Impact of Flood on Rhizophora Plantation in Batticaloa, Sri Lanka

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***Abstract*—Planting mangroves for restoration became popular after the 2004-tsunami in Batticaloa. About 9500 individuals *Rhizophora* were planted at ten sites around the Batticaloa estuary. Only 8 % plants were remained at the end of 2010. Heavy rain flooded Batticaloa in January and again in February 2011. The followings were recorded one week after the floods: inundation height, each plant height, status of plant shoot (% of green and brown), number of dead plants and salinity of water. Mean height of the first and second inundation were 1.84±0.06 and 1.68±0.08 m respectively. During first inundation, 79 % of the plants had been fully submerged and 21 % partially submerged. During second inundation 24 % of the plants had been fully submerged and 76 % partially submerged. Number of dead plants was 81.3% and 31% during first and second inundations respectively. After first inundation, 52 % of plants had more than 90% of brown-shoot but it was 32% after the second inundation. Salinity was almost zero during inundations. Majority of the isolated individuals were lost whereas majority of the survived plants were from the centre of big patches. Inundation seems to be the main reason for death of plants, but physical forces cannot be overlooked.**

***Index Terms*—patches, browning, inundation, survival**

I. Introduction

Mangroves in Batticaloa district are mainly found in the adjoining areas of the three major estuaries such as Batticaloa, Valaichenai and Vaharai. It was reported that 127 number of patches were available with an average area of 13.04 ha, ranging from 0.29 ha to 192.8 ha [1]. Planting mangroves for restoration became popular after the 2004-tsunami, in Batticaloa, Sri Lanka. However, it was noted that *Rhizophora apiculata* is the only species used for planting since 2006, as isolation and groups of 10-30 individuals. *Bruguiera* and *Exoecaria* were planted in minor scale.

The main objective of planting mangroves is to uplift the livelihood earnings of local people through increasing lagoon fisheries productivity. The mangrove restoration/planting programme was also intended to provide higher fish catches and also to generate awareness on biodiversity conservation. Mangrove plantations were limited in 3 coastal DS divisions out of 14 DS divisions in Batticaloa district, such as Manmunai South Eruvilpattu (MSEP), Manmunai North (MN) and Koralipattu North (KPN) [2]. Small scale mangrove plantations took place in certain areas around the estuaries and water bodies, like thona. But fairly good amount of mangroves have been planted in the Batticaloa estuary, by “Mandru”, an NGO (Fig. 1). Planting mangroves along the lagoons, without giving consideration to water flow, quantity and distribution could upset the natural balance and facilitates the rate of siltation of lagoons in Sri Lanka [3].

More than 90 % of the planted sites failed to establish mangroves and the success rate was 0.1% in Batticaloa district. It was reported that failures are more common than success in mangrove replanting programme all over the world and it is more prominent in low tidal countries, like Sri Lanka [4]. It is evident that in West Bangal, India 9,050 ha of mangroves was planted with the success rate of 1.52% [5]. Understanding normal hydrology (depth, duration and frequency of tidal flooding) [6] and [7] with adequate site assessment [8] are the most essential tasks that control establishment and growth of target species.

Heavy rain flooded Batticaloa district in January and again in February 2011. All the low-lying areas along the Batticaloa estuary, in MN division had been submerged at various levels. Severe damage was caused by the floods on livelihoods, paddy, dairy, landscapes as well as planted mangroves. Landmass that connects the Batticaloa estuary and the sea was cut and opened to release the flood into the sea. It caused severe impacts on the coastal environment such as erosion and formation of sea-bed. Post- flood activities were launched to help the affected people but no efforts have been made on the flood-affected environment in the Batticaloa district. This study was mainly looked into the impact of the flood on the planted mangroves.

II. Materials and Methods

A. Study Site

The name of the study site was Puthupalam-Urani (site 10, Fig. 1), which is located along the Batticaloa estuary with a distance of 2.5 km. Mangroves were planted along the bank of the estuary of the study site. The estuary of the study site has comparatively stagnant water with slow flow towards the sea when compared with the other sites. This was believed due to the unplanned construction of the bridge (new bridge) and road [9]. *Rhizophora* is the

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only one species planted around the Batticaloa estuary (fig. 1). About 9,500 individuals were planted at ten sites around the Batticaloa estuary, from 2006. At the end of 2010, only 794 (8 %) were remained. The remaining *Rhizophora* was found only at our study site (site 10). *Rhizophora* had been planted as isolation and patches in a distance of 75-100 m from the road. There were 3 big patches comprising of 20-30 individuals and 12 small patches comprising of 10-15 individuals (fig. 2). The rest of the sites had sparsely distributed plants. Post planting care was minimal or none. Garbage was noted into the estuary especially in front of the residential area. The amount of garbage was increased after the first flood due to the damaged households from the residential area.

Figure 1. MNDS division, Batticaloa district. Planted *Rhizophora*, since 2006, marked with bold yellow lines. Arrows indicate the flow direction of the flood. 1-Light house, 2-Mattikali, 3-Seelamunai, 4-Munich colony, 5-lloyds avenue, 6-Lady Manning drive, 7-Nochimunai, 8-Kallady Uppodai, 9-Navatkudah, 10-Puthupalam Urani (Source Google earth)

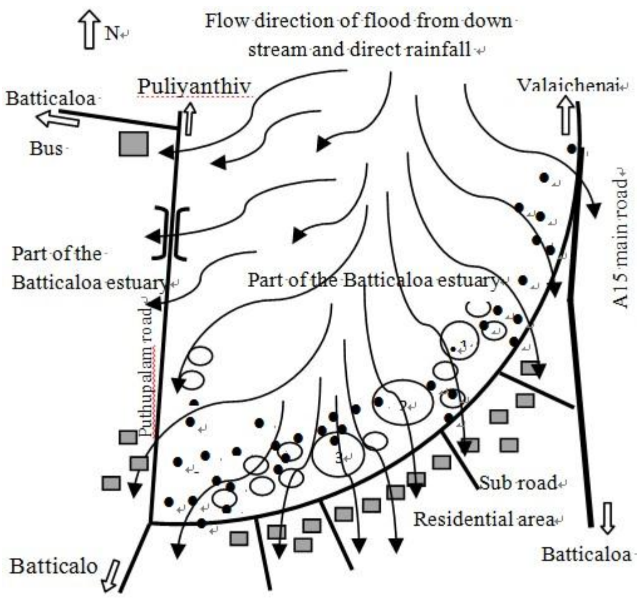

Figure 2. Flow pattern of flood at the site 10 and the pattern of planted mangroves. Circle and black dots are indicating density of *Rhizophora* (not drawn to scale)

B. Data Collection

Field survey was carried out one week after the first and second inundations. Inundation height was recorded as illustrated in the Fig. 3, both after first and second inundations. Height and status (percentage of green and brown shoots) of each plant was recorded. Number of dead plants also recorded (Fig. 4). Salinity was recorded at twenty five locations, at the study sites, along the Batticaloa estuary, at 100 m intervals.

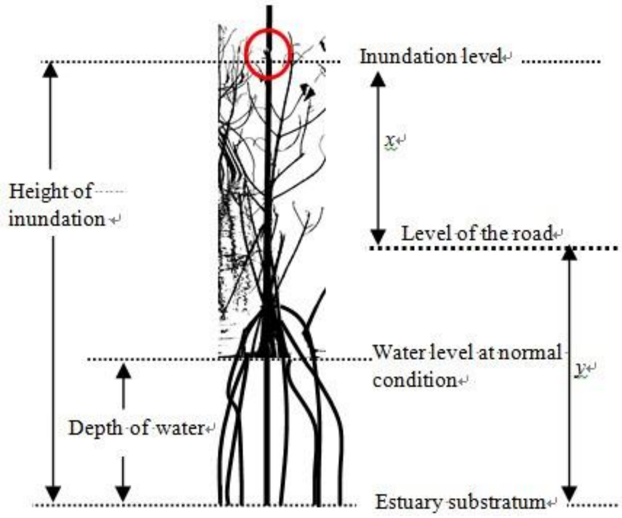

Figure 3. The inundation level of flood at planted *Rhizophora*. Inundation height = (x+y) m. Inundation level is equal both for road and Estuary.

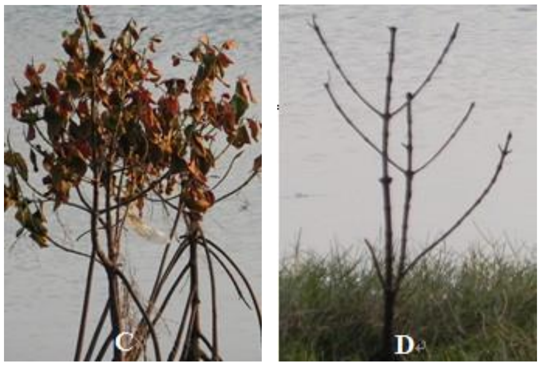

Figure 4. Percentage of browning of planted *Rhizophora*. Percentage of brown shoots: A-0%, B-50% and C-90%. D- dead plant.

III. Results and Discussion

A. First Inundation

High inundation level was recorded at the sites 4, 5, 6 and 10 (Fig. 1). Mean height of the inundation (3rd -9th January 2011) at the estuary was 1.84±0.06 m (range: 1.52 – 2.03 m) and on ground level was 0.8±0.06 m (range: from 0.5-1.2 m). It was remained for 5-7 days. The inundation extended to a maximum distance of 500-600 m towards land. Mean height of *Rhizophora* was 1.53±0.43 m (range: 0.32 – 2.85 m). Due to the inundation, 79 % of the plants had been fully submerged and 21 % partially submerged (Table I). Seventy two percent of plants (ranged between 0 and 100 %) were turned to brown, whereas 28% remained as green. Among the browned, 93 % of plants were fully submerged and 7 % partially submerged. Forty seven percent of plants had 100 % of browning of shoots, which were only from the fully submerged plants. Plant death was recorded as 81.3%.

TABLE I. Comparison of Browning and Survival of Fully and Partially Submerged Plants, after the First and Second Inundations

	Category of *Rhizophora*	*Rhizophora* fully submerged under water		*Rhizophora* partially submerged under water		Total	
		Number (a)	% [(a)/(c)*100]	Number (b)	% [(b)/(c)*100]	Number (c)	% [(c)/792*100]
First Inundation							
	Total number	625	78.91	167	21.09	792	100
	Browning	525	92.59	42	7.40	567	71.59
	Browning-100%	372	100	00	00	372	46.97
	Green	100	44.44	125	55.55	225	28.41
	Survived	16	10.81	132	89.19	148	18.67
Second inundation (calculation based on the remained plants)							
							% [(c)/148*100]
	Total number	36	24.32	112	75.68	148	100
	Browning	36	64.29	20	35.71	56	37.84
	Browning -100%	36	100	00	00	36	28.38
	Green	00	00	92	100	92	62.16
	Survived	00	00	102	100	102	68.92

B. Second Inundation

Mean height of the inundation (1st -7th February 2011) at the estuary was 1.68±0.08 m (range: 1.46 – 1.98 m), on ground level was 0.5±0.08 m (range: from 0.25-1.2 m) and it was remained for a period of 4-6 days. The inundation extended to a maximum distance of 500-600 m towards land. Mean height of the remaining plant was 1.63±0.62 m. Due to the inundation, 24 % of the plants had been fully submerged and 76 % partially submerged (Table I). Thirty eight percent of plants (ranged between

0 and 100 %) were turned to brown, whereas 62 % remained as green. Among the browned, 64 % of plants were fully submerged and 35 % partially submerged. Twenty eight percent of plants had 100 % of browning of shoots, which were only from the fully submerged plants. Plant death was recorded as 31 % (46 nos.) of the remained plants that survived after the first inundation. More than 90 % of the shoot of individual plant had turned to brown in 52 % of *Rhizophora* after the first inundation but it was 32 % of the remained plants, after the second inundation. Chi-square test showed a highly positive association ($p<0.05$) between the inundation level and the percentage of browning. The loss of planted *Rhizophora* could be due to low salinity level, physiological stress (oxygen depletion, osmotic imbalance, reducedphotosynthesis, etc.) and physical damage by the flood itself and garbage that dumped in the estuary. Salinity was almost zero during this time. It was pointed out that the salinity level could be zero particularly in the rainy season and remained at the same level for a long period, and this reduces the survival of planted *Rhizophora mucronata* [4]. It is also reported that inundation frequency with saline water affects the growth performance of *R. mucronata* seedlings under laboratory conditions [10]. Low salinity associated with long periods of flooding contributes mangrove degradation [11]. Majority of the isolated individuals were lost whereas majority of the survived plants were from the centre of big patches. Mangroves on the peripheral and the isolated individuals seem to be more vulnerable for various forces during the flooding than the mangroves in the centre of big patches. Therefore, inundation seems to be the main reason for death of plants, but physical forces cannot be overlooked as the survivors are from centre of patches. It is also noted that mangroves in the other sites totally lost before the flood. Failures are more common than success in mangrove replanting programme all over the world and it is more prominent in low tidal countries like Sri Lanka [4]. Understanding normal hydrology (depth, duration and frequency of tidal flooding) is the most essential task that control establishment and growth of the target species [6] and [7] with adequate site assessment [8] and spacing between seedlings [12] and [13]. Lack of post-planting cares also one of the reasons for the failure of planting efforts [8].

IV. Conclusion

Planted *Rhizophora* had been lost in 9 sites out of ten in Batticaloa, at the end of 2010 (before the flood). First inundation leads to 81.3% death of planted mangroves where as the second inundation leads to 31 % (46 nos.) death of remained plants that survived after the first inundation. Inundation seems to be the main reason for death of plants, but physical forces cannot be overlooked as the survivors are from centre of patches. Unpredictable natural disasters are beyond our control and thus also pointed that a scientific approach and designing are vital when selecting species at right site when consider restoring or establishing ecosystems.

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