

Journal of Biological and Chemical Research

GIF

GLOBAL IMPACT FACTOR



SJIF Scientific Journal Impact Factor

An International Journal of Life Sciences and Chemistry

EISSN 2319-3077 (Online) | ISSN 0970-4973 (Print)

 www.jbcr.co.in |  jbiolchemres@gmail.com

Journal Impact Factor: **4.275**, | Global Impact Factor: **0.876**, | InfoBase Impact Factor: **3.66**

Scientific Journal Impact Factor: **3.285**, | IC Value: **82.43**

Scope

Life Sciences (Botany and Zoology), Medical Sciences, Chemical Sciences, Agricultural Sciences, Biochemical Sciences, Environmental Sciences, Biotechnology, Molecular Biology and Tissue Culture



Volume 42 (1&2), December, 2025



Indexed, Abstracted and Cited

Index Copernicus International (Europe), Research Bible (Japan), Scientific Journals Impact Factor Master List, Directory of Research Journals Indexing (DRJI), Indian Science. In, Database Electronic Journals Library (Germany), Open J-Gate, J Gate e-Journal Portal, Info Base Index, International Impact Factor Services (IIFS) (Singapore), Scientific Indexing Services (USA), International Institute of Organized Research (I2OR), World Cat, International Innovative Journal Impact Factor, Swedish Scientific Publishing, Eye Source and cifactor.org Journals Indexing Directory, Cosmos Science Foundation South-East Asia, Indexing of International Research Journals and ImpactFactor.pl - Kompendium wiedzy o czasopismach naukowych, Philadelphia.



Dr. Arshad H. Rizvi

REVIEW ARTICLE

Received: 22/02/2025

Revised: 28/04/2025

Accepted: 29/04/2025

Ecological Disruptions and Climate Change in the Sundarbans: A Systematic Review of Current Challenges

Arshad H. Rizvi and Mohd. Zahid Rizvi

Department of Botany, Shia P.G. College, Lucknow, U.P., India

ABSTRACT

The Sundarban, the largest mangrove in the world, has a great diversity of mangrove species. However, the forest is one of the worst climate change hotspots on the globe. The impacts of climate change include increased seawater temperature, sea level rise, salinity intrusion, tropical cyclones, and accelerated coastal erosion. The sea surface temperature in the Sundarbans has increased by 0.5°C per decade, which can have a disastrous impact on biodiversity and human habitat. Moreover, due to seawater warming, high-intensity events such as severe cyclones and tidal surges are becoming more frequent. Sea levels in the Sundarbans are rising faster than the global average, which is also alarming for the mangrove habitat. It has been projected that the Sundarbans will shrink up to 60% in the year 2100 with 88 cm sea-level rise. The main impact of sea level rise on water resources is the reduction of freshwater availability due to salinity intrusion through rivers and estuaries. Sundari, the dominant tree species in the Sundarbans, suffers from top dyeing disease because of increased salinity. The islands of the forest and its ecosystem, including the community, are rigorously strained over the availability of natural resources and are extremely vulnerable to changes in climate. In this study, an overview of the future threats and challenges to the Sundarbans delta due to climate change has been presented.

Keywords: *Sundarbans, Climate Change, Salinity intrusion, Mangrove ecosystem.*

INTRODUCTION

Sundarbans, the largest single block of tidal halophytic mangrove forest in the world, is located on the Ganges-Brahmaputra Delta at the point where it merges with the Bay of Bengal (Figure 1). The total area of Sundarbans encompasses about 10,000 km² of which 60% area belongs to Bangladesh and the rest of the portion in India (WWF, 2010). About 70% of the total geographical area of Sundarbans is covered with forest and the remaining part includes water

bodies comprising of hundreds of morasses, swamps, estuaries, rivers, canals, and creeks are interlinked almost in every direction (BBS, 2001).

The Sundarbans mangrove is principally a salt-tolerant forest ecosystem like the other coastal mangroves of Southeast Asia, but a moderately fresh water ecosystem also cohabits (Haq, 2010). The forest is a home of large number of flora and fauna. The biodiversity comprises about 350 species of vascular plants, 250 fishes and 300 birds, besides numerous species of phytoplankton, fungi, bacteria, zooplankton, benthic invertebrates, molluscs, reptiles, amphibians and mammals (Gopal and Chauhan, 2006). The mangrove forests of the Sundarbans are also the most significant thresholds of the Royal Bengal Tiger, an endangered species.

Currently, Sundarbans is threatened by both anthropogenic and natural factors. The natural threats include climate change stimulated sea level rise. The Intergovernmental Panel on Climate Change (IPCC) projected that the state of tropical forest ecosystems is likely to get worse due to climate change. The impact of climate change specifically changes in temperature, CO₂, precipitation, cyclones and storms, and sea level, combined with anthropogenic threats is believed to have some changes in the overall environment of the Sundarban (Kamruzzaman, 2013). There are diverse ranges of impact of climate change on the Sundarban mangrove forests. The major impact will be sea level rise and fresh water unavailability. Sea level rise will decrease availability of fresh water due to salinity intrusion (Nishat, 2013). Both water and soil salinity along the coast will increase with the rise in sea level. In the following sections the threats and challenges concerning Sundarban delta due to climate change has been briefly discussed.

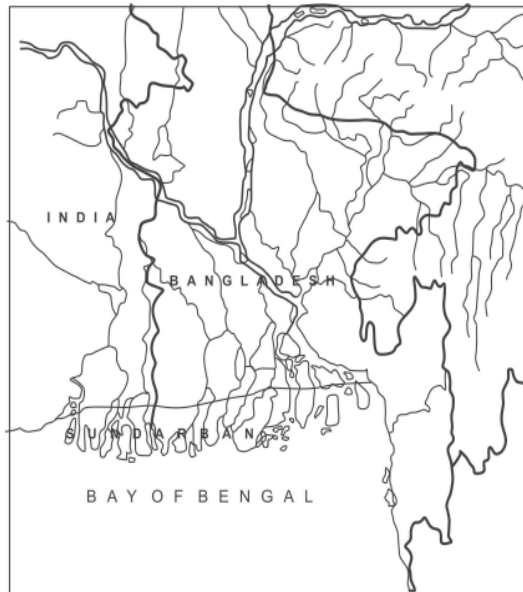


Figure 1. Location of the Sundarban in the Ganga Brahmaputra Delta (Gopal and Chauhan, 2006).

EMERGENT THREATS

A. Increasing Temperatures

It has been observed that between 1980 and 2007, the sea water temperature in the Sundarbans has increased at an accelerated rate of 0.5°C per decade compared to the

experiential global sea surface temperature warming at the rate of 0.06°C per decade (CSE, 2012). This faster increase of sea water temperature has severe ramifications on aquatic life. This change has great impacts on the Sundarbans area as it is an estuarine delta. Further, it detrimentally affects the health of the mangrove ecosystem (Mahadevia and Vikas, 2012).

B. Rising Sea-levels

In the past 25 years, sea level has raised at a rate almost double the global average (Mahadevia and Vikas, 2012). This is due to a combination of factors including land subsistence patterns (Samanta et al., 2023). Due to continuous submergence in higher water, as an implication of rise of sea level, the plants are being noted to be shorter and narrower with fewer branches and leaves resulting in lower rates of photosynthesis and regeneration of the mangroves. The sea level rise is also affecting the availability of sediment, directly impeding the establishment of new groves (Mahadevia and Vikas, 2012).

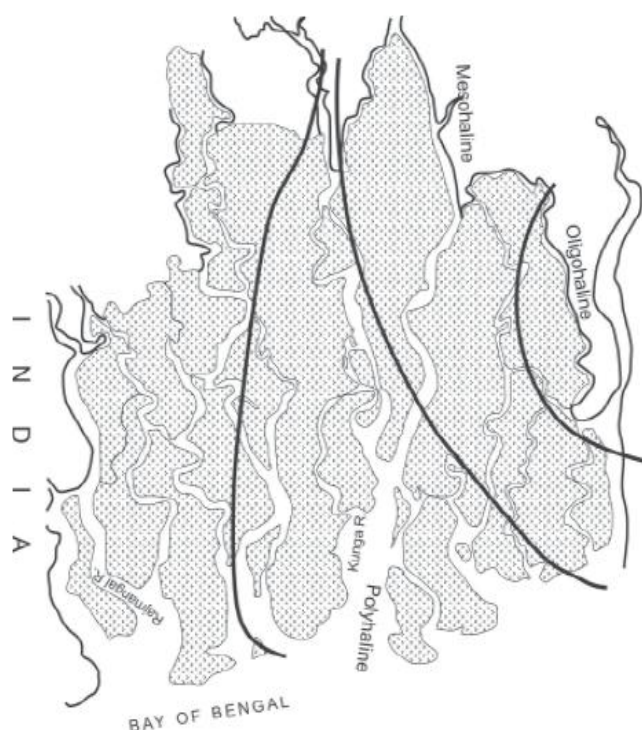


Figure 2. Salinity zones in the Bangladesh Sundarban (Gopal and Chauhan, 2006).

C. Rise in Salinity

The health of Sundarbans Forest depends upon a number of ecological parameters of which, salinity, inundation, and sedimentation are the most important physical parameters (Uddin et al, 2013). The eastern part of the Sundarban in Bangladesh is oligohaline (<5 ‰ salinity) whereas most of the Indian Sundarban is polyhaline (Fig. 2). Studies suggest that in the last two decades, the runoff in the eastern rivers of Sundarbans has decreased resulting in ever

increasing salinity and sea water-sulfate concentrations. The decrease in fresh water runoff has affected mangrove growth (Samanta et al., 2021).

Sundari, the most typical kind of tree in the Sundarban is thought to suffer from top dyeing disease because of increased salinity. Due to salinity ingress aquatic organisms will migrate inward, a majority of the mesohaline areas will be transformed into polyhaline areas (Kamruzzaman, 2013). The resultant increase in salinisation and accretion of sediments may alter vegetation composition. Impacts on animal communities may also occur due to both, the direct effects of salinity and indirectly through food chain modifications caused by the alterations in the nature and amount of detritus available in the mangrove ecosystem, which is directly a threat to the living bio-diversity (Ahmed et al., 2022). Eventually the species offering dense canopy cover would be replaced by non-woody shrubs and bushes, while the overall forest productivity would decline significantly (Mahadevia and Vikas, 2012).

D. Cyclones

It has been observed that there has been an increase in the intensity of cyclonic storms hitting the Sundarbans between 1951 and 2010. Recent research suggests that such increase in intensity may be attributed to an increase in sea surface temperature. Studies also suggest that more than 40% cyclones crossed through the Sundarbans over the last 100 years (Fig 3).

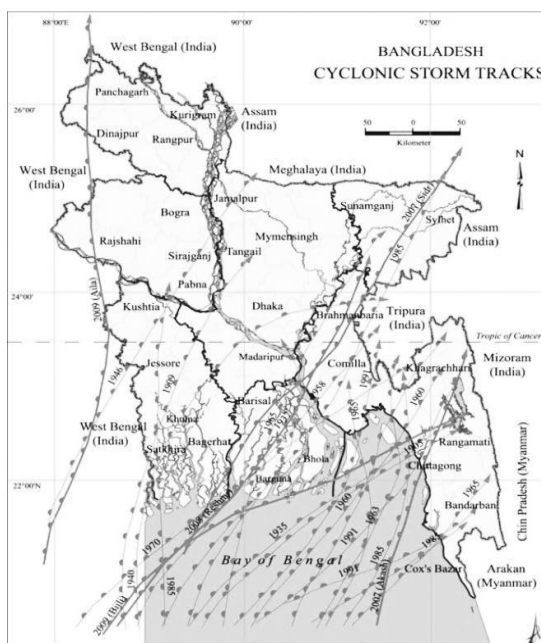


Figure 3. Track of Cyclones of last 100 years over Bangladesh (Banglapedia, 2020).

The Sundarban has been already severely affected by several tropical cyclones. The recent two cyclonic storms (SIDR in 2007 and AILA in 2009) have wrecked a massive destruction in the Sundarban area. About a quarter of the forest was destroyed and according to the researchers, it will take several decades for the forest to regenerate by itself from this catastrophe. All the species were affected by SIDR which led in severely damaging the ecosystem.

E. Coastal Erosion

The loss of land due to the rise of the sea level is one factor in the decreasing size of the Sundarbans landmass. The other is the constant erosion of embankments built to stop the seas from invading islands. This is a repeated premise throughout the islands of the Sundarbans where there is a constant battle between man and sea to stop large chunks of land being dragged away. Consequently, there are lots of uninhabited people and many inhabitants who had their houses a kilometer away from the river and have now reached almost at the edge of the river. Such witnesses are now offering strong evidence in the direction of a changing climate.

UPWARD CHALLENGES

A. Over-exploitation of Forest Resources

Fishery and collection of non-timber forest provide supplement for the scanty agricultural income of the local population. However, extensive deforestation and overfishing have confronted the environment under tremendous pressure. Fish stock is diminishing because of a combination of over exploitation and climatic changes. It has been perceived that fish density in shallow waters has reduced and the quantity of commercially important fish has declined. Furthermore, increase in demand for prawn products has led to the local population to abandon sustainable traditional fishing practices and adopt excessive prawn seed culture. This has caused irreversible harm to the environment due to erosion of the mangrove eco-system which comprises of mud dykes that protect the Sundarbans from the assault of the sea (Mahadevia and Vikas, 2012). In addition, this has led to the destruction of the mangrove trees whose roots are essential to bind the mud dykes and the taking of a heavy toll of fish seedlings, which will adversely affect the delta's fish population. In the long run, this methodology of fishing will not be a sustainable source of livelihood for the local population (Mahadevia and Vikas, 2012).

B. Lack of Effective Disaster Management Program

In spite of the fact that the Sundarbans is a cyclone prone area and is heavily populated, there is a lack of an operational disaster management plan and disaster protections. The problem of frequent natural disasters such as cyclones is complicated by the inaccessibility and remoteness of the delta, lack of infrastructure (such as roads, hospitals) and limited access to resources. The continuous submergence of agricultural lands and frequent cyclonic events has forced large number of people to migrate as environmental refugees (Mahadevia and Vikas, 2012). As more and more land continues to be claimed by rising sea waters, more families find themselves joining the growing ranks of refugees. An effective long term mitigation goal would be to provide disaster resistant homes to the residents of Sundarbans as well as construct more disaster shelters.

C. Increase in Salinity

During the period of British colonization, large swathes of the Sundarbans were cleared for agricultural purposes. Furthermore, to prevent ingress of sea water approximately 3,500 km long embankments have been built over time along the bank of creeks and along the sea shore (Mahadevia and Vikas, 2012). However, the embankment impeded the natural process of sedimentation. The embankments trapped silt choking the river and making the channels

increasingly shallow. As a direct result, while the river beds were elevated, the flood plains remained at the same height. As a consequence of which, the rainwater remained stagnant in the floor plains for long periods of time.

D. Distend of Diseases

Due to long periods of water stagnation, the population is at a greater risk from water borne diseases which consequences an increase in incidences of morbidity and mortality (Mahadevia and Vikas, 2012). Similarly increase of intensive cyclones is likely to cause more injuries and deaths. Increasing temperatures may lower yields which already are not sufficient for the population of the region.

E. Increase in Man-Animal Conflict

As climate change adversely affects the vegetative production and biomass on which the wild animals thrive, there is an increased threat of conflicts between human being and animals outside the forests (Mahadevia and Vikas, 2012). A conflict situation has always been injurious for both man and animal and has caused in death of either of the two. This is particularly threatening for the survival of the critically endangered Royal Bengal Tigers in the Sundarbans region that are historically known to prey on humans. In fact, several unfortunate tigers that have drifted into human habitat have been killed due to fear of attack (Wahid et al., 2025).

FUTURE OF THE SUNDARBANS

Global climate change is expected to increase the average temperature and spatio-temporal variability in precipitation, as well as cause a rise in sea level. It has been anticipated that the most bio diverse areas in the Sundarbans will be reduced from 60% to 30% in the year 2100 with 88 cm sea level rise compare to the status in 2001, (CEGIS, 2006). In addition to increasing inundation, salinity pattern will be changes in the Sundarbans due to sea level rise and change in upstream freshwater flow. The low saline area (0 -1ppt) would decrease from 10.8% in base condition (2001) to 4.0% with 88 cm sea level rise in 2100 (CEGIS, 2006). The increase in temperature and variability in rainfall will force further pressure on freshwater resources and thus, reduce the freshwater inflows to the mangroves. If precipitation decreases in the Ganga-Brahmaputra basins it may lead to a further reduction in the availability of freshwater in the deltaic section. Some models of climate change also indicate an increased frequency of tropical cyclones and storm surges, which may trigger further changes in freshwater-seawater interactions and hence affect the mangroves. In this case, extensive areas of the Sundarban along the coast are expected to be inundated by seawater, and the increased inland salinity intrusion would affect the biotic composition. Eventually, the future of the Sundarban mangroves depends upon the efficiency of managing the limited freshwater resources for meeting both human and environmental needs, coupled with successful adaptive responses to the enhanced threats from climate change.

ACKNOWLEDGEMENTS

Suggestions and help provided by friends and colleagues are duly acknowledged.

REFERENCES

- Ahmed, S., Sarker, S. K., Friess, D. A., Kamruzzaman, M., Jacobs, M., Islam, M. A., Alam, M. A., Suvo, M. J., Sani, M. N. H., Dey, T., Naabeh, C. S. S., & Pretzsch, H. (2022). Salinity reduces site quality and mangrove forest functions: From monitoring to understanding. *Science of the Total Environment*, 853, 158662.
- Banglapedia (2020). "Cyclone" Accessed 30 March, 2020.
- BBS, "Statistical Year Book" (2001). Bangladesh Bureau of Statistics, Dhaka.
- CEGIS (2006). "Coastal Land Use Zoning in the Southwest: Impact of Sea Level Rise on Landuse Suitability and Adaptation Options" Center for Environmental and Geographic Information Services, Dhaka, Bangladesh, 2006.
- CSE (2012). "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans" Center for Science and Environment, New Delhi, India, 2012.
- Gopal, B. and M. Chauhan (2006). "Biodiversity and its conservation in the Sundarban Mangrove Ecosystem" *Aquat. Sci.*, Vol 68, pp 338–354, 2006.
- Haq, A.Z. (2010). "Impact of climate change on Sundarbans, the largest mangrove forest: ways forward" 18th Commonwealth Forestry Conference, Scotland, UK, 2010.
- Kamruzzaman, M. (2013). "Climate change and mitigating role of Sundarban mangrove forest" 2013, Nymphaea Publication, Dhaka.
- Mahadevia, K. and M. Vikas (2012). "Climate change – impact on the Sundarbans: a case study" *International Scientific Journal*, Vol 2, pp 7-15, 2012.
- Nishat, A. (2013). "Climate change impact and the sundarban," 2013, Nymphaea Publication, Dhaka.
- Samanta, S., Hazra, S., French, J. R., Nicholls, R. J., & Mondal, P. P. (2023). Exploratory modelling of the impacts of sea-level rise on the Sundarbans mangrove forest, West Bengal, India. *Science of the Total Environment*, 903, 166624.
- Samanta, S., Hazra, S., Mondal, P. P., Chanda, A., Giri, S., French, J. R., & Nicholls, R. J. (2021). Assessment and attribution of mangrove forest changes in the Indian Sundarbans from 2000 to 2020. *Remote Sensing*, 13(24), 4957.
- Uddin, S., A. R. Shah, S. Khano, and K. Nesha (2013). "Climate change impacts on the Sundarbans mangrove ecosystem services and dependent livelihoods in Bangladesh" *Asian Journal of Conservation Biology*, Vol. 2 (2), pp. 152–156, December 2013.
- Wahid, S., Mainuddin, M., Chiew, F., Karim, F., Nahiduzzaman, S., Alam, R., & Hasib, M. R. (2025). Salinity dynamics in the Sundarbans of Bangladesh: Influence of climate, freshwater inflow, and sea level changes. *Environmental Monitoring and Assessment*, 197(11), 1219.
- WWF (2010). "Sundarbans: Future imperfect climate adaptation report" World Wildlife Fund for Nature (WWF), India, 2010.

Corresponding author: Dr. Mohd. Zahid Rizvi, Associate Professor of Botany, Department of Botany, Shia P.G. College, Lucknow, U.P., India
Email: zahid682001@gmail.com
