



Original article

An interdisciplinary framework to evaluate bioshield plantations: Insights from peninsular India



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ABSTRACT

Bioshields or coastal vegetation structures are currently amongst the most important coastal habitat modification activities in south-east Asia, particularly after the December 2004 tsunami. Coastal plantations have been promoted at a large scale as protection against severe natural disasters despite considerable debate over their efficacy as protection measures. In this paper, we provide an interdisciplinary framework for evaluating and monitoring coastal plantations. We then use this framework in a case study in peninsular India. We conducted a socio-ecological questionnaire-based survey on government and non-government organizations directly involved in coastal plantation efforts in three 2004 Indian Ocean tsunami affected states in mainland India. We found that though coastal protection was stated to be the primary cause, socio-economic factors like providing rural employment were strong drivers of plantation activities. Local communities were engaged primarily as daily wage labour for plantation rather than in the planning or monitoring phases. Application of ecological criteria has been undermined during the establishment and maintenance of plantations and there was a general lack of awareness about conservation laws relating to coastal forests. While ample flow of international aid has fuelled the plantation of exotics in the study area particularly after the Indian Ocean tsunami in 2004, the long term ecological consequences need further evaluation and rigorous monitoring in the future.

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1. Introduction

Bioshields are defined as coastal vegetation used or promoted for protection of the coast from extreme events such as storms and tsunamis (Mukherjee et al., 2010). Bioshields range from pristine ecosystems (e.g. mangroves) to coastal monoculture plantations (e.g. *Casuarina equisetifolia*) (Feagin et al., 2010). The establishment of bioshield plantations is currently one of the major coastal habitat modification activities in the Asia Pacific region (ITTO/ISME, 2008). In the aftermath of severe natural disasters in the past decade (e.g. Cyclone Haiyan in November 2013, Japan tsunami in March 2011, Cyclone Aila in May 2009, Cyclone Nargis in May 2008 and the

Indian Ocean tsunami in December 2004), several international organizations (e.g. United Nations Environment Programme-UNEP, International Union for the Conservation of Nature-IUCN and Food and Agricultural Organisation-FAO) have suggested that coastal ecosystems need to be restored and rehabilitated for coastal defence against extreme events (Mukherjee et al., 2010). As a reaction to these extreme events, local governments in some Southeast Asian countries have launched large-scale bioshield plantation projects as restoration efforts. Eminent international organizations like the World Bank, IUCN, Asian Development Bank, Overseas Economic Cooperation of Japan have provided enormous funds for such projects (Primavera and Esteban, 2008). For instance, the Indian Government, in association with the World Bank, launched the Emergency Tsunami Reconstruction Project (2006) and National Cyclone Risk Mitigation Project (2004) in tsunami-affected areas, which included the construction of bioshields as one of its major goals (Mukherjee et al., 2009). In Bangladesh, the Forest Department and IUCN have initiated several plantation projects (Biswas

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et al., 2008). Indonesia, Malaysia, Sri Lanka and Thailand have also witnessed the rise of such plantation projects (ITTO/ISME, 2008).

Evaluating the success (or failure) of bioshields is urgently needed given their large spatial scale, the massive funds involved in such projects and the social and ecological consequences of these plantations. Moreover, it is necessary to critically assess past and current plantation projects in order to avoid future failure and improve the ecological functionality of such plantations. This is particularly relevant for bioshields as their efficacy has been the subject of intense scientific and political debate in South and Southeast Asia in the last decade (Baird et al., 2009; Bhalla, 2007; Das and Vincent, 2009; Feagin et al., 2010; Kathiresan and Rajendran, 2005, 2006; Kerr et al., 2006; Vermaat and Thampanya, 2006, 2007).

While mangrove plantation efforts have been reviewed sufficiently (Bosire et al., 2008; Primavera and Esteban, 2008), assessments of bioshield initiatives involving primarily *C. equisetifolia* have seldom been reported in scientific literature. Currently, there is no readily available framework that can be used to analyse these bioshield plantations. Moreover, existing frameworks on mangrove restoration do not consider the long term financial support required for plantation activity (as they are mostly from short term aid projects). This aspect is critical in the post plantation phase e.g. in maintaining required hydrological regime through construction of drainage channels for sustained growth of the plantation (Bosire et al., 2008). Given the multidisciplinary context within which such projects are implemented, a multipronged approach may be necessary to create an evaluation scheme.

In this paper, we first discuss insights from published literature on the success or failure of mangrove plantations. We then develop it further and extend it to the context of bioshields and propose a socio-ecological framework for evaluation and monitoring coastal plantations consisting of mangroves or *C. equisetifolia*. In this new framework, we address three aspects of bioshields, i.e. ecological, social and economic (in terms of financial support for plantations) aspects. We then use this framework in a case study in peninsular India to evaluate on-going bioshield plantations. Currently, there is a plethora of interdisciplinary frameworks available in social-ecological systems research (Balmford et al., 2002; Costanza et al., 1997; Ostrom and Nagendra, 2006). These frameworks however differ in their disciplinary background, approach and applicability amongst other things. Binder et al. (2013) provide a comprehensive overview, comparing ten frameworks in terms of their conceptualization, scale, applicability and anthropocentric versus ecocentric approaches. In this study, the framework developed is related to the Human Environment Systems Framework though we have used an ecocentric approach in our analysis rather than an anthropocentric one (Binder et al., 2013).

1.1. Insights from literature on coastal plantations

Lewis (2005) noted that successful restoration projects are frequently reported, while failures are seldom mentioned. In spite of this, there is ample evidence to suggest that majority of past plantation projects, particularly mangroves, have either failed or had limited success (Bosire et al., 2008; Dahdouh-Guebas and Jayatissa, 2009; Hastrup, 2011; Primavera and Esteban, 2008). Though several factors could affect the success or failure of plantations, the foremost ones based on published literature are discussed here in three temporal phases: pre-plantation, plantation and post-plantation.

1.2. Pre-plantation

1.2.1. Assessment of drivers

The success or failure of a plantation is often determined by motivation for the establishment of the plantation, both in terms of

their value for stakeholders, as well as for the implementing agency (Bosire et al., 2008; Feagin et al., 2010). Despite the apparent focus on the coastal protection function of bioshields, recent studies have suggested that there might be other drivers for their establishment based on the ecosystem services that such plantations provide (Bosire et al., 2008; Feagin et al., 2010; Mukherjee et al., 2009). For instance, in a detailed review of mangrove restoration efforts worldwide, Ellison (2000) pointed out that silviculture was the prime reason for restoration while Bosire et al. (2008) found that classic mangrove restoration projects were aimed at natural resource production e.g. wood products. In the Philippines, where 95% of brackish water ponds were derived from mangroves (1952–1987), massive plantation projects were undertaken to stem the over-exploitation and mangrove loss (Primavera and Esteban, 2008). Assessment of drivers is thereby an essential first step in evaluating a plantation particularly if there are discrepancies between local drivers and the funding agencies. Understanding the motivations behind the establishment of current coastal plantations might also enable future plantation activities to be directed towards more sustainable and ecologically sound drivers. Time of initiation of plantation effort (before or after an extreme event) can be used as a proxy for assessing the underlying drivers for plantation.

1.2.2. Land tenure

Land tenure is one of the most critical factors in driving land use change (Guillerme et al., 2011; Lambin et al., 2001; Ostrom and Nagendra, 2006). In South and Southeast Asia, plantations established on private land or village common lands are subject to land use change based on the discretion of the individual landowners or village leaders (Mukherjee et al., 2009). On the other hand, plantations established on government land may be protected by law and are expected to be more secure in the long term and thereby less susceptible to anthropogenic impacts, though this is not always the case (McElwee, 2006).

1.2.3. Social support for plantations

Long-term sustenance of plantations has been observed to be heavily dependent on local support for such activities particularly when the plantation takes place outside government owned land (Tanaka, 2009). For instance, as pointed out above, plantations on Government land are more likely to be secure in a way even though they have less community participation, buy in and support, whereas plantations in village common land or private land may be more dependent on community support. Community participation is required at the initial stage of identifying drivers for the plantations to ensure continued local support during and after plantation (Biswas et al., 2008). Thereby, documenting community perceptions towards the plantation activity is crucial. However in South and Southeast Asia, plantation establishment is frequently carried out with a top-down rather than a participatory approach (Hastrup, 2011; Mukherjee et al., 2010). Involvement of local communities in the planning and implementation could be used as a proxy for social support for plantations.

1.2.4. Financial resources

Since plantations require maintenance, both in the initial phase of planting and also in subsequent phases to prevent grazing, illegal harvesting, encroachment etc., it is necessary to have financial resources earmarked for monitoring and maintenance. Lack of funding support is known to be a major issue in the sustainability of plantations (Biswas et al., 2008).

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