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RESEARCH ARTICLE

REGENERATION OF MANGROVE FOREST DEVASTATED BY TYPHOON HAIYAN IN EASTERN SAMAR, PHILIPPINES

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ABSTRACT

The mangrove forest devastated by typhoon Haiyan in November 2013 was assessed to determine the rate of regeneration of trees and natural regeneration of seedlings in four sites in Eastern Samar. Two sites in the Pacific coast and two sites in the Leyte Gulf coast of Eastern Samar were studied. A 10 X 10 meter plot at 100 meters interval was laid parallel to the coast line at the center of damaged mangrove forest. The dead trees, length and number of regenerated shoots, number and height of seedling were counted and measured inside the plot. The dead trees were identified by formation the basal roots. Result showed that the highest rate of regeneration of mangrove trees differ from the Pacific and Leyte Gulf Coast; *Sonneratia* (40%) and *Avicennia* (25%) in Balangkayan, *Avicennia* (19 %) and *Sonneratia* (18%) in Hernani, *Xylocarpus* (88%) and *Bruguiera* (86%) in Giporlos and *Xylocarpus* (50%) and *Ceriops* (33%) in Lawaan. The natural regeneration of seedlings was highest in Giporlos (875/ha) with *Bruguiera* as highest percentage (71%), followed by Hernani (375/ha) with *Avicennia* as highest percentage (73%), and Balangkayan and Lawaan (100/ha) with *Rhizophora* and *Ceriops* with highest percentage (42%) respectively. It is recommended that the mangrove species with highest percentage of regeneration in a specific area will be prioritized in planting in mangrove rehabilitation projects.

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INTRODUCTION

Rationale

Mangrove forest in Eastern Samar are predominantly located along the shoreline and in river banks. Aside from its function in coastal protection, it serves as natural habitat of fishes and invertebrates with high commercial value such as mangrove crab (*Scylla serrata*). Hundreds of fishermen depend their livelihood in mangrove crab fisheries. The destruction of mangrove forest by the storm surge of Typhoon Yolanda, affected hundreds of fisher folks who depend on mangrove forest for their livelihood. According to Alura *et al.* (2015) the damaged to mangrove directly hit by typhoon Yolanda in Eastern Samar was 86 percent.During the first few months after the typhoon, its general condition seems beyond recovery. However, after one and one half years, it was observed that new shoots and stems regenerated from the destroyed mangrove trees.

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Mangrove forests are usually restored through natural regeneration, or via artificial restoration using planted seedlings. Through natural re-colonisation most of the local species occupy the shoreline and natural succession can take place (Macintosh, 2002). The major advantage of natural regeneration is that the resulting forest is expected to be more similar to the local mangrove species. In addition, natural regeneration is relatively easy and more vigorously establish, less labour is required and result in minimum soil disturbance. However, it may be hampered by lack of seeds and propagules, weed competition, pollution, poor soil conditions or disturbed hydrodynamics of the site (Field, 1996). The natural regeneration in the devastated mangrove should be assessed to provide information in the rehabilitation effort of the Government. This study assessed the natural regeneration of mangrove in areas devastated by typhoon Haiyan.

Objectives

- To determine the percentage of mangrove genera that regenerated after 1 and 1/2 years from devastation by Typhoon Haiyan.

- To find out the species and density of seedlings naturally growing in the devastated mangrove forest.
- To determine the growth of new shoots that emerges from the different mangrove genera damaged by storm surge

Significance of the Study

Results of the study will provide information on the growth of different mangrove genera and the seedlings that emerges after typhoon in relation to the density of mangrove present in the area. Likewise the result can be useful in mangrove rehabilitation program of the government particularly in the deciding the rehabilitation strategy in faster mangrove forest recovery.

Review of Related Literature

The natural regeneration process allows the mangrove forests remain over time. Both, biological and physical factors can affect the establishment and early stages along the development of trees. The results indicated that the sediments input rates and sunlight play an important role in the survival of natural regeneration of mangrove species (Hoyos *et al.,* 2013). Regeneration capacity of mangrove was proportion to species density (Mchenga and Ali, 2014). The presence of wide gaps in the affected areas allows full penetration of solar radiation which is among the necessary factors for the growth of plants (Taylor, 1984). Canopy gap creations are justified to be the key driver in the natural regeneration of the tropical mangrove, and in particular Rhizophora-dominated mangroves (Kathiresan, 2001). In the study of commercial mangrove regeneration in Sumatra Indonesia, Sakardjo (1987) reported that the mangrove forest areas of TanjungBungin, Banyuasin District, South Sumatra belong to the production forest. Typical Rhizophora-dominated stands were sampled from two inundation classes (Watson, 1928, III and IV) of the virgin mangrove forest of TanjungBungin. The sampling method used a 20 × 10-m quadrat for tress. A 5 × 5-m subplot and a 1 × 1-m sublot, for saplings and seedlings respectively, were made in each of the main plots at 10-m intervals. The distribution pattern of R.apiculata and B. gymnorrhiza seedlings studied indicates that regeneration of R. apiculata by seedling establishment is generally sufficient to ensure local propagation in inundation III subplots where Acrostichumaureum is absent. Due to the abundance of A. aureum as a weed in inundation IV zones, the regeneration of both commercial mangrove species is inadequate.

MATERIALS AND METHODS

Study Sites

The sampling sites were all located in the path of typhoon Haaiyan. Two sampling sites in the Pacific side of Eastern Samar (Balangkayan and Hernani) and two in the Leyte Gulf side of Eastern Samar (Giporlos and Lawaan). The mangrove forests in these municipalities were heavily damaged by the storm surge of Typhoon Haiyan. Balangkayan and Hernani are located far from the center of the typhoon compared to Giporlos and Lawaan which are located closer. All municipalities are within the area of 120 plus kilometres per hour wind. The mangrove forest in the four sampling sites are located along the shoreline which extend 100 meters to one kilometre to the agricultural land. As seen in figure 1, the sampling sites facing the Pacific Ocean are the location of the landfall of typhoon Haiyan.

Sampling Procedure

A 10 X 10 meter plot was established at 100 meters interval parallel to the coast line at the center of the damaged mangrove forest. There were 3 to 5 plots in every sites depending on the extent of damaged mangrove forest.

The number of dead trees inside the plot were counted. The number of regenerated trees and the height of the shoots (branches) were also counted

- Measure the Height of the regenerated trees, count the number of regenerated branches
- Count the number of new seedlings of each species in each plot, count the leaves of each seedlings and measure the height.
- Count the number of dead and alive saplings.

Identification of dead mangrove species

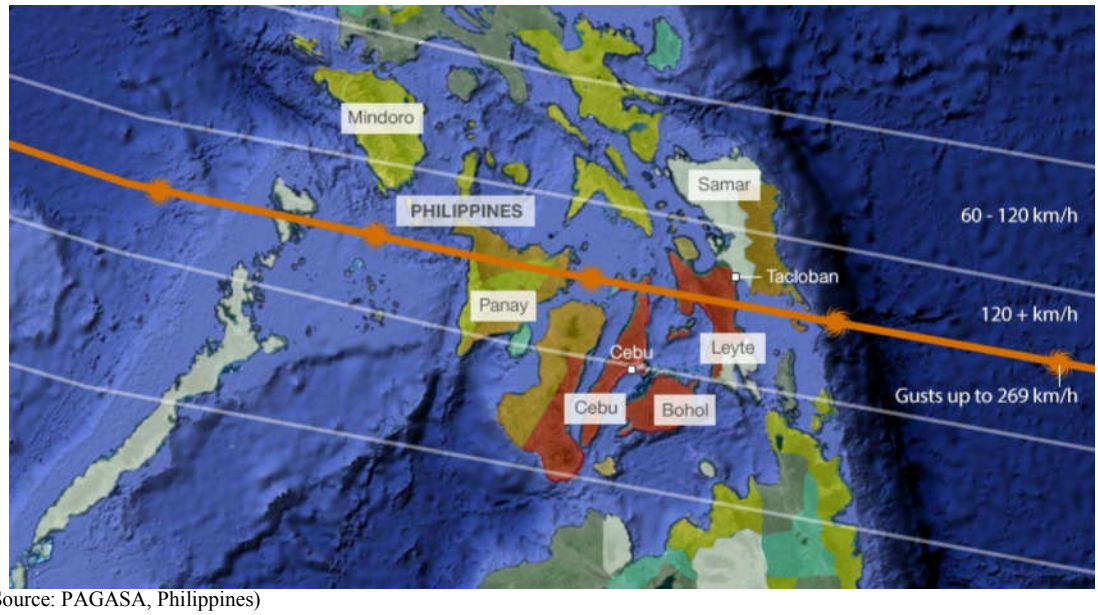
The root systems of the different mangrove were used as basis in the identification of mangrove genera (Primavera et al)as follows:

Rhizophora - Prop roots
Avicennia - Pencil like nuematophores
Sonneratia - Hard conical nuematophores
Bruguera - Knee roots, low buttresses
Ceriops - Knee roots, low butressses
Lumnitzera - Aerial roots
Aegiceras - Surface roots
Xylocarpus - Low buttresses, plank or ribbon

RESULTS AND DISCUSSION

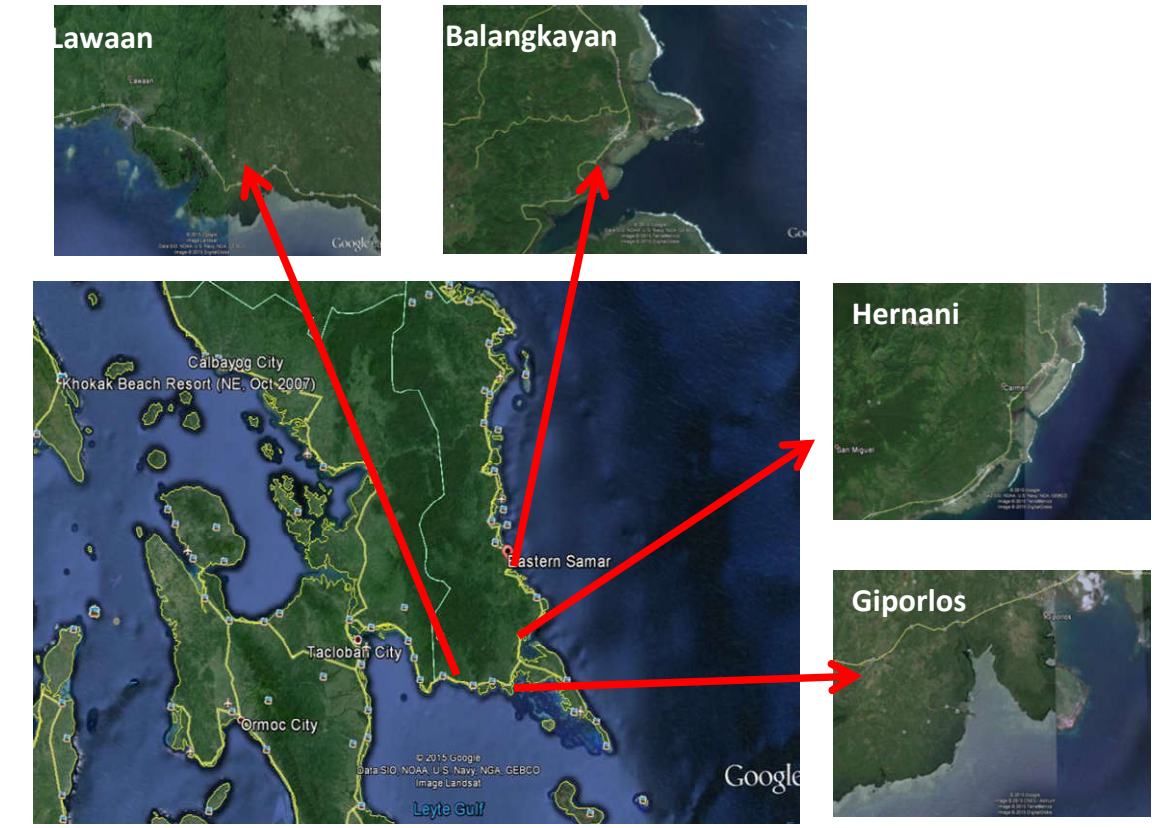
Regeneration Percentage

The regeneration percentage after 1 and ½ years from devastation of typhoon Haiyan was determined from the four sampling site municipalities. As presented in table 1, the species with the highest regeneration percentage is the *Xylocarpus* (88.2%) and is followed by *Bruguiera* (85.7%), both are from the municipality of Giporlos. *Xylocarpus*also has the highest regeneration percentage in Lawaan (50%) followed by *Ceriops* (33%). In Balangkayan, *Sonneratia* has the highest regeneration percentage (40%) followed by *Avicennia* (25%). On the other hand, *Avicennia* has the highest regeneration percentage (19.3%) in Hernani, followed by *Sonneratia* (17.6%). From the data gathered (Table 1), it is evident that mangrove regeneration in every municipality differs in species. There were three species that regenerates both in two municipalities, *Avicennia* and *Sonneratia* both regenerates in Balangkayan and Hernani while *Xylocarpus* regenerates in Giporlos and Lawaan. The rest of the mangrove species regenerates in only one municipality.



(Source: PAGASA, Philippines)

Fig. 1.Path of Typhoon Haiyan and the location of the sampling sites



(Source: Google Earth)

Fig. 2. The four sampling sites in Eastern Samar

Table 1. Regeneration (%) of trees in Eastern Samar 18 months after typhoon Yolanda

Species	Balangkayan	Hernani	Giporlos	Lawaan
Avicennia	25	19	-	-
Sonneratia	40	18	-	
Rhizophora	0	0	5	0
Aegiceras	8	0	-	-
Lumnitzera	6	0	-	-
Bruguiera	-	-	86	0
Ceriops	-	-	0	33
Xylocarpus	-	-	88	50

Table 2. Natural regeneration of seedlings (Density per hectare and height in cm)

Species	Balangkayan		Hernani		Giporlos		Lawaan	
	Density	Height	Density	Height	Density	Height	Density	Height
Avicennia	50	55	267	35	0		0	
Sonneratia	25	47	33	44	0		0	
Rhizophora	125	58	67	71	175	63	75	57
Aegiceras	0	-	0	-	50	32	0	
Lumnitzera	100	30	0	-	0		0	
Bruguiera	0	-	0	-	625	76	100	75
Ceriops	0	-	0	-	0		75	57
Xylocarpus	0	-	0	-	25	64	50	64
Total/mean	300	48	367	50	875	59	300	63

Table 3.Growth of mangroves in terms of average height of shoots (cm) and average number of shoots (shts) in Eastern Samar 18 months after typhoon Haiyan

Species	Balangkayan		Hernani		Giporlos		Lawaan	
	cm	shts	cm	shts	cm	shts	cm	shts
Avicennia	44	34	45	26	-	0	-	0
Sonneratia	61	64	64	7	-	0	-	0
Rhizophora	-	0	-	0	76	15	-	0
Aegiceras	14	16	-	0	-	0	-	0
Lumnitzera	20	63	-	0	-	0	-	0
Bruguiera	-	0	-	0	79	21	-	0
Ceriops	-	0	-	0	-	0	59	42
Xylocarpus	-	0	-	0	56	47	28	17

Seedling Species and Density

After one and a half year from devastation of typhoon Yolanda, there were seedlings found growing in the devastated area. As reflected in Table 2, the natural regeneration of seedlings in terms of density was highest in Giporlos (875/ha) with *Bruguiera* as highest percentage (71%), followed by Hernani (375/ha) with *Avicennia* as highest percentage (73%), and Balangkayan and Lawaan (100/ha) with *Rhizophora* and *Ceriops* with highest percentage (42%) respectively. For the height, the mangroves in has the highest mean height (63 cm) followed by Giporlos (59 cm). Most species with zero regeneration may be explained by the result of the study of Severino *et al.* (2014), stating that lack of seedling recruit and unfavourable soil conditions may limit long-term recovery of the typhoon impacted stands. According to Roth (1992), after hurricane Joan, the establishment of abundant regeneration of all the original mangrove species in the area was favored.

This implies that the species that naturally regenerated in a specific mangrove area is its original mangrove species. *Bruguiera* might be an original mangrove species of Giporlos and Lawaan mangrove area and as well as other mangrove species which only regenerated in specific mangrove areas. *Rhizophora* seedling was found to regenerate in all four sampling sites. *Avicennia* and *Sonneratia* seedlings only regenerate in Balangkayan and Hernani while *Bruguiera* and *Xylocarpus* only found to regenerate in Giporlos and Lawaan. *Aegiceras* natural regeneration of seedling was only found in Giporlos, *Lumnitzera* was only found in Balangkayan and *Ceriops* was only found in Lawaan. In considering which mangrove species to plant in a specific mangrove area, the presence of mangrove species that regenerated naturally with the highest percentage of regeneration in the area should be considered. Mangroves can recover in most areas, as long as ecological and social conditions are appropriate for mangrove recovery. Mangrove recovery may require more active intervention. Where there is small scale erosion it may be possible to reduce erosive impacts through protecting individual seedlings until they become more established. In disturbed areas such as former aquaculture ponds active levelling and the restoration of hydrological flows may be needed. The restoration of sediment supplies may also require the alteration of coastal engineering structures or even water flows from inland dams, to allow sufficient sediment to flow back into coastal areas (Spalding *et al.,* 2014).

Growth of New Shoots

The growth of regenerated mangroves were measured and according to the data (Table 3), in Balangkayan, where only *Avicennia*, *Sonneratia*, *Aegiceras* and *Lumnitzera* regenerated, *Sonneratia* has the highest growth in height with 61 cm and also has the highest number of shoots that regenerated. In Hernani, only *Avicennia* and *Sonneratia* regenerated where *Sonneratia* is better in terms if height of shoots with 64 cm but *Avicennia* is better in terms of number of shoots (26 shoots). In Giporlos, where three mangrove species regenerated (*Rhizophora*, *Bruguiera* and *Xylocarpus*), *Bruguiera* has the highest growth in terms of height (79 cm) and *Xylocarpus* in terms of number of shoots (47 shoots). In Lawaan, *Ceriops* has the highest growth in terms of height of shoots and number of shoots compared to *Xylocarpus*. Overall, in terms of growth, Bruguiera in Giporlos has the highest height of shoots (79 cm) and Sonneratia in Balangkayan has the highest number of shoots (64 shoots). The average height and number of shoots is beneficial when typhoon comes, according to Spalding et. al., 2014, mangrove trunks and branches are expected to reduce the energy and force of incoming tsunami waves. Taller trees are less easily overtopped by a tsunami than small ones. Mature forests with thicker trees can withstand greater wave energy.

Conclusion

Based on the findings of the study it was concluded that *Avicennia* and *Sonneratia* have the highest the regeneration with 18 to 40 percent in the pacific side of Eastern Samar. *Bruguiera* and *Xylocarpus* with 33 to 88 percent regeneration in the Leyte Gulf side. The density of naturally regenerated seedling range from 300 to 875 per hectare. The growth of regenerated shoots ranges from 14 to 79 cm height and 15 to 74 shoots per regenerated trees.

Recommendation

It is recommended that the mangrove species with highest regeneration in a specific mangrove area must be considered as planting material in mangrove rehabilitation. Mangrove planting should be done in heavily devastated mangrove forest such as in Balangkayan, Hernani and Lawaan and natural regeneration in Giporlos mangrove forest.

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