Magnificent Mangroves – for sustainable development

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Abstract

The Mangroves form a very unique ecosystem characterized by a range of features displayed by this dominant vegetation of the subtropical and tropical areas, found in the tidal and intertidal regions of several countries of the world. Mangroves play the roles of providers, protectors and processors at the same time. They are rich in terms of food resources; they can withstand the furies of nature in terms of velocity of winds and storms as well as act as filters in polluted environments. They have an exceptionally high potential for carbon dioxide sequestration. The challenges of climate change are real and will need a combination of interventions in which mangroves have the potential to give a greater return on investment than many other efforts. It is a rich natural renewable resource but unfortunately mangrove areas are rapidly declining due to coastal development, logging, tourism, aquaculture, overexploitation due to foraging and most of all due to ignorance of the dearth of benefits they can offer humankind. Conservation of should be taught early through formal and informal forms of education.

Key Words: unique eco system**,** front-line defense, socio – economic benefits, conservation.

Introduction: The mangroves are a very unique category of plants lacing the delicate edges where the land meets the sea. They are the life lines of the coastal regions (Chavan, Gokale & Telave, 2007). They are the most productive ecosystems in the world and are extremely important coastal resources, which are vital for socio–economic development besides holding numerous benefits to humankind. Several studies have shown that the dense green canopies of the mangrove forests have an unusual potential to act as powerful carbon dioxide sinks, (Suratman, 2008), (Bouillon, Borges, Castañeda-Moya, et al. (2008), (Donato, et al. 2011) as well as the power to withstand the mighty forces of storms and tsunamis... They are aptly called 'bio shields' (GEC, 2012) because of this unique ability to stand as natural barriers and act as first line of defence against the energy of the waves and help to hold coastlines together by trapping sediments in their roots (Kathiresan; Spalding et al., 2010; Stone et al., 2008) cited by Chattopadhyay, A. (2013). . Swell waves are rapidly reduced as they pass through mangroves, lessening wave damage during storms (Spalding, McIvor, Tonneijck, Tol, van Eijket al., 2014) thus minimising loss to lives and property. Mangrove forests also keep groundwater clean by preventing seawater from entering inland, and stop the spread of metal pollution by absorbing heavy metals in their sediment (Kathiresan & Bingham, 2001). These intertidal forests provide an extensive habitat to fauna ranging from tigers to insects on land and crocodiles to shrimps in the aquatic medium, thus forming a very complex, highly productive and a rich sustainable eco-system. Mangroves are also considered to be a good potential source of recreation and tourism for humans. But this rich natural renewable resource is rapidly declining due to coastal development, logging, tourism and aquaculture (ENVIS, 2005), Alongi (2002); Giri, Zhu, Tieszen, Singh, Gillette & Kelmelis (2008), and there is little attempt made to conserve mangroves areas. The coastal mangroves vegetation is being destroyed by uncontrolled anthropogenic activity. Among the 70 mangrove species listed globally, 11 are declared 'threatened' species by International Union for Conservation of Nature (IUCN) (Polidoro et al. 2010). Decision makers, and the public, need to take full account of the many benefits and consider the true costs that may incur from mangrove loss (Spalding et al., 2014).

Distribution: Etymologically the word 'mangrove' originated from the Portuguese and English words 'Mangue' and 'Grove' respectively, indicating that mangroves constitute a grove of plants as well as trees. Mangroves which grow along the inter-tidal coastline, in tropical and subtropical areas (GEC, 2012) range from low shrubs to trees, some of which can even grow to 30 to 50 meters in height if left undisturbed such as those found in Latin America, Africa, and Asia (Dahdouh-Guebas, 2006).

The longitudinal and vertical strata is very distinct and it forms a compact mass of canopy from high tide level to the low tide level with varying colours of canopies ranging from pale green, pale yellowish green to dark green and blackish green from high tide level to low tide level (State of Forest Report, 1997). Based on the world atlas of mangroves database, Spalding, Kainuma & Collins (2010) report the existence of 73 mangrove species along with few recognized hybrids, distributed in 123 countries with a territorial coverage of about 150,000 km^2 area globally, but they are more prolific in Southeast Asia. Mangrove biodiversity is highest in the Indo-Malay Philippine Archipelago. Between 36 and 46 mangrove species occur in this region (Polidoro et al., 2010). India with a long coastline of about 7516.6 km^2 (Singh, Ansari, Kumar & Sarkar, 2012), has a mangrove cover of about 6,749 km, the fourth largest mangrove area in the world (Naskar & Mandal, 1999). In India there are 46 true mangrove species belonging to 14 families and 22 genera, which include 42 species and 4 natural hybrids. From among these D'Souza & Rodrigues (2013) reported the presence of 17 mangrove species in Goa that include 14 true and 3 associated mangrove species.

Distribution of Mangroves in Goa: Goa state is located in western coast of India and mangrove vegetation in Goa occupies 500 ha of area (State of Forest Report, 1997). Along the entire course of the rivers of Goa, there exists an intricate network of creeks, backwaters and swamps. A luxuriant growth of mangroves (some of which are degraded) can be observed along most of the water bodies within the estuarine reaches (Mascarenhas, 1995). According to the National Bureau of Fish Genetic Resources (ICAR), Lucknow, the dominant mangroves flora in Goa comprises of *Rhizophora mucronata, Avicennia alba, Sonneratia alba, S. caseolaris, Kandelia candel* and *Acanthus*. *Kandelia candel* found in the oligohaline region has better formation in Goa as compared to other States (Singh et al., 2012). Unfortunately, these highly productive habitats are being increasingly reclaimed in the name of development.

Adaptation: Mangrove ecosystems are fragile, complex and dynamic, and are dependent on abiotic factors such as temperature, rainfall, wind and tidal amplitude and biotic factors such as microorganisms. However, they form highly specialized ecosystems.

Mangroves are halophytic species of trees and shrubs growing in saline marshes. The composition and configuration of mangrove species in estuaries varies as per the salinity gradient i.e. from below 5% to about 49%. The gradient varies from the mouth of the river to the rise of the river, from the banks to the distance inside the land. It also varies from day to day, due to the high tide-low tide phenomena (Lambs, Muller & Fromard, 2008).

These unique plant forms display some special modifications characteristics to their species e.g.
L*eaves:* Their dense green canopies of the mangrove forests not only act as powerful carbon dioxide sinks but also possess xeromorphic features such as thick cuticle, sunken or chambered stomata, water storage tissue, palisade like mesophyll, bundles terminating in tracheid and mucus cells. These features enable the conservation of water by minimising transpiration to tide over the difficulty of water absorption from highly saline water. The excess salt that enters the plant body is then concentrated in the sap and excreted through special glands in their leaves (Abhinay & Jayakumar, 2015).

Root systems: Adaptations in the *root system* are seen in the shallow but extensive branching in the poorly aerated, waterlogged or wet substratum. Therefore, to help them grow well in adverse conditions there are various types of roots such as strut and stilt roots, aerial prop roots, knee roots, buttresses and pneumatophores that rise up above the soil to 'breathe'. The interlocking network of roots holds the soil from eroding with the tides (State of Forest Report, 1997).

Seeds: An interesting feature seen in mangroves is *vivipary*. The seeds germinate while the fruit is still attached to the parent plant. In some varieties the pointed dart like embryos (propagules) grow out of the seeds and fall erect on the soft mud to prevent being washed away (State of Forest Report, 1997) and grow into new plants. If they fall at high tide they get carried away and when they touch land, they grow, sometimes forming new colonies.

Growing in the inter-tidal areas along sea coasts and estuaries in tropical and subtropical regions the mangroves form clayish mud from fine silt deposits brought by the rivers. Typical mangrove soils are rich in organic matter produced by the mangroves themselves, with their living roots and also with the dead leaves and woody materials trapped in the dense network of fine roots that keep the soil from erosive forces and, trap and bind soil particles together. Mangrove soils are often waterlogged and so have very low oxygen content (anaerobic conditions), hence much of the organic matter that accumulates forms a layer of peat that increases in thickness over time (Spalding et al., 2014).

Highly Specialised Ecosystems: Mangroves are highly productive wetlands that sustain and enrich a very wide variety of life forms both on land and in water. They house various biotic communities which form complex food webs and are of immense ecological and economical significance in any bioregion. Mangrove forests are a tremendous eco-system in themselves. They support flora that include a variety of plants like *paanlata*, glory bower, sedge, ceasalpinia, toothbrush tree, crabs eye creeper etc.

The mangroves and associated fauna together form a very complex, highly productive and a vast, rich sustainable eco-system. Since microbial organisms like yeast, bacteria and fungi decompose mangrove foliage to regenerate nutrients and minerals, producers like angiospermic flora, phytoplankton and marine algae flourish and support faunal elements like zooplankton and benthic animals to make the mangroves rich and highly nutritive nurseries for various aquatic life forms such as molluscs, crustaceans, fish etc. (State of Forest Report, 1997).

The mangrove vegetation and associated animal communities form various food chains i.e. the fauna present thrives on leaves, branches, flowers and fruits of mangroves, which thereafter become food for bigger animals such as monkeys, crocodiles, turtles, otters, jackals etc. Mangroves are also a haven for residents as well as for migratory birds and several endangered and rare species.

The mangrove areas have shallow water levels; warm water temperatures due to various decaying activities and the waterflow is slow and hence ideal place for growing of algae and for spawning for fish, shrimps and marine animals. They are breeding, feeding and nursery grounds for many estuarine and marine organisms (Asokan, 2012). Besides the wide variety of fish, crabs, prawns, shell fish, oysters, etc. that inhabit here, the amphibious mud-skipper fish (Singh et al., 2012), mud lobsters and the one-armed fiddler crabs arouse a lot of interest. Burrowing activity of the fiddler crabs not only alters the topography and micro-hydrology of the mangrove ecosystem but also functions as a system of channels that carry oxygen rich water with dissolved nutrients to the anaerobic soils around their roots. This bioturbation helps in enhancing the nutrient content, the decomposition and mineralization provision of nutrients to improve mangrove viability (Amarasinghe, 2009, cited by Bulow & Ferdinand, 2013). Among the fish species, hilsa, mullets, barramundis, threadfin salmons, red snappers are of immense commercial importance. In fact, the fauna ranges from shrimps to crocodiles in water and insects to tigers on land. The various biotic communities which they house, form complex food webs and are of immense ecological and economical significance in any bioregion.

Benefits of Mangroves: Apart from protecting against natural calamities and serving as vital nurseries for the breeding of aquatic species, they improve the quality of water by filtering out sediments and purify the air. On average, they store around 1,000 tonnes of carbon per hectare in their biomass and underlying soil, making them some of the most carbon-rich ecosystems on the planet. Many of the coastal people eke out a living from the produce of mangrove forests that range from sea food to tea, sugar, fruits, vegetables, wax, honey, medicines, raw materials for beer, and cigarettes, fuel wood, green manure, charcoal, tannin, timber, material for thatching, cordage, rope, art and craft, bow making and so on (ENVIS, 2005).

Threats to Mangroves: Mangrove species that are basically found in patches in the high intertidal and upstream estuarine zones, and which usually require specific amount of freshwater, are the most threatened because they are often the first cleared for development of aquaculture and agriculture. Almost 40% of the mangrove area along the West coast alone has been converted for agricultural and urban development. Inspite of their indispensable role of protecting life, property as well as biodiversity, these unique mangrove habitats have been facing tremendous threats due to indiscriminate exploitation for multiple uses like fodder, fuel wood, timber for building material, alcohol, paper, charcoal and medicine (Upadhyay et al. 2002). Mangroves are also often destroyed due to attachment of barnacles to their stem, fishing nets and barge movements, due to oil slicks, solid waste deposition etc.

Consequences of Mangrove Forest Degradation: The loss of mangrove species will have devastating economic and environmental consequences for coastal communities, especially in those areas which have a low mangrove diversity and high mangrove area or species loss. if existing protective measures are not strictly followed then species that are at high risk of extinction may disappear well within the next decade. Agriculture, aquaculture, human habitation, tourism and over exploitation through coastal development put a tremendous pressure on mangroves. The loss of individual mangrove species also negatively impacts human livelihoods (Alongi, 2002). The Indo-Malay Philippine Archipelago has one of the highest rates of mangrove area loss globally, with an estimated 30% reduction in mangrove area since 1980. In India alone, over 40% of mangrove area on the West coast has been destroyed for agriculture and urban development (Polidoro, 2010). Official statistics indicate that presently out of Goa's total land area of 3,70,000 hectares (ha), mangrove areas comprise 500 ha. This reveals a sharp decline since 1987, which recorded 20,000 ha. (Kumar, 2000) (TNN, 2011).

In the mangrove fauna category, crocodiles, lizards, turtles and mud clams are listed in the high-risk category while snakes, otters, jackals, mud crabs, oysters, white clams and tiger prawns are listed in the medium-risk category.

Among the fish, the giant perches, mullets, sand whitings, snappers, groupers and thread fin salmons are placed in the high-risk category while pear spot, catfish, spotted catfish, Harry hotlips, half beak, herring, and trevally formerly have fallen in the medium-risk category.

The cormorant, great cormorant, large egret, Indian shag, grey heron and painted stock-birds forming part of the mangrove ecosystem had been placed at a higher risk compared to the little egret, small blue kingfisher, white breasted kingfisher, black-capped kingfisher, collard kingfisher, western reef egret, blue breasted rail, Asian *koel*, rose-ringed parakeet, common myna, jungle myna, brahminy kite, spotted dove and pond heron (Monteiro, 2015).

Past efforts and future suggestions: Reversing the trend of mangrove loss and the growing vulnerability of coastal peoples will require a real commitment by governments to develop and implement robust high-level policies. A five-year mangrove management plan for Goa was prepared in 1991-92 by the Mangrove Society of India - a NGO formed by retired scientists - involving five north Goa schools to preserve mangroves in Goa and create awareness about its increasing destruction. It was implemented with financial assistance from the Government of India, and 100 ha of mangroves were planted each year as planned (TNN, 2011), (Kumar, 2000). While the next five-year plan is underway, Dr. V. K. Dhargalkar of the Mangrove Society of India, says:

> "Large mangrove areas along the Goa coast are being indiscriminately and illegally reclaimed for developmental purposes and no action is being initiated. It is felt that except for few people there is no overall awareness about the importance of mangroves amongst the local people".

Convinced that conservation efforts should start at the grassroots with the student community along the coastal belt, he wants to create awareness about mangrove conservation among the young generation and develop trained manpower for mangrove conservation (TNN, 2012).

Mangrove Action Project 2013 – 2017 is an interesting way to teach the young. It involves children by introducing a suitable curriculum in the education system on the lines of the one developed originally for the Caribbean region in 1999, '*The Marvellous Mangroves Curriculum'*. Introduced into over eleven countries across the globe and used by over 1500 teachers and 250,000 students by 2015, it has since been adapted for the English-speaking Colombian Caribbean islands of San Andres and Providence. It has been translated into Spanish and adapted for use in Colombia, Honduras, and Guatemala. It has also been translated and adapted for use in Indonesia, Sinhala and integrated into the Sri Lanka national science curriculum. Brazil has adapted it and used it as part of their official school curriculum in Portuguese. China has introduced into three provinces in Mandarin. In 2013, it was introduced into Belize schools. Queensland in Australia too had adapted it for a section of their teachers and students.

Now a part of the local Cayman curriculum it has been adapted and introduced by schools in several countries from USA to Australia, including Cayman Islands, Honduras, Guatemala, Colombia, Brazil, Bangladesh, Sri Lanka, Indonesia, China, Belize, Suriname and the Dutch Antilles, Panama, Senegal and the United Arab Emirates'[32A] among others. Why can it not be introduced in India? We could begin by including it in our educational course content, e.g. knowledge on '*mangroves as habitat, human impacts on mangroves, exploring mangroves, making the change'* [32B]and provide research opportunities for young students in related areas.

On the commercial front there is a need to:
- Increase efforts to recover lost mangrove forests and restore their ecosystem services.
- Ensure the involvement of local communities in mangrove management.
- Implement sustainable mangrove forestry practices ensuring long-term benefits to local communities.
- Establish protected areas which are a powerful tool for ensuring the protection and conservation of mangrove biodiversity. Establish clear legal and management structures.
- Encourage and support mangrove ecotourism to generate income and employment for local communities and to improve outreach and education. (Van Lavieren, Spalding, Alongi, Kainuma, Clüsener-Godt & Adeel, 2012).

Well planned aquaculture could generate a lot of income from the local market as well as through exports.

Conclusion: Studies reveal mangroves to be life savers in times of floods and cyclones, purifiers of air and water so also sources of valuable commercial products like black tea, mosquitocides, gallo tannins, microbial fertilizers, antiviral drugs, UV-screen compounds…Hence, loss of mangroves could be catastrophic if conservation of mangroves is not undertaken in a serious and well organised manner. There is too little awareness among the local population about the immense wealth and biodiversity in the mangroves and the powerful role that these plants can play in supporting life. It is imperative that consistent efforts be made to protect the mangroves and harvest its resources through balanced and sustainable development.

Mangroves must be carefully managed and protected through strict Government policies. As part of sustainable development, 'cash crops' must also be developed as sources of high value commercial products. Fishery and other aquatic resources can be planned and developed to get rich dividends. Mangroves can also be developed, as sites for a burgeoning eco-tourism industry.

Their unique features may also make mangroves ideal sites for experimental studies of biodiversity and ecosystem function. Involvement of local communities as well as educating and training students, in particular school and college students in the conservation and 'wise' use of our precious mangrove resources will ensure that these unique 'Magnificent Mangroves' ecosystems survive, flourish and become one of our indispensable solutions for a Sustainable Planet!

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