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Dynamics of the Response of Coastal Ecosystems to Tsunami Catastrophe

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Introduction

Tsunami, the killer wave swept nearly two thirds of the coast of Sri Lanka on 26th December, 2004. About 40,000 people died and around 500,000 people were displaced, more than 119,000 houses got damaged either fully or partially. The coastal zone was the recipient of this devastation having more than 75% of its area affected. About 13 coastal districts were directly affected, the north and east suffered the major brunt accounting for about 2/3 of deaths and 60% of displacements. In terms of ecological aspects, a sea of debris was deposited on the coastline. Major cities were destroyed, their sewer lines and garbage disposal sites damaged, shops selling hazardous chemicals were damaged resulting in organic and inorganic contamination of water sources. Apart from few trees most of the vegetation was damaged either completely or partially, lagoons, estuaries, coral reefs, sea grass beds, salt marshes, mangroves experienced the damage at varying levels.

Situation of Ecosystems Just After Tsunami

As an immediate response to the tsunami catastrophe several organizations including govt. and non govt. carried out environmental assessments in the tsunami affected areas. Out of these the Rapid Assessment by the Ministry of Environment and Natural Resources (MENR) in close cooperation with the Central Environmental Authority (CEA) with the assistance and support of the United Nations Environment Programme (UNEP) can be specially mentioned. It consisted of two parts, focusing on the 'green' environment (ecosystems, biodiversity, protected areas and farmlands) and the 'brown' environment (pollution, debris and impacts on human settlements and infrastructure).

On Coral Reefs and Sea Grass Beds

The ability of intact, healthy coral reefs to absorb and dissipate over 90% of the energy from waves has been demonstrated in locations as far apart as Australia, Central America, the Caribbean and the Red sea. However, the coral reefs of Sri Lanka were far from pristine prior to the Tsunami since in many areas they had been all but destroyed by the mining of coral rock for making lime and cement and elsewhere they were still recovering from a major coral bleaching event in 1998 which was caused by the unusually high water temperatures. The reefs of Sri Lanka, then were already stressed and weakened where they still existed and even in protected areas they had long been vulnerable because management capacity was too weak to prevent destructive fishing techniques from being used there. The force of Tsunami was sufficient to move boulders and sections of reef, as well as huge weight of smaller fragments, sand and silt. There was also a powerful back-wash, carrying wastes, debris, rubble, soil and organic matter into and across the reefs. Despite all this potential for devastation, damage to reefs was very patchy, ranging from total destruction in some areas to almost no impact in others. This presumably reflects a complex interaction between the condition of the reef in each location and the precise way in which tsunami energy was delivered to that particular environment. Damage to sea grass beds was minor and where present, was mostly due to shifting rubble; hardly any uprooting was observed. Among the reefs which suffered high damage Kapparatota/Weligama, Hikkaduwa, Unwatuna, Dutch Bay and Salklithievu (eastern coast) can be mentioned. The reefs in Polhena, Palchenai (eastern coast) suffered less damage while the reef in Rumassalla and Kalmunai did not show significant damage (MENR, 2005).

Mangroves and Other Coastal Forests

At Odu Lagoon and Nasiva village (Valachenai) in Batticaloa District, the Tsunami was about 6 meters high at the shore and penetrated up to one km inland across a mixed landscape comprising beach, mangrove-fringed lagoon, coconut plantation, scrub forest, homegardens and the village. This complex environment evidently absorbed and dissipated much tsunami energy and by the time the wave reached the village it was less than 40cm high and caused no loss of life (IUCN, 2005). The beach showed extensive erosion and about 40% of the coconut palms close to the sea were broken or uprooted, but the lagoon was little affected. Its fringing mangroves comprised a band of trees 5-6m deep, of which the first 2-3m (mainly *Rhizophora apiculata* and *Ceriops tagal*, both belonging to family Rhizophoraceae) were severely damaged by the tsunami. The inner 3-4m of mangrove vegetation, however, was much less damaged and this pattern was also seen on two mangrove dominated islets in the lagoon. IUCN recommended that mangrove restoration particularly in the first 300m on both sides of the lagoon should be a high priority in this location in view of their importance both from a biodiversity and environmental security point of view. IUCN also observed that extensive stands of mangroves appeared to have played a role in buffering the inland landscapes from the tsunami by reducing the energy of the incoming waves and absorbing the tsunami waters into a network of mangrove creeks and channels. Agricultural lands such as rice fields, roads, human settlements and buildings were relatively less damaged in those sections of the coastline which had continuous thick stretches of mangroves (eg. between Akkaraipattu and Batticaloa; Sallithievu and Vaharai) as compared to similar areas where such mangrove systems were absent.

Other coastal forests proved much less able than mangroves either to survive or to moderate the impact of tsunami. A 10-15m shelterbelt of *Casuarina* trees in the Nawaladi area of Batticaloa Town did not succeed in protecting heavily populated inland areas and were themselves badly damaged, with almost complete uprooting in several sections (IUCN, 2005). Elsewhere, for example at Manalkadu in Jaffna District, planted *Casuarina equisetifolia* trees did not seem to contribute to protecting the area, but helped to stabilize sand dunes which supported other features of the complex landscape in absorbing tsunami impact.

Coconut palms (*Cocos nucifera*) were resistant to physical impact and salinity effects. Although their stands were too open to contribute much to protecting inland areas from the tsunami, they did play a role in reducing beach erosion (IUCN, 2005). The other common palm of coastal Sri Lanka, the Palmyrah (*Borassus flabellifer*) proved to be more vulnerable to the tsunami than the coconut, being more fragile and more susceptible to salt poisoning. Other trees, such as the Eucalypts (*Eucalyptus* spp.), Neem (*Azadirachta indica*), Tulip tree/Gam suriya (*Thespesia populnea*), Mango (*Mangifera indica*), Tamarind (*Tamarindus indicus*), Country Almond/Kottamba (*Terminalia catappa*), Banyan tree (*Ficus bengalensis*), Cassia (*Cassia spp.*), Guava (*Psidium guajava*), Oleander (*Nerium oleander*), Temple tree (*Plumeria obtusa*), Indian Willow (*Polyalthia longifolia*) and Jackfruit (*Artocarpus heterophyllus*) showed some breakage or uprooting and the survivors reacted to increased soil salinity by showing significant defoliation. Long term mortality rates are to be observed.

Lagoons, Estuaries and Wetlands

The lagoons are complexes of other wetland systems and often contain marshes, mangrove areas, seagrass beds and mudflats. The health of the lagoons and estuaries is heavily dependent on the steady flow of fresh water from the interior of the island which determines their prevailing salinity. Hence lagoons are vulnerable to being opened to the sea in new ways with resulting changes in salinity and hence ecology. Lagoons and estuaries in particular represent zones of tension between the influences of freshwater from the land and saltwater from the sea; to the extent that they form and remain for long periods. Tsunami upset this balance temporarily in many places, inducing changes among the biota of lagoonal and wetland ecosystems as salt and marine sand had intruded through the breach of sand barriers. The drainage channels have less recovered ecologically since the tsunami except to the extent that they had accumulated sand, debris and litter (IUCN and MENR, 2005).

Beaches, Sand Spits and Dunes

Severe beach erosion was observed both in the east and south west but was patchy in its occurrence (NARA, et al, 2005) Beaches in the east showed extensive erosion and sand migration, with some of them losing over 50% of their width and up to a meter in height (IUCN, 2005). Much of this loss seems to have occurred due to the tsunami back wash so the overall pattern may have been that the tsunami deposited marine sand had been taken inland and the beach sand has been taken to the sea. Beach vegetation was much damaged; particularly *Ipomea* but clumps of *Pandanus* and *Spinifex* often remained standing. Among the beaches which had high erosion and scouring Moragalla, Kosgoda in Kalutara District, Kalmunai in Ampara District, Kalladi in Batticaloa District, Nayaru and Nanthi Kadai in Mullativu District can be mentioned. Among the damaged sand spits, Bentota in Galle District can be mentioned. Kosgoda sand spit in Galle District was breached but self repaired. Sand dunes were shifted and changes in shape occurred. In the instances where the sand dunes were breached by anthropological actions waves were able to penetrate to greater distances inland and caused serious damage. A classic example can be taken from Yala where the two hotels were flattened which had flattened the dunes for beach access. The hotel which was behind the intact dune was protected. In Palliwatte – Duwa in Negombo and also Singhapura in Ampara, the dune was not overtopped and it was able to protect the settlements yonder.

Coastal Protected Areas and Special Area Management Sites

At Yala and Bundala National Parks, vegetated coastal sand dunes completely stopped the tsunami which was only able to enter where the dune line was broken by river outlets (DWLC, 2005). In Block 1 of Yala National Park there were seven such places and at one of them considerable damage was done to park facilities as well as to forest and grassland with many trees uprooted and the vegetation largely dead and brown. There were a further two sites of tsunami entry in Block 2 of the Park with damage up to 1.3 km inland in flat areas. Much of the vegetation covering Kumana wetlands in the north end of Yala was flattened and temporarily inundated and appeared brown.

Excluding the beach and seaward sides of dunes, about 5000 ha or less than 1% of Yala Park area was affected by the Tsunami. Natural recovery is expected as salt levels are reduced, and most ponds have already reverted to freshwater with amphibians, birds and mammals all abundant. Regeneration of vegetation rather than succession appears to be prevalent in affected areas. There is concern that damaged areas of the parks may be colonized by alien invasive species such as prickly pears (*Opuntia*) and the salt tolerant mesquite (*Prosopis juliflora*). IUCN had stressed that recovery should be monitored against this possibility and intervention needed if alien invasives do start to become established.

Among the eight Special Area Management (SAM) sites managed by the Coast Conservation Department seven were affected by the Tsunami; Negombo, Lunawa, Maduganga, Hikkaduwa, Habaraduwa, Mawella and Kalametiya.

The Impact of Tsunami on the Soil and Water Resources

About 75% of the coastal area was completely flooded and saline water infiltrated through the unsaturated zone especially in areas with permeable soils. In the coastal belt, the affected areas extended up to 0.5 to 2 km inland. The ground water resources were badly affected by increased saltwater intrusion and invaded pollutants to the wells. The pollutants present on the surface were spread with the water and contributed to the contamination of ground water. The wells were also polluted by bacteria and virus. Since the tsunami waters disturbed the equilibrium which exists between seawater and freshwater salt water was mixed with the freshwater. This phenomenon was especially seen in areas with permeable soil layers.

In a study conducted along the 8 km coastal belt of 0.5 km distance in Weligama Bay area, two aquifer systems were subjected to pollution due to the Tsunami Wave. The results showed that Salinity, Total Dissolved Solids, Electrical Conductivity (EC) of ground water had not been rectified even after 9 months of Tsunami. However, the ground water wells which lied at 2-3 depth had a slight quality improvement during the past period. This may be associated with the ground water influx from the upper catchment after the rains (Weerasinghe *et al*, 2005).

In another study conducted by Nawas *et al*. (2005) on the impact of tsunami on groundwater in coastal areas of Kalmunai Municiapl Council area in Ampara District, the EC value of the ground water soon after tsunami was around 20,000 uS/cm but after 3-4 months, the salinity in the wells (that have not been used since December, 2004) showed values not higher than 4000 – 5000 uS/cm as all salty water had infiltrated to the aquifer.

Walpola *et al.* (2005) working on the effect of tsunami on the soil organic matter and wet aggregate stability in the Hambantota District of southern Sri Lanka reported that sea water intrusion had badly affected agricultural lands causing failure in crop production. Apart from elevating salinity level, addition of sodium ion with sea water had created dispersion of soil particles destroying its aggregates or the structure, prompting immediate need of rehabilitating affected lands in order to sustain the productivity. With regard to soil organic matter (SOM) the tsunami affected soils had much less SOM (0.27%) against that of the non tsunami affected soils (1.06%). The removal of SOM by means of soil erosion and or deposition of large amounts of sand could be the reason behind this. With regard to Mean Weight Diameter (MWD) which is a measurement of wet aggregate stability, was low in tsunami affected soils. There was a positive correlation between SOM and Wet Aggregate Stability indicating an urgent need to improve soil management practices that increase SOM levels and as a result increase the soil aggregate stability in order to ensure sustained crop production in affected soils in Hambantota District.

The Response of the Ecosystems One Year after Tsunami in 2005/6

After almost one year after Tsunami a study was commissioned by the Food and Agricultural Organisation of the United Nations (FAO) to Prof. Hemanthi Ranasinghe, Professor of Forestry and Environmental Science, University of Sri Jayewardenepura to scientifically assess the current status of damage after almost one year of the incident with a view to understand how the nature had reacted to this major catastrophe with the passage of time. This study focused mainly on five tsunami affected districts; Kalutara, Galle, Matara, Hambantota and Ampara. When the community was interviewed with regard to the transition of vegetation in the tsunami affected areas they stated that at the initial stages except for few trees the entire area including ground vegetation, trees/shrubs were devastated from tsunami. This was due to the force of the wave as well as the high salt content it brought inland. After 3-4 months the vegetation started appearing gradually.

A significant observation had been that leaf vegetables like Sarana (*Triamthema decandra*), Kankun (*Ipomea aquatica*), Thampala (*Nothosaerva brachiata),* Mukunuwanna (*Alternanthera sessilis*) etc. and plants of the family Cucurbitaceae ie Seeni kekiri (*Cucumis sativus*) Wal kekiri, Watakka (*Cucurbita mixima*) etc. have proliferated almost all the home gardens especially in the Western Coast. They had yielded high for some time but at the time of the present survey (December, 2005) the incidence of the above plants was very low. Papaw trees were growing in bunches in many places and according to the neighboring communities; they were yielding even better than pre tsunami conditions. Banana trees had been uprooted or damaged by tsunami and had not recovered well. The following trees did not get much affected from tsunami; Coconut (*Cocos nucifera*), Kottamba (*Terminalia catappa*), Mudilla (*Barringtonia sp.)*. Gam suriya (*Thespesia sp.*). The trees which suffered from tsunami damage most were Del (*Artocarpus nobilis*), Palmyrah (*Borassus flabellifer*), Araliya (*Plumeria* acuminata), Puwak (*Areca catechu*), Banana (*Musa spp*), Kitul (*Caryota* urens), Guava (*Psidium guajava*), Avacardo pears (*Persea gratissima*), trees of Citrus family ie Oranges, Lemon, Lime (*Citrus spp.*) Alstonia, Teak (*Tectona* grandis) etc.

At the time of the study in December, 2005, almost all the areas were either fully or partially covered with ground vegetation. Some species which are normally prevalent in the beach and proximal areas had invaded the inland areas ie. Mudu bim thamburu (*Ipomea pescaprae*) especially in the west coast.

The species which contributed most in the Kalutara district were Nidikumba (*Mimosa pudica*), Hathavariya (*Asparagus falcatus*), Kumburu wel (*Caesalpinia bonduc*) and Pada wel. In the Galle District, Mudu leema (*Vigna caracalla*), Mudu bimthamburu (*Ipomea pescaprae*), Nidikumba (*Mimosa pudica*) and common grasses contributed the highest. In the Matara district, the ground vegetation was primarily dominated by Mudu bim thamburu followed by Nidikumba, common grass, common sea grass, Gira pala (*Commelina eelvata*), Adanahiriya (*Clitoria* lauifolia), Olu (*Nymphea lotus*), Hambupan (*Typha agustifolia*), Kankun (*Ipomea* aquatica) and Polkichchanbada. The vegetation in Hambantota district was significantly different from that of other districts in the west coast. The most abundant species was Maha ravana ravul (*Spinifex sp*) followed by Mudu bimthamburu (*Ipomea* pescaprae), Kayan/Korakaha (*Memecylon angustifoloium*), Kuppameniya (*Acalypa indica*), Kathurupila (*Tephrosia purpurea*). In mangrove areas Pan (*Cyperus spp*), Hambu pan (*Typha agustifolia*) and Karankoku (a mangrove associate) (*Acrostiochum aureum*) were most abundant. In the eastern districts ie Ampara there was a diversity of species in the ground vegetation. The most dominant ones in the natural sites ie sand dunes were Kayan/Korakaha (*Memecylon angustifoloium*). Species of the cucurbitaceae family were also seen in abundance. With regard to the relative abundance of plant species, In the Kalutara district Wetakeiyya (*Pandanus sp.*), Gam suriya (*Thespesia sp.*), Coconuts (*Cocos nucifera*), Mudilla (*Barringtonia sp*), Vara (*Calotropis sp.*), Papaw (*Carica papaya*) and Ahu (*Morinda* citrifolia) were abundant in the 0-50m stretch from the high water line. Further from that, Kottamba (*Terminalia catappa*), Endaru (*Ricinus communis)*, Polkichchanbada, Coconuts were seen in abundance. In general, the following form the major coastal treescape in the Kalutara District; Pandanus, Pawta, Mudilla, Gam suriya, Kottamba, Ahu, Polkichchanbada, Endaru, Papaw, Indi (*Phoenix spp*).

In the Galle District, Coconut (*Cocos nucifera*), Kottamba (*Terminalia catappa*), Mudilla (*Barringtonia sp.*), Wetakeiyya (*Pandanus sp.*) were dominant as tree species while Tholabo (*Crinum* asiaticum) Gandapana (*Lantana* camera), Wal midi (*Premna obtusifolia*), Elabatu (*Solanum melongena*), Habarala (*Alocasia* spp) and Gliricidia occurred as shrub vegetation in the 0-50m stretch. In the stretch beyond 50m, Coconut, Mudilla, Gam suriya, Kottamba, were present as tree species while Aba (*Brassica juncea)* Vara (*Calotropis* spp), Wal midi (*Calotropis gigantean*) Heen anoda/Wal bavila, Tholabo, Andanahiriya etc. were present as shrubs. When taken the District in general, Coconut, Mudilla, Wetakeiyya, Kottamba, Gam suriya were prominent as trees in the coastal treescape while Vara, Polkichchanbada, Aba, Wal midi, Heen Anoda/Wal bavila, (*Sida* cordifolia) Elabatu (*Solanum* spp) were present as shrubs.

In the Matara district, In the first 0-50m from the high water line, Coconut, Domba (*Calophyllum inophyllum*) Wetakeiyya, Kottamba, Papaw were seen as most abundant trees while Balu nakuta (*Dichapetalum gelonioides*), Aththana (*Datura metel*) Polkichchanbada were seen as shrubs. Beyond this line, Kottamba, Gansuriya, Neem were seen as trees. Among the shrubs, Polpala (*Avera javanica*), Nil katarodu (*Clitoria ternatea*), Podisinghamaran, Polkichchanbada, Endaru (*Ricinus communis*) Heen anoda/Wal beli (*Naringi* crenulata) were prominent. Among the trees which suffered the damage most, Del (*Artocarpus nobilis*), Jak (*Artocarpus* heterophylla), Beli (*Aegle* marmelos),Teak (*Tectona grandis*) can be noted. After the Tsunami, there was a proliferation of Endaru (*Ricinus communis*) Aththana (*Datura metel*) Balunakuta (*Dichapetalum* gelonioides) and other weeds in general.

The vegetation in Hambantota District showed a marked variation from that of other districts studied in the west coast. Pathok (*Euphorbia neriifolia*) Ranawara (*Cassia auriculata*) Karawila (*Memodica* charantia), Indi (*Phoenix* spp), Thibbotu (*Solanum violaceum*), Aththana (*Datura* metel), Maliththan (*Woodfordia* fruticosa) can be seen as trees/shrub species within the 0-50m belt from the high water line. Beyond that in mangrove sites, Mal Kadol (*Bruguiera spp*) Kara (*Canthium coromandelicum*), Vara (*Calotropis gigantean*), Karawila (*Memodica charantia*), Pathok (*Euphorbia* nerifolia), Kalapu Andara (*{Prosopis juliflora*}, Indi (*Phoenix spp*), Kohomba (*Azadirachta* indica) and Maliththan (*Woodfolia* fruitocosa) could be seen. Pathok and Kalapu Andara had resisted the tsunami attack well. Maliththan and Lunuwarana trees have suffered the attack much but had regenerated. Others have suffered to varying extents but most of them are regenerated. Among the shrubs and ground vegetation which had shown marked growth after tsunami, Ranawara, Aththana and Wal kochchi can be mentioned. The latter two are becoming almost invasive in most of the sites including Yala, Mahalewaya etc. Casuarina trees especially those that had been planted in Mirijjawila area had sustained the attack of tsunami.

In Ampara District, in the areas which are at close proximity to the sea (0-50m) the prominent vegetation comprised of Palu (*Manilkara hexandra*), Maila (*Bauhinia racemosa*), Madan (*Syzygium* cumeni), Ethdemata (*Gmelina arborea*), Mangroves like Maha Kadol (Thelakiriya etc. as trees and Hana (*Agaves pp*), Hinguru (*Caesalpinia digyna*), Niyagala (*Gloriosa superba*), Vara (*Calotropis spp*), Kayan/Korakaha (*Memecylon angustifoloium*) as shrub vegetation. In the areas beyond this limit, Palu (*Manilkara hexandra*), Kumbuk (*Terminalia arjuna*) Coconut (*Cocos* nucifera), Gamsuriya, (*Thespesia* spp), Madan *(Syzygium* sppLunuwarana (*Crateva spp.*), Maila (*Bauhinia racemosa*), Palmyrah (*Borassus* flabellifer) were prominent as trees while Vara (*Calotropis spp*), Indi, (*Phoenix* spp), Gandapanna *(Lantana* camera), Thel kola, Kayan/Korahana (*Memecylon angustifoloium*) comprised the dominant shrub vegetation.

The biological diversity varied with the sampling locations in each district. However, there was no significant variation among the district in this regard.

Physical and Chemical Properties of Soil

According to the soil analysis, soil carbon content showed a decrease with the increase in distance from the beach. The figures for Galle District were much higher than those for other districts studied. The Electrical Conductivity (EC) also showed a decreasing trend with the increasing distance from the beach in all the districts studied pointing to the fact that salinity is on the decreasing trend towards inland. In general, all the nutrients (Total N, Available P, Available K, Ca, Mg and Na showed an increase around 50m compared with the non tsunami levels and subsequently decreased with the increasing distance from the sea. Around 150- 200m these nutrient levels were comparable with that of the control. The areas which are at close proximity to the sea (0-50m) showed a higher value of salinity while the values at 150-200m were comparable with the non tsunami levels.

Physical Properties of Water

The pH values of water samples taken at different locations in each district were close to neutral. A significant difference was not observed between the districts in this. However, the Electrical Conductivity values of the water samples taken at different districts showed a significant difference, the values for Ampara being much higher than others. Hambantota district showed the least value. However, except for Hambantota, all the values were more than 4 mili semens which are the threshold value. The pH of the water samples taken in all the districts were between 7- 8 indicating a neutral level.

From the observations and information from the community survey it was noted that components of the ecosystems like sand dunes, mangroves, thick coastal vegetation had played an important and significant role in curtailing the damage inland. Among these, the sand dunes take the lead.

The Response of Ecosystems Two Years after Tsunami – in 2006/7

A study was conducted by Mr. Anuradha Vanniarachchy and Prof. Hemanthi Ranasinghe of the Department of Forestry and Environmental Science in 2006/7 two years after the incident. According to the results, a significant variation was observed in % ground cover, % abundance and floral diversity compared with that of Ranasinghe (2006) for FAO conducted on the same plots in same districts one year after Tsunami. In general, species which were more adaptable to the saline soils like Wetakeiyya (*Pandanus sp*), Mudilla (*Barringtonia sp.*), Kottamba (*Terminalia catappa*.), Gamsuriya (*Thespesia sp.*) showed a lesser abundance when taken as a percentage of the district as many other species which represent the natural vegetation type of the area were present. In certain plots of Hambantota District, the increased incidence of Kalapu Andara (*Prosopis juliflora*), Wal kochchi, Daluk was seen while decreased incidence of Etuna was seen. The presence of many seedlings of species showed that the regeneration is taking place unheeded.

The study districts differed in species diversity where the highest was recorded in Matara followed by Galle, Kalutara and then Hambantota. Further, these districts differed in species abundance. Among the trees and shrubs, *Pandanus,* Coconut and Kottamba, Lantana were most abundant in Kalutara District. In addition to these Ahu seemed to be most abundant in Galle District. In Matara District, in addition to Pandanus, Coconut and *Terminalia,* Maduruthala and Gandapana (*Lantana camera*) were abundant. Hambantota District differed from the other three in species abundance where the dominant vegetation comprised of Daluk and Pathok, Kalapu andara, Ranawara (*Cassia auriculata*) , Gandapana, and Wal kochchi. The latter two had become almost invasive.

Among the ground cover vegetation, in Galle District, Mudu bim thamburu (*Ipomaea pescaprae*), common grasses including Rata thana and Geta thumba (*Leucas biflora*) were most abundant. In Matara District, common grasses and Mudu bim thamburu occupied the highest abundance. In both Galle and Matara Districts, the proliferation of Mudu bimthamburu to inland areas was a common sight. In Hambantota District, the ground vegetation comprised largely of Maha ravana ravul (*Spinifex sp.*).

It was recommended to continue long term studies to understand the long term responses of coastal ecosystems to catastrophes like Tsunami. The soil and water analysis should also be carried out along with the vegetation studies to understand the ecosystem dynamics fully.

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