Coastal lagoons, Estuaries and Coral reefs: Vital Coastal ecosystems providing a wide array of services and its threats

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ABSTRACT

Marine ecosystem is considered as the hub of divergent and dynamic ecosystems with varied ecosystem and provisional services under its ambit. The current review discusses about three most important coastal ecosystems - Coastal lagoons, Estuaries and Coral reefs. The review outlined about the features of coastal lagoons, estuaries and coral reefs. Coastal lagoons and estuaries provide a range of ecosystem provisions which comprises of support to fisheries, effective cycling of nutrients, a source of biodiversity, buffer against varied sea inundations and water filtration. Particularly, the role of coastal lagoons and estuaries acting as a buffer against an array of sea inundations - cyclones, floods, sea surges and others in the context of climate change is remarkable and noteworthy. The cause for concern is different threats, for instance, pollution, habitat degradation and climate change deleteriously affects both the coastal lagoons and estuaries. The review also discusses about coral reefs ecosystem, which serve as a hub of bio diversity besides providing varied provisional services viz… coral aquaculture, gardening and farming and varied applications in bio medical and clinical research. Just like the coastal lagoons and estuaries, coral reefs also deleteriously affected by factors viz… anthropological establishments, dangerous fishing practices to coral bleaching and climate change. Therefore, keeping in view of not just because of varied services provided by these valuable ecosystems, but also for nature's ecological balance, these valuable ecosystems should be conserved in a sustainable way.

Introduction

Under the head of aquatic ecosystems on planet earth, the largest is the marine ecosystem. Marine ecosystems not only provide a myriad of ecological and economic services to the humans, but also sustain the biological, physical and chemical processes of the biosphere. At the global level, the multifarious services provided by the marine ecosystems comprising majorly of carbon sequestration, O_2 production and nutrient cycling and at local/regional level marine ecosystem provides key services like cultural, bioremediation, most importantly shoreline protection and others (MARBEF, 2008). Different and divergent types of ecosystems come under the ambit of marine ecosystem for instance, coral reefs, estuaries, lagoons, mangroves, mudflats, salt marshes, deep sea, pelagic ocean &intertidal zones. One of the fragments of marine ecosystem is coastal ecosystem. In this review we would discuss about three most important coastal ecosystems - Estuaries, Coastal lagoons and Coral reefs. Highly Productive

Coastal Ecosystems situated along the margins of both oceanic islands and continents (Miththapala, 2013). The ambit of coast comprises of a number of divergent ecosystems starting from mangroves, coral reefs, estuaries, lagoons, sand dunes, tidal flats, salt marshes and sea meadows. Individual coastal ecosystems are unique in their way in the way of supporting a number of species and a wide variety of provisional services which are significant to human being (Miththapala, 2013).

Such unique and significant coastal ecosystems are under intense pressure owing to a multitude of anthropogenic driven threats which embodies habitat fragmentation / degradation and destruction to over exploitation, pollution and climate change, which specifically requires no introduction (Miththapala, 2013).

Objectives of the Review

➢ An Overview on the Ecological Characteristics of Coastal lagoons, Estuaries and Coral reefs.
➢ To Assess the Ecological and Provisional services of Coastal lagoons, Estuaries and Coral reefs.
➢ Review of varied threats affecting Coastal lagoons, Estuaries and Coral reefs.

I. Coastal Lagoons

Coastal lagoons, are a shallow coastal stretch of water where in, by means of a barrier separates from sea (or) ocean. Coastal lagoons and Oceanic (or) Atoll lagoons are the two types of lagoons. (Kennish and Paerl, 2010; Kjerfve, 1986; 1994). Various kinds of coastal and geological structures may act as barriers ranging from sand bar, barrier islands, coral reefs, shingle / spit and less often rocks (Kjerfve, 1994). Atoll / Ocean lagoons are lagoons encircled by string of coral islands (or) circular coral reef (Miththapala, 2013).

Coastal lagoons sprawl parallel to the stretch of shoreline, their length is longer than their width (Kennish and Paerl, 2010). Rarely the coastal lagoon's depth goes beyond few meters (Kjerfve, 1994). Depending on the way the water is exchanged between ocean and lagoon, coastal lagoons are of three types 1. Choked 2.Restricted and 3.Leaky (Kjerfve, 1994). A narrow channel to sea / ocean is present in choked lagoons, where restricted lagoons found to contain wide channel (s) to sea / ocean (Kjerfve, 1994). The formation of coastal lagoons as a shallow basin in the proximity of the shore is at-tributed to the small tidal range, which is the key topographical feature (Isla, 2009). Sparing Antarctica, coastal lagoons sprawls in all continents and its length is longer than width. Across the global coasts, the share of coastal lagoons is around 13 % (Kennish and Paerl 2010). The share of coastal lagoons across the coasts of different continents is as follows, with Africa being highest in percentage of coastal lagoons with 17.9 %, the rest in descending order : North America – 17.6 % ; Asia – 13.8 %; South America – 12.2 % ; Australia – 11.4 % finally, the least comes from Europe with 5.3 % (Barnes, 1980).

II. Estuary: An estuary is a coastal ecosystem where river meets the sea. Estuaries represented as coastal transitional bodies from terrestrial to marine ecosystems, besides from fresh water to marine water ecosystems (https://archive.epa.gov/water/test/web/html/index-4.html). The distinction between estuaries and lagoons is with respect to Hydrological dynamics where in, the nature of water in lagoons is shallow with sluggish flow water. In estuaries, there is a strong and fast flow of water (Miththapala, 2013). Generally, estuarine water depth is deeper than lagoons (Kjerfve, 1986). Estuary found to contain three zones; First zone found to contain more fresh water, second zone contains equal mix of salt and fresh water; the third and last zone mostly contains salt water (http://www.nhptv.org/natureworks/nwep6a.htm)**.**

Coastal lagoons and Estuaries; a unique source of Ecotones

The unique landscape of estuaries and lagoons sprawling at the transitional juncture of marine and terrestrial ecosystems embodies diversified ecosystems ranging from fringing mangroves, salt marshes, sand dunes, barrier islands, beaches, sea grasses and spits. Lagoons and estuaries besides representing dynamic land scape of ecosystems also encompass 3 unique ecotones. Ecosystem which sprawls in ecotone 1 ranges from mangroves, inland terrestrial vegetation, varied submerged vegetation for instance, sea grass mangroves and salt marshes. Ecotone 2 comprises of beaches and Open Ocean stretching from estuary / lagoons to shore line of oceans, sand dunes and salt marshes vegetation. Ecotone 3 confines to aquatic body traversing as per the salinity gradient begin from freshwater island – brackish water – marine water at the opening of the sea (De wit, 2011). It is clearly indicates that since

estuaries and lagoons harbours unique and diverse ecosystems, in turn encompasses wide range of biodiversity (Kennish and Paerl, 2010). The genesis of estuaries and coastal lagoons attributes to sea level rise, dates back to early Holocene (12,000 to 8,000 years ago) (Kjerfve, 1994). In fact, Coastal lagoons and estuaries constituted by the mud flat / marsh fillings occupies a greater percentage of the coasts across the globe (Day and Yáñez-Arancibia, 1982).

Ecosystem provisions of Coastal lagoons and Estuaries

i. Support to fisheries and livelihood: The resources of both estuaries and Lagoons are essential for the flourishment of coastal fisheries in the way of number of edible fish and shell fish which in habituates the estuaries, lagoons, mangroves and sea grasses (as associated bodies) (Miththapala, 2013). The practice of artisans and traditional fisheries relies on the tranquil habitats of lagoons (Bjork *et al.,* 2008).

Number of shell and fin fish consider estuaries and lagoons as breeding and nursery places (Amarasinghe, 1997; Beck *et al.,* 2011; Samarakoon and Samarawickrama, 2012).

All along the srilankan coastal stretch of 1,340 km both estuaries and lagoons sprawls in such a way that it sustains the coastal livelihood which amounts to 5, 00,000 people (2% of total srilankan population). The financial tally of over 5 billion rupees (39.6 million US $) generating from fisheries, which are supported by estuaries and lagoons (Samarakoon and Samarawickrama, 2012).

Coastal fishermen consider estuaries and lagoons as places for anchoring their vessels (Samarakoon and Samarawickrama, 2012).

ii. Efficient Nutrient cycling: The nutrients do enter lagoons and estuaries, cycling of nutrients is performed followed by exchange of nutrients with the open ocean (Kennish and Paerl, 2010). As far as flushing rates are concerned, it is low for lagoons and therefore, nutrients are subjected to multiple cycling prior to their exchange with ocean culminating to higher primary production (Kennish and Paerl, 2010).

iii. Coastal lagoons and Estuaries: Hub of coastal biodiversity

Owing to the high ability of coastal lagoons and estuaries with respect to primary production and effi-

cient cycling of nutrients, which in turn supports rich coastal bio diversity. The huge bio diversity of coastal lagoons and estuaries and relies on the divergent ecological diversity of lagoons, estuaries, mangroves, sea grass meadows, deltas, beaches and tidal mud flats all comes under the ambit of landscape of lagoons and estuaries (Miththapala, 2013).

iv. As Buffer zones against varied sea inundations

Owing to its interface and transitional location at the juncture of sea and land, lagoons and estuaries serve as buffering zones guarding coastal communities against varied sea inundations – cyclones, floods, storm surges and related, in the way of dissipation of discharge of river, wave action dampening and storing of water provisionally, therefore, we can decipher that lagoons and estuaries serve as gigantic sponges (Miththapala, 2013).

v. Sedimentation trap and water filtration: Diversified habitats sprawling within the landscape of estuaries and lagoons, for instance, mangroves, sea grass meadows and salt marshes serve as mega filters to extract harmful pollutants, excess nutrients, industrial and municipal waste water originated sediments and run off from storm water (Miththapala, 2013).

Threats to Coastal lagoons and Estuaries

The Quality of Hydrological aspects is the deciding factor for the substance of lagoons and estuaries (Samarakoon and Samarawickrama, 2012). Diverse anthropogenic activities become a deterrent to the healthy status of Lagoons and Estuaries (Kennish and Paerl, 2010). Notable anthropological factors which affect the ecosystem quality of Lagoons and Estuaries are unplanned and uncontrolled anthropological developments and over population (Kennish, 2002). The current review paper discusses about the major threats to lagoons and estuaries.

i. Point and Non point source pollution

Point Source pollution refers to the existence of a contaminated area in a specific location either at (or) in the proximity of pollution source (Miththapala, 2013) for instance, occurring of a toxic water spill at a specific location (Loage and Corwin, 2005) similarly, shrimp farms are the areas of source pollution discharging polluting effluents into the water, which is also the water source. The resulting pollutants are due to the addition of a combination of artificial feeds, comprising of insecticides and additives be-

sides antibiotics which all enhance the shrimp growth (Miththapala, 2013). The effluents released by the shrimp farms reported to contain higher B.O.D levels (60 – 180 mg /l) and suspended solids (200 – 600 mg /l) (Dayaratne *et al.,* 1997).

Non point source pollution refers to a number of smaller spatially distributed sources diffusing into ecosystem, for instance, urban, agricultural and industrial run off which are directed to estuaries and lagoons (Loage and Corwin, 2005). Similarly, eutrophication resulting from higher quantities of phosphorous and nitrogen added through agricultural run off (Gamito *et al.,* 2005). The Zhu Jiang River, which opens into the South China Sea, where in, harmful algal blooms (HABs) which are sprawled in the river resulting to the mass mortality of fish in 1988, incurring heavy financial losses culminated to 45 million U.S.D (Wang *et al.,* 2007).

ii. Sedimentation

In order to increase the quality of living and economic growth in number of Asian countries, which results to adversarial changes in land use pattern and establishment of anthropological developments in turn modify the patterns of sedimentation (Miththapala, 2013). Raise in sedimentation levels in water increases the quantity of suspended materials there by increasing levels of turbidity, which lowers the availability of sunlight, culminating to effect of food web in concerned water bodies (Kennish and Paerl, 2010).

iii. Habitat degradation: Habitat degradation that takes place in the catchment area of the inland with respect to lagoons, and river with respect to an estuary had detrimental effects on lagoons and estuarine ecosystems (Miththapala, 2013). Onsite wetlands reclamation for the development of aquaculture, agriculture and infrastructure culminates to cascading impact on the ecosystem of lagoons and estuaries where in, adversarial changes in the composition of species is a matter for concern (Kennish, 2002). Habitat degradation severely affects the coastal ecosystem across the globe (Michelle *et al.,* 2009; Duarte *et al.,* 2008; Kennish, 2002).

iv. Climate change: Climate change is the most detrimental factor which the modern man is facing today where in, the latter is the cause of the former. The annual carbon dioxide (CO_2) emissions rise by about 80 % between 1970 – 2004. The level of CO_2 increased by twelve fold during the 20th century

rise in greenhouse gases emissions (CO_2 and CH_4) leads to global warming (Miththapala, 2013). All these detrimental aspects of climate change will deteriorate the ecosystems of estuarine and lagoons. Temperature variations may leads to rise in evaporation, salinity variations besides affecting the dissolved oxygen in aquatic bodies which in turn, severely effects the fauna and flora of the estuaries and lagoons. Rainfall variations may also drastically effects the freshwater inputs along with rise in upstream sedimentation (Miththapala, 2013). The banks of estuaries and lagoons could be subjected to the risk of erosion owing to accentuation of storms (Anthony *et al.,* 2009).

iii. Coral reefs

Corals belonged to the Class - Anthozoa; Phylum - Cnidaria, which are the unique marine animals secreting calcium carbonate exoskeleton. Coral reefs are majorly formed by the coral types – Scleractinian corals, coralline red algae and hydro corals. Reefs are nothing but coral polyps colonies and majorly are of three types – Fringing, Barrier and Atoll (Knowlton and Jackson, nd). The age of modern coral reefs dates back to under 10,000 years where in, rapid Holocene sea level rise drowned the older reefs (Hubbard, 1997). Nearly a million coral species may in habituate coral reefs, and over 10 % of it has been taxonomically identified (Reaka-Kudla, 1997). The true stony corals which comprises of anthozoa and scleractinia and stony hydrozoans, milleporina particularly are the two major groups of anthozoans which are the primary builders of coral reefs (Knowlton and Jackson, nd) and are considered as hermatypic corals (Maragos *et al.,* 1996). Corals undergo both asexual and sexual reproductions where in, asexual propagation ways in corals are many and divergent (Kramarsky - winter and Loya, 1996; Kramarsky–winter *et al.,* 1997; Richmond, 1997) with fragmentation is the major way of asexual propagation (Highsmith, 1982; Richmond, 1997). Zooxanthellae, which are the Dinoflagellate algae leads a mutualistic association with corals (Trench, 1987; Muscatine, 1990; Falkowski *et al.,* 1993; Rowan, 1998). Though the share of Coral reefs is under 0.1 % of the floor of the ocean, but encompasses multitude services in the way of higher bio diversity and a wide range of pivotal ecosystem provisions for instance, coastline protective role, home ground for fisheries and a tourist hub owing to its scenic beauty (Wild *et al.,* 2011). A massive scale of around 275

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million people in habituate within 30 km range of coral reefs (Burke *et al.,* 2011) where in, such an enormous number of people would depends on coral reefs, which provide varied ecological services comprising of Regulating services – Protection of shore line and maintenance of water quality; Provisioning services - Livelihood, particularly for fishermen, food and medicinal products and Supportive services – Nutrient recycling and primary production (Hoegh – Guldberg, 2011).

The Ecosystem of Coral reefs is the hub of species diversity (Talbot, 1994)

The revitalization and sustenance of coral reefs is attributed to its versatile biodiversity in the way of presence of sea urchins, reef fishes, coralline algae and many other additional animals and plants species for instance, coralline algae aids in cementing coral reefs (Maragos *et al.,* 1996). Nearly one third of global coral reefs are coming from south east asia, which is considered as the cradle of biodiversity (Maragos *et al.,* 1996). The number of coral species in the Caribbean region is higher than 48 (Goreau and Wells, 1967) where as higher than 700 coral species occurred in Indo – Pacific region (Wells, 1957; Veron, 1986). The inception of coral species dates back to around 300 milion years ago sprawled in the erstwhile Pangaea continent i.e prior to continental drift (Veron, 1986).

Provisional services of Coral reefs

Coral Aquaculture: Rise in anthropological demand for corals leads to the flourishment of coral aquaculture on commercial lines (Subha, 2013). People belongs to different walks of life starting from scientists, researchers, business men and traders of ornamental business, practice coral aquaculture owing to profitable trade coral ornaments, at the same time private firms also practise coral aquaculture (Pomeroy *et al.,* 2006).

Gardening and Farming: Coral replantation and Coral reef construction of the damaged and lost coral reefs is possible by the coral aquaculture facilitated gardening and farming (Rinkevich, 2008).

Biomedical research and Climatic research applications: Coral reefs are widely explored for biomedical research, as the same had therapeutic role in AIDS, Cancer and other health oil ailments besides, coral reefs also employed in orthopaedic surgeries in the way of bone grafting (Subha, 2013). The deep sea

bamboo corals form growth rings during the coral development, which becomes an indicator and a pivotal tool in the assessment of aging site and for construing and research of current climatic scenario (Smithers and Woodroffe, 2000).

Threats to Coral reefs

Researchers suggest that in the present global coral population, 10% of the corals have been lost, whereas anthropogenic encroachments pose risk to atleast 60 % of coral reefs especially in the south east asian region and the threat of deleteriousness to the coral reefs amounts to 80 % (Tun *et al.,* 2004).

Anthropological establishments causing adversarial effects on coral reef ecosystem

The development of anthropological establishments and infrastructure which generally takes place in the proximity of urban centres poses heavy risks to coral reefs eco system in the way of change in the land use pattern and clearance for construction of residents, varied agricultural practices, animal husbandry particularly livestock grazing leading to soil erosion which culminates to the deterioration of the valuable ecosystem. In addition to it, varied man made infrastructures ranging from harbors, roads, channels, shore protection constructions, air fields, sewage units to different industrial establishments all impacts the harmony of coral reefs ecosystem (Maragos *et al.,* 1996).

Deleterious fishing practices a cause for concern

Use of deleterious and detrimental fishing practices for instance, employing illegal gear, poisons and dynamite which are against the law causing heavy damage to coral reefs. Illegal anchorage of foreign fishing vessels as remote and mostly uninhabited coral islands and atoll reefs to poach giant clams species which are rare. Such deleterious fishing practices pose heavy risk to the ecological sensitivity of coral reefs (Maragos *et al.,* 1996).

Coral bleeching and Climate change

The most detrimental aspect of climate change with respect to coral reef ecosystem is mass coral bleaching and death (Gattuso *et al.,* 2014). Similarly, ocean acidification triggers chemical dissolution and biological erosion of coral reefs, which culminates to lowering of biodiversity, coral calcification intensity besides rising the dissolution rate of coral reef frame work and the reef forming corals were deleteriously

effected by the synergistic effects of ocean acidification and ocean warming (Gattuso *et al.,* 2014). Bruno and Selig, 2007 reported that in number of south east asian and pacific coral areas, there is a steep declining of plenty of corals which forms the reefs @ 1 – 2 % per annum for the period 1968 – 2004.

Conclusion

From the review, it can be deciphered that all the three discussed coastal ecosystems - coastal lagoons, estuaries and coral reefs provides a multifarious ecological services, which will benefit not only human but also maintain nature's ecological integrity. But, such valuable ecosystems are under intense anthropological stress particularly in the way of climate change and habitat degradation. Therefore, the onus rests on the humans to revitalize such magnificent ecosystems, which has to be done by formulating and implementing norms at global, national and regional level specific to individual ecosystems. Integration of vital stake holders in this regards may leads to holistic and sustainable development of coastal lagoons, estuaries and coral reefs.

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