



## The Effect of Oil Spill on the Sundarban Mangrove Forest of Bangladesh

**Fahim Jaman**

Department of Civil Engineering, University of Asia Pacific, Dhaka, Bangladesh  
tfahimjaman.info@gmail.com, <https://orcid.org/0000-0003-4024-2592>

**Md Bony Amin**

Department of Civil Engineering, European University of Bangladesh, Dhaka, Bangladesh

Received 4<sup>th</sup> May 2023, Accepted 7<sup>th</sup> Jun 2023, Online 18<sup>th</sup> Jul 2023

**Abstract:** *The best mangrove woodlands on this planet is a region of the planet's finest delta molded by the streams Ganges, Brahmaputra, and Meghna. One-of-a-kind marine cars use this channel as a transportation route and cause setbacks, but no longer loads of examinations targeted this problem. On December 9, 2014, an oil massive hauler setback within the Sundarbans of Bangladesh provoked the appearance of approximately 358,000 liters of widespread gasoline oil into the circulation and mangrove climate. 500 thousand humans are sincerely and by idea structured upon the Sundarbans for their positions. Attributable to streaming systems, oil showed up at little creeks, channels boondocks flooring. Thick stupid radiator oil is stored money on the soil of intertidal zones, woodlands flooring, plant life leaves, stems, floating natural items, roots pneumatophores, and many others. A large part of the surfaces of the streams, springs and streams of the Southeastern piece of the Sundarbans had been included through the thick oil spills. It's miles met an affiliation of streaming channels, streams streams. It is covered an area of 6000 km<sup>2</sup> of which 3956 km<sup>2</sup> of mangrove woods grounds and extra than 1800 km<sup>2</sup> of water bodies. This perceives the individual of the spilled oil, the quantity of the spillage, and the effect of the spillage on the maritime surroundings, mangroves, and individuals. In which the hazardous components within the Sela stream water checks outperformed pretty a long way set through the Prosperity affiliation (WHO) with a dropping solicitation of Co > Cd > Pb > Ni independently. Considering the water best file (WQI), metal defilement report (MPI), and steel nice rundown (MI), the Sela flow's water is not sensible for drinking anyway may be used for flooding agrarian and vegetable yields. This look discovered that the stream residue had higher polluting component (Cf) values for series, slight characteristics for Pb, Cr, Cu, Zn, Mg, and As, and inferior qualities for Mn, Fe, Ca, Na, and k. The mark of the audit is to perceive and examine the community of the Sundarbans and its on their occupation with the hazard regarded through the Sundarbans in step with reliable and further created vessel traffic the board, making plans, discernment equipment and enjoy, that allows you to chip away at the response to regular emergencies and lessening the consequences for adjacent groups and the herbal framework.*

**Keywords:** Sundarbans, Bangladesh, Oil Spill, Biggest mangrove.

## Introduction

Sundarban, the largest delta inside is likewise the largest mangrove woodland within the with 10, two hundred squarekm of mangrove woodland break up during Bangladesh (approximately 6000 square kilometre of held timberland), India (4200 square kilometre of stored Timberland), and India (4200 squarekm of stored Timberland). The Sundarban location in India is another 5400 square kilometre of owned, non-forested land across the north and north-western edges of mangrove forests. As a result, the Sundarban Biosphere Reserve covers a complete region of 9600 squarekm in India. Muriganga, a canal, and the streams Harinbhahga and Raimangal, to the east and west, respectively, Indian Sundarban. The important streams Saptamukhi, Thakuran, Matla, and Goasaba also flow through this eco-framework (Rahman Bright Exploration Collaborator et al. 2017).

'Shelariver' was connected with a variety of cargoes and watercraft. The harmful effects of this oil spill must be investigated, and this study considers how they may affect the local population and the climate around the Sundarbans (Rahman and Rakhimov 2015).

## 2. Project Depiction

The Sundarbans, a UNESCO international historical past web page, is the biggest mangrove wooded area on the earth. It spans 10,000 rectangular kilometers, with a prime element (60%) prepared in Bangladesh and the remainder (forty%) in India. The mudflats, sandflats, and flowers alongside the shore are seen to be crucial additives of the herbal environment that help a variety of plant sorts, inclusive of a mix of marine birds and different untamable species. Additionally, the proximity of the Inlet of Bengal makes the biodiversity of the Sundarbans more known to numerous marine lifestyles. Inside the Sundarbans, 334 exceptional forms of flowers are preserved. Further, it supports 270 fowl species 42 species of properly-advanced mammals, which includes the fantastic Bengal Tiger (*Panthera Tigris*), and 35 species of reptiles, including Estuarine (Crocodiles penetrable) and 8 land and species. Only 170 tigers are now present in the Sundarbans, according to the 2015 Tiger. In nature, the Sundarbans mangrove forest region is primarily regarded as a crucial transition zone from the sea to freshwater ecosystems and natural organic structures, providing a habitat for many species of untamed living fauna. This enormous biological structure is, however, unusually danger due to another direction. The most noteworthy causes of biodiversity loss are illegal poaching, area decimation and intermittent login overexploitation of forest resources, including the use of forest area streams for commercial purposes, oil spills, and impromptu company movements (Rahman and Rakhimov 2015).

Considering their relationship and concentration, oil-based products generally fundamentally affect the mangrove environment. Occasionally, it results in the environment's compound synthesis progressing, and changes to real characteristics cause the mangrove biomass's sustaining capital to be destroyed, which is detrimental to animal prosperity and the natural climate's equilibrium (Rahman and Rakhimov 2015).

### 2.1 Area of Sundarbans

The Sundarbans is the biggest unmarried vicinity of flowing halophytic mangrove forests in the world, and it's far positioned in the southwest area of Bangladesh (21° 31' - 22° 38'N and 89° 00' - 89° fifty five'E). It become a Ramsar website online in 1992 and a world history using UNESCO in 1997. Round 10,000 square kilometers of the Sundarbans are covered, with 60% of that region in Bangladesh and the

remainder in India. A complete 6017 km<sup>2</sup> of land is included a forest in Bangladesh, with 4143 km<sup>2</sup> of that vicinity being land and the ultimate 1874 km<sup>2</sup> being water our bodies inside the form of a spread of streams, channels, and creeks. Khulna, Bagerhat, and the rest of the districts in the Patuakhali and Barguna areas are some of the nearly absolutely covered territories through the Sathkhira district. The woodland area district is extraordinarily rich in natural assets, especially bloom and faunal range, with 334 kinds of plant life, 425 varieties of normal lifestyles, inclusive of 300 kinds of birds, 40 styles of vertebrates, 35 styles of reptiles, 177 kinds of fish, 24 varieties of shrimp, and 7 kinds of crabs, amongst other matters. Approximately 5 million people depend at once or circuitously on the Sundarbans for their livelihoods, with sixty nine% of them related to maritime resources, 22% to a variety of wood assets, five% to non-amble wooded area things, and four% to different purposes (Rahman amazing research accomplice et al. 2017).

### 3. Literature Review

The Sundarbans, a UNESCO background, are the largest mangrove forests on the planet, protecting around 10,000 square kilometers, of which a primary portion (60%) is located in Bangladesh and the last (forty%) in India. The mudflats, sandflats, and vegetation alongside the coast are to be the simple additives of a standard habitat that assist a variety of plant life kinds, as well as a huge variety of marine birds and different untamable animals. Much like how the Inlet of Bengal's presence familiarizes diverse marine life with the Sundarbans' biodiversity. The Sundarbans are home to 334 different plant species. Additionally, it supports 270 different bird species, 150 different fish species, 35 different reptile species, including the estuarine crocodile (Crocodyles porous), and 8 land- and water-capable species. Among these sophisticated creatures are the Magnificent Bengal Tiger (*Panthera Tigris*) and 42 other types of all-around animals. There are simply a hundred and seventy tigers in Sundarbans, in keeping with the 2015 Tiger Enumeration. In nature, the Sundarbans mangrove wooded area appeared as crucial transitional sector from marine to freshwater and terrestrial ecological structures that helps a selection of wild animal species. But, this critical biological gadget is in grave hazard from several guidelines. The most well-known causes of biodiversity degradation include illegal poaching, territorial obliteration and discontinuity, overvaluing of woodland assets, using timberland waterways for commercial purposes, oil spills, and spontaneous travel (Rahman and Rakhimov 2015). Due to their structure and emphasis, oil-based products typically have a major negative impact on the mangrove ecosystem (Rahman and Rakhimov 2015).



**Fig: Geological area of Sundarbans Saved Backwoods (Bangladesh), organizes 21°56'59"N 89°10'59.988"E (Bautista and Rahman 2016)**

### 3.1 Outline of Sundarbans Delta Oil

A large carrier (OT Southern superstar) wearing 357,664 liters of great gasoline oil collided with some other vessel on December 9, 2014, approximately 5:00 a.M. Local time, and in the Shela circulation organized in the Sundarbans mangrove sector in Bangladesh. A large layout flaw caused an oil spill into the flow and other aspect channels and canals. By the nighttime of the following day, the oil had traveled nearly 20 kilometers upstream to Mongla and almost 20 kilometers downstream to Hori Tana. The natural framework, the biggest mangrove forest the global a Ramsar web page when you consider that approximately 1992, as well as portions of it, have been particular UNESCO international Inheritance sites seeing that around 1997 due to the tragedy. The whole Sundarbans (6,017 rectangular kilometers) are to some kind of kingdom confirmation because of abundance of herbal variety. In addition, the Sundarbans provide meals, employment, and a safe shelter for a big portion of Bangladeshis. The Chandpai normal location of shelter, which turned into constructed to guard the habitat of wonderful dolphins, is the oil catastrophe came about.

A network reaction effort was supervised and suggested via the division of forest the help of surroundings and wooded area regions (MoEF) of the general public authority of Bangladesh (GoB). Fishers and the encompassing community had been employed to assemble the oil. Additionally, to prevent oil from getting into feeder/distributary creeks and channels all through ebbing tides, best pass segment nets were positioned across their mouths. To salvage the oil that became flowing downstream, fishing nets have been covertly sent along the riverbanks. The response responsibilities had been finished around 12 days (from December

12 to 22), during which time networks collected and purchased 68, two hundred liters of oil that have been located (Spill 2016). The United international locations improvement program (UNDP) (growth 1) received a sale from the financial family members department (ERD) of the assist of coins on December 15 to offer special help to:

1) verify the oil spill recommendations and easy-up desires; and a pair of) lead an evaluation and draft a motion plan for recommended balance measures. On December 17, and the eu fee via the association ordinary protection device, as well as representatives of the authorities, the academic network, UNDP, various institutions, and non-regulatory affiliations (NGOs), had been delivered to the collection. The plan of events is given in. (UNEP/OCHA 2014)

#### 4. Research Methodology

The ethnic organization consisted of the Bagerhat location's Chila, Paschim Chila, and Joymonigul human beings. Fisheries accounted for ninety% of the occupations in those networks, with a variety of job portfolios consisting of fishing (primary commercial enterprise), fish drying, fish exchanging, internet retouching, boat building and restore work, as well as the collection of gas timber, timber, and protecting material (Kumar et al. 2016).

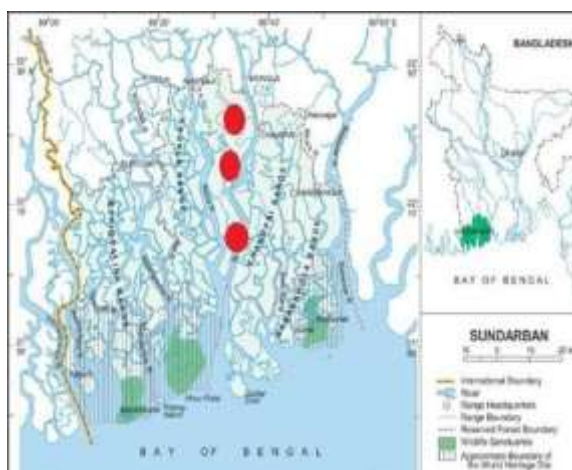


Fig: Map of the study areas (Kumar et al. 2016)

#### 4.1 Reasons for Calamity

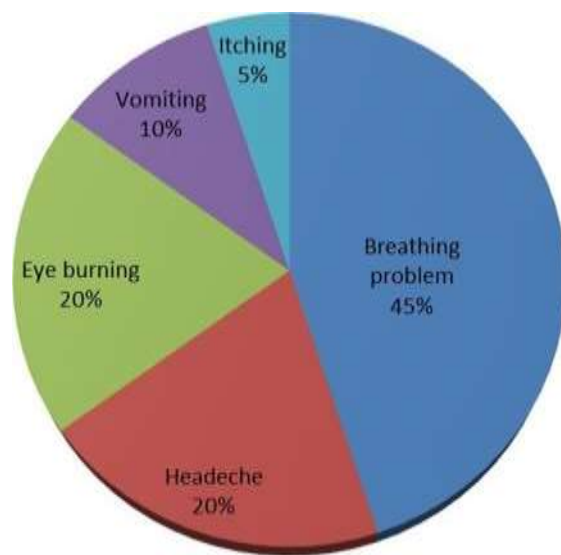
On December nine, 2014, an oil huge transporter twist of fate launched 94,000 gallons of deep-heat oil into the Shela circulation. Radiator oil has a high consistency just like that of a profound fuel oil and is a darkish, thick additional gas. Because of cycles of evaporation, deterioration, photograph oxidation, and biodegradation, the physical and chemical properties of this form of oil exchange exactly while it's far transported. While this sort of oil is transported at a high fee to an oceanfront environment, it has super unfriendly results at each day biomass of that unique surroundings. The oil slick may additionally spread to areas near oceans, uncontrolled seas, and marine and terrestrial living locations due to water streams and winds (Kingstone, 2002). For oil this is less solid, a component may additionally evaporate, thickening the oil (Kingstone, 2002). A number of the oil might also split in water spreading to form a thick mousse, even as other portions can also sink and integrate with particles to shape tar balls in storage (Kingstone, 2002).

#### 5. Aftermath (Effects And Impacts Of Oil Spill)

Effect of oil slick on Mangrove

The Sundarbans provide us with an expansion of climate amenities, which include soil development and safety, hydrological cycle law, sogginess content material, scattering, weather, and guarantee of the country from ordinary disasters. Similar natural resources are supported by the Sundarbans. A significant portion of the Sundarbans mangrove environment was impacted by oil that leaked from the gasoline tank and spread 15 kilometers downstream from the boat. It caused the second mortality of *Heritiera* sp. and *Excoecaria* sp. seedlings, and it also caused patches of grass that were coated in oil to die. Nine streams and four wooded floor obstructions had their oiling condition, mangrove abundance, and potential cleanup techniques examined. The flexibility of the oil observed the plant life turned into investigated, in conjunction with likely routes for vertical penetration into the dust and crab apertures. 8 of the nine indicated streams have been diagnosed as having minimal surface oiling on mangrove leaves, trunks, prop roots, and soil substrates. The additional one's plant life turned into called unassumingly lubricated. Deep fuel oil, the kind of oil, changed into concept to be much less seriously toxic to mangroves than lighter oil whilst having the capability to be extra consistent inside the environment over time.

Oil is noxious to basically all living creatures. The unfavorable effect relies upon the and centralization of the oil, and the responsiveness of the species motivated. Oil spills have both quantitative and emotional costs. It reasons the evaporating of unsullied untamed lifestyles dwelling area. The hostile effect integrates eye unsettling affect on, coming approximately visual weak spot, throat exacerbation and cerebral agony. Ingestion of hydrocarbons can provoke infection and detachment of the entrails. Neighborhood additionally stated comparable scientific issues at some point of interview. Among 120 interviewee forty five% noted the defied inconvenience in respiratory, 20% itemized cerebral pain, 20% uncovered eye consuming, 10% declared heaving and 5% exposed shivering. Humans have been entreated to make use of cover at some stage in oil variety by using the division of forest region, however shroud had been no longer on hand within the nearby shop.

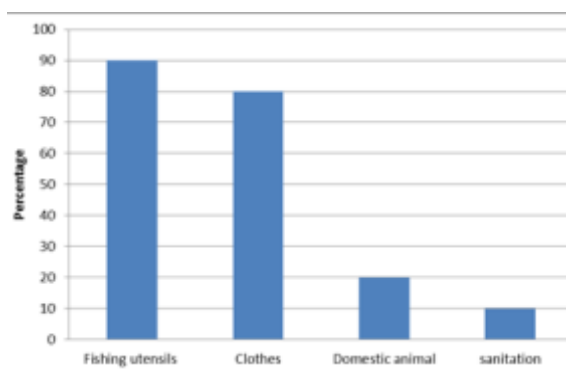


**Fig: Effect of spilled oil on Human Effect of spilled oil on Human**

Oil includes a ramification of mixtures that is probably dangerous to human beings, mostly unstable natural compounds (VOCs), consisting of PAHs (Polycyclic Hydrocarbons), in addition to metals and mixtures such as sulfur and nitrogen. Additional PAHs may arise as early unintended results around small accumulation particles when oil is seared. The quantity and duration of oil transparency will undoubtedly.

### Effect of spilled oil on Occupations

The Sundarbans massive series of wooden and non-timber woodland area items that provide both instantaneous and indirect forms of help. Direct businesses integrate development resources (blunder, rail line sleeper, mining props, boat constructing, cowl, wall), gasoline (charcoal and fuel), local use (stick), fishing machines (fishing stakes, fishing boat, tanning for internet and fish), and supportive (treatment of ringworm, mange, sore throat, and stoppage, among different things). The general public employees noted the oil spill's hard results on their jobs starting fourteen days after the setback. Most people of the interviewees stated damage to their clothes (80%) and fishing tools (ninety%) while 20% centered on the absence of neighborhood ducks and 10% stated that their water supply and different sanitary places of work have been affected.



**Fig: Effect of spilled oil on Occupations**

### Effects on fish

Notably much less knowledge exists on the outcomes of oil on fish, fish eggs, and fish hatchlings. The full-size amount of fish that perished because of the Sundarbans oil spill that the outcomes can be severe and lengthy-lasting. Fish may also become angry by way of oil in many distinctive approaches. Fish that might be exposed to grease in water, meals, or dregs quickly soak up the oil components in their tissues. Big objects in oil may be breathed in by way of fish thru their gills. Fish uncovered to oil may additionally be afflicted by altered heart and respiratory quotes, enlarged livers, stunted growth, growing lack of scale and blade, in addition to other negative influences at the biochemical and atomic stages. Within the opportunity that this doesn't without delay kill, the oil can also regenerating capability or maybe result in a deformed backbone. Generally speaking, fish eggs and hatchlings are greater susceptible to oil pollutants than adult fish. Water-solvent gas fixes had been anticipated to supply lethal consequences (LC50) on hatchlings within the variety of 0.1 to at least one mg/kg. Heintz et al. (1999) observed that herring and purple salmon immature organisms had a more suggested response to skilled Exxon Valdez fuel oil with lengthy-term exposure. The majority of least found compelling concentrations (LOECs) had been from very oil and have been approximately 1 g/kg (ppb) of general PAH. Absolute

PAH from less skilled oil changed into much less lethal, demonstrating that the greater risky PAHs were more often than not liable for the strangely persevered oil's harmfulness.

### **Impacts on Vegetation**

Organic structures along the seashore are typically impacted by oil spills. The oil's substance toxicity affects plant water relationships, absorption, becomes harmful to cells, hinders the photosynthesis of marine plants, and prevents oxygen uptake from the atmosphere and soils. When oil spills during a deep tide, it enters the Sundarbans' point of confluence and coats the plants' leaves and stems. This prevents the stomata from opening, which reduces oxygen delivery to the roots and impedes plant growth. According to reports, oil-covered floating objects like water hyacinths (*Eichhornia crassipes*) are assisting oil in spreading throughout the Sundarbans as well. That has recently been incorporated into soil has reduced oxygen production, resulting in anaerobic conditions that essentially increase plant pressure. According to the research's primary finding, plants with irritated leaves are more seriously impacted as compared to plants in tarnished soils (Ko & Day 2004). Visual observation makes it obvious that a substantial portion of the plants in the Sundarbans, including the most well-known ones like Sundari (*Heritiera fomes*) and Nipa palm (*Nypa Fruticans*), are covered with oil.

The loss of leaves from certain active mangrove trees along the low tide line is one of the obvious, harmful impacts of oil presentation that has been noted. Additionally, the oil cleanup process disturbs and compacts the soil and plants (Hester, Lin, and Nyman, 2000).

### **Impacts on Untamed**

Simple quick- and long-term negative results of oil spills are felt with the useful resource of human beings of all trophic degrees who move approximately their lives along the coast. Dr. Abdullah Harun Chowdhury of Khulna provided records that showed 27 oiled animals (5 frogs, show reptiles, crocodiles, 17 egrets, and one otter) in every 15 superb areas near the spill web page December 11 and 25, 2014. IUCN lists the Irrawaddy Dolphin (*Orcaella*) and Oriental Little battered Otter (*Amblonyx Cinereus*) as endangered species that have perished due to the oil leak. The presence of vultures following the oil spill over the Sundarbans similarly demonstrates the large extinction of wild animals.

The oil spill's brief results are shown the above result. In any event, the repercussions of an oil spill are outrageously lengthy-lasting. Ten years after the Exxon Valdez oil disaster, it changed into with the aid of Jewett, Senior Woodin, Hoberg, and Stegeman (2002) making use of biomarkers of hydrogen prove sure that near-shore fishes have now been uncovered to hydrocarbons.

**6. Preventions.** Oil evacuation activity Following the event, a few Joymoni residents located that they had started to stockpile oil because they noticed the oil as each a threat to their community and a likely treasured aid. Fishermen assembled the floating oil the use of each tool at their disposal. In a single instance, it changed into visible that a channel structure become closed to save oil from coming into the neighborhood affiliation. Nets had been positioned throughout the mouths of springs and channels. Fishing nets had been hired to gather oil, in addition to those been regularly used to capture shrimp hatchlings with the tide. The nicely-healthy mosquito nets worked nicely to attain the heavy gasoline oil. For utilization as a transient collecting for the recovered oil object, pits had been dug in the coast occasionally coated with plastic. Humans similarly accumulated oiled flora (water hyacinth and grasses) along the coast and on the and warmed it to hold a liquid oil object. After foaming, plant depend turned gathered at DF meeting places, dumped on the seaside, or veiled and piled in unlined pits at diverse places



across the community. There was neither the use of respiratory safety device (PPE) nor confidential defensive device (PPE) the grouping and raising of oiled flora, in line with reports and pictures. The DF answered on December 10 and oversaw the spill reaction operation from that factor December 22. The DF attempted to set up an oil effect to manipulate the waft of oil from the indented vessel even operating with the Maritime strength to transport nets at the mouths of rivers to prevent oil spills into those streams. The impact is stated to been restricted in its usefulness. Tree stress washing turned into however abandoned due to its lack of effectiveness. Dispersants were not claimed to have been hired due to concerns approximately their potential impact on the mangrove ecosystem. Similarly, individuals may be visible taking place the coast and kicking oil into the particles in video footage of emergency efforts.

## 7. Discussion

The assessment findings show that the revenue from alternative methods of subsistence during the first two weeks was significantly impacted by not fishing in the rivers or using the forest resources. According to the majority of responders, the number of fish and shrimp caught may decrease as a result of the oil slick. Short-term health hazards existed for people who collected oil directly. However, no patient instances were found because of the health dangers that oil collecting poses. Together, the community and the Department of Forests collected a significant amount of oil, reducing the impact on their way of life. (UNEP/OCHA 2014)

## 8. Conclusion

From an environmental perspective, the oil spill incident inside the Shela Waterway of the Sundarban natural habitat has been as a primary twist of fate. Some globally full-size natural life species have perished, in step with records. The majority of plant species have oil coverings on their leaves and stems. Because Bangladesh is an agricultural u. S ., the extra results of oil spills is probably greater debilitating due to a lack of professional manpower and suitable generation for powerful cleanup procedures.

## References

1. Kumar A, Ramanathan AL, Prasad MBK, et al (2016) Distribution, enrichment, and potential toxicity of trace metals in the surface sediments of Sundarban mangrove ecosystem, Bangladesh: a baseline study before Sundarban oil spill of December, 2014. *Environ Sci Pollut Res* 23:8985–8999.
2. <https://doi.org/10.1007/s11356-016-6086-6>
3. Rahman KMM, Rakhimov II (2015) Ecological effects of oil spill on Bangladesh Sundarbans biodiversity. *Int Sci Pract Conf “Complex Probl Technosph Safety”* 6:17–22
4. Rahman Sunny Research Assistant A, Project EB, Fish Bangladesh W, et al (2017) Impact of oil spill in the Bangladesh Sundarbans. ~ 365 ~ *Int J Fish Aquat Stud* 5:365–368
5. Spill SOIL (2016) re. 7:
6. UNEP/OCHA (2014) SUNDARBANS OIL SPILL ASSESSMENT: Joint United Nations/Government of Bangladesh Mission Union Civil Protection Mechanism
7. Sunny AR. Drivers of changes in ecosystem services and human well- being in the Bangladesh Sundarbans. Master thesis Department of Coastal and Marine Fisheries, Faculty of Fisheries, Sylhet Agricultural University, 2015.
8. Hossain S, Dearing JA. Recent changes in ecosystem services and human well- being in the Bangladesh coastal zone. Springer, 2015. doi 10.1007/s10113-014- 0748-z

9. Islam MR. Managing diverse land uses in Coastal Bangladesh: Institutional approaches. In: Hoanh C. T., Tuong T.P., Gowing J.W., Hardy, B. (eds). Environment and livelihoods in tropical coastal zones. CAB International and International Rice Research Institute (IRRI), Manila, 2006.  
doi:10.1079/9781845931070.0237
10. Islam MS, Tanaka M. Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis. Marine Pollution Bulletin, 2004; 48:624-649.
11. MEA. Ecosystems and human well- being: a framework for assessment. Millennium ecosystem assessment, Island Press, Washington, 2005.
12. Hossain S, Dearing JA. Recent changes in ecosystem services and human well- being in the Bangladesh coastal zone. Springer, 2015. doi 10.1007/s10113-014- 0748-z
13. DoF. (Department of Fisheries), Integrated resources management plans for the Sundarbans. Forest Department, Ministry of Environment and Forests, Dhaka, Bangladesh, 2010.
14. Rahman MR, Asaduzzaman M. Ecology of sundarban, bangladesh. J. Sci. Foundation, 2010; 8 (1-2):35-47.
15. Swapan MSH, Gavin M. A desert in the delta: participatory assessment of
16. changing livelihoods induced by commercial shrimp farming in southwest Bangladesh. Ocean coast management, 2011; 54:45-54.
17. Livelihood, conflict and tourism: An assessment of livelihood impact in Sundarbans, West Bengal <https://doi.org/10.1016/j.ijgeop.2022.07.004>
18. Heavy metals contamination of river water and sediments in the mangrove forest ecosystems in Bangladesh: A consequence of oil spill incident <https://doi.org/10.1016/j.enmm.2021.100484>.
19. Sundarbans oil spill assessment-Joint United Nations/Government of Bangladesh Mission; Joint UNEP/OCHA Environment Unit, December. - 2014.
20. Kingstone P. Long-term environmental impact of oil spills', Spill Science & Technology Bulletin. - 2002. - Vol. 7. - No. 1. - P.P. 53-61.
21. Seidensticker J, Hai MA. The Sundarbans Wildlife Management Plan: conservation in the Bangladesh coastal zone. IUCN, Gland, Switzerland, 1983, 120.
22. Salter RE. Integrated development of the Sundarbans, Bangladesh: status and utilization of wildlife, FO: TCP/BGD/2309(MF). Report No. W/R0034. FAO, Rome, 1984, 59.
23. Blower J. Sundarbans Forest Inventory Project, Bangladesh. Wildlife conservation in the Sundarbans. Project Report 151.Overseas Development
24. Hussain KZ, Acharya G. Mangroves of the Sundarbans. Volume two: Bangladesh. IUCN, Bangkok, Thailand, 1994. ISBN: 2831702100.
25. Islam MS, Tanaka M. Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis. Marine Pollution Bulletin, 2004; 48:624-649.
26. MEA. Ecosystems and human well- being: a framework for assessment. Millennium ecosystem assessment, Island Press, Washington, 2005