas in the region, although countries like Pakistan and Afghanistan may experience a decline in rainfall by 20-50 per cent.

Coastal and low-lying areas in the region will be at an increased risk of flooding, it says, adding that 19 of the 25 cities most exposed to a one-meter sea-level rise are located in the region, seven of which are in the Philippines alone.

The report says that Indonesia will be the most affected country in the region by coastal flooding with approximately 5.9 million people expected to be affected every year until 2100.

Increased vulnerability to flooding and other disasters will significantly impact the region - and the world - economically, the report notes.

"Global flood losses are expected to increase to USD 52 billion per year by 2050 from USD 6 billion in 2005," it says.

It adds that 13 of the top 20 cities with the largest growth of annual flood losses from 2005-2050 are in Asia and the Pacific namely Guangzhou, Shenzhen, Tianjin, Zhanjiang, and Xiamen (PRC); Mumbai, Chennai-Madras, Surat, and Kolkata (India); Ho Chi Minh City (Viet Nam); Jakarta (Indonesia); Bangkok (Thailand); and Nagoya (Japan).

To mitigate the impact of climate change, the report highlights the importance of implementing the commitments laid out in the Paris Agreement.

These include public and private investments focused on the rapid decarbonization of the Asian economy as well as the implementation of adaptation measures to protect the region's most vulnerable populations.

"Climate mitigation and adaptation efforts should also be mainstreamed into macro-level regional development strategies and micro-level project planning in all sectors, in addition to the ongoing renewable energy and technology innovation efforts in urban infrastructure and transport.

"The region has both the capacity and weight of influence to move towards sustainable development pathways, curb global emissions, and promote adaptation," the report concludes.

**Coastal resource management**

Coastal resource management -- CRM -- is about the sustainable use and management of coastal resources. One definition for CRM was supplied by Alan White and Nelson Lopez in a 1991 publication: comprise those activities that achieve sustainable use and management of economically and ecologically valuable resources in the coastal areas which consider interaction among and within resource systems as well as those of humans and their environment.

CRM is also referred to as ‘coastal management’, ‘coastal zone management’, ‘coastal area management’, and ‘integrated coastal management.’ In more specific terms, it means planning, implementing and monitoring the sustainable use of coastal resources. Accepted wisdom says the process must be participatory, that is, it must be consultative, multisectoral and interdisciplinary. It must consider the interconnectedness of the various ecosystems. It must encourage cooperation among individuals, among communities, among countries. It must, in other words, be rooted in the truth that we all share but one ocean.

CRMP’s approach to CRM was both holistic and integrated, covering a diverse set of project activities designed to bring about effective management of coastal resources at both the national level and the local level. To support the replication and sustainability of the project, activities were directed at enhancing the capability of national and local governments and the communities themselves to develop and implement resource management processes and systems.

Community participation was therefore an inherent and integral part of CRMP: Throughout the CRM process, we worked with and through a wide cross-section of coastal resource users, including fisherfolk, local governments, the national government, NGOs, the private sector, and POs.

CRMP included the following project activity components:

* identification and development of coastal leaders
* development and institutionalization of community-based CRM processes and systems
* local government capacity-building
* building constituency groups and empowerment of coastal communities
* training in skills relevant to CRM implementation
* policy analysis and formulation
* public education and social mobilization
* alternative enterprise development
* continuing research on and development of community-based CRM approaches

*Coastal Regulation Zone Rule*

The most important rule that is concerned with coastal zone is the notification under EPA 1986 issued in February 1991 declaring coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters as Coastal Regulation Zone (CRZ). The details of this notified act and the Ocean Regulation Zone Act to be notified by Department of Ocean Development to cover ocean part of the coastal zone are presented below.

**Boundary**: From the high tide line up to 500 m in the land-ward side. Area between the low tide line and high tide line. In the case of rivers creeks and backwaters, the distance from the high tide level shall apply to both sides and this distance shall not be less than 50 m or the width of the creek, river or backwater whichever is less.

**Category I (CRZ I):** Areas that are ecologically sensitive and important such as national parks, marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals, coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty, historically important and heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as notified by government from time to time.

**Category II (CRZ 11):** The areas that have already been developed up to or close to the shoreline. For this purpose, developed area is referred to as that area within the municipallimits or other legally designated urban areas which is already substantially built up and which has been provided with drainage and approach roads and other infrastructure facilities such as water supply and sewerage lines.

**Category III (CRZ III):** Areas that are relatively undisturbed and those which 'do not belong to either category I or II. These will include coastal zone in the rural areas (developed and underdeveloped) and also areas within municipal limits or in other legally designated urban areas which are not substantially built up.

**Category IV:** Coastal stretches in the Andaman and Nicobar islands, Lakshadweep and other small islands except those designated as category I, II and III.

*Ocean Regulation Zone*

**Boundary**: From the lowest low water line up to territorial sea water boundary (l2 nautical miles).

**Category I:** Territorial sea areas adjacent to mainland and Andaman and Nicobar and Lakshadweep islands that are ecologically sensitive and important such as those prescribed for CRZ 1.

**Category II:** Territorial sea areas adjacent to the coastal areas that have already been used for development such as

1. Construction of berths, warfs, navigational channels etc. in major and minor ports;
2. Sea off coastal industries, power plants, refineries and other industries;
3. Reclaimed areas, oil/gas transfer facilities;
4. Municipal limits of cities and towns;
5. Ship building and breaking areas;
6. Selil off beach resorts and marinas etc.

**Category III:** Territorial sea areas adjacent to the coastal areas which are yet to be used for developmental purposes (not used for activities mentioned under category II) and which have been used for developmental purposes to a limited extent (construction of fishing harbours and navigation) and also the sea areas between two developed areas.

As per CRZ notification, the coastal states must prepare a coastal zone management plan identifying and classifying the CRZ areas within 1 year from the date of CRZ notification i.e. February 1992, but in reality, till 1996 most of the states did not do it. The CRZ notification also stated that during the interim period till the coastal zone management plans are prepared and approved, all developments and activities within CRZ will not violate the provisions of this notification.

*Prohibited and Regulated Activities in Coastal Areas*

Land Part

• Prohibited activities:

As per the EPA 1986, Coastal Regulation Zone Notification 1991, the following activities are banned:

* + S~tting up and expansion of new industries, fish processing except those which require water front;
	+ Manufacture or handling or storage of disposal of hazardous substances and discharge of untreated waste and effluents from industries, cities or towns and other human settlements;
	+ Dumping of fly ash from thermal power stations and other solid waste dumping;
	+ Land reclamation, bounding or disturbing the natural course of sea water;
	+ Mining of sand, rocks and other substrate materials other than raw minerals;
	+ Drawal of ground water within 200 m of HTL;
	+ Any construction activity between the low and high tide line;
	+ Altering of sand dunes and other natural features including landscape changes.

• Permissible activities:

* + Construction activities due to defence;
	+ Construction of ports, harbours and light B;ouses;
	+ Construction of thermal power plants;
	+ All activities with investments exceeding Rs. 5 crores.

Ocean Part (proposed)

• Prohibited activities in category I:

In the ecologically sensitive areas, construction of civil and other man-made structures like breakwaters for harbour, floating industries, laying of pipelines, reclamation of sea and its bed, sea bed mining and ship breaking activities are prohibited. However, they can be permitted at a no-impact distance from the outer limit of ESA.

Discharge of untreated and treated domestic, industrial, aquaculture wastes, nuclear and thermal power plants, dredged materials and operational discharges are prohibited in ESA (may be permitted beyond no-impact distance from the outer limits).

• Permissible activities in Category II and III:

* + Waste disposal after proper treatment as per standards;
	+ Disposal from marine and brackishwater aquaculture as per the guidelines and standards;
	+ Construction of ports, harbours, breakwaters and dredging of navigational channels can be regulated according to the guidelines;
	+ Sea bed mining based on EIA Studies;
	+ Construction and operation of OTEC plants;
	+ Construction and operation of oil platforms;
	+ Movement of ships and tankers.

Fisheries Management

The existing Indian Fisheries Act was passed in 1897 and later amended in 1927 and in 1980. The objectives of these legislations are:

* to prohibit the use of dynamite in all waters within its jurisdiction,
* the prohibition or regulation of the use of fixed engines for the capture of fish and construction of weirs,
* the prohibition or regulation of the use of nets with a mesh below a minimum size,
* the prohibition or regulation of the capture of OR sale of all or any kinds of fish during any closed season,
* the total close of any water for a period not exceeding 2 rules thereunder,
* vesting with the government the exclusive privilege over chanks and chank fisheries.

**Further reading:**

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