

# Policy Brief: Sand Dunes

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THERE HAS BEEN CONSIDERABLE PRESSURE from ill-planned developmental activities on the coastal areas of the east coast of India, especially Tamil Nadu, which already have led to repercussions on the coastline and its ecology. Though ecosystems like mangroves, coral reefs and sea-grass beds are getting much recognition as important coastal ecosystems and shoreline stabilisers, sandy beaches and sand dunes do not get adequate attention as important coastal ecosystems in their own right, and their role in stabilising the coastline is mostly overlooked.

After the December 2004 tsunami that hit the southeast coast of India, there has been recognition among the coastal communities living adjacent to coastal sand dunes about the value of sand dunes in not only protecting the hinterland and coastal hamlets, but also their role in preventing saltwater intrusion as a result of inundation by large waves. There is also better recognition of their cultural, social and ecological significance. Post-tsunami community initiated attempts to conserve and revive sand dune ecosystems in some parts of Tamil Nadu is in itself a good indicator of the fact that communities have recognised the value of sand dunes. In spite of all this, sand dunes have not enjoyed the kind of attention or popularity that is given to other coastal ecosystems like mangroves

and coral reefs. In fact, both funds and attention have been focused on bioshields for coastal protection, which are in fact controversial from both ecological and community perspectives. General neglect of the coastal sand dune ecosystems by the scientific community has led to a serious oversight of this critical ecosystem of the coast. There is a major dearth of information on coastal sand dunes available/accessible by the community, institutions and managers and decision makers.

## Introduction to Sand Dunes

In physical geography, a coastal sand dune is a hill of sand built by wind action (eolian process). Dunes are subject to different forms and sizes based on their interaction with the wind. Most kinds of dunes are longer on the windward side where the sand is pushed up the dune, and have a shorter 'slip face' in the lee of the wind. The 'valley' or trough between dunes is called a 'slack'. (Figure 1.)

Formation of dunes is through sand accretion. Sand that is brought in by the winds gets trapped by the shrubs, creepers, trees and other obstacles that are found on the coast. This accumulated sand forms mounds of sand that keep growing over time to form large dunes. (Figure 2.)

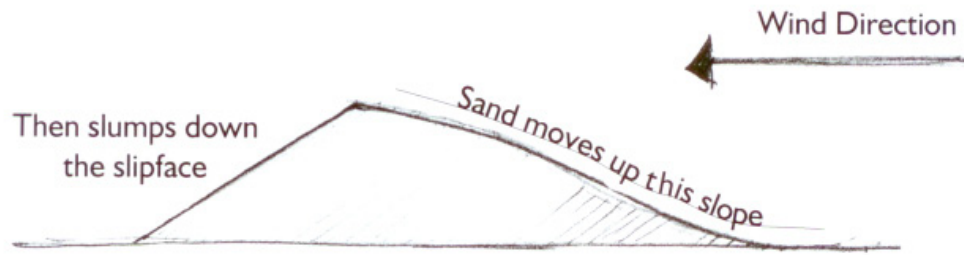


Figure 1.  
Courtesy: D. Radhakrishnan, Handesigns. 2008.

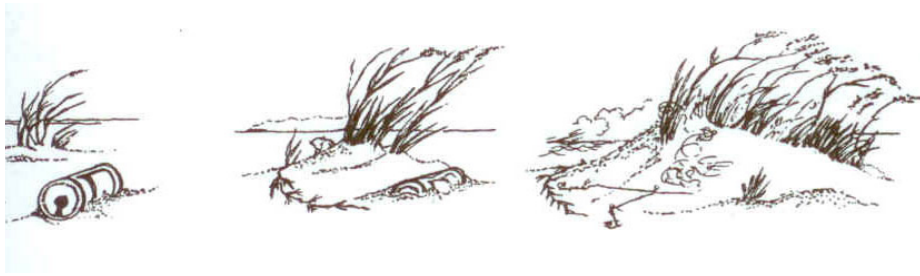


Figure 2.  
Source: McLachlan, A. and A. C. Brown. 2006. *The ecology of sandy shores*. California, USA. Academic Press. 373 pp.

Dunes are broadly classified into:

1. Transgressive: Those dunes where lesser vegetative cover make them more mobile and dynamic.
2. Retentive: Those dunes that are comparatively more vegetated and static.

Some coastal areas have one or more sets of dunes running parallel to the shoreline directly inland from the beach. In such cases, the dunes at the front facing the sea are generally called primary dunes, and those behind are called secondary and tertiary dunes.

Coastal sand dune ecosystems have conditions quite similar to those of desert dunes with shifting sand, extreme conditions of exposure to air and the sun, and poor moisture retention that inhibit plant growth. In addition, dune systems have several physical and chemical parameters typical of the ecosystem, which limit the distribution of flora and fauna. Such parameters include poor nutrient levels, soil salinity, salt spray, changes in organic matter and pH. In order to cope with these harsh environments, plants have mechanisms that enable them to establish successfully.



Sand spinifex and morning glory colonising front dunes, with larger shrubs like ironwood and trees like palmyra occupying back dunes.



An advanced stage of plant succession on the lee-ward side of a dune in south Poigainallur, Nagapattinam district, Tamil Nadu.



## Ecological Succession and Plant Colonisation of Dunes

Plant species that initially settle on dunes have deep roots which reach for the water table, root nodules that produce nitrogen compounds, and fleshy stem and leaves that assist in retaining water. The deep roots hold the sand in place, and the dune grows into a foredune as more sand is blown over. Grasses nitrify the soil, thereby allowing less hardy plants to colonise the dunes. These too are adapted to low soil water content and have small, prickly leaves which reduce transpiration. Leaching occurs on the dunes, washing humus into slacks, and the slacks may support a wider array of flora and fauna than the exposed tops of dunes. It is usually in the slacks that rarer species are found; sometimes the soil of the dune slacks get waterlogged and only marsh plants can survive.

### Flora

Some of the most common coastal sand dune flora are creepers like beach morning glory (*Ipomoea pes-caprae*, Tamil vernacular *attukal*), sand spinifex (*Spinifex littoreus*, Tamil vernacular *Ravana meesai*) and trees like toddy palm or palmyra (*Bororus flabellifer*, Tamil vernacular *panamaram*), casuarina (*Casuarina equisetifolia*, Tamil vernacular *savukku maram*), cashew (*Anacardium oxydentrum*, Tamil vernacular *mundiri maram*), screw pine or umbrella tree (*Pandanus* sp., Tamil vernacular *talai* or *kettakai*), ball nut or beach mahogany (*Calophyllum inophyllum*, Tamil vernacular *nagam*, *punnai*), etc. Tree species like tamarind (*Tamarindus indica*, Tamil vernacular *pulimaram*), Indian coral tree (*Erythrina indica*, Tamil vernacular *kalyana murungai*) and *Hibiscus tiliaceous* (Tamil vernacular *nirparuthi*, *attuparuthi*) have the ability to survive in dune systems, but are mostly restricted to landward slopes of the rear dunes.

### Fauna

Coastal sand dune fauna are limited and are a generally neglected group, especially in the Indian context, but contain unique faunal elements. The harsh conditions on dunes have led to an impoverished faunal and floral diversity, but most of the existing organisms are highly adapted and specialised to overcome harsh environmental conditions. Microscopic meiofauna of sand dunes include nematodes, turbellarians, gastrotrichs, copepods, ostracods, amphipods, decapods and polychaetes. Insects of the orders hymenoptera, coleoptera and diptera predominate. Vertebrates include reptiles like the fan-



Beach morning glory (*Ipomoea pes-caprae*) commonly found along beaches in Tamil Nadu.



*Spinifex sericeus* beds in Narippur, southeast Tamil Nadu.



Olive ridley turtles nesting in large numbers on the beaches of Orissa.





An Indian fox pup emerging from its den in the dunes in Orissa.



Sand boa (*Eryx conicus*)

throated lizard (*Sitana ponticeriana*), sand boa (*Eryx conicus*), birds like terns and gulls, a few small raptors, and mammals, especially rodents like common rats and mice, small carnivores like jackal (*Canis aureus*), fox (*Vulpes bengalensis*), mongoose (*Herpestes edwardsi*) and common palm civet (*Paradoxurus hermaphroditus*). Olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) nest on the beaches of India and its offshore islands. Olive ridley turtles are commonly reported to nest along the Tamil Nadu coast. Olive ridleys also nest in significant numbers along the Andhra Pradesh coast and in large numbers in Orissa.

### Importance of Sand Dunes

#### *Ecological and Ethnobotanical Significance*

The dunes are occupied by a highly adapted group of plants and animals specially suited to life in such harsh conditions. Coastal sand dunes are also vital in maintaining the groundwater level of coastal areas, which is vital in sustaining not only the flora and fauna, but also form an important source of freshwater for coastal populations. Dunes are known to prevent intrusion of saltwater into the fresh aquifers of coastal areas. Very often, extensive sand dune systems may have inter-dunal



Shallow man-made pits on the lee-ward side of dunes of south Poinainallur are source of fresh water for irrigation and domestic use.



Natural swales behind sand dunes serve as sinks for rainwater, recharging groundwater aquifers and maintaining groundwater levels.

swales (freshwater bodies), which are low elevation areas located between dunes. Swales are otherwise known as dune slacks, and sometimes as inter-dunal wetlands. These water bodies are formed in areas where the water table is high. They act as sinks for the rainwater and help in recharging the aquifers. Swales typically support densely populated wetland plant communities that form a striking contrast with the surrounding dry vegetation.

Many dune plant species have ethnobotanical importance. A few dune plant species are used for fish aggregation in traditional fishing. Our knowledge of ethnobotanical aspects of coastal sand dune vegetation is inadequate. Sand dune legumes as cover crops in coconut (*Cocos nucifera*) basins serve as nitrogen fixers, and provide green manure and mulch. They also serve as nutritious fodder for the livestock. Latex from *Launaea sarmentosa* is commonly used by fishermen to heal skin injury caused by fish spines while fishing.

### ***Protection of Coastal Areas***

As geomorphic features, dunes act as physical barriers and protect the hinterland from the forces of the ocean, including wave run-up due to storm surges. Wide beaches and high dunes act as efficient dissipaters of wave energy offering protection to inland property. They also protect coastal cash crops, acting as barriers, warding off the salt laden wind from the sea.

Sand dunes have long been known by scientists and resource managers to be nature's own means of protecting the shores. Foreshore sand dunes are important coastal protective formations. They hinder the movement of storm waves and tides into the land area behind the beach.



Undisturbed foredunes begin right beyond the high tide line and help stabilise the beach after storms.

Dunes are considered as the first line of defence against erosion. They further serve as stockpiles to feed the beach, and can provide protection more effectively and at a lower cost than building a seawall. The undisturbed system of dunes acts as a flexible coastal barrier against sea erosion. The system may retreat under wave attack when sand is lost to form off-shore bars, but may advance during calm weather as the coastal vegetation traps windblown sand that has been returned by wave action from the off-shore bars to the beach.

### ***Socio-cultural Significance***

The beach space which includes the beach and the nearby sand dunes also are an important part of the social and day-to-day activities of fisherfolk. Foredunes and beaches are used for various purposes such as for landing boats, mending nets, auctioning of fish, sorting catch, drying fish and even for settlement. Further, fisherfolk prefer elevated regions of the coast (mainly on dunes) to build their houses, as this not only offers security from storms and waves, it also affords them a direct view of the sea, which is vital for them to determine the direction of winds and the weather conditions prior to a fishing trip. In many hamlets along the coast of Tamil Nadu, communities have traditionally located their hamlets on sand dunes and elevated places and many of the village names end with the word medu which, in Tamil, means 'an elevated place' (for e.g., Kottaimedu, Chinnakotaimedu, Kottucherimedu, etc.).

Sand dunes are also closely integrated to the socio-economic life of the coastal population living adjacent to them. A very good example of this is the palmyra,



Secondary stage where shrubs colonise the leeward side of the dunes, consolidate the dune further.





Palm tree leaves are used for thatching roofs of houses (south Poigainallur, Nagapattinam).



A dune adjacent to the fishing village of Chandrapadi being used for drying a large haul of sardines.

which is quite common on the sand dunes of south India. Before sugar was introduced into markets in south India, palmyra was a major plantation in southern Tamil Nadu from which jaggery was extracted. Jaggery was not only a major substitute for sugar; it was also a major source of livelihood for the Nadar community of south India. Their economy centered on palmyra, the only commercially viable crop in the region then. Jaggery extraction is still a source of livelihood for coastal communities in some parts of southern Tamil Nadu. The palmyra also yielded other useful products—mats and baskets were woven from its fronds, and the tree trunks were used as poles and roof beams for houses. Further, the leaf fronds were and are used for thatching roofs.



Fisherfolk settlement on coastal dunes in Karaikkal.



Beach space and adjacent foredunes play a vital part in day-to-day activities of fisherfolk.

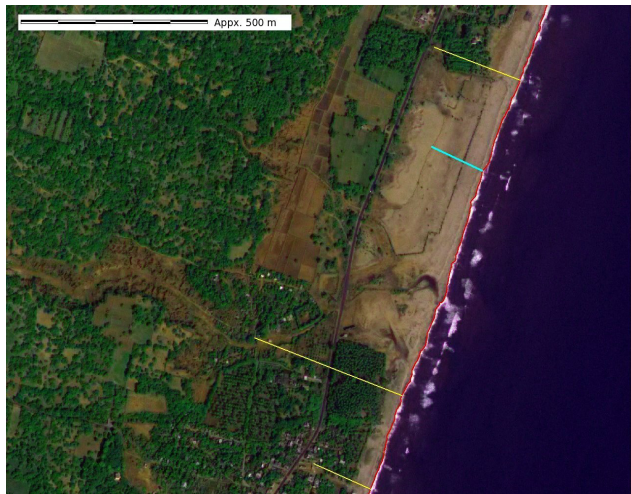


Palm jaggery extraction still remains a livelihood source for some of the coastal people of south Tamil Nadu.



## Protection from Tsunami

Evidence of sand dunes as a defense against tsunami inundation is persuasive. Dunes act as windbreaks, protect against storm surges and tsunami inundation. Studies along the Pondicherry coast on the inundation of seawater during the tsunami have shown that areas with sand dunes had less inundation compared to areas with vegetative cover. Unfortunately, dunes are not considered a worthy ecosystem, and sometimes condemned even by ecological restoration projects. However, they are integral to the livelihood of artisanal fishing communities. The Praxis reports observed that during the December 2004 Indian Ocean tsunami, many coastal villages along Tamil Nadu were protected by the presence of sand dunes.



Satellite shot of inundation along vegetation (yellow) and the Bommayapalayam Dune (blue). (Imagery not to scale)



Looking north, near the blue transect shown above.  
Source: FERAL, Pondicherry

## Case Studies and Community Perceptions

Traditionally, coastal sand dunes have been valued as an important coastal ecosystem offering protection to the hinterland, in maintaining the water table of coastal areas and even protecting the coastal crops/agriculture from the salt laden winds blowing from the sea. As in most cases, traditional value systems have died out and so has the value of sand dunes. But after the tsunami hit the coastal areas of Tamil Nadu, and many villages and coastal hamlets were saved from the direct impacts of the massive waves, these communities now recognise the value of dune ecosystems. We provide below case studies of some such villages and the perceptions of people of the value of these ecosystems after the tsunami.

### Chinnurpettai

Chinnurpettai is on elevated land and there are high sand banks right by the shore. Locals attribute the comparatively lower degree of loss and fewer deaths in the tsunami to the sandbanks and the elevated location of the village on top of dunes. All houses that were on higher ground were relatively undamaged in the tsunami as water moved into the low-lying areas around the village. Many villagers, who did not realise this advantage, ran in fear and panic onto the low-lying land near their homes and lost their lives.

### Nambiyarnagar

The center of the village is located on an elevated plane and hence was less affected by the tsunami. After the giant waves passed, water congregated to form a small pond on the southern side of the village. *Karuvai* (*Prosopis juliflora*) bushes, on the southern side were also washed away by the tsunami.

### Nayakarkuppam

The village is roughly 1 sq. km in area. The nearest seafront house stands 500 metres from the sea. A concave shaped sand dune 5 feet in height is the natural defense for the village against the sea. The dune is crest shaped, sloping down to the sea and spreading from the north to the south of the village and beyond. There are three different sand dunes between the shoreline and the village. About 50 metres east of the village is a canal that runs parallel to the shoreline. The community sees these as natural barriers.

### Kottucherryedu

Sea-front houses escaped the impact of the tsunami as they were built on raised sand dunes. When the tsunami hit Kottucherryedu, it engulfed the village from both sides leaving the houses on top of the sand dunes unaffected. The sand dunes were about 15 feet high, but the tsunami has eroded the dunes and now they only stand 6-7 feet tall.

## **Distribution of Sand Dunes Along Tamil Nadu Coast**

Coastal sand dunes along the Tamil Nadu coast have been very poorly documented or studied. Earlier studies report vast stretches of sand dunes along almost all the coastal districts like Thiruvallur, Chennai, Kancheepuram, Vilupuram, Ramanathapuram, Thoothukudi, Thirunelveli and Kanyakumari. The Chennai-Pondicherry belt, Pondicherry-Portonovo belt, Cauvery delta and Point Calimere region, Rameswaram region and the Tuticorin and Cape Comorin regions especially have well-developed sand dunes.

Some of the oldest and best established dunes of Tamil Nadu lie close to the south Poigainnallur region in Nagapattinam district of Tamil Nadu. Dunes here reach heights of 30-40 feet and the villagers and local populations value the dunes and have protected them efficiently.

### **Threats to Coastal Sand Dunes**

Some of the major threats that lead to degradation of coastal sand dune ecosystems are detailed below.

#### ***Sand mining***

Coastal sand is rich in valuable minerals and metals and this has led to large scale mining of beach sand by large industries. Large scale extraction of sand from beaches impoverishes the supply of sand to the adjacent sand dunes altering coastal topography considerably. Sand is also extracted in large amounts for construction activities.



Sand mining on beaches and dunes of Vattakottai, (Kanyakumari) south Tamil Nadu, by mining companies has led to drastic erosion in beach structures.

## ***Seawalls and groynes***

The extent of coastline using seawalls and groynes for coastal protection - erected for the most part to protect areas of housing and industrial development - is increasing every year. Coastal sand dunes depend on the adjacent sandy beaches for their supply of sand. Building seawalls along the shores not only changes the sediment dynamics of the coast, leading to drastic changes in the natural balance between erosion and accretion, it also starves the sand supply on the adjacent sand dunes, leading to more erosion of dunes and making the coastline more vulnerable.

### ***Infrastructural development***

This includes housing estates and tourism related activities along the coastal areas that have degraded sand dunes considerably. Such developments increase recreational pressure and disturb natural, interdependent systems like topography, vegetation and water table levels, amplifying the need to undertake artificial coastal defence. They also prevent the natural retreat of the dunes. Future developments need to facilitate natural ecological processes, particularly along sections of the coast with natural sea defence.

### ***Pollution***

Pollution, both on and offshore, can have detrimental effects on coastal flora and fauna. Beach pollution, especially from oil, can shift public pressure to the more sensitive foredunes resulting in greater erosion. Plastic



Razing these dunes for building roads and for other development activities, will make the coast more susceptible to natural hazards like storms and hurricanes.



flotsam and other non-biodegradable material on the coast leads to major changes in the sand budget of coastal areas. It also chokes the flora and fauna.

### ***Recreational pressure***

This is a very serious threat to sand dunes and shingle habitats. Unlimited public access to coastal sand dunes leads to its deterioration and can accelerate erosion and blow-out formation.

### ***Casuarina plantations***

Such plantations on dunes has been taking place on a large scale along the entire east and west coasts of India and this has had a major effect on large areas of dune landscape. Some sites hold large casuarina plantations which have the effect of suppressing the dune vegetation communities and lowering the water table. They also outcompete most of the local varieties of plants, causing considerable local reduction of biodiversity.

### **Legislations on Sand Dunes**

Explicit legal protection is afforded to the Indian coastline by the Coastal Regulation Zone (CRZ) notification, 1991, issued under the Environment (Protection) Act, 1986. The CRZ notification explicitly mandates the protection of sand dunes. According to the notification, sand mining is a prohibited activity on the mainland coast. The notification also prohibits the 'dressing or alteration' of sand dunes, hills and natural features for either beautification or recreation or landscape changes.



Seawall construction on the beach affects sand dynamics of the beach and in turn affects sand budget of coastal dunes.

However, various amendments to this notification have allowed for sand mining and other destructive activities.

### **Implications of Legislation Changes**

Despite all the criticism that the CRZ can be charged with, as a legal measure, it was the only law that explicitly recognised the need to protect some of these ecosystems. There are changes that are being proposed to the CRZ notification and to the whole coastal regulation regime. The Ministry of Environment and Forests (MoEF) constituted the M.S. Swaminathan Committee to review the functioning of the CRZ notification and to suggest an alternative legal regime. The Swaminathan Report



Casuarina plantations on the Karaikkal coast.

highlights the importance of beaches and sand dunes. However, the report is equivocal about the 'uses' of dunes for sand mining and mineral extraction. A review of the Swaminathan Committee report highlights these limitations and shows that there are ambiguities in the report on sand mining, where 'restricted sand mining' is advocated in one section, but discussion on banning the same activity appears in another section.

Based on the recommendations of the Swaminathan Committee, the MoEF has introduced a new draft notification termed as the Coastal Management Zone (CMZ) notification. Similar to the CRZ notification, the CMZ notification also proposes to declare sand dunes as CMZ-I areas. However, there are serious concerns with the entire notification, which nullify its seemingly positive aspects. The new notification is viewed by many as toeing the industry line, and is in line with environmental governance 'reform' measures that the MoEF has been pursuing. The most serious concern identified by several groups is that there is no clarity on the issue of violations that are yet to be dealt with under the 1991 notification. The recommendations of the Swaminathan Committee do not anywhere state that violations committed under the 1991 notification must be dealt with before any new notification is considered.

The main concern with the newly proposed coastal regime is that there is absolutely no implementation of the earlier notification that had the MoEF responsible for the same. The critics state that the present draft CMZ notification

does not have a convincing implementation mechanism to ensure coastal protection. Instead they highlight the possibility of unregulated development as a result of this law. Critics are sceptical whether the MoEF will show any keenness and political will to ensure the implementation of a stronger protection regime given the hostile response from the influential industrial and development lobbies operating today.

## Recommendations

### *Ecological research*

Research on dynamics of sand dune ecosystems and documentation of flora and fauna, their ecology and threats are limited. Effective research needs to be conducted so as to protect this ecologically sensitive and socially important ecosystem. Apart from dune vegetation, some dunes with swales/slacks have unique and interesting flora and fauna. It is imperative to study their ecology as well. For example, in many regions of the Andhra Pradesh and the Tamil Nadu coast, it was observed that local species of sand dune flora have been replaced by extensive *Prosopis juliflora* invasion. This may in turn affect the faunal composition and diversity. The possible effects of extensive planting of exotic species like *Casuarina* are still quite poorly understood. A lot of research needs to be carried out to understand the consequences of ecological and physical changes in the shoreline and coastal areas as a result of such large scale plantation of introduced species.



Traditional sand dune management practice in south Poigainallur, Nagapattinam - Leaves of toddy palm being used to trap sand.



Casuarina plantation replacing pioneering plant (sand spinifex) species on the beach.



### ***Monitoring***

Status surveys, ecological studies and monitoring have been carried out in the last century elsewhere in the world, but in India, barring a few dune surveys and dune vegetation studies done, no studies have been carried out on aspects of ecology of floral and faunal communities, their interactions and monitoring programmes to study dune health.

### ***Management***

In spite of the legal protection enjoyed by coastal sand dunes, they are still being exploited and are under serious anthropogenic pressure. Some possible management measures that can be undertaken to protect these valuable ecosystems are:

- Legal protection of the existing sand dunes from further losses to anthropogenic factors, whether caused directly or indirectly.
- Development and promotion of planning policies and procedures which will aim to prevent or minimise further losses of sand dune habitat to development.
- Official and legal recognition and involvement of local initiatives for sand dune protection and restoration
- Reviving of traditional sand dune restoration and management practices that have proved successful.
- Restoration of sand dune habitat lost to forestry, agriculture or other human uses.
- Raising public awareness of the essential mobility of coasts and the value of maintaining unrestricted coastal processes.
- Engagement and support (monetary and technical) to local communities for the restoration and protection of sand dunes and associated ecosystems.



Sand dunes in south Poigainallur in Nagapattinam district of Tamil Nadu shield the hinterland from the forces of the sea and help in maintaining the water table, thereby permitting farming and agriculture on the leeward side.



A typical sand dune ecosystem in Kadapakkam, Tamil Nadu.

## Bibliography

- Arun, A.B., K.R. Beena, N.S. Raviraja and K.R. Sridhar. 1999. Coastal sand dunes: A neglected ecosystem. *Current Science* 77: 19–21.
- Bhalla, R.S. 2007. Do bio-shields affect tsunami inundation? *Current Science* 93(6): 831–832.
- Mascarenhas, A. 2002. Restoration of sand dunes along human-altered coasts: A scheme for Miramar beach, Goa. In: Proceedings of the International Conference on Eco Balance and Life Cycle Assessment in India organized by the Indira Gandhi Institute of Development Research from 13 to 15 February 2002 in Mumbai, India, pp. 27–31.
- Mascarenhas, A., K. Sawkar, A.G. Untawale and P.V. Sathe. 1998. The distribution of and impacts on sand dune systems of Rajebhag (Nagorcem), Canacona, Goa. Coastal Environment Series, NIO, November 1998, 16 p.
- Mathew, T (ed.). 2005. Accountability overdue: Learning from participatory engagement with the tsunami affected. Praxis-Institute for Participatory Practices, New Delhi, India, 50 pp.
- McGwynne, L.E. and A. McLachlan. 1992. Ecology and management of sandy coasts. Report No.30. Institute of Coastal Research, University of Port Elizabeth, South Africa, 84 p.
- McHarg, I. 1995. *Design with nature*. New York: John Wiley Publication, 208 p.
- McLachlan, A. and A. C. Brown. 2006. *The ecology of sandy shores*. California, USA. Academic Press, 373 p.
- Ranwell, D.S. 1972. *Ecology of salt marshes and sand dunes*. London: Chapman and Hall.
- Sanjeevi, S. 1996. Morphology of dunes of the Coromandel coast of Tamil Nadu: A satellite data based approach for coastal landuse planning. *Landscape and Urban Planning* 34 (3): 189–195.
- Silverside, A. J. 2001. British habitats maritime sand-dunes. Biological Sciences, University of Paisley Biodiversity, <http://www-biol.paisley.ac.uk/bioref/Habitats/dunes1.html>
- Sridhar, A., M. Menon, S. Rodriguez and S. Shenoy. 2008. Coastal Management Zone notification '08: The last nail in the coffin. A review by ATREE, Bangalore, India, 81 p.
- Tinley, K.L. 1985. Coastal dunes of South Africa. S.A. National Scientific Programmes Report No. 109. CSIR. Pretoria, 304 p.
- U.S. Army Corps of Engineers, 1984. Shore protection manual. Coastal Engineering Research Center, Washington, DC, USA, pp. 108–112.

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