View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by University of Queensland eSpace

12. CASUARINA COASTAL FOREST SHELTERBELTS IN HAMBANTOTA CITY, SRI LANKA: ASSESSMENT OF IMPACTS

Mangala De Zoysa

The definition of coastal forest shelterbelts in urban landscapes is highly complex. Growing of *Casuarina equisetifolia* as a small shelterbelt on the beach in Hambantotota City was implemented to protect the beautiful natural sand dunes, preserve visual amenity and be a barrier to seawater salt spay. The casuarina shelterbelt has become popular because it was the only undamaged area in Hambantota City after the devastating 2004 tsunami. The objective of the study was to assess the impacts of the casuarina shelterbelt in economic, social and environmental terms. The city dwellers close to the shelterbelt were interviewed and information collected based on their observations and experiences. According to them, the casuarina shelterbelt has not been able to reduce the wind speed. Although the belt has increased the size of the sand dunes, the casuarina trees have suppressed the growth of native species as an under-storey. The belt has improved the aesthetic value of the beach. No impact of the shelterbelt has been identified in protecting agricultural crops and reducing the corrosion of household goods from seawater salt spay. The city dwellers have not recognized the economic importance of casuarina timber but are impressed with the increase of fuelwood supply from the shelterbelt. The shelterbelt has prevented illegal settlement, but facilitated anti-social and illegal activities of the poor city dwellers. The attractiveness of the beach for tourism has been enhanced. Empirical evidence reveals that the casuarina belt in Hambantota City has greater environmental and social impacts than economic impacts.

INTRODUCTION

Hambantota City in southern coastal Sri Lanka has an intensely hot arid zone climate and a 700 to 1000 mm annual rainfall. Coastal erosion is a severe problem along the Sri Lankan southern coasts including in Hambantota City. As in most of the arid zones, wind erosion is a serious problem in Hambantota. Since the 1980s there has been a growing understanding of the importance of the urban shelterbelt to mitigate damage along the coastline.

Growing of *Casuarina equisetifolia* as a coastal shelterbelt on the attractive beach in Hambantotota City was implemented during the period of 1986–97 under a forestry development project funded by the Norwegian Agency for Development Cooperation (NORAD). The main aims of the project were to reduce the harmful effect of dry winds and dust storms, protect the beautiful natural sand dunes, and act as a barrier to seawater salt spray. The casuarina coastal shelterbelt has become a popular focal point for discussion because it was the only area where casualties and material damage were limited in one of the cities totally destroyed by the devastating tsunami tragedy on 26 December 2004. The coastal shelterbelt along the sand dunes in Hambantota has proven the capacity of coastal vegetation as a 'soft' solution for many coastal issues and helped to protect coastal settlements and property from the tsunami (Urban Development Authority 2006). Similarly, in the Nagapattinam coast of India, casuarina shelterbelt planting is believed to have acted as a barrier and reduced the impact of the giant tsunami waves (Ganesan 2005). Under normal circumstances, most sand removed by storms from beaches in coastal areas is stored offshore, and moves back to the beach via wave transport. On the beach, casuarina roots retain the sand. Stabilizing of shifting sand dunes is based on the principle of reducing the threshold velocity of wind by the tree-belt. Sand dune stabilization with plant species is more permanent than mechanical mulching and chemical fixation techniques (FAO 1989).

Casuarina equisetifolia is a popular rapid-growing low-maintenance shelterbelt species, used extensively for windbreaks and coastal stabilization. Casuarina is often planted in sandy soil as windbreaks considering its root suckering habit, extensive foliage which arrests wind velocity and ability to reclaim soil under excess salinity conditions (Torrey 1976). Although casuarina is not a legume, it does have the ability to form root nodules and fix atmospheric nitrogen (National Research Council 1984). The coastal shelterbelt generally moderates local climate, slowing wind and storm water, cooling and cleaning the air, providing shade, increasing scenic value and enhancing coastal

tourism and recreation. The definition of a coastal shelterbelt in an urban landscape is highly complex because it needs to define the relationship of trees to other elements of the urban environment. It is a challenge to understand the dynamic nature of the coastal shelterbelt and its anticipated environmental, social and economic changes of urban environment.

The objective of this study has been to assess the impacts of the casuarina coastal shelterbelt in economic, social and environmental terms, with the view of promoting further coastal shelterbelts to mitigate damages while reaping benefits for urban landscapes.

RESEARCH METHOD

The few officials (6) of the Forest Department and Urban Council of Hambantota directly involved in the project were interviewed informally concerning their views on establishment and maintenance of the casuarina coastal shelterbelt. A survey was conducted of a random sample of 50 city dwellers selected from the list of residents close to the shelterbelt using a pre-tested questionnaire. Field observations also added qualitative information for the study. The study was conducted in October 2005 and had almost 100% response of the interview of officers while about 90% of the survey of city dwellers.

In the survey of city dwellers, qualitative data on main impacts were collected using the Likert scale of: 1 = very low; 2 = low; 3 = moderate; 4 = high; and 5 = very high. The data were analysed using the non-parametric sign test. The responses of the individual city dwellers before and after the establishment of the shelterbelt were counted as n^+ (an increased rating) and n^- (a reduced rating) using the Likert scale. n+ and n- are binomially distributed with p = q = 1/2 and N = (n+) + (n-). $(n^+) + (n^-) = N > 25$. The null hypothesis was that the shelterbelt has not led to a change in each of the impact categories, while the alternative hypothesis is that the shelterbelt has led to a change. The test statistic of $Z = (| n^+ - n^- | - 1)/\sqrt{(N)}$, approximated with a standard normal distribution, defined as

$$Z = \frac{(x + 0.5) - n/2}{\sqrt{n/2}}$$

ENVIRONMENTAL IMPACTS OF THE SHELTERBELT

The personal interview of officials revealed the background information. The survey of city dwellers facilitated to collect primary data using the Likert scale through ranking their responses. The mean values of the ranks respondents are reported in Table 1.

Table 1. Mean Likert scale scores for before and after shelterbelt establishment

Impact category	Before shelterbelt establishment	After shelterbelt establishment
Environmental impacts:		
Wind-speed	3.72	3.10
Size of sand dune	1.86	2.58
Native plant growth	1.88	1.08
Aesthetic value	2.26	3.48
Economic impacts:		
Crop growth	2.32	2.44
Corrosion	3.88	3.82
Timber value	1.66	1.80
Supply of firewood	2.14	2.82
Social impacts:		
Prevent illegal settlements	3.10	1.24
Tourist attraction	3.18	4.12
Anti-social activities	1.94	3.28

The test results of the each impact categorized under environment, economic and social impacts are presented in Table 2.

Table 2. Sign test results

Impact category	No. of non-ties	Percent of the difference of the values	Z statistic	Probability level
Environmental impacts:				
Wind-speed	16	50.00	-0.25	0.803
Size of sand dune	33	84.85	3.83	0.000*
Native plant growth	30	13.33	3.83	0.000*
Aesthetic value	15	80.00	2.07	0.039*
Economic impacts:				
Crop growth	12	75.00	1.44	0.149
Corrosion	10	40.00	0.32	0.752
Timber value	4	100.00	1.50	0.134
Supply of firewood	16	81.25	2.25	0.024*
Social impacts:				
Prevent illegal settlements	30	0.00	5.30	0.000*
Tourist attraction	26	76.92	2.55	0.011*
Anti-social activities	22	81.82	2.77	0.006*

* Significant at the 5% level.

Effectiveness of the Shelterbelt in Reducing Wind Speed

The experiences in Hambantota City in the semi-arid zone show unfavourable conditions of climate and shortage of water which are intensified by the strong winds. Planting of casuarina in a protective coastal shelterbelt was expected to reduce wind velocity and provide shade in order to improve living conditions of the city dwellers and agricultural production in the adjoining area. According to FAO (1989), a shelterbelt generally protects an area over a distance up to its own height on the windward side and up to 20 times its height on the leeward side, depending on the strength of the wind.

According to the city dwellers the wind-speed was high (mean score = 3.72) before establishment of the shelterbelt and subsequently is slightly reduced to a moderate speed (mean score = 3.10). The casuarina shelterbelt has not been able to reduce the wind speed significantly ($Z = 0.250$, $P = 0.803$). It is observed that the city is at an elevated location relative to the sea.

Impact on Size of the Sand Dunes

Often sand bars form in front of beaches, and shelterbelts prevent bare strips due wind erosion. Sand dunes without vegetation cover move in the direction of the wind, endangering the condition of city households, agricultural crops and roads. To prevent encroachment by tidal waves, the sand dunes must be stabilized. One method of sand dune stabilization is to establish a vegetative cover. The sand dunes in Hambantota City coast are backed by the manmade shelterbelt of casuarina trees. The city dwellers judged that the size of the sand dune which was low (mean score = 1.86) has been increased to a moderate level (mean score = 2.58). The casuarina shelterbelt has significantly increased the size of the sand dune ($Z = 3.830$, $P = 0.000$) which was able to prevent damage from the tsunami. It could be observed that the shelterbelt has grown taller and lifted the sea wind off the beach creating a large sand dune between sea and trees.

Impact of the Shelterbelt on Native Plant Growth

Salt marshes and dry saline communities are found in the arid extremes of the southeast coasts including Hambantota. The terrain is generally flat with sand dunes bordering the coastline, and vegetation consists mainly of dry thorny scrublands. The semi-arid thorn scrub covers a high proportion of the coastal area providing some ground cover for soil against excessive loss of moisture. Characteristic species of semi-natural coastal woodlands usually support a rich ground flora. Casuarina in its natural state is gregarious, forming a pure crop with little or no undergrowth except grass and a few coastal shrubs. The heavy root mat and deep litter layer of the casuarina trees reduce or eliminate competitors (National Research Council 1984). The city dwellers considered that the casuarina trees have reduced the undergrowth limiting to less plants and biomass from moderate (mean score = 1.88) to low (mean score = 1.08). The trees have significantly suppressed the growth of those native species under the canopy within the shelterbelt area ($Z = 3.834$, $P = 0.000$).

Impact on Aesthetic Value

One of the key concerns relating to the impact of forests on landscape character is the great value for recreation and visual amenity. Beautifying the landscape means changing the coastal area from its normal brown colour to greening of the landscape. One of the main objectives of planting the casuarina shelter belt was to increase the visual amenity of the Hambantota beach. The city dwellers in Hambatota have the feeling that the shelterbelt has improved the aesthetic value ($Z = 2.066$, $P = 0.039$) of the beach from a low level (mean score = 2.26) to a high level (mean score = 3.48). This type of shelterbelt with casuarina trees planted along coastal area has reduced the brown colour and heat of the sandy beach and beautified the urban landscape.

ECONOMIC IMPACTS

Impact of the Shelterbelt on Growth of Agricultural Crops

The lack of vegetative cover exposes the soil to the desiccative effects of hot, dry wind, resulting in dust storms and other forms of severe wind erosion. The growth of agricultural crops, particularly the rice and vegetables, are badly affected by wind through transport of soil particles and the desiccating effect. Further, the farmers are experiencing salt concentration in the rooting zones of agricultural crops due to the increase of evaporation in irrigated agricultural fields. Generally, such damage can be reduced by the establishment of shelterbelts. Surprisingly, the farmers in Hambantota have not recognized a change in crop growth from the low level before shelterbelt establishment (mean score = 2.32) to after the establishment (mean score = 2.44). The impact of the shelterbelt on their urban and peri-urban cultivation of agricultural crops was non-significant ($Z = 1.443$, $P = 0.149$). The agricultural officials still believe that to control wind erosion and protect agricultural land, establishment of well-designed shelterbelts along the coastal zone is essential.

Prevention of the Deterioration of Household Goods

Coastal currents transport seawater salt spray along the shore, exposing a much larger area of the residents to its ill effects. The deterioration and corrosion of household goods in Hambantota urban area by seawater salt spray cause high economic loss for the city dwellers. They are experiencing a loss of durability and higher maintenance cost of their furniture and metal goods. Almost all the city dwellers want to live as close to the sea edge as possible, but they do not want the sea wind, salt spray and sand blowing into their houses. It is believed that the coastal shelters do moderate strong winds around buildings. However, according to the urban households the casuarina shelterbelt has not reduced the corrosion problem at all, the problem remaining high both before (mean score = 3.88) and after (mean score = 3.82) the shelterbelt was established ($Z = 0.320$, $P = 0.752$). Casuarina has not successfully checked the degradation of household goods mainly the metals due to salt laden coastal winds. A bushy and sturdy coastal shelterbelt is needed to withstand strong winds to check the degradation of household goods due to salt laden coast winds.

Timber Value of the Casuarina's Shelterbelt

Presently, government attention is focused not only on tree planting but also on increased public awareness of the value of trees and their commercial products. Further, there is a need to expand shelterbelts along the coastal areas to provide timber through fast growing and high-yielding tree species, and to ensure the natural forests are protected. The city dwellers in Hambantota have not recognized the change of the timber value in the area before (mean score = 1.66) and after (mean score = 1.80) shelterbelt establishment. They do not recognize the importance of timber from casuarina trees which have been grown on the beach ($Z = 1.500$, $P = 0.134$). The choice of species, however, is based on considerations of suitability for the difficult physical conditions on the site. The Forest Department is of the opinion that the best indicator of the most suitable species for an area is the trees already grown there successfully. Casuarina is a salt tolerant, wind resistant species, is adaptable to poor soils and has the ability to fix atmospheric nitrogen. It thrives in close proximity to the sea on loose sand and even grows in close proximity to high-tide level. Generally, attempts to saw and season casuarina for use as lumber have not been satisfactory (Loughborough undated), and it has little commercial value. The pulping properties of casuarina are acceptable (Rockwood *et al*. 1983).

Impact on the Supply of Firewood

Forest plantations in arid zones including Hambantota are often proposed for the production of fuelwood, a product crucial for city dwellers. About 38% of respondents in Hambantota rely on fuelwood for their domestic needs because they cannot afford other sources of energy. If fuelwood is scarce, more time must be spent in fuel gathering from distant sources at the expense of productive work. The coastal shelterbelt also provides the city dwellers with trees that could be cut for fuel and fencing material. The residents of this poor city have been impressed with the increase in fuelwood supply from the casuarina shelterbelt, with a mean Likert score increasing from low (mean score = 2.14) to moderate (mean score = 2.82) level (Z = 2.250 P = 0.024). Cutting of shelterbelt trees to obtain firewood is prohibited, although collecting fallen twigs from the forest floor is allowed. Casuarina trees are well suited for fuelwood because of their high growth rate and coppicing potential. Although casuarina wood has a high density, the green wood moisture content is relatively low, making the energy value considerably higher than that of other species (Rockwood *et al*. 1983), and casuarina wood dries rapidly and burns well.

SOCIAL IMPACTS

Impact on Prevention of Illegal Settlements

Planning of coastal shelterbelts in cities needs to take into account the existing settlement patterns, land uses, livelihood needs and structures, and environmental sustainability issues within the urban centre. The conflicts over competing interests for use of the land have to be reconciled. It is common in many Sri Lankan cities that the urban poor have obtained access to land through informal settlements in fringe areas and even hazardous lands. The illegal settlements on the coast of Hambantotata City could have resulted in rapid deterioration of the coastal environment with untreated waste, erosion and uncontrolled access to the natural resources. The government authorities in Hambantota City, together with the Forest Department have taken the responsibility for protecting coastal area from irreparable environmental and social consequences. The casuarina tree belt has successfully prevented illegal settlement from a moderate level (mean score = 3.10) to very low level (mean score = 1.24), the change being statistically significant (Z = 5.295, P = 0.000). Illegal settlements are put up by the poor city dwellers, particularly the fishermen, on the city's beach. It is still not possible to accurately forecast tsunamis and tidal storm disasters. The building of the coastal shelterbelt in Hambantota City and also keeping settlements away from the coastline are vital to mitigate both environment and storm damages. It is believed that the coastal shelterbelts absorb the force of waves from a tsunami or typhoon before they can reach inhabited areas by the shore. After the devastating tsunami the government has declared a 50 m wide coastal conservation buffer zone to protect the coastal population and the environment.

Impact on Attractiveness for Tourism

Coastal beaches are considered as one of the most popular tourist attractions in Sri Lanka. Tourism in Hambantota City has been recognised as an industry with great potential for further economic development. The Forest Department has initiated the promotion of ecotourism because the tourism industry is dynamic in the city. Both the Forest Department and forestry development project of the Integrated Rural Development Project of the Hambantota were involved in the establishment of the casuarina coastal shelterbelt. The city dwellers have recognized that the casuarina shelterbelt has enhanced the attractiveness of the city beach as a tourist destination mainly due to its beautiful shade, from moderate (mean score = 3.18) to high (mean score = 4.12), a significant change (Z = 2.550, P = 0.011). The public has become increasingly interested in nature tourism, and appreciation of the landscape and the environment in general is growing. Sri Lanka declared the year 2000 as the 'Year of Ecotourism', in recognition of this fast growing segment in the tourism sector. The casuarina shelterbelt has also increased the comfort of travellers on the main road moving to the highly respected religious destination of Kataragama, by providing shade and attractive surroundings. The environment of the seafront has been improved, with shelter and amenities as well as access for car parks.

Impact on Prevalence of Anti-social Activities

The accessibility of woodlands and natural spaces has implications for crime and safety issues. Instead of enjoying the spaces available to them, unfortunately the shelterbelt facilitates many anti-social and illegal activities by the urban poor. Although the anti-social activities in Hambantota City were comparatively low (mean score = 1.94), the shelterbelt has increased many activities presently to a moderate (mean score = 3.28) level (Z = 2.772, P = 0.006). The anti-social activities

by the city dwellers which are of direct concern are the incidents of arson, car break-ins, illegal alcohol and drug selling, and theft. These anti-social activities together with a fear of crime have a considerable impact on the urban communities. They expressed concern that the shelterbelt made the beach a potentially threatening place at night, dangerous to walk along and creating many blind spots behind the trees.

CONCLUSIONS AND POLICY IMPLICATIONS

The coastal shelterbelt in Hambantota City appears not to have reduced the speed of salt-laden winds blowing through the city as was expected, and suppresses native plant growth under the casuarina trees, a negative impact. The increase of the size of sand dunes and the promotion of the aesthetic and micro-climatic advantages of the beach are considered as the main positive environmental impacts. The casuarina shelterbelt is not able to act as a windbreak for adjacent agricultural fields, to reduce the corrosion of household goods by salt laden winds, or even to produce timber with economic value for the area. However, the shelterbelt provides city dwellers with fuelwood, saving both money and time spent on fuelwood collection. Prevention of illegal settlement by the poor and creating attractive surroundings for tourists on the beach of the city are two important social impacts of the shelterbelt. The increase of illegal activities within the shelterbelt has created some social concern among the city dwellers.

It is expected that shelterbelts will be established in other coastal cities, given the favourable results already achieved on the Hambantota City coast. The coastal shelterbelts should be designed and established by the Forest Department and City Council together with the Coastal Conservation Department and in consultation with the city dwellers. The shelterbelts should be designed as bushy and sturdy structures with tree species having economic, social and environmental importance, and maintained to ensure the positive impacts and to reduce real and perceived dangers. A national tourism policy focusing on ecotourism with a potential component of integrated coastal zone management is required by the residents of the coastal zones, city councils and the Tourist Board in order to reap greater benefits from coastal shelterbelts.

REFERENCES

FAO (1989), *Arid zone forestry: A Guide for Field Technicians*; Publications Division, Food and Agriculture Organization of the United Nations, Rome, Italy.

Ganesan, S. (2005), 'Shelter belt plantations take on killer waves'; The Hindu Online edition of India's National Newspaper, India, Sunday, 2 January 2005, p. 3.

Loughborough, W.K. (undated), A study of the seasoning and allied characteristics of Casuarina equisetifolia, unpublished report, University of Florida, School of Forest Resources and Conservation, Gainesville.

National Research Council (1984), *Casuarinas: Nitrogen-fixing Trees for Adverse Sites*', National Academy Press, Washington, DC.

Rockwood, D.L., Huffman, J.B. and Conde, L.F. (1983), 'Potential of Casuarina spp. for biomass production in Florida', *Silvicultura*, 8(30): 376–377.

Torrey, J.G. (1976), 'Initiation and development of root nodules of Casuarina', *American Journal of Botany*, 63(2): 335–344.

Urban Development Authority (2006), *Basic Guide to Design and Planting of Coastal Green Belt in Sri Lanka*; Urban Development Authority, Colombo, Sri Lanka.