

# COASTAL CITIES ON THE BENGAL DELTA – SUSTAINABLE DEVELOPMENT

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## **Abstract**

About 60 percent of world's population lives on or near the coast. Many large cities are located in coastal zone. The unsustainable pattern has damaged the ecosystem with construction, pollution, erosion, sedimentation, change of biodiversity and natural disasters. Due to climate change and sea level rise large amount of low elevation coastal areas will be submerged with entry of salt water. There are two strategies, often unrelated, reduction of green house gas, energy conservation and use of alternate source of energy and another is to control the effect of climate change especially in coastal zones, for which environmental parameters are to be identified with carrying capacity of ecosystem. The planning and development of coastal cities can not be isolated exercise but a holistic regional planning. Case study from Bengal delta has been given. It has Sunderbans Biosphere with rich biodiversity, mangroves, wildlife sanctuaries and rivers and canals. The biosphere protect the megacity Kolkata and smaller towns from natural disaster and principles of conservation, environment and developments are to be adopted.

**Keywords :** Aquaculture, Biodiversity, Carrying Capacity, Ecosystem, Climate Change.

## **1. Introduction**

Urbanization and civilization are associated with oceans and rivers and human settlements in the coastal areas grew due to maritime activities for trade or defense, recreation and other reasons. Throughout the world coastal areas have shown unprecedented growth of urbanisation but many areas are vulnerable to natural disaster and there are adverse environmental impact on fragile ecology, flora and fauna. The unsustainable pattern of development, reclamation, practice of agriculture and fishery, destruction of mangrove forests, coral reef and marine life, soil erosion or excessive sedimentation in estuaries, and canals and land use changes etc. are responsible for deterioration. The coastal wetlands are increasingly being polluted from oil spills, agriculture and urban waste. In some areas flooding is frequent with intrusion of salt water.

About 60 percent (3.6 billion) of the world population lives within 60 km. of the coast. According to the United Nations this proportion will rise to 75 percent (6.4 billion) in the three decades. Of the

world's 23 megacities (each more than 2.5 million population). 16 are in the coastal belt. An OECD report says that Kolkata (Calcutta) in India and Miami in USA will be at risk flooding of 2070 (Krieger, 2007). Besides the two cities, eight other cities will be vulnerable to coastal flooding and storm surge Mumbai, Dhaka, Guangzhou, Hochi Minh City, Shanghai, Bangkok, Yangon and Hiphong. The author is from Kolkata with concern for evolving a sustainable development of coastal area including coastal cities. At first impact of climate change on coastal cities will be studied and the need for integrated planning will be emphasized. At the end aqueous Bengal delta with megacities Kolkata and Dhaka will be presented.

## **2. The Impact of Climate Change**

Cities on the coast and many of them are in low land near the water – these will be affected by sea level rise in the climate change. There are three aspects – one is due to green house gas emission and development in the cities. Secondly the sea level rise due to global warming and the third is regional context when natural disaster like cyclone, flooding etc. affect the coastal cities and areas. These disasters are likely to occur frequently due to climate change. Many studies and research are being done and many scientific investigations are going on. One is due to pollution and green house gas emission, sulphur dioxide component cause quicker cloud formation and sequestration process in carbon storage in the oceans has been reduced and ultimately low pressure in the atmosphere is likely to be developed covering storm etc. A study in 2000 has calculated the low elevation of land near or on coast in all countries – China has 182000 sq.km. USA 235000 sq.km. India 82000 sq.km. Indonesia 177000 sq km, Bangladesh 54000 sq.km. etc. These areas will be submerged with sea level rise (McGranahan et al., 2007)

According to Intergovernmental Panel on Climate change (IPCC) average global temperature have increased by  $0.74^{\circ}\text{C}$  in the last 100 years, and the rate of sea level rise has increased in the last decade to 3.1mm/year compared to 1.8mm/year for previous years (IPCC, 2007).

The UN Human Development Report 2007/08 has mentioned the serious challenges of climate change, the unprecedented phenomenon and identified five areas of concern (a) Agricultural production (b) water stress and water in-security (c) Rising sea levels and exposure to climate disasters (d) ecosystems and biodiversity and (e) human health (UNDP, 2008). Coastal cities and their hinterland are affected by all these.

Both the cause and effect are to be analysed. There are now studies on green buildings and green cities. There are energy conservation codes, utilisation of solar and other renewable energy, greening with plantation, use of bicycle and public transport, pedestrian walkway, use of sustainable construction and building materials etc. Two low carbon cities are being planned, one is Masdar, Abudhabi, other is Dongtan, China. Different organizations like Royal British Institute of Architects are issuing directives to design low carbon buildings and cities. However in already existing coastal cities it is difficult to implement the rules.

There are new innovations if low elevation areas are submerged. Elevated plinth, drainage system and creation of wetlands, lagoons, afforestation specially in mangrove forest, adoption of salt resistance crop, rainwater harvesting both big and small and creation of wetlands, lagoons for storage of water for developing aquaculture.

Many people living in coastal areas of many developing countries do not have access to proper water supply and sanitation with depletion of ground water, aquifer level has come down and there is salt water intrusion. The ground water has also become contaminated with various chemicals affecting health and hygiene of people.

The World Heritage Centre, Unesco is concerned about the impact of climate change on world heritage site, especially those located near the coastal areas. It calls for research into both natural and cultural heritage. It says (WHC, 2008).

(a) Understanding the vulnerability of materials (indoor, outdoor) to climate variables (with much and little moisture effects). (b) Understanding how traditional materials and practices need to adopt to extreme weather events and changing climates. (c) Development of safe methods and technologies for monitoring impact of climate change on properties. (d) Understanding climate change impacts, livelihoods, and their relation with their heritage.

Global Water Partnership, Stockholm in a policy brief on climate change says “If our global energy habits are the focus for mitigation, the way we use and manage our water must become the focus for adaptation”. It is said further that ‘change in climate will be amplified in the water environment’ (GWP, 2008). Where water availability is reduced water habit is to be changed with conservation of water. Hydro electricity will be reduced and on the other hand more rainfall means additional cost of flood protection and drainage. If stream flow is reduced dilution of pollution becomes slow, sea water

intrusion will decrease the fresh water and bringing water from distance will be expensive. A public awareness is necessary.

On the other hand Global International Waters Assessment (GIWA), Kalmar, Sweden (GIWA, 1999) has published causal chain analysis focusing five problem areas and 23 issues which are

- 1) *Freshwater Shortage* - Reduction in stream flow, pollution of existing water supplies, lowering of the water table.
- 2) *Pollution* – Microbiological pollution, eutrophication, chemical pollution, suspended solids, solid wastes, thermal pollution, spills etc..
- 3) *Habitat and Community Modification* – Loss of ecosystems or ecotones, modification, of ecosystem or ecotones including community structure and/or species composition.
- 4) *Unsustainable exploitation of fisheries and other living resources* – Inappropriate harvesting practices, resource habitat changes, habitat destruction, decreased viability of stock through contamination and man induced change in the physical environment and biodiversity impacts.
- 5) *Global Change* – Changes in hydrological cycles, sea level changes, increased UV – radiation result of ozone depletion, change in ocean carbon dioxide source / sink function.

Human activities and their environmental impact are also widespread. These are listed by UNCHS (1996) under (i) urban activities (ii) rural activities and (iii) sea based activities. Risk assessment and disaster management including prevention, mitigation, preparedness, response and recovery is an essential element of a safer world in the 21st Century. The Tsunami or sea earthquake in the Indian ocean (December 26, 2004) has shaken the conventional concepts of development on the coastal area for fishing, port, industry, tourism, recreation, human settlement etc. The deforestation and destruction of mangroves and coral reefs aggravated the impact of tsunami.

After the tsunami, besides, relief and rehabilitation, some adhoc measures were taken up and suggested – Developing a safe zone, developing early warning system, developing earthquake and flood resistance building, building walls, hills, and safety structures drainage system, infrastructure development, developing a culture of prevention, education training and capacity building strengthening local governments and participatory process.

After the tsunami most governments imposed coastal zone regulations with no development on shore, like India 200 m, Sri Lanka 100 m, Indonesia 2 km and Thailand 40 m and suggested alternative

rehabilitation elsewhere but most people wanted to come back to original place. Various NGOs have helped the people to adopt people oriented rehabilitation.

### **3. Integrated Coastal Planning and Management**

Integrated Coastal Zone Management (ICZM), International Coastal Planning and Management (ICPM) and other names describe various studies and research as well as international recommendations in the last one or two decades. Sorensen (1993) defines the integrated coastal planning and management as follows “A dynamic process in which a coordinated strategy is developed and implemented for the allocation of environmental, socio cultural and institutional resources to achieve the conservation and sustainable multiple use of the coastal zone”. Cecin-Sain (1993) identifies five functions of ICZM :

- (a) Area based planning, based on an analysis of the interrelationship between the physical and ecological processes and human activities in the coastal area including resources utilisation, regulation of new development and planning for future uses.
- (b) Conflict resolution and the mitigation of industrial impact.
- (c) Stewardship including preservation of the integrity of ecosystems and environmental quality through pollution control and conservation.
- (d) The protection of the general public through the reduction of vulnerability to natural hazards.
- (e) The achievement of a balance between environmental protection, appropriate economic development and cultural values.

Doumenge mentions about basic concepts for a coastal management action plan (a) carrying capacity (b) limits of acceptable change, and (c) integrated coastal zone management. Carrying capacity is the threshold level and four types have been mentioned by Shelby and Heberlein (1984)

- (a) Ecological capacity (ecosystem parameters). Zoological capacity can be used to indicate the general productivity or ecosystem performance.
- (b) Physical capacity (space parameters). Physical capacity belongs to the nature and dynamics of ground coastal morphology induces specific biota, sandy beaches, muddy flats, mangroves, and coral reefs. There are other areas like lagoon, estuary etc. which many change.
- (c) Facility parameters (Development parameters) – manmade improvements.
- (d) Social capacity (experience parameters). Social capacity reforms to inputs – level of use and education is important.

The nature of impacts should be identified. Doumenge says that overall carrying capacity is not always based on natural resources but also on social, economic and physical aspects.

#### **4. The Aqueous Bengal Delta**

A delta is a low water land at the mouth of river/rivers. It is formed from the silt, sand and small rocks which flow downstream in the river and are deposited in the delta. It is often shaped like a triangle and it is named after the Greek letter 'delta'. Bengal delta formed by two great rivers, the Brahmaputra and the Ganges, many small rivers, tributaries etc. is the largest in the world, located in eastern India and Bangladesh facing the Bay of Bengal. Over the centuries the lower gangetic delta was formed which was aqueous by deposition of debris and sedimentation (Chowdhury, 1994). Asian deltas are mostly located on long tide – dominated coasts. According to Dr. Yashiko Saito, tectonic subsidence has caused local sea level to rise on a millennial scale with region of Ganga-Brahmaputra delta resulting in a concave shoreline topography with features such as transgressive estuaries, in contrast to other mature Asian Deltas, which exhibit convex topography (Saito, 2002).

The Sunderbans (In Bengali language, Sunder means beautiful and ban is forest) is rich in terrestrial, aquatic and avian faunal species and has 40% of 1 million ha water and land. The Unesco has declared it as one of the biospheres, rich in flora and fauna and world heritage site is about 9630 sq km in. It includes wildlife sanctuaries. The tidal swamps and estuaries are degraded by deforestation, unsustainable farming practice, cities, villages small islands, mangrove forests etc. These areas were identified as core area, buffer area and transition area.

The Unesco's programme outlines three functions (a) conservation function preserving flora, fauna, landscape etc. (b) development function sustainable development of social, culture economic and ecological aspects (c) support to logistic function – education, training and capacity building. Initially World Heritage Site was 1400 sqkm, 910 sq km land and 490 sq km of water was earmarked. Wider areas have been declared as reserve forests and total Sunderbans area is 9630 sq km. Some islands have been reduced in area and some have been vanished due to soil erosion and subsidence. A few appeared again due to sedimentation. Two large megacities of Asia, Kolkata in India and Dhaka in Bangladesh are located on the top of delta and there are other towns and some are on the islands on the coast. The conflict exists between man and nature. The delta is an ecosystem. Conservation, environment and development are to be promoted in an integrated holistic plan.

Besides Kolkata Metropolitan area, with 15 million people, there are about 4 million people in Indian part of Sunderbans and the entire population is scattered in different patterns of human settlements. Towns have smaller population but migratory population in fishing and seasonal agriculture harvesting add more people. For example in the small town on Sagar island, from one fourth to one half million people come for a religious festival each year. The planning and development of coastal city cannot be an isolated land use planning exercise but a holistic process is advocated integrating different sectors and achieving an equilibrium balance with the density of population and the carrying capacity of ecosystem.

About 7000 years ago Sunderbans was submerged in the Bay of Bengal. Bengal delta grew due to upstream sedimentation (Mukherjee, 2007) Kolkata was built on marshy land. Traces of Sundari tree were found in underground construction of metro railway.

Mangroves are part of coastal ecosystem which has high degree of biological diversity, mangroves help in the protection of coastal areas and towns from cyclone and other disasters. It helps in carbon sequestration. Mangrove has originated from the Portuguese word 'mangue' meaning community and the English word 'grove' meaning trees or bushes. Mangroves have helophytic plant species and provide fuel, timber, fishes etc. But human habitations and unsustainable pattern of developments have caused deterioration – agriculture practice, prawn culture, deforestation and habitations together with pollution from nearby industries, water disposal, tourism facilities, construction of port/harbour and oil spill etc. Some sea based activities are also responsible. Due to sedimentation, rising beds of rivers and canals often cause water logging and there is intrusion of salt water also.

According to FAO Survey mangroves in Asian countries was 6661717000 ha in 1991 which became 5832737000 ha in 2000. In some countries management has been taken mostly in economic term but mangrove management is management of ecosystem. (FAO, 2003). Coral reefs are being damaged due to bleaching and due to a number of factors like coastal erosion, canal subsidence, off shore drilling and sand mining, construction, tourism etc. (Yelmin, 2008).

Different countries have enacted legislation on townplanning and development control in connection with coastal regulation zone. The Govt. of India has issued notification in May 2008 replacing the earlier one 1991 (GOI, 2008). The four categories of coastal management zones have been kept

- (a) Areas between high and low tide line and ecological sensitive areas like mangroves, biosphere, sanctuaries etc.
- (b) Areas clearly developed and close to shore line, heritage areas, foreshore activities, ports.
- (c) Undeveloped area, rural areas.
- (d) Special areas, island etc.

The previous set back of 500 m from shoreline has been replaced by vulnerability factor to natural and manmade disasters. This is based on elevation, geomorphology, sea level trend and horizontal shoreline development (erosion or accretion) Permissible activities have been listed.

The Bengal delta specially the Sunderbans is a ecosystem and planning will be different.

Methodological guide to integrated coastal zone management by Unesco's Intergovernmental and Oceanographic Commission (Unesco, 1997) identified three categories of problems

- (a). Problems generated by the direct effect of anthropogenic activities on the local environment.
- (b) Problems generated by the effect of natural phenomena on human settlements.
- (c). Problem generated by the interaction of the multiple activities developed in coastal zones.

These types of qualification criteria of coastal space were identified

- (a) Physical criteria
- (b) Biological criteria
- (c) Human Activity criteria
- (d) Environmental status criteria.

A regional environmental plan based on analysis of interrelation amongst physical, spatial development and environmental ecological process and human activities and socio-economic objectives is necessary.

The following are some suggestions for study for preparing the coastal zone integrated management plan within context of climate change (Ghosh and Kirtikar, 2005).

- (a) A comprehensive study with inventory on urban rivers, canals, wetlands etc. from physical, ecological, social and economic aspects.

- (b) A longrange regional environmental plan for water basin, coastal zone including urban water system on or near the coast.
- (c) Restoration of rivers, lakes, canals including dead rivers and dried up water bodies.
- (d) Development of water transport and water front development without disturbing the ecosystem.
- (e) Preservation of natural and historic area and biodivesity area including flora, fauna, mangroves.
- (f) Measures to mitigate waterlogging and flooding of urban flora including drainage and storage.
- (g) Abatement of pollution of ground area and surface water . Removal of unauthorised encroachment with alternate accumulation.
- (h) Productive use of rivers estuaries and wetlands for developing fisheries and aquatic resources and adjustment of new agriculture practices.
- (i) Impact analysis of construction of dams, bridges, enginaring and building construction
- (j) Introduction of participatory process and citizen's involvement.

## 5. Conclusion

Kolkata Metropolitan Area of about 1800 sq km is on the top of Bengal delta. Kolkata is connected with bay of Bengal with rivers, canals and wetlands. Though about 80 km from sea shore line it has low elevation 0.5 to 1.5 m above mean sea level. Every munsoon the streets are flooded, with global warming and sea level rise this metropolis will likely to be submerged in future. On the other hand Dhaka in Bangladesh, is on high land some areas about 2.5 m above mean sea level but on south and eastern side, vast areas are very low and large area is likely to be submerged. Coastal city is not necessarily a city near shore line but a city connected with sea and affected by sea. A regional environment ecological plan with land and water is required.

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