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Present Status of Salinity Rise in Sundarbans Area and its Effect on Sundari (*Heritiera fomes*) Species

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Abstract: The world largest mangrove forest, Sundarbans is situated at the western coastal zone of Bangladesh that covers about 40% of the total forest and gives good feedback to the national economy. But for last few years, salinity increasing drastically in this particular region due to sea water intrusion, reduction of fresh water flow and human activities like shrimp farming. In this study both field survey (primary data) and historical (secondary) data were used to assess the present status of salinity rise in Sundarbans area as well as the effect of salinity rise on species destruction like Sundari (*Heritiera fomes*) which is the climax species of Sundarbans. It was observed that sea level is rising in the Sundarbans coast at the rate of 4 mm/year that is much higher than global trend of 2 mm/year and results more areas to inundate by tidal water. Besides, the water diversion and withdrawal of fresh water in the upstream significantly hampering salt balance system in Sundarbans that leads to permanent and high level of salinity. The soil salinity rise increases with the increase of depth of soil and high level of salinity in the root zone of the plants results a high concentration of sodium salts within the plants body that causes to the reduction of the forest production, restricting the growth of the species like Sundari (*Heritiera fomes*) and even causes to die.

Key words: Forest, Sundarbans, Sundari, Salinity, Species.

INTRODUCTION

The coastline of Bangladesh extends about 710 km including 120 km long beach of Cox's Bazar. Most of the coastal regions except the eastern zone hardly lay one meter above the sea level. Most of the western part of the coastal zone is covered by the world largest mangrove forest Sundarbans which represents about 40% of the natural productive forest and provides livelihood for at least half a million people[3]. The water body within the Sundarbans and in the head of the Bay of Bengal is the most extensive fishing area. The livelihood of many people in coastal areas is based upon the exploitation of both terrestrial and aquatic resources[2]. The forest also plays important role in wildlife conservation, recreation and serves as a protective barrier against coastal erosion, cyclonic storms and tidal surges. In addition, it provides the vital breeding and nursery grounds for a large population of the finfish, shrimp, crustaceans and Mollusks.

According to Karim[8], Mangroves are salt-tolerant forest ecosystems of tropical and sub-tropical inter-tidal regions of the world. The plants are halophytes that are well adapted to salt water and fluctuation of tide level. Even germination of seeds of some halophytes is dependent on a certain level of salinity. Different species prefer different levels of salinity. There is an optimum salinity range for maximum growth of different mangrove species. Sundari (*Heritiera fomes)* has strong preference for low salinity and its growth rate significantly decreases with increasing levels of salinity.

Due to the various man-made and also for some natural reasons different species in Sundarbans are reducing at a significant level. Mangrove forest named Chokoria Sundarbans is already destroyed and not a single naturally grown species is remaining there. Sundari (*Heritiera fomes)*, the pioneer species of Sundarbans is under serious threat at present. Therefore the total productivity of the forest is decreasing. Other species are also losing their habitat due to high salinity in soil[9]. This article includes the present scenario of salinity rise in the study area and probable causes behind the fact. In addition the impact of salinity rise on the species diversity especially on Sundari (*Heritiera fomes)* has been also addressed in this article.

Profile of the Study Area: The study area lies between the latitudes from 21° 30' N to 22°30' N and Longitudes

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from 89°7' E to 89°55' E. It occupies total land area 5773 sq. kilometer. Out of which 4074 sq. kilometer is mangrove reserve forest and 1699 sq. kilometer is open water bodies. Sundarbans is bounded heavily populated agricultural land on the north and east and by the Indian Sundarbans on the west whereas the Bay of Bengal lies on the south[2].

The forest is within the three administrative districts of Khulna, Satkhira and Bagerhat. Administered by the Forest Department (FD), the area is divided into four forest ranges, namely; Sarankhola, Chandpai, Khulna and Burigoalini. Three patches of the forest in the south have been declared as "Wildlife Sanctuaries" which includes Kachikhali-Katka sanctuary in the Sarankhola range, Neelkamol at Hiron point in Khulan range and Mandarbaria in the Burigoalini range. UNESCO has declared them in 1997 as the "World Heritage Sites." The four main seasons are pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November) and dry winter (December-February). The annual average rainfall is between 1640 and 2000 mm. The rainfall is strongly seasonal and 85 per cent falls during the monsoon. The impact of severe storms on the forest is profound. Water in Sundarbans is saline and has varied level of salinity. Rivers and rainfall are the sources of fresh water, whereas tides are the causes of saline water intrusion. The forest is flat and elevation is hardly three meters above the mean sea level. A complex network of streams and rivers varying considerably in width and depth intersects the entire area. Tides in the Sundarbans are of semidiurnal type with a small diurnal irregularity. Largest rise and fall of the tides are found where tidal currents are swiftest and this is usually in the northern part of the forest. The time of high tide at Kutubdia Island and Passur River (Hiron Point) lags behind the mouth of the Hoogly by one hour forty five minutes i.e. the tidal wave goes from west to east.

Habitat Specification of Sundari (***Heritiera fomes)***: *Heritiera fomes* is one of the important species of the genus *Heritiera* which is the climax species in Sundarbans, dominates in the slightly saline and also in the moderately saline zone and accounts for 73% of the growing stock. It shows growth where the level of ground is intermediate between high strip along Khal (canal) and low Bill (wet land) areas. Growth of Sundari in strongly saline zone is very slow. The trees do not prefer regular inundation. Sundari grows well in a well-drained soil inundated by tidal water of low degree of salinity[7]. The height of Sundari trees is observed within the range of 15 m to 25 m according to locality where the average height is within 10 m to 15 m. It attains a height of 15 to 2 1m in the northern part of Sundarbans where it grows best[8]. It decreases in height to 4.5 m to 6 m in the south-eastern part of the forest. The tree grows well in regions with a warm and equable climate and fairly heavy rainfall[6].

MATERIALS AND METHODS

The data of different important environmental parameters such as tidal inundation, fresh water flow, rainfall, agricultural practices of the areas etc. were collected from Bangladesh Water Development Board (BWDB) and Institute of Surface Water Modeling (IWM), Dhaka Bangladesh as secondary source for proper analysis and evaluation of Salinity condition in the study area, Sundarbans. Seasonal variation of salinity and its rise was calculated by using the detailed daily basis salinity data. In order to find out the relationship between the upstream fresh water inflow and salinity, the seasonal variation of the river inflow of the important rivers were also considered. Salinity distribution maps of different seasons were prepared in ArcView GIS and finally compared between previous and recent one to find out the change in salinity affected areas. Visual observation and primary data along with the secondary data analysis were also used during the determination of salinity effect in the study area. The Soil and leaf samples were collected from banks of Passur where top drying region as well as the regions of healthy vegetations of Sundari tree was observed. On the other hand, the water samples were collected from 2 feet below the top surface of the rivers and canals. Six sampling points along the Passur River were chosen to collect water, soil and leaf sample. SP 1 is the first upstream sampling point just near to the station Mongla, which is situated in slightly saline zone and SP 6 is the most downstream sample collection point which is situated in moderately saline zone as well as in the south part of Sundarbans. SP 2, SP 3, SP4 and SP 5 are other four sampling points situated between the point SP1 and SP 6 (Figure 2). Water sample were collected from all sampling points whereas soil sample were collected from SP 2, SP 3, SP5 and SP 6 for laboratory analysis. On the other hand, leaf sample were collected from SP2, SP 4 and SP 6. After collection the samples they were tested in the water supply, sewerage engineering and pollution control laboratories of the "Department of Civil and Environmental Engineering" in Shahjalal University of Science and Technology, Sylhet by using the standard method[4].

Intensity of salinity rise in the study area:

Seasonal Variation: Salinity level remains lowest during the monsoon due to huge fresh water inflow and rainfall whereas the maximum concentration is found at the end of the winter (during the month May-June). Figure 3 to 5 represents the seasonal salinity gradient of selected points from the month January to December for low salinity zone (0.4 to 15 ppt), moderate

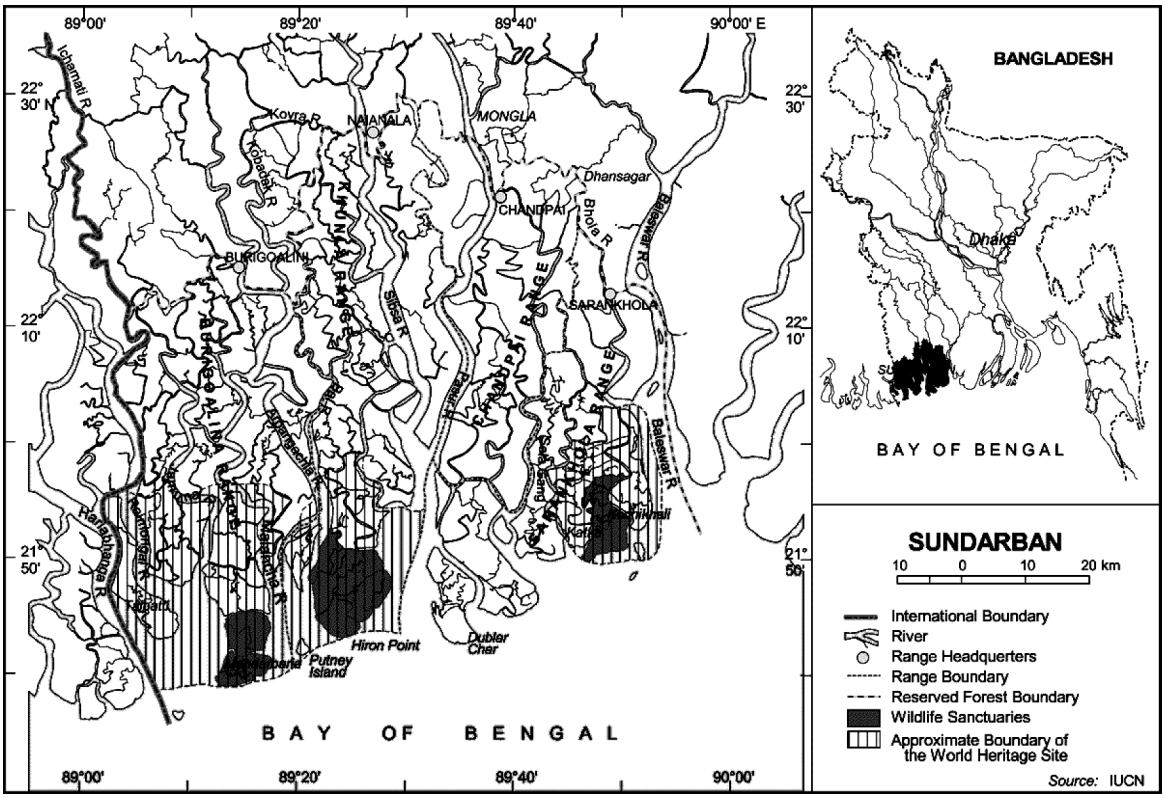


Fig. 1: Location of the study area.

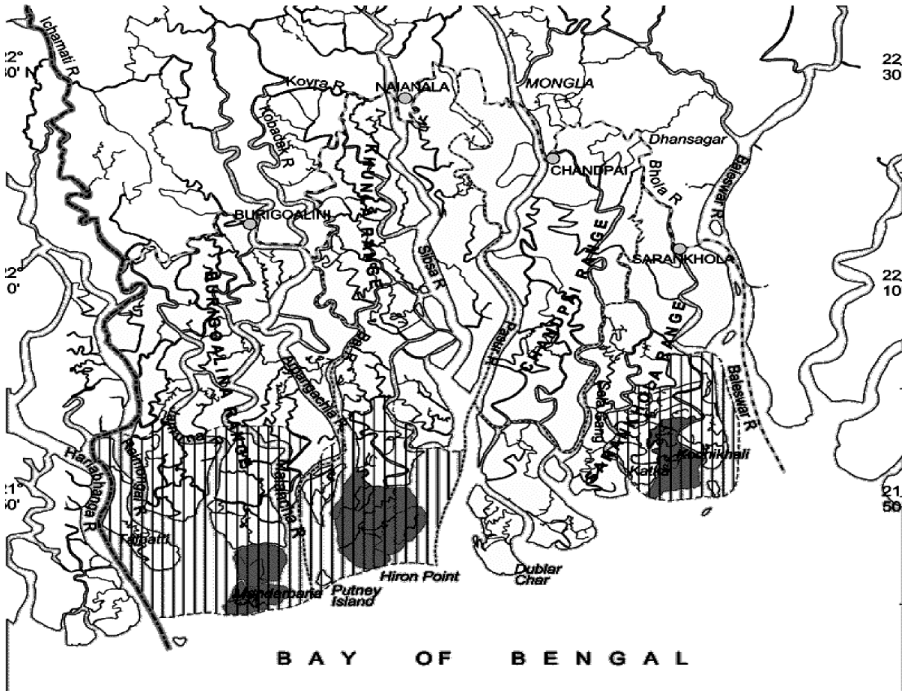


Fig. 2: Location of sampling points for conducting laboratory experiment

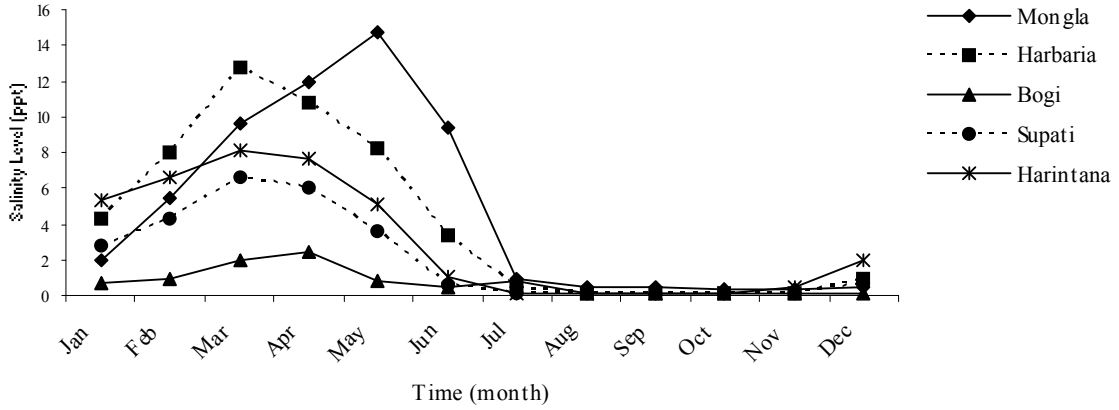


Fig. 3: Seasonal salinity gradient of Mongla, Harbaria, Bogi, Supti, and Hrintana (low salinity zone) (year 2001-2003)

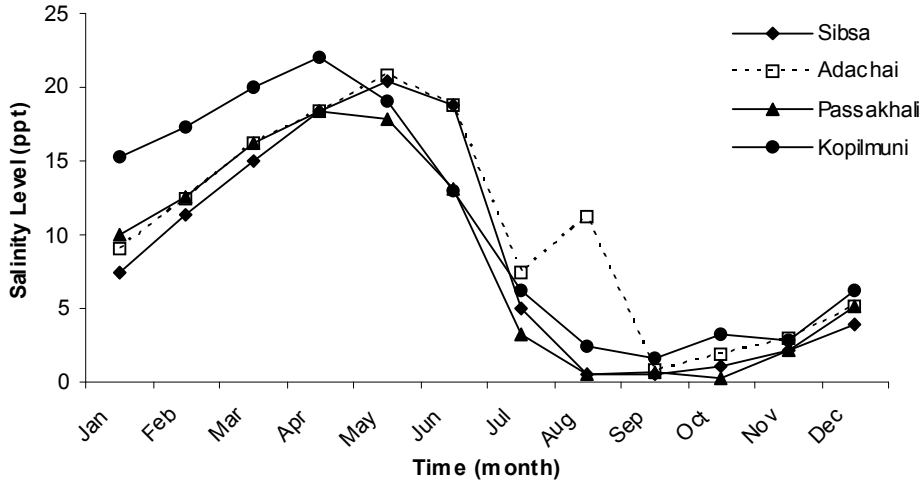


Fig. 4: Seasonal salinity gradient of Sibsa, Adachai, Passakhali and Kopilmuni (Moderate salinity zone) (year 2001-2003)

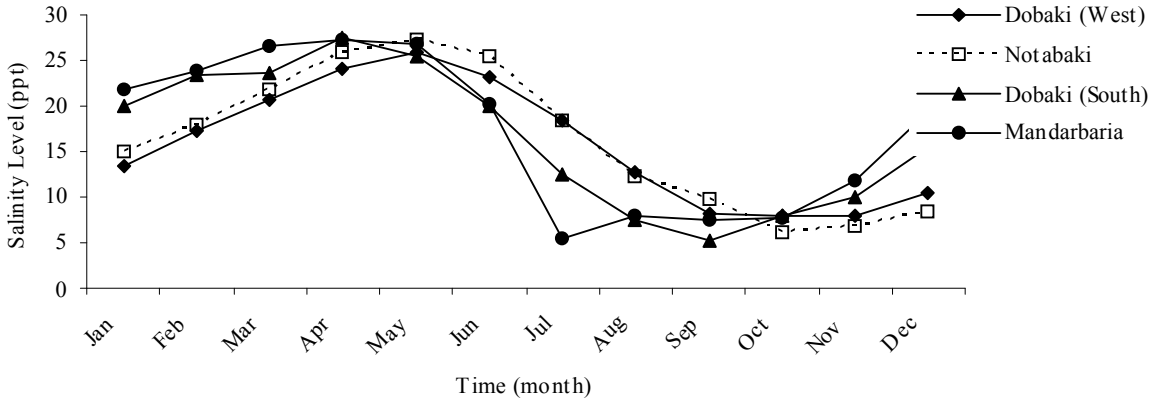


Fig. 5: Seasonal salinity gradient of Dobkai (west), Notabaki, Dobaki (South) and Mandarbaria (strong salinity zone) (year 2001-2003)

Table 1: Laboratory test result of pH and conductivity of Water, Soil and Leaf samples.

Sampling point	Water Samples		Soil Samples		Conductivity of Leaf Samples (ms)	
	pH	Conductivity (ms)	pH	Conductivity (ms)	Tender leaf	Aged leaf
1	6.7	1.65	-	-	-	-
2	7.6	1.80	7.7	1.45	11.9	12.3
3	7.8	2.50	8.0	3.12	-	-
4	7.7	4.08	-	-	13.4	15.2
5	8.3	6.89	8.1	15.10	-	-
6	8.4	7.90	8.3	20.65	14.3	15.7

salinity zone (maximum 22 ppt) and strong salinity zone (maximum 27.5 ppt) respectively. The salinity level remains 5 ppt and above in all points of the strong salinity zone even in monsoon.

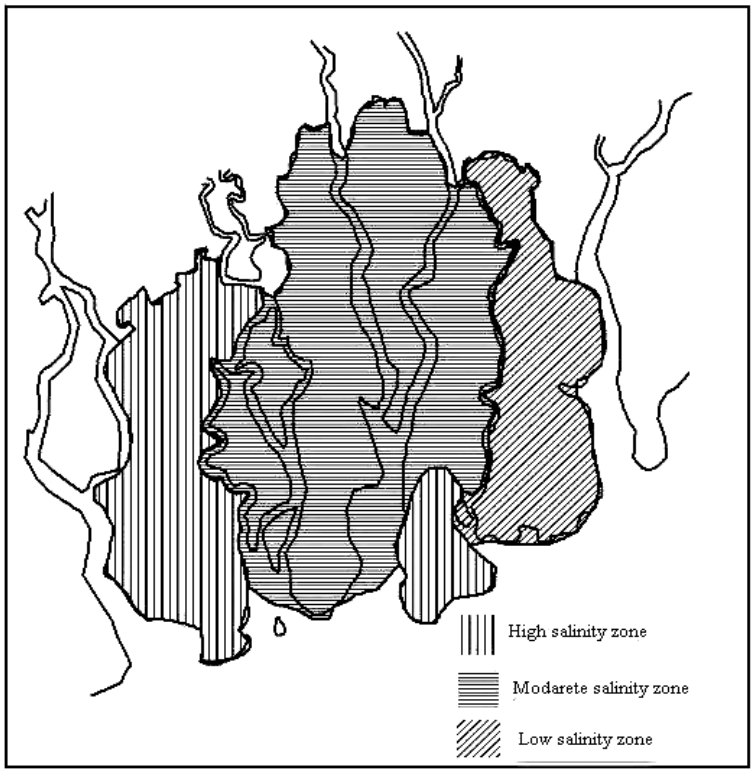
Salinity Distribution: The high salinity level was observed in the western part and the some areas on the south of the study area and low salinity zone was dominated in the eastern part. Hassan and Razzaque[5] showed that the major part of the Sundarbans were under moderate salinity zone (Figure 6). A new salinity distribution map was prepared through the observation during the period 2001-2003 with the help of secondary data which is represented in the Figure 7. The figure depicts that the high salinity zone is dominating in most of the western as well as southern part of the Sundarbans. Figure 8 represents the overlay of old and newly prepared high salinity zone which shows a clear indication of salinity rise of the study area that leads to a threat to the ecosystem in Sundarbans.

Analysis of the laboratory result: Laboratory tests were done with collected water, soil and leaf samples of the study area (Figure 2) to observe the pH and conductivity. It was found that the conductivity of water rises along the upstream to down stream of the river Passur and at Mongla port. It is only 1.65 ms at sampling point 1 whereas it becomes as higher as 7.90 ms at the sampling point 6. Surface water pH ranges from 6.7 to 8.4 (Table 1).

Samples 2 and 3 represent the location where the trees are healthy and no destruction of Sundari species is observed. In these locations conductivity of soil samples ranged from 1.45 ms to 3.12 ms whereas the value varies from 11.9 ms to 12.3 ms for tender leaf and aged leaf respectively. The samples 4, 5 and 6 were collected from the areas dominated by top dying affected trees. Here the conductivity of soil sample was found more than 20 ms (sample 6). The highest value of conductivity was found 14.3 ms and 15.7 ms for tender and aged leaf samples respectively (sample 6) (Table 1), where the health of Sundari was found very poor. The study also reveals that the salt concentration of aged leaf is higher than that for tender one and that plays a significant role for the species destruction in the study area.

Effect of salinity rise on the Sundari Species (*Heritiera fomes*): During the study the Sundari was found as a rare species in strong salinity zones whereas its presence was observed in the moderate and the low salinity zones of the Sundarbans forest. However, the top dying was observed beside the river or the canals where inundation by the saline water is much and has water-logging problem. Rahman[9] reported that top dying symptom is seen in areas where most of the pneumatophores have been buried partially. The laboratory experiments also show a significant indication of salinity rise in the water, soil as well as leaf samples from the areas with severely affected sundari trees (Table 1). Most the places of low and moderate salinity zones showed a salinity level of <10 ppt. A salinity level of 10 ppt or more in the water that inundating the shores of rivers and canals causing the increase of salinity in soil. Symptoms of excess chloride include burning and firing of leaf tips or margins, bronzing, premature yellowing, abscission of leaves and, less frequently chlorosis. Smaller leaves and slower growth also are typical. Symptoms of excess sodium include necrotic areas on the tips, margins, or interveinal areas[10].

Conclusion: On the basis of the primary and secondary data analysis it is evident that salinity is raising day by day within the Sundarbans regions. Due to high level of salinity Bangladesh is losing forest production and forest coverage. Agricultural production is decreasing due to conversion of agricultural fields to shrimp ponds. Though Sundari (*Heritiera fomes*) is the climax species in Sundarbans forest but at present it is affected by salinity rise and the species is found dying at an alarming rate. It is thus clear that top dying of Sundari results in huge



Low (< 5 ppt), Moderate (5 - 15 ppt), High (>15 ppt)

Fig. 6: Salinity distribution map of Sundarbans based on Hassan and Razzaque[5].

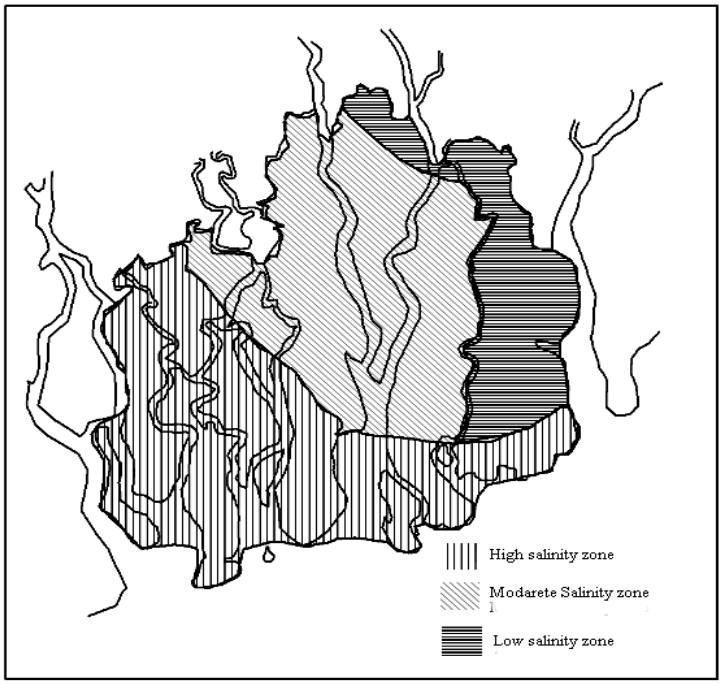
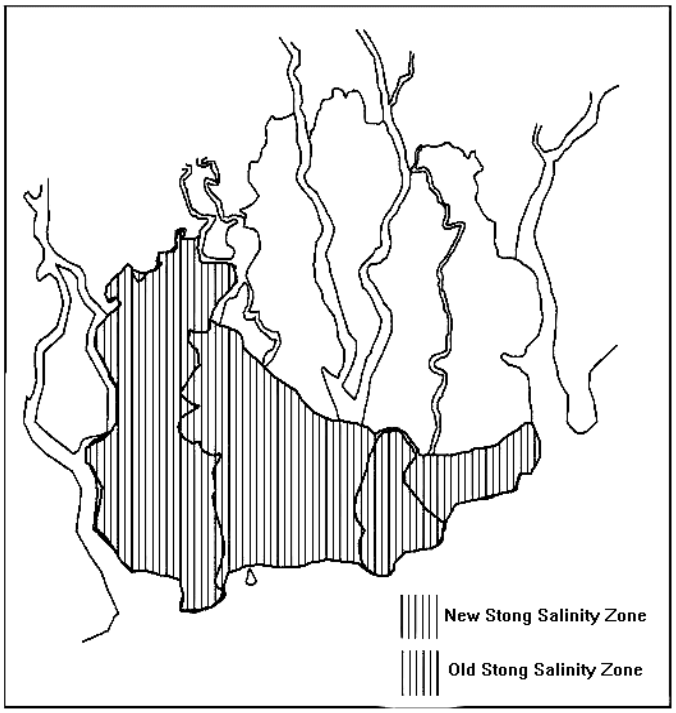


Fig. 7: Salinity distribution map of Sundarbans based on the study 2001-2003.



Low (< 5 ppt), Moderate (5 - 15 ppt), High (>15 ppt)

Fig. 8: Overlay of old and newly identified high salinity zone in Sundarban.

quantity of wood loss. The disease or disorder is of vital importance in the management of the Sundarbans. Therefore, efforts should be made to develop better understanding of the problem so that appropriate management strategy could be developed for improved and sustainable management of the Sundarbans with particular reference to top dying of Sundari.

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