Evaluating research addressing effects of salinity on biodiversity in a trans-boundary mangrove forest

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EVALUATING RESEARCH ADDRESSING EFFECTS OF SALINITY ON BIODIVERSITY IN A TRANS-BOUNDARY MANGROVE FOREST

Abstract

The Sundarban Mangrove Ecosystem, situated within both India and Bangladesh, is locally and globally important but threatened by rising salinity. In this paper, we reviewed current research linking salinity and various metrics directly or indirectly related to salinity. Most studies were conducted in Bangladesh and assessed trees and other plants, and few involved both regions. The results of our review suggested that salinity generally appeared to exert a negative effect on biodiversity. Furthermore, both salinity and biodiversity have been linked to ecosystem function and processes in the Sundarbans, making management and mitigation of salinity impacts on biodiversity a key goal. Future policy directions should improve international cooperation for a more effective response.

Plain Language Summary

Throughout this paper, research that looks at the influence of salt concentration in water and soil on biodiversity of the Sundarban mangrove ecosystem is analyzed. The chosen papers that were reviewed were sometimes from India and sometimes from Bangladesh, but rarely both. Studies from Bangladesh were more common, and most of them studied trees and other plants. The papers that were analyzed revealed that increased salinity decreased the overall biodiversity in the Sundarbans. Salinity and biodiversity can affect important processes in the Sundarbans and future policy should involve cooperation between India and Bangladesh.

Introduction

Wetlands are areas that are inundated or saturated by water with sufficient frequency and duration to support vegetation adapted for saturated soil conditions (Hartig 2005). These ecosystems provide services such as wave attenuation, carbon sequestration, and erosion control as well as habitat for incredible biodiversity, including a number of rare species, but in many regions the majority of wetland habitats have been lost (Denny 1994; Li et al. 2018). As such, the protection of globally important wetlands should be prioritized in conservation.

Coastal wetland ecosystems such as mangroves and salt marshes face a wide range of challenges such as land reclamation, channel construction, decreased sediment input, sea level rise, and erosion (Li et al. 2018). Among them, increasing salinity, attributable to freshwater flow alterations, land clearance, irrigation, wastewater effluent, sea level rise, storm surges, and de-icing salt application (Herbert et al. 2015), is a key ecological stressor that detrimentally affects these sensitive biomes and can result in loss of biodiversity, the diversity of life from the genetic to the ecosystem level, of which two important facets are species richness and species evenness (Purvis and Hector 2000).

Generally speaking, increased salinity levels induce pathways that aim to facilitate water retention and acquisition, protect chloroplast functions, and maintain homeostasis (Parida and Das 2005) and may result in plant turgidity loss, severe cell dehydration, and, ultimately, cell death (Shirastava and Kumar 2015). Rising soil salinity has the potential to contribute to species, biodiversity, and ecosystem loss and threaten rare plant species (Jung et al. 2019; Maccioni et al. 2021; Dajic-Stevanovic et al. 2009). In fact, even low levels of soil salinity can result in significant plant diversity decline (Rahman, Lund, and Bryceson 2011). Because biodiversity is vital to overall ecosystem function including processes such as primary productivity and nutrient cycling (Gamfeldt, Hillebrand, and Jonsson 2008), salinity-induced biodiversity loss is of major concern.

Modeling of coastal ecosystems under soil salinization has demonstrated how certain soil communities are threatened by salinity increases, therefore illustrating the potential for salinity to induce biodiversity loss (Pereira et al. 2018). As coastal ecosystems, coastal wetlands and their salinity are sensitive to multiple drivers; in arid and semi-arid coastal wetlands, for instance, periods of increasing salinity result from high evaporative conditions, variability of inflows, proximity to the sea, and human pressures (Jolly, McEwan, and Holland 2008). Rising salinity in turn induces physiological stress, wetland community shifts, and changes in ecosystem function (Herbert el. al 2015). For example, in a Spanish coastal wetland, the ecological damage of increased salinity was described by quantifying the potentially affected fraction of species for a change in salinity (Amores et al. 2013).

The mangrove forest, a type of coastal wetland, has great ecological importance and covers a large area of the Earth's surface (Lee et al. 2014; Giri et al. 2010). They act as carbon sinks, serve as nurseries for many species, help to build land vertically, and aid in shoreline protection (Lee et al. 2014). Mangroves themselves are halophytes that complete their life cycle in saline conditions (Flowers et al. 1986), but under increased salinity, individual mangroves exhibit higher tissue salt levels and experience reduced water availability, which in turn decreases productivity (Field 1995). Thus, salinity levels can have profound effects on mangrove ecosystems. Optimal salinities for different mangrove developmental stages and mangrove species vary (Ball and Pidsley 1988). As a result, growth responses of mangroves to salinity vary greatly and reflect differences in salinity tolerance (Ball 1988).

The Sundarban Mangrove Ecosystem, the world's largest mangrove forest, was formed roughly 7000 years ago through sediment deposition that arrived from the Himalayas within the Ganges River (Aziz; Ranjan-Paul 2015). The Sundarban Mangrove Ecosystem lies in the delta of the Ganges River within the Bay of Bengal (Ramsar Sites Information Services 2019) between Bangladesh and India (**Figure 1**).

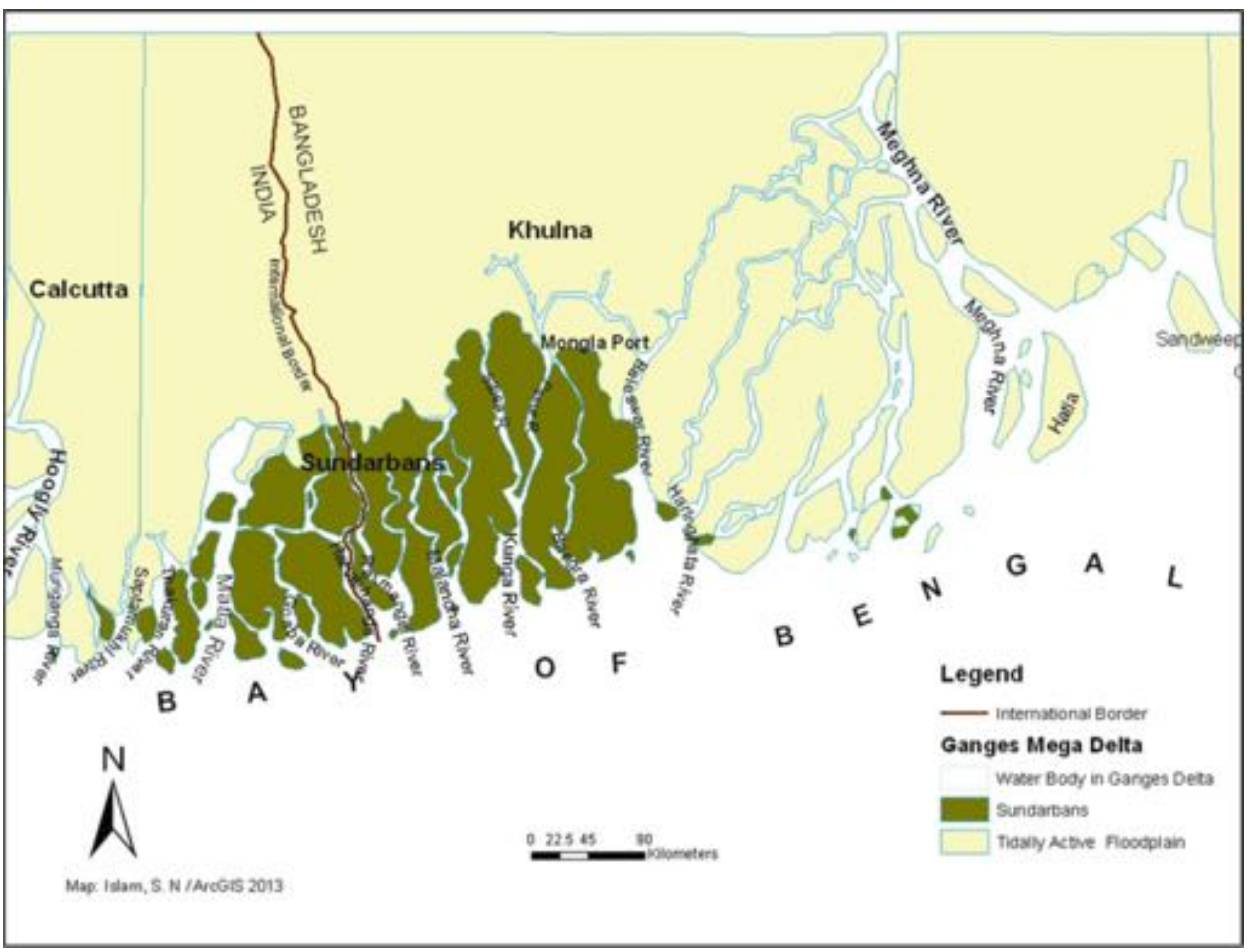

Figure 1. A map of the Sundarbans Mangrove Ecosystem (taken from Islam 2019).

The wetland is home to incredible biodiversity; in the Bangladesh Sundarban Mangrove forest alone 70 species of flora have been reported (Aziz; Ranjan-Paul 2015). Furthermore, in the Sundarban Mangrove Forest, a total of 1136 species of wildlife have been recorded; these include 315 types of birds, 289 terrestrial species, and 678 aquatic species (Aziz; Ranjan-Paul 2015). The Indian Sundarban Mangrove forest is similarly diverse, and is the most biodiverse mangrove forest in India (Mandal, Das, and Naskar 2010).

The Sundarbans mangrove forest is therefore of critical importance, but it faces mounting threats, particularly with regards to salinity. Recent work has revealed alarming salinity trends that vary spatially (**Figure 2**). Declining freshwater inputs resulting from diversion of Ganges water in India has contributed to increased salinity in the rivers flowing through the Bangladesh Sundarbans (**Figure 3**) (Islam and Gnauck 2011). In the Indian Sundarbans, salinity has decreased in the eastern and western sectors due to river, estuary, and dam water, but has increased in the central sector due to siltation of and decreased flow from the Bidhyadhari River (Subrata et al. 2016). Because of the prevalence of rising salinity and the potentially adverse effects it has on biodiversity, the effects of salinity on biodiversity within the Sundarban wetlands have been extensively studied.

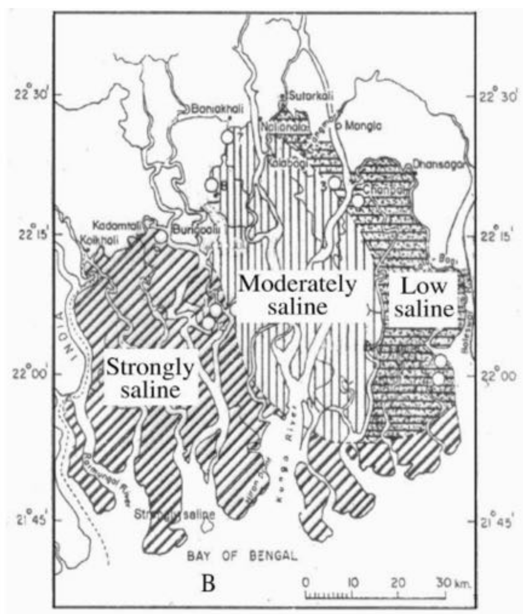

Figure 2. Salinity zones in the Bangladeshi Sundarbans as depicted in Siddiqi 1994.

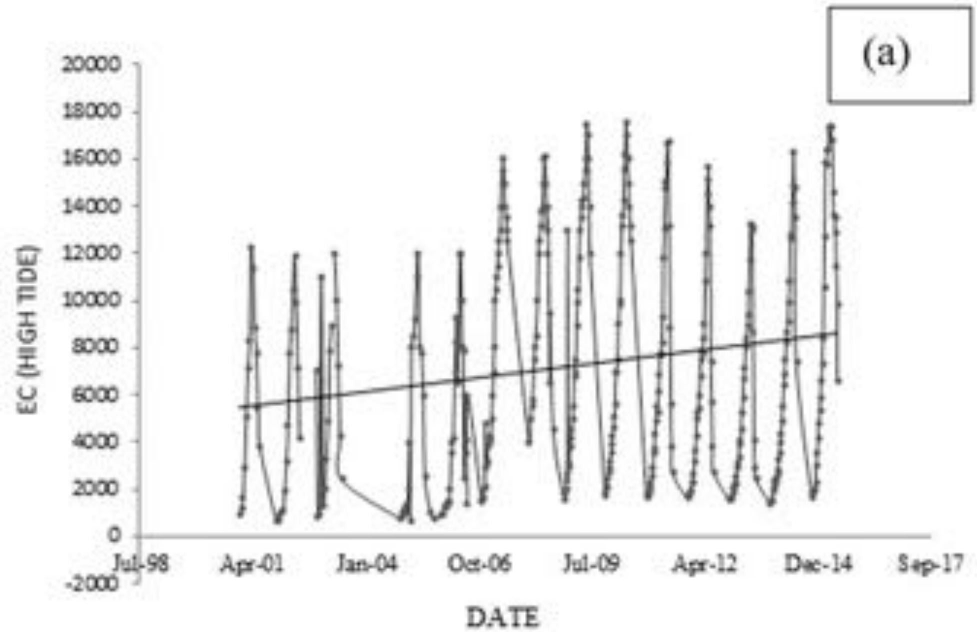

Figure 3. Change in river salinity over time at Daratona Station, Bangladesh (adapted from Hasan et al. 2020).

Beyond just the problems of increasing salinity in the Sundarbans, efforts to conserve this wetland must also overcome the issue of it being transboundary. In other words, it spans international boundaries, in this case those of Bangladesh and India. This means that conservation efforts, policies, and research do not always align across the entire wetland. Work to understand and protect such transboundary regions often only encompasses one country's part of the ecosystem and neglects the other, which may render conservation efforts inefficient or ineffective.

With roughly 60% of the wetland in Bangladesh and about the other 40% in India (Gopal and Chauhan 2006), the Sundarbans are no exception. There is little published research that looks at the effect of these rising salinity levels on the entire wetland, but instead research is usually limited by the countries' boundary. Thus, most conservation plans are proposed from the point of view of the effects on just the Indian or just the Bangladesh side, but are not a holistic representation of the entire wetland.

Here we aim to synthesize current research and identify differences, if any, in research on the salinity-driven biodiversity response across borders of the Sundarbans. Although many studies deal heavily with how salinity affects biodiversity, few studies simultaneously consider sites on both sides of the India-Bangladesh border. Should differences exist in studies of the effect of salinity on biodiversity, this would highlight the need for trans-boundary research and management. Furthermore, we will briefly touch on national policies that may be potentially responsible for such differences and provide recommendations for more effective trans-boundary wetland management. Thus, by describing patterns across the entirety of the Sundarbans, we hope to gain a clearer picture of the unique challenges faced by this important ecosystem and by trans-boundary ecosystems in general.

Methods

We searched the Gale, Academic Search Ultimate, GeoRef, Agricola, Web of Science, and GeoScienceWorld databases for the key terms “Sundarbans”, “biodiversity”, and “salinity” up through 2022/12/01. This initial search was followed by a brief search of Google Scholar for the same keywords until a total of 28 studies were assessed. Results were manually evaluated for relevance and relevant studies were compiled and summarized by study region (India, Bangladesh, and both), group assessed (e.g. trees, fish), metric assessed (species diversity index, species performance, complexity index), and response direction (i.e. increasing, decreasing, no change, or insufficient).

Each paper was generally compiled by a single reviewer and must have involved a study of the Sundarbans, considered salinity as a factor, and looked at one of the following metrics: species richness, species diversity, species performance, spatial distribution (of species), or complexity index. Response direction was as presented in the paper if statistically significant or otherwise substantiated. For instance, an “increasing” response direction for species performance would indicate that a species performed better (using performance measures such as aboveground biomass) under higher salinity. If some species assessed had increased performance whereas performance decreased for others, response direction was “insufficient”. On the other hand, “decreasing” response direction for spatial distribution would indicate that a species’s geographic range and habitat decreased in areas with higher salinity. If salinity-intolerant species ranges contracted whereas salinity-tolerant species ranges expanded, this was counted as “decreasing”, with the expected ultimate outcome being increased dominance of salt-tolerant species, loss of salt-intolerant species, and a concomitant loss of biodiversity.

Once relevant information was compiled, two sets of bar graphs were constructed, one for the number of studies assessing each taxonomic group (**Figure 4**) and one for the number of studies assessing each metric (**Figure 5**). Within sets of bar graphs, individual graphs were divided by area of study (India or Bangladesh). A third graph was constructed for cumulative results between regions. No graphs were constructed for studies that simultaneously assessed both regions because the number of studies that did so was relatively small. The bars themselves were divided by response direction. For the set of graphs depicting the number of studies that assessed a certain metric, if a single study had more than one metric it was counted more than once, i.e. once for each metric it considered.

Results

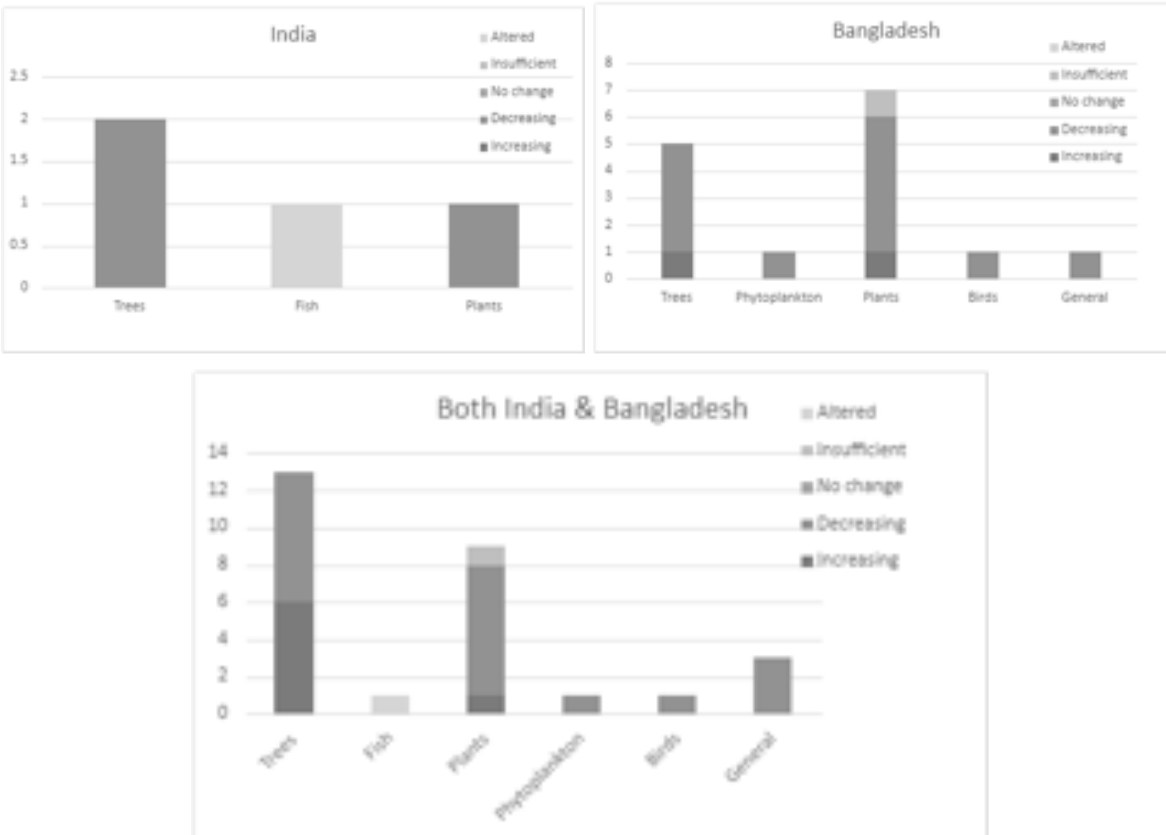

Figure 4. Graphs showing the number of studies for each taxonomic group, divided by response direction to increasing salinity, for (top left) India, (top right) Bangladesh, and (bottom) both.

This set of graphs shows the number of studies that were performed for each taxonomic group in response to changing salinity levels in that area of the Sundarban wetlands. Beginning with the graph on the top left that looks at studies conducted in India, the three main taxonomic groups that were studied in the literature were trees, fish and plants. The most frequent studies looked at trees, and then fish and other plants. Second, the graph on the top right looks at studies that were conducted in Bangladesh with a more diverse set of taxonomic groups. These studies focused on trees, phytoplankton, plants, birds and finally a category of general biodiversity. These studies did not name specific taxonomic groups during their writing. Lastly, on the bottom this graph combined studies from India and Bangladesh and also included studies that took place in both regions simultaneously.

Overall, the majority of studies assessed trees, followed by other plants. More studies were conducted in Bangladesh than in India. Furthermore, most metrics tended to decrease with increasing salinity.

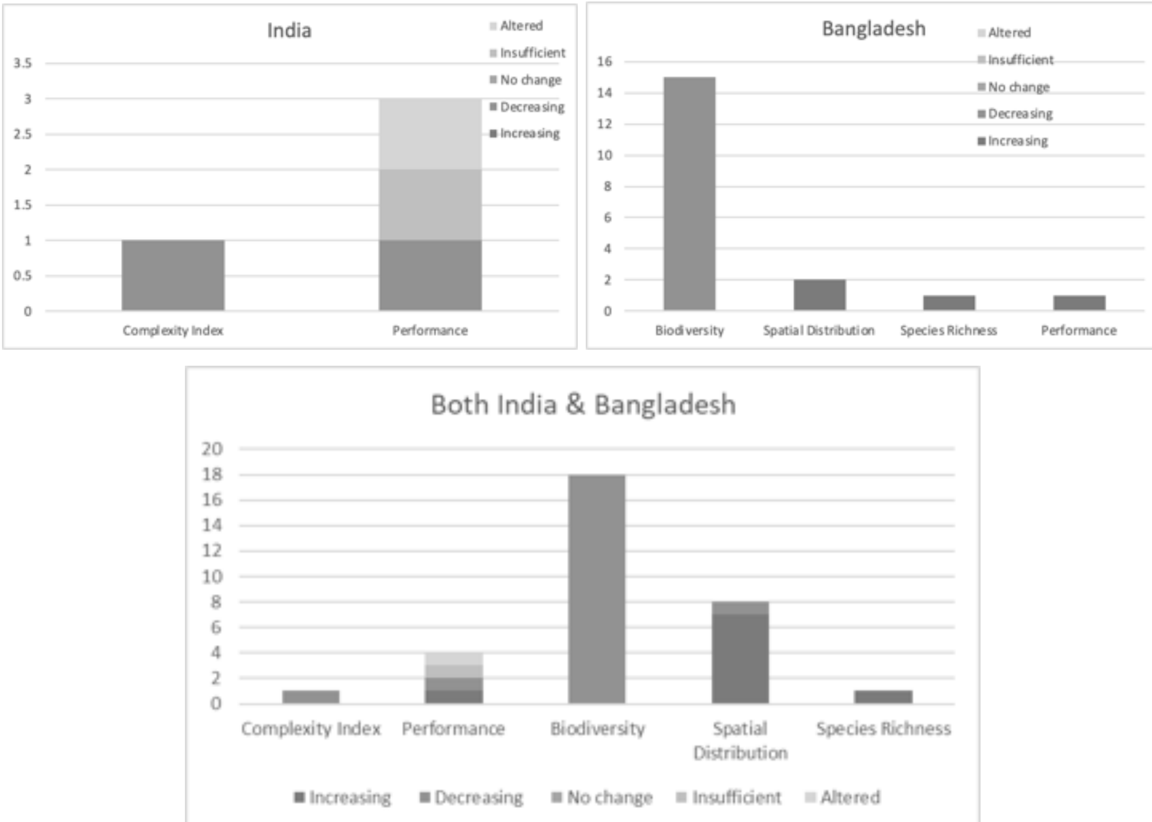

Figure 5. Graphs showing the number of studies for each metric, divided by the response direction for increasing salinity, for (top left) India, (top right) Bangladesh, and (bottom) both.

This set of graphs focuses on the number of studies that were performed in each region of the Sundarban wetlands and were organized by the metric that was assessed for each paper. The most studies that were done took place in Bangladesh and assessed biodiversity. Starting with the top left graph for studies that were conducted in India, the majority of these studies used the performance metric. To the left of that is the graph that focuses on studies performed in Bangladesh, and the most frequent metric used for these studies was the Biodiversity metric. Finally the bottom graph looks at the combined studies of both areas with the biodiversity metric being studied most frequently. Overall, increasing salinity was most commonly linked with decreased biodiversity or related metrics.

Study area	Key findings	Reference
India	Different plants had different distributions along soil pH and salinity gradients, and some plant species were restricted to low salinity areas. The complexity index, a measure of vegetation structural complexity, was highest in least saline areas.	Joshi and Ghose 2003
India	The endangered mangrove species *Heritiera fomes* was restricted to low salinity environments, with its aboveground biomass (AGB) increases over time being significantly higher in sectors where salinity is decreasing over time compared to areas where salinity is increasing. For comparison, AGB of the three most common mangrove species was used as a proxy for the entire forest. It was estimated to have a constant increase in both sectors with no discrepancy between them, regardless of whether salinity was increasing or decreasing.	Banerjee, Gatti, and Mitra 2017
Bangladesh	Salinity was one dominant environmental stressor that was found to contribute to decreasing mangrove tree diversity. It had no observable effect on species richness, but was related to increasing compositional heterogeneity and range contraction of salt-intolerant specialists.	Sarker et al. 2019b

Study area	Key findings	Reference
Bangladesh	Freshwater phytoplankton diversity in the rivers of the Bangladesh Sundarbans was slightly reduced as a result of salinity intrusion.	Uddin, Tumpa, and Hossain 2021
Bangladesh	Herbaceous plant biodiversity was spatially dependent and decreased with salinity.	Selim et al. 2021
Bangladesh	Seasonal abundance of finfish and shellfish was strongly influenced by salinity, with some more abundant in high salinity areas and others more abundant in low salinity areas.	Hoq, Wahab, and Islam 2006
Bangladesh	Forest species richness and diversity indices decreased with salinity. There were strong species composition dissimilarities between low salinity zones and moderate and high salinity zones.	Islam et al. 2016

Study area	Key findings	Reference
Bangladesh	Shannon-Wiener diversity index for undergrowth vegetation was much higher in oligosaline than polysaline zones, and species richness also declined with increasing salinity.	Rashid et al. 2008
Bangladesh	For seedlings, the species diversity index, Shannon-Wiener diversity index, and species evenness index increased with salinity, whereas number of seedlings, mean seedling density, and Simpson's index decreased with salinity. Overall, the condition of the Sundarbans Mangrove Forest that was assessed was poor in terms of biodiversity.	Siddiqui et al. 2021
Bangladesh	At all historical time points assessed, hyposaline mangrove communities were the most diverse and heterogeneous in terms of species composition, whereas hypersaline communities were the least diverse and the most homogeneous. There is a trend of compositional homogeneity and spatial contraction of distinct and diverse areas.	Sarker et al. 2019a
Bangladesh	Tree species richness increased with salinity and Shannon-Wiener diversity was highest in most saline conditions.	Ahmed et al. 2022

Table 1. A table summarizing study region (India or Bangladesh) and key findings for selected papers relating salinity in some way to diversity.

Discussion

Mangrove forests provide many key ecosystem services, such as shoreline protection, but their protective capacity may be reduced by species shifts due to anthropogenic stressors (Lee et al. 2014). Rising salinity, the core component of environmental stress in this study, can have profound impacts on mangrove ecosystems. At the species level, species must be able to adapt to saline conditions. For example, adaptive responses in a major pioneer mangrove tree species to high salinity in the Sundarbans has been demonstrated, with nutrient resorption/re-translocation efficiency, an important nutrient-conserving mechanism for mangroves under salt stress, being comparatively highest in the high saline zone (Nasrin, Hossain, and Rahman 2019). Furthermore, under high saline conditions, species performance in mangrove ecosystems often declines. In one study, traits such as height, diameter at breast height, and aboveground biomass (AGB) of two dominant mangroves decreased with increased salinity (Islam et al. 2022). One of these species in particular, *Heritiera fomes* and locally referred to as Sundari, is vulnerable to a disease suggested to be associated with salinity (Ghosh, Kumar, and Roy 2016). It is also stenoecious, or restricted in terms of habitat, and its increases in AGB over time were demonstrated to be relatively lower in areas of higher salinity, whereas AGB increases for the three most common mangrove trees did not differ between salinity zones (Banerjee, Gatti, and Mitra 2017). For an economically valuable species for materials such as timber, the decline and even disappearance of *H. fomes* in some areas (Ghosh, Kumar, and Roy 2016) is alarming and results in a loss of provisioning ecosystem services.

Heritiera fomes (from Schueman 2022).

The literature search conducted in this study revealed that at the community level, species-level responses translate into altered species ranges. Multiple studies found that ranges of salt-intolerant species tended to contract whereas ranges or densities of salt-tolerant species expanded or increased, or alternatively that species were in some way restricted to low salinity areas or being replaced by salinity-tolerant species (Banerjee, Gatti, and Mitra 2017; Ghosh, Kumar, and Roy 2016; Giri et al. 2014; Haque and Reza 2017; Hema and Ghose 2003; Mukhopadhyay et al. 2015; Rahman 2020; Sarker et al. 2019b). This relates to the concept of how stressors (in this case, salinity) are able to perturb coexistence between species with similar ecological niches and cause indirect competitive exclusions (Burgess et al. 2019). As a result of shifting spatial distributions, overall, the Sundarbans are now becoming more spatially homogeneous in terms of species composition (Sarker et al. 2019a). In studies directly assessing richness and biodiversity metrics, salinity was often related to a reduction in biodiversity (Islam et al. 2016; Rashid et al. 2008; Sarker et al. 2019a; Sarker et al. 2019b; Selim et al. 2021; Uddin, Tumpa, and Hossain 2021), but not always (Ahmed et al. 2022; Siddiqui et al. 2021). Thus, salinity appears to be a major driver of biodiversity loss.

Biodiversity decline is concerning because biodiversity is vital to ecosystem functioning (Gamfeldt, Hillebrand, and Jonsson 2008). They have been linked through biodiversity-ecosystem functioning (BEF) relationships. Although this relationship is complex, the importance of diversity to the magnitude and stability of ecosystem processes has been established in a wide range of studies (Hooper et al. 2005). That said, BEF experiments are often small-scale and may not in fact be of practical use to conservation managers, except in the case of restoration efforts (Srivastava and Vellend 2005), but there are ongoing efforts to scale up BEF research (Gonzalez et al. 2020).

In any case, biodiversity plays a key role in the provisioning of ecosystem services, and multiple studies in the Sundarbans have linked them to salinity, biodiversity, or both. For instance, a study in the Indian Sundarbans found increased salinity caused declines in forest cover, led to the disappearance of salinity-sensitive species, and inhibited nutrient cycling and resulted in nutrient-poor soils, thus acting as a primary mechanism for mangrove degradation (Chowdhury et al. 2019). Increased salinity was also found to impede forest growth and biomass production and was associated with decreased aboveground, soil organic, and root carbon stocks in the Bangladesh Sundarbans; however, polyhaline regions were in this study also found to have higher biodiversity (Ahmed et al. 2022). An integrated Bayesian hierarchical model applied to the Bangladesh Sundarbans was able to capture observed stress responses in trees and predicted that if historical increases in salinity and siltation are maintained, one-third of ecosystem productivity will be lost by the year 2050 (Sarker, Reeve, and Matthiopoulos 2021). Furthermore, sediment salinity, taxonomic diversity, functional diversity, and especially functional distinctiveness were found to have strong explanatory power for plant biomass carbon, sediment organic carbon, and total ecosystem carbon storage in the Bangladesh

Sundarbans, indicating the functional composition of diverse tree assemblages is a strong driver of carbon storage and that protecting and restoring mangrove biodiversity also increases the potential of carbon storage and climate change mitigation in mangroves (Rahman et al. 2021). Though results vary by study, salinity and biodiversity appear to be strong drivers of ecosystem function in the Sundarbans, and in many cases efforts to reduce salinity levels for biodiversity conservation could have co-benefits in terms of ecosystem services.

The Sundarbans Mangrove Ecosystem is of enormous importance to the coastal community in terms of agriculture, fisheries, drinking water, and other services, but this ecosystem is highly sensitive to salinity (Islam 2019), particularly with regards to biodiversity as demonstrated by this study. As such, there is a pressing need to protect this sensitive mangrove ecosystem against salinity-driven biodiversity loss.

This increase in salinity in the Sundarbans Mangrove Ecosystem has several contributing factors, both natural and anthropomorphic in origin. Research shows that natural processes like rising sea levels and the silting up of certain rivers that used to feed freshwater to the Ganges have partially contributed to the increasing salinity rates over time (Islam and Gnauck 2009). However, man-made contributions, like India's construction of the Farakka Barrage on the Ganges or the rapid increase of shrimp cultivation, have further cut off or encroached upon the freshwater of the wetland, exacerbating the elevating salinity levels (Rahman et al. 2011; Islam and Gnauck 2009).

To combat this threat to biodiversity, both countries have passed legislation and set up protected areas like sanctuaries and national parks to help mitigate the impact of salinity degradation (Gopal and Chauhan 2006). However, lax enforcement around things like illegal hunting and logging as well as continued deforestation and land use change raise questions of whether the existing measures are enough to protect the wetland (Aziz and Paul 2015; Islam and Bhuiyan 2018; Gopal and Chauhan 2006). To further complicate this issue, the Sundarbans are a transboundary wetland, or in other words, it spans international boundaries, specifically those of Bangladesh and India (Griffin and Ali 2014). Research shows that this can, and in the case of the Sundarbans, unfortunately does, lead to differing environmental policies and conservational efforts that don't align across the entire ecosystem which in turn leads to inefficient or even ineffective mitigation efforts (Gopal and Chauhan 2006). The results of our study further suggest that different degrees of research may be available in different countries, which could potentially contribute to differences in understanding and translate into differences in policy.

Studies show that garnering the international cooperation necessary to protect transboundary ecosystems through effective policy can be difficult, especially considering that discussions are usually framed in terms of individual needs instead of mutual interests (López-Hoffman et al. 2010; Griffin and Ali 2014). Reframing these agreements in these terms however motivates cooperation as it reveals what both countries have to lose, and thus, both countries can move forward and efficiently implement resources to effectively protect the wetland.

Looking to the future, a couple studies have also suggested strategies to help mitigate the Sundarbans' salinity problem. One plan is to work to find a more equitable way to distribute the Ganges water caught by the Farakka Barrage, taking the environment as well as the needs of all the countries in the Ganges floodplain into consideration (Aziz and Paul 2015). Another solution is to raise local awareness of the plight of the Sundarbans through awareness programs and also working to decrease the dependence of locals on the wetland, all while working to implement better monitoring, stronger legal protections, more research, and disaster management (Islam and Bhuiyan 2018). Overall, work must be done soon to better protect the wetland as global climate change will only put further pressures on the ecosystem and exacerbate the existing problems (Gopal and Chauhan 2006; Griffin and Ali 2014; Islam and Bhuiyan 2018).

Conclusion

The Sundarbans Mangrove Ecosystem is the largest mangrove forest in the world. It is host to incredible biodiversity and provides critical services to coastal communities, highlighting the importance of the conservation and management of this system.

To illustrate our current understanding of the Sundarbans, in this study we compiled and reviewed 28 studies relating salinity level to species richness, species biodiversity, species spatial distributions, species performance, and additional metrics (i.e. complexity index). We then divided these studies by study region (India, Bangladesh, or both) and then by response direction (increasing, decreasing, no change, insufficient, and altered). We found that the majority of studies were conducted in Bangladesh, there was a strong tendency of studies to assess trees and other plants, and very few studies examined both regions at once. Overall, our review of the literature strongly suggests that salinity negatively impacts biodiversity in the Sundarbans in general. Spatially scaling up research and incorporating a greater range of taxonomic groups would better illustrate the ecosystem-level relationship between salinity and biodiversity, particularly because local dynamics and specific species responses may differ from the ecosystem as a whole.

Though the mechanisms and magnitude of this relationship are sometimes unclear, both salinity and biodiversity can play a key role in ecosystem functioning and ecosystem services. In the Sundarbans, current studies have linked increased salinity to inhibited nutrient cycling, decreased carbon stocks, and ecosystem-scale productivity. Higher biodiversity has also been linked to increased total ecosystem carbon storage. However, few studies of the Sundarbans exist that link salinity or biodiversity to ecosystem processes and services, and a greater number of studies would elucidate the role of biodiversity in ecosystems and highlight or clarify its significance.

Both countries do have legislation and other protective measures in place in order to combat salinity-induced degradation. However, lax enforcement and lack of legislative cohesion between the two countries due to a focus on individual instead of mutual interests has led many conservation efforts to be inefficient if not simply ineffective. International cooperation and stricter enforcement are crucial steps to developing a more effective response to salinity challenges in the Sundarbans.

Future work should seek to bridge political boundaries to gain a broader understanding of processes and challenges in the Sundarbans Mangrove Ecosystem. A greater understanding of how different taxonomic groups respond to rising salinity may also be valuable, especially in the case of threatened species that are not plants. Furthermore, more work is needed in establishing salinity and especially biodiversity to ecosystem function and services, an area which is largely unstudied. Doing so could motivate greater biodiversity conservation in the future. Finally, being able to identify other stressors to the Sundarbans and study them in combination with rising salinity, especially in the face of worsening climate change, would offer a clearer picture of current threats to the Sundarbans and be able to more effectively guide policy and future decisions.

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