Institute of Economic Growth

POLICY BRIEF

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CASUARINA MONOCULTURES ARE NOT EFFICIENT COASTAL SHELTERBELTS: SOME EVIDENCE FROM ODISHA

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Coastal bio-shields are expected to protect human settlements against coastal disasters such as cyclones, tsunamis, and high-speed winds. Since the early 20th century, Casuarina plantations have been raised extensively along the vast Indian coastlines as shelterbelts, despite concerns that they are detrimental to local biodiversity and native ecosystems that provides a habitat to native species. But, during the October 1999 super cyclone along the Odisha coast, Casuarina plantations failed to protect human lives, whereas native vegetation like mangroves and mixed cashew plantations did. This policy brief examines and compares the storm protection of Casuarina with native species of vegetation found along the same coastline, in the form of preventing loss of human lives during the super cyclone that occurred in October 1999 in the eastern Indian state of Odisha. The coastal blocks of Puri and Kendrapada districts of Odisha were the study area for this analysis. It concludes that, for effective ecosystem-based management of coastal areas, Casuarina should be used along with native species (a mixed species approach against Casuarina monoculture). Alternatively, a cautious approach may be followed in planting Casuarina along vulnerable coastal areas.

BACKGROUND

Coastal bioshields may protect human lives by attenuating storm surge velocity, which is the biggest killer during tropical storms. Field observations and laboratory research conducted after the Indian Ocean tsunami have established that the magnitude of tsunami mitigation offered by various types of coastal forests is determined by several key parameters of vegetation. These are forest width, tree density, age, tree diameter, tree height, and species composition and locational factors like shore slope, bathymetry, spectral characteristics of incident waves, tidal stage upon entering the forest, etc.

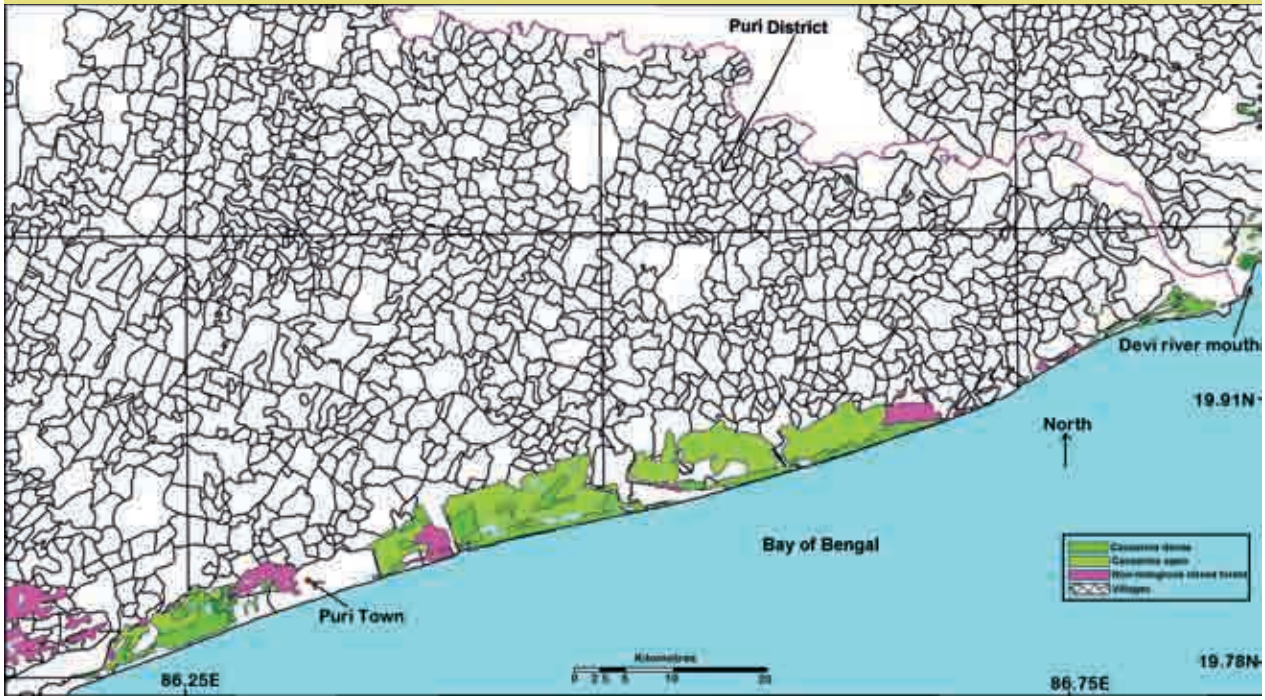
In this project, however, the comparison of storm protection services of natives against exotics was from the same site with same locational features. Therefore, the difference in protection services should primarily be due to the different features of the vegetation, not coastal landscape. Both numerical simulation and field experiments have shown mangroves to be reducing wave heights and dissipating wave energy substantially, but there are no such studies on Casuarina or other types of coastal vegetation.

HISTORY OF CASUARINA PLANTATIONS IN ODISHA

Casuarina trees are native to Australia. A review of studies on these trees' ecosystem services suggests that these trees retain soil within ecosystems; regulate hydrological flow of water and atmospheric carbon (by storing it as wood); improve nutrient cycling, nitrogen fixation, salt tolerance, and the suppression of soil-borne diseases; and serve as a habitat for birds. But there is no evidence that these trees protect the coast or are used as a coastal shelterbelt in Australia.

This policy brief is based on the following paper: Das, S and H. Sandhu, 'Role of exotic vegetation in coastal protection: An investigation into the ecosystem services of Casuarina in Odisha', *Economic and Political Weekly*, 4 January 2014, XLIX (1), 42–50. Saudamini Das is at the Institute of Economic Growth, Delhi, and Harpinder Sandhu is at Flinders University, Adelaide, Australia. The analysis is based on data collected for the project 'Evaluation of Storm Protection Services of Mangroves: Analysis of Super Cyclone of October 1999', funded by the South Asian Network for Development and Environmental Economics (SANDEE).

Figure 1a. Coastal vegetation, Puri district



In the state of Odisha, where Casuarina trees are exotic, these were planted first in 1913 in Puri district to supply fuel wood to Puri town. According to the Orissa District Gazetteer, Puri 1977, '[t]he original idea for planting Casuarinas to supply fuel wood to the town of Puri was conceived in 1913 by the then conservator of forest, Carter. In between 1915 and 1919, 300 hectares were planted. Subsequently, it was felt necessary to raise a coastal belt plantation along the entire coast of the district to prevent sand dunes, cyclones and tidal water damaging agricultural field and villages and 2023 hectares were brought under it.' Thus, the objective and location of plantations seem to have changed over time. Today, Casuarina is the most dominant species and in many places, forms monocultures along the Puri coast (Figure 1a). According to the Orissa District Gazetteer, Puri, 1990, the other littoral species found in this area are *Pongamiapinnata*, *Pandanustectorius*, *Calophylluminophyllum*, and *Calotropisgigantea*, which are native species. Thus, the policy of planting Casuarina for coastal protection seems to have no historical support of coastal protection being an ecosystem service of these trees.

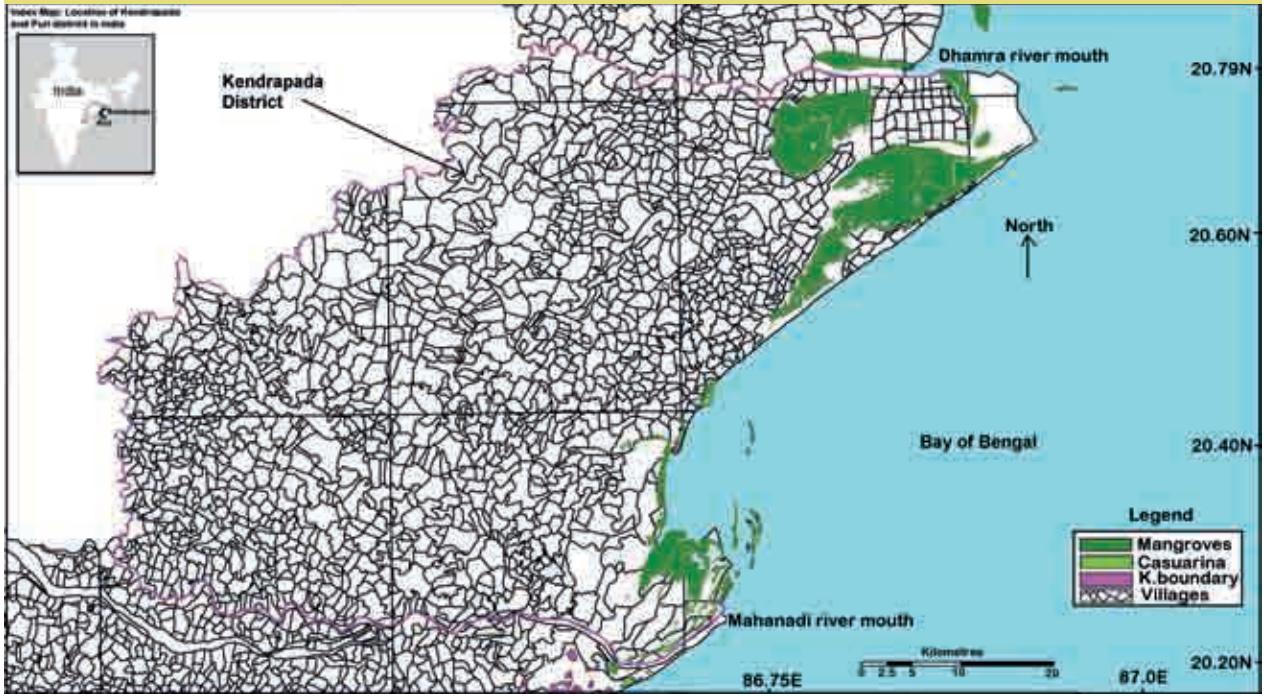
In 1971, a severe cyclonic storm killed more than 10,000 people in Odisha. Thereafter, a coastal shelterbelt scheme was set up, and Casuarina plantations were set up in Kendrapada district, a swampy area that is primarily a mangrove habitat and not suitable for Casuarina trees, in 1974. According to the Orissa District Gazetteer, Cuttack, 1996, '[t]o protect coastal areas from the ravages of cyclonic storms which are quite frequent and consequent tidal waves and spreading of coastal sand dunes, the State Government took up afforestation within one kilometre belt of the sea coast as an anti-cyclonic measure from the year 1974 onwards .... Under the scheme, Casuarina, cashew and coconut plantations were raised all along the seacoast of the district.'

The trees survived only in some coastal pockets. Though the Kendrapada coast is largely covered with mangroves, there are some coastal areas with Casuarina (Figure 1b).

ROLE OF CASUARINA IN SUPER CYCLONE

The study examined the storm protection role of three different types of coastal forests, i.e., mangroves, non-mangrove mixed cashew nut forests, and Casuarina during the super cyclone of October 1999. Mangroves and mixed forests are indigenous, whereas Casuarina is an exotic species planted under the coastal shelterbelt

Figure 1b. Coastal vegetation, Kendrapada district



plantation scheme of the state government as explained above. An empirical model was used and tested with data from the coastal districts of Kendrapada (428 villages of Mahakalpada and Rajnagar blocks, called study area 'A') and Puri (391 villages of Astarang, Kakatpur, and Gop blocks, called study area 'B') of Odisha. These areas were battered by the super cyclone and witnessed 231 and 188 deaths respectively.

Kendrapada district is low lying, and has mangroves and some Casuarina in its coastline; Puri district has an elevated sandy beach with plenty of Casuarina and some mixed cashew nut forests. The average elevation of both these districts is less than 10 metres across the coast, but Kendrapada coast, being a mangrove habitat, is likely to be more low-lying. Therefore, data from these districts were examined separately, and the storm protection of Casuarina in Kendrapada district was compared with mangroves found there; and the storm protection of Casuarina of Puri district was compared with mixed cashew forests found there.

Both these samples comprised villages that can be categorised into: (1) unprotected (not having any vegetation between the village and the coast); (2) protected by only native vegetation; (3) protected by only non-native (Casuarina) vegetation; or (4) protected by both native and non-native vegetation. First, Table 1 compares the incidence of human death over these categories of villages in Kendrapada, and shows that it was highest in the villages behind Casuarina (highest average deaths = 2.74) and the least in the ones behind mangroves (lowest average death = 0.28). In Puri, however, villages behind both Casuarina and mixed forest suffered similarly (average death = 0.4).

However, this finding cannot be conclusive, as storm impact, socioeconomic features, and other factors could have caused such variation. Next, the study examined these findings econometrically. These other features were controlled by using many other variables in the econometric model so that the roles of vegetation types on death occurrences are separated. The dependent variable in the model was human casualties witnessed due to the storm, and explanatory variables were multiple other factors like cyclone impact, spatial, geographical and socioeconomic features of the villages, including the width of the type of vegetation in between the village and coast. Zero-inflated negative binomial estimates were derived for the coefficients after clustering the standard errors by the gram panchayats to which the villages belong. Such models were estimated separately for the two

Table 1. Deaths from the 1999 super cyclone

Districts	Source of protection	Number of villages	Total deaths	Deaths per village
Kendrapada	Not protected by any forest (open coast)	198	103	0.52
	Protected by only mangroves	166	47	0.28
	Protected by only Casuarina	23	64	2.74
	Protected by both mangrove and Casuarina	41	17	0.41
	Total number of villages	428	231	0.54
Puri	Not protected by any forest (open coast)	118	78	0.66
	Protected by only Casuarina	230	92	0.40
	Protected by only mixed forests	42	18	0.43
	Protected by both mixed forests and Casuarina	1	0	0
	Total number of villages	391	188	0.48

study areas to control for the distinct topographies of the two districts.

RESULTS

In Kendrapada district villages, the variables that significantly reduced deaths (coefficient was significant with negative sign) were width of mangrove forest, percentage of literate people, and percentage of scheduled caste people, whereas the variables that aggravated the death occurrences were being behind Casuarina, closeness to the cyclone eye path, and having a higher percentage of marginal workers. In villages in Puri, the width of mixed forests, the presence of village roads, and similar factors seemed to have reduced deaths significantly; in contrast, villages close to the coast or to the cyclone eye path witnessed significantly higher deaths. Casuarina forests, aplenty in the district before the storm, had an insignificant effect on deaths. Thus, native vegetation (mangroves in Kendrapada and mixed cashew nut forest in Puri) protected lives and reduced the death toll in both the study areas, whereas Casuarina aggravated death occurrences in the low-lying Kendrapada coast and was insignificant in deaths along the comparatively elevated Puri coast. Thus, econometric analysis supported the summary findings presented in Table 1.

These findings do not support the hypothesis that Casuarina provides storm protection, but that native forests like mangroves and other non-mangrove mixed forests with indigenous trees do. As the mixed forests also had some Casuarina along with the native trees, a mixed Casuarina plantation seem to be better than Casuarina monoculture.

POLICY IMPLICATIONS

Casuarina have higher commercial value than native species, particularly for timber and fuel wood. But these do not serve as shelterbelts, particularly in mangrove habitats, and seemed to aggravate death occurrences in such areas where they are promoted as bioshields. For effective ecosystem-based management of coastal areas, a significant policy shift is required towards using Casuarina along with native species (a mixed species approach against Casuarina monoculture). Alternatively, a cautious approach may be followed in planting Casuarina along vulnerable coastal areas, especially the mangrove habitats.

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