

SOME OBSERVATIONS ON THE STATE OF THE COASTAL ENVIRONMENT OF GOA, WEST COAST OF INDIA

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1. INTRODUCTION

The coastal zone of Goa had been exclusively used for agriculture, farming, shell fishing, traditional fishing and low key recreation (Alvares, 1993). Native Goans used the shoreline and the hinterland water bodies to fish by using hand-cast and hand-pulled nets, gather shells for economic and various other purposes. Traditional fishing was the main economic activity of coastal populations. The only identifiable structures along the shore were a few cabins and thatched huts made of coconut tree leaves that housed sea going canoes, some of which can still be seen today. The large plain areas behind the dune belts were used for farming and paddy cultivation, activities which are common at certain places even at present. Recreation was restricted; Calangute, Miramar and Colva being the only beaches which were most frequented (Mascarenhas, 1998).

Ever since tourism was declared a potential revenue earner, the coastal scenario started changing. Construction boom has not spared Goa. Coastal communities have experienced a rapid growth of structures such as high rise buildings, resorts, residential dwellings, commercial establishments, beach-side bars that mushroomed almost everywhere along the shores. Several coastal areas have changed from virtual wilderness in 1970's to haphazardly developed stretches with buildings and related structures, in less than 20 years (Alvares, 1993; Mascarenhas, 1998; Sawkar et al., 1998). Some of the coastal strips are now overdeveloped in such

a manner that they bear little resemblance to the coast that existed prior to development.

Tourism and related anthropogenic activities are prominent in the state of Goa. Various adverse impacts of coastal tourism have been expressed world-wide (Miller and Auyong, 1991; Uppenbrink, 1997). Considering that the open sea front of Goa is being built up at a very fast pace, and that this activity is now shifting inland along rivers and backwaters, it is not known in what way the heavy developmental activity is affecting the coastal zone in general and the ecosystems in particular. This paper describes the state of coastal environment with reference to human intervention on coastal systems.

2. COASTAL ECOSYSTEMS

The open sea front of Goa is characterized by a combination of beaches, rocky shores and headlands which protrude into the sea. The headlands are made of basaltic or metamorphic formations capped by laterite and intruded by igneous dykes. Linear sandy beaches are located between promontories; sandy pockets are found at the base of coastal hill slopes; the width of the beaches varies between 50 and 180 meters. Of the 105 km long coast, more than 70 km comprise sandy beaches (including those within estuaries), all backed by several rows of 1 to 10 m high sand dunes which extend almost half a kilometer or more before merging with the hinterland coastal plain.

Five key regions have prominent sand dune complexes (Mascarenhas, 1998): Querim - Morjim with pristine beaches and turtle nesting sites; Chapora - Sinquerim belt; Caranzalem - Miramar (Mandovi estuary), the most prominent dune belt within the estuaries of Goa; Velsao - Mobor linear stretch being the longest strip of the most exquisite dune system of the entire coastal zone of Goa and Talpona - Galgibaga. In addition, the coastal stretches also consist of several sandy areas and secluded coves backed by cliffs, rocky shores, headlands or promontories and wooded or bare hill slopes (Mascarenhas, 1998). Some islands with an appreciable forest cover are found off Goa.

From north to south, the coastal zone of Goa is traversed by seven major dynamic estuarine rivers and four minor river systems. The Kumbarjua canal is the only connection between two such major rivers. Most of the major rivers which cut across hinterland formations originate in the western Ghats (Alvares, 1993). The important water ways are: R. Tiracol (28 km), R. Chapora (31 km), R. Mandovi (81 km), R. Zuari (67 km), R. Sal (35 km), R. Talpona (31 km) and R. Galgibaga (15 km). All the rivers are lined by dense mangroves, except at places. Several islands and shoals inhabited by thick mangroves are found within the rivers, the Choraio island being the most prolific.

Throughout the course of these rivers, one can find an intricate network of creeks and backwaters scattered all over the coastal zone. A luxuriant growth of mangroves (some of which are degraded) and associated swamps can be observed in most water bodies. The most prominent and extensive backwaters with mangroves are located east of the capital city of Panjim.

The coastal plain of Goa varies in width. In the northern part, it extends to about 35 km, virtually to the base of the western Ghats, whereas it is about 20 km wide in the central part. In the southern part, the coastal plain is less prominent, identified only adjacent to the two rivers; this sector is mostly occupied by evergreen forests.

In general, the coastal plains comprise an intricate system of wetlands, tidal marshes, cultivated paddy fields, all intersected by canals inland lakes, bays, lagoons and creeks. All the rivers and the extensive backwaters in the hinterland are governed by regular tides. The prominent lowlands found adjacent to most of the rivers are locally known as "khazan lands" which are almost at, and even below, the sea level.

3. HUMAN ACTIVITIES ALONG THE COASTS, RIVERS AND BACKWATERS

Some of the human activities identified over the last two decades along the open sea coasts and hinterland water bodies of Goa are briefly described below:

1. *Resorts:* Since 1974, building of beach resorts is the most prominent tourism oriented activity, observed mostly along the sandy stretches, and to lesser degree along the rivers and backwaters. They are more concentrated in north Goa.
2. *Dwellings:* Migration of population towards coasts, preference for a sea side home, as well as tourism related facilities have resulted in a large number of residential dwellings mushrooming along the coastal stretches. Coastal hill slopes are also being occupied by habitations.
3. *Sand mining:* Mining of dune sands was more rampant during the 1980's than at present. However, extraction of river sand is very active in the rivers of north Goa in particular.
4. *Infrastructure:* Facilities such as laying of roads in sandy areas are common at many places where a former path existed as access to the beach. Such coast-perpendicular roads are seen at regular intervals along the entire coast.
5. *Reclamation:* Creation of new land is seen as a result of reclamation of shallow water bodies in backwaters, river banks and mangrove marshes. The largest land reclamation is seen on the eastern outskirts of the capital city of Panjim.
6. *Shoreline constructions:* Construction of structures along the water line of open sea coast as well as rivers are multiplying rapidly. The Mandovi estuary is one such example.

7. *Ground water pumping:* Indiscriminate pumping of ground water for drinking and commercial purposes is common. The stretch from Miramar to Dona Paula where every residential complex has a bore well, is one of the examples.
8. *Railway embankment:* A huge embankment, at places 10 m high, traverses three estuaries in south Goa, and the largest "khazan land" in central Goa. It also crosses several mangrove marshes.
9. *Barge building yards:* Repairs of barges are done in yards located along the upper reaches of major rivers.
10. *Sea walls:* Retaining walls are seen at several places as a measure to protect (and also reclaim) riverside property. Seawalls built to check erosion are also identified at Campal.
11. *Beach shacks:* These temporary huts, made of bamboo and thatched leaves and serve food to beach users, are seen along the entire coast, except at places where these are not permitted. Their numbers seem to be multiplying.
12. *Recreation:* This is an age old activity on the beaches of Goa. Although restricted to a few spots in the past, many new places are now frequented by pleasure seekers.
13. *Sewage disposal:* Indiscriminate disposal of untreated sewage and garbage by hoteliers as well as residents is adding to the ever increasing problem of beach litter.
14. *River cruises:* This activity is slowly gaining popularity and momentum during the tourist season. Earlier restricted to river Mandovi, now it is conducted in river Sal as well.

15. *Farming and pisciculture*: Traditional farming has been an age old practice. Presently, intensive aquaculture (although banned) is taking its place.
16. *Offshore diving*: Amateur diving is observed only at Grande Island (off Marmagoa harbour), known for the presence of corals.
17. *Water sports*: This activity is seen at a many places along the open sea coast, and some selected sites within rivers and backwaters. Water sports has not gained the importance it deserves.
18. *Ore transport*: Transport of iron ore by barges is frequently seen along the major rivers. Ore is loaded at several points, upstream of major rivers.

4. VIOLATIONS OF ENVIRONMENTAL REGULATIONS

As large scale unrestrained and haphazard development had started along the coasts of the country as well, the Ministry of Environment and Forests (MEF), New Delhi, enacted a legislation called the Coastal Zone Regulation (CRZ) Notification (Anonymous, 1991) issued under the Environment Protection Act of 1986. The main purpose of this notification was to control and minimise environmental damage to coastal stretches including estuaries and backwaters. The new legislation, however, hurt the powerful builders lobby, resort owners and influential members of the society some of whom had already acquired large tracts of prime coastal lands. Thus, the CRZ Notification was sought to be criticised, undermined and misinterpreted (Mascarenhas, 1999).

Despite clear rules and guidelines (Anonymous, 1991, 1996,a,d), the implementation of the CRZ notification leaves a lot to be desired. Lopsided developmental plans with no corresponding infrastructure facilities are being pushed. Attention is only paid to short term gains by ignoring long term effects. The result is seen in the form of large scale violations of CRZ regulations with consequent damage to ecosystems along the open sea front, rivers and backwaters of Goa.

The CRZ violations due to human intervention on coastal ecosystems are briefly summarised below:

Coastal structures: Based on our field observations, numerous infringements on coastal sandy stretches, rivers, backwaters and plains are identified. The setback lines as stipulated in the notification are spurned (Anonymous, 1995, 1996,c, 1997,a, 1998). There are many such cases in the Baga - Candolim sector; the Calangute panchayat has been hauled up for the maximum number of environmental violations (Anonymous, 1996,c). The Mobor peninsula which was once declared as a green cover area, has witnessed a proliferation of structures which have violated the environmental guidelines (Anonymous, 1998). Our observations show that the latest negative developments are in Palolem where a number of small buildings, including a ramp to allow vehicles on the beach, have mushroomed close to and even on the high tide line (HTL). Similarly, several hotels have built up river banks, and low lying areas and mangrove swamps have been filled up and portions of rivers have been reclaimed for various purposes.

Removal of sand : Unscientific dune sand extraction is rampant at several sites along the sandy coasts (Anonymous, 1997,c), although this activity is prohibited by law. Unrestricted sand mining is also observed at several sites along rivers, being most conspicuous along rivers Chapora and Tiracol.

Bore wells: Since piped water supply is often irregular and does not meet the existing demands, many real estate owners, the hotel promoters in particular, and even the public resort to unfair methods of ground water tapping by sinking bore wells (Alvares, 1993; Chachadi and Kalavampara, 1995). Bore wells are not allowed within 200 m from HTL, and permission is needed outside this stretch.

Roads: In some cases, ancient paths used by beach users are slowly being converted into roads some of which are already tarred, whereas others are incomplete

and/or stopped by legal means. New pathways are also seen across mangrove swamps.

Fences: Several promoters of hotels and resorts have put up fences and walls in the no development zone, sometimes up to the HTL. Existing law does not allow such structures within the 200 m zone and yet they are seen at Calangute, Candolim and Colva, for example.

Public access: Courts had to intervene in some cases so as to restore public access to the beach. Several resorts in coastal areas have indulged in such malpractice.

Till November 1998, all the matters related to the development of coastal stretches of Goa were examined by a state level apex body known as the Goa State Committee for Coastal Environment (GSCCE). This committee issued licences for buildings, hotels or resorts after deliberating on various issues. The CZM plans are also approved by this body. Unfortunately, out of twenty odd members, this committee comprised only of a few coastal scientists, the rest of the members being from other fields with a meagre knowledge of coastal sciences. Considering various illegal buildings that are sprouting along the coastal stretches, the legitimacy of this coastal committee was under question. This committee failed to implement the prevailing coastal environmental guidelines.

It appears therefore that the unplanned human intervention along the coastal zone, and also the illegal activities that have been observed, are primarily responsible for the changing coastal configuration that we observe at present.

5. FATE OF COASTAL ECOSYSTEMS

Our ancestors had understood the nature and importance of coastal ecosystems, and had somehow grasped the sanctity of Nature. Until the 1970's, nowhere did we have evidence wherein, for example, sand dunes were razed or backwaters were filled so as to build houses. Ancestral mansions, roads, traditional

villages, and any major activity along the coast were all located at safe places away from and behind the dunes, and also away from rivers, backwaters and wetlands. This type of age old planning can still be identified from Baga to Candolim, Panjim to Caranzalem, and the entire stretch from Majorda to Betul, as well as areas around backwaters. Between ancient coastal dwellings and the beach, and between ancient houses and backwaters, vast strips of luxuriant paddy fields can still be found today, being prominent in the central parts of Goa. Such places landward of dune belts thus remained as areas of peace and tranquillity, and free from anthropogenic influences. Therefore, such a setup could be cited as a unique example of the harmony that prevailed between man and Nature (Lobo, 1988; Alvares, 1993).

Of late, however, newspapers are replete with a variety of coastal issues, mostly connected with the human interference on coastal systems (Anonymous, 1996,a,b,c,d,e; Anonymous 1997,a,b,c; Anonymous, 1998; Narayan, 1997). Subversion and violation of CRZ laws, accusations against haphazard tourism expansion, constructions along the high tide line; proliferation of coastal resorts, buildings, beach shacks; unchecked sand extraction from dunes and rivers; excessive withdrawal of ground water; constructions along coastal hill slopes; filling of inland mangrove swamps and lowlands, blocking public access to beaches, side-tracking coastal regulations, overdevelopment and concretisation of some coastal belts. This is evidenced by the acceleration in the pace of constructions particularly in north Goa, as this coast bears little resemblance to the primitive shores that existed earlier. Combined together, all these impacts amount to one of the most powerful indictments of international tourism (Wilson, 1997). Therefore, the outlook appears bleak.

Our study reveals that tourism and allied activities have affected the open sea coast very severely as compared to the rivers, backwaters and "khazan lands" where building activity is now shifting. Sandy stretches, the dunes in particular, are the worst affected. Whereas localised structures along river banks have led to significant morphological changes, the major environmental impact on the low-lying khazans is

associated with the newly built railway embankment. The coastal hill slopes are also being encroached, and may assume alarming proportions in due course.

The destruction of sand dunes in Goa is almost exclusively anthropogenic (Mascarenhas, 1990, 1996,a, 1998, 1999) because they are now too frequented. They have suffered greatly from the assaults of tourism and other related infrastructure activities which have spread over coastal spaces during the last two decades. Their existence is therefore in peril: destabilisation due to the degradation of their vegetation which is sensitive to the human presence, flattening due to sand extraction (Cavelossim), or their destruction and elimination due to the creation of plots by the sea side (Candolim). Their disappearance is total where sand is being extracted for construction activities, and also where dunes have been simply levelled and flattened to erect buildings (Caranzalem - Miramar) and resorts (Baga - Sinquerim and Colva - Cavelossim).

Irrespective of the agents responsible, the degradation of sand dunes pose various consequences for the coastal environment (Miossec, 1988; Paskoff, 1994, Nordstrom, 1994,a,b). Disrobing a sand dune results in the formation of free sand which is rendered mobile; sand therefore keeps shifting. Along the coast of Goa, the transfer of sand landward far into the hinterland is a common phenomenon observed particularly during windy days at several places; the Baga - Candolim sector is one such example. The risks of inundation are increased when sand is removed on a large scale. Excessive pumping of fresh water leads to salt water ingress and contamination of coastal acquifers. Elimination of dunes also induce erosion, as beaches are starved of the requisite sand budget. All these factors adversely affect coastal equilibrium and hence its stability. The major drawback is that the human intervention on the sand dunes of Goa has never been quantified, an issue that requires immediate attention.

Natural coastal erosion is noted at many sites; however, man-induced erosion merits discussion. Along the entire Goan coast, including inland water bodies, several structures (including sea walls) have been identified along the HTL at Miramar, and other smaller units at Anjuna and Palolem. Excavations and removal of dune sand for

erection of these structures close to the beach have created deficiencies in the volume of sand. All these sites are precisely the ones where significant erosion has been noted. Although the erosive processes are localized at the moment, it is found that these hard structures which are in direct contact with marine water are mainly responsible for shoreline erosion and coastline changes, as clearly observed at Palolem. Sand is eroded wherever waves break against hard structures (Kraus and Pilkey, 1988). Human intervention has indeed resulted in shoreline changes, wherein the sea is advancing landward as observed over the last few years. The erosive activity at Palolem is clearly attributed to human intervention on coasts.

Sand eroded from a particular site has to be deposited elsewhere. We have identified various sand bars / spits at river mouths as in Talpona, accretion of beaches as in Miramar, and also islands, shoals (and mud flats) within all the seven rivers of Goa. A jetty / ramp at the mouth of river Tiracol has been engulfed by sand deposits; a new ramp had to be built for ferry users. Whether these accretionary processes are a direct consequence, atleast partly, of erosive phenomena is not known; a formal scientific proof is lacking.

Beach shacks and recreation along Goan beaches appear less damaging. Beach shacks are a unique sight on all major beaches, and are of a purely temporary nature. The ever increasing competition has resulted in their proliferation as almost 220 shacks are erected along 60 km of beach length (D'Mello, 1997). A sandy beach, being dynamic in nature, keeps adjusting itself towards an equilibrium as a beach generally restores itself. Therefore, beach shacks which come and go are not expected to induce any large scale damaging effects from the environmental point of view. The only major problem is their number which is on the rise, leading to over exploitation of limited beach space.

As shacks are frequented by a large number of people, they generate huge quantities of garbage which unintentionally mixes with sand and hence litter large areas, and invariably finds its way into the estuaries. The Baga - Candolim stretch, Miramar, Colva and even Benaulim can easily be singled out. For instance, the annual

sea food festival held at Miramar produced heaps of garbage, a part of which gets mixed with the sand unless combed. At Colva, the creek is used as a dumping site for all types of waste. Hotels in south Goa produces large dumps of non-biodegradable garbage which along with sewage is discharged in the river Sal. Interestingly, large rafts of plastic waste were found floating in the river Sal; a close observation of this recurring phenomenon revealed that plastic items (and even seals) originate from starred hotels.

Activities of pleasure seekers and picnickers can be observed wherever sandy stretches as the dunes are found. Some dunes in Baga and in Candolim are regularly used as a football ground by the villagers and also tourists. Although these recreational activities may not be termed as harmful to the dune environment, it does create ecological degradation in areas which are most sought and frequented. Driving of motorised vehicles on the beach, play fields on dunes, continuous movement by pedestrians and cyclists destroys dune vegetation, flatten dunes and renders the sand mobile, factors which induce shifting of sand thus affecting the stability of sand dunes.

Close in line with the open sea coast, the rivers and backwaters of Goa appear to be under mounting environmental stress due to a variety of anthropogenic activities. Mangrove populations are under threat due to various reasons: structures along river banks, conversion of paddy fields, reclamation of marshes for settlements, and the railway line (described below) which cuts across the entire coastal zone.

At several places, mangrove swamps and marshes bordering backwaters and "khazans" have been filled and reclaimed for various purposes. The large area occupied by the Kadamba Transport Corporation in Panjim and the proliferating buildings south of it, can be classified as the largest reclamation of backwaters during the last two decades. Road bypasses have been constructed over mangrove swamps south of Mapsa city and east of Panjim city. Significant mangrove areas were taken over and filled for the railway embankment. Mangrove forests have been sacrificed for barge building yards, as evidenced in Quelosim. Reclamation of mangrove areas which act as spawning and breeding grounds for marine organisms was recently reported at

Bainguinim and also identified at Ribandar, Santa Cruz and particularly at Talpona. Therefore, a gradual decrease of mangrove forests is a major concern.

The coastal hill slopes and even promontories are not covered by the CRZ Notification. However, wherever buildings are coming up, leaving a reasonable setback from the edge of the cliff or hill slope is imperative, be it from the safety or environmental points of view. But in reality, this rule is not observed. Negative development can be identified along the hill slopes of Dona Paula - Bambolim stretch, along the river Zuari. A large number of constructions have gradually taken over and encroached the coastal hill slopes, some of which have almost reached the water line. In addition, hill slopes at many other places adjacent to rivers and estuaries have been sliced for widening of roads as in Betim and laying of railway tracks as in Cortalim, Talpona and Galgibaga.

The environmental impacts of such actions can be manifold. Human activity along hill slopes has led to mud flows into the rivers resulting in heavy siltation at places. This is clearly evident on either side of the railway track at Talpona. Construction activity is not only spoiling coastal aesthetics but is gradually leading to the degradation, deforestation and concretisation of coastal hill slopes. Shoals and mud flats which are promptly colonised by mangroves within rivers are a direct consequence of negative impacts due to interference of man along these slopes.

The low-lying "khazan lands" of Goa are now under threat due to several reasons. Indiscriminate filling of these lowlands is the concern at the moment. Although these lands are being reclaimed for settlements or dwellings, agriculture is badly affected due to human activities (Sawkar et al., 1998). Tampering with traditional sluice gates has allowed saline water into the fields due to which a large fields (Rachol) have now turned into lagoons and rendered paddy fields saline and unsuitable for paddy. That is why some places are being cultivated whereas large areas are lying fallow and have been abandoned (Almeida, 1997).

These lowlands have been in focus ever since the new rail line was built. Although the railway is bound to usher a new era in the region, the environmental degradation associated with building of embankments, particularly across lowlands, is significant. The impacts are seen in the form of subsiding embankments, disruption of natural drainage patterns, cutting of hills, siltation in the fields and rivers, elimination of mangroves and flooding of coastal plains as the major part of the railway embankment is laid across coastal lowlands.

The railway which traverses the most extensive "khazan lands" of Goa from Carambolim to Cortalim, has contributed to a substantial environmental degradation (Mascarenhas, 1992; Gadgil and Chandran, 1993; Alvares, 1993; Anonymous, 1996,e; Dias, 1996; Almeida, 1997):

(i) Mangrove swamps have been filled at Divar, Neura, Mandur, Agassaim, Cortalim, Galgibaga, as well as a part of a natural lake at Carambolim, (ii) Cutting of hills is noted at Mayem, Divar, Carambolim, Cortalim and Talpona, mostly in and around estuaries, so as to collect mud for embankments. Large scale cutting of hills has resulted in their erosion, landslips and destruction of hills, siltation and sedimentation of mud in "khazans" (and rivers) thus affecting paddy cultivation, (iii) Effects on fish spawning and breeding grounds in ponds and "khazans", traditional farming and fishing activity has been affected, (iv) Natural drainage systems which were in place for centuries have been altered leading to flooding of lowlands, rendering them saline as well as creating breeding grounds for mosquitoes. This is noticed at Mayem, Neura and Agassaim, (v) Many traditional sluice gates have been rendered non functional; natural irrigation tanks have been destroyed, (vi) The large volume of mud for high embankments has resulted in sinking embankments due soft underlying organic marine sediments (Mascarenhas and Chauhan, 1998) with a consequent uplift of adjacent paddy fields. At Cortalim, the bed of a creek was uplifted thus blocking the narrow natural waterway. In this area the environmental problems were so intense that the entire embankment was subsequently removed and a viaduct erected in its place. This embankment which is still sinking tantamount to a human error. Unfortunately, a

detailed comprehensive study of the share of the environmental impacts of railway in Goa has never been attempted.

Some river banks of Goa are dotted by hotels, restaurants and allied structures, identified along the major rivers at Verem, Miramar, Ribandar, San Pedro, Bainguinim, Dona Paula, Cavelossim, Betul, Mobor. These structures also consist of concrete retaining walls virtually in the water. Similarly, several barge / boat building yards have occupied several sites particularly along Mandovi and Zuari rivers, the most prominent being the Sancoale - Chicalim and Quelossim banks. The barge/boat builders are recovering large areas from rivers and extending their activities seaward. In addition to the Vasco - Mormugao port stretch, the Mandovi river bank from Panjim to Miramar, consisting of a series of jetties and even restaurants, are the most heavily built up of all rivers in Goa. The impacts of such activities and structures within rivers is seen in the form of erosion of adjacent banks as clearly identified at Miramar, for example. Hard embankments or sea walls along the water line increase the turbulence of waves resulting in the sand erosion (Kraus and Pilkey, 1988).

The railway line has also affected rivers. Our observations reveal that the coffer dams which were laid across all rivers during the construction of bridges, were never removed, except for the top part. Over a period of time, the heap of mud has been redistributed by waves and currents, leading to siltation and sedimentation within rivers. This phenomenon is most pronounced in Talpona where a large amount of coarse mud has been deposited in the estuary, a little downstream of railway bridge. A similar effect on a lower scale is seen at Galgibaga estuary. During low tide, the river bed is exposed, indicating a drastic shoaling of the river at Talpona. Deposition of sediment in the estuary has severely hampered navigation and has also decreased the fishery potential. The existence of river Talpona is now at stake.

It may be noted that coastal tropical ecosystems have a definite role to play and specific functions to perform. Any unplanned interference can prove detrimental to its intrinsic value. Coastal ecosystems show a dynamic behaviour which has to be understood, respected and not contradicted by anthropogenic influences. Coastal dune

belts for example, are among the most diverse landscapes in the world (Nordstrom, 1994,a,b); they have multiple functions and hence of value to society (Carter, 1988). The role of sand dune ecosystems can be summarised as follows (Carter, 1988; Mascarenhas, 1990, 1996,b, 1998):

(i) The beach - dune environment is a highly organized system, features of coastal stability, the result of a delicately balanced ecological equilibrium between the forces of the ocean and loose coastal sediments. (ii) The dune environment is classified as edifices of extreme fragility, sensitive and vulnerable due to its propensity for changes under even slight environmental stress. (iii) Sand dune chains, as high as 10 m, are categorized as Nature's line of defense as they arrest blowing sand, deflect wind upwards, assist in the retention of fresh water and protect the hinterland from attack by waves. (iv) Coastal sand dunes serve as "sand banks", are sources of beach nourishment and also neutralize and dissipate wave and current energy in the coastal zone and maintain the sedimentary and dynamic equilibrium of the dune - beach ecosystem. (v) Dune vegetation acts as sand binders and preclude loose sand from advancing inland and thus menacing coastal populations. (vi) Dunes protect the hinterland from winds and other forces and hence make the zones behind dunes as areas of peace and tranquillity. (vii) Sand dunes of Goa can be as old as 6400 years (see Mascarenhas, 1998). (viii) Dunes stand guard against any sea level rise as they will act as Nature's wall of defense. Therefore, these geomorphic edifices have to be preserved.

Mangroves play a crucial role along tropical coastlines (Carter, 1988): they are highly productive ecosystems, support a diverse heterotrophic food chain, act as spawning and breeding grounds and hence nurseries for marine biota, offer protection from erosion, tides and storm waves, help in natural building of land and stability of shorelines. These coastal forests are important in maintaining the health of estuaries. Therefore, mangroves should continue to form an integral part of coastal ecosystems.

Goa is marked by evergreen hills and promontories with wooded or bare hill slopes which often jut into the sea. Besides controlling soil erosion and recharging

aquifers, wooded hill slopes offer an intrinsic natural beauty. Forests along hill slopes also contribute towards slope stability. Therefore, coastal hill slopes particularly the wooded ones which recharge aquifers and arrest erosion are integral parts of the coastal zone ecosystems and need to be protected from any development.

The "khazan lands" have been traditionally a source of livelihood for many, as these lowlands were originally used for paddy cultivation, traditional farming, pisciculture and salt extraction. Khazans were mostly used as paddy fields for centuries, by using "bundhs" to keep sea water away, and sluice gates to control the inflow of saline water. These coastal systems have been the rice bowl of coastal communities of yesteryears. Unless protected from misuse, a functional unit of coastal ecosystems will be lost.

The rise in sea level during the last century is estimated to be 1 to 1.5 mm/year along western India including Goa (Subrahmanya, 1996). This effect may be less severe on the sandy beaches of Goa as most of them have an appreciable gradient. However, even a nominal rise in sea levels will significantly influence inland water bodies and particularly the low-lying "khazan lands" of Goa as these lowlands are at or even below the present sea level. Although the nature and intensity of losses cannot be predicted, the future trends cannot be questioned (Haq and Milliman, 1996). The issue of an eventual sea level rise has not been examined by the local planners and policy makers. Nevertheless, the best protective measure against rising sea levels is the retention of natural ecosystems, by retreat and appropriate setback lines.

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