IMPACT OF DREDGING IN THE PASHUR RIVER ON AGRICULTURAL LAND AND ECOSYSTEM ASSESSMENT

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Foreword

The Pashur is one of the most important rivers in the Sundarbans and many people's livelihood are depending on this river. The study has been done on 'the impact on the agricultural lands and ecosystem due to dumping of dredging materials of the Pashur River'. The subject of this research is related to ecology and biodiversity, soil fertility of the agricultural land, aquatic life and local livelihood. The study area is situated on the eastern periphery of the Pashur river under Mongla upazila of Bagerhat district, Bangladesh. The exploration was finished in and around villages of the dredging dykes. This study was very much difficult because no such data were available on the impact of dumping dredged soil on the agricultural lands, ecosystems, and also the impact of dredged soil on the surrounding human inhabitants.

I would like to thank and express my sincere gratitude to the villagers and different stakeholders of the study areas, all members of the research team, Bangladesh Poribesh Andolon (BAPA), Waterkeepers Bangladesh, Mr. Noor Alam Sheikh, Mr. Bijon Boeydo and others who supported me during the samples and data collection in the fields and for providing financial support. I hope the result of the research will be helpful to implement the next development works and it will also be beneficial for the local people and the environment.

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THE IMPACT OF DREDGING IN THE PASHUR RIVER ON AGRICULTURAL LAND AND ECOSYSTEM ASSESSMENT

1. Introduction

The World Heritage Committee of the United Nations for Educational, Scientific and Cultural Organization (UNESCO) prepared and submitted a report concerning the Sundarbans World Heritage Property, Bangladesh to the government on November 28, 2016, according to the Decision 39 COM 7B.8. This was the first document that showed the importance of occasional dredging in the Pashur River in Mongla. The Pashur is a tidal river, and its siltation rate is high. As such, to ensure navigability, occasional dredging is essential. This occasional dredging does not only help to maintain the navigability of the Pashur channel; rather it ensures a sufficient volume of water to maintain the ecosystem including biodiversity in and around the Sundarbans. Without dredging the river would have been silted up with high detriment to the mangrove ecosystems. According to the report, the area has less fertile and minimum agricultural land and the dredged material of Mongla Port to Rampal Power Plant will be disposed of in the low laying area of acquired land by Bangladesh Power Development Board. The total area of low land is 1834 acres. Up to 2016, 485 acres have been developed and the remaining area is to be used for disposing of the dredged material. The disposed of the dredged material will be protected by an earthen dyke/ embankment to prevent the spill of dredged material into the river. As far as dredging of the outer bar is concerned, the dredged material was to be disposed of in deep-sea during ebb tide only along the south-east side of fairway buoy, where present water depth is around 28 m from CD, and which is far away from Swatch of No Ground.

Unfortunately, these resolutions mandated by UNESCO was not followed to date. Presently, the GoB has planned to dredge the Pashur river from Mongla port to the Rampal project site which is around 4 km river distance from the Sundarbans Reserve Forest (SRF) and around 80 km River distance from the World Heritage Site (WHS). Although the EIA presented for this dredging project was in favor of the operational and maintenance of the Rampal Coal Power Plant, in reality, this is degrading the local environmental and ecological landscape. The environmentalists say that it is a signal

that the operation of a power plant so close to the forest would inflict damage on it. According to the ECNEC meeting, the Pashur river is being dredged at a depth of 8.5 meters so that large ships can sail into it. The biodiversity of the Pashur river snaking past the mangrove forest is threatened by vessels that dump oil into its water. Most importantly, the soils extracted from the Pashur river are being dumped on the nearby agricultural fields which are threatening the already less fertile agricultural lands. Field-based observations, consultation with local people, and representatives of the local government ensured that the agricultural lands are not being preserved by dumping of this dredged soil. However, the policy says no agricultural land is tampered/damaged, might be dumped plan-wise in shallow places in the river upon technical considerations, connection *khals* (channels) are not disconnected, etc.; and the best way of management to fill up low land (following Conservation Act 2000) or pile in government-owned *khas* (wasteland). Unfortunately, these policies are not in place and the dredged soils from the Pashur River are being indiscriminately dumped on the nearby agricultural lands which may threaten ecological, livelihood, biodiversity, and aquatic life options of the whole area.

British Standard (1991), Abul-Azm and Rakha (2002), Bogers and Gardner (2004), England and Burgess-Gamble (2015), Gob *et al.* (2005), Jonge *et al.* (2012), Cai *et al.* (2012), Freedman and Stauffer (2013) studied on the dredging related activities, deposition of dredged soil, impacts, policies, etc. in different countries. Institute of Water Modeling (2015) studied the feasibility study on the capital dredging in the Pashur river from Mongla Port to Rampal Power Plant.

From the above literature review and initial observation, it is evident that abandoning the dredged soil on these agricultural lands leads to a myriad of environmental problems. Against this backdrop, it is necessary to assess the effects of river-dredged sediments on nearby agricultural soil health and related physico-chemical changes. More specifically, assessment should be on the following elements (not exclusive) of the nearby agricultural lands that are being affected by dumped soils extracted from the Pashur River:

1. **Ecology and Biodiversity**
    a. Loss of habitat and degradation of habitat quality of endangered life forms, such as animals, insects, birds, and trees.

      b. Change in the local food chain and ecological biology.

      a. Land reclamation using fill material from offshore sources.

      c. Prevention of re-colonization of the sites by native life forms and species.

2. **Soil Fertility of the Agricultural Lands**

      a. Change in degree of change in soil compaction and composition.

      b. Extreme acidification and heavy metal pollution.

      c. Evidential information on the decrease in soil pH, Ca, and Mg.

      d. Evidential information on the decrease in the levels of soil Mn, Cu, Fe, Zn, and Si.

3. **Local Livelihood**

      b. Loss of land and house of local people.

      c. Migration to other areas due to infertile lands.

4. **Aquatic Life**

      a. Impact on increase/decrease in fish number and species.

no such data are available on the impact of dumping dredged soil on the agricultural lands, ecosystems, and also the impact of dredged soil on the surrounding human inhabitants.

Under these circumstances, it has become imperative to institute an investigation on the impacts of dredged soil on the agricultural lands, ecosystem, and surrounding inhabitants; especially (i) loss of habitat and degradation of habitat quality of endangered life forms, such as animals, insects, birds, and trees; (ii) change in the local food chain and ecological biology; (iii) land reclamation using fill material from offshore sources; (iv) soil fertility of the agricultural lands, (v) change in the degree of soil compaction, composition, and physico-chemical conditions; (vi) loss of land and house of local people; (vii) migration of villagers to other areas due to infertile lands, etc.

2. Study Methodology

The study area is situated on the eastern periphery of the Pashur river under Mongla *upazila* of Bagerhat district, Bangladesh. The research was done in and around villages of the dredging dykes. Fortnight sampling was carried out from January 2022

to March 2022 and air, water, soil and biological samples were studied in the field and laboratory. Secondary data were collected from published documents and different government offices. All data were analyzed and potential environmental impacts were identified and calculated by using standard tools and methodologies (Hoshmand 1998).

The physico-chemical parameters were measured *in-situ* and *ex-situ* conditions by following Welch (1948), APHA (1989), Mishra *et al.* (1992), and Gautam (1990). Air Pollution was measured by using a high-volume sampler (Envirotech APM-415).

Shovels and large ladders were used for collecting the soil from different agricultural lands and dredging sediments (soil) samples according to Trivedy (1993). Soil (from agricultural land) and sediment quality were determined in the laboratory by following Jackson (1973) and Page *et al.* (1982). The populations of aquatic and terrestrial plants in the field were measured by following quadrat method (Ambasht 1974). Standard observations and

Latitude	Longitude
22°27′24′′ N	89°35′38′′ E
22°24′36′′ N	89°36′66′′ E
22°24′31′′ N	89°37′49′′ E
22°24′33′′ N	89°37′51′′ E
22°24′18′′ N	89°37′50′′ E
22°24′21′′ N	89°37′48′′ E
22°24′32′′ N	89°37′50′′ E
22°24′72′′ N	89°37′36′′ E
22°24′73′′ N	89°37′39′′ E
22°24′80′′ N	89°37′35′′ E
22°24′90′′ N	89°37′32′′ E

Figure 1: Study locations

monitoring methods (Jayaraman *et al.* 1998) (Foot/Pug marks per quadrat area/ a standard area curve) were followed for the different faunal studies. Latitude and longitude were measured by using a hand GPS meter (model GARMIN GPSMAP® 78s). Statistical analysis among the different parameters was done by following Hoshmand (1998). The investigation tools also were site observations and spot analyses; Key Informants Interview (KII); Focus Group Discussions (FGD) with community people of that area.

Impact assessment (IA): Most of the development projects produce impacts on or changes in the state of the natural environment. Of which some are positive and some are negative. Similarly, some positive and negative impacts were identified in this study by following the DOE (1997) guidelines for industries, ADB (2003) environmental assessment guidelines and FPCO (1992) guidelines. These issues and impacts were evaluated in terms of distribution, quantity, quality, seasonality, and ecological and socio-economic importance.

The team has conducted field visits, reconnaissance surveys, and consultations with local stakeholders, and collected primary data on water resources, air quality, land resources, agriculture, livestock, fisheries, ecosystems, and socio-economic condition through focus group discussion (FGD), rapid rural appraisal (RRA), participatory rural appraisal (PRA), questionnaire survey (QS) and other methods for the assessing of baseline conditions of the Project.

The team has also identified important environmental and social components likely to be impacted by this dredging project. Other research parameters are the assessment of environmental and social impacts of the proposed interventions of the capital dredging in the designated areas of the Pashur River, conducting comprehensive public consultations; and inclusion of the environmental assessment report and environmental management plan (EMP). The sources of information for the scoping process were - (1) Field visits and environmental surveys; (2) Collected data from different sources, departments, institutes, *upazilas*, UPs, etc. (3) Meetings with chairmen, members, local people, govt. officials, teachers, social workers, different stakeholders, etc.

Impact assessment matrix: The impact assessment matrix was done in consultation with multi-disciplinary team members. When an impact could not be quantified, qualitative judgment was used based on professional experience. The scoring was done within a 21point score scale ranging from –1 to –10 for negative impacts and +1 to +10 for positive impacts while "0" was used for no impact (neutral impact) (Pastakia and Jensen 1998).

3. Results and Discussion

3.1. Physico-chemical Condition of Water and Soil

The physico-chemical and biological conditions of water in study areas have been presented in Table 1. Physico-chemical conditions of the soil and air quality have been presented in Tables 2 and 3 respectively.

The recorded data indicate that high total suspended solids (379±101 mg/l), total hardness value (1673±151 mg/l) and higher chemical oxygen demand (COD) value (377±32 mg/l) were present during the period of study in the surrounding water bodies i.e., fish culture and domestic ponds which are being contaminated continuously by

the leaching of dredging dyke water and sediments. On the other hand, low transparency (14±1.4 cm), low pH (5.8±0.5) and productivity (1.9±0.4 mg/l) values, poor abundance of phytoplankton (134±25 units/l), zooplankton (51±13 units/l) and benthos (09±2 no./kg) were recorded in the surrounding water bodies.

Whereas, the previous recoded data (before dredging) of the same study area indicate the values of total suspended solids (27±2.3 mg/l), chemical oxygen demand (133±28 mg/l), and total hardness (952±37 mg/l) were lower than those of dredging areas. Similarly, the values of transparency (25±4 cm) and productivity (7.9±0.7 mg/l), and abundance of phytoplankton (369±58 units/l), zooplankton (92±13 units/l), and benthos (37±6 no./kg) the study areas before rapid dredging were much higher than those of the surrounding water bodies of the dredging dykes. Physico-chemical conditions (Table 2) of the soil of the dredging areas are being changed day by day due to the dumping of sediments; this contamination is being increased gradually by the continuous dumping of dredging materials and dredging activities. High values of total suspended solids, chemical oxygen demand, and total hardness; low pH, poor values of productivity and transparency; poor abundance of phytoplankton, zooplankton, and benthos of water, physico-chemical conditions of soil and air quality (Table 1, 2 & 3) indicate that the study areas ecosystems are being changed by the rapid dredging activities on the periphery (eastern site of the Pashur river).

This finding has been supported by the studies of England and Burgess-Gamble (2015), Freedman and Stauffer (2013), Jonge *et al.* (2012), Cai *et al.* (2012), Gob *et al.* (2005), and Bogers (2004).

Barbe *et al.* (2000), Cai *et al.* (2012), Claret *et al.* (1999), Jonge *et al.* (2012), Hossain *et al.* (2004), Licursi and Gomez (2009), McCabe *et al.* (1998) recorded in their studies that different dredging materials contamination in the water body were responsible for increasing of total suspended solids, COD and total hardness values of water and for decreasing of transparency, productivity, and abundance of phytoplankton and zooplankton of water.

Chowdhury and Zaman (2001 and 2002) and Bhuiyan (1983) supported the present findings as they observed in their studies that high total suspended solids, COD, and total hardness values of water and low transparency are responsible for low productivity and poor abundance of phytoplankton and zooplankton of water.

According to the ecological law of limitation (Ambast 1990) access sodium (Na) and iron (Fe) are not suitable for the natural growth of micro and macro flora-fauna. In the present study, it was recorded that gradually sodium and iron contents are increasing in the surroundings waterbodies and soil of the dredging dykes by leaching of dredging materials. All most similar observations were recorded by England and Burgess-Gamble (2015), Freedman and Stauffer (2013), Gob *et al.* (2005), and Bogers (2004). Barbe *et al.* (2000), Cai *et al.* (2012), Claret *et al.* (1999), Jonge *et al.* (2012), Hossain *et al.* (2004), Licursi and Gomez (2009), McCabe *et al.* (1998) in their studies.

More irons create low pH in the aquatic habitats (Table 1 and 2) which can be lethal for the aquatic lives (APHA 1989). The suitability of domestic uses water is being decreased by the recorded higher content of total suspended solids and total dissolved solids, and low productivity also creates a problem for the fish culture surrounding sites of the dredging dykes (Table 1 and 2). The recorded SPM, PM 10 and PM 2.5 values (Table 3) indicate that dust pollution is increasing by the dry dredging materials in and around the study areas. Recorded SPM, PM 10 and PM 2.5 values are higher than that of Bangladesh environmental standard during normal wind flow time, but it becomes serious when heavy wind flow creates in the study areas. The members of more or less 2500 families or villagers are continuously sufferings from the dry sands (dry dredging materials) as their respiration and eyes are being affected by the dust pollution (villagers complained). Especially children, old ages people, and women are being affected seriously by the dust pollution.

3.2. Flora and Fauna

The recorded present floral and faunal conditions of the study areas, and before and without dredging areas have been presented in Table 4.

During the period of study, it was observed that many agricultural lands (all-time fish and one-time rice cultivation lands) were converted into dredging dykes (to dump dredging sediments) (Photos). Many natural tidal canals which were connected with the Pashur river were filled by the dredging sediments, whereas those canals were the source of diversified natural fishes and aquatic lives. The canals were the also flood plain of the Pashur River. Many birds and reptiles were coming into these canals for their food. These canals were also the source of protein and livelihoods of the poor

villagers, as well as a source of natural fish fries of the fish cultivars. Sources of natural fish and cultured fish are being reduced day by day by the dredging sediments. Birds' food chain has been affected and reduced due to the filling of natural tidal canals and rice-fish agricultural lands. The scarcity of domestic animals' foods has been increased by the reduced rice cultivation and deposition of dredging sands as a result villagers are bound to sell their domestic animals.

During the period of study different homestead plants i.e., aam (mango), tentul (tamarind), khejur (dates), narikel (coconut), supari (areca nut), taal (palm), kola (banana), sofeda (sapodilla), kul/boroi (Jujube), kamramga (carambola), peyara (guava), pepe (papaya), kalojam (jambul/jamun or jambolan), etc. were recorded from the villages which are not been adjacent to the dredging dykes. Some common seasonal vegetables and permanent vegetables and spices like tomato, gol alu (potato), palong shak (spinach), begun (eggplant), kumra (pumpkin), pui shak (malabar spinach/basella spinach), lalshak (red amaranth), data sak (stem amaranth), sim (broad beans), laou (gourd), olkopi (kohlrabi), morich (chili), ada (ginger), etc. were recorded also from different houses. Basak (lemon basil), tulshi (holy basil), pudina (mint), neem, arjun, ghitokumari (aloe vera), pathorkuchi (*Kalanchoe pinnata*), etc. were observed in the homestead gardens. But due to the impact of dredging sediments in and around the homestead plants, gardening, medicinal plants, etc. are being affected.

Parameter	Unit	Present Study				Previous Study (Before dredging)			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Air temperature	°C	27.9	2.1	21.2	35.8	27.1	1.2	20.3	34.5
Water temperature	°C	28.4	1.5	21.2	34.6	26.5	0.9	20.6	29.1
Transparency	cm	14	2.4	09	17	25	4	23	32
Total suspended solids	mg/l	379	101	207	516	27	2.3	18	75
pH		5.8	0.5	5.2	6.2	8.1	0.4	7.8	8.8
Dissolved oxygen	mg/l	5.1	0.3	2.4	6.2	6.4	0.6	5.3	7.2
Total dissolved solids	g/l	21	1.8	15.8	25	13	1.4	10.9	15.2
Salinity	ppt	13.5	3.2	12.1	23.5	11.8	1.3	11.2	17.6

Parameter	Unit	Present Study				Previous Study (Before dredging)			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Total hardness	mg/l	1673	151	1594	2106	952	37	815	1028
Biological oxygen demand (BOD$_5$)	mg/l	3.8	0.6	2.7	5.4	2.1	0.5	1.6	2.8
Chemical oxygen demand	mg/l	377	32	283	598	133	28	75	192
Silicate	mg/l	8.87	2.01	5.91	11.4	5.73	0.68	4.94	6.77
Calcium	mg/l	812	71	754	892	576	49	481	690
Magnesium	mg/l	513	64	507	619	317	34	235	448
Sodium	mg/l	953	19	678	1129	435	22	288	669
Iron	mg/l	0.5	0.08	0.48	0.77	0.3	0.01	0.2	0.4
Productivity	mg/l	1.9	0.4	1.5	2.8	7.9	0.7	7.1	11.4
Phytoplankton (Abundance)	units/l	134	25	117	148	369	58	275	462
Zooplankton (Abundance)	units/l	51	13	4	68	92	13	80	126

Table 1: Physico-chemical and biological conditions in the water bodies of the study

- = Not detected

Parameter	Unit	Present Study				Previous Study (Before Dredging)			
		Mean	SD	Min	Max	Mean	SD	Min	Max
pH		5.6	0.4	4.9	6.2	8.2	0.2	7.9	8.5
Salinity	Ppt	11.9	0.7	11.2	14.6	12.1	0.3	11.4	13.9
Total Nitrogen	%	0.27	0.022	0.23	0.31	0.16	0.005	0.12	0.19
Phosphorus	µg/g soil	183	39	89	257	21	1.8	14	25
Sulfur	µg/g soil	114	11	93	129	72	5	61	98
Calcium	meq/ 100g soil	13.8	1.1	13.2	15.9	15.8	0.4	14.6	16.5
Magnesium	meq/ 100g soil	10.9	0.4	9.6	12.1	11.6	1.5	10.7	12.9
Potassium	meq/ 100g soil	2.07	0.12	1.28	1.82	1.64	0.38	1.49	2.02
Sodium	mg/g soil	1.39	0.17	1.14	1.68	0.88	0.09	0.72	0.96
Iron	mg/g soil	0.43	0.013	0.35	0.59	0.26	0.004	0.21	0.28

Table 2: Chemical conditions of the soil of the study areas

Parameters	Study Area	Before Dredging
SPM (mg/m^3)	272- 685	115 – 180
PM 10 (mg/hour)	354 – 597	83 – 114
PM 2.5 (mg/hour)	386 – 616	21 – 44
NO_x ($µg/m^3$)	19 – 28	11 – 18
SO_x ($µg/m^3$)	14 – 31	8 – 13

Table 3: Air quality of the study area

Name of the flora and Fauna	Units	Present Study (dredging sites)	Previous and without dredging areas	Comments
Seedling of tidal plants	no./5m^2	No seedlings were observed	07-12	
Saline water lily on intertidal zones	no./5m^2	No plant bodies were recorded	10-16	Most of the intertidal canals/ zones were being filled by the dredging sediments
Different tidal plants	no./5m^2	3-07 no. tidal plants were recorded in the surrounding areas of dredging dykes	10-19	Dredging dykes were filled by the riverbed sands. Deposited sands height was more or less 3 meters from the normal land height. All tidal plants were removed for making dykes.
Homestead plants	no./5m^2	Any homestead plant was not observed in and around the dykes	Different homestead plants i.e., aam, tentul, khejur, narikel, supari, tal, kola, sofeda, kul, kamramga, peara, pepe, jam etc. are present.	Few houses with many homestead plants were acquired for dykes to deposit dredging sediments.
Vegetable cultivation	no./5m^2	No vegetable was observed in and around the dykes	Some common seasonal vegetables and permanent vegetables and spices like tomato, gol alu, palong sak, begun, kumra, pui sak, lalsak, data sak, sim, laou, olkopi, morich, ada etc. were recorded from different houses	Villagers are always cultivating their necessary vegetables and spices in their homestead gardens
Medicinal plants	no./5m^2	No medicinal plants were recorded	Basak, tulshi, pudina, neem, arjun, ghitokumari, pathorkuchi, etc. were recorded	Some villagers planted the mentioned medicinal plants in their homes
Rice cultivation		No rice cultivation is possible in the surrounding areas of dredging dykes	More than 80% landowners cultivated Amon rice on their lands	All dredging dykes developed on the high productive (rice and fish

Name of the flora and Fauna	Units	Present Study (dredging sites)	Previous and without dredging areas	Comments
				both were cultivated) lands
Different fishes i.e., Parshe, Khursula, Bagda, Harina, tengra, etc.		Many natural tidal canals and fish cultivation lands were filled by the dredging sediments	All natural canals and flood plains were the sources of the mentioned fishes, as well as cultivated by the villagers as a major crop	Decreased protein sources of the poor villagers and livelihoods of the many villagers especially acquired lands owners have been affected seriously
Mudskippers, mud crabs, snails, frogs, etc.	no./m^2	No mudskippers, crabs, snails and frogs were present in the dyke area but very poor no. were observed outsides the dykes	Mudskippers, crabs, snails, and frogs are common	Dykes surroundings lands (fish and rice culture lands) are being filled gradually by the erosion of dykes
Common Birds (Heron, Kingfisher, etc.)	Study period	Any birds were not observed in and around the dredging dykes areas	Birds are common	Birds' food chain has been affected and reduced due to filled of the natural tidal canals and rice-fish agricultural lands
Fishing cat - intertidal zone of the Pashur river & canals are habitats	Study period	Only 2 foot marks of fishing cats were observed surrounding the fish culture lands	Foot marks of fishing cats are common	Sources of natural fishes and cultural fishes are being reduced day by day by the deposited sediments of dredging
Domestic animals	Study period	Dykes surrounding villagers are selling their domestic animals due to scarcity of foods	Villagers have common domestics animals	Reduced rice cultivation and deposition of dredging sands increasing the scarcity of animals' foods as a result villagers are bound to sell their animals

Table 4: Floral and faunal status of the study areas, and before and without dredging areas

3.3. Environmental Impact

The main objective is to examine, analyze and assess the planned project activities' effects on the baseline conditions. The impact assessment process starts with a procedure to identify the key environmental and social features from the baseline information. This procedure identifies the key biological, physical, and human components of the project area.

The potential positive and negative changes resulting from the project activities/aspects are then predicted for the study area over the time span of filling operations needed as part of the site development project. These predicted changes (impacts) are then evaluated using a significance ranking process. An outline of the impact assessment includes identification of the valued receptors, identification of the project aspects, impact evaluation, and significance ranking.

A valued receptor (VR) is any part of the environment that is considered to be important or valuable. The VRs may be selected according to economic, social, esthetic or ethical criteria, as well as physical and biological characteristics. The selection of VRs is dependent on the nature of the option under investigation. This depends on the types of interaction with the environment that the project is expected to have, given its component activities and area of influence.

Each valued receptor is categorized in terms of its perceived environmental and social value, taking into account local, national or international designations and legal protection status, if appropriate. Based on these considerations the environmental and social values are allocated a category of low, medium, and high.

The evaluation has been conducted using the basic criteria for defining an impact, which are magnitude, spatial extent, and duration. The magnitude is an indication of the proportion of VR that will experience the impact in relation to the total resource. Spatial extent is the geographical area over which the impact is experienced. Duration is the length of time over which the impact will be experienced. An impact may be present only while a project is active, or it could persist long after the project activity has ceased, in which case the duration may be regarded as the time the VR needs to recover from the effect.

Each potential impact is evaluated by applying descriptors to each of the above criteria, based on qualitative or, to the extent possible, quantitative evaluation, as shown in Table 5.

Basic criteria of impact	Very low 1	Low 2	Moderate 3	High 4	Very high 5
Magnitude	Very small proportion of the VR is affected	Small proportion of the VR is affected	Moderate proportion of the VR is affected	Large proportion of the VR is affected	Very large proportion or all of the VR is affected
Spatial extent	Local impact in the immediate area of the activity	Local impact in the study area	Regional-scale impact	National scale impact	Transboundary scale impact
Duration	Less than 1 year	1–5 years	5–10 years	Greater than 10 years	Irreversible

Table 5: Impact Index

The importance of each valued receptor (VR) was identified as shown in Table 6. These VRs include terrestrial ecology (habitat, flora, and fauna), intertidal ecology (benthic organisms, birds), human-environment (health hazards, agricultural activities, and fishing activities), land (morphological change), and surface water.

Valued receptor	Importance	Categorization
Ecology		
Terrestrial ecology		
Habitat	Important for ecosystem wellbeing and proper functioning	High

Valued receptor	Importance	Categorization
Flora	Important for ecosystem wellbeing and proper functioning. Floral populations are being affected.	High
Fauna	Important for ecosystem wellbeing and proper functioning. The presence of faunal population and diversity is being decreased in the study areas	High

Intertidal ecology

Benthic organisms/ biota	Importance to the well-being of all biological content of the ecosystem	Moderate
Different birds	Importance to the wellbeing of all common birds of the ecosystem. Limited count of species and population	Moderate

Human environment

Population	Almost 25000 families are living around the dredging sediments deposited dykes. Permanent major residential settlements, schools, temples, and community places are present in these areas.	High
Traffic	Creation of high traffic roads affecting goods transport and road users	Low

Economic activities

Agriculture activities	Vast areas to the east, southeast and northeast are cultivated lands of rice and fish. These cultivations are the main source of income for many families in the study areas.	High
Fishing activities	Fishing activities were practiced in the natural canals and cultivated lands. Due to dumping of dredging sediment activities on the canals and fish culture lands changed the habitats of fish.	High

Land

Geomorphology	Soil sustains life and can influence groundwater quality.	Moderate

Valued receptor	Importance	Categorization
Topography	Topography of the study areas are being changed by the dumping of dredging sediment as a result the groundwater level, ecology, inter-tidal creatures also will be changed	High
Water		
Surface water	Water quality is being changed, reducing the amount of domestic water, creating health hazards, etc.	High
Groundwater	Groundwater is considered a highly limited renewable resource in the study areas, maybe reduce the level of ground water.	Moderate
Air and climate		
Air quality	Good air quality is required for population health, the health of crops and climate regulation but the air is being polluted by the high suspended materials and will create health hazards	Moderate
Temperature	Temperature will be increased	Moderate

Table 6: Identified valued receptors (VRs)

Figure 2: Photographs 1-3. New dykes – for dumping dredging sediments; 4. Dumping dredging sediments inside the dyke; 5-7. Showing heights of the dykes; 8. Already filled dyke by the dredging sediments/sands

Figure 3: Photographs: 9-10. Agriculture and fish culture ghers beside the dykes; 11. Erosion of dykes' wall beside the agriculture lands; 12. Cultivated lands are being filled by the debris of dykes due to erosion; 13. Dredging dyke beside the government school

3.4. River systems and Erosion

The Pashur and all its distributaries are tidal channels and are the main river to control drainage systems of the total study areas. The average elevation of the sites is about 2 m above the mean sea level. The study area slopes gently towards the Southwest. Small tributaries and canals finally join the river Pashur but due to the deposition of the dredging sediment, all canals are already filled. The problems are being created by the erosion of the dyke's wall (made by the sediment) for the adjacent houses and their lands. The height of the dykes is more or less 3 meters from those areas' land as a result of easily surrounding fish culture lands, domestic ponds, and houses being filled and affected by the erosion of the dredging sediments. The topography outside of the dykes is being also changed gradually and unproductive lands are increasing day by day. In the future, some villagers will be bound to migrate from their forefather's residences.

Environmental Impact Assessment (EIA) of the physical, biological, social, and economic environment of the surrounding areas dredging dykes indicate that the impacts of dumping the dredging materials/sediment are negative and irreversible (-31) which can't be mitigated in any way. It is indicating that climate, topography, land use pattern, air and water quality, floral and faunal diversity, aquatic ecosystems, and capture fisheries of the surrounding areas of dykes will be affected permanently due to the continuous dumping of dredging materials.

Increasing dyke walls erosion and health hazards, loss of cultural fisheries, health hazards, and destruction of agriculture will be happened due to unplanned dredging dykes. These problems may be reversible after a long mitigation process except in agriculture. But all reversible mitigations are negative (total no. is -48). Mitigation of agricultural loss will be very difficult and many people will face the problem of livelihood, and a few people will be bound to migrate from the area. There is no sustainable mitigation number, which indicates that the study area is not suitable for the dumping of the dredging materials (Table 7). There are no benefits/facilities of the dredging dykes and dumping of the sediment in the study areas but many negative impacts are being created and, in the future, some more will be created.

ECs	Present Amount/ Frequency	Industrial Impact	Impact Type	Impact Rating
A. Physical Environment				
Climate:				
Temp	Mean temperature was recorded 27.9 ±2.1°C	Will be increased	RM	-2
Rainfall	Annual mean 268 mm.	May slightly decrease	IR	-1
Topography	Highly disturbed in and around the dykes areas.	May be highly disturbed in all areas.	IR	-5
Land Use	Agricultural land use dominated with rural set up.	Changed into unproductive land.	IR	-5
Erosion of dyke walls	Common in the dykes	Increase erosion for the dumping of sediment	RM	-4
Water Pollution	No	Will be increased due to the mixing of dredging materials from the dykes	RM	-4
Water Bodies	Natural canals, many ghers, and domestic ponds exist.	Water bodies will be reduced by the deposition of the dredging materials/ sediment	RM	-4
Air Pollution	No	Air pollution will be increased by increasing SPM, PM10, PM 2.5, and sands	IR	-3
B. Biological Environment				
Habitat	About 50-60% of habitats for flora and fauna in the villages of surrounding dykes	Reduced habitats of flora and fauna.	RM	-4
Flora	Among the existing species, some are decreasing due to	Natural and homestead floral species will be	RM	-4

ECs	Present Amount/ Frequency	Industrial Impact	Impact Type	Impact Rating
	different hazards of dredging sediment	decreased in the study areas.		
Wildlife	Common species of the study areas	Most of the wildlife will be migrated in and around the dykes areas	IR	-3
Capture Fisheries	Meet the 20-25% of fish demand.	All-natural water bodies are being filled by the dredging sediment	IR	-5
Culture Fisheries	Meet the 55-60% of fish demand.	All dykes developed on the fish culture ghers	IR	-4
Agriculture	Amon rice cultivation is a common practice in the study areas	No rice will be produced in and around the dykes areas	IR	-5
C. Social Environment				
Human Settlement	30-40% areas are covered by the settlement.	Decrease human settlement due to land acquisition.	RM	-3
The landless population	Poor no.	The landless population will be increased.	RM	-2
Migration	Less than 5%	Migration will be increased	RM	-2
Status of husbandless Women	Poor no.	No. of husbandless women will be increased.	RM	-2
Health hazards	Poor in the study areas except for salinity.	Health hazards will be increased by increasing air and water pollution.	RM	-4
Human Diseases	Prevalence of diarrhea, skin diseases, worm infection, and anemia.	Lung and pharyngeal diseases, air and water-borne diseases will be increased.	RM	-3
D. Economic Environment				
Livelihoods	Most of the people have some selective occupation	Livelihoods will be affected in a different way	RM	-2

ECs	Present Amount/ Frequency	Industrial Impact	Impact Type	Impact Rating
Business	More or less 30% of people are involved in different businesses	Business opportunities will be reduced	RM	-2

Figure 4: Environmental Impact Assessment Matrix for deposition of dredging materials in the study areas

**S – Sustainable, SM – Sustainable with Mitigation, RM – Reversible with Mitigation, IR – Irreversible

So environmentally, physically, socially, and economically the study areas are not suitable to dump the dredging materials/ sediment. The findings of the present study also indicate that dredging sediment/ soil already created different hazards problems in and around the sediment dumping sites (Dykes), which may create more irreversible negative impacts in the future if dumping activities will continue. More or less similar observations were recorded Barbe *et al.*(2000), Bellmore *et al.* (2012), Cai *et al.*(2012), Claret *et al.*(1999), Cook (1997), Darmody *et al.* (2004), Jonge *et al.*(2012), Freedman and Stauffer (2013), Gob *et al.* (2005), Hossain *et al.*(2004), Koel and Stevenson (2002), Lee *et al.* (2011), Licursi and Gomez (2009), Maron *et al.* (2008), McCabe *et al.*(1998), Miller and Payne (2004), Morin *et al.* (2000), Romagnoli *et al.*(2002), Skilleter *et al.*(2006), Su *et al.* (2002) and Tamuno *et al.*(2009) in their studies in different locations of the worlds. Institute of Water Modeling (2015) also mentioned in their study that the dredging of wet materials has an impact on the soil fertility of the nearby agricultural lands. Therefore, alternative sustainable options should find out to solve the dredging problems specially to deposit the dredging sediments. A long-term research and intensive monitoring must be done to find out the detailed information on the long-term impact of dredging on the biodiversity and ecological conditions of both sides of the Pashur River.

4. Summary

➤ The study concluded that the present condition of dredging dykes of the Pashur river and its surrounding areas have reflected a sign of threat to the environment.

➤ The existing dredging dykes are solely responsible for the depletion of fish and

other natural resources, increasing sedimentation in and around the agricultural lands and houses.

➤ These dykes are creating different health hazards for humans and increasing unproductive lands.

➤ Continuously discharge of the dredging materials/ sediments will create ecological imbalance and livelihood problems.

➤ Local communities (local govt. representatives, local political leaders, journalists, fishermen, farmers, businessmen, religious leaders, general people, etc.) mentioned that already the people of the surrounding dredging dykes are facing different hazards created by the dredging materials/ sediments.

5. Acknowledgment

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