Chapter 10

Bioshields and Ecological Restoration in Tsunami-Affected Areas in India

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Abstract

There has been considerable interest in activities concerning 'bioshields' in India following the December 2004 tsunami. There is an ongoing debate about the effectiveness of these bioshields with respect to the tsunami within both scientific circles and local communities. Despite the lack of concrete evidence of their role in protecting the coast and the ambivalence in data and opinion, there have been numerous post-tsunami initiatives that have established and promoted plantations as bioshields in India. In this chapter, we present a brief overview of such initiatives by the government and by nongovernmental organizations (NGOs). We have collated information on the work done on bioshields and attempted to evaluate them from an ecological perspective. The results indicate that such plantation efforts are not new (post-tsunami) but have been practiced for decades by the government. Scant attention has been paid to the ecology of the species being planted in such 'restoration efforts' and very little science has been used either in the formulation of policies governing bioshields or in the implementation of the same. We propose long-term monitoring of these 'restored sites' or shelterbelts to evaluate their effectiveness and sustainability in the long run.

10.1 Introduction

The Indian Ocean tsunami that was caused by an earthquake of intensity of 8.9 on the Richter scale hit the coastline of peninsular India on 26 December 2004 (http://www.eeri.org/lfe/clearinghouse/sumatra_tsunami/reports/EERI-Report-Combined-Yeh-India.pdf, accessed on 15 January 2008). This mammoth natural disaster affected 2260 km of the coastline in mainland India and led to death of 12 405 people in three states (namely Tamil Nadu, Andhra Pradesh and Kerala) in India (UN Report, 2005). Subsequently, the protection of the coast by bothnatural and artificial structures gained added impetus. It is not surprising therefore that there has been considerable interest in activities concerning 'bioshields' after the tsunami. Bioshields, as the name indicates, are coastal vegetation structures (both natural and planted) that are supposed to contribute to

the protection of the coast from storms, cyclones and even tsunamis to varying extents. In the majority of cases along the Tamil Nadu coast, they consist of mangroves and *Casuarina* plantations.

There has been an ongoing debate about the effectiveness of these plantations and other coastal forests in providing protection from the tsunami (Kar and Kar, 2005; Kathiresan and Rajendran, 2005; Kerr et al., 2006; Vermaat and Thampanya, 2006). Kar and Kar (2005) were the first to point out the need for research on the beneficial role of mangroves in mitigating the effects of the tsunami. Kathiresan and Rajendran's (2005) work in 18 tsunami-affected hamlets located along 25 km of the coastline in Tamil Nadu indicated that hamlets protected by (i.e. located on the landward side of) mangroves and other coastal vegetation suffered less human death and damages. Danielsen et al. (2005) also pointed out that in Cuddalore district, Tamil Nadu, the impact of the tsunami was significantly lesser in mangrove- and *Casuarina*-protected villages than in others. However, Kerr et al. (2006) reanalyzed the data of Kathiresan and Rajendran (2005), and came to the conclusion that mangroves and other vegetation did not have a significant effect on the impact of the tsunami. Rather, topography and distance from the shoreline were the major factors determining impact of the tsunami. Following this, Kathiresan and Rajendran (2006) pointed out that the study was limited to 18 hamlets of a particular area and the tsunami run-up there was only 2.8 m. Vermaat and Thampanya (2006) also reanalyzed the data of Kathiresan and Rajendran (2005), supporting the original conclusion that mortality and property loss were actually less behind mangroves. Thus, at least in the scientific literature, there appears to be no clear consensus about the effectiveness of bioshields, particularly *Casuarina*, in coastal protection and tsunami mitigation.

Local communities too have diverging opinions about coastal plantations. While some communities depend on mangroves and other vegetation for their subsistence, there is also evidence that in many hamlets, local fishing communities have opposed and even uprooted *Casuarina* saplings (Rodriguez, 2007). The main causes for this conflict are rights to the coastal land and accessibility to the sea, both of which are affected by *Casuarina* plantations. However, works supporting plantations as bioshields have often been cited to further plantation efforts in various places and substantial work has been done on bioshields in India after the tsunami. Both government and nongovernmental agencies have contributed significantly to the planting of bioshields. In India, most of the plantations along the coast are under the jurisdiction of the Forest Department, which is a government organization. There are also a large number of nongovernmental organizations (NGOs), which work either independently or in close collaboration with the Forest Department in raising these plantations. International bodies are either directly involved or fund bioshields in India.

Author: We have replaced word "literature" with "works" for grammatical reasons. Could you please confirm that it is OK?

Past studies elsewhere have demonstrated that monoculture stands may not be sustainable in the long term and provide fewer ecosystem services (Field, 1999; Ellison, 2000). For instance, Walters (2000) found no post-planting recruitment of different mangrove species (other than those used for plantation) into 50–60-year-old 'restored' sites in the Philippines. Often such rehabilitation/restoration efforts move directly into the planting stage without any assessment of stress factors affecting natural regeneration, the suitability of the site for restoration activities or assessment of the socioeconomic dependence of local communities on mangrove resources at the restoration sites (Ellison, 2000). A sizeable proportion of such efforts therefore end in failure. Very often, restoration programs end with the final activity of planting, and very few plantations are assessed with respect to their functionality.

Bosire et al. (2008) propose 'ten commandments' for mangrove restoration. In this study, we focused on these questions in an attempt to evaluate bioshield plantation initiatives that are currently underway in three states in southern India:

(a) What is the scale and extent of bioshields in tsunami-affected states in India?
(b) Did ecological science play a role in the decision-making process?
(c) What are the flaws in such practices from an ecological perspective?
(d) Were local people involved in the process of raising plantations?

10.2 Methods

In India, the Forest Department is the governmental organization, which is primarily responsible for raising plantations along the coast. We conducted structured interviews with Forest Department officials (from the head of the department, the Principal Chief Conservator of Forests, in each state to local Range Forest Officers) in Tamil Nadu, Andhra Pradesh and Kerala states in southern India. We also procured maps and details of the post-tsunami micro-plans of the Forest Department (see Table 10.1 for an illustration of this administrative setup in Kerala state). We collected information regarding various local NGOs working on plantations through repeated field visits and interactions with local communities between November 2006 and June 2007. We also contacted the regional representatives of major funding agencies to get contact details of NGOs raising plantations. Structured interviews were conducted with representatives of NGOs in Andhra Pradesh and Kerala. We also visited some of their plantation sites to gain a better understanding of ground realities.

The following four objectives were focused on to answer the research questions:

- Scale and extent: In the three different states, we tried to estimate the following: How much area was planted? What was the major source and amount of funds?

Table 10.1 Administrative setup of Kerala Forest Department.

Category	Number of circles	Number of divisions	Number of ranges	Number of Sections	Number of beats
Territorial	5	23	74	177	303
Wildlife	3	12	19	48	49
Working Plan and Research	1	9	14	23	–
Vigilance	2	8	19	25	90
Social Forestry	3	14	37	223	–
Nature Study Centre	1	–	1	–	–
Training	1	2	.	–	–

Source: http://www.kerala.gov.in/dept_forest/forest.htm, accessed on 10 October 2007.
Category: Refers to the various administrative divisions of the Forest Department.
Circle: Each state is divided into a number of circles for better administration.
Division: Each circle is subdivided into divisions headed by a Divisional Forest Officer.
Range: With each division are nested several ranges each headed by a Range Officer.
Section and beat: Each division in turn comprises of sections (headed by Section Officer) and each section is subdivided into beats (headed by Beat Officer). The origin of the term 'beat' dates back to colonial times when a beat officer's job was to beat the bushes (along with forest guards further down in the hierarchy) to scare away wild animals when a higher official was accompanying him in the forest.

- Ecology:
  (a) Was the plantation a monoculture/polyculture?
  (b) was any site selection carried out before the process of planting?
  (c) Was any monitoring of the plantation done post-plantation?
- Gaps or flaws: What are the gaps or flaws in the plantation process from an ecological perspective on the basis of the above-mentioned parameters in ecology?
- Involvement of local people: Were local people directly involved in the process of plantation? What are their perceptions toward plantations and were these perceptions heeded to in the policy-making process for bioshields?

10.3 Results

10.3.1 Scale and extent

10.3.1.1 Forest department initiatives

Tamil Nadu: The Tamil Nadu Forest Department has been raising shelterbelt plantations along its coastline since 1960 (Table 10.2). As a result, about 2239 ha had been covered under shelterbelt plantation prior to the tsunami under various plantation schemes like Tamil Nadu Afforestation Programme and National Afforestation Programme. Immediately after the tsunami, the Forest Department conducted a rapid assessment to identify sites for further plantations. An area of about 17 754 ha was found to be available along the coast for raising shelterbelts 'after leaving room for encroachment'. Out of this total area, about 11 500 ha of areawas found suitable for shelterbelt (*Casuarina* spp.) and 6254 ha for mangroves. Currently, 2000 ha of *Casuarina* spp. plantation and 400 ha of mangroves are being planted in this state. With the assistance of the World Bank, the Forest Department implemented two schemes: (a) *Emergency Tsunami Reconstruction Project* (ETRP) and (b) *National Cyclone Risk Mitigation Project* (NCRMP). Under ETRP alone, 1.75 million US dollars were sanctioned for *Casuarina* shelterbelt plantation and US$ 250 000 for mangrove plantations.

Andhra Pradesh: The Andhra Pradesh Forest Department also started planting bioshields after the tsunami. A project titled Andhra Pradesh Community Forest Management (APCFM) is currently being implemented. The duration of this project is 5 years and the estimated budget for this project is approximately 162 million US dollars (http://forest.ap.nic.in/JFM%20CFM/CFM/A%20P%20CFM%20Index.htm, accessed on 10 October 2007). International Development Agency and Government of Andhra Pradesh are financing this project. Although the main agenda of this project is to reduce the pressure of natural resource extraction on existing forests and poverty alleviation, coastal bioshields are being planted as a part of this project after the tsunami (see Figure 10.1 for flow of funds in this project).

Kerala: In Kerala, the state government had already constructed sea walls along 550 km of their 600 km coastline. Thereby the emphasis on bioshields after the tsunami has been less than the other two states. The Forest Department has, however, played an active role in raising mangrove plantations along the extensive backwaters in this state to prevent rapid erosion of the riverbanks.

Table 10.2 Details of Shelter belt plantations raised by Forest Department of Tamil Nadu.

S. no.	Coastal districts	Year of planting	Area (ha)
1	Villupuram/Cuddalore	1978	54.3
		1985	110
		1988	31.4
		1991	11.7
		1992	19.7
		2000	10
2	Thanjavur and Pudukottai	1988	30
		1999	16.5
		2001	450
		2004	150
3	Nagapattinam and Thiruvarur	1989	59
		1994	15
		1998	5.5
		2000	250
4	Ramanathapuram	1969	200
		1974	23
		1975	200
		1986	10
		1990	33
		1991	23
		1999	17.5
		2001	300
5	Tuticorin	1998	15
		1999	15
6	Tirunelveli	1974	30
		1975	30
		1990	2.5
		1992	5
		1997	0.5
7	Kanyakumari	1960–1973	28

10.3.1.2 Nongovernmental organization initiatives

In addition to the government, several NGOs have also been involved in establishing plantations after the tsunami (see Table 10.3 for a summary of the work done by various NGOs; Figure 10.2 provides a representative map of plantation activities in Tamil Nadu).

In sharp contrast to the government, the majority of the NGOs started plantation activities only after the tsunami. In a sizeable number of instances, many NGOs themselves have been established post-tsunami, or have included plantations within their institutional themes after the tsunami. With the exception of those NGOs that work in close association of the Forest Department and get funded by the department, most of the NGOs interviewed by us are dependent on international funding. The amount received by each organization ranged from a minimum of US$ 12 000 to about US$ 200 000.

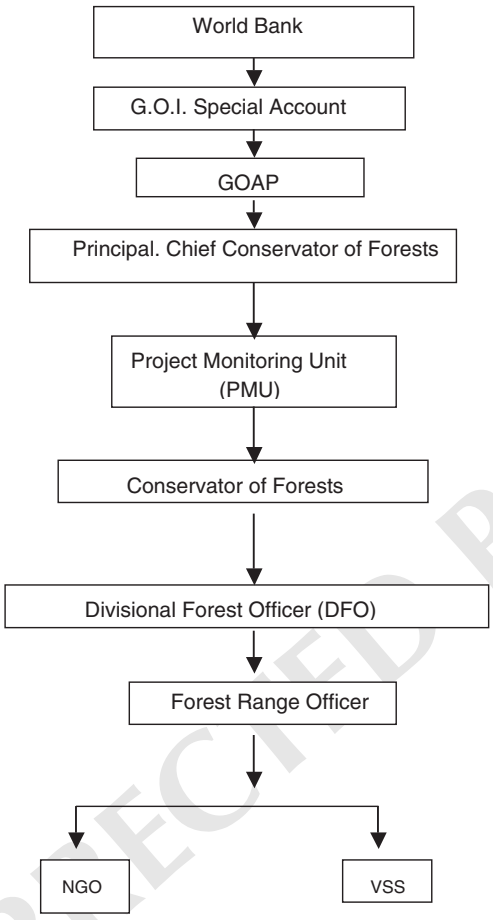

Figure 10.1 Flow chart showing flow of funds from the World Bank through the Forest Department to local organizations implementing the plantation project. (*Source*: http://forest.ap.nic.in/JFM%20CFM/CFM/PIP/03_Financial%20Management/03_Financial%20management%20manual.doc.)

10.3.2 Importance given to science (ecology)

10.3.2.1 Forest Department

Species planted: Rarely has knowledge of ecological science played a role in the plantation protocols. Based on our questionnaire surveys, we found that majority of the plantations raised by NGOs and the government in Tamil Nadu and Andhra Pradesh are monocultures. The species that is widely used for mangroves is *Avicennia marina* with *Rhizophora* spp. being used in some sites. In the case of non-mangrove shelterbelts, *Casuarina equisetifolia* is planted on a large scale. A clear exception here is a plantation practice in northern Kerala where the Forest Department has used locally available species in mostly mixed culture plantations.

Table 10.3 A list of nongovernmental organizations involved in restoration in the tsunami-affected states in India.

State/UT	Name of the organization	Place	Area	Species	Funding agency
Tamil Nadu	M.S. Swaminathan Research Foundation (MSSRF)	Muzhkuthurai, Samiarpettai, Killai Panchayat and Madavamedu		*Rhizophora mucronata*, *Avicennia marina* in mangrove plantations and *Thespesia*, coconut and cashew along with *Casuarina*	DBT
	Anawim	Mangalavadi	2 ha	*Casuarina*	Greencoast
	The Covenant Centre for Development (CCD)	Rameshwaram			
	Social Education and Environmental Development Scheme Trust (SEEDS Trust)	Rajakamangalam Kanyakumari	Established nursery with 15 000 nos	*Rhizophora mucronata*, *A. marina*	Greencoast
	The Palani Hills Conservation Council (PHCC)	Kaatucherry Tarangambadi	4 ha	*Rhizophora mucronata*, *A. marina*, *Bruguiera cylindrica*	Greencoast
	Centre for Appropriate Technology (CAT)	Manakudi Kanyakumari	3 ha	*Rhizophora mucronata*, *A. marina*	Greencoast
Pondicherry	Regional Ecology and Environment Federation (REEF)	Thengaithittu	3 ha	*Rhizophora mucronata*, *A. marina*	Greencoast
	Centre for Environment and Agricultural Development (CEAD)	Veerampatinam	3 ha	*Rhizophora mucronata*, *A. marina*, *Bruguiera cylindrica*	Greencoast

(*Continued*)

Table 10.3 (Continued)

State/UT	Name of the organization	Place	Area	Species	Funding agency
Andhra Pradesh	M.S. Swaminathan Research Foundation (MSSRF)	Machilipatnam (Krishna district and Todangi (E. Godavari district)	120 ha of mangroves and 40 ha of *Casuarina* respectively	*A. marina*, *A. officinalis*, *Rhizophora mucronata*, *Excoecaria agallocha*, *Bruguiera cylindrica*	CIDA, IDRC
	Chaitanya Development Society	Chinnaganjam	50 ha	*A. marina*, *A. officinalis*, *Rhizophora mucronata*, *Bruguiera cylindrical*, *Excoecaria agallocha*	AFRO and CARE
	Training for Rural Economic and Education (TREE)	Gundamala pathepallipalem Ongole	2 ha	Seeds collection is being carried out for establishing nursery.	Greencoast
	Generation of Awareness and Rural Development Society (GARD)	Nizampatnam, Baptla	5 ha	Awaiting for monsoon for direct seed transplantation and nursery raising	Greencoast
	Gift of God Ministries (GGM)	Baptla	2 ha		Greencoast
	District Fishermen's Youth Welfare Association (DFYWA)	Vishakapattinam	2 ha		Greencoast

Society for National Integration through Rural Developments (SNIRD)	(a) Ulavapadu Mandal (Prakashan district) and Kavali Mandal (Nellore district) (b) Kothapatnam Mandal (Prakasham district)	(a) 80 ha of *Casuarina* (b) 67 ha of *Casuarina*	*A. marina*, *A. officinalis*, *Rhizophora mucronata*	Christian Aid; DKA, Austria and NOVIB
Sravanti	Chollangi and Island Polavaram	30 ha	*A. marina*	OXFAM, CEE (Bangalore)
Coastal Community Development Programme	Prakasam Dist	50 ha		ITC, CARE India,
Sangamitra	Krishna district	260 ha (proposed)	*A. marina*, *A. officinalis*, *Rhizophora mucronata*, *R. apiculata*	DEA (Germany)

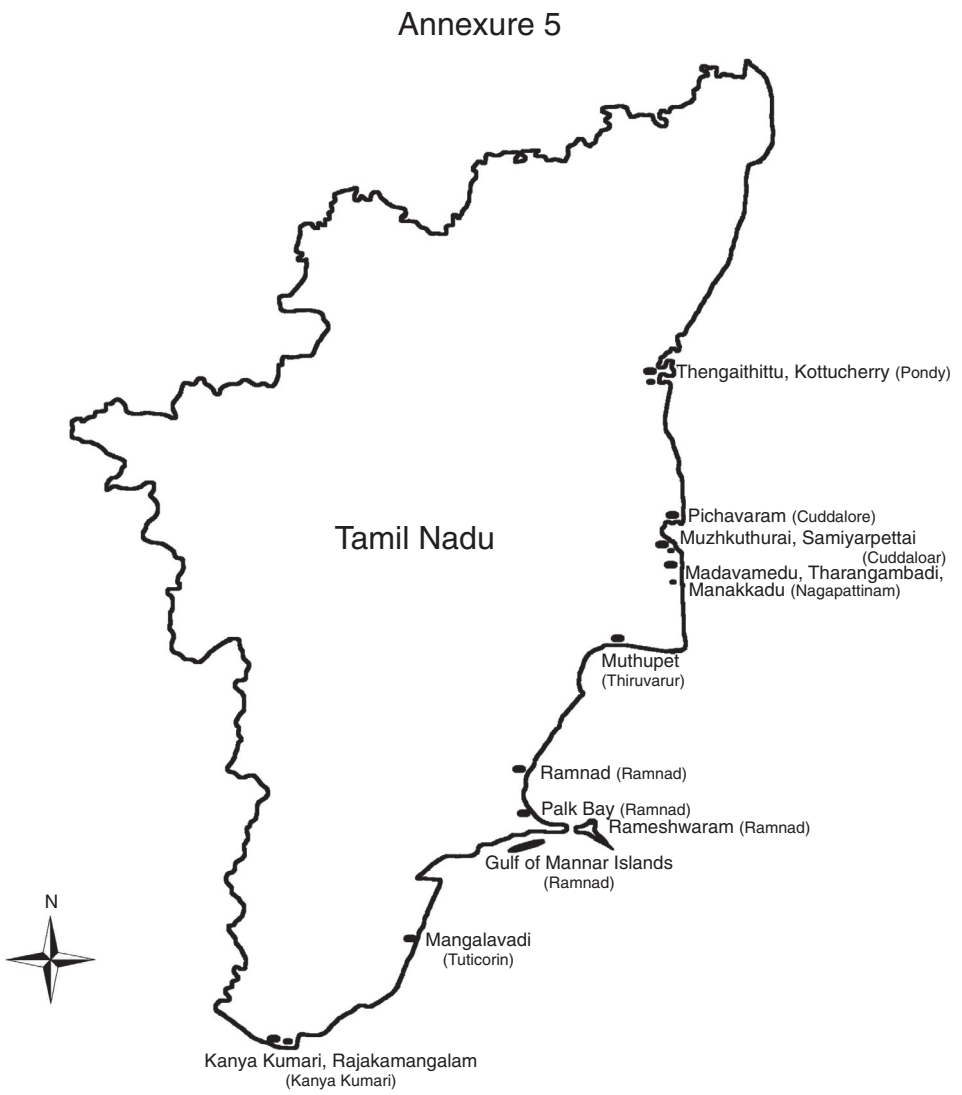

Figure 10.2 Map showing plantation activities in Tamil Nadu.

Soil suitability certificate

It is to certify that I have inspected the_____

_____

Site selected for raising_____

Plantations of_____ Km _____

(Species) in _____ village of _____ Mandal in Ongole (SF)

Range, and after ascertaining soil and rainfall requirements, I am satisfied that the site

selected is fit for raising of _____species.

Forest Range Officer,
Social Forestry, Ongole

Counter Singned

Divisional Forest Officer,
Social Forestry Division
Ongole.

Figure 10.3 A copy of the soil suitability certificate emphasizing site selection before plantation in Andhra Pradesh.

Site selection: In almost all instances, we found that no prior site selection was done before the plantation activity. Interestingly, however, there exists a government policy according to which it is mandatory to conduct site selection before plantation (Figure 10.3).

Monitoring: In the majority of cases, plantations are not monitored for growth rate, regeneration status, colonization of nonplanted species, etc., owing to lack of funds and skilled labor.

10.3.2.2 Nongovernmental organizations

Species planted: Almost all NGOs are raising monocultures. *A. marina* and *A. officinalis* are widely used in mangrove plantations. *Rhizophora* spp. is also used occasionally. In the case of non-mangrove plantations, only *C. equisetifolia* is planted. In some places, *Palmyrah* is also being planted.

Site selection: Similar to the Forest Department, most NGOs have not done any prior site selection before the plantation activity.

Monitoring: The status of monitoring is even more dismal in the case of NGOs. Several of theses plantations are fairly recent and there was no component of monitoring in their working plans.

10.3.2.3 Gaps/Flaws

Based on species: According to most government working plans in the east coast, a mixture of 90% *Casuarina* sp. with 10% mixed species are supposed to be planted. This consists of *Acacia planifrons*, *Syzygium cumini*, *Holoptelea integrifolia*, *Bambusa arundinacea*, *Dalbergia sissoo*, *Thespesia populnea*, *Jatropha* spp., *Borassus flabellifer*, *Acacia curticulliformis* and *Cocos nucifera*. However, in most of the circles, only *A. planifrons* is being used sparingly in Tamil Nadu. In Andhra Pradesh, *Casuarina* is planted exclusively. Almost all NGOs are planting monocultures. The coastline is progressively becoming dotted with nonnative uniform *Casuarina* plantations.

Site selection: Despite a government policy, which makes it mandatory to conduct site selection before plantation (Figure 10.3), it is never practiced on the ground. The NGOs too seldom followed any site selection protocol. The importance of remnant natural coastal ecosystems like sand dunes and sandy beaches, which might be altered by such exotics, is also being ignored.

Monitoring: The government policy states that *Casuarina* should to be monitored for the succeeding 5 years after plantation and mangroves for the next 3 years. This is seldom practiced as noted by our field surveys. As mentioned earlier, the situation is worse in the case of NGOs who seldom have any funds allocated to monitoring.

10.3.3 Involvement of local people

Based on the questionnaire surveys and interviews, we found that in Tamil Nadu, the involvement of the local communities was significantly less than in Andhra Pradesh. The Tamil Nadu Forest Department had to bring in migrant labor form neighboring districts during the plantation season. A considerable portion of the resident local communities was opposed to such plantation activities in the state. In Andhra Pradesh, the Forest Department is raising plantations with the village conservation committees in four coastal circles as documented in Forest Department working plans.

There is greater involvement of local people in the plantation process in the case of NGOs. Most NGOs are engaged with the local communities in other initiatives like rural development, education programs and livelihood enhancement. This enables them to interact with the communities at a deeper level than with the Forest Department.

10.4 Discussion

A fruitful collaboration between management and ecological research is required for effective forestry activities. As a beginning, we offered suggestions from ecological and socioeconomic perspectives. In the case of mangroves, the importance of the hydrologic regime and soil characteristics of a site cannot be overemphasized during site selection (see Ellison, 2000). There is ample documented evidence to suggest that plantation/afforestation need not be the only approach to 'restoration' of mangroves (see Lewis, 2004). On the contrary, according to some researchers, it may be the last option that should be put into practice (Stevenson et al., 1999). Often, altering the hydrology or soil characteristics that

facilitate natural regeneration of mangroves may be the most cost-effective and self-sustaining method to bring back mangroves in a degraded mangrove site. If afforestation is the only option, then mixed plantations should be practiced rather than monoculture of *Avicennia*. After establishing the plantations, the sites should be monitored on a long-term basis to understand the sustainability of such efforts.

In the case of *Casuarina* plantations, the area where such plantations are being carried out needs to be carefully evaluated. Critical turtle nesting sandy beaches and sand dunes should be left untouched. Moreover, the ratio of other mixed species can be raised. A host of tropical dry deciduous or dry evergreen species can be used (e.g. *Manilkara hexandra*, *Mimusops elengi*, *Diospyros ebenum*, *Strychnos nux-vomica*, *Eugenia* spp., *Drypetes sepiaria* and *Flacourtia indica*). In this context, the flora in the recent past in the plantation sites could be of importance. At a more generic level, emphasis should shift from raising artificial plantations to preserving the natural dune ecosystems found in these regions.

The natural resource use of the local people in the vicinity of the plantation site should be borne in mind before the choice of species is made. Their perception toward plantations and their need for the particular plantation (e.g. fuel, firewood or bioshields) should be considered. Their involvement is crucial to the long-term sustainability of such plantations as about two thirds of the population lives close to the coast. Thus, it is critical to weave local support into restoration and management plans.

At a much larger scale, it is vital to analyze policies at local and regional levels, which regulate bioshield management (cf. Dahdouh-Guebas and Koedam, 2006; Rist and Dahdouh-Guebas, 2006). This is particularly significant for mangroves because they occur in diverse land use patterns where multiple policies come into play. Quite often, when there are multiple stakeholders, the policies do not overlap. In such cases, it is essential to be able to identify and comprehend those policies that are of relevance to bioshields.

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