# University of Barishal

## A Project proposal

**Title: Dominant species losing functions to salinity in the Sundarbans Mangrove Forest, Bangladesh**

**Applied Course: Computer Fundamental & Office Applications**

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# Contents

# Dominant species losing functions to salinity in the Sundarbans Mangrove Forest, Bangladesh


## Abstract

Globally, mangrove forests are deteriorating due to several natural and anthropogenic factors such as sea level rise, habitat fragmentation, over-exploitation, pollution, etc. Sea-level rise - driven salinity would influence the functional activity of dominant species by declining their structure and functions, which is not well understood. Therefore, we tried to understand the increased salinity impact on the structures and functions of two identified dominant mangrove species (i.e., Excoecaria agallocha and Heritiera fomes) in the Sundarbans Mangrove Forest (SMF), Bangladesh. We test our hypothesis that salinity significantly retards the functions of dominant species structure and functions by evaluating two consecutive years of inventory data from 60 permanent sample plots (100 m2 each) established in three distinct salinity zones in the SMF. The study revealed that structural parameters of dominant species such as tree height, diameter at breast height (DBH), and basal area decreased in higher saline zones than in less saline zones. E. agallocha and H. fomes stored more biomass and carbon in less saline and moderate saline zones compared to high saline zone. Besides, functional variables such as above-ground biomass carbon and total biomass carbon decreased with salinity for both dominant species. This study demonstrated that salinity shapes dominant species by declining their height, DBH, growth, etc., which indicates salinity is a critical discriminating variable for losing species' stand structures and functions. This information is critical to determine the physiological response of dominant species across the globe, which is crucial to predicting future climate change impacts such as sea-level rise.


## Introduction

Indiscriminate environmental changes with anthropogenic pressures in the mangrove forest of tropical and sub-tropical regions have threatened ecosystem functions and services (Sarker et al., 2019, Rivera-Monroy et al., 2017). However, mangrove forests represent a significant amount of net primary production (i.e., 30%–40% of global carbon cycle) (Mitra et al., 2011, Clark et al., 2001) and act as a critical C sequestrator (i.e., 3–5 times higher per unit C) than terrestrial ecosystem (Ahmed and Kamruzzaman, 2021, Rahman et al., 2015, Donato et al., 2011). Mangroves playing crucial role as a unique contributor by providing massive tangible and intangible benefits such as thatching materials, medicinal products, coastal shelterbelt etc. to the local community and global scale (Hossain et al., 2021, Islam et al., 2020, Iftekhar and Saenger, 2008, Siddiqi, 2001, Sarker et al., 2016). In spite of having such benefits, the widespread global mangrove ecosystem has already been deprived of its 50% coverage since

1950 (Sarker et al., 2019), whilst the present rate of deforestation is about 1%–2% per year in the mangroves (Sarker et al., 2019, Madelon et al., 2015). In addition, magnitude of global warming as well as rising sea-level (Sarker et al., 2016, Sarker et al., 2019, Rahman et al., 2021b, Rahman et al., 2021a, Rahman et al., 2015) alter land use, habitat alteration, and changes in vegetation pattern of mangroves, which extirpate global biodiversity and its functions tremendously over a spatial temporal period (Rahman et al., 2015, Detwiler and Charles, 1987, Sarker et al., 2016, Sarker et al., 2019, Mitra et al., 2011, Islam, 2019). On the contrary, 16% of mangrove species are classified as highly endangered or vulnerable, while the remaining 10% are classified as near-threatened (Sarker et al., 2016). In addition, many mangroves are hampered in their growth and development by extreme salt stress (Sarker et al., 2016). Excessive salinity levels hinder the structural development of mangrove species that maintained key functions around the globe (Hossain et al., 2021, Hossain, 2015). Another perilous alarm is that by 2050, one-third of total production will have been lost owing to salinity in the Sundarbans mangrove forest (Sarker et al., 2021).

Furthermore, the largest dominant single territory mangrove forest, Sundarbans is unquestionably prepotently highly productive and carbon rich forest (Ahmed and Kamruzzaman, 2021, Rahman et al., 2021b, Rahman et al., 2021a, Hossain et al., 2019, Rahman et al., 2015) by providing innumerable goods and services in the coastal region locally, nationally and globally (Aziz and Paul, 2015, Dey et al., 2020, Helal Siddiqui and Islam, 2019, Islam, 2019, Islam et al., 2021, Sheikh et al., 2021). This forest is already in a drastically stressed condition of having ongoing freshwater flows reduction and salinity intrusion in the perspective of sea level rise (Dahdouh-Guebas et al., 2020, Aziz and Paul, 2015). Nonetheless, the freshwater supply to the Sundarbans has declined by 90% and the degree of salt has increased by 60% since the Farakka barrage was erected in India in 1975 (Aziz and Paul, 2015); Kumar and Jha. As a result less saline zone (LSZ) is converting to moderate saline zone (MSZ) and moderate saline zone to strong saline zone (SSZ) at the same time (Sarker et al., 2016, Sarker et al., 2019, Iftekhar and Saenger, 2008). Due to chronological changes in salinity biodiversity and abundance of mangroves species have altered in the ecological zones viz., LSZ, MSZ and SSZ, respectively (Iftekhar and Saenger, 2008, Sarker et al., 2019).

However, dominant species traits are one of the key factors associated with driving ecosystem functioning and as a result, increasing biomass and carbon uptake in the mangroves (Fotis et al., 2017, Lin et al., 2016, Sonkoly et al., 2019). Furthermore, salinity along with vegetation structures of identified dominant species is one of the pivotal components to affecting global biomass–carbon stock (Rahman et al., 2015, Adame et al., 2013) to maintain ecosystem functioning. The Sundarbans, being a Ramser site and a World Heritage site as declared by UNESCO in 1997 are immensely indispensable by considering its multipurpose roles (Rahman et al., 2015), which indicates the inevitability of sustainable conservation of that forest in relation to withstand salinity in salinity zone (Rahman et al., 2015, Sarker et al., 2016). However, different structural and functional parameters of dominant mangrove species such as basal area, mean tree height and diameter etc. affects biomass and carbon potentiality (Rahman et al., 2015, Mitra et al., 2011, Iftekhar and

Saenger, 2008). Stand structure of mangrove species greatly depends on tidal inundation and many physiological activities through salinity intrusion (Kumar and Jha, 2010, Khan and Aziz, 2001, Karim and Karim, 1993), which ultimately may affect the functional activities of the mangrove forest. About 10% to 50% variation of salinity in sea water is required for optimal growth (Karim and Karim, 1993, Kumar and Jha, 2010, Khan and Aziz, 2001), increased salinity inhibited plant growth in mangroves (Khan and Aziz, 2001). Although in terms of high and changing salinity and water logging environments, mangroves are facultative (Ayma-Romay and Bown, 2019).

Numerous studies have been conducted worldwide, focusing on biomass and carbon storage potential, salt tolerance mechanisms aiming to conserve and manage the mangrove wetland (Ahmed and Kamruzzaman, 2021, Khan and Amin, 2019, Kamruzzaman et al., 2017a, Kamruzzaman et al., 2018, Sitoe et al., 2014, Rahman et al., 2015, Mitra et al., 2011, McKee, 1995, Khan and Aziz, 2001, Kumar and Jha, 2010, Rashid and Ahmed, 2011, Ahmed et al., 2011) but the role of dominant mangrove species in the salinity zones, as well as salinity gradient, in the context of global climate change and key functional activities adjacent to the coastal wetland communities, remains inconclusive. Meantime, several research studies have been conducted in the Sundarbans mangrove forest focusing on the stand structure, spatial variation of carbon stocks in the vegetation of mangrove species, carbon storage, above-ground productivity, phenological traits, fine root biomass and its contribution, salinity effect on plant growth (Mitra et al., 2011, Rahman et al., 2015, Karim and Karim, 1993, Ahmed and Kamruzzaman, 2021, Ahmed et al., 2021a, Ahmed et al., 2021b, Kamruzzaman et al., 2017a, Kamruzzaman et al., 2018, Azad et al., 2020) and so on. However, to our knowledge, no consensus study has yet paid attention to the structural attributes of dominant species with respect to salinity and how salinity shapes these functional variables in the salinity zones and gradient in the Sundarbans. Furthermore, there is a fundamental knowledge gap regarding dominant species functions with salinity, which posits us to know the inevitability of up taking study as tropical forests are the potential terrestrial blue carbon pool (Yu and Chen, 2015) and mangrove provides 25% of C burial to the worldwide coastal zone by maintaining their functional composition and stand attributes over- a spatio-temporal period (Lin et al., 2016, Fotis et al., 2017, Hossain et al., 2021, Sarker et al., 2016). Eventually, such knowledge inadequacies may create an impediment to conserving mangrove ecosystem in this delta (Sarker et al., 2016, Sarker et al., 2019, Ahmed et al., 2011). Moreover, it is critical and imperative to observe the effect of salinity on the dominant mangrove species structures and its functions in spite of having challenges and uncertainty simultaneously in the Sundarbans, Bangladesh (Ayma-Romay and Bown, 2019, Masha et al., 2017). Thereafter we comprehensively investigated it through asking two research questions, e.g.,

1.

How do the salinity gradients and zones impact the structure of dominant species?

2.

How does salinity shape the functional variables such as biomass and carbon, and their changes over time of dominant species?

Consequently, we hypothesized that increased salinity (higher salinity and salinity zones) has significant and negative impacts on the structure and functions of identified dominant species. To answer these questions and to test the hypothesis, we evaluated stand structure, vertical and horizontal diversity, functional variables such as above and belowground biomass, and carbon stocks of dominant mangrove species from two years of inventory data, highlighting salinity gradients and zones in the Sundarbans mangrove forest, Bangladesh.

## Study site and forest inventory

This research was carried out in the Sundarbans Mangrove Forest (SMF) of Bangladesh across three salinity zones. In the Ganges–Brahmaputra estuary, the Sundarbans of Bangladesh (21°30

–22°30

N and 89°00

–89°55

E) are part of the world's largest river delta (Sarker et al., 2016). Bangladesh accounts for over 60% of the world's mangrove forest, with India sharing the remaining 40% (Siddiqi, 2001). Diverse oligohaline or Less Salinity Zone (LSZ), (

2 dsm−1), mesohaline or Moderate Salinity Zone

## Variation in structure of H. fomes and E. agallocha with salinity (i.e., zones and gradient)

Studied dominant species stand structural attributes across three different salinity zones were presented in Table 1. Mean height, DBH and basal area of E. agallocha and H. fomes is more in LSZ (8.52 m, 11.21 cm and 0.008 m2 ha−1) and MSZ (9.25 m, 14. 47 cm and 0.018 m2 ha−1) respectively than the rest two other zones (Table 1). However, density (trees ha−1) of E. agallocha and H. fomes varies from 295–585 and 80–450 corresponding LSZ–MSZ and SSZ–LSZ consecutively (Table 1). All structural

## **Variation in structure of H. fomes and E. agallocha across the zones and** with salinity

This study demonstrates the distinctive structural parameters of dominant mangrove species and their changes with salinity. However, significant variation of structural parameters of dominant species was observed across salinity zones, and again, increasing salinity had a negative impact on those structures over the two years, which strongly supports our hypothesis in this study. Furthermore, structural parameters, such as, height (m), DBH (cm) and basal area ($m2\ ha^{-1}$) of E. agallocha and H.

## Fauna

A large variety of faunal species including fish fauna are available in the Bangladesh part of Sundarbans. It is estimated that BSMF covers a wide range of 1136 wildlife species. Among these, 315 are bird species along with 84 migratory birds. The common birds are storks, herons, gulls, and terns. The avifauna of the BSMF and the surroundings covers approximately 48% of total avifauna of Bangladesh. Among the faunal species, around 49 species are mammal. Royal Bengal Tiger is one of the familiar mammal species in the Sundarbans. BSMF is enriched with the aquatic species. There are almost 678 aquatic species in this part of Sundarbans. There is a list (Table 6) of important aquatic species of BSMF that represent 35% of total fauna of Bangladesh (Aziz & Paul, 2015, p. 257):

Aquatic Species Number

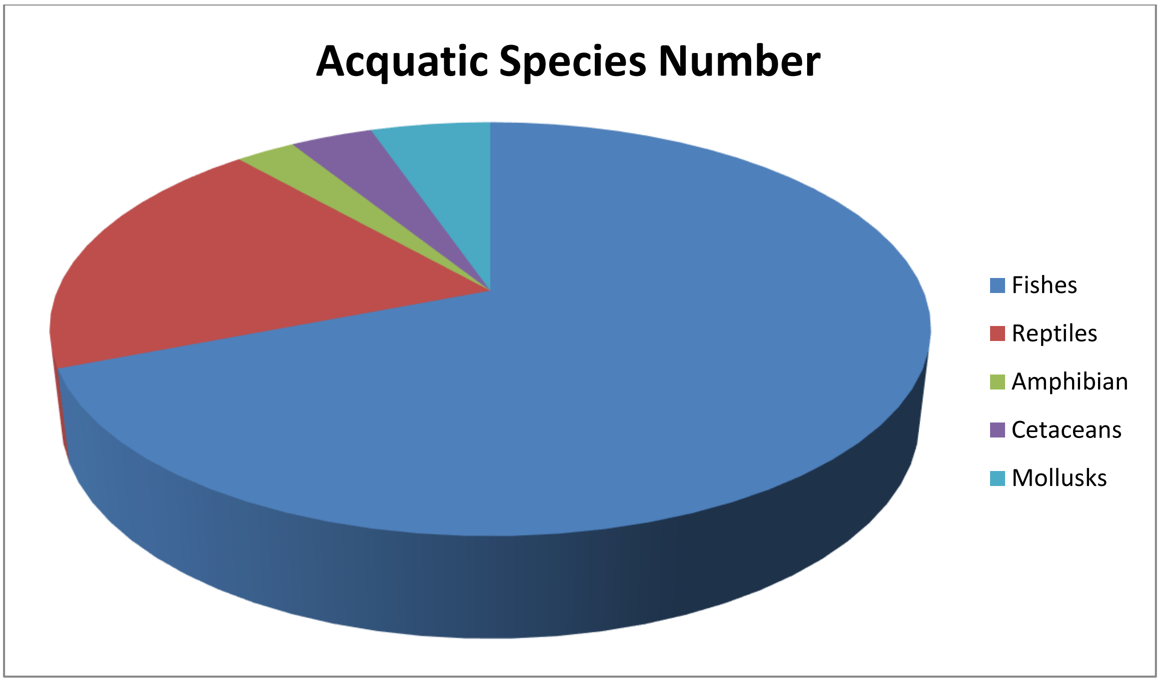
Fishes 210

Reptiles 59

Amphibian 8

Cetaceans 11

Mollusks 16




## Conclusions

This study of dominant mangrove species (i.e., E. agallocha and H. fomes) revealed that increasing salinity declined the stand structure of highlighted dominant species in the Sundarbans mangrove forest. Furthermore, the loss of functional variables of dominant mangrove species with salinity indicates that these species, as well as the mangrove ecosystem, are severely vulnerable to salinity. The results of this study illustrated that this chronological pattern of reducing growth with increasing

## Limitations of the study

To conduct studies in natural ecosystems have some inherent problems which may occur due to different biotic and abiotic variables to influence functional variables. We accredit that, we consider only trunk living trees to estimate biomass and carbon, but we are able to postulate a explanation of losing functions with salinity which mostly supports our hypothesis. At the same time, geographic and climatic variation may affect the variables with salinity, but repercussion is relatively small as

## Credit authorship contribution statement

Md. Akramul Islam: Conceptualization, Data collection, Formal analysis, Writing - original draft, review and editing. Shamim Ahmed: Conceptualization, Formal analysis, Software, Visualization, Writing - original draft, Writing - review & editing. Tanmoy Dey: Data collection, Final review. Rahul Biswas: Data collection, Final review. Md. Kamruzzaman: Data collection, Final review. Shanewas Hossain Partho: Data collection. Biplab Chandra Das: Data collection.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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