Environmental Impact Assessment (Draft) — Annexes

February 2018

BAN: Rupsha 800 MW Combined Cycle Power Plant Project

Prepared by North-West Power Generation Company Limited for the Asian Development Bank.

List of Annexes

Annex 1
Approved Terms of Reference (ToR) of EIA for Component 1 by DoE

Government of the People's Republic of Bangladesh
Department of Environment
Head Office, E-16 Agargaon
Dhaka-1207
www.doe.gov.bd

Memo No: Doe/Clearance/5584/2016/564 Date: 05/11/2017

Subject: Exemption from IEE and Approval of Terms of Reference (TOR) for Environmental Impact Assessment (EIA) of Proposed Rupsha 800 MW Combined Cycle Power Plant Project at Khalishpur, Khulna.

Ref: Your Application dated 29/10/2017.

With reference to your letter dated 29/10/2017 for the subject mentioned above, the Department of Environment hereby gives Exemption from IEE and approval of TOR for Environmental Impact Assessment (EIA) in favour of Proposed Rupsha 800 MW Combined Cycle Power Plant Project at Khalishpur, Khulna subject to fulfilling the following terms and conditions:

I. The project authority shall submit a comprehensive Environmental Impact Assessment (EIA) considering the overall activity of the said project in accordance with the TOR and time schedule submitted to the Department of Environment (DOE) and additional suggestions provided herein.

II. The EIA report should be prepared in accordance with following indicative outlines:

1. Executive summary.
2. Introduction: (Background, brief description, scope of study, methodology, limitation, EIA team, references).
3. Legislative, regulation and policy consideration (covering the potential legal, administrative, planning and policy framework within which the EIA will be prepared).

4a. Project activities:

- A list of the main project activities to be undertaken during site clearing, construction as well as operation
- Project Plan, Design, Standard, Specification, Quantification, etc.

4b. Project schedule: The phase and timing for development of the Project.

4c. Resources and utilities demand: Resources required to develop the project, such as soil and construction material and demand for utilities (water, electricity, sewerage, waste disposal and others), as well as infrastructure (road, drains, and others) to support the project.

4d. Map and survey information

Location map, Cadastral map showing land plots (project and adjacent area), Topographical map, Geological map showing geological units, fault zone, and other natural features.

5. Baseline Environmental Condition should include, inter alia, following: (Identification and Quantification of Physical Situation that has been proposed to be changed)

- Physical Environment : Geology, Topology, Geomorphology, Land-use, Soils, Meteorology and Hydrology
- Biological Environment : Habitats, Aquatic life and fisheries, Terrestrial Habitats and Flora and Fauna
- Environment Quality : Air, Water, Noise, Vibration, Soil and Sediment Quality
- Relate baseline in both Quantitative and Qualitative term with the anticipated outcomes, achievement of goals, objectives and changes due to project interventions

6. Socio-economic environment should include, inter alia, following:

   - Population: Demographic profile and ethnic composition
   - Settlement and housing
   - Traffic and transport
   - Public utilities: water supply, sanitation and solid waste
   - Economy and employment: employment structure and cultural issues in employment
   - Fisheries: fishing activities, fishing communities, commercial important species, fishing resources, commercial factors.

7. Identification, Prediction and Evaluation of Potential Impacts (identification, prediction and assessment of positive and negative impacts likely to result from the proposed project).

   In identification and analysis of potential impacts'-the 'Analysis' part shall include the analysis of relevant spatial and non-spatial data. The outcome of the analysis shall be presented with the scenarios, maps, graphics etc. for the cases of anticipated impacts on baseline. Description of the impacts of the project on air, water, land, hydrology, vegetation-man maid or natural, wildlife, socio-economic aspect shall be incorporated in detail.

   Appropriate models shall be used for prediction of potential impacts of the project on surface water and ambient air quality using updated data. Model prediction shall be compared with national water and air quality standards and specific sensitivity data of the organisms known to be present in the project area (likely impacted area) for impact assessment.

8. Management Plan/Procedures:

   For each significant major impact, proposed mitigation measures will be set out for incorporation into project design or procedures, impacts, which are not mitigable, will be identified as residual impacts Both technical and financial plans shall be incorporated for proposed mitigation measures.

   An outline of the Environmental Management Plan shall be developed for the project.

   In Environmental Monitoring Plan, a detail technical and financial proposal shall be included for developing an in-house environmental monitoring system to be operated by the proponent's own resources (equipments and expertise).

9. Consultation with Stakeholders/Public Consultation (ensures that consultation with interested parties and the general public will take place and their views taken into account in the planning and execution of the project)

   Beneficial Impacts (summarize the benefits of the project to the Bangladesh nation, people and local community and the enhancement potentials)

10. Risk assessment, risk management, system of valuation of environmental and properties damage, damage compensation issues shall be addressed

11. Emergency Response Plan and Disaster Impact Assessment

12. Conclusion and Recommendations

III. Without approval of EIA report by the Department of Environment, the project authority shall not be able to open L/C in favor of importable machineries.

IV. Without obtaining Environmental Clearance, the project authority shall not be able to start the physical activity of the project.

V. The project authority shall submit the EIA report along with the filled-in application for Environmental Clearance in prescribed form, the applicable Environmental Clearance fee in a treasury chalan, the applicable VAT on clearance fee in a separate treasury chalan, the No Objection Certificate (NOC) from local authority, NOC from Forest Department (if it is required in case of cutting any forested plant, private or public) and NOC from other relevant agencies for operational activity etc. to the Khulna Divisonal Office of DOE in Khulna with a copy to the Head Office of DOE in Dhaka.

VI. A soft copy of the image data as well as the maps to be generated from the image shall be submitted to DOE Head Office along with the EIA report.

05.11.2017

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Copy Forwarded to :

1) PS to The Secretary, Ministry of Environment and Forests, Bangladesh Secretariat, Dhaka.
2) Secretary, Power Division, Ministry of Power, Energy & Mineral Resources, Bangladesh Secretariat, Dhaka.
3) Chairman, Bangladesh Power Development Board, Biddyut Bhaban, 1, Abdul Goni Road, Dhaka.
4) Director, Department of Environment, Khulna Divisonal Office, Khulna.
5) Assistant Director, Office of the Director General, Department of Environment, Head Office, Dhaka.

Annex 2

"Chance Find" Procedures for Physical Cultural Resources
Component 1 – 800 MW Rupsha CCPP

1.0 Introduction

1. These procedures describe the measures to be undertaken if an accidental discovery or chance find, or an encounter with a physical cultural resource (PCR) occurred during the construction phase. The chance find procedures will be finalized as Physical Cultural Resources Plan (PCRP) by NWPGCL and the EPC Contractor, in consultation with the Department of Archaeology (DOA) or the Ministry of Cultural Affairs to ensure compliance to The Antiquities Act 1968 (amended 1976), National Cultural Policy 2006, and applicable regulations. The PCRP will be included in the Construction Management Plan that will be required by NWPGCL from the EPC Contractor. The objectives of these procedures are to identify and promote the preservation, protection, and recording of any PCR that may be discovered or exposed during excavation, demolition, other earthmoving works, and ground alteration within the project site for Component 1 – 800 MW Rupsha CCPP in Khalishpur, Khulna.

2.0 Orientation and/or Briefing of Workers

2. The EPC Contractor, with technical support from the DOA or Ministry of Cultural Affairs and PMU, NWPGCL will conduct an orientation or training for all workers, particularly those who will be involved in earth movements and excavation works on how to recognize artifacts that they may potentially encounter or discover. The EPC Contractor will be responsible for creating awareness to construction personnel on the ADB requirements for any unanticipated impacts such as discovery of a physical cultural resource. NWPGCL will ensure compliance of this ADB requirement.

3. An archeological map of Bangladesh (if available) will be obtained from the DOA or other relevant sources to examine if there are potential "hot spots" within the project area. This map will be part of the references on-site to guide the construction supervision staff in determining and recognizing the potential "hot spots."

3.0 Procedures

3.1 General

4. In case a PCR was encountered during excavation, construction activities including traffic within a 30.5-meter radius in the area will be stopped immediately by the EPC Contractor. The discovery will be reported by the site engineer or representative from the EPC Contractor to PMU, NWPGCL environment staff (or Consultant). The site or area discovered will be marked or demarcated using a global positioning system (GPS) unit to determine the exact coordinates and photographs will be taken. The construction supervision staff of the EPC Contractor and PMU, NWPGCL site engineer/staff will secure the site to prevent damage, loss or pilferage of removable objects. Site Engineer of PMU, NWPGCL or designated staff will be responsible for coordinating with DOA.

5. If the encounter involves removable items, a security person will be posted until the representative of DOA or Ministry of Cultural Affairs arrives to assess and determine its value. The DOA staff will be responsible in determining the appropriate course of action. Further excavation or earth moving works may be conducted at the distance and demarcation area recommended by the DOA staff.

6. If the chance find will have significant cultural value, this may entail consequent changes in the lay-out particularly if the discovery is considered or assessed as remains of cultural or archeological importance that is not removable.

7. EPC Contractor will not be entitled for compensation due to work stoppage as a result of the discovery and its associated subsequent actions.

3.2 Assessment and Recovery

8. Appropriate heavy equipment such as wheel loader will be made available to recover the excavated material from the excavation site to allow the geologist onsite or the DOA staff to inspect, recover or conduct sampling. A safe storage area will be provided to protect the discovered object. If the chance find is part of a large artifact, deposit or structure, the inspection or recording will include photography and video on an "as-is, where is" manner. The exact location will be recorded using a GPS unit.

3.3 Resumption of Work

9. The Contractor can continue with excavation and construction works within the affected area after the DOA staff has given clearance. All the discovered objects of value will be given to the Government.

4.0 Reporting

10. The EPC Contractor will prepare a “Chance Find” Report within a week showing the date and time of discovery, specific location, description of the PCR, and interim protection measures implemented. This Report will be submitted to PMU, NWPGCL who will provide it to the DOA or Ministry of Cultural Affairs. The chance find including measures on how it was dealt with will be included in the environmental monitoring report submitted to ADB.

Annex 3

List of Species Found within the Study Area

Table 1: Terrestrial vegetation growing within the study area

No.	Scientific Name	Local Name	Habit
Homestead			
1	*Abroma augusta*	Ulatkambal	Shrub
2	*Acacia moniliformis*	Akashmoni	Tree
3	*Aegle marmelos*	Bel	Tree
4	*Albizia lebbeck*	Sirish	Tree
5	*Albizia procera*	Silkaroi	Tree
6	*Albizia richrdiana*	Gogon Sirish	Tree
7	*Alstonia scholaris*	Chatim	Tree
8	*Annona reticulata*	Ata	Tree
9	*Areca catechu*	Supari	Tree
10	*Artocarpus heterophyllus*	Kathal	Tree
11	*Artocarpus lakoocha*	Dewa	Tree
12	*Averrhoa carambola*	Kamranga	Tree
13	*Azadirachta indica*	Nim	Tree
14	*Bambusa sp.*	Bans	Tree
15	*Barringtonia acutangula*	Hijal	Tree
16	*Bombax ceiba*	Shimul	Tree
17	*Borassus flabelifer*	Tal	Tree
18	*Carica papaya*	Papay	Tree
19	*Citrus grandis*	Jambura	Tree
20	*Citrus limon*	Lebu	Shrub
21	*Cocos nucifera*	Narikel	Tree
22	*Crataeva nurvala*	Baroon	Tree
23	*Dillenia indica*	Chalta	Tree
24	*Diospyros blancoi*	Bilatigab	Tree
25	*Diospyros perigrina*	Deshigab	Tree
26	*Erythrina ovalifolia*	Talimandar	Tree
27	*Ficus benghalensis*	Bot	Tree
28	*Ficus religiosa*	Assawath	Tree
29	*Lagerstromia speciosa*	Jarul	Tree
30	*Lennea coromandelica*	Zika	Tree
31	*Litchi chinensis*	Lichu	Tree
32	*Mangifera indica*	Aum	Tree
33	*Moringa oleifera*	Sajna	Tree
34	*Musa sapientum*	Kala	Tree
35	*Neolamarckia cadamba*	Kadam	Tree
36	*Ocimum americanum*	Tulshi	Herb

No.	Scientific Name	Local Name	Habit
37	*Phoneix sylvestris*	Khejur	Tree
38	*Phyllanthus reticulatus*	Amloki	Tree
39	*Polyalthia longifolia*	Debdaru	Tree
40	*Pongamia pinnata*	Karoch	Tree
41	*Psidium guajava*	Peyara	Shrub
42	*Spondias dulcis*	Amra	Tree
43	*Streblus asper*	Sheora	Shrub
44	*Swietenia mahagoni*	Mahogoni	Tree
45	*Syzygium cumini*	Kalojam	Tree
46	*Tamarindus indica*	Tetul	Tree
47	*Tectona grandis*	Segun	Tree
48	*Terminalia arjuna*	Arjun	Tree
49	*Terminalia catappa*	Katbadam	Tree
50	*Trema orientalis*	Jiban	Tree
51	*Trewia nudiflora*	Pitali	Tree
52	*Zizyphus mauritiana*	Baroi	Tree
Crop field			
1	*Acalypha indica*	Muktajhuri	Herb
2	*Achyranthes aspera*	Apang	Herb
3	*Alternanthera sessilis*	-	Herb
4	*Amaranthus spinosus*	Kata note	Herb
5	*Calotropis gigantea*	Akand	Shrub
6	*Calotropis procera*	Akand	Shrub
7	*Carissa carandas*	Karamcha	Shrub
8	*Chenopodium ambrosoides*	Chapali ghash	Herb
9	*Clerodendrum inerme*	Bhant	Herb
10	*Cotula hemispherica*	Kancha ghash	Herb
11	*Crotolaria retusa*	Ban-san	Herb
12	*Croton bonplandianum*	Banjhal	Herb
13	*Cuscuta australis*	Swarnalata	Herb
14	*Cynodon dactylon*	Durba	Herb
15	*Cyperus diformis*	-	Herb
16	*Dentella repens*	Hachuti	Herb
17	*Euphorbia hirta*	Dudhia	Herb
18	*Marsilea quadrifolia*	Susnishak	Herb
19	*Nicotiana plumbaginifolia*	Bantamak	Herb
20	*Nyctanthes arbortristris*	Sefali	Herb
21	*Rhynchospora rufescens*	Shimbhatraji	Herb
22	*Rorippa indica*	Bansarisha	Herb
23	*Saccharum spontaneum*	Kash	Herb
24	*Sacciolepis interrupta*	Nardulla	Herb
25	*Sesbania rostrata*	Dhaincha	Herb

Table 2: The list of terrestrial and wetland wildlife occurring within the study area

No.	English Name	Scientific Name
Birds		
1	Abbott's Babbler	*Malacocincla abbotti*
2	Ashy Wood swallow	*Artamus fuscus*
3	Asian Koel	*Eudynamys scolopaceus*
4	Asian Open bill	*Anastomus oscitans*
5	Asian Palm Swift	*Cypsiurus balasiensis*
6	Barn Owl	*Tyto alba*
7	Baya Weaver	*Ploceus philippinus*
8	Bengal Bush Lark	*Mirafra assamica*
9	Black Drongo	*Dicrurus macrocercus*
10	Black headed Ibis	*Threskiornis melanocephalus*
11	Black Kite	*Milvus migrans*
12	Black-crowned Night Heron	*Nycticorax nycticorax*
13	Black-headed Munia	*Lonchura malacca*
14	Black-hooded Oriole	*Oriolus xanthornus*
15	Black-naped Monarch	*Hypothymis azurea*
16	Black-winged Kite	*Elanus caeruleus*
17	Blue-throated Barbet	*Megalaima asiatica*
18	Brahminy Kite	*Haliastur Indus*
19	Bronze-winged Jacana	*Metopidius indicus*
20	Brown Fish Owl	*Ketupa zeylonensis*
21	Brown Shrike	*Lanius cristatus*
22	Brown-headed Gull	*Larus brunnicephalus*
23	Cattle Egret	*Bubulcus ibis*
24	Chestnut-tailed Starling	*Sturnus malabaricus*
25	Cinnamon Bittern	*Ixobrychus cinnamomeus*
26	Citrine Wagtail	*Motacilla citreola*
27	Clamorous Reed Warbler	*Acrocephalus stentoreus*
28	Common Black-headed Gull	*Larus ridibundus*
29	Common Greenshank	*Numenius nebularia*
30	Common Hawk-Cuckoo	*Hierococcyx varius*
31	Common Iora	*Aegithina tiphia*
32	Common Kestrel	*Falco tinnunculus*
33	Common Kingfisher	*Alcedo atthis*
34	Common Myna	LC *Acridotheres tristis*
35	Common Pigeon	*Columba livia*
36	Common Pochard	*Atthya ferina*
37	Common Redshank	*Tringa tetanus*

No.	English Name	Scientific Name
38	Common Sandpiper	*Actitis hypoleucos*
39	Common Shelduck	*Tadorna tadorna*
40	Common Snipe	*Gallinago gallinago*
41	Common Tailorbird	*Orthotomus sutorius*
42	Common Tern	*Sterna hirundo*
43	Coppersmith Barbet	*Megalaima haemacephala*
44	Cotton Pygmy Goose	*Nettapas coromandelianus*
45	Crested Serpent Eagle	*Spilornis cheela*
46	Dusky Warbler	*Phylloscopus fuscatus*
47	Eurasian Collared Dove	*Streptopelia decaocta*
48	Eurasian Hoopoe	*Upupa epops*
49	Fulvous Whistling Duck	*Dendrocygna bicolor*
50	Fulvous-breasted Woodpecker	*Dendrocopos macei*
51	Garganey	*Anas querquedula*
52	Great Egret	*Casmerodius albus*
53	Great Tit	*Parus major*
54	Greater Coucal	*Centropus sinensis*
55	Green Bee-eater	*Merops orientalis*
56	Grey Heron	*Ardea cinerea*
57	House Crow	*Corvus splendens*
58	House Sparrow	*Passer domesticus*
59	Indian Cormorant	*Phalacrocorax fuscicollis*
60	Indian Cuckoo	*Cuculus micropterus*
61	Indian Pond Heron	*Ardeola grayii*
62	Jungle Babbler	*Turdoides striatus*
63	Jungle Myna	*Acridotheres fuscus*
64	Large-billed Crow	*Corvus macrorhynchos*
65	Lesser Sand Plover	*Charadrius mongolus*
66	Lesser Whistling Duck	*Dendrocygna javanica*
67	Lineated Barbet	*Megalaima lineata*
68	Little Cormorant	*Phalacrocorax niger*
69	Little Egret	*Egretta garzetta*
70	Little Ringed Plover	*Charadrius dubius*
71	Long-tailed Shrike	*Lanius schach*
72	Northern Pintail	*Anas acuta*
73	Olive-backed Pipit	*Anthus hodgsoni*
74	Oriental Magpie-Robin	*Copsychus saularis*
75	Oriental White-eye	*Zosterops palpebrosus*
76	Pacific Golden Plover	*Pluvialis fulva*
77	Paddy field Pipit	*Anthus rufulus*

No.	English Name	Scientific Name
78	Pied Kingfisher	*Ceryle rudis*
79	Pied Myna	*Sturnus contra*
80	Plain Prinia	*Parus inornata*
81	Purple-rumped Sunbird	*Leptocoma zeylonica*
82	Red Turtle Dove	*Streptopelia tranquebarica*
83	Red-vented Bulbul	*Pycnonotus cafer*
84	Red-wattled Lapwing	*Vanellus indicus*
85	River Tern	*Sterna aurantia*
86	Rose-ringed Parakeet	*Psittacula krameri*
87	Rufous Treepie	*Dendrocitta vagabunda*
88	Rufous Woodpecker	*Celeus brachyurus*
89	Scaly-breasted Munia	*Lonchura punctulata*
90	Small Minivet	*Pericrocotus cinnamomeus*
91	Spotted Dove	*Streptopelia chinensis*
92	Spotted Owlet	*Athene brama*
93	Streak-throated Woodpecker	*Picus xanthopygaeus*
94	Striated Babbler	*Turdoides earlei*
95	Striated Heron	*Butorides striata*
96	White Wagtail	*Motacilla alba*
97	White-breasted Water hen	*Amaurornis phoenicurus*
98	White-browed Wagtail	*Motacilla madaraspatensis*
99	White-throated Kingfisher	*Halcyon smyrnensis*
100	Wood Sandpiper	*Numenius glareola*
101	Yellow-billed Egret	*Egretta intermedia*
102	Yellow-footed Green Pigeon	*Treron phoenicopterus*
103	Zitting Cisticola	*Cisticola juncidis*
Mammals		
1	Smoth coated Otter	*Lutrogale perspicillata*
2	Ganges River Dolphin	*Platanista gangetica*
3	Golden Jackal	*Canis aureus*
4	Indian flying Fox	*Pteropus giganteus*
5	Jungle Cat	*Felis chaus*
6	Fishing Cat	*Felis viverrina*
7	Small IndianMongoose	*Herpestes autopunctatus*
8	Field Mouse	*Mus booduga*
9	House Shrew	*Suncus murinus*
10	Asian Palm Civet	*Paradoxurus hermaphroditu*
11	Small Indian Civet	*Viverricula indica*
12	Irrawaddy squirrel	*Callosciurus pygerythrus*
13	Northern palm squirrel	*Funambulus pennantii*

No.	English Name	Scientific Name
14	Greater Bandicot Rat	*Bandicota indica*
Reptiles		
1	Indian Roofed Turtle	*Pangshura tectum*
2	Ganges softshell Turtle	*Aspideteres gangeticus*
3	Spotted Flapshell Turtle	*Lissemys punctata*
4	Common Garden Lizard	*Calotes versicolor*
5	Tokay Gecko	*Gekko gecko*
6	Common House Gecko	*Hemidactylus frenatus*
7	Keeled Grass skink	*Mabuya carinata*
8	Spotted Litter skink	*Sphenomorphus maculatus*
9	Bengal Monitor	*Varanus bengalensis*
10	Water Monitor	*Varanus salvator*
11	Jerdon's Blind Snake	*Typhlops jerdoni*
12	Olive Keelback	*Atretium schistosum*
13	Striped Keelback	*Amphiesma stolatum*
14	Common Smooth Water Snake	*Enhydris enhydris*
15	Common Wolf Snake	*Lycodon aulicus*
16	Indian Rat Snake	*Ptyas mucosus*
17	Checkered Keelback	*Xenochropis piscator*
18	Common Krait	*Bungarus caeruleus*
19	Indian Cobra	*Naja naja*
20	Monocled Cobra	*Naja kaouthia*
Amphibians		
1	Indian Bull Frog	*Hoplobactrachus tigerinus*
2	Ornate Microhylid	*Microhyla ornata*
3	Two-striped Grass Frog	*Sylvirana taipehensis*
4	Asian Brown Tree Frog	*Polypedates leucomystax*
5	Indian Tree Frog	*Polypedates maculatus*
6	Large Tree Frog	*Rhacophorus maximus*

Table 3: The list of wetland plants occurring within the study area

No..	Scientific Name	Local Name	Habit
1	*Alternanthera philoxiroides*	Helencha	*Herb*
2	*Arundo donax*	Baranal	*Herb*
3	*Ceratophyllum desmersum*	Jhangi	*Herb*
4	*Eclipta alba*	Kalokeshi	*Herb*
5	*Eichhornia crassipes*	Kochuripana	*Herb*
6	*Enhydra fluctuans*	Helencha	*Herb*
7	*Fimbristylis milliaceae*	Joina	*Herb*

No..	Scientific Name	Local Name	Habit
8	*Hygroryza aristata*	Putki	*Herb*
9	*Hydrocharis dubia*	-	*Herb*
10	*Ipomoea aquatica*	Kalmi sak	*Herb*
11	*Lemna perpusilla*	Khudipana	*Herb*
12	*Limnophila sessiliflora*	Bijatighas	*Herb*
13	*Ludwigia abscendens*	Keshordam	*Herb*
14	*Ludwigia hyssopifolia*	Keshordam	*Herb*
15	*Mersilea quadrifoliata*	Susnisak	*Herb*
16	*Monochoria hatata*	Kechur	*Herb*
17	*Myriophyllum tetrandrum*	-	*Herb*
18	*Nachamendra alternifolia*	Kaisa	*Herb*
19	*Nymphaea nouchali*	Shapla	*Herb*
20	*Nymphaea stellata*	Nilshapla	*Herb*
21	*Nymphoides indicum*	Panchuli	*Herb*
22	*Phragmites karka*	Nol	*Herb*
23	*Pistia stratiotes*	Topapana	*Herb*
24	*Polygonum barbatum*	Bishkatali	*Herb*
25	*Polygonum glabrum*	Bishkatali	*Herb*
26	*Polygonum lanatum*	Bishkatali	*Herb*
27	*Sagittaria sagittifolia*	Chhotokul	*Herb*
28	*Salvina cucullata*	Kuripana	*Herb*
29	*Scirpus juncoides*	Chisra	*Herb*
30	*Spirodela polyrhiza*	Khudipana	*Herb*
31	*Trapa natans*	Singra	*Herb*
32	*Vallisnaria spiralis*	*Bicha*	*Herb*

Annex 4

Sample Advertisement of the Consultation in the Local Newspaper

দৈনিক পূর্বাঞ্চল

The Daily Purbanchal

www.purbanchal.com

বিজ্ঞপ্তি

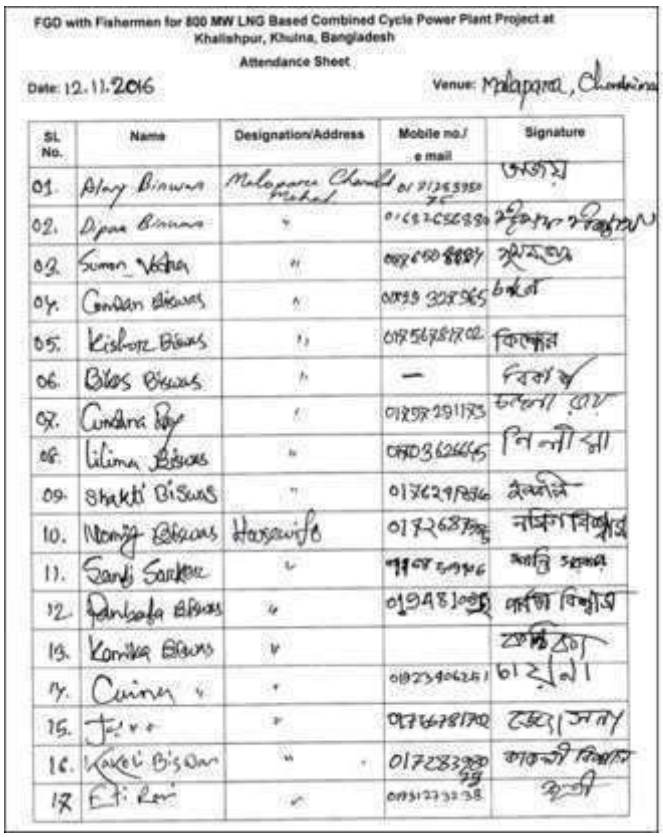
রূপকল্প-২০২১ অনুযায়ী 'পাওয়ার সিস্টেম মাস্টার প্লান, ২০১০' এর আলোকে ২০২১ সালের মধ্যে দেশের সকল ঘরে বিদ্যুৎ পৌঁছে দিতে বর্তমান সরকার প্রতিশ্রুতিবদ্ধ। সরকারের এ লক্ষ্য পূরণের উদ্দেশ্যে নর্থ-ওয়েস্ট পাওয়ার জেনারেশন কোম্পানি লিঃ (বাংলাদেশ বিদ্যুৎ উন্নয়ন বোর্ডের একটি প্রতিষ্ঠান) খুলনার খালিশপুরে রূপসা ৮০০ মেঃ ওঃ কম্বাইন্ড সাইকেল বিদ্যুৎ কেন্দ্র বাস্তবায়নের কাজ হাতে নিয়েছে। উক্ত প্রকল্প বাস্তবায়নের ফলে সম্ভাব্য পরিবেশগত ও আর্থ-সামাজিক প্রভাব সমীক্ষা করার জন্য পানি সম্পদ মন্ত্রণালয়ের অধীনস্থ CEGIS - কে দায়িত্ব দেয়া হয়েছে। এরই অংশ হিসেবে সংশ্লিষ্ট বিভিন্ন সরকারী ও বেসরকারী প্রতিষ্ঠান এবং জনগণের সুচিন্তিত মতামত ও পরামর্শ গ্রহণের লক্ষ্যে আগামী ২১ অক্টোবর, ২০১৭ইং তারিখ রোজ শনিবার সকাল ১১:০০ ঘটিকায় খুলনার খালিশপুরস্থ ইঞ্জিনিয়ার্স ইন্সটিটিউট-এর সম্মেলন কক্ষে একটি মতবিনিময় সভার আয়োজন করা হয়েছে। উক্ত মতবিনিময় সভায় উপস্থিত থেকে এ বিষয়ে আপনাদের সুচিন্তিত মতামত প্রদান করার জন্য অনুরোধ করা যাচ্ছে।

আর-৩৩০১

Annex 5

List of Participants during Consultations

A. 12-13 November 2016



FGD with Fishermen for 800 MW LNG Based Combined Cycle Power Plant Project at Khalishpur, Khulna, Bangladesh

Attendance Sheet

Date: 12.11.2016 Venue: Malapara, Chandbi...

SL No.	Name	Designation/Address	Mobile no./ e mail	Signature
01.	Alay Biswas	Malapara Chandbi Mahal	01712653950	
02.	Dipa Biswas	"	01552556884	
03.	Suman Vaidya	"	0155 6508887	
04.	Gouran Biswas	"	01733 328565	
05.	Kishore Biswas	"	01756781702	
06.	Bilas Biswas	"	—	
07.	Candana Roy	"	01758 291173	
08.	Lilima Biswas	"	01713626665	
09.	Shakti Biswas	"	01762978946	
10.	Monju Biswas	Housewife	01726877[illegible]	
11.	Sanji Sarkar	"	[illegible]	
12.	Ranjana Biswas	"	01948[illegible]	
13.	Konika Biswas	"		
14.	Quiney "	"	01923406261	
15.	Jiva "	"	01766781702	
16.	Kakoli Biswas	"	01728[illegible]	
17	Eti Rani	"	01512732738	

SL No.	Name	Designation/Address	Mobile no./ e mail	Signature
18	Anjona	Malapara, Chandbi Mahal	01726637454	
19	Mita	"	01892350956	
20	Monna	"	01961157185	
21	Mangna	"	01918[illegible]	
22	Biswajit	"	0192[illegible]	
23	chanli	"	01768[illegible]	
24	Jagannath	"	01721[illegible]	
25	Polok		01627[illegible]	
26	Anup		01961162185	
27	Nikhil		01756607808	
28	Bishwa		01892330[illegible]	
29	Eti Biswas		01931273238	
30	Kalpana		01767721865	
31	Amit		01766[illegible]	
32	Robin Biswas		0	
33	Pappu		01938[illegible]	
34	Mithun		01921[illegible]	
35	Shanti		01961162185	

Fisherfolks in Dighalia

Imam and mosque adherents

Mosque

FGD with Imam and adherent for 800 MW LNG Based Combined Cycle Power Plant Project at Khalishpur, Khulna, Bangladesh

Attendance Sheet

Date: 12.11.2016 Venue: IEB, Khulna

SL No.	Name	Designation/Address	Mobile no./ e mail	Signature
01.	NAZ MOSSAMOL	[illegible]	01911[illegible]	
02.	MD. AMINUR		01925[illegible]	
03.	MD. SHALIM[illegible]		01722[illegible]	
04.	MD. GAMAL		01774[illegible]	
05.	MD. MOKLAS		01737[illegible]	
06.	MD. Faruk, Ali			
07.	MD. Rabbi			
08.	HARUN OR RASID		01918[illegible]	
09.	HABIBOR RAHMAN		01911[illegible]	
10.	ASAD HOSSEN			
11.	JAFOR IQBAL			
12.	Ismail [illegible]		01911[illegible]	
13.	[illegible]		01711[illegible]	
14.	[illegible]		01[illegible]	
15.	MD [illegible]		01911[illegible]	
16.	Mahmood Hasan		01[illegible]	
17.	MD. Najib		01[illegible]	

MOSQUE

Date: 12.11.2016 Venue: IEB, Khulna

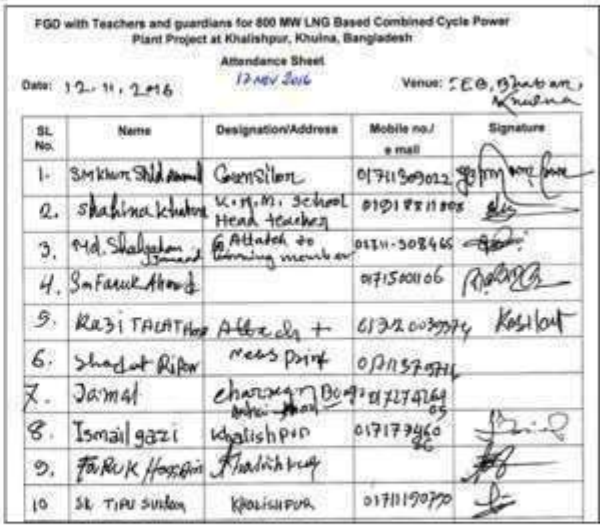
SL No.	Name	Designation/Address	Mobile no./ e mail	Signature
18	MD Faruk [illegible]		01[illegible]	
19	G.M. Nasrul [illegible]		01716[illegible]	
	Yusuf		01912[illegible]	
20	Bakir Hasan		01[illegible]	
21	Dr. [illegible]	[illegible]	01917[illegible]	
22	Yun [illegible]	ADB	[illegible]	
23	Yinping Jing	ADB	[illegible]	
24	[illegible]	[illegible]	[illegible]	
25	Engr. Rafiqul [illegible]	CEGIS	01711 [illegible]	
26	[illegible]	[illegible]	[illegible]	
27	[illegible]	[illegible]	[illegible]	

Government officials, school management committee, students, etc.

12 NOVEMBER 2016
IEE CONSULTANT
KHULNA

800 MW KHULNA POWER PROJECT
STAKEHOLDERS' CONSULTATION MEETING
FGD (BOYS & GIRLS SCHOOL)
TERMINAL & PROJECT

SL No.	Name	Designation/Address	Mobile no./ e mail	Signature
1	[illegible]	[illegible]	[illegible]	
2	REISHA JONES	[illegible]	[illegible]	
3	MAHBUBUL HAQUE	K.N.M SCHOOL Ass. teacher	01915199985	
4	NAZMUSSAKIB	K.N.M school Ass. teacher	01961174775	Sakib
5	MITHUN MONDAL	Asst. teacher K.N.M school	01917-565659	
6.	Afsih Islam	Student	01770757[illegible]	
7.	SALMA BEGUM	Guardian, KNM school	01611180083	Salma
8.	Sufia Begum	Guardian. KNM School.	01947238516	
10.	Choudhury Habiba Rahman.	SMC	01911710[illegible]	
11.	Shahina Khatun	Head teacher K.N.M School	01911811[illegible]	
12	Farzana Rahman	student	01719[illegible]	Farzana
13	Yaojung Jang	ADB	+63 999 999 3413	
14	Yuri Zhou	ADB	+63 999 999 3413	
15	Dr. Kazi Nooruz CEGIS	CEGIS	01817549[illegible]	
16	Jalal Ahmed choudhury	CEGIS	01933242[illegible]	Jalal
17.	Pronab K. Shill	Environmental Expert CEGIS	01717530[illegible]	
18.	SM Khurshid Alam	Commissioner	01711309022	
19.	Engr. Rafiul Islam	Electrical Engg.	01810 961061	



FGD with Teachers and guardians for 800 MW LNG Based Combined Cycle Power Plant Project at Khalishpur, Khulna, Bangladesh

Attendance Sheet

Date: 12.11.2016 17 NOV 2016 Venue: IEE, Khulna

SL No.	Name	Designation/Address	Mobile no./ e mail	Signature
1.	SM Khurshid Alam	Commissioner	01711309022	
2.	Shahina Khatun	K.N.M. School Head teacher	01911811[illegible]	
3.	Md. Shahjahan	Attached to Planning member	0131-508465	
4.	Sm Faruk Ahmed		01715001106	
5.	Razi TALAT Hossain	Advocate	01320039[illegible]	
6.	Shadat Rifat	News Point	01711570[illegible]	
7.	Jamal	Chairman Boat	01717[illegible]	
8.	Ismail gazi	Khalishpur	01717[illegible]	
9.	Faruk Hossain	Khalishpur		
10	Sk. Tipu Sultan	Khalishpur	01711190770	

B. 21 October 2017

খুলনা ৮০০ মেগাওয়াট কয়লাভিত্তিক সাইকেল বিদ্যুৎ কেন্দ্র প্রকল্পের পরিবেশগত ও আর্থ-সামাজিক প্রভাব নিরূপণ বিষয়ক মতবিনিময় সভা উপস্থিতির তালিকা

স্থান: সম্মেলন কক্ষ, ইঞ্জিনিয়ার্স ইনস্টিটিউট ইন্সটিটিউট, খালিশপুর, খুলনা।

তারিখ: ২১ অক্টোবর, ২০১৭ খ্রি

সময়: সকাল ১১:০০

ক্রমিক নং	নাম	পদবী/ঠিকানা	ইমেইল ও মোবাইল নং	স্বাক্ষর
১.	[illegible]	[illegible]	[illegible]	[illegible]
২.	[illegible]	[illegible]	০১৭১১-৬৪৯৩২২	[illegible]
৩.	[illegible]	[illegible]	০১৭১১-৪২২ ৪৭০	[illegible]
৪.	[illegible]	[illegible]	০১৭৫৫-৫৩০৫৩	[illegible] 21.10.17
৫.	[illegible]	[illegible]	০১৭৩-০৬৫৭৪৭	[illegible] 21.10.17
৬.	Shariful Islam	Consultant/ADB	০১৭৭৫৪৭৭৫৬	[illegible]
৭.	Ruby Dewkra Africa	ADB - Environment Consultant	—	[illegible]
৮.	Shamsuddin Ahmed	ADB - Consultant (Gas Sector Specialist)	shams7.bd@gmail.com	[illegible]
৯.	Mohsin Jahir	ADB Bank	mnahar@adb.org	[illegible]
১০.	[illegible]	[illegible]	[illegible]	[illegible]
১১.	[illegible]	[illegible]	০১৩৩৪৭৪৭৮২	[illegible]
১২.	[illegible]	[illegible]	০১৭১২-২০২৮৪	[illegible]
১৩.	Shaikh Waseem	Shaikh Waseem	[illegible]	[illegible]
১৪.	Aziz Yusupov	Energy Spec ADB	[illegible]	[illegible]
১৫.	Md Shahidul Monir Jowadar	[illegible]	[illegible]	[illegible]

খুলনা ৮০০ মেগাওয়াট কয়লাভিত্তিক সাইকেল বিদ্যুৎ কেন্দ্র প্রকল্পের পরিবেশগত ও আর্থ-সামাজিক প্রভাব নিরূপণ বিষয়ক মতবিনিময় সভা উপস্থিতির তালিকা

স্থান: সম্মেলন কক্ষ, ইঞ্জিনিয়ার্স ইনস্টিটিউট ইন্সটিটিউট, খালিশপুর, খুলনা।

তারিখ: ২১ অক্টোবর, ২০১৭ খ্রি

সময়: সকাল ১১:০০

ক্রমিক নং	নাম	পদবী/ঠিকানা	ইমেইল ও মোবাইল নং	স্বাক্ষর
১৬.	Syed Imdad Hossain	Manager, GTCL Aranyghata, Khl	Gossain.um@gmail.com 01709639723	[illegible]
১৭.	Engr. Nizam uddin	manager SoC 01711047398	uddinengr@gmail.com	[illegible]
১৮.	Abdullah Al Mamun	Asst. Teacher 01710027985	[illegible]	[illegible]
১৯.	[illegible]	[illegible]	01713 [illegible]	[illegible]
২০.	Mahuda Faraiin	Manager(Env)(Unit) NWPGCL	[illegible] 01777736409	[illegible] 21.10.17
২১.	MD. Jamal uddin	AM (EHS) NWPGCL	Jamalmy666@gmail.com	[illegible] 21.10.17
২২.	MD. HAMAT ALI	XEN NWPGCL	[illegible]	[illegible] 21.10.17
২৩.	Kamal Alam Khan	Assistant Secretary AL-13	[illegible]	[illegible]
২৪.	Md Zakir Hossain	13 no Ward [illegible]	01712179692	[illegible]
২৫.	[illegible]	[illegible]	[illegible]	[illegible]
২৬.	[illegible]	[illegible]	[illegible]	[illegible]
২৭.	[illegible]	[illegible]	[illegible]	[illegible]
২৮.	[illegible]	[illegible]	[illegible]	[illegible]
২৯.	[illegible]	[illegible]	01616229332	[illegible]
৩০.	[illegible]	[illegible]	01919606449	[illegible]
৩১.	[illegible]	[illegible]	01926291008	[illegible]

খুলনা ৮০০ মেগাওয়াট কম্বাইন্ড সাইকেল বিদ্যুৎ কেন্দ্র প্রকল্পের পরিবেশগত ও আর্থ-সামাজিক প্রভাব নিরূপণ বিষয়ক মতবিনিময় সভা উপস্থিতির তালিকা

ক্ষুদ্র সম্মেলন কক্ষ, ইঞ্জিনিয়ার্স ইনস্টিটিউট ইনস্টিটিউট, খালিশপুর, খুলনা।

তারিখ ২১ অক্টোবর, ২০১৭ খ্রি সময়: সকাল ১১:০০

ক্রমিক নং	নাম	পদবী/ঠিকানা	ইমেইল ও মোবাইল নং	স্বাক্ষর
০১.	[illegible] দাস	চরখালিশপুর, ৬নং ওয়ার্ড		[illegible]
০২.	[illegible] দাস	চরখালিশপুর, ৬নং ওয়ার্ড		[illegible]
০৩.	শাহীন বিশ্বাস	চরখালিশপুর, ৬নং ওয়ার্ড		শাহীন বিশ্বাস
০৪.	[illegible]	১৬ ওয়ার্ড		[illegible]
০৫.	মো: রিপু [illegible]	১০নং ওয়ার্ড, [illegible]		[illegible]
০৬.	মো: [illegible]	[illegible]		[illegible]
০৭.	[illegible]	[illegible]		[illegible]
০৮.	[illegible]			
০৯.	মো: [illegible]	কে. ডি. এ.	01917710447	[illegible]
১০.	সাহিনা খাতুন	[illegible]	01918811008,	[illegible] 21.10.2017
১১.	অপর্ণা রায়	সহকারী শিক্ষক [illegible]	01927406881	[illegible] 21.10.17
১২.	মুক্তা	[illegible]	01782550353	Mukta
১৩.	[illegible]	[illegible]	0171[illegible]	[illegible]
১৪.	[illegible] পুতুল	[illegible]	019[illegible]	Putul
১৫.	নুপুর	[illegible]	0173 5[illegible]	Nupur

3

খুলনা ৮০০ মেগাওয়াট কম্বাইন্ড সাইকেল বিদ্যুৎ কেন্দ্র প্রকল্পের পরিবেশগত ও আর্থ-সামাজিক প্রভাব নিরূপণ বিষয়ক মতবিনিময় সভা উপস্থিতির তালিকা

ক্ষুদ্র সম্মেলন কক্ষ, ইঞ্জিনিয়ার্স ইনস্টিটিউট ইনস্টিটিউট, খালিশপুর, খুলনা।

তারিখ ২১ অক্টোবর, ২০১৭ খ্রি সময়: সকাল ১১:০০

ক্রমিক নং	নাম	পদবী/ঠিকানা	ইমেইল ও মোবাইল নং	স্বাক্ষর
১৬.	মো: [illegible]	[illegible]	[illegible]	[illegible]
১৭.	মো: [illegible]	[illegible]	01739447955	[illegible]
১৮.	[illegible]	[illegible]	01917-[illegible]	[illegible]
১৯.	[illegible]	[illegible]	01[illegible]	[illegible]
২০.	[illegible]	[illegible]	0172003939	[illegible]
২১.	মো: [illegible]	[illegible]	01954-443450	[illegible]
২২.	[illegible]	[illegible]	0171617003[illegible]	[illegible]
২৩.	[illegible]	[illegible]	017777 3[illegible]	[illegible]
২৪.	মো: [illegible]	[illegible]	01948157910	[illegible]
২৫.	[illegible]	[illegible]	—	[illegible]
২৬.	Yoojung Jung	ADB-HQ	[illegible]@adb.org	[illegible]
২৭.	ZHANJING MU	ADB	[illegible]@adb.org	[illegible]
২৮.	SM Faruk Ahmed	BUSINESS	0171500[illegible]	[illegible]
২৯.	মো: [illegible] ইসলাম	[illegible]	01921390469	[illegible]
৩০.	[illegible]	[illegible]	[illegible]	[illegible]

4

খুলনা ৮০০ মেগাওয়াট কম্বাইন্ড সাইকেল বিদ্যুৎ কেন্দ্র প্রকল্পের পরিবেশগত ও আর্থ-[illegible]
নিরূপণ বিষয়ক মতবিনিময় সভা উপস্থিতির তালিকা

ক্ষুদ্র সম্মেলন কক্ষ, ইঞ্জিনিয়ার্স ইনস্টিটিউট ইনস্টিটিউট, খালিশপুর, খুলনা।

তারিখ ২১ অক্টোবর, ২০১৭ খ্রি সময়: সকাল

ক্রমিক নং	নাম	পদবী/ঠিকানা	ইমেইল ও মোবাইল নং	
৩১.	[illegible]	[illegible]	[illegible]@[illegible].com 01[illegible]	[illegible]
৩২.	[illegible] ইসলাম	Electrical [illegible] CEGIS	01710-564066	[illegible]
৩৩.	ড. [illegible]	Advisor, CEGIS	[illegible]@cegisbd.com	[illegible] 21/10/17
৩৪.	Md. Hasan	AGM. IEB KLN.	01558[illegible]	[illegible] 21/10/17
৩৫.				

Annex 6

Photo documentation of Consultations

A. 12-13 November 2016


Consultation workshop


FGD with KNM School Management Committee and teachers


FGD with Imam and KNM mosque adherents

FGD with fisherfolks

B. 21 October 2017


Project Presentation by CEGIS and NWPGCL


Representatives from Khulna City Corporation




Q & A Portion

Annex 7
Handout in Bengali Given During Consultation, 21 October 2017

নর্থওয়েস্ট পাওয়ার জেনারেশন কোম্পানী কর্তৃক অত্র এলাকায় গৃহীত খুলনা ৮০০ মেগাওয়াট গ্যাস ও তেল ভিত্তিক কম্বাইন্ড সাইকেল বিদ্যুৎ কেন্দ্র এবং সংশ্লিষ্ট উপাদান সমূহের তথ্য, খুলনা

✓ সভার মূল উদ্দেশ্য

- অদ্যকের সভার মূল উদ্দেশ্য হচ্ছে প্রস্তাবিত ২ x ৪০০ (৮০০) মেগাওয়াট গ্যাস ও তেল ভিত্তিক বিদ্যুৎ প্রকল্প ও অত্র প্রকল্প সংশ্লিষ্ট উপাদান সমূহ স্থাপিত হলে প্রকল্প সংলগ্ন এলাকায় কী ধরণের পরিবেশগত ও আর্থ-সামাজিক প্রভাব পড়তে পারে এ সম্বন্ধে এলাকার জনগোষ্ঠীর মতামত গ্রহণ করা।
- একই সাথে প্রকল্প নকশা ও নির্মাণ পর্যায়ে জনগণের প্রভাব নেওয়া যাতে প্রকল্প বাস্তবায়নে তাদের আকাঙ্ক্ষার প্রতিফলন ঘটে।

✓ প্রস্তাবিত প্রকল্প ও সংশ্লিষ্ট বিষয়াদি

- *বাংলাদেশ সরকার ক্রমবর্ধমান বিদ্যুতের চাহিদা পূরণের লক্ষ্যে একটি মহাপরিকল্পনা, Power System Master Plan প্রণয়ন করে, যার মূল প্রতিপাদ্য বিষয় হচ্ছে:*
  - স্থানীয় যথাযথীকরণ যেমন: গ্যাস, এলএনজি, কয়লা, এইচএসডি, ফার্নেস অয়েল দক্ষতাসম্পন্ন স্থাপনাদি ইত্যাদি।
  - স্থানীয় উৎস সর্বোচ্চকরণ ও এর সর্বোত্তম ব্যবহার নিশ্চিত করণ।
  - স্থানীয় উৎসের ও সরবরাহের সুবিধাদির ভিত্তিতে বিদ্যুৎ প্রকল্প নির্বাচনে ছান নির্ধারণ।
  - বিদ্যুতের ক্রমবর্ধমান চাহিদার উপর ভিত্তি করে উৎপাদন ক্ষমতা বৃদ্ধি করা, যা জাতীয় বিদ্যুৎ গ্রীডের মাধ্যমে নিরবিচ্ছিন্নভাবে বিদ্যুৎ সরবরাহ করতে পারবে।
- *ডলকল্প-২০২১ অনুযায়ী 'পাওয়ার সিস্টেম মাস্টার প্লান, '২০১০ ও ২০১৬' এর আলোকে দেশের দক্ষিণে বিদ্যুৎ পৌঁছে দেয়ার লক্ষ্যে নর্থ-ওয়েস্ট পাওয়ার জেনারেশন কোম্পানী লি: (NWPGCL) খুলনা জেলায় গ্যাস ও তেল ভিত্তিক বিদ্যুৎ প্রকল্প নির্মাণ করে ১০০০ মেগাওয়াটের অধিক বিদ্যুৎ উৎপাদনের লক্ষ্য নির্ধারণ করেছে।*

✓ পরিবেশগত ও আর্থ-সামাজিক প্রভাব বিশ্লেষণ সংক্রান্ত তথ্য সংগ্রহ ও প্রয়োজনীয় পরীক্ষানিরীক্ষা

- *CEGIS এই প্রকল্পটির পরিবেশগত ও আর্থ-সামাজিক প্রভাব বিশ্লেষণে দায়িত্বপ্রাপ্ত হয়ে বিভিন্ন পর্যায়ে এলাকার জনগনের সাথে এই বিষয়ে আলাপ আলোচনা করে পরিবেশ ও আর্থ-সামাজিক প্রেক্ষাপটের বর্তমান অবস্থা বিশ্লেষণ করার চেষ্টা করেছে এবং পরিবেক্ষণ করার জন্য সংশ্লিষ্ট অফিসগুলো থেকেও তথ্য সংগ্রহ করে, যেমন:*
  - বৃষি অফিস থেকে ফসল, ফসলী জমি ও সেচ সংক্রান্ত তথ্য।
  - মৎস্য অফিস থেকে মাছ ও মাছের আবাস সংক্রান্ত তথ্য।
  - ইউনিয়ন পরিষদ থেকে সামাজিক ও অর্থনৈতিক বিষয়াদি সংক্রান্ত বিভিন্ন তথ্য।
  - বিভিন্ন প্রকার শিল্প থেকে নির্গত দূষণ সম্পর্কিত তথ্য সংগ্রহ।
- *প্রকল্প এলাকার বিভিন্ন বৈশিষ্ট সঠিকভাবে বিশ্লেষণ করার নিমিত্তে নিম্নলিখিত পরীক্ষা-নিরীক্ষা করা হয়:*
  - ভূ-তাত্ত্বিক জরিপ যার মাধ্যমে প্রকল্প এলাকার মাটি ভঙ্গুর-পূর্ণ পানি সম্বন্ধে ধারণা পাওয়া।
  - বন্যার পানির সর্বোচ্চ উচ্চতার বিষয়টি বিশ্লেষণ করে কতটুকু মাটি ভরাট করতে হবে তা জানা।
  - পানির গুণাগুণ যাচাই করার জন্য ভূ-পৃষ্ঠ ও ভূ-পৃষ্ঠ পানি পরীক্ষা-নিরীক্ষা করা হয়।
  - বায়ুর দূষণ মাত্রা যাচাই করার জন্য বায়ু পরীক্ষা-নিরীক্ষা করা হয়।
  - শব্দ দূষণ মাত্রা যাচাই করার জন্য শব্দ দূষণ যন্ত্র ব্যবহার করা এবং দূরত্ব থেকে ৫০০ মি. চারপাশে শব্দ দূষণ পরিমাপক যন্ত্রের মাধ্যমে শব্দের তীব্রতা মাপা হয়।
- *পরিবেশগত ও সামাজিক প্রভাব বিশ্লেষণের জন্য প্রকল্পকে কেন্দ্র করে চারপাশে ১০ কি.মি এলাকা পরিবেক্ষণ করা হয়েছে*

✓ পরিবেশগত ও আর্থসামাজিক প্রভাব বিশ্লেষণ - প্রকল্প বাস্তবায়ন পরবর্তী অবস্থা বিশ্লেষণ (পরিবেশগত প্রভাব বিশ্লেষণ)

- *৮০০ মেগাওয়াট গ্যাস ও তেল ভিত্তিকবিদ্যুৎ প্রকল্প বাস্তবায়ন পরবর্তী পরিবেশগত প্রভাব বিশ্লেষণ*
  - বিভিন্ন সংবেদনশীল এলাকায় বায়ু দূষণের মাত্রা মাপা হয়েছে এবং বায়ু দূষণের ক্ষেত্রে আন্তর্জাতিক মানদন্ডের মাধ্যমে CO_2, SO_x, NO_x বিশ্লেষণ করে দেখা গেছে উল্লিখিত দূষণের মাত্রা বাংলাদেশ ও আন্তর্জাতিক গ্রহণযোগ্য সীমার নীচে আছে।
  - শব্দ দূষণের মাত্রা উল্লিখিত শব্দ দূষণ নিয়ন্ত্রন বিধি-২০০৬ এর গ্রহণযোগ্য সীমার নীচে থাকবে।
  - মেশিন চালুকালে ভূ-কম্পনের মাত্রা সহনশীল পর্যায়ে থাকবে।
  - প্রকল্প চালু করার সময় তুলি টাওয়ার এর জন্য টৈবর নল থেকে একশীল ৪০,০০০ ঘন মিটার পানি উত্তোলন করা হবে এবং পরবর্তীতে প্রকল্প চালু অবস্থায় টৈবর নল থেকে প্রতি ঘন্টায় ২১০ ঘন মিটার পানি উত্তোলন করা হবে যা খুবই কম এবং চলমান নদী প্রবাহের মাত্র ০.১২%।
  - ভূ-পৃষ্ঠ পানিস্তরের মাত্রা বর্তমানে উল্লিখিত ইলিয়াস- ১৯৯৭ এর গ্রহণযোগ্য সীমার নীচে থাকবে।
  - বিদ্যুৎ কেন্দ্র থেকে নির্গত তরল পদার্থ পরিশোধিত করে গ্রহণযোগ্য সীমার মধ্যে রাখতে হবে নতুন পরিবেশ বিপন্ন হবে।
  - বৃষ্টিপাতের পানির কোন সংকট হবে না এবং মাছ চাষের উপর কোন বিরুপ প্রভাব পড়বে না।
  - ২১৫ টি গাছের উপর প্রভাব পড়বে যা আইইসিএন এর লাল তালিকা বহির্ভূত।
- *গ্যাস পাইপলাইন প্রকল্প বাস্তবায়ন পরবর্তী পরিবেশগত প্রভাব বিশ্লেষণ*
  - উল্লিখিত গ্যাস পাইপলাইন প্রকল্প বাস্তবায়নের ফলে বায়ু দূষণ, শব্দ দূষণ, বর্জ্য দূষণ, পানি দূষণ অথবা সংশ্লিষ্ট এলাকায় পানির কোন অভাব দেখা দেবে না। এছাড়া উক্ত প্রকল্পের কারণে কৃষি জমি ও মাছ চাষ প্রকল্পের কোন ক্ষতি হবে না। তবে ১৮.৫০ কিমি পাইপলাইনের জন্য কিছু গাছের উপর প্রভাব পড়বে যা বাংলাদেশ সরকার উল্লিখিত নির্ভিউটিল বহির্ভূত। উল্লেখ্য, উক্ত প্রকল্পের কারণে কোন প্রানি যা সর্বত্রকারে পরিবেশের উপর তাৎপর্যপূর্ণ কোন প্রভাব পড়বে না।
- *ওকরবেড ট্রান্সমিশন লাইন প্রকল্প বাস্তবায়ন পরবর্তী পরিবেশগত প্রভাব বিশ্লেষণ*
  - উল্লিখিত ওকরবেড ট্রান্সমিশন লাইন প্রকল্প বাস্তবায়নের ফলে বায়ু দূষণ, শব্দ দূষণ, বর্জ্য দূষণ, পানি দূষণ অথবা পানির কোন অভাব দেখা দেবে না। উক্ত ২৯ কিমি ২৩০ কেভি লাইন কোন প্রানি, কৃষি জমি এবং সামাজিকভাবে পরিবেশের উপর তাৎপর্যপূর্ণ কোন প্রভাব ফেলবে না।

✓ পরিবেশগত ও আর্থসামাজিক প্রভাব বিশ্লেষণ - প্রকল্প বাস্তবায়ন পরবর্তী অবস্থা বিশ্লেষণ (আর্থসামাজিক প্রভাব বিশ্লেষণ)

- গ্যাস ও তেল ভিত্তিক ৮০০ মেগাওয়াট কম্বাইন্ড সাইকেল বিদ্যুৎ প্রকল্প স্থাপনের জন্য খুলনা সরকারি সিটিকলিজি মিলের পরিত্যক্ত ৫০ একর জমি দেয়া হয়েছে। উক্ত এলাকায় পরিত্যক্ত মিলের ৩৫টি পরিবার স্থানান্তরিত হওয়ার কারণে অর্থনৈতিকভাবে প্রভাবিত হবে। অত্র জরিপে প্রকল্প এলাকায় কোন অধিবাসি ও ঘুকিপূর্ণ পরিবার নেই।
- অত্র প্রস্তাবিত ৮০০ মেগাওয়াট বিদ্যুৎ প্রকল্প এলাকায় বর্তমানে অবস্থিত ০১ টি বাণক উচ্চ বিদ্যালয় ও ০১ টি কলিজা উচ্চ বিদ্যালয় স্থানান্তরিত করা হবে। ২১৫ টি গাছ অপিহার্য হবে।
- গ্যাস ট্রান্সমিশন লাইন (১৮.৫০ কিমি) খুলনা বাস্তা সংলগ্ন সড়ক ও জনপদের জমির উপর স্থাপিত হবে। এ ক্ষেত্রে মূর্তি সহ মোট ২৪ টি ক্ষুদ্র ব্যবসায়িকে নিকটবর্তী পরিত্যক্ত জায়গায় স্থানান্তরিত করা হবে এবং ৫২৯ টি গাছ অপিহার্য হবে। এ কিমি লাইন লাইনের ক্ষেত্রে প্রস্তাব লাগের ০৯ টি ক্ষুদ্র দোকান ব্যবসায়ী নিকটবর্তী স্থানে স্থানান্তরিত হবে ও ৪০ টি গাছ অপিহার্য হবে। উল্লেখ্য কোন স্থাপনা অপিহার্য হবে না।
- ২৯ কিমি ওকরবেড ট্রান্সমিশন লাইন প্রকল্প কৃষি জমি, নদী এবং বিভু খাড়ী, সামাজিক প্রতিষ্ঠানের উপর দিয়ে যাবে তবে কোন প্রত্নতাত্ত্বিক এবং ঐতিহাসিক স্থাপনার উপর দিয়ে যাবে না। উল্লিখিত প্রকল্পের আওতায় টাওয়ার স্থাপনের ফলে ০৭ টি পরিবার স্থায়িভাবে অপিহার্য হবে যার মধ্যে ০৫ টি পরিবারের ঘরবাড়ীও অপিহার্য হবে এবং অপিহার্যদের মধ্যে ০২ টি পরিবার ঘুকিপূর্ণ। এছাড়া উক্ত প্রকল্পের কারণে পশ্য ও ০১ টি মাছের ঘের সাময়িকভাবে অপিহার্য হবে।

- **বায়ু দূষণ মোকাবেলায় করণীয়:**

  - Advance Dry Low NOx Burner যা বায়ুর একরকম দূষণ (NOx)-কে নিয়ন্ত্রণ করবে।
  - প্রস্তাবিত চত্বরটিকে ও খোলা জায়গায় সবুজ বেষ্টনী তৈরীর ব্যবস্থা রাখা হয়েছে যা বায়ু দূষণের প্রভাবকে নিয়ন্ত্রণ করবে।
  - প্রধান ও বাইপাস চিমনীর উচ্চতা যথাক্রমে ন্যূনতম ৬০ মি. ও ৫০ মি. হবে যাতে প্রস্তাবিত ধোঁয়া আকাশে মিশিয়ে যায় এবং পরিবেশের উপর ক্ষতিকর প্রভাব না ফেলে।

- **পানি দূষণ মোকাবেলায় করণীয় :**

  - তুলিং টাওয়ারের কারণে কোন প্রকার গরম পানি নদীতে পড়বে না।
  - প্রস্তাবিত নির্গত পানি যথাযথ পরীক্ষা-নীরিক্ষার পর পুণ:ব্যবহার করা হবেতা পরিবেশের উপর কোন ক্ষতিকর প্রভাব ফেলবে না।
  - তেল ও গ্রীজ পানি থেকে আলাদা করণের জন্য বেটুমিক্টিাপল যন্ত্রের ব্যবহারের ব্যবস্থা রাখা হয়েছে। অপসারকৃত তেল এলাকার ভেন্ডরদের কাছে বিক্রি করা হবে।
  - বিদ্যুৎকেন্দ্র থেকে নিঃসরিত তরল আধুনিক বর্জ্য ব্যবস্থাপনার (ETP) মাধ্যমে পরিশুদ্ধ করা হবে। ফলে নদীর মাছ ও পানির তেমন কোন ক্ষতি হবে না।
  - প্রস্তাবিত বিদ্যুৎকেন্দ্রে পয়ঃনিষ্কাশন ব্যবস্থাপনারও সুবিধা থাকবে।

- **পানি উত্তোলন সীমিতকরণ ব্যবস্থা:**

  - প্রকল্প চলু অবস্থায় তৈরব নদ থেকে প্রতি ঘণ্টায় ২১০ ঘন মিটার পানি উত্তোলন করা হবে যা খুবই কম এবং চলমান নদী প্রবাহের মাত্র ০.১২%।
  - উল্লেখ্য, সর্ত অনুসারে প্রকল্প চালুর জন্য কখনই ভূ-গর্ভস্থ পানি উত্তোলন করা হবে না।
  - উক্ত বিদ্যুৎ কেন্দ্রে ব্যবহৃতকৃত জনসাধারনের ব্যবহার পানির জন্য পৃথক ব্যবস্থা করণ পাইপ লাইন দ্বারা সরবরাহকৃত পানি ব্যবহার করা হবে।

- **শব্দ দূষণ মোকাবেলায় করণীয়:**

  - আধুনিক প্রযুক্তি সম্বলিত মেশিনারী স্থাপন করা।
  - ঘূর্ণন মেশিনারীর জন্য শব্দ দূষণ প্রতিরোধী ছাদ বা ঢাকনার ব্যবস্থা করা।
  - প্রস্তাবিত চত্বরটিকে ও খোলা জায়গায় সবুজ বেষ্টনী তৈরীর ব্যবস্থা রাখা হয়েছে যা শব্দ দূষণের প্রভাবকে নিয়ন্ত্রণ করবে।
  - শব্দ দূষণ কমানোর জন্য প্রয়োজন স্থানে ক্ষুদ্র ভিত্তিক দেশীয় জাতের গাছ লাগানো।
  - ঘূর্ণন মেশিনারীর ভিতরে যারা কাজ করবে তাদেরকে অবশ্যই সিলিই (PPE) যেমন: ইয়ার প্লাগ, মাফলার ইত্যাদি পরতে হবে।
  - ধোঁয়া বের হওয়ার পথে চিমনীতে সাইলেন্সার লাগানো।
  - শব্দ প্রশমনীয় দেয়াল নির্মাণ করা।

- **কম্পন মোকাবেলায় করণীয়:**

  - মীয় (স্ট্রো ১/১০০০ ইঞ্চি) প্রযুক্তির ব্যবহার করা।

- **পরিবেশ ও জলজ প্রাণি ব্যবস্থাপনায় করণীয়:**

  - প্রস্তাবিত ৮০০ মেগাওয়াট বিদ্যুৎ কেন্দ্র হতে নিঃসৃত সকল তরল বর্জ্য ও পয়ঃনিষ্কাশন যথাক্রমে ইটিপি (ETP) ও এসটিপি (STP) এর মাধ্যমে পরিশোধিত করে মাণসম্মত বাংলাদেশ বিধি ও আইএফসি (IFC) গাইডলাইনের প্রযোজ্য সীমার মধ্যে রাখা হবে যাতে জলজিন সহ পরিবেশ ও জীববৈচিত্র দূষণের প্রভাব মুক্ত থাকে।

  - প্লান্ট সাইন ও OHT line এর ক্ষেত্রে প্রকল্প এলাকার কর্মচারীদের বাসস্থানের পয়ঃনিষ্কাশন পরিশোধনের মাধ্যমে বাংলাদেশ বিধি (ECR,1997) প্রযোজ্য সীমার মধ্যে রাখা হবে।
  - অত্র প্রকল্প চালু অবস্থায় EMP সংক্রান্ত পর্যবেক্ষণ ব্যবস্থা নিয়মিত করন থাকবে এবং উক্ত পর্যবেক্ষণ এর আওতায় প্রকল্প এলাকার পরিবেশ ও জীববৈচিত্র (জলজিন সহ) এর উপর নিরীক্ষা করা হবে এবং প্রয়োজনীয় প্রশমন পরিক্ষন অনুযায়ী ব্যবস্থা নেয়া হবে।

✓ **আর্থসামাজিক সম্পর্কীয় প্রশমনব্যবস্থা**

- *৮০০ মেগাওয়াট বিদ্যুৎ প্রকল্প বাস্তবায়ন পরবর্তী আর্থসামাজিক সম্পর্কীয় প্রশমনব্যবস্থা*

  - অত্র প্রকল্পটি বাস্তবায়নের জন্য উদ্বৃত্বিত খুলনা সরকারি সিটিকর্পোরেশন মিলের পরিত্যক্ত ৫০ একর জমি সরকারি প্রথা অনুসারে নির্ধারিত মূল্য পরিশোধ সাপেক্ষে মেসার্স এয়েসী পাওয়ার জেনারেশন কোম্পানী লি: এর অনুকূলে বরাদ্দ দেয়া হয়েছে।
  - অত্র প্রস্তাবিত প্রকল্প এলাকায় উদ্বৃত্বিত ০২ টি বিদ্যালয় (০১ টি বালক ও ০১ টি বালিকা) পরিত্যক্ত পেপার মিলের অধিশী (৩৭.৮০ একর) জমির উপর পূর্ণনির্মিত হবে যা পাওয়ার প্লান্টের সীমানার বাইরে অবস্থিত। এবং উক্ত বিদ্যালয় দুটিতে উন্নতমানের পাকা ইমারতসহ প্রয়োজনীয় আধুনিক সুযোগ সুবিধা যথা: কম্পিউটার ল্যাব, বিজ্ঞানাগার, পাঠাগার, খেলার মাঠ, সুপেয় পানি,শৌচাগার, ইত্যাদির সুব্যবস্থা থাকবে।
  - উক্ত এলাকায় পরিত্যক্ত মিলের ০৫টি স্থানান্তরিত পরিবারকে মেসার্স এয়েসী পাওয়ার জেনারেশন কোম্পানী লি: কর্তৃক ক্ষতিপূরণ দেয়া হবে।
  - উক্ত প্রকল্প এলাকা সংলগ্ন মসজিদ ও কবরস্থানের সংস্কার করা হবে এবং প্রকল্পাধীন সর্বসাধারনের ব্যবহারের জন্য ব্যবস্থা থাকবে।

- *গ্যাস পাইপলাইন প্রকল্প বাস্তবায়ন পরবর্তী আর্থসামাজিক সম্পর্কীয় প্রশমনব্যবস্থা*

  - গ্যাস ট্রান্সমিশন লাইন (৩০.৫০ কিমি) মূলত সড়ক ও জনপথের জমির উপর অনুমতি সাপেক্ষে স্থাপিত হবে। উক্ত প্রকল্পে মুট সহ মোট ২৪ টি ক্ষুদ্র ব্যবসায়িকে আর্থনৈতিক ক্ষতির জন্য ক্ষতিপূরণ প্রদান করা হবে। এছাড়া ৩২৬ টি গাছের ক্ষতিপূরণ প্রদান করা হবে । উল্লেখ্য, ২ কিমি পাইপ লাইনের ক্ষেত্রে রাস্তার পাশের ০৯ টি ক্ষুদ্র দোকান ব্যবসায়ীকে আর্থনৈতিক ক্ষতিপূরণ ও ৪০ টি গাছের জন্য ক্ষতিপূরণ দেয়া হবে।

- *ওকাবাকের ট্রান্সমিশন লাইন প্রকল্প বাস্তবায়ন পরবর্তী আর্থসামাজিক সম্পর্কীয় প্রশমনব্যবস্থা*

  - অত্র প্রকল্পের আওতায় টাওয়ার স্থাপনের ফলে ০৭ টি পরিবারকে ক্ষতিপূরণ দেয়া হবে যারা স্থায়ীভাবে ক্ষতিগ্রস্থ হবে এবং এদের মধ্যে ০২টি পরিবার ভূমিহীন। এছাড়া উক্ত প্রকল্পের কারণে শস্য ও ০১ টি মাছের ঘেরের সাময়িকভাবে ক্ষতির ক্ষতিপূরণ দেয়া হবে।

সারসংক্ষেপ

- প্রকল্পের পরিবেশগত প্রভাব প্রশমনের সুপারিশসমূহ যথাযথভাবে বাস্তবায়ন করা।
- প্রকল্পের আর্থ-সামাজিকসুপারিশসমূহ, সরকারি ও উদ্বৃত্বযোগ্য উদ্যোগ/অনুশীলন বাস্তবায়ন করা।
- যথাযথভাবে পরিবেশগত নিরীক্ষণ কার্যক্রম পরিচালনা করা এবং প্রয়োজনীয় পদক্ষেপ গ্রহন করা।
- আর্থ-সামাজিক বিষয় সংক্রান্ত অভিযোগ ও অসন্তুষ নিপিবদ্ধ করা ও তা প্রশমনের ব্যবস্থা নেয়া।
- আমরা প্রকল্পের পরিবেশগত ও আর্থ-সামাজিক বিষয়ের উপর আপনার সুচিন্তিত মতামত/সুপরামর্শ গ্রহণ করবো যা EIA প্রতিবেদনে লিপিবদ্ধ করা হবে।
- অত্র প্রকল্প চলাকালীন ইএমপি (EMP) সংক্রান্ত বিষয়ের সার্বক্ষণিক পর্যবেক্ষণ ব্যবস্থা জলজ থাকবে এবং জলজিন সহ পরিবেশ ও জীববৈচিত্রের জন্য প্রয়োজনীয় টেকসই রক্ষণাবেক্ষণ পরিকল্পনা করা হবে।

Annex 8

Format of Environmental Monitoring Report

Environmental Monitoring Report

{Annual/Semestral} Report
{Month Year}

BAN: Rupsha 800 MW Combined Cycle Power Plant Project

Prepared by the North-West Power Generation Company Limited for the Asian Development Bank

CURRENCY EQUIVALENTS

(as of {Day Month Year})

{The date of the currency equivalents must be within 2 months from the date on the cover.}

Currency unit	–	{currency name in lowercase (Symbol)}
{Symbol}1.00	=	${ }
$1.00	=	{Symbol_____}

ABBREVIATIONS

{AAA}	–	{spell out (capitalize only proper names)}
{BBB}	–	{spell out}
{CCC}	–	{spell out}

WEIGHTS AND MEASURES

{symbol 1 (full name 1)}	–	{Definition 1}
{symbol 2 (full name 2)}	–	{Definition 2}
{symbol 3 (full name 3)}	–	{Definition 3}

GLOSSARY

{Term 1}	–	{Definition 1}
{Term 2}	–	{Definition 2}
{Term 3}	–	{Definition 3}

NOTE

In this report, "$" refers to US dollars.

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Annex 9
Environmental Code of Practice

Introduction

These Environmental Code of Practices (ECPs) are established to address all potential and general construction-related impacts of Component 1 - Rupsha 800 MW CCP. The ECPs are only meant to provide guidelines for best operating practices and environmental management guidelines and are not an absolute thumb rule. Project authorities and contractors can modify and change the code of practice to better suite their organization and to better implement their environmental management system. These ECPs shall be annexed to the general conditions of all the contracts, including subcontracts, carried out under the Project. The list of ECPs prepared for Component 1 is given below.

ECP 1: Waste Management
ECP 2: Hazardous Goods Management
ECP 3: Water Resources Management
ECP 4: Drainage Management
ECP 5: Soil Quality Management
ECP 6: Erosion and Sediment Control
ECP 7: Top Soil Management
ECP 8: Topography and Landscaping
ECP 9: Air Quality Management
ECP 10: Noise and Vibration Management
ECP 11: Protection of Flora
ECP 12: Protection of Fauna
ECP 13: Protection of Fish and Aquatic Ecosystems
ECP 14: Road Transport and Road Traffic Management
ECP 15: Construction Camp Management
ECP 16: Cultural and Religious Issues
ECP 17: Worker Health and Safety
ECP 18: Construction and Operation Phase Security
ECP 19: Demolition of the Structure

Contractors will prepare site specific management plans, namely Construction Environmental Management Plan (CEMP), in compliance with guidelines of funding institutions and the Environmental Conservation Rules of 1997 of Bangladesh and based on the guidance given in the ECPs. The CEMP will form part of the contract documents and will be used as monitoring tool by NWPGCL for compliance. It is mandatory for the main contractors procured directly by NWPGCL to include these ECPs in their subcontracts. Violation of these requirements will be treated as non-compliance leading to corrections or otherwise imposing penalty on the contractors.

ECP 1: Waste Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
General Waste	Soil and water may be polluted due to improper management of wastes from the construction sites.	The Contractor shall • Develop site specific waste management plan for various waste streams (e.g., reusable waste,

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		flammable waste, construction debris, food waste etc.) prior to the commencement of construction works. • Dispose all construction related wastes in the designated disposal sites approved by the Project authority. • Minimize the production of waste materials via 3R (Reduce, Recycle and Reuse) approach. • Segregate all wastes, wherever practical. • Transport wastes in fully covered vehicles to prevent spilling waste along the route. • Train all personnel on waste management practices and procedures. • Provide refuse containers/ bins at each worksite. • Request suppliers to minimize packaging where practicable. • Place a high emphasis on good housekeeping practices. • Clean and maintain construction sites • Provide and maintain appropriate facilities for temporary storage of all wastes before being transported for final disposal. • Avoid use of non-biodegradable plastic bag wherever possible.
Hazardous Waste	Health hazards and environmental impacts due to improper waste management practices.	The Contractor shall • Store chemical wastes in a sealed container. • Label all chemical containers for easy recognition. • Store, transport and handle all chemicals avoiding potential environmental pollution. • Store all hazardous wastes/ chemicals appropriately in bunded areas away from water sources. • Maintain and document Material Safety Data Sheets (MSDS) for all hazardous materials/ chemicals on-site during construction period. • Construct concrete or other impermeable hard-stand to prevent

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		seepage of hazardous chemicals/ lube oils in case of any accidental spills. • Keep sufficient stock of absorbents for generally used chemicals or for petrochemicals (e.g., dirt, sawdust, etc.) within the storage area to contain accidental spills.

ECP 2: Hazardous Goods Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Hazardous goods and equipment.	Improper storage and handling of lubricants, chemicals, hazardous goods/materials on-site, wash down of plant and equipment, and potential spills may harm the environment or health of construction workers.	The Contractor shall • Prepare spill control procedures and Hazardous Substance Management Plan. • Train the relevant construction personnel in spill control procedures. • Store dangerous goods in bunded areas on top of a sealed plastic sheet away from water sources. • Store all liquid fuels in fully bunded storage containers. • Store and use chemicals in accordance with the information provided in material safety data sheets (MSDS). • Make sure all containers, drums, and tanks that are used for storage are in good condition. • Check the containers regularly for leakage, dents or any other abnormalities. Any container, drum, or tank that is dented, cracked, or rusted should be notified to the supervisors immediately and replaced promptly. • Take all precautionary measures (e.g. hazard labeling, wearing of personal protective equipment (PPEs) etc.) when handling and storing fuels and lubricants, avoiding environmental pollution. • All machinery is to be stored away from any water body, drainage inlets or natural drainage area, where practical. • Transport waste of hazardous/ dangerous goods to an approved waste disposal facility.

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		• Avoid washing of plant equipment and vehicle near the drainage inlets. The contractor shall construct a designated pit/bund away from waterways where washing activities may take place. • Keep stock of absorbent and containment material (e.g., absorbent matting, dirt, sawdust, etc.) where hazardous material are used and stored. The contractor shall also ensure the training of staffs of their proper use. • Chemical spills and washouts shall be cleaned up and collected immediately, where safety permits. Disposal of cleanup/ washout materials shall be made on an approved waste disposal facility. • Materials shall be transported by an approved / licensed transporter. • Provide appropriate PPE (protective clothing, safety boots, helmets, masks, gloves, goggles, etc.) to the construction personnel, depending on the materials being handled. • Use materials that are environment friendly and avoid materials that have the potential for contamination.

ECP 3: Water Resources Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Hazardous material and Waste	Water pollution from the storage, handling and disposal of hazardous materials and general construction waste, and accidental spillage.	The Contractor shall • Follow the management guidelines proposed in ECP 1: Waste Management and ECP 2: Hazardous Goods Management. • Minimize the generation of spoils, oil and grease, excess nutrients, organic matter, litter, debris and any form of waste (particularly petroleum and chemical wastes). Steps should be taken to ensure these substances do not enter waterways or storm water systems.
Discharge from	Construction activities,	The Contractor shall

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
construction sites	sewerages from construction sites and work camps may affect the surface water quality. The construction works will modify groundcover and topography, changing the surface water drainage patterns of the area. These changes in hydrological regime lead to increased rate of runoff, increase in sediment and contaminant loading, increased flooding, and effect habitat of fish and other aquatic biology.	• Install temporary drainage system (channels and check dams) in areas required for sediment and erosion control and around storage areas for construction materials. • Install temporary sediment lagoons, where appropriate, to capture sediment-laden run-off from work site. • Divert runoff from undisturbed areas around the construction site. • Stockpile materials away from drainage lines. • Prevent all solid and liquid wastes entering waterways by collecting spoils, chemicals, bitumen spray waste and wastewaters from brick, concrete and asphalt cutting where possible and transport to an approved waste disposal site or recycling depot. • Wash out ready-mix concrete agitators and concrete handling equipment at washing facilities off site or into approved bunded areas on site. The contractor shall also ensure that tires of construction vehicles are cleaned in the washing bay (constructed at the entrance of the construction site) to remove the mud from the wheels. This should be done in every exit of each construction vehicle to ensure the local roads are kept clean.
Soil erosion and siltation	Soil erosion and dust from the material stockpiles will increase the sediment and contaminant loading of surface water bodies.	The Contractor shall • Stabilize the cleared areas, not used for construction activities, with vegetation or appropriate surface water treatments as soon as practicable following earthwork to minimize erosion. • Ensure that roads used by construction vehicles are swept regularly to remove dust and sediment. • Water the loose material stockpiles, access roads and bare soils on a required basis to minimize dust. Increase the watering frequency during periods of high risk (e.g. high winds).
Drinking water	Untreated surface water is not suitable for drinking	The Contractor Shall • Provide drinking water that meets

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
	purposes due to presence of suspended solids and *E. coli*.	National and WHO Drinking Water standards.

ECP 4: Drainage Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Excavation and earth works, and construction yards	Lack of proper drainage for rainwater/liquid waste or wastewater owing to the construction activities may harm environment in terms of water and soil contamination, and mosquito growth.	The Contractor shall • Prepare drainage management procedures. • Prepare a program to prevent standing waters, which the project proponent will verify in advance and confirm during implementation. • Provide alternative drainage for rainwater if the construction works/ earth-fillings cut the established drainage line. • Establish local drainage line with appropriate silt collector and silt screen for rainwater or wastewater connecting to the existing established drainage lines already there. • Rehabilitate road drainage structures immediately if damaged. • Build new drainage lines as appropriate and required for wastewater from construction yards connecting to the available nearby recipient water bodies. • Ensure wastewater quality conforms to National Standards, before being discharged into the recipient water bodies. • Ensure that there is no water stagnation at the construction sites and camps. • Provide appropriate silt collector and silt screen at the inlet and manholes and periodically clean the drainage system to avoid drainage congestion. • Protect natural slopes of drainage channels to ensure adequate storm water drains. • Regularly inspect and maintain all drainage channels to assess and alleviate any drainage congestion problem.
Ponding of	Health hazards due to	• Do not allow ponding of water

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
water	mosquito (vector) breeding.	especially near the waste storage areas and construction camps. • Discard all the storage containers that are capable of storing of water, after use or store them in inverted position.

ECP 5: Soil Quality Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Storage of hazardous and toxic chemicals	Spillage of hazardous and toxic chemicals might contaminate the soils.	The Contractor shall • Strictly maintain the waste management plans proposed in **ECP 1: Waste Management** and **ECP 2: Hazardous Goods Management**. • Construct appropriate spill containment facilities for all fuel storage areas. • Establish and maintain a hazardous material register detailing the location and quantities of hazardous substances including the storage, and their disposals. • Train personnel and implement safe work practices for minimizing the risk of spillage. • Identify the cause of contamination and contain the area of contamination. The impact may be contained by isolating the source or implementing controls around the affected site. • Remediate the contaminated land using the most appropriate available method.
Construction material stock piles	Erosion from construction material stockpiles may contaminate the soils.	The Contractor shall • Protect the toe of all stockpiles, where erosion is likely to occur, with silt fences, straw bales or bunds.

ECP 6: Erosion and Sediment Control

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Clearing of construction sites	Cleared areas and slopes are susceptible to erosion of top soils, which affects the growth of vegetation and causes ecological imbalance.	The Contractor shall • Prepare site specific erosion and sediment control measures and submit them for supervision consultant for approval. • Reinstate and protect cleared areas as

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		soon as possible. • Cover unused area of disturbed or exposed surfaces immediately with mulch /grass turf/ tree plantations.
Construction activities and material stockpiles	The impacts of soil erosion are (i) Increased run off and sedimentation causing a greater flood hazard to the downstream and silt accumulation and (ii) destruction of aquatic environment by erosion and/or deposition of sediment damaging the spawning grounds of fish.	The Contractor shall • Relocate stockpiles away from drainage lines. • Protect the toe of all stockpiles, where erosion is likely to occur, with silt fences, straw bales or bunds. • Remove debris from drainage paths and sediment control structures. • Cover the loose sediments of construction material and water them if required. • Divert natural runoff around construction areas prior to any site disturbance. • Install protective measures on site prior to construction, for example, sediment traps. • Install 'cut off drains' on large cut/fill batter slopes to control water runoff speed and hence erosion. • Observe the performance of drainage structures and erosion controls during rain and modify as required.
Soil erosion and siltation	Soil erosion and dust from the material stockpiles will increase the sediment and contaminant loading of surface water bodies.	The Contractor shall • Stabilize the cleared areas, not used for construction activities, with vegetation or appropriate surface water treatments as soon as practicable following earthwork to minimize erosion. • Ensure that roads used by construction vehicles are swept regularly to remove sediment. • Water the material stockpiles, access roads and bare soils on a required basis to minimize dust. Increase the watering frequency during periods of high risk (e.g. high winds).

ECP 7: Top Soil Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Land clearing	The top portion of soil is	The Contractor shall

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
and earth works	generally enriched with plant growth essential nutrient. Earth work might degrade the fertile top soil.	• Top soil removal from project site might not exceed 35 cm and store in stoke piles height not exceed 2 m. • The stockpiles should be done in slops of 2:1, so that, rate of surface runoff reduces and percolation rate increases. • Removed top soil should be stored outside of the core project facilities and drainage line. This soil mass should also be protected from erosion. • Locate topsoil stockpiles in areas outside drainage lines and protect from erosion. • Construct diversion channels and silt fences around the top-soil stockpiles to prevent erosion and loss of topsoil. • Spread the topsoil to maintain the physic-chemical and biological activity of the soil. The stored top soil will be utilized for covering all disturbed area and along the proposed plantation sites. • Prior to the re-spreading of topsoil, the ground surface should be ripped to assist the bunding of the soil layers, water penetration and re-vegetation.
Transport	Vehicular movement outside ROW or temporary access roads might affect the soil fertility of the agricultural lands.	• All kind of unnecessary vehicular movement should be restricted within the construction facility. • Limit equipment and vehicular movements to within the approved construction zone. • Planed construction for road alignment should be maintained from the beginning to minimize the loss of top soil. • Plan construction access to make use, if possible, of the final road alignment.

ECP 8: Topography and Landscaping

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Land clearing and earth works	Construction activities especially earthworks will change topography and disturb the natural	The Contractor shall • Prepare landscaping and plantation plan and submit the plan to supervision consultant for approval.

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
	rainwater/flood water drainage as well as change the local landscape.	• Ensure the topography of the final surface of all raised lands (construction yards, approach roads and rails, access roads, etc.) are conducive to enhance natural draining of rainwater/flood water. • Keep the final or finished surface of all the raised lands free from any kind of depression that causes water logging. • Undertake mitigation measures for erosion control/prevention by grass-turfing and tree plantation, where there is a possibility of rain-cut that will change the shape of topography. • Cover immediately the uncovered open surface that has no use of construction activities with grass-cover and tree plantation to prevent soil erosion and better landscaping. • Reinstate the natural landscape of the ancillary construction sites after completion of works.

ECP 9: Air Quality Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Construction vehicular traffic	Air quality can be adversely affected by vehicle exhaust emissions and combustion of fuels.	The Contractor shall • Prepare air quality management plan (under the Pollution Prevention Plan) and submit the plan for supervision consultant approval. • Fit vehicles with suitable exhaust systems and emission control devices. Keep these devices in better working condition. • Function the vehicles in a fuel productive way. • Cover pulling vehicles conveying dusty materials moving outside the development site. • Impose speed limits on all vehicle movement at the worksite to reduce dust emissions. • Control the movement of construction traffic. • Water construction materials prior to loading and transport.

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		• Service all vehicles regularly to minimize emissions. • Limit the idling time of vehicles not more than 2 minutes.
Construction machinery	Air quality can be adversely affected by emissions from machinery and combustion of fuels.	The Contractor shall • Fit hardware with suitable fumes frameworks and discharge control devices. Keep up these devices in great working condition as per the details characterized by their makers to amplify ignition productivity and limit the contaminant discharges. Verification of support enlist should be required by the hardware providers and temporary workers/sub-contractors. Pay special consideration to manage emissions from fuel generators. • Machinery causing over the top contamination (e.g., unmistakable smoke) will be restricted from development destinations. • Service all equipment regularly to minimize emissions. • Provide filtering systems, dust collectors or humidification or other techniques (as applicable) to the concrete batching and mixing plant to control the particle emissions in all stages, including unloading, collection, aggregate handling, cement application, circulation of trucks and machinery inside the installations.
Construction activities	Dust generation from construction sites, material stockpiles and access roads is a nuisance in the environment and can be a health hazard, and also can affect the adjacent water bodies.	The Contractor shall • Water the material stockpiles, access roads and bare soils as needed basis to minimize the potential for environmental nuisance due to dust. Increase the watering frequency during periods of high risk (e.g. high winds). Stored materials such as gravel and sand shall be covered and confined to avoid their being wind-drifted. • Minimize the extent and period of exposure of the bare surfaces. • Restore disturbed areas as soon as practicable by grasses or trees. • Store the cement in silos and minimize

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		the emissions from silos by equipping them with filters. • Establish adequate locations for storage, mixing and loading of construction materials, in a way that dust generation is minimized during such operations. • Use water as dust suppression in such way that will never produce any liquid waste stream. • Crushing of rock and aggregate materials shall be wet-crushed, or performed with particle emission control systems. • Not permit on burning of solid waste.

ECP 10: Noise and Vibration Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Construction vehicular traffic	Noise quality will be deteriorated due to vehicular traffic.	The Contractor shall • Prepare a noise and vibration management plan (under the Pollution Prevention Plan) and submit the plan for supervision consultant/Owner's Engineer (OE) for approval. • Keep up all vehicles to keep it in great working condition as per produces support strategies. • Ensure all drivers will conform to the activity codes concerning most extreme speed restrain, driving hours, and so on. • Perform the loading and unloading of trucks, and handling operations minimizing construction noise on the work site.
Construction machinery	Noise and vibration may have an impact on people, property, fauna, livestock and the natural environment.	The Contractor shall • Appropriately organize all noise generating activities to avoid noise pollution to local residents. • Utilize the calmest accessible hardware and gear in development work. • Maintain all equipment in order to keep them in good working order in accordance with manufactures maintenance procedures. Equipment

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		suppliers and contractors shall present proof of maintenance register of their equipment. • Install acoustic fenced in areas around generators to decrease noise levels. • Fit high productivity suppressors to fitting development hardware. • Avoid superfluous utilization of alerts, horns and sirens.
Construction activity	Noise and vibration may have an impact on people, property, fauna, livestock and the natural environment.	The Contractor shall • Notify nearby landholders preceding normal noise events outside of light hours. • The operator should be educated about the construction equipments and technique to reduce noise level. • Employ best accessible work practice nearby to limit work related noise levels. • Install temporary noise control barriers where appropriate. • Notify affected people if major noisy activities will be undertaken, e.g. blasting. • Plan activities on site and deliveries to and from site to minimize impact. • Monitor and consider noise and vibration come about and modify development practices as required. Avoid undertaking the noisiest exercises, where conceivable, when working during the evening close to the neighborhoods.

ECP 11: Protection of Flora

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Vegetation clearance for site preparation	Clearance of vegetation for materials storing, labour shed construction and all kind of civil structures construction.	The Contractor shall • Prepare a plan of vegetation clearance supervised by experienced botanist. • Use comparatively barren places for storing/ labour shed to minimize vegetation damage. • Clear only the vegetation that needs to be cleared in accordance with the engineering plans and designs. These measures are applicable to both the

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		construction areas as well as to any associated activities such as sites for storing, labour movement and construction vehicle running. • Aware and train the workers regarding nature protection and the need of avoid vegetation damage during construction. • Implement proper plantation with native species after completion of construction works prior to engaging experienced plantation planner (Landscape ecologist).

ECP 12: Protection of Fauna

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Construction activities	Damage of wildlife habitat and relocation wildlife from the construction site due to vegetation damage and demolition of physical structures.	The Contractor shall • Survey faunal communities at first before site clearing and prepare a plan for protection of fauna supervised by experienced consultant. • Use comparatively barren places for storing/ labour shed to minimize vegetation damage. • Limit the construction works within the designated sites allocated to the contractors. • Check the site for trapped animals, rescue them by the help of a qualified person and release them in nearer protected area. • Appoint wildlife biologist and wildlife capture and relocation experts. • Demolish buildings one after another in order to save natural relocation of wildlife.
Night time lighting	Disturbance to nocturnal animals for excess lightening at the site.	The Contractor shall • Use lower wattage flat lens fixtures that direct light down and reduce glare, thus reducing light pollution. • Avoid floodlights unless they are required. • Use motion sensitive lighting to minimize unneeded lighting. • Install light shades or plan the direction of lights to reduce light spilling outside

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		the construction area. • Avoid working in night time.
Excess level noise	Scaring wildlife like dolphins, birds and rodents due excess noise.	The Contractor shall • Use sound limiter with gas stacks. • Implement green belt with dense canopy plants surround the proposed power unit.

ECP 13: Protection of Fish and Aquatic Ecosystems

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Movement of vessels	Deterioration of aquatic habitat quality of nearby river channel due to disposal of waste like ballast and bilge water.	The contractor shall • Warn the vessel sailors about spillage in the river. • Ensure the construction equipment used in the river are well maintained and do not have oil leakage to contaminate river water. • Prepare an emergency oil spill containment plan (under the Hazardous Substances Management Plan).
Accidental discharge of hazardous effluents and hot water	Aquatic dolphins/fishes may be affected and habitat quality may deteriorate.	The Contractor shall • Follow mitigation measures proposed ECP 3: Water Resources Management and ECP 4: Drainage Management.

ECP 14: Road Transport and Road Traffic Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Construction vehicular traffic	Increased traffic may affect the safety of the road-users and obstruct their daily movement.	The Contractor shall • Prepare a traffic management plan and implement them strictly. • Ensure uninterrupted traffic movement during construction and shall include in the traffic plan: detailed drawings of traffic arrangements showing all detours, temporary road, temporary bridges, temporary diversions, necessary barricades, warning signs / lights, road signs, construction schedule etc. • Provide signs at strategic locations of the roads complying with National

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		Traffic Regulations.
	Accidents and spillage of fuels and chemicals.	The Contractor shall • Restrict heavy vehicle movement, where practicable, to day time working hours only. • Restrict the transport of oversized loads. • Enforce on-site speed limit, especially close to the sensitive receptors, schools, health centers, etc.

ECP 15: Construction Camp Management

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Set-up of construction camps	Health, safety and security of workers might be affected due to the set-up of construction camps.	The Contractor shall • Prepare a construction camp management plan. • Set-up camps within the designated sites or at areas which are acceptable from environmental, cultural or social point of view and approved by the supervision consultant/OE or the Client. • Conduct consultation with communities including local government institutes bodies prior to set-up/ construction of the camp. • Submit a detailed layout plan to the project authorities for approval in order to develop the construction camp, which should include relative locations of all temporary buildings and facilities along with the location of access roads, fuel storage areas (for use in power supply generators), solid waste management and dumping locations, and drainage facilities. • Inform local authorities the setup of camp facilities so as to maintain effective surveillance over public health, social, and security matters.
Provision of construction camp facilities	Lack of basic facilities, such as housing, water supply, and sanitation facilities may lead to substandard living conditions and possible health hazards.	Contractor shall provide the following facilities in the campsites • Adequate housing for all workers. • Safe and reliable drinking water supply, conforming to national and

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		international (e.g. WHO) standards. • Hygienic sanitary facilities and sewerage system. • Separate toilet facilities for males and females. The minimum number of toilet facilities required is one toilet for every ten persons as per Labour Rules, 2015. • Treatment facilities for sewerage of toilet and domestic wastes. • Storm water drainage facilities. • Paved internal roads. • . • In-house community/ common entertainment facilities.
Disposal of waste	Waste run-off to nearby water sources, leading to pollution	The Contractor shall • Ensure solid wastes are properly collected and disposed of within the construction camps. • Ensure waste segregation at source. Wastes should be segregated on separate color-coded bins as per national waste management laws/ rules. • Store inorganic wastes in a safe place within the household and clear organic wastes on daily basis to waste collector. Establish waste collection, transportation and disposal systems with the manpower and equipment/vehicles needed.
Fuel supplies for cooking purposes	Illegal sourcing of fuel wood by construction workers will impact the natural flora and fauna.	The Contractor shall • Provide alternative fuels like natural gas or kerosene to the construction camps for their domestic purpose, in order to discourage them to use fuel wood or other biomass. • Conduct awareness campaigns to educate workers on preserving the protection of biodiversity and wildlife of the project area, and relevant government regulations and punishments on wildlife protection.
Health and Hygiene	Spreading of vector borne diseases such as, malaria, due to inadequate health and safety practices.	The Contractor shall • Provide adequate health care facilities within construction sites. • Provide first aid facility round the

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
	Risk of spreading of sexually transmitted diseases (STD), such as HIV/AIDS.	clock. • Maintain stock of medicines in the facility and appoint fulltime designated first aider or nurse. • Provide ambulance facility for the labours so that they can be transported to nearest hospitals in case of an emergency health hazard. • Conduct health screening of the laborers coming from outside areas. • Train all construction workers about basic sanitation and health care issues and safety matters, and on the specific hazards of their work. • Provide awareness on sexually transmitted diseases, such as HIV/ AIDS to all workers on a regular basis. • Provide and maintain adequate drainage facilities throughout the camps to minimize the spread of vector borne diseases. The contractor shall also regularly spray mosquito repellant during rainy season in offices, construction camps and yards. • Provide awareness drives and training on personal hygiene and waste disposal.
Security and Safety	Inadequate security and safety provision in construction camps may create security and safety problems of workforces and assets.	The Contractor shall • Provide appropriate security personnel (police or private security guards) and enclosures to prevent unauthorized entry into the camp area. • Maintain register to keep a track of entry and exit of people within the camp at any given time. • Encourage use of flameproof material for the construction of labor housing / site office. Also, ensure that these houses/rooms are of sound construction and capable of withstanding wind storms/cyclones. • Provide appropriate type of firefighting equipment suitable for the construction camps. • Display emergency contact numbers clearly and prominently at strategic places in camps.

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		• Communicate the roles and responsibilities of laborers in case of emergency in the monthly meetings with contractors.
Site Restoration	Demolition of construction camps may lead to dust emission, elevated noise levels and possible health hazard.	The Contractor shall • Dismantle and remove all the established facilities from the site of the construction camp ensuring minimum dusts emission. Wet spray grounds to minimize dust emission. • Dismantle camps in phases instead of waiting for the entire work to be completed. • Provide prior notice to the laborers before demolishing their camps/units. • Maintain the noise levels within the national standards during demolition activities. • Hire different contractors to demolish different structures to promote recycling or reuse of demolished material. • Dispose excess debris at the designated waste disposal site. • Restore the site to its condition prior to commencement of the works.

ECP 16: Cultural and Religious Issues

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Construction activities near religious and cultural sites	Disturbance from construction works to the cultural and religious sites leading to annoyances. Contractors lack of knowledge on cultural issues leading to social disturbances.	The Contractor shall • Avoid activities that may lead to the blocking of access to cultural and religious sites. • Avoid construction works during prayer time. • Avoid working in areas where there is any church/mosque/religious/ educational institutions and health centers close to the construction sites, if possible. Project proponent should issue warning to the people before commencing construction activities. • Establish a mechanism that allows local people to raise grievances arising from the construction process.

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		• Provide compensations or relocate, whichever is best, if any grievances are raised by the community where any culturally important areas are to be demolished. • Take special care and use appropriate equipment when working next to a cultural/ religious center. • Stop work immediately and notify the site manager, if during construction, an archaeological or burial site is discovered. • Provide independent prayer facilities to the construction workers. • Show appropriate behavior with all construction workers especially women and elderly people. • Allow the workers to participate in praying during construction time, if there is a request. • Resolve cultural issues in consultation with local leaders and supervision consultants. • Inform the local authorities before commencement of civil works so as to maintain effective surveillance over public health, social, and security matters.

ECP 17: Worker Health and Safety

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Construction work at Plant site	Construction works may pose health and safety risks to the construction workers and site visitors leading to severe injuries and deaths. The population in the proximity of the construction site and the construction workers will be exposed to a number of (i) biophysical health risk factors, (e.g., noise, dust, chemicals, construction material, solid waste, waste water, vector transmitted diseases, etc.), (ii)	The Contractor shall • Prepare an Occupational Health and Safety and Hazard and Risk Assessment plan. • Implement suitable safety standards for all workers and site visitors, with sufficient provisions to comply with international standards (e.g. International Labor Office guideline on 'Safety and Health in Construction; International Finance Corporation/World Bank Group Environmental, Health, and Safety General Guidelines') and contractor's

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
	risk factors resulting from human behavior (e.g., STD, HIV/AIDS, etc.) and (iii) road accidents from construction traffic.	own safety standards, in addition to complying with national standards. • Provide the workers with a safe and healthy work environment, taking into account inherent risks in its particular construction activity and specific classes of hazards in the work areas. • Conduct tool box meeting before starting any construction related work. Maintain a registry of the person present during the toolbox meeting. Anyone not participating in the tool box meeting will not be allowed to work. • Provide personal protective equipment (PPE) for workers, such as safety boots, helmets, masks, gloves, protective clothing, goggles, full-face eye shields, and ear protection. Maintain the PPE properly by cleaning dirty ones and replacing the damaged ones. • Implement safety procedures including provision of training and protective clothing to workers involved in hazardous operations and proper performance of their job. • Appoint an environment, health and safety manager to look after the health and safety of the workers. • Inform the local authorities before commencement of civil works and establishment of construction camps so as to maintain effective surveillance over public health, social and security matters.
	Child and pregnant labor.	The Contractor shall • Not hire children of less than 18 years of age and pregnant women or women who delivered a child within 8 preceding weeks.
	Lack of first aid facilities and health care facilities in the immediate vicinity will aggravate the health conditions of the victims.	The Contractor shall • Ensure health care facilities and first aid facilities are readily available. • Document and report occupational accidents, diseases, and incidents. • Prevent accidents, injury, and disease

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		arising from, associated with, or occurring in the course of work by minimizing, so far as reasonably practicable, the causes of hazards, in a manner consistent with good international industry practice. • Identify potential hazards to workers, particularly those that may be life-threatening and provide necessary preventive and protective measures. • Provide adequate lighting in the construction area, inside the tunnels, inside the powerhouse cavern and along the roads.
Provision of construction camp facilities	Lack of basic facilities, such as housing, water supply, and sanitation facilities may lead to substandard living conditions and possible health hazards.	The Contractor shall provide facilities in the camp sites to improve health and hygienic conditions as mentioned in ECP 16: Construction Camp Management.
Trainings	Lack of awareness and basic knowledge in health care among the construction workforce may make them susceptible to potential diseases.	The Contractor shall • Train all construction workers in basic sanitation and healthcare issues (e.g., protection against malaria and other vector borne diseases, transmission of sexually transmitted infections (STI) etc. • Train all construction workers in general health and safety practices and about specific hazards related to their work. Training should consist of basic hazard awareness, site specific hazards, safe work practices, and emergency procedures for fire, evacuation, and natural disaster, as appropriate. • Implement malaria, HIV/AIDS and STI education campaign targeting all workers hired, international and national, female and male, skilled, semi- and unskilled workforces, at the time of recruitment and thereafter pursued throughout the construction phase on ongoing and regular basis. This should be complemented by easy access to condoms at the workplace as well as to voluntary counseling and testing.

ECP 18: Construction and Operation Phase Security

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Construction work	Inadequate construction site security poses a significant risk to assets, construction materials and property. Theft/ vandalism of assets, materials and property may increase construction costs and may cause delays in project completion.	The Contractor shall: • Provide appropriate security personnel (i.e. security guards) to prevent unauthorized entry into the camp area. • Ensure all assets (i.e., tools, equipment, etc.) and construction materials at construction site are identified, recorded and tracked as closely as possible. All assets should be clearly labeled and marked. Keep records of tool serial numbers and check inventory on a regular basis. • All tools and equipment should have a check out/in system. If they are not in use, they should be securely stored in a proper place to prevent theft or loss. • Ensure that there is proper fencing around construction site perimeter. Fencing should be chain-link at least 2.4 m high and secured with a steel chain and lock. • The entire site should be fenced, if possible. If not, at least the construction trailer and equipment storage areas should be fenced. • Ensure construction site has controlled access points (one or two entry points at most), allowing for close monitoring of comings and goings from the site. • Workers should be easily identified and have credentials that indicate site access. • List of employees who have after hour access to the property should be available to the PMU and local authorities. • Ensure job site is properly lighted at night. Well-lit areas should include any office trailers and equipment storage trailers. Floodlights operated by sensors should also be installed where appropriate. • Pre-employment screening

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		investigations should be used to verify the applicants relating to their employment, education and criminal history background.
Operation Phase	Vandalism/damage (including use of explosives) of RMS, Gas Pipeline, Plant transfer station and storages.	• Routinely conduct patrols and inspections of transmission mains Plant area and facilities. • Monitor suspicious activity and notify local authorities and NWPGCL in event of any such occurrence/incident of vandalism or theft. • Ensure strategic infrastructure sites such as RMS, Gas Pipelines, and main Plant transfer stations, storages are secured and fenced with controlled access points. Fencing should be chain-link at least 2.4m high and secured with a steel chain and lock.

ECP 19: Demolition of Structures

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
Demolition of structures	Rubbles and dust raised from the demolition/ decommissioning of structures may affect the surrounding environment (air, water resources, landscape, agricultural lands etc.), flora, fauna and health of the surrounding communities.	The Contractor shall: • Provide appropriate demolition/ decommissioning plan. • Inform nearby communities 5 days prior to the start of any demolition/ decommissioning activities. • Conduct thorough investigation of site and site history to identify potential risks and hazards to workers, local people and the environment. • Use of techniques to minimize compaction of soil. If necessary, soil should be carefully removed and stored for subsequent works. • Use dust control strategies (e.g. wet technique). • Set the route and time of movement of heavy trucks carrying demolition debris off site for disposal so as to avoid residential areas or other sensitive human receptors (e.g. schools, hospitals, nursing homes). • Avoid building of access roads near

Project Activity/Impact Source	Environmental Impacts	Mitigation Measures/Management Guidelines
		riparian zones. • Implement adequate site security • Recover, reuse and recycle salvaged materials, whenever possible. • Install and implement appropriate water management system as early as possible. Effectively stabilize altered landforms so as to minimize soil erosion and the potential for water pollution from suspended solids. • Incorporate existing habitat features into site design and protect them from any adverse change. • Preserve sites of archaeological or cultural interest where possible. If not, relocation should be considered where damage is unavoidable. • Implement management system that should aim to minimize disturbance to adjacent residential and recreational areas.

Annex 10

Fauna Rescue and Handling Procedures
Component 1 – 800 MW Rupsha CCPP

1.0 Introduction

1. The following outlines the actions and measures that will be undertaken in the event of an accidental encounter with a threatened fauna during the construction phase of Component 1. This chance find procedures will be finalized in consultation with among others, IUCN Bangladesh, Bangladesh Wildlife Advisory Board, Forest Department (DoF), and DoE to ensure compliance with applicable regulations.

2. These procedures will be included in the Construction Management Plan that will be required by Project Management Unit (PMU), NWPGCL from the EPC Contractor and will be an integral part of the bid documents. NWPGCL will ensure compliance of this ADB requirement. These procedures aim to identify and promote the protection and recording of threatened fauna that may be encountered during the site preparation and construction activities.

2.0 Scope

3. This will be applicable to construction activities by workers or personnel who may have the potential to encounter or contact with threatened species from the construction activities for Component 1.

3.0 Orientation of Workers

4. The EPC Contractor, with the assistance from relevant authorities of GoB such as DoE and DOF, will conduct an orientation of all workers, particularly those who will be involved in the site preparation for Component 1, on how to recognize and identify the potential threatened species that may be encountered including the appropriate actions to be done. The orientation will be done prior to construction works and during the regular toolbox talks/meetings.

5. Clear pictures of the threatened species, with sightings in the project site, including a brief description of their habitats will be posted at strategic locations within the construction site (about 50 acres or 20.23 hectares). This will help workers and staff in creating awareness and familiarity with the species. These pictures will be part of the references on-site to guide construction supervision staff. Local people recruited during pre-construction and construction phase may be familiar with these species and can provide assistance with their local knowledge and experience.

4.0 Procedures

6. The environmental staff (or consultant) of EPC Contractor together with the environmental staff of PMU, NWPGCL will be responsible for implementing these procedures. ADB will monitor compliance of NWPGCL.

7. Table 4.1 lists the species of conservation status according to IUCN Bangladesh 2015. The EPC Contractor will post the pictures of these species to assist the workers in identifying them.

Table 4: List of species of conservation status

English Name	Scientific Name	Bangladesh Wildlife (Preservation) Order 1973	IUCN Bangladesh Status (2015)	IUCN Global Status	Distribution	
					Project Site	Study area
Mammals						
Fishing Cat	*Prionailurus viverrinus*	Third Schedule[1] [1]Protected animals not to be hunted, killed, or captured	Endangered	Vulnerable	Temporary visitor but core habitat is within the study area outside project site	Yes
Smooth-coated Otter	*Lutrogale perspicillata*	Third Schedule	Vulnerable	Critically Endangered	No	Yes
Ganges River Dolphin	*Platanista gangetica*	Third Schedule	Vulnerable	Endangered	No	Yes
Small Indian Civet	*Viverricula indica*	Third Schedule	Near Threatened	Least Concern	Reported by Interviewee as temporarily found as visitor for hunting of preys	Yes
Jungle Cat	*Felis chaus*	Third Schedule	Near Threatened	Least Concern	Reported by Interviewee as temporarily found as visitor for hunting of preys	Yes
Birds						
Black headed Ibis	*Threskiornis melanocephalus*	---	Vulnerable	Near Threatened	Reported by Interviewee as temporarily found as visitor for hunting of preys	Yes
Reptiles						
Water Monitor	*Varanus salvator*	Third Schedule	Vulnerable	Least Concern	Reported by Interviewee as temporarily found as visitor for hunting of preys	Yes
Bengal Monitor	*Varanus bengalensis*	Third Schedule	Near Threatened	Least Concern	Reported by Interviewee as temporarily found as visitor for hunting of preys	Yes
Black Krait	*Bungarus niger*	---	Near Threatened	Not Assessed	Reported by Interviewee as temporarily found as visitor for hunting of preys	Yes
Monocled Cobra	*Naja kaouthia*	---	Near Threatened	Least Concern	Reported by Interviewee as temporarily found as visitor for hunting of preys	Yes
Indian Cobra	*Naja naja*	---	Near Threatened	Not Assessed	Reported by Interviewee as	Yes

English Name	Scientific Name	Bangladesh Wildlife (Preservation) Order 1973	IUCN Bangladesh Status (2015)	IUCN Global Status	Distribution	
					Project Site	Study area
					temporarily found as visitor for hunting of preys	
Floral species						
West Indian Mahogany	*Swietenia mahagoni*	---	Not Assessed	Endangered	Cultivated species in Bangladesh and non-native in Bangladesh and also not listed in the IUCN Red list of Bangladesh	Yes

Source: CEGIS field survey from 29-30 October 2016 and secondary information from IUCN (2015)

8. In the event a threatened species is encountered or discovered during construction activities, the following steps will be done:

a) Stop the work within the vicinity of the species and immediately notify the environmental staff (or consultant) of the EPC Contractor and the construction supervision staff or site engineer.

b) The environmental staff will assess the impacts; identify the species, and the appropriate management measures such as relocation. The location where the species was encountered will be identified using a global positioning system (GPS) unit to determine the exact coordinates and photographs will be taken.

c) The construction supervision staff will secure the approval of the environmental staff of PMU, NWPGCL (in consultation with relevant agencies of GoB) before resuming the construction works.

d) Construction works will resume as soon as the environmental staff (from EPC Contractor and PMU, NWPGCL) has done the following actions:

- Secured the approval/permit (if required)
- Corrective actions and/or management measures identified
- Complete the rescue event record/report to include: date and time the species was found, location, type of fauna (e.g., snake, fish, turtle, etc.) and species name, actions taken (e.g., treated by fauna specialist, fauna relocated and where, etc.)

9. The EPC Contractor will not be entitled for compensation due to work stoppage as a result of the encounter and the associated subsequent actions.

Final Report

Biodiversity Assessment for Rupsha800 MW Combined-Cycle Power Plant Project

IUCN Bangladesh Country Office February 2018

Final Report

Biodiversity Assessment for Rupsha 800 MW Combined-Cycle Power Plant Project

Submitted to

North-West Power Generation Company Limited (NWPGCL)

Prepared by

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Contents

Executive Summary

IUCN Bangladesh has been awarded a nine-month-long project entitled 'Biodiversity Assessment for Rupsha 800MW Combined-Cycle Power Plant' by North-West Power Generation Company Limited (NWPGCL) to be funded by Asian Development Bank (ADB). The project is designed to conduct dolphin and other related surveys on the project site and vicinity of this power plant to assess possible impacts of this project on aquatic biodiversity and to identify ways to mitigate these impacts. The survey will be conducted in a total of 30 km length along the Bhairab, Atai and Rupsha Rivers and their confluence in different seasons. As per contract the pre-monsoon, monsoon, post-monsoon and comprehensive survey reports were submitted to NWPGCL.

A total of seven surveys were conducted during pre-monsoon (one survey), monsoon (two surveys), post-monsoon (two surveys) and winter (two surveys). The survey period was May 2017 to January 2018. These results include data on dolphins, other animal presence, fish and fishing gears, fishing areas, physical and chemical water quality parameters, vegetation, plankton and watercrafts from the surveys. Water depth was also measured and pollution sources were also identified.

The survey results show a total of 284 sightings from four surveys (one pre-monsoon, two monsoon and first post-monsoon) of **Ganges River Dolphins**, with overall encounter rate is **1.18**/ **km** including 13.76% calves. The most important area determined from the surveys for dolphins is the confluence of Atai-Bhairab-Rupsha Rivers where feeding behavior was recorded and a large number of calves were seen.

Three surveys (second post-monsoon, first and second winter) were conducted using **the mark-recapture** method and the results of three surveys are used in this report. An average **47** and **34** dolphins were calculated for the project area by using the 'Chapman's Modified Lincoln-Petersen Mark-Recapture Estimator' and the 'Huggins Conditional Likelihood Model', respectively.

In the second winter survey, a group of four Irrawaddy Dolphin was recorded from the project site opportunistically. This species is considered globally Endangered and nationally Near Threatened.

Critical Habitat Analysis was done following the IFC guidelines and using the dolphin number as **34** from the mark-recapture method. The results of the analysis indicate that the project site is not a Critical Habitat for Ganges River Dolphins under any criteria of the guidelines.

Long term continuous **monitoring** of the project area is needed to understand the effects of construction of the power plant especially in the important dolphin areas that were identified.

Other wildlife includes a total of 41 species of birds and four other wildlife species were recorded during the survey period.

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Watercrafts were also counted during the survey period. A total of 676 watercrafts comprised of mechanized and non- mechanized were recorded. The highest was mechanized boats with a total of 373. Rupsha River had the highest number of water vessels with a total of 253.

Fishing gears and fish species were counted during the surveys. A total of 19 types of fishing gears was identified along transects. A total of 50 fish species was also recorded based on direct field visit and questionnaire survey, out of which ten are nationally threatened. **Water depth** readings were recorded and presented in this report. The depth was measured in every 1 km using an echo sounder.

A total of 117 individuals of 29 species of **vegetations** were enumerated from six sample plots. *Syzygiumcumini L*. (Jam), *Areca catechu L*. (Supari), *Cocosnucifera L*. (Narkel), *LanneacoromandelicaMerr*. (Jial) and *Mangiferaindica L*. (Aam) are the five most abundant species in the study area.

Water quality parameters were tested to measure the concentration of different pollutants among the listed areas and illustrated the difference between two seasons. Furthermore, 15 genera of **phytoplankton** and two unknown genera of **zooplankton** were found in the study sites.

Additionally this report includes **the potential impact and mitigation** measures as well as some recommendations.

1. Introduction

An 800 MW combined-cycle power plant is proposed to be built in Khalishpur Thana, Khulna District along the Bhairab River by North-West Power Generation Company Limited (NWPGCL) and is funded by the Asian Development Bank (ADB). A draft Environmental Impact Assessment (EIA) prepared in December 2016 by the Center for Environmental and Geographic Information Services (CEGIS) showed the presence of the Ganges River Dolphin (*Platanista gangetica gangetica*) in the Bhairab River within the immediate vicinity of the proposed power plant site.

Dolphin survey at the Rupsha River, 22 October 2017. ©IUCN/ A.B.M. SarowarAlam

The Ganges River Dolphin is a freshwater dolphin which occurs in all connected rivers and tributaries of Ganges-Brahmaputra-Meghna river system, and Karnaphuli-Sangu river system.[1] In 2012, International Union for Conservation of Nature (IUCN) classified the Ganges River Dolphin as Endangered globally.[2] In Bangladesh, the species is considered as Vulnerable[3]. It is estimated that there are 225 individuals in Sundarbans and 125 in Karnaphuli-Sangu Rivers. There has been no study done on the species in the present study site that is in the Bhairab-Atai-Rupsha river system.

[1]Sinha, Ravindra and KurunthachalamKannan. Ganges River Dolphin: An Overview of Biology, Ecology, and Conservation Status in India. *Ambio.*2014, 43:1029-1046.Royal Swedish Academy of Sciences.
[2] Smith, B.D. and Braulik, G.T. 2012. *Platanistagangetica*. The IUCN Red List of Threatened Species 2012: e.T41758A17355810. http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T41

758A17355810.en. (Accessed 17 August 2017)
[3]Alom, Z.M.2015. (*Platanistagangetica).*In:*IUCN Bangladesh. Red List of Bangladesh*, Volume 2: Mammals, p. 107.

A land-based sighting survey was done in October 2016 in the confluence of the Bhairab and Atai Rivers close to the project site. The survey showed 33 surfing occurrences of the species, out of which 11 were at the confluence and the rest along the Bhairab River. Another line-transect survey was conducted in March 2017.
About 20 km stretch of the Bhairab River from the confluence of Bhairab-Madhumati Rivers (covering 10 km upstream) to the confluence of Bhairab-Atai Rivers until the Rupsha River at Khanjahan Ali Bridge (covering 10 km downstream) was covered. A total of 25 dolphins was recorded from different points of the survey.

The Safeguard Policy Statement 2009 (SPS 2009) of ADB sets out the requirements for environmental safeguard that applies to all the projects considered for financing. Under the SPS 2009, impacts and risks of projects are analyzed within the context of the project's area of influence.

The dolphin population in the proposed power plant project's area has the potential to be significantly impacted by the construction of the power plant. The impacts need to be adequately assessed and mitigated for in accordance with the biodiversity requirements of the SPS 2009. These include specific requirements for projects located within a critical habitat, and thus ensuring no net loss of biodiversity.

In June 2017, IUCN Bangladesh was awarded a nine-month-long project to conduct dolphin and other related surveys in the power plant project sites with the main aim to determine if the project site and vicinity is a critical habitat for dolphins and to identify the potential impact of the power plant on dolphins. A total of seven surveys were conducted from May 2017 to January 2018, where three surveys were done using Mark-recapture method. The results of all the surveys are presented in this report. Alsoincluded in this report are the literature review, survey methodology, Critical Habitat Analysis, important dolphin areas, impact and mitigation, and recommendations.

Surfing of a Irrawaddy Dolphin at the Atai River on 24 January 2018.©IUCN/ Sakib Ahmed

2. Literature Review

Smith *et al.* (1998) referred in a paper called "River Dolphins in Bangladesh: Conservation and the Effects of Water Development" that a vast survey was done in the upstream of the confluence of the Jamuna River and in some sections of downstream of Kushiyara River where 38-68 dolphins were seen in Jamuna river where the sighting rate was 0.13 sightings/km. Also 34-43 dolphins were found in Kushiyara River with a sighting rate 0.08 (sightings/km). The study also included that they found 2 or 3 dolphins during a short visit to Burhiganga River near Dhaka.

Smith *et al.* (2006) in another paper referred that a survey was done in mangrove channels of Sundarbans delta in Bangladesh. The title of the paper was "Abundance of Irrawaddy Dolphins (*Oecaella Brevirostris*) and Ganges River Dolphins (*Platanista Gangetica Gangetica*)" estimated using concurrent counts made by independent teams in waterways of the Sundarbans mangrove forest in Bangladesh". This paper shows that 451 individuals of Irrawaddy Dolphins and 225 individuals of Ganges River Dolphins were found in the survey area.

In addition, a paper named "Habitat selection of freshwater-dependent cetaceans and the potential effects of declining freshwater flows and sea-level rise in waterways of the Sundarbans mangrove forest, Bangladesh" written by Smith *et al.* (2009) mentioned that a survey was made in Sundarbans mangrove forest to identify the presence of Ganges River Dolphins and Irrawaddy Dolphins. During low water season survey 62 Ganges River Dolphins were found and the encounter rate was 15.1 individuals/100 km. 236 Irrawaddy Dolphins were detected and the encounter rate was 8.6 individuals/100 km. During high water season survey, 71 individuals of Ganges River Dolphins and 52 individuals of Irrawaddy Dolphins were seen and their encounter rate was 7.0 and 9.6 individuals/100 km respectively.

Smith *et al.* (2010) stated in the paper titled "Identification and channel characteristics of cetacean hotspots in waterways of the eastern Sundarbans mangrove forest, Bangladesh" that a survey was executed in the Eastern Sundarbans Mangrove forest. Six 5-km segments were selected for the survey. From the study it was found that the encounter rate of Ganges River Dolphins was 0.46 (sightings/survey) and the encounter rate of Irrawaddy Dolphins was 0.06 (sightings/survey).

Aziz *et al.* (2014) stated in the paper entitled "Biodiversity in the floodplain Ecosystem of Bera, Santhia and Sujanagar Upazilas of Pabna District in Bangladesh" that a survey was done in the 4 hotspots in the Padma-Jamuna River section. The study found that the estimated population of Ganges River dolphins was between 58-103.

Alom *et al.* (2014) mentioned in "Identification and Ecological Characteristics of Freshwater Dolphin 'Hotspots' in the Sundarbans, Bangladesh", that a survey was done in 6 hotspots and 6 non hotspot segments in the Eastern Sundarbans Reserved Forest. In the hotspot 334 Ganges River Dolphins including 67 calves, 41 Irrawaddy Dolphins and in non hotspot segments 62 Ganges River Dolphins including 18 calves and 17 Irrawaddy Dolphins were found. During dry, pre-monsoon, monsoon and post-monsoon seasons the encounter rate of Ganges River Dolphins in hotspot segments

was 3.0-4.0 individuals/survey and in non hotspot segments was 0.3-1.0 individuals/survey. The study highlighted that the encounter rate of Irrawaddy Dolphins was 0.4 individuals/survey in the hotspots and the encounter rate was 0.2 individuals /survey in the non hotspot segments.

3. Objectives of the Study

The study aims to determine if the stretch of the Bhairab River along the power plant project site and the adjoining rivers at the confluence are a critical habitat to the survival of the Ganges River Dolphins.The study will provide a baseline in understanding of the following:

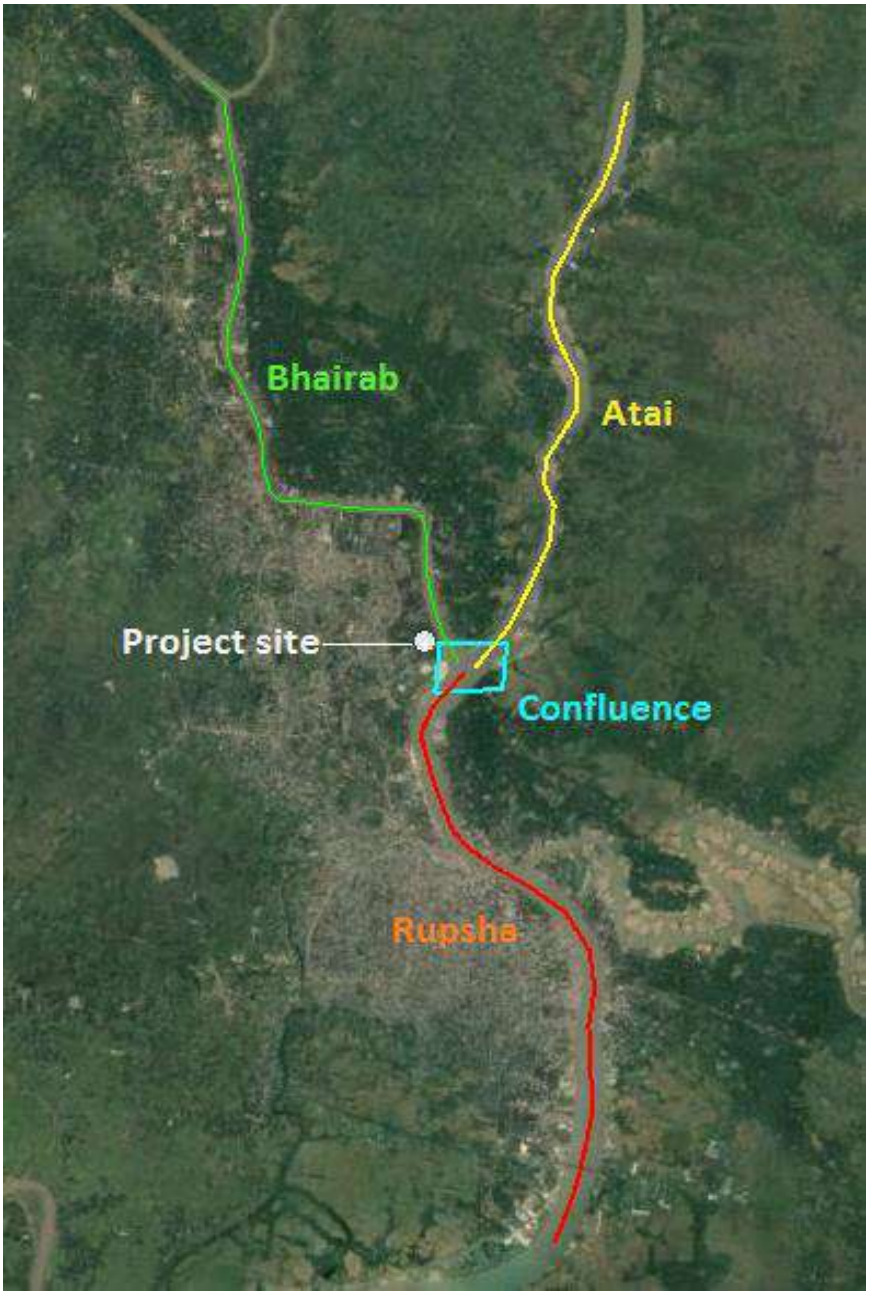
(i) Presence and persistence of Ganges River Dolphins within the 10 km upstream (the Bhairab and Atai Rivers total 20 km) and 10 km downstream (Rupsha River) of the proposed power plant site;
(ii) Ecological requirements of the Ganges River Dolphins prey, and the composition and status of fish and fishing activities co-existing with them;
(iii) Changes in the way the Ganges River Dolphins use the Bhairab, Atai and Rupsha Rivers according to season, water level, water flow, water quality, and nature and extent of human activities such as fishing and navigation; and
(iv) Potential impacts of construction and operation of the proposed power plant operations such as construction of jetty, heavy equipment transport, intake, discharge, etc. to Ganges River Dolphins.

A section of the confluence of the Bhairab, Atai and Rupsha Rivers on 31 May 2017.

4. Study Area

The area to be surveyed (Map 1) will cover the following transects:

- 10 km of the Rupsha River (downstream of the power plant site),
- 10 km of theBhairab River (upstream of the power plant site),
- Confluence of Bhairab-Atai-Rupsha Rivers, and
- 10 km of the Atai River (upstream from the confluence of station).



Map 1: Map of thearea to be surveyed under the present study.

5. Scope of Work

The following activities will be undertaken during the present survey project:

(i) **Dolphin survey**: Conduct dolphin surveys covering seasonal variations to determine habitat use, distribution, abundance, as well as record environmental conditions during the surveys (i.e. overcast, windy, glare);

(ii) **Other wildlife survey**: List species identified along the Bhairab, Atai and RupshaRivers according to its conservation status both from IUCN and national requirements including endemism/range restriction/migration/congregation, if any, and provide inputs to the determination of the presence of any critical habitat;

(iii) **Fish and fisheries resources survey**: Conduct surveys (once per season) on each section of the three rivers to describe and identify the fish and fisheries resources, fishing gears used by the fisher community, map the existing fishing areas, and record fishing practices including daily and seasonal variations;

A boat carrying fishing traps on the Bhairab River, 31 May 2017.

(iv) **Plankton and riparian vegetation survey**: Conduct survey for phytoplankton and zooplankton, and riparian vegetations along transect;

(v) **Watercraft survey**: Separately record the number and type of watercraft users including their movements/directions during the time dolphin surveys are conducted;

(vi) **Water quality analysis**: Conduct river water surveys/sampling and *insitu* water quality measurements (once per season) on each section of river to understand the physico-chemical characteristics of the Bhairab, Atai and RupshaRivers. Water quality parameters will include temperature, pH, salinity, dissolved oxygen, hardness, electrical conductivity, nitrates, phosphates, turbidity, suspended sediment, biological oxygen demand (BOD), chemical oxygen demand (COD), coliforms, and other relevant parameters include water depth and flow direction;

Fishing at the Bhairab River, 23 October 2017. ©IUCN/ A.B.M. Sarowar Alam

(vii) **Pollution mapping**: Identify/map existing sources of river water pollution and identify/map the presence of any meanders, eddies, and hydrogenological complexities;

(viii) **Impact assessment**: Assess potential impacts of proposed power plant activities during construction and operation, such as dredging, heavy equipment transport, withdrawal of river water, discharges, and construction of jetty and intake channel along the Bhairab, Atai and RupshaRivers on aquatic flora and fauna and provide inputs to the determination of whether critical habitat (if any) requirements are met; and

(ix) **Mitigation measure**: Identify mitigation measures and/or conservation management measures for species of conservation status. This may include mitigation measures as a part of the project design or offsets in the project area of influence or further afield to ensure the SPS 2009 requirement of no net loss of biodiversity is met.

6. Methodology and Workplan

This following sectionpresents the detailed methodology of the surveys that will be conducted. In addition, a detailed workplan is also provided showing the timeline of stipulated activities to be carried out during the project period.

6.1 Survey Methodology

6.1.1 Dolphin Survey

The dolphin survey is to be conducted in monsoon, post-monsoon and winter in the study area. A total of six surveys are to be conducted in July, September, October, November, December and February. A pre-monsoon survey has already been facilitated by NWPGCL following the same methodology. The dolphin surveys follow the standard methodology set by Smith *et al.*(2006and 2009)[4]. The first four surveys (pre-monsoon, first and second monsoon and first post-monsoon) were conducted by calculating encounter rate, and the last three surveys (second pre-monsoon, first and second winter) were conducted using Mark-recapture method.

To Analyze Encounter Rate

To conduct the survey, three transects are set (the Bhairab River Transect, the Atai River Transect and the Rupsha River Transect) and each transect is 10 km long. Three observers stand and actively search for dolphins along transects at all times and record sighting data. One observer is stationed on the port and one on starboard side of the vessel. These two observers search with handheld binoculars and naked eye from the beam to about 10˚ past the bow. The third observer stands in the centre and scans with the naked eye in about a 20˚ cone in front of the bow. This observer also keeps records in specialized data sheets. The observers are rotated through the three positions every half an hour. The height from the water level tothe observer is approximately 3 meters. The speed is set to 10 km/hour.

[4]Smith, B.D., Braulik, G., Strindberg, S., Ahmed, B. and Mansur, R. 2006. Abundance of Irrawaddy dolphins (Orcaellabrevirostris) and Ganges river dolphins (*Platanistagangeticagangetica*) estimated using concurrent counts from independent teams in waterways of the Sundarbans mangrove forest in Bangladesh, *Marine Mammal Science* 22(3): 527-547.

Smith, B.D., Braulik, G., Strindberg, S., Mansur, R., Diyan, M.A.A. and Ahmed, B. (2009). Habitat selection of freshwater dependent cetaceans and the potential effects of declining freshwater flows and sea-level rise in waterways of the Sundarbans mangrove forest, Bangladesh. Aquatic Conservation: Marine and Freshwater Ecosystems, 19, pp. 209-225.

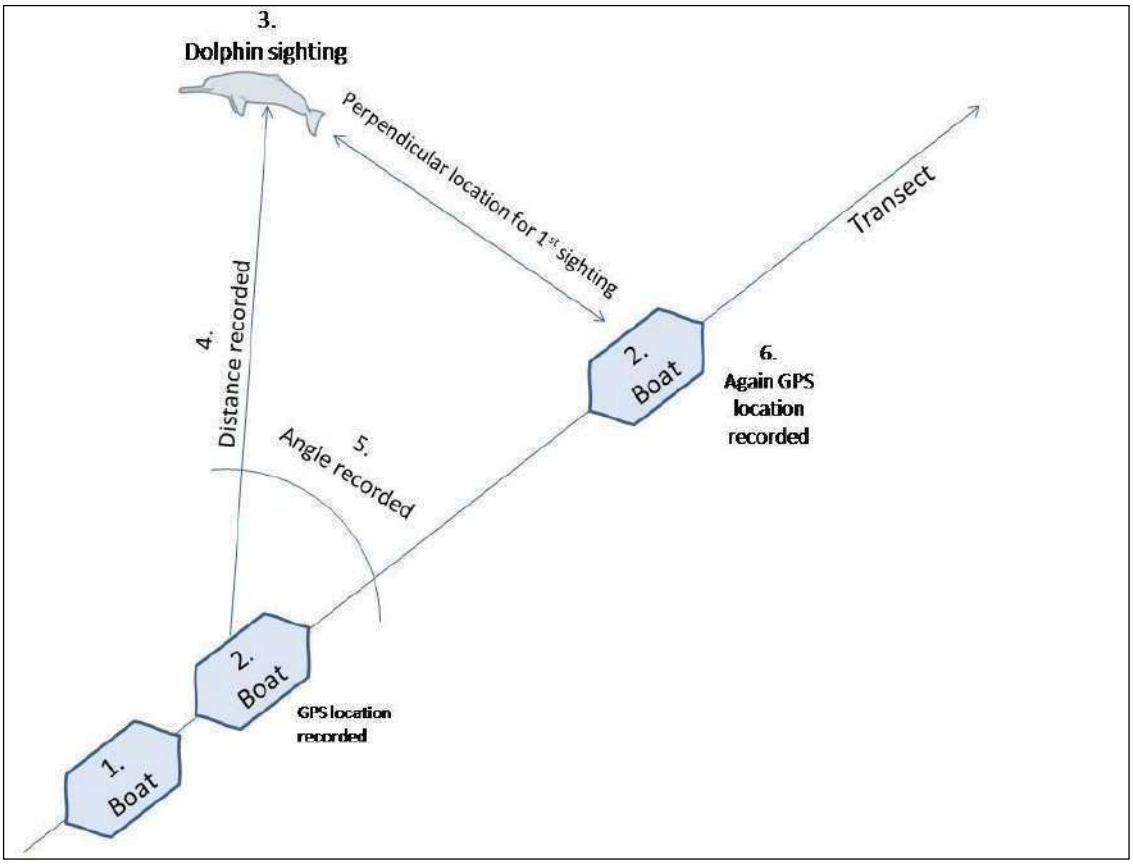


Illustration of the detailed methodology for dolphin survey described in Smith et al.(2006)

Once dolphins are spotted, the GPS coordinates of the exact spot where the animals were seen is recorded. The group size and the age class are then estimated.

To Calculate Population Number using Mark-recapture Method

The detailed methodology is in Appendix 2.

Along with this, weather conditions (wind, glare, and rain/fog) are recorded as well. These factors are given codes of 0, 1, or 2, where '0' corresponds to good (no effect on sighting conditions), '1' corresponds to fair (small effect on sighting conditions), and 2 corresponds to poor (large effect on sighting conditions) conditions, respectively.

6.1.2 Other Wildlife Survey

This survey will be done with the dolphin survey in July, September, October December and January. During the survey, the presence of other wildlife will be recorded along the transect by direct observation or call (for birds).The vessel will cover the transects at 10 km/hour and one observer will survey for other wildlife using binoculars and naked eyes. Furthermore, opportunistic encounters will be recorded as well. Locals will be interviewed for further information on the presence of other species in the area during the survey as well.

 A *fishing boat on the Rupsha River, 31 May 2017.*

6.1.3 Fish and Fishing Gear Survey

This survey will be done three times, in July, October, and November. Fishing communities and fishermen will be targeted for questionnaire surveys to gather information on fish species that are caught in various seasons and types of fishing gear used. Also, direct sampling will be done by visiting fishing boats and collecting data on fish species and fishing gears.

6.1.4 Riparian Vegetation Survey

For determining the riparian vegetation species diversity, quadrate method will be applied. This survey will be done in October. The size of each quadrate will be considered as 2 x 2 meter.The survey will be conducted 500m zone from the proposed power plant. The detailed methodology is in Appendix 11.

Different types of vegetation alongside the Atai River,31 May 2017.

6.1.5 Surface Water Quality Parameters

Water quality samples will be collected and analyzed during monsoon, post-monsoon and winter surveys. The surface water quality parameters are evaluated for physical, chemical, and biological characteristics of aquatic systems in relation to ecological conditions, and designated uses. Before the samples are collected for evaluation, the total area is mapped and ten stations are selected based on the concentration of pollution sources and confluences.

Sample Collection Seasons: Samples will be collected during monsoon, post-monsoon and winter seasons from 10 selected stations to assess the real concentration of different types of pollutants and their spatial distribution.

Sources of pollution at the Rupsha River, 31 May 2017.

Selecting Sample Sites: The first round of water samples will be collected from ten different locations along the entire river course. Spatial information of all sample sites will be collected using a handy GPS to prepare GIS maps. Quality of the river water will be assessed by comparing the selected parameters with the industrial water standard prepared by the Department of Environment (MoEF,1997)[5]. Location information of all the pollution sources as well as water sample collection points should be collected using GPS to develop pollution GIS maps.

Field Measurements: The field parameters, such as water temperature, pH, dissolved oxygen, and specific conductance will be measured using multi-probe instruments. For

[5]MoEF(1997). *The Environment Conservation Rules*. Ministry of Environment and Forests, Government of the People's Republic of Bangladesh.

each sampling trip, field measurements and observations will be recorded in a field data logbook or on a field data sheet.

For each visit to a specific station where field measurements and samples will be collected, the following information are needed to be noted:

- Station ID,
- Sampling date, location,
- Sampling depth,
- Sampling time, and
- Samplecollector's name.

All measured field parameters and their respective values and observationswill be recorded.

Brick field on the bank of the Atai River, 31 May 2017.

Field physicochemical parameters include part or all of the following:

- Dissolved oxygen,
- Temperature,
- Specific conductance,
- pH, and
- Salinity.

General Observation: It is always important to record field observations to aid in the interpretation of water quality information. Some common observations will be noted:

1) *Water appearance:* General observations on water might include colour or an unusual amount of suspended matter, debris, or foam.

2) *Unusual odours*: Examples include hydrogen sulphide, mustiness, sewage, petroleum, chemicals, or chlorine.

3) *Observations related to water quality*: If the water quality conditions are exceptionally poor, note that standards are not met in the observations—for example; dissolved oxygen is below minimum criteria. Uses may include swimming, wading, boating, fishing, irrigation pumps, or navigation. This type of information may be used in evaluating compliance with standards.

Collecting Samples: The 250 ml plastic bottles were washed properly and rinsed with 1-2 ml 2% industrial HCl. The bottles will be rinsed again with sampled water and will be properly labelled. Aeration during sampling will be avoided as much as possible. The water samples will be carefully transported to the laboratory and will be preserved for physical and chemical analyses. Water samples (including bacteriological) are generally collected before field measurements are taken.

Water samples to be collected at the same location for both bacteriological and chemical analysis. Water samples to be collected at the *centroid* of flow. The *centroid* is defined as the midpoint of that portion of the river width which contains 50 percent of the total flow. For river samples, the centroid of flow must be accessible for sampling physicochemical parameters, either by wading, from a bridge, or from a boat. If the water depth at the sampling point is less than 0.5 m, collect samples at a depth equal to one-third of the water depth measured from the water surface. If the water depth is greater than 0.5 m, collect samples at a depth of 0.3 m below the surface.

Sample containers should be new, unused, clean polyethylene containers or glass jars or used laboratory cleaned containers. Prior to sample collection, collectors should rinse containers three times with ambient water and discard water away from the sample location. However, new, unused containers or those cleaned in a laboratory may be used without rinsing.

Collection of Water Samples.

Collecting Water-Chemistry Samples: Examples of routine (baseline) conventional parameters include total suspended solids (TSS), chloride, sulfate, total nitrate, total phosphate (TP), total organic carbon (TOC), and chlorophyll a. Laboratory measured total dissolved solids (TDS) and orthophosphate (OP) are not routine parameters. Both laboratory analyzed TDS and field-filtered OP may be sampled and analyzed as needed for specific purposes.

Sample Preservation:
Ice: Samples must be placed on ice immediately after collection. Place all samples that require cooling only on ice before preserving other samples with acid. Sufficient ice will be needed to lower sample temperature to < 6ºC but not to the freezing point. Sample temperature must be maintained at < 6ºC until delivery to the laboratory. Take care at all times during collection, handling, and transport to prevent exposure of the sample to direct sunlight.

Acid: Label samples requiring preservation with sulphuric acid (H2SO4) in a way that lets the laboratory know that acid has been added. For example, put an X on the container cap to signify that acid was used for preservation, or label container "2 mL H_2SO_4 added." Add approximately 2 mL of 1:1, analytical reagent grade H_2SO_4 to each litre of sample to be analyzed for ammonia, total Kjeldahl nitrogen, total phosphorus, and total organic carbon. This amount is adequate to reduce the pH to less than 2. Maintain the temperature at < 6ºC until arrival at the laboratory. Preservation with acid must occur in the field within 15 minutes of collection. Samples must be cooled to < 6ºC, but should never be frozen.

Surfing of a Ganges River Dolphin at confluence of the Rupsha, Bhairab and Atai Rivers, 23 October 2017.

Water sample for anion and cation analysis: At each sampling point, water will be collected in two different bottles. One will be acidified properly for heavy metal analysis and the other non-acidified water sample was preserved for anion.

Physical properties such as color, odor and temperature, and chemical properties such as pH, electrical conductivity, dissolved oxygen, biological oxygen demand and total dissolved solids are important quality parameters of water. The pH will be determined by digital pH meter (HANNA Instrument 211, Microprocessor pH). Total dissolved solids and electrical conductivity will be determined by digital TDS meter and EC meter (HM digital). Temperature will be determined by Thermometer. Dissolved oxygen will be determined by Winkler's Iodometric method, and biological oxygen demand (BOD) and alkalinity will be determined by titrimetric method as described by Huq and Alam (2005)[6].

There are lots of organic materials in river water. In order to assess BOD and chemical oxygen demand (COD), the organic materials in the river water will needed to be oxidized by oxidizing agent like sulphuric acid, potassium dichromate. Later, titrimetric method will be used after digestion (150°C for 2 hours) and cooling the samples properly. Alkalinity will be measured and reported in terms of CaCO3 equivalent. Analysis of water samples for Cation will be done using AAS machine and the anion using IC machine.

6.1.6 Biological Parameters

Collecting and Analyzing Biological Samples: The indicator organisms used for determining support of the recreation use are *Escherichiacoli* in freshwater and *Enterococcus* in marine waters and some saline inland waters. Baseline bacteriological samples should be collected at all monitoring sites under all flow conditions. To maximize the processing time for the laboratory, bacteriological samples will be collectedlast at a site. In streams and rivers, care should be takento find an undisturbed location if other work, like flow or sediment collection, will be done at the site. When collecting samples from a bucket of water (bridge site), the bacteriological sample should be collected before other samples. Water into the bacteriological-sample container will be poured. water-sample containers should never be immersed in the bucket; doing so could introduce contamination.

Sample Collection: Few important measures to be undertaken while collecting samples. They are as follows:

Clean hands: Bacteria samples are the easiest to contaminate. Take steps to help eliminate possible contamination by using either an alcohol-based hand sanitizer that contains at least 60 percent alcohol prior to sample collection or wearing disposable latex gloves when collecting a sample.

Never pre-rinse the sample container: When submerging the sample container, take care to avoid contamination by surface scum. The surface film is enriched with particles and bacteria not representative of the water mass.

*

[6]Huq, S. and Alam, M. (2005).*A Handbook on Analyses of Soil, Plant and Water*. BACER-DU, University of Dhaka, Bangladesh.

Leave sufficient headspace: The lab needs to mix the sample prior to processing to redistribute bacteria in the sample. Fill the sample container to the top. This allows the lab to process the sample according to their procedures.

Flowing streams: Dip the open sample container to a depth of 0.3 m, or roughly half the depth in very shallow streams. Avoid contact with the sediment. With the open end facing upstream, push the mouth of the bag upstream at this depth until full. Always hold the mouth of the sample container upstream of the sampler, the sampling apparatus, and any disturbed sediments.

Abandoned cargo vessels on the Atai River,31 May 2017.

Sample Labeling: Each sample will be labeled with the sample number, date, and time collected.

Sample Preservation: Place samples on ice immediately after collection. No more than one bacteria sample per gallon of cooler capacity may be placed inside the cooler; these should be evenly spaced inside the cooler and completely covered with wet ice. Cool the samples as quickly as possible to < 6ºC but do not allow the samples to freeze.

Sample Holding Time: Holding time is defined as the amount of time between collection and the initiation of analysis. Plan sample collection so that samples are set up within the required holding time. Do not report samples that are not prepared within the time limit or are reported from the laboratory as exceeding the holding time. Laboratories are required to process bacteriological samples within eight hours of sample collection whenever possible. The 8-hour holding time includes 6 for transporting and 2 for processing. Field personnel should submit samples to the lab within 6 hours when possible. When transport conditions cause delays in sample preparation longer than 8 hours, the holding time may be extended up to 48 hours for *E. coli*. However, any extension should be minimized.

Foggy condition in the Atai River which affects dolphin sighting on 31 May 2017.

Collecting and Analyzing Phytoplankton and Zooplankton: To identify and quantify phytoplankton and zooplankton in the river water, concentrated one litrewater sample will be collected in plastic bottles by concentrating 20 litres of water into one litre. The water samples will be immediately preserved by adding formalin so that concentration becomes 8%. Water samples will be immediately transported to laboratory and will beworked out to enumerate both phytoplankton and zooplankton.

In the laboratory, water will be taken out with the help of 1 ml pipette and then one drop of it will be spread onto a Sedgewick/Rafter chamber. A cover slip will be placed on the slide. Finally, the slide will be observed under microscope to get results about the abundance of targeted species (Zeiss microscope with digital camera, Nikon).

6.1.7 Water Depth

Water depth will be measured in pre-monsoon, monsoon, post-monsoon and winter periods. It will be measured during the dolphin survey. The water depth is measured by an echo-sounder every 1 km on the transects during high and low tides.

An eddy observed where highest depth recorded at the AtaiRiver, 31 May 2017.

6.1.8 Watercraft Survey

Survey for watercrafts and other water transports will be done in monsoon, post-monsoon and winter months in July, October and November, respectively. This survey coincides with three dolphin surveys and will be done simultaneously. The vehicles are categorized as cargo (C), non-cargo (NC), mechanized (M), and non-mechanized (NM).

Motorized cargo vessel carrying sand on the Bhairab River, 31 May 2017.

6.1.9 Pollution Mapping

Sources that will be identified during collection of water samples will be used to produce GIS-based maps, which will show the pollution sources. Along with this, the results from the water samples analysis will be used to produce GIS maps.

Existing power plant by the Bhairab River,31 May 2017.

6.1.10 Assess Potential Impacts and Identify Mitigation Measure

Using the results of the surveys, criteria for determining critical habitat will be analyzed as per IFC Guidance Notes[7]and through various literature reviews, and potential impacts and mitigation measures will be shared.

A portion of fishing area in the Atai River, 31 May 2017.

[7]International Finance Corporation, http://www.ifc.org/wps/wcm/connect/e280ef804a0256609709ffd1a5d13d27/GN_English_2012_Full-Document.pdf?MOD=AJPERES.

6.2 Workplan

The workplan below provides the timeline when each of the activity will be done during the project period (June 2017-February 2018)

Workplan for Biodiversity Assessment																																					
Season	Monsoon																Post-monsoon								Winter													
Month	June				July				August				September				October				November				December				January				February					
Action / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Study team formation, background information collection and mapping																																					
Dolphin Survey																																					
Fish/Fisheries/Fishing Gears/Vegetation																																					
Watercraft																																					
Water quality Parameters Collection and analysis																																					
Mapping																																					
Other Species Survey																																					
Data analysis																																					
Report preparation and Submission																																					
Submission of pre-monsoon and monsoon survey Report												X																									
Submission of post monsoon report(1)																		X																			
Submission of post monsoon report(2)																					X																
Submission of winter survey report																												X									
Final Report																																			X		

7. Surveys

The surveys include dolphins, other wildlife, watercrafts, water depth, eddies, fish species, fishing areas, fishing gears, vegetation, and surface water quality parameters and biological parameters.

Post-monsoon survey Dolphin survey 09 November 2017

8. Survey Findings

8.1 Dolphin Survey

A total of 284 sightings of Ganges River Dolphins were recorded during pre-monsoon, monsoon and first post-monsoon surveys (May-October 2017) (Map 1 and Figure 1). The overall encounter rate is 1.18/ km (Table 1).Calculation is in Appendix 1.

In the second winter survey, a group of Irrawaddy Dolphin consisting of four individuals was recorded from Atai river opportunistically. The species is considered globally Endangered and nationally Near Threatened.

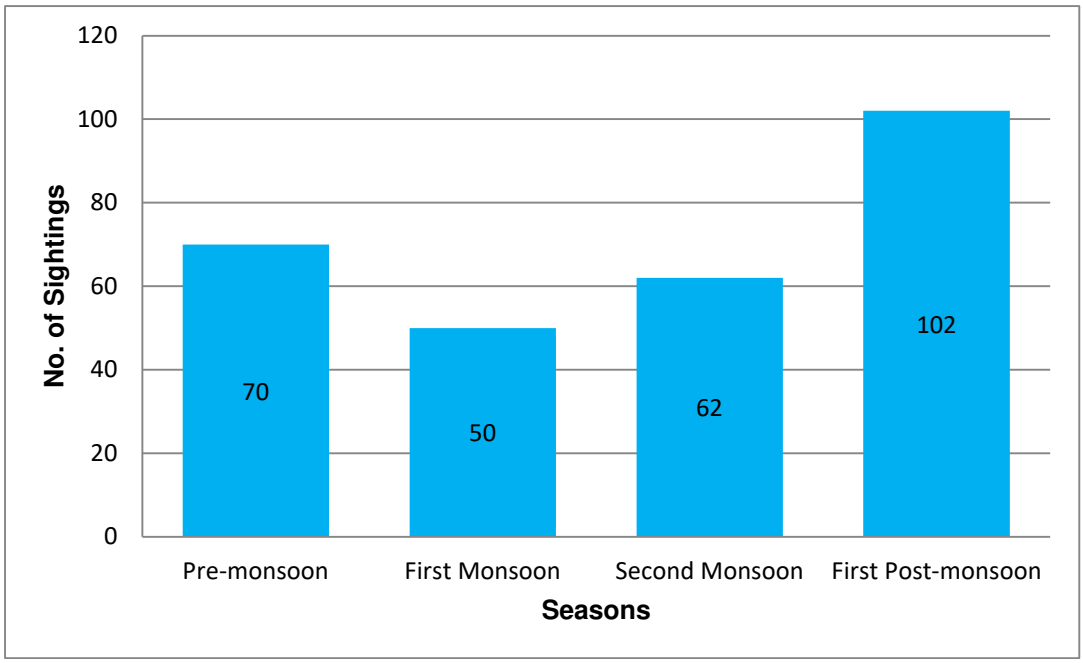


Figure 1. Graph showing seasonal variation of dolphin sightings during the survey period.

Table1. Table showing encounter rates of dolphins in all surveyed seasons and tides.

Survey season	Encounter rate (High Tide)	Encounter Rate (Low Tide)	Encounter Rate (Average)
Pre-monsoon survey	1.40	0.93	1.16
First monsoon survey	1.33	0.33	0.83
Second monsoon survey	1.03	1.03	1.03
First post-monsoon survey	1.23	2.16	1.70
Total	4.99	4.45	4.72
Average	**1.24**	**1.11**	**1.18**

Three surveys were conducted using the mark-recapture method (Details in Section 6.1.1) and the result of three surveys is used in this report.

An average of **47** and **34** dolphins were calculated for the project area by using the 'Chapman's Modified Lincoln-Petersen Mark-Recapture Estimator' and the 'Huggins Conditional Likelihood Model', respectively (Table 2 and 4).

The 'Chapman's modified Lincoln-Petersen Estimator' revealed that the sum of groups detected by both the groups($n_p + n_s$)was always greater than the corrected number of groups(G_c).

$$n_p + n_s > G_c$$

$$G_c = (n_{p+1})(n_{s+1})/(m_{ps} + 1) - 1$$

Where, "n_p"is the number of groups detected by the primary observer team and "n_s" for the secondary observer team. Also, $m_{ps}$is the total number of group detected by both teams

The correction factor 1.26, 1.18 and 1.69 were used for the groups missed by primary and secondary observer team during the second post-monsoon, first winter and second winter respectively. This number was then multiplied with the mean group size to calculate the dolphin abundance in the survey area (A_d). The upper (19) and lower range (8) of dolphin abundance (Table 2)at the 95% confidence interval then calculate using

$$A_d \pm \sqrt{VAR(A_d)}\ .$$

Table2: Estimated dolphin population using Chapman's Modified Lincoln-Petersen model

Model	**Dolphin population**		
	Second post-monsoon survey	First winter survey	Second winter survey
Chapman's Modified Lincoln-Petersen model	28 ~ 58	41 ~ 51	38 ~ 64
No. of Dolphin (Mean)	43	46	52
Average	47		

'Huggins Conditional Likelihood Model' has the advantage of incorporating covariates directly into the modeling process by maintaining the link between individual mark-recapture records (here, five occasions were considered) and their respective covariate values (three covariates: group size, channel width, and sighting conditions). So, considering the maximum likelihood Huggins Model, average **34** dolphins were estimated for the study area.

Apparently, the 'Chapman's Modified Lincoln-Petersen Mark-Recapture Estimator' is relative less rigorous and straight forward, as it does not consider the variables. Both the models were done to compare the results.

Although, the 'Chapman's Modified Lincoln-Petersen Mark-Recapture Estimator' showed a little over-abundance than the Huggins Conditional Likelihood Model', we rely more on the probabilistic 'Huggins Conditional Likelihood Model' for estimating dolphin population and Critical Habitat analysis.

Table 3: The number of Ganges River Dolphin detected by the primary and secondary observer teams during search effort in second post-monsoon, first winter and second winter, the number of corrected groups and their associated co-efficient of variations from the Chapman's modified Lincoln-Petersen mark-recapture estimator.

Second post-monsoon survey					
Ganges River Dolphin	Number of Sighting (Primar	Number of Sighting (Secondary Team, n_s)	Number of Sighting detected by Both Teams, m_{ps}	Corrected No. of Groups (G_c)	Coefficient of Variation (CV_c)

	y Team, n_p)				
Group Size (1)	8	11	7	13	0.069
Group Size (2-3)	8	5	4	10	0.112
Group Size(>3)	2	1	1	2	0
First winter survey					
Ganges River Dolphin	Number of Sighting (Primary Team, n_p)	Number of Sighting (Secondary Team, n_s)	Number of Sighting detected by Both Teams, m_{ps}	Corrected No. of Groups (G_c)	Coefficient of Variation (CV_c)
Group Size (1)	11	7	6	13	0.087
Group Size (2-3)	5	7	4	9	0.113
Group Size(>3)	3	2	2	3	0
Second winter survey					
Ganges River Dolphin	Number of Sighting (Primary Team, n_p)	Number of Sighting (Secondary Team, n_s)	Number of Sighting detected by Both Teams, m_{ps}	Corrected No. of Groups (G_c)	Coefficient of Variation (CV_c)
Group Size (1)	7	7	5	10	0.104
Group Size (2-3)	6	8	4	12	0.158
Group Size(>3)	2	2	1	4	0.247

The 'Huggins Conditional Likelihood Model', in the MARK software, ran to derive the probabilities under closed capture condition. The Horvitz-Thomson estimator was used to calculate the abundance, it was considered that, capture probability equals to recapture probability ($p = c$), total Dolphin Abundance ($\tilde{N}$) = M_{t+1}.

Nine different models with different number of parameters simulated (built-in models in the MARK software) and compared with the selected model having the lowest AIC value. The likelihood ratio test revealed that the chosen model performs better than other compared models considering both the number of parameters and the AIC value (Appendix 6,7,8).

According to the model result, an average **34** (Table 4) dolphin found in the mark-recapture (closed abundance) analysis. The detailed results, parameters, covariates are summarized in Appendix 3,4,5.

Table 4:Estimated dolphin population using Huggins conditional likelihood model

Huggins conditional likelihood model	**Dolphin population**		
	Second post-monsoon survey	First winter survey	Second winter survey
Lowest AIC Value	123.8927	96.589	106.726
Dolphin number	35	35	32
Average	**34**		

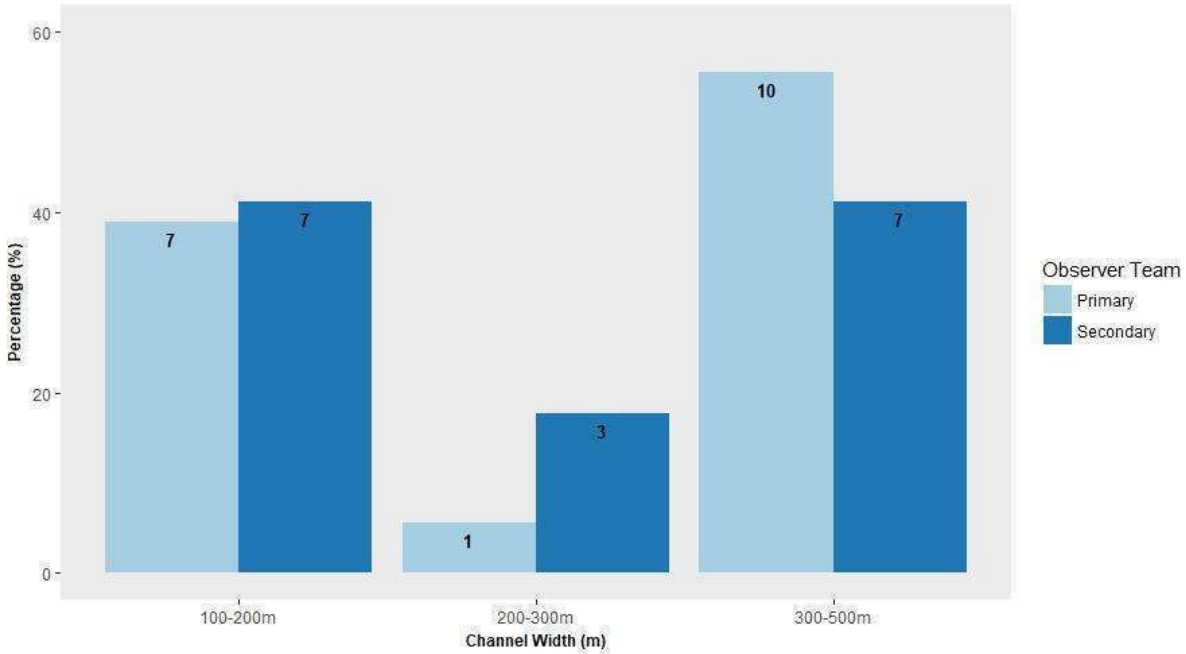


Figure 2. Channel width (m) measured by primary and secondary team during post-monsoon survey

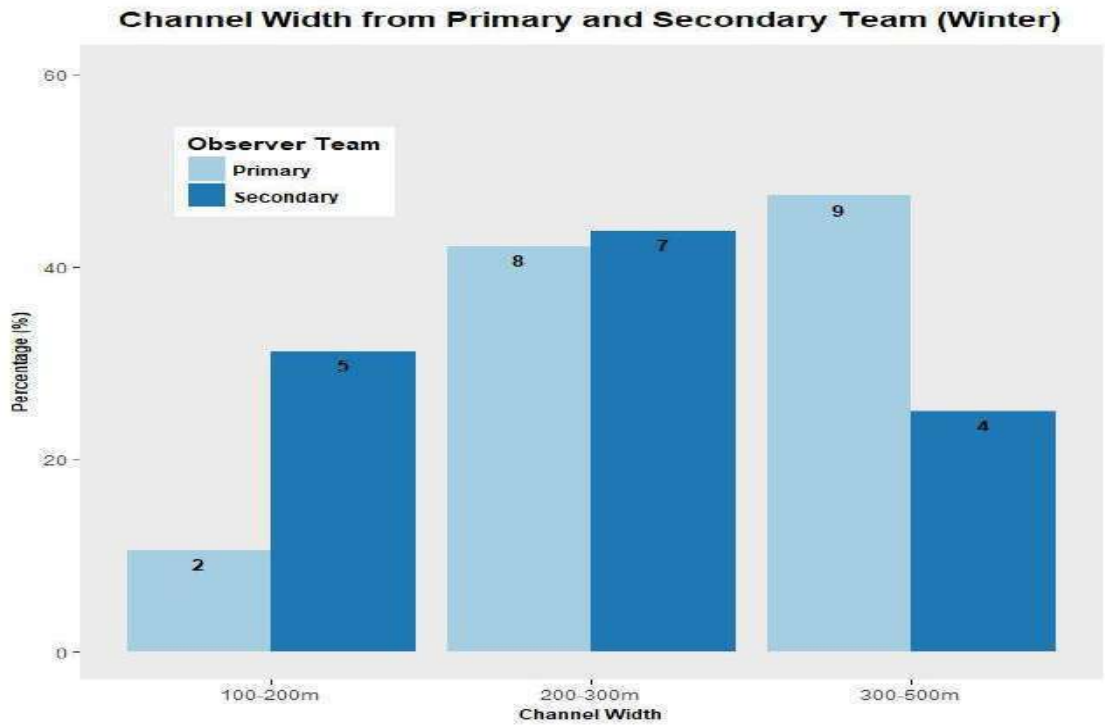


Figure 3. Channel width (m) measured by primary and secondary team during first winter survey

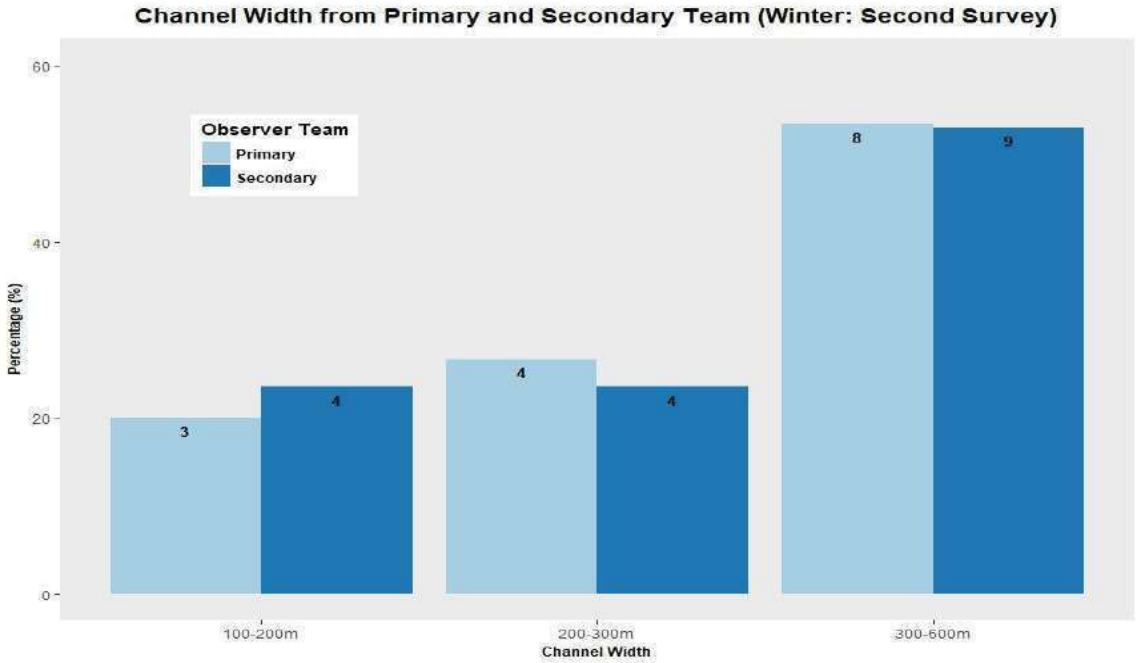


Figure 4.Channel width (m) measured by primary and secondary team during second winter survey

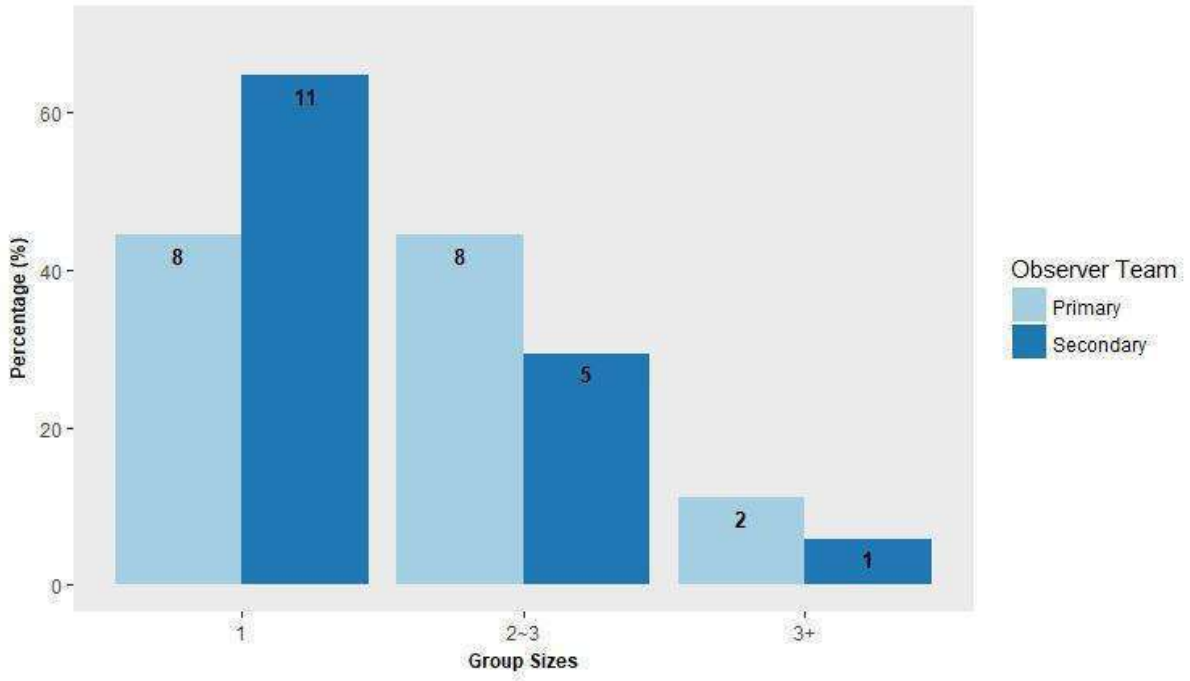


Figure 5. Group sizes recorded by the primary and secondary team during second post-monsoon survey

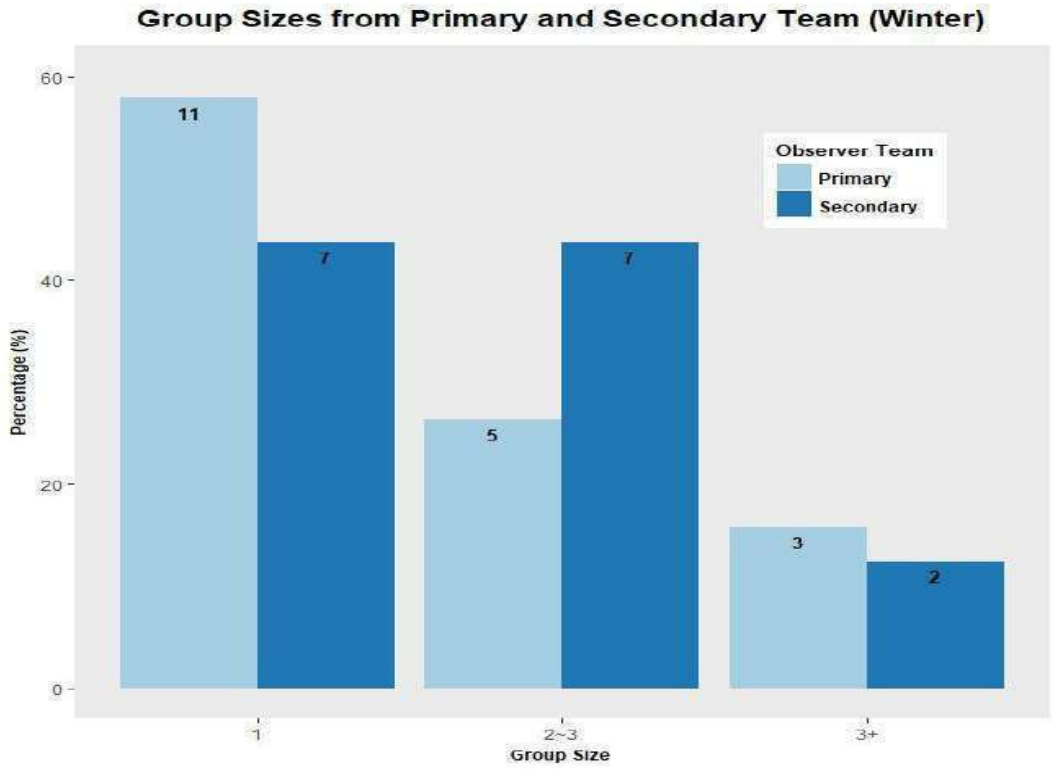


Figure 6. Group sizes recorded by the primary and secondary team during second post-monsoon survey

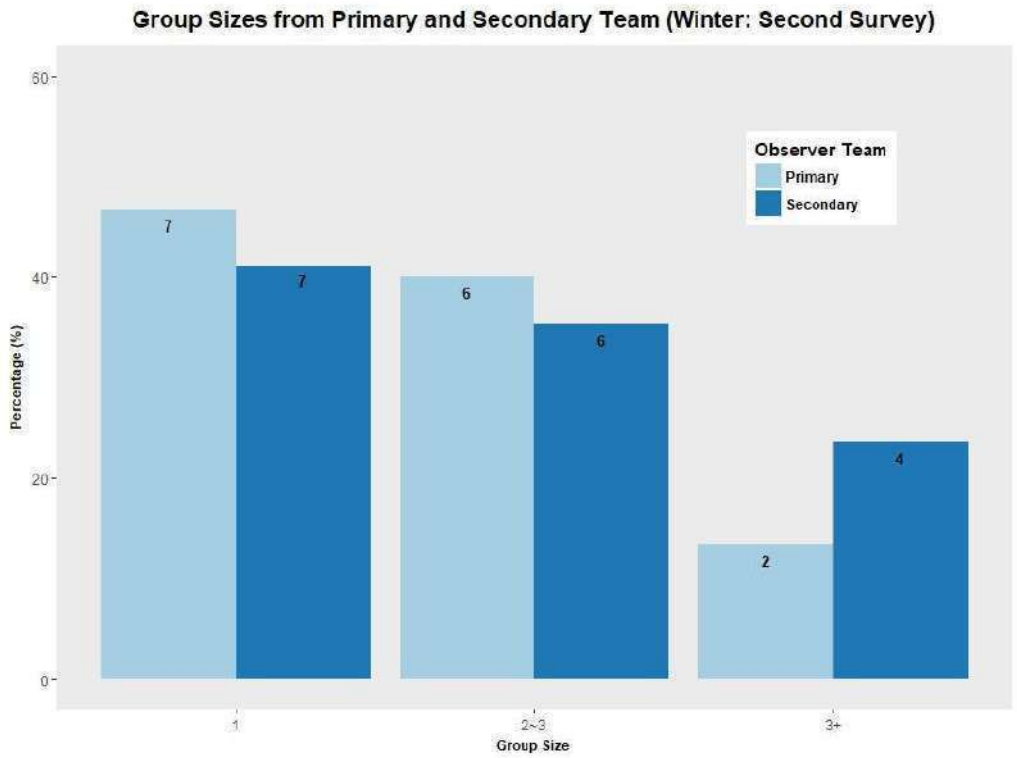


Figure 7. Group sizes recorded by the primary and secondary team during second post-monsoon survey

Important Dolphin Area

From all the surveys, specific areas within the total area have been identified with high concentration of dolphin sighting including calves. The areas can be considered as important dolphin areas based on the number of sightings and considering the channel width and other parameters (Map 3 and Table 5).The most important area is the confluence of Atai-Bhairb-Rupsha Rivers which is c.500m from the project site.

From the surveys, it was understood that the dolphin population in the area is <7.5% of the total known national population. So, the entire 30 km area should be considered as an important area.

Table 5. Details of important dolphin areas

Rank	Name of important dolphin site	Location in Map	Sighting number in pre-monsoon, monsoon and post monsoon surveys
1	Confluence of the Bhairab-Atai-Rupsha	Confluence	75
2	Atai river	Atai	59
3	Near Rupsha bridge	Rupsha 2	47
4	Bhairab-Madhumati Confluence	Bhairab 1	27
5	JelkhanaGhat confluence	Rupsha 1	20
6	Near Daulatapur	Bhairab 2	17

Critical Habitat Analysis

According to the International Finance Corporation (IFC) Guidelines, critical habitats are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes. Critical habitat is defined by the following criteria;

-Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species
-Criterion 2: Endemic and/or restricted-range species
-Criterion 3: Migratory and/or congregatory species
-Criterion 4: Highly threatened and/or unique ecosystems
-Criterion 5: Key evolutionary processes

Critical Habitat Analysis for Dolphins

Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species

Criterion 1 states that any species threatened with global extinction and listed as CR and EN on the IUCN Red List of Threatened Species shall be considered as part of Criterion 1.

There are two tiers with sub-criteria under Criterion 1.

From the surveys following mark-recapture method conducted for the Ganges River Dolphin in the project area. The probabilistic 'Huggins Conditional Likelihood Model' was relied upon for estimating dolphin population and Critical Habitat analysis.

Table 6: Details of Ganges River Dolphins

Species Name	Global Status	National Status	Global Population	National Population	Population in Project Site	% of Global Population	% of National Population
Ganges River Dolphin	Endangered	Vulnerable	<5000	Unknown (225 in Sundarbans, 125 in Karnaphuli River, 38–58 in Jamuna River and 34–43 in nine groups in Kushiyara River)	34	<0.68%	<7.5%

Source: Braulik and Smith (2017), IUCN Bangladesh (2015), Smith *et al.*(1998)

Under the Tier 1 sub-criteria of Criterion 1, the project site cannot be declared as Critical Habitat as percentage of dolphins found in the project site is not ≥ 10 percent

of the global population and the habitat cannot be considered as a discrete management unit. The project site holds less than 0.68% (Table 6) of the global population of the species. Furthermore, the project area is not one of 10 or fewer global discrete management site for this species.

The project site cannot be declared as Critical Habitat under Tier 2 sub-criteria of Criterion 1, as it does not support an regionally important concentration of this species (in comparison to densities of the species elsewhere in Bangladesh and beyond). There is also no other reason to consider the area of significant importance to the species.

Finally, the loss of this habitat will not significantly impact the long-term survivability of the species owing to its small population at the project site compared to global population.

The habitat does not contain nationally important concentration of CR or EN species, as the species is considered nationally Vulnerable.

Lastly, the species is nationally Vulnerable and globally Endangered. If the species was considered as nationally CR or EN, the area would have been considered Critical Habitat under Tier 2 sub-criteria of Criterion 1.

Criterion 2: Endemic and/or restricted-range species

The project site cannot be considered as Critical Habitat under Criterion 2, as there was no record of any endemic or restricted-range species from the surveys.

Criterion 3: Migratory and/or congregatory species

The project site cannot be considered as Critical Habitat under Tier 1 of Criterion 3 as no migratory or congregatory species were recorded whose ≥ 95% population relies on this habitat.

The project site cannot be considered as Critical Habitat under Tier 2 of Criterion 3, as the project site were fulfill the standers of Tier 2.

Criterion 4: Highly threatened and/or unique ecosystems

The project site cannot be considered as Critical Habitat under Criterion 5, as it cannot be considered as a highly threatened and/or unique ecosystem under the given standards.

Criterion 5: Key evolutionary processes

The project site cannot be considered as Critical Habitat under Criterion 5, as area does not fulfill the standards set under criterion.

Critical Habitat for Fish and Other Wildlife

A total of 6 species of fish were found to be included in the recently published National IUCN Redlist (2015). These six fish species have EN status as per the National RedList, but the global status of these 6 species are: four Least concerned (LC) and two Near threatened (NT)(Detail Appendix 10). The data collected on these species is inadequate to analyze the species abundance as well as Critical Habitat. Due to the unavailability of the data, the Critical Habitat analysis was done using the national/regional range of these species as a proxy. When considering the range of the species, the project site cannot be considered as critical habitat for these species. Details in the Table 6a.

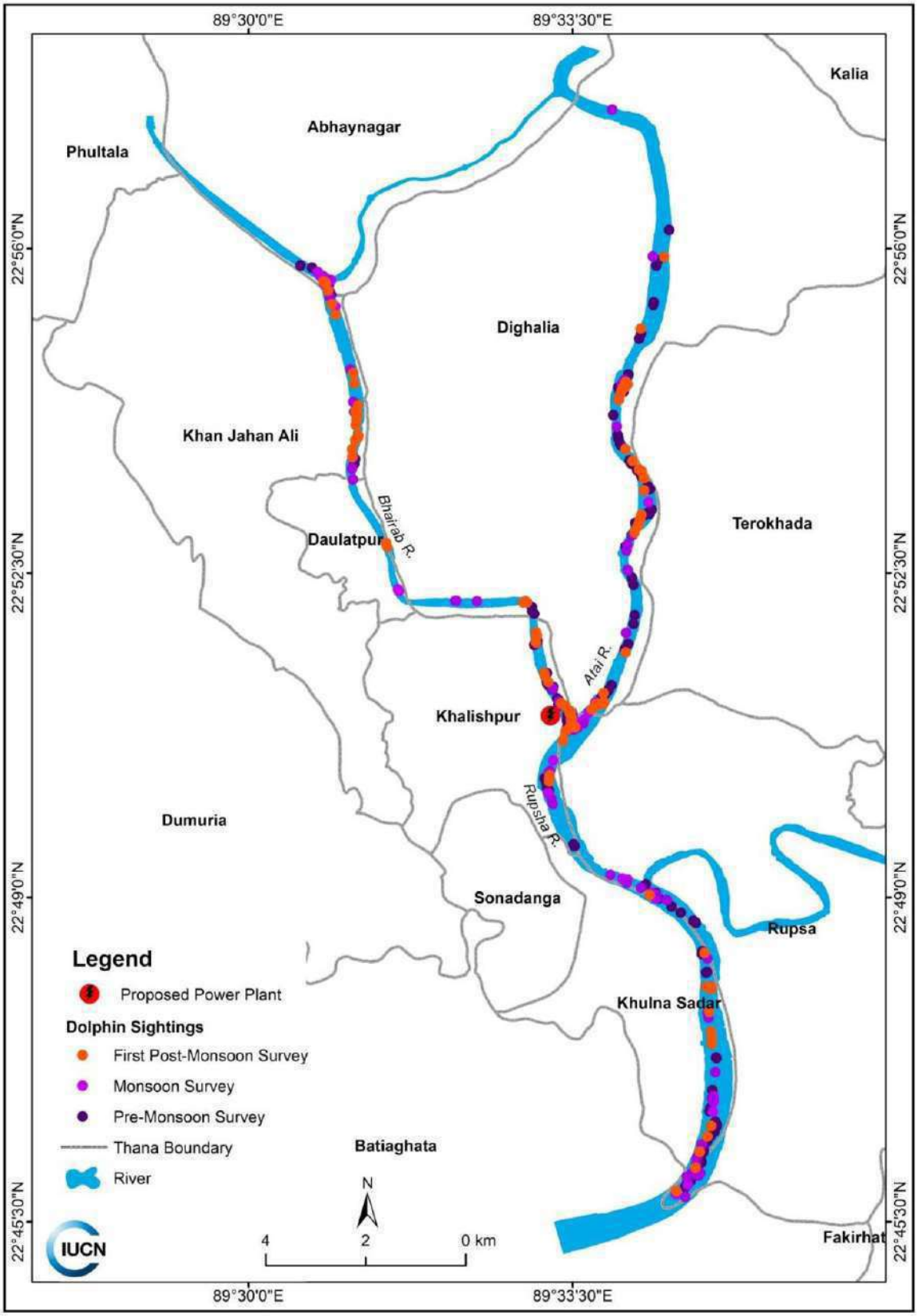
Regarding Smooth-coated Otter, we have no direct evidence/sighting during field survey period. Due to the unavailability of the data, the Critical Habitat analysis was done using the national/regional range of these species as a proxy. When considering the range of the species, the project site cannot be considered as critical habitat for these species.

Regarding Irrawaddy Dolphin, only one sighting of a group consisting of four individuals was recorded. This sighting was only during the second winter survey. There was no other sightings from previous six surveys. Although the species is globally Endangered, and nationally Near Threatened, the population in the project area is not large enough to fall under any criterion of Critical Habitat. The national population of this species is around 6000 individuals (IUCN 2015).

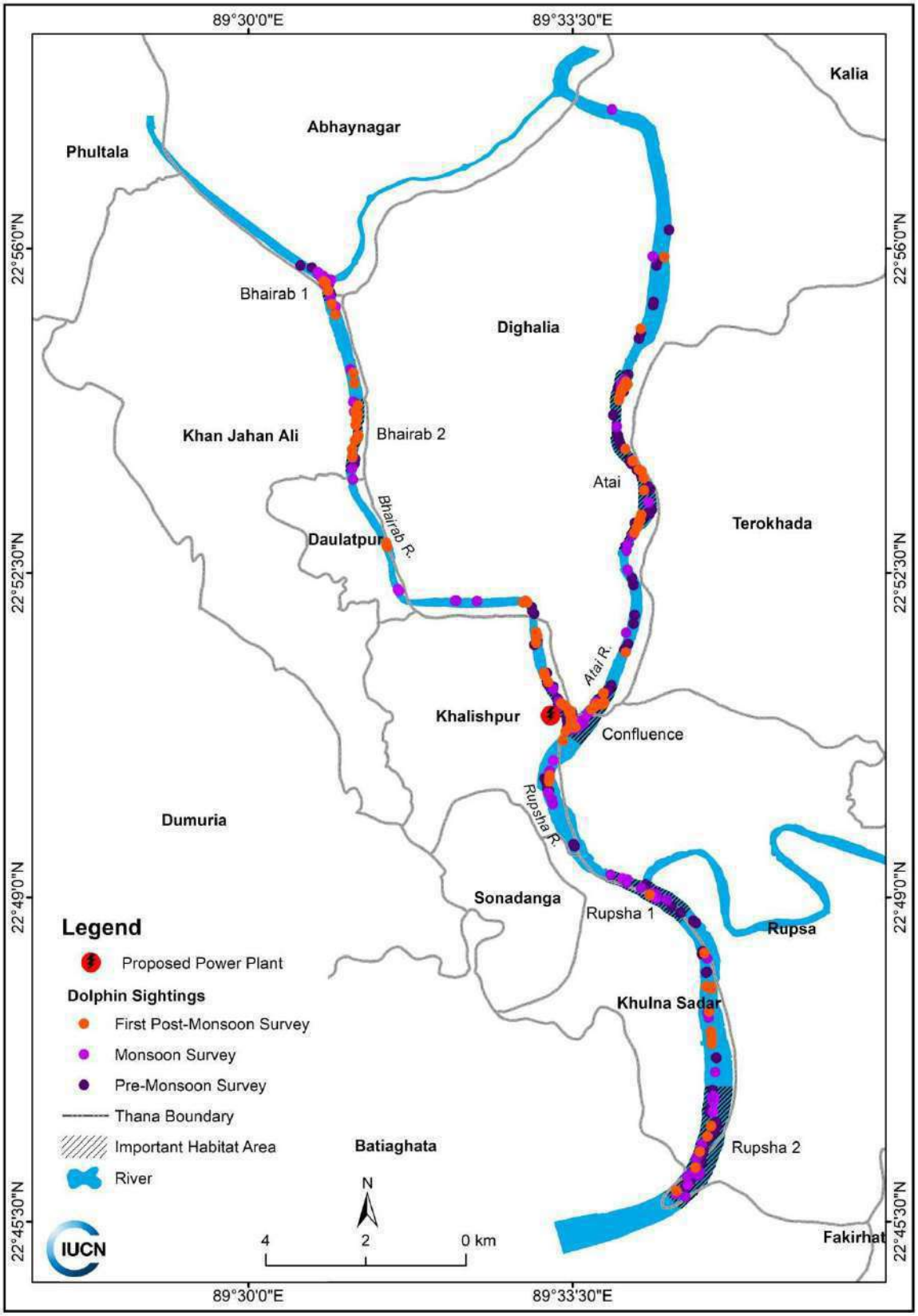
Table.6a. Species distribution range in Bangladesh

Species Name	**Distribution range in Bangladesh (IUCN 2015 Redlist)**	**Remarks**
Smooth-coated Otters(*Lutrogale perspicillata)*	This species is mainly found in hilly areas of northeast, southeast coastal region with the largest population is in Sundarbans. The total extent of occurrence is 1,34,973 km^2	Although the species is considered as CR nationally, it still has a large area of occupancy, and thus cannot be considered for the Critical Habitat assessment. Furthermore, there have no direct evidence/sighting during field survey period. Interviews of local people were held and only one person had claimed(out of 6 interview surveys) that the species was sometimes found in the area
Fish		
Tire-track Spinyeel (*Mastacembelus armatus)*	Found in rivers, canals, beels, ponds, and inundated fields throughout Bangladesh. The total extent of occurrence is 2,17,468 km^2	Although the species is considered EN nationally, the species has a fairly large area of occupancy and found throughout Bangladesh. Considering

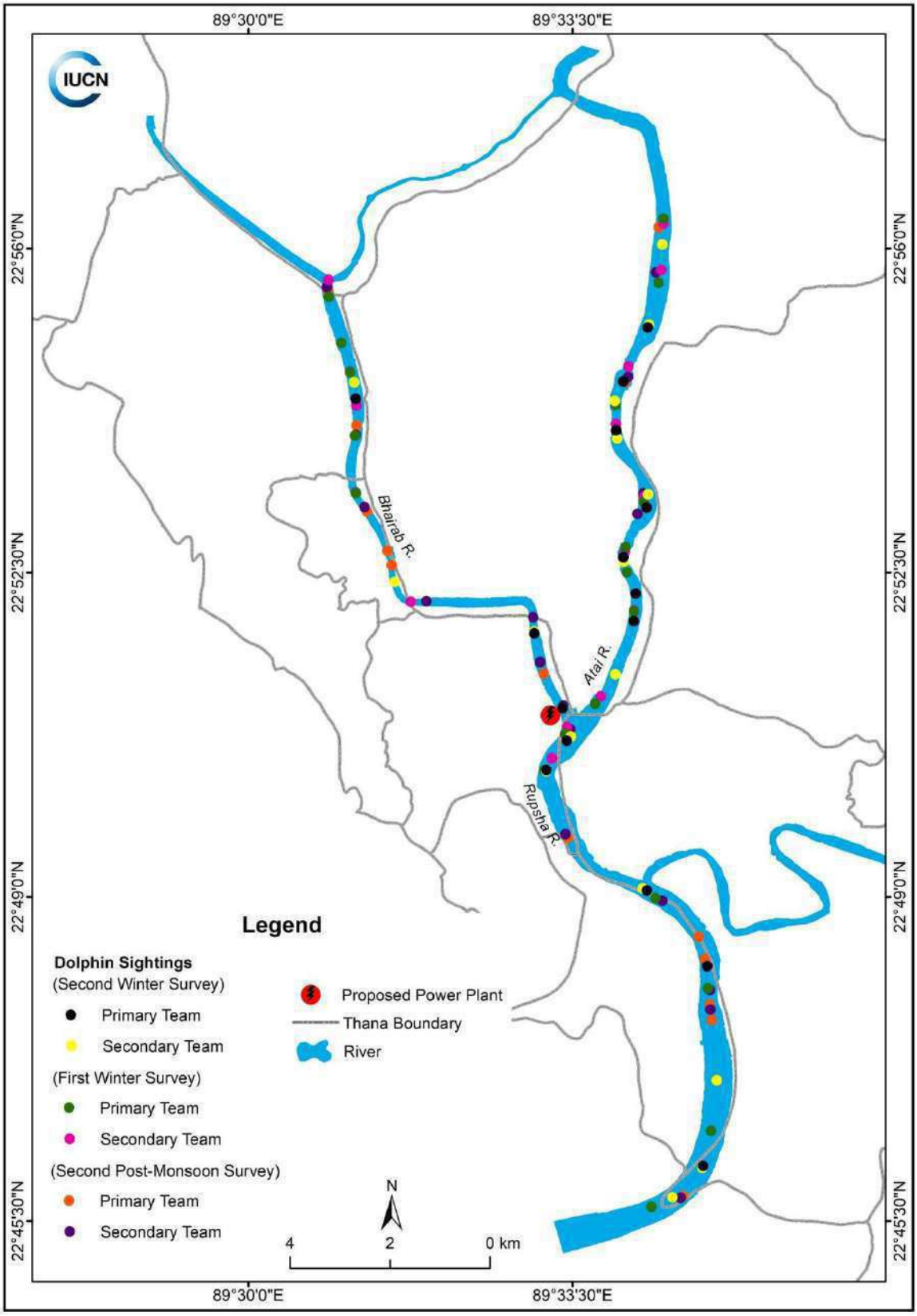
		the range of this species, the area cannot be considered CH for this species.
Humped Featherback (*Chitala chitala)*	Considered as a widely distributed species in rivers, beels, haors, reservoirs, canals and ponds. The total extent of occurrence is 1,31,403 $km^{2.}$	The species is recorded through interview survey (2 out 3 surveys) and there was no direct evidence of the project site. Furthermore, the species is widely distributed through out the country and considering the range and area of occupancy, this species, the area cannot be considered CH for this species.
Giant Snakehead (*Channa marulius)*	The Padma, Padma distributaries, Borulia haor (Nikli, Kishorganj), Mahananda, Choto Jamuna, Ichanoi Beel (Gaibandha), Dogger Beel (Chandpur), Titas, larger haors in Greater Sylhet and Mymensingh Districts, beels and larger water bodies in Dhaka, Manikganj and Tangail Districts. The total extent of occurrence is 70254 $km^{2.}$	The species is recorded through interview survey (1 out 3 surveys) and there was no direct evidence of the project site. According to the national distribution, this species is not found in or near the project area.
Pabda catfish (*Ompok pabda)*	The species is widely distributed throughout Bangladesh and reported from Padma, Jamuna, Meghna, Surma, Kushira, Manu Ichamati, Banglali, Turag, Baral, Choto Jamuna, Mahananda, Muhuri, Barnai and Titas Rivers Feni Reserviour, Tanguar Haor, Hakaluki Haor, Chalan Beel and Medha Beel. The total extent of occurrence is 1,21,601$km^{2.}$.	The species has a large EOO and found throughout Bangladesh. Considering the range of this species, the area cannot be considered CH for this species.



Map2. Map showing dolphin sightings of pre-monsoon, monsoon and first post-monsoon surveys along the three transects



Map 3. Map showing important dolphin areas in the project area.



Map4. Map showing dolphin groups observed by primary and secondary team in the second post-monsoon and winter survey along the transect

8.2 Other Wildlife

Other wildlife includes a total of 41 species of birds among which are 8 are migratory species and four other species (Water Monitor, Indian Flying Fox, Smooth-coated Otters and Irrawaddy Dolphin) were recorded during the survey period. The highest number of species recorded was from monsoon (28 species) followed by post-monsoon (26 species), winter (17 species) and pre-monsoon (11 species). The highest number counted was of Little Cormorant with 241individuals. Details are in Appendix 9.

8.3 Watercraft Survey

Watercrafts were also counted during the survey period. A total of 676 watercrafts comprised of mechanized and non- mechanized were recorded. The highest was mechanized boats with a total of 373 from all surveys. Rupsha River had the highest number of water vessels with a total of 253, followed by Atai River with 225 and Bhairab River with 198. The details of water vessels are given in (Table 7).

Table 7. Table showing number water vessels recorded during the surveys.

Survey season		**Non-Cargo**		
	Cargo	**Mechanized**	**Non-mechanized**	**Total**
Pre-monsoon survey	11	32	19	62
First monsoon survey	20	53	62	135
Second monsoon survey	8	71	15	94
First post-monsoon survey	40	90	42	172
Second post-monsoon survey	19	30	9	58
First winter survey	06	52	11	69
Second winter survey	32	45	9	86
Total	**136**	**373**	**167**	**676**

8.4 Water Depth

Water depth was measured along transects every 1km intervals using an echo-sounder. Table 8 presents the details of the water depth surveys.

Table 8. Table showing the water depth recorded during the surveys.

Transect	**Tide**	**Pre-monsoon**		**Monsoon (1st& 2nd monsoon average)**		**Post-monsoon**	
		Max	**Min**	**Max**	**Min**	**Max**	**Min**
Rupsha	High	34.4	3	22.75	8.8	30.8	8.2
	Low	23.9	10	27.1	8.8	29.3	11.9
Bhairab	High	20.1	6.6	12.65	6.45	13.5	5.2
	Low	17.3	6.3	12.95	5.65	19.5	5.9
Atai	High	30.4	18.7	32.1	8.65	27.6	6.8
	Low	24.3	6.6	43.9	9.8	34.6	10

8.5 Eddy

Eddies were recorded in five surveys in the project areas. The number of eddies found in each rivers in high and low tides in the surveys is presented in Table 9.

Table 9. Table showing number of eddies in each river during five surveys

Transect	Tide	Pre-monsoon	First monsoon	Second monsoon	First post-monsoon	Second post-monsoon
Rupsha	High	0	0	0	0	0
	Low	0	1	0	0	0
Bhairab	High	0	0	0	0	0
	Low	0	0	0	2	0
Atai	High	0	0	0	0	0
	Low	4	3	4	6	5

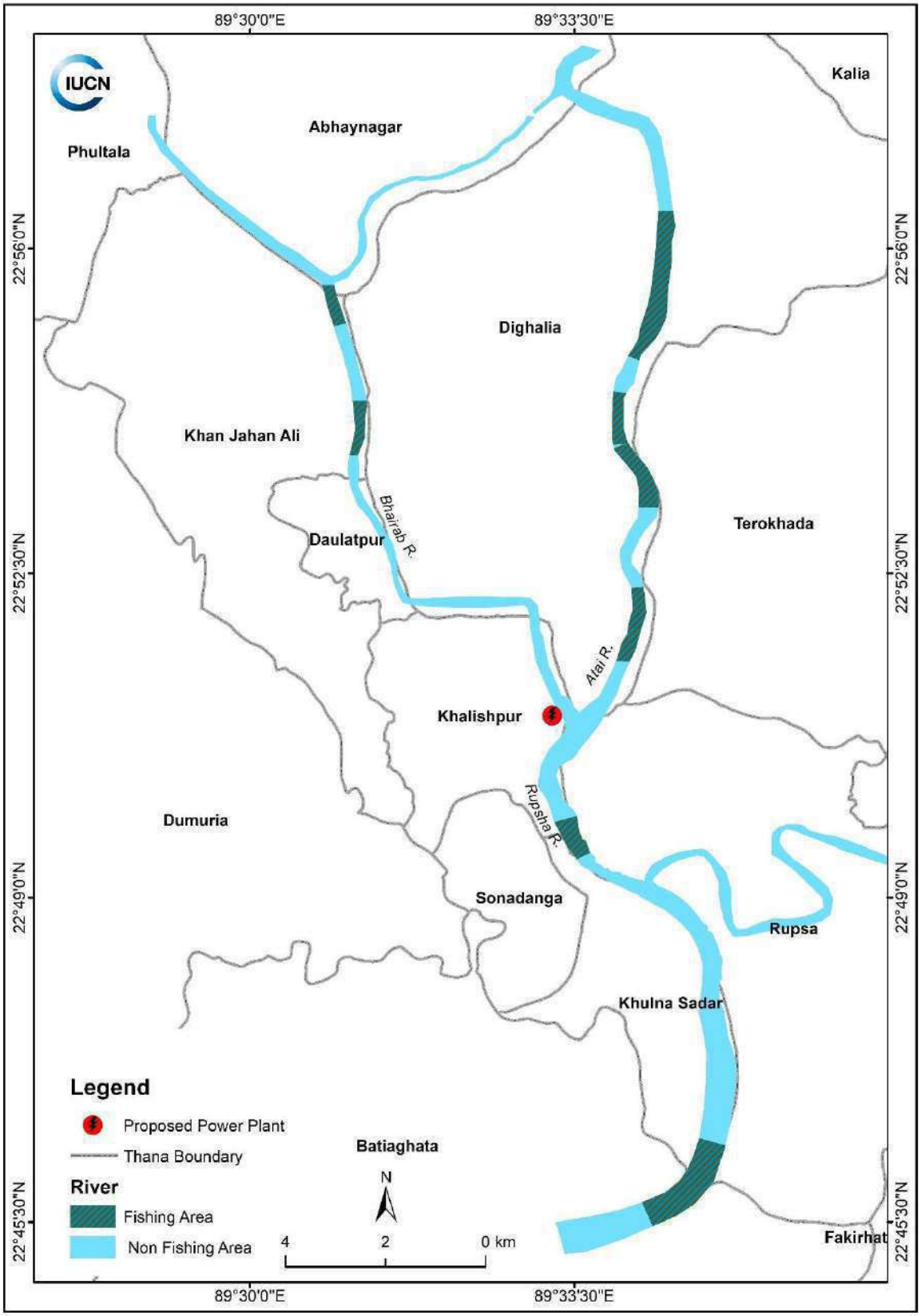
8.6 Fishing Gear and Fishing Area

Fishing at Atai River, 09 November 2017. ©IUCN/ A B M SarowarAlam.

A total of 19 types of fishing gears were recorded in the three seasons that were surveyed. Table 10shows types of gears used in the project areas. Fishermen catch fish in the rivers by using different types of fishing gears as mentioned below. Among these, small-mesh drifting gill net (jatkailishjal), monofilament gill net (current jal), set bag net (bheundi jal) and long shore net (charpatajal) are widely and illegally used for fishing. The mesh size of small-mesh drifting gill net and monofilament gill net is very small. The hand set bag net and long shore net are zero mesh size net. These net are used to catch eggs, spawn and larvae of all the fish species along with adult fish. Fishing areas were identified and a map was prepared. Map 5 shows the identified fishing areas of the three transects.

Table 10. Table showing the types of fishing gears recorded from the surveys.

S.N	Gear Type	Local Name	Operational Fishermen	Monsoon	Post-monsoon	Winter
1	Big-mesh drifting gill net	Ilishjal	2 or 3	√	√	√
2	Small-mesh drifting gill net	Jatkailishjal	2	√	√	√
3	Medium–mesh drifting gill net	Faksha/Poajal/Phasajal	2 or 3	√	√	√
4	Monofilament gill net	Current jal	2	√	√	√
5	Long shore net	Charpatajal	2	√	√	√
6	Creek net	Khalpatajal	2	√	—	—
7	Set bag net	Behundi/Bhadajal	2 or 3	—	√	√
8	Drag net	Moijal	1	√	—	√
9	Hand push net	Thelajal	1	√	—	—
10	Post-larvae seine net	Parse ponarjal	2 or 4	√	√	—
11	Large lift net	Vesaljal	2 or 3	√	—	√
12	Small lift net	Saine/Khotjal	1	√	√	√
13	Cast net	Jhaki/Kheplajal	1	√	√	√
14	Drag net	Pangaserponarjal	2 or 3	√	—	√
15	Gill net	Pangaserjal	2 or 3	√	√	√
16	Long line with many hooks	Doriborshi/Donborshi/Tanaborshi	2	√	√	—
17	Hook and rod	Chhipborshi	1	√	—	—
18	Hand fishhook	Hath borshi	1	—	√	—
19	Box trap	Chai	1 or 2	—	—	√



Map 5. Map showing important fishing areas in the project areas.

8.7 Fish Survey

A total of 50 species of fishes were identified during the surveys. Among them 6 species are nationally Endangered (*Mastacembelusarmatus, Chitalachitala, Channamarulis, Ompokpabda, Pangasiuspangasius, Rita rita*), 4 species are nationally Vulnerable (*Sperataaor, Wallagoattu, Gudusiachapra, Notopterusnotopterus*), 7 species are nationally Near Threatened (*Hemibagrusmenoda, Labeogonius, Mystuscavasius, Plotosuscanius, Pseudambassisbaculis, Nandusnandus, Cirrhinuscirrhosus*).

Out of 50, 39 species of fishes were sighted by using the method of direct sighting and 11 species of fishes were recorded by using the method of questionnaire surveys. 22 species was recorded in the Monsoon, 45 species in the Post-monsoon and 36 species in the winter. Details of fish species are in Appendix 11.

Fishermen at Bhairab River, 09November 2017. ©IUCN/ Sultan Ahmed

8.8 Vegetation Survey

A total of 117 individuals of 29 species were counted from six sample plots(methodology in Appendix 7). *Syzygiumcumini L.* (Jam), *Areca catechu L.* (Supari), *Cocosnucifera L.* (Narkel), *LanneacoromandelicaMerr.* (Jial) and *Mangiferaindica L.* (Aam) are the five most abundant species in the study area (Table 11). All the identified species are listed in Table 12.

Table 11**.** Ranking of five most abundant species in the study area

Species rank	Species name	Tree/ha
1	*Syzygiumcumini L.*(Jam)	317
2	*Areca catechu L.* (Supari)	233
3	*Cocosnucifera L.* (Narkel)	200
4	*LanneacoromandelicaMerr.* (Jial)	167
5	*Mangiferaindica L.* (Aam)	133

Cocosnucifera L. (Narkel), *Mangiferaindica L.* (Aam), *Swieteniamahagoni (L.) Jacq.* (Mehgoni), *FicushispidaL.f.* (Dumur) and *Leucaenaleucocephala (Lam.) de Wit* (Ipilipil) are the five high frequency species in the study area. Natural regeneration is higher and frequently available in the study area. The natural regeneration is occurred by the mother tree available here. The regeneration is higher in the newsprint mill area because of fewer disturbances by the human.

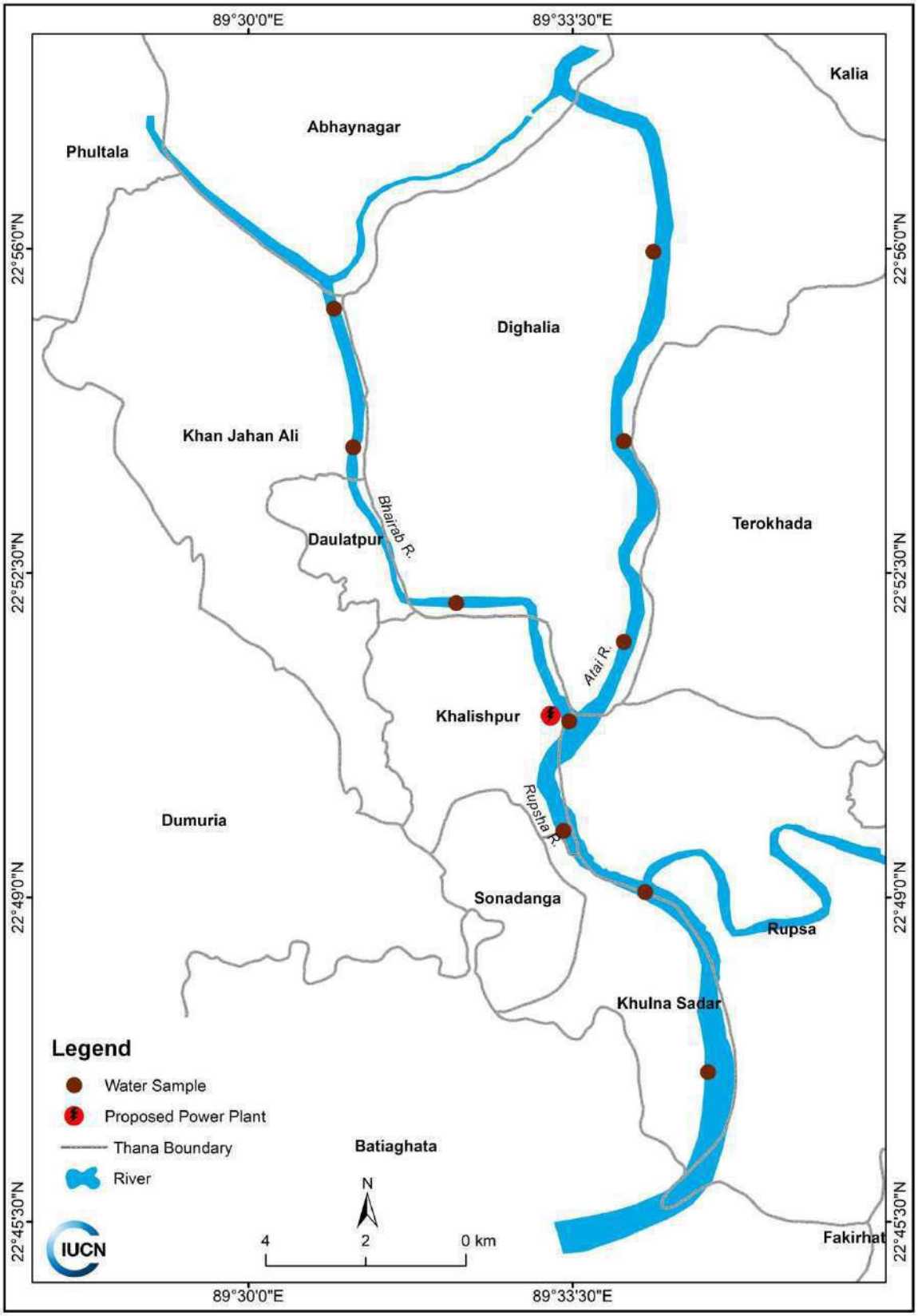
Table 12.List of identified species in the study site

Sl. No.	Scientific Name	Family
1	*Cocos nucifera*	Palme
2	*Mangifera indica*	Anacardicaea
3	*Swietenia mahagoni*	Annonaceae
4	*Ficus hispida*	Moraceae
5	*Leucaena leucocephala*	Leguminoceae
6	*Phoenix sylvestris*	Palmae
7	*Albizia saman*	Leguminoceae
8	*Dalbergia sissoo*	Leguminoceae
9	*Phyllanthus emblica*	Euphobiaceae
10	*Spondias pinnata*	Anacardiaceae
11	*Terminalia arjuna*	Combretaceae
12	*Ziziphus mauritiana*	Rhamnaceae
13	*Aegle marmelos*	Rutaceae
14	*Punica granatum*	Lythraceae
15	*Polyalthia longifolia*	Meliceae
16	*Terminalia chebula*	Combretaceae
17	*Syzygium cumini*	Annonaceae
18	*Lannea coromandelica*	Anacardiaceae
19	*Trema orientalis*	Ulmaceae
20	*Ficus racemosa*	Moraceae
21	*Limonia acidissima*	Rutaceae
22	*Citrus aurantiifolia*	Rutaceae
23	*Artocarpus heterophyllus*	Myrtaceae
24	*Azadirachta indica*	Meliaceae
25	*Elaeis guineensis*	Arecaceae
26	*Psidium guajava*	Myrtaceae
27	*Moringa oleifera*	Moringaceae
28	*Areca catechu*	Palme
29	*Borassus flabellifer*	Palmae

8.9 Water Sample Collection

Water samples collected from the middle of the Rupsha, Bhairab and Atai River based on pollution sources (Map 6). Samples collected from the same location as it was in the monsoon survey. Table 13shows location, GPS coordinates and major infrastructures on the river bank. Samples were collected in first winter survey, but the data is being analyzed and is not included here.

Confluence of Bhairab-Rupsha-Atai River, 22 October 2017,©IUCN/ Sultan Ahmed



Map6. Map showing water sample collection points along transects

Table 13.Water sample collection along the transects with GPS coordinates and major infrastructure on the river bank.

Stations	GPS Co-ordinates		Major infrastructures in the River bank
	Latitude	Longitude	
Station 1 (Rupsha)	22°47.115' N	89°34.958' E	Khulna shipyard, Seven ring cement industry, Fish processing zone
Station 2 (Rupsha)	22°49.060' N	89°34.281' E	Jelkhanaghat, Purobi Salt Factory
Station 3 (Rupsha)	22°49.719' N	89°33.400' E	5 no. fishery ghat, goods load and unload zone
Station 4 (Confluence)	22°50.898' N	89°33.459' E	Brick field, Khalishpurghat, Power plant
Station 5 (Bhairab)	22°52.174' N	89°32.243' E	Padma, Meghna and Jamuna petroleum industry, Jute mill
Station 6 (Bhairab)	22°53.857' N	89°31.130' E	CSD ghat, F.R. jute mil
Station 7 (Bhairab)	22°55.352' N	89°30.921' E	Sheikh cement industry, Brick field
Station 8 (Atai)	22°55.968' N	89°34.370' E	Human settlements
Station 9 (Atai)	22°53.924' N	89°34.051' E	Human settlements, Brick field
Station 10 (Atai)	22°51.758' N	89°34.052' E	Brick field, human settlements

8.10 Water Quality Test Result

Physio-Chemical Parameters

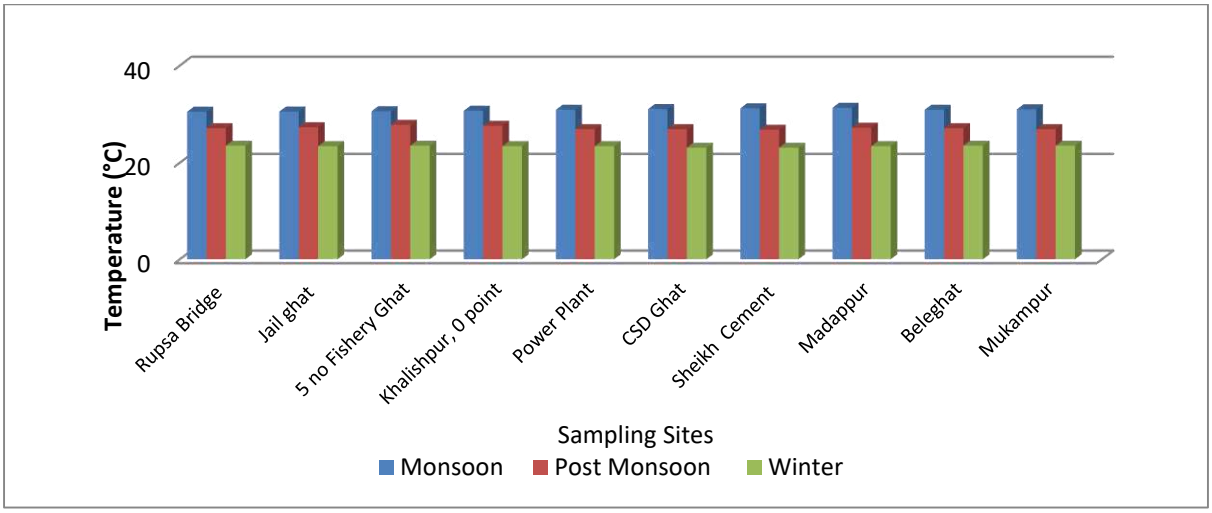


Figure 8. Temperature at the sample sites of the project area in monsoon, post-monsoon and winter season surveys.

Figure 8illustrates the temperature difference during thethree different time periods i.e. monsoon,post-monsoon and winter season of different river points of the study area. The highest temperature difference was found in Madappur point. The mean

temperature value in monsoon,post-monsoon and winter season was 30.87°C, 27.17°C and 23.38°C, respectively. However, the temperature was found within the permissible limit for both monsoon and post-monsoon season.

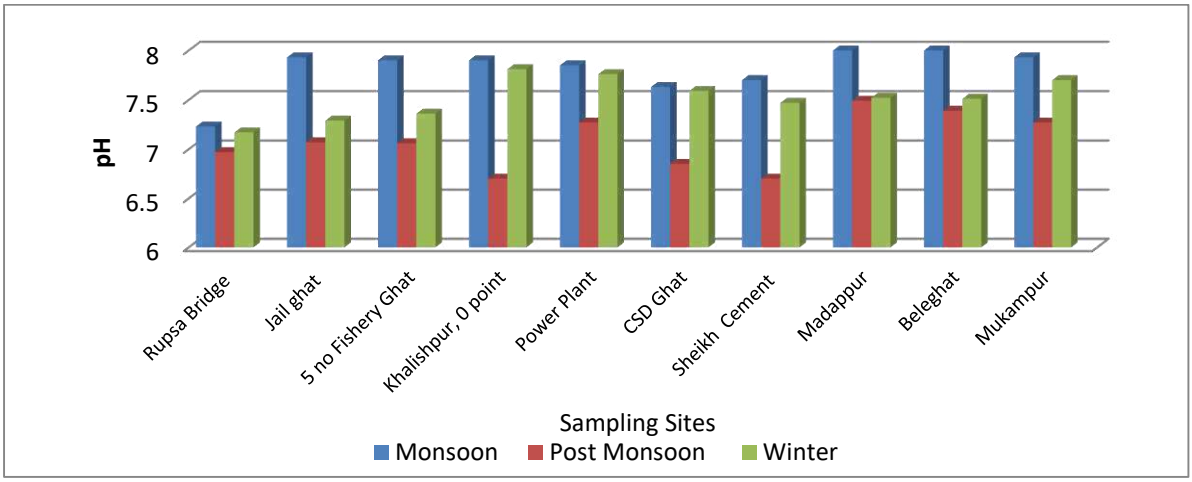


Figure 9. pH at the sample sites of the project area in monsoon, post-monsoon and winter season surveys.

Figure 9illustrates the pH values during monsoon, post-monsoon and winter season at different sample points of survey area. The pH value did not cross the standard value for Bangladesh in all three seasons. The average pH value was found a bit higher in monsoon season (mean value 7.8) than that of both post-monsoon season (mean value 7.07) and winter season (mean value 7.52). The maximum pH value in monsoon and post-monsoon seasons was found in Madappur Point. But in case of winter season, the maximum pH value (7.81) was found in Khalishpur Zero Point. The mean pH value in monsoon, post-monsoon and winter season was 7.807, 7.077 and 7.518 respectively. The cause of such may be related to the effluent water discharge from the cement factory. The standard pH value of surface water ranges from 6.5-8.5 (ECR, 1997).

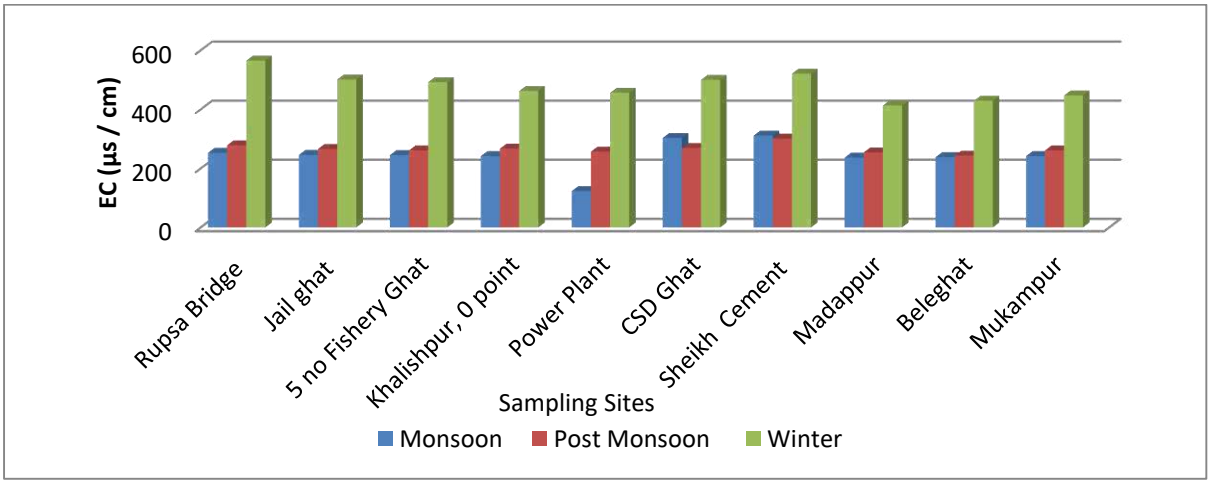


Figure 10. Electrical conductivity at the sample sites of the project area in monsoon, post-monsoon and winter/dry season surveys.

Figure 10 illustrates the EC values during dry, post-monsoon and monsoon season at different sample sites of project area. The EC value was found very high in dry season than that of the monsoon and post-monsoon season. Highest value of electrical conductivity (565) was found in Rupsha Bridge point. The mean EC value in monsoon, post-monsoon and dry season was 243.8, 265.7 and 478.6, respectively. However, in all other sample points, the EC value was below the standard EC value of river water for Bangladesh.

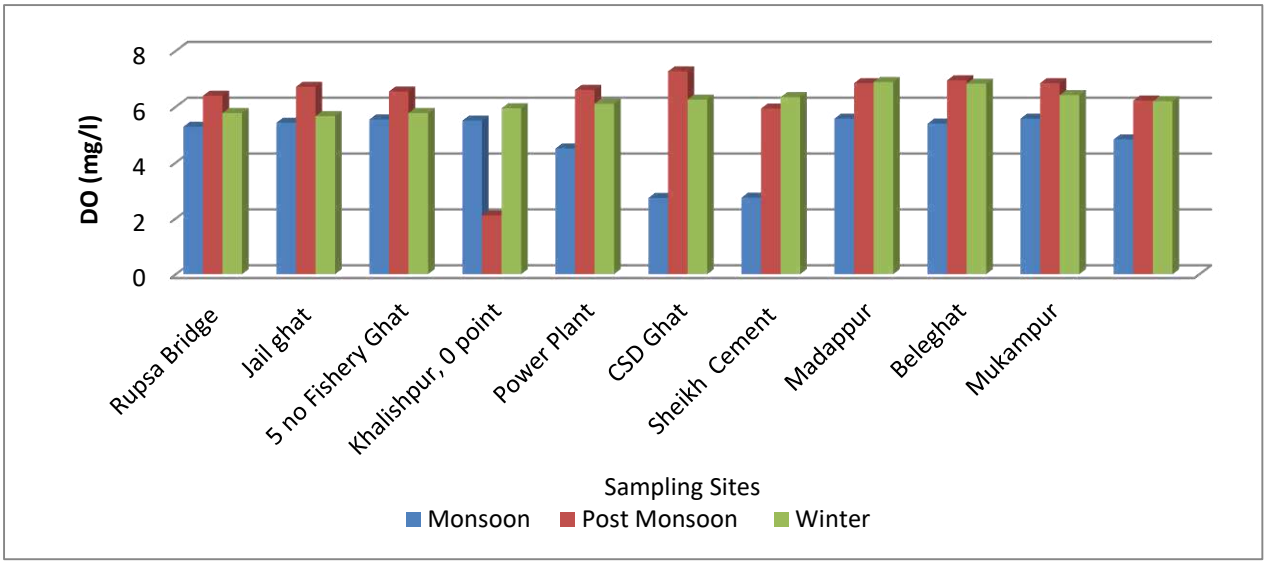


Figure 11. Dissolved oxygen at the sample sites of the project area in monsoon, post-monsoon and winter season surveys.

Figure 11 illustrates the DO values during dry, post-monsoon and monsoon survey at different sample sites of the study area. As we know, the level of Do required for survival of aquatic life is between 5 to 6 mg/l and DO level below 1.0 mg/l will not support any aquatic species. DO in the sampled water was found satisfactory during monsoon season. However, this concentration increases for all sample location in both post-monsoon and dry seasons with a maximum concentration at CSD Ghat (i.e. 7.26) in post-monsoon season and at Madappur point (i.e. 6.88) in dry season. The average concentration of DO in post-monsoon season was 6.22 mg/l whereas it was 4.8 mg/l in monsoon season and 6.19 mg/l in dry season. Therefore, it can be said that the concentration of Dissolved Oxygen (DO) was found higher in post-monsoon season and winter season and thus indicates water pollution at moderate level in the sampled river water.

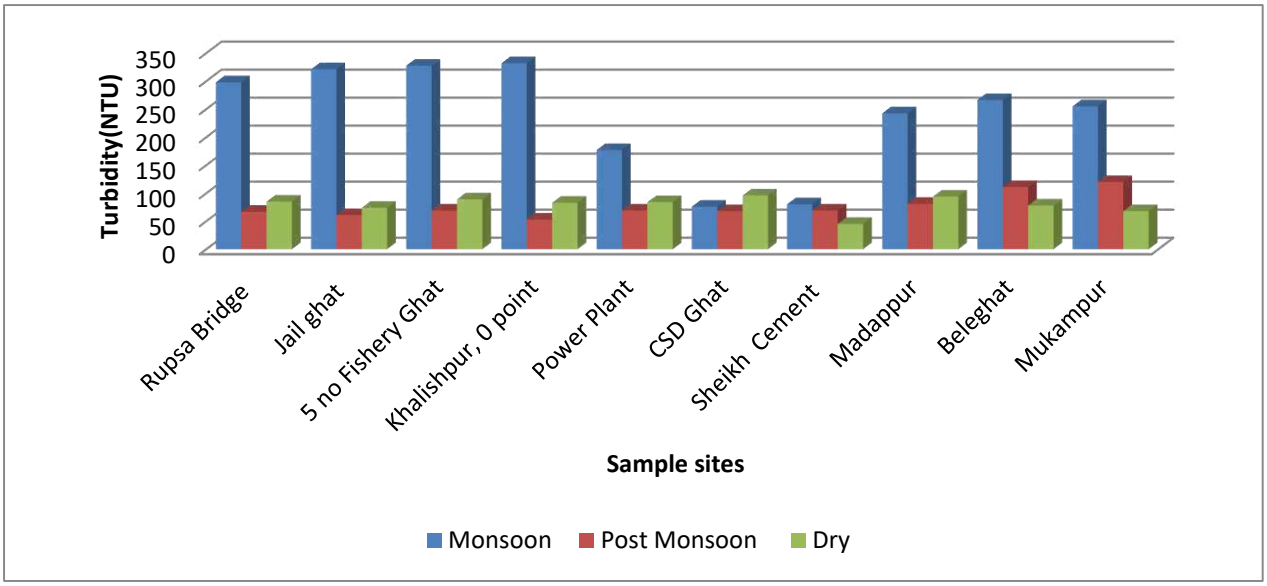


Figure 12. Turbidity at the sample sites of the project area in area in monsoon, post-monsoon and winter/dryseason surveys.

Figure 12 illustrates the turbidity values during dry, post-monsoon and monsoon surveys at different sample sites of project area. Though in dry and post-monsoon season turbidity was found almost steady at all sampled locations, it varied widely in the monsoon season with highest concentration at Khalishpur (327 NTU). The mean Turbidity value in monsoon, post-monsoon and winter season was 237.62 NTU, 76.8 NTU and 79.62 NTU, respectively.

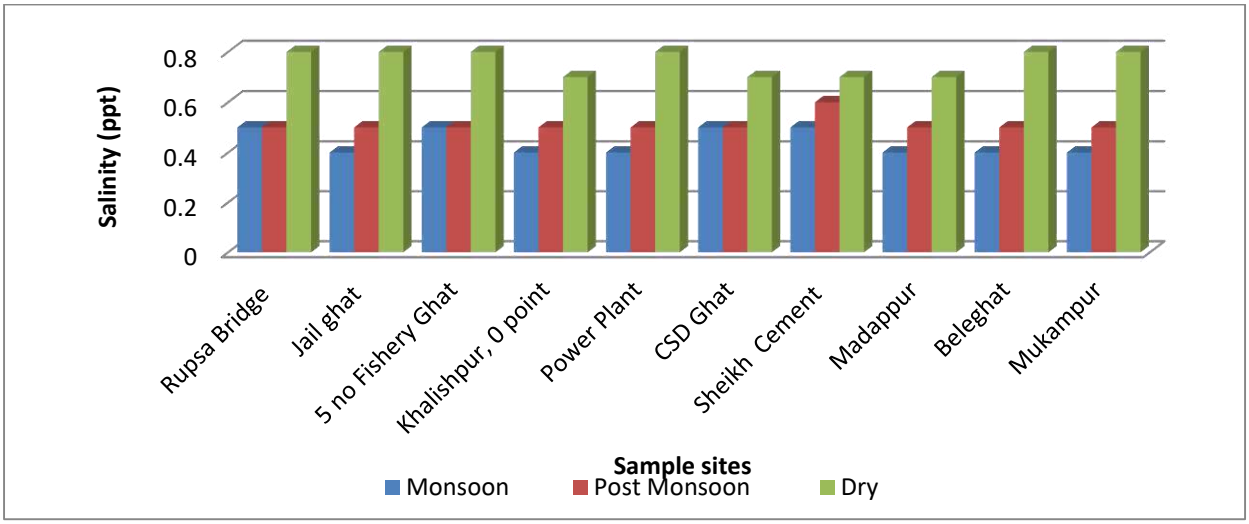


Figure 13. Salinity at the sample sites of the project area in area in monsoon, post-monsoon and winter/dry season surveys.

Figure 13 illustrates the difference in salinity during dry, post-monsoon and monsoon season at different sample sites of the project areas. The salinity concentration in the river water was found higher in winter season, whereas slightly higher in post-

monsoon season than in monsoon season. The mean salinity concentration in monsoon, post-monsoon and dry season was found 0.44, 0.51 and 0.76, respectively.

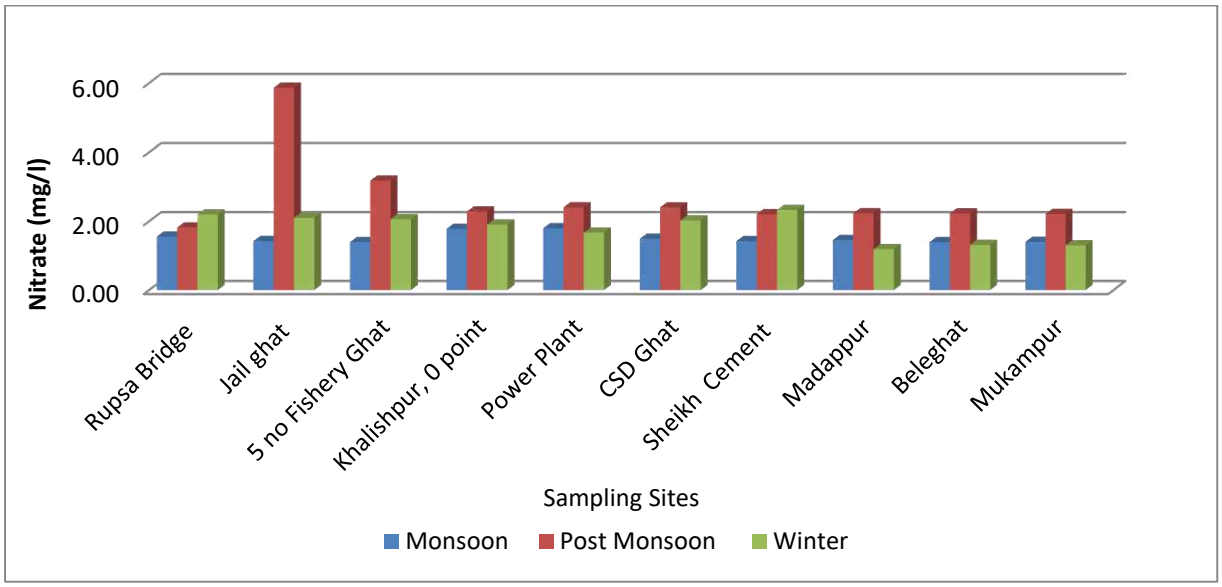


Figure 14. Nitrate value at the sample sites of the project area in area in monsoon, post-monsoon and winter season surveys.

Figure 14 illustrates the nitrate values during dry, post-monsoon and monsoon surveys at different sample sites of the project areas. Nitrate concentration of sample water ranges from lowest of 1.40 mg/l to a maximum 1.80 mg/l in the monsoon, from a lowest of 1.82 mg/l to a maximum of 5.87 mg/l in post-monsoon and from a lowest of 1.19 mg/l to a maximum of 2.20 mg/l in winter season. The standard nitrate value is 10 mg/l. The post-monsoon season nitrate concentration was found a little bit higher than that of the monsoon and dry season (2.68, 1.51 and 1.81 mg/l, respectively). This small amount of nitrate was probably coming from the adjacent agricultural land. However, the highest concentration of nitrogen was found in Jail Ghat (5.87 mg/l) and the probable cause might be the obvious direct discharge of agricultural waste into the river.

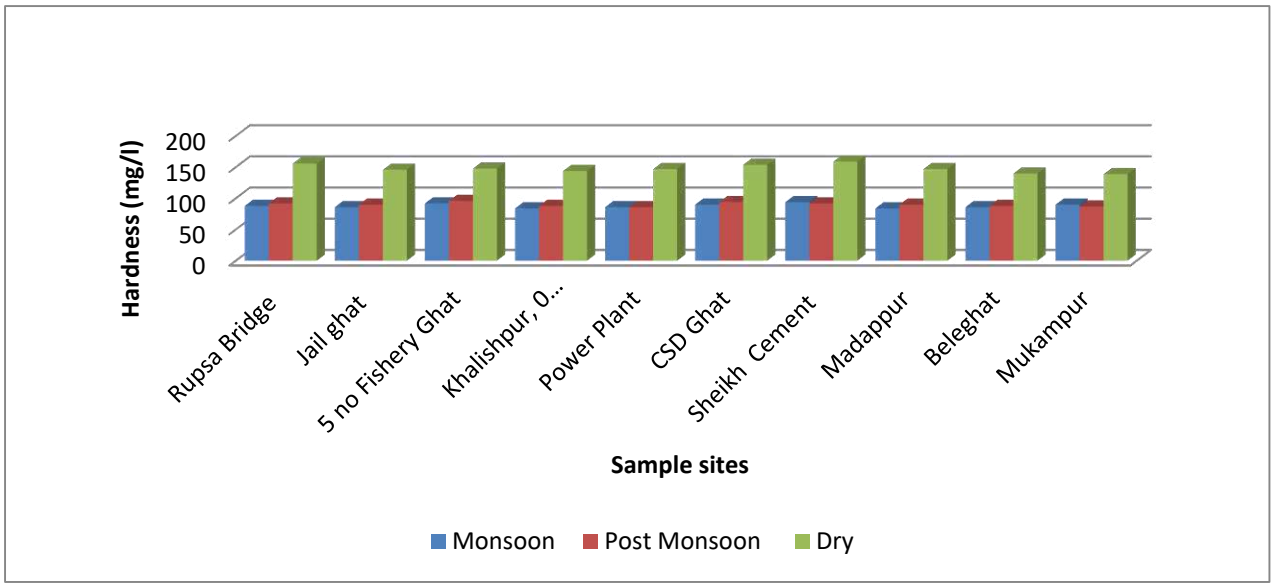


Figure 15. Hardness at the sample sites of the project area in area in monsoon, post-monsoon and winter/dry season surveys.

Figure 15 illustrates the hardness value during winter, post-monsoon and monsoon season at different sample sites of project area. Significant difference in hardness of the river water was found between post-monsoon and monsoon season with dry season. The mean Hardness value in monsoon, post-monsoon and dry season was found 88, 90.3 and 148, respectively. Highest value of Hardness (i.e. 159 mg/l) was found in Sheikh Cement point at winter season.

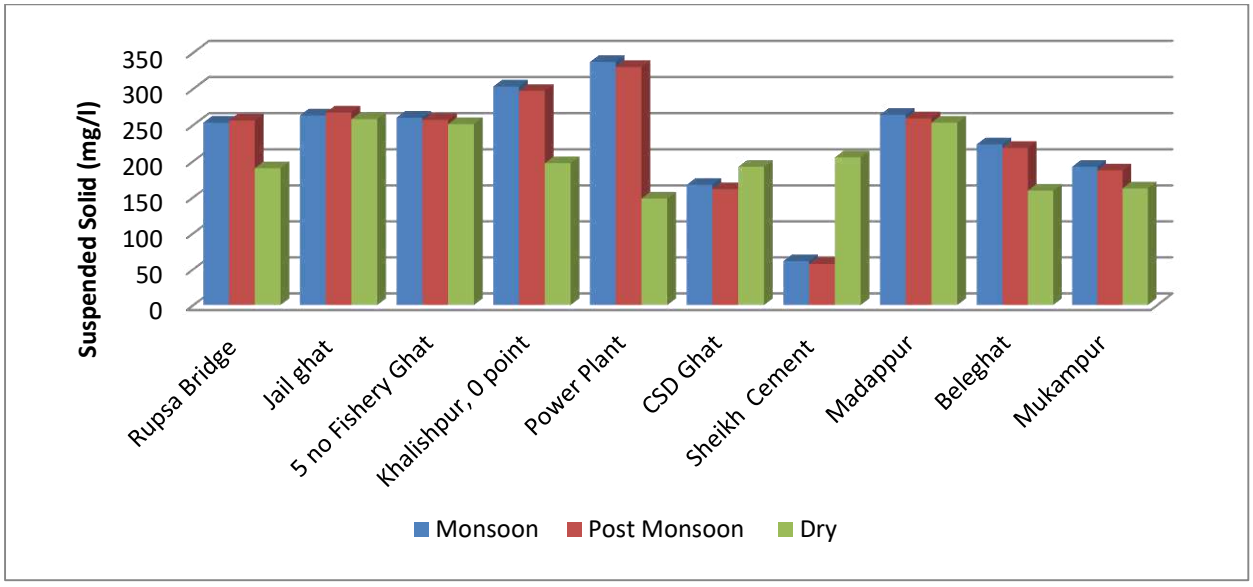


Figure16. Suspended solid at the sample sites of the project area in area in monsoon, post-monsoon and winter/dry season surveys.

Figure 16 illustrates the suspended solid values during post-monsoon and monsoon season at sample sites of project area. Concentration of suspended solid was found higher than the standard value (150 mg/l) at all sample sites, irrespective of the season. However, no significant seasonal difference was found in concentration of the suspended solid. The average suspended solids in post-monsoon and monsoon season was 228.9mg/l and 232.3 mg/l, respectively.

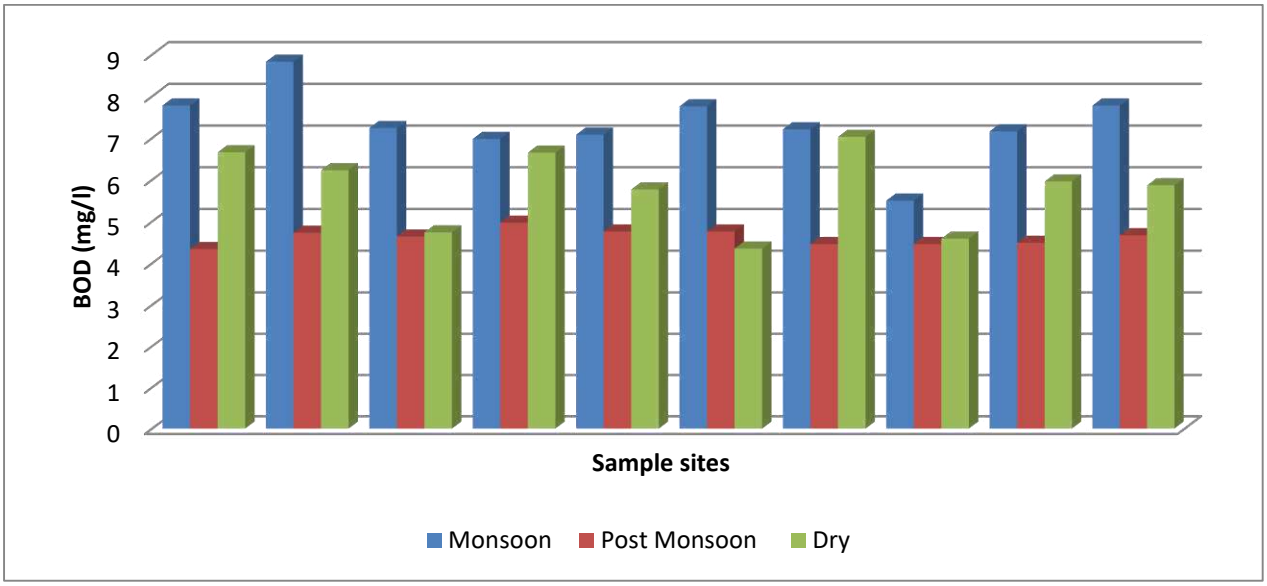


Figure 17. Biological Oxygen Demand at the sample sites of the project area in area in monsoon, post-monsoon and winter/dry season surveys.

Figure 17 illustrates the BOD values during winter, post-monsoon and monsoon season at different sampled sites of the project area. The standard limit of BOD concentration in surface water is 50mg/l. None of the water samples collected in the dry, post-monsoon and monsoon season crossed the standard value for BOD. However, it is observed from the data that the BOD level in monsoon season decreases compared to other seasons. The average BOD level was 7.33, 4.62 and 5.8 mg/l of monsoon, post-monsoon and dry season, respectively. The maximum difference in BOD concentration was found in Jail Ghat location (8.83 mg/l). However, the overall BOD concentration in the river water was found satisfactory and it was well below the standard limit for surface water quality.

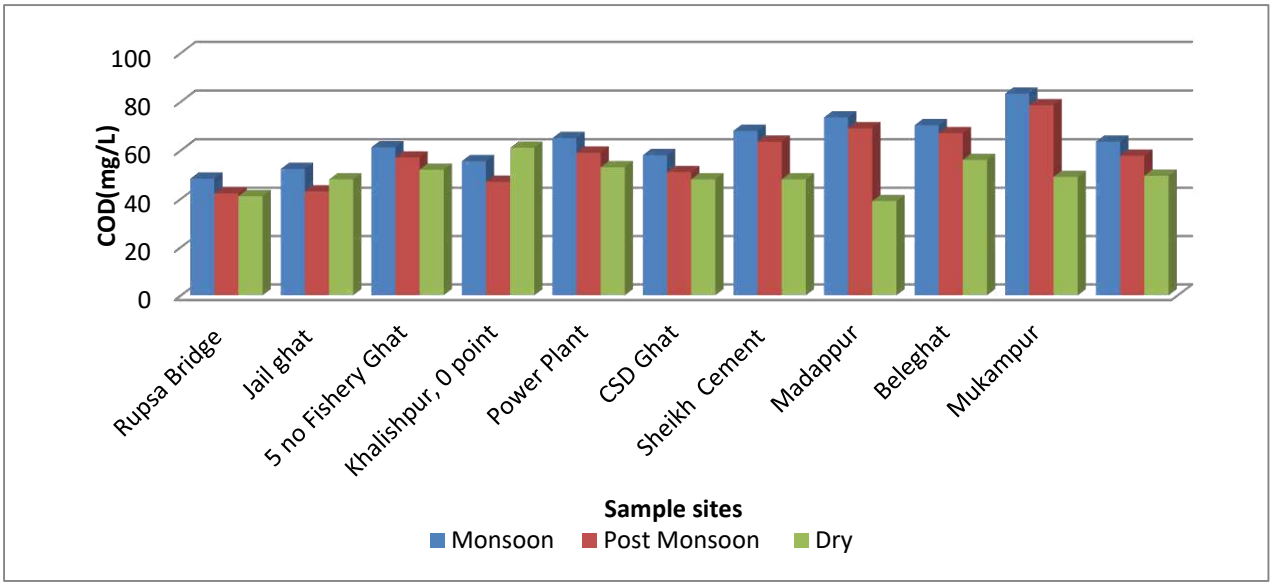


Figure 18. Chemical Oxygen Demand at the sample sites of the project area in area in monsoon, post-monsoon and winter/dry season surveys.

Figure 18 illustrates the difference in COD value during dry, post-monsoon and monsoon season at the sample sites of project area. Average COD of the collected water samples for winter, post-monsoon and monsoon season was found to be 49.5 mg/l, 57.53 mg/l and 63.53mg/l, respectively; which is much lower than the national average of 200 mg/l.

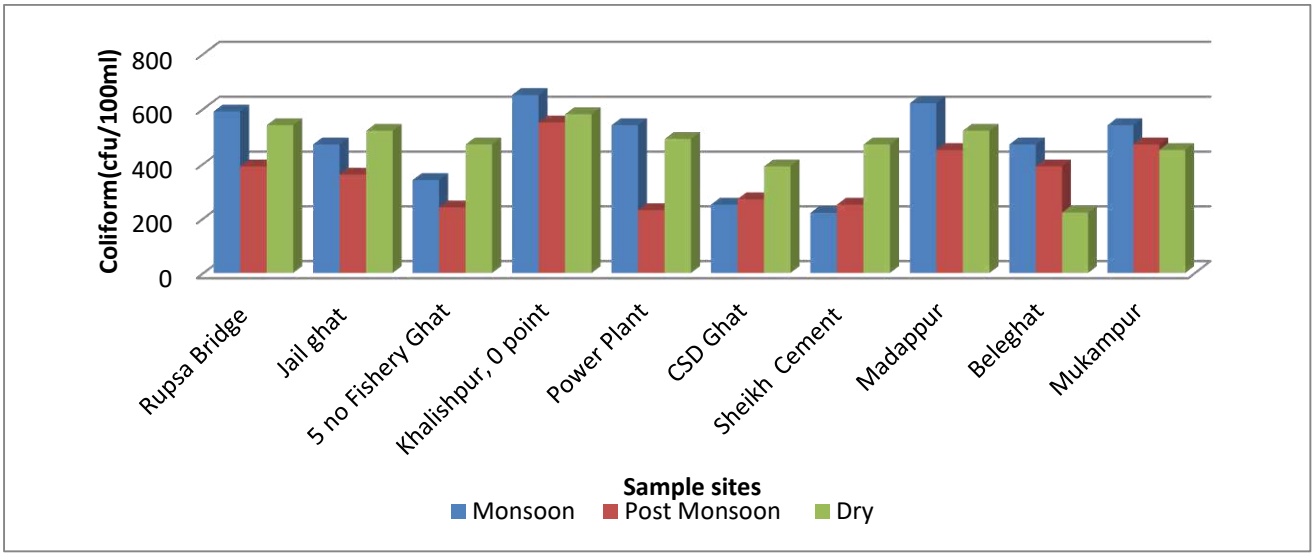


Figure19. Coliform at the sample sites of the project area in area in monsoon, post-monsoon and winter/dry season surveys.

Figure 19 illustrates the total coliform value during winter, post-monsoon and monsoon season at the sample sites of project area. Average coliform concentration was found to be higher in the monsoon season (469 cfu/100 ml) which is close to the concentration of winter season (465.1 cfu/100 ml). The minimum average coliform concentration was in post monsoon season (360 cfu.100 ml).

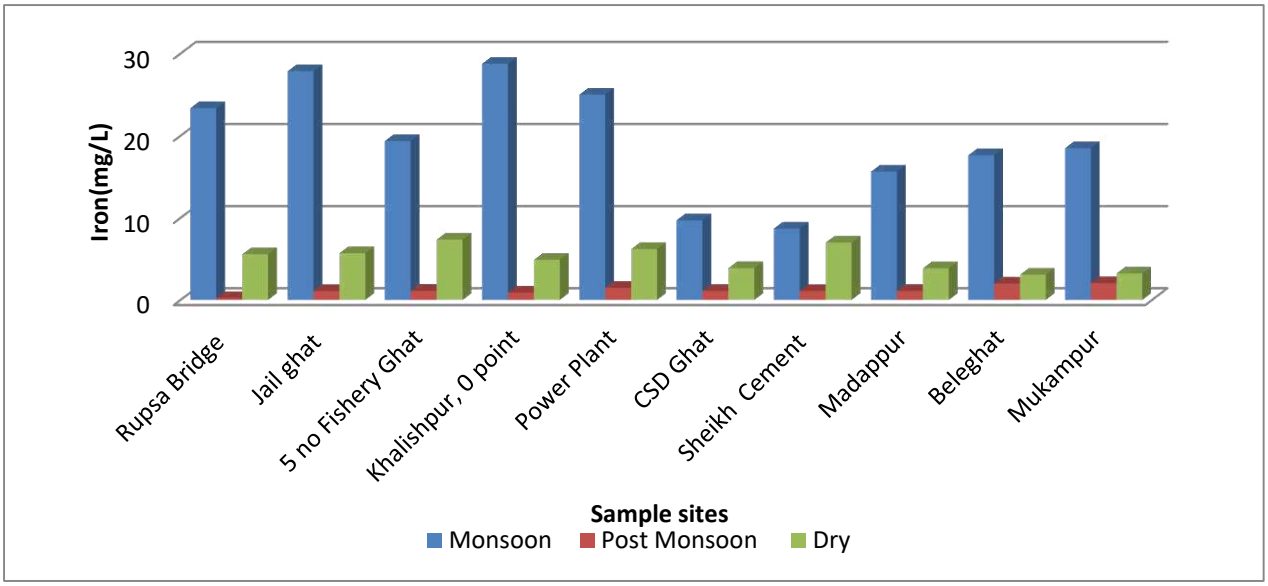


Figure 20. Salinity at the sample sites of the project area in area in monsoon, post-monsoon and winter or dry season surveys.

Figure 20 illustrates the iron value during winter, post-monsoon and monsoon season at the sample sites of the project areas. Average concentration of iron in the collected water sample in monsoon season was much higher than that of the post-monsoon and dry season concentration (average 19.44 mg/l, 1.219 mg/l and 5.08 mg/l, respectively). Flood water brings lot of sediments and minerals from the upstream region and this might be the reason for high concentration of iron in the river water during monsoon season.

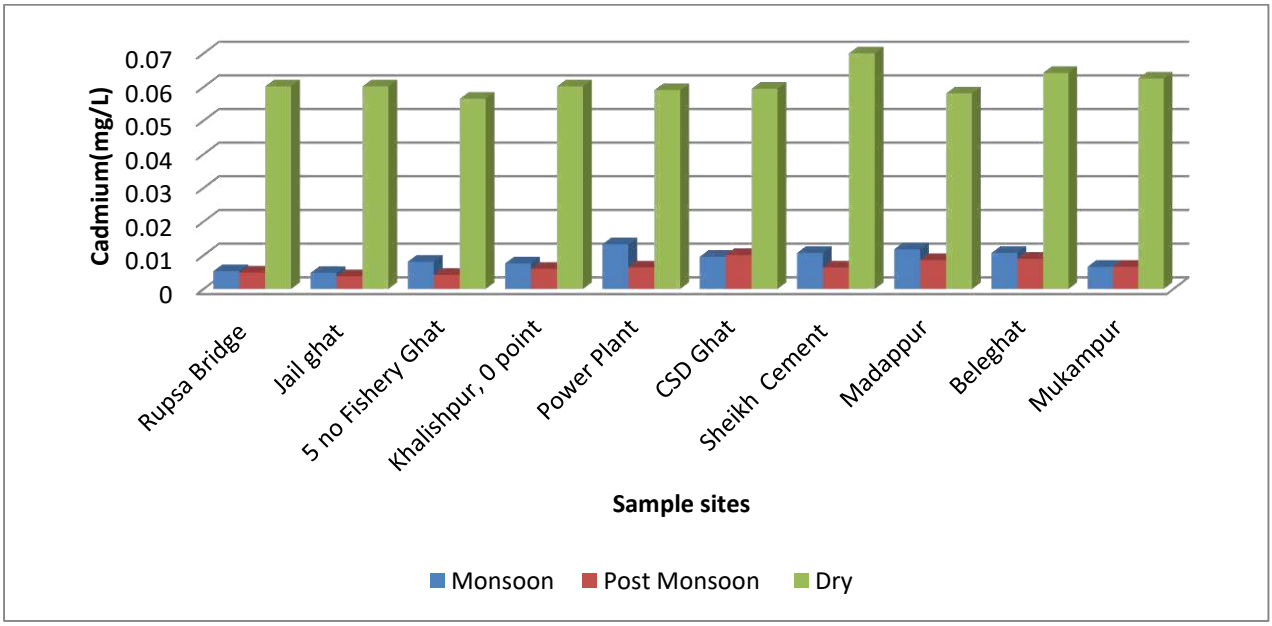


Figure 21. Cadmium at the sample sites of the project area in area in monsoon, post-monsoon and winter/dry season surveys.

Figure 21 illustrates the Cadmium values during dry, post-monsoon and monsoon season at sample sites of the project area.Average Cadmium concentration was found to be very high in the dry season (0.06mg/l) which is little over the surface water quality standard for Bangladesh of 0.05 mg/l. Although elevated iron concentration was found in some water samples, however in general, concentration of cadmium in the river water did not exceed relevant quality standard during monsoon (0.009 mg/l) and post-monsoon season (0.007 mg/l), beyond which it becomes a threat to freshwater life. The highest cadmium concentration (i.e. 0.0642 mg/l) was found in the Beleghat point.

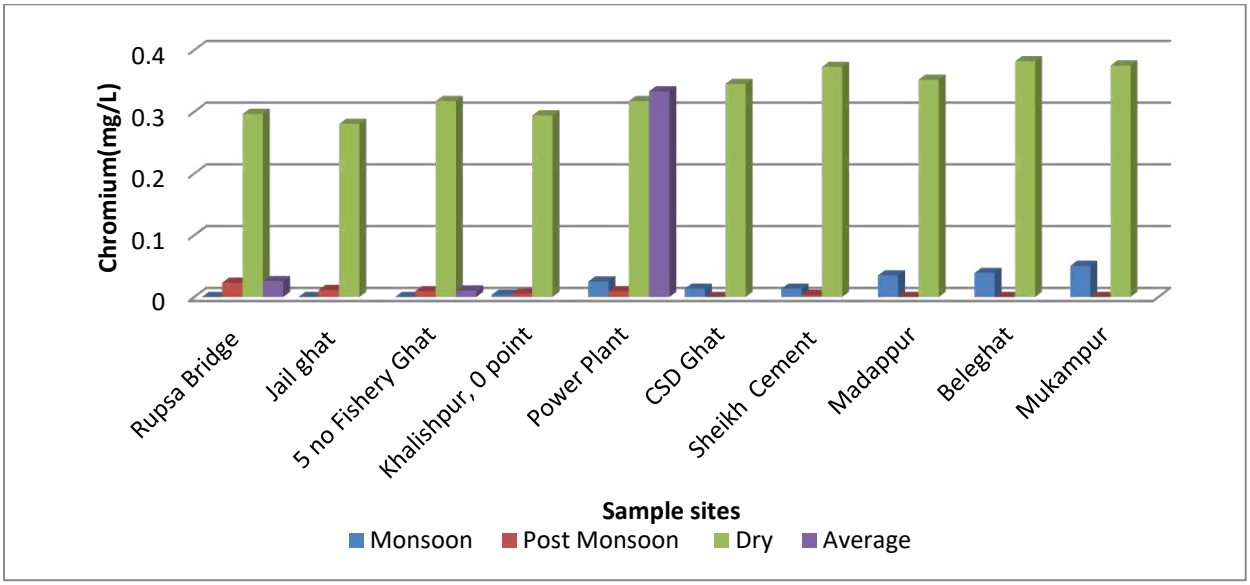


Figure 22. Chromium at the sample sites of the project area in area in monsoon, post-monsoon and winter/dry period surveys.

Figure 22 illustrates the Chromium values during winter, post-monsoon and monsoon season at sample sites of the project area. Average Chromium concentration was found to be very high in the dry season (0.33 mg/l) than that of the monsoon (0.026 mg/l) and post-monsoon (0.01 mg/l) season, which is much below than the national standard of 0.5 mg/l.

8.11 Biological Parameters

A total of 15 genera of phytoplankton and two unknown genera of zooplankton were found in the 6 study sites. Among the plankton, *Oscillatoria* and *Melosira* were found in all 6 study sites indicating that these two genera are common in the study area. On the other hand, *Nostoc*, *Pediastrum,Cymbella* and *Volvox* were found only in single site indicating that these genera are less common in the study area. Maximum number of genera (10) were found in 5 No. Fishery ghat, Rupsha and minimum number of genera (4) were found in the site of Rupshabridge, Rupsha. *Microsystis* sp. is considered as indicator of water pollution. This genus was found more abundantly in 5 No. Fishery ghat, Rupsha than other sites indicating that water of this site might be polluted.

Table 14**.** Abundance (individuals/litre water) of plankton in the study sites

Sl. No	**Name of organisms**	**Family**	**Rupsa bridge, Rupsa**	**Jail ghat, Rupsa**	**5 no. fishery ghat, Rupsa**	**Khalispur, Confluence**	**Power plant, Bairab**	**CSD ghat, Bairab**
1	*Oscillatoria* sp.	Oscillatoriaceae	8.8×10^4	1.84×10^5	1.2×10^5	1.36×10^5	4.0×10^4	6.4×10^4
2	*Melosira* sp.	Melosiraceae	1.12×10^5	1.04×10^5	1.2×10^5	1.12×10^5	1.44×10^5	1.28×10^4
3	*Gloeocapsa* sp.	Microcystaceae	1.6×10^4	-	-	-	-	-
4	*Closterium* sp.	Desmidiaceae	8.0×10^3	8.0×10^3	8.0×10^3	-	3.2×10^4	-
5	*Microsystis* sp.	Microcystaceae	-	8.0×10^3	1.6×10^4	1.6×10^4	8.0×10^3	8.0×10^3
7	*Navicula* sp.	Naviculaceae	-	8.0×10^3	8.0×10^3	-	-	8.0×10^3
8	*Anabaena* sp.	Nostocaceae	-	1.6×10^4	-	-	-	-
9	*Synedra* sp.	Fragilariaceae	-	-	8.0×10^3	1.6×10^4	8.0×10^3	8.0×10^3
10	*Gyrosigma* sp.	Naviculaceae	-	-	-	8.0×10^3	-	-
11	*Nostoc* sp.	Nostocaceae	-	-	8.0×10^3	-	-	-
12	*Pediastrum* sp.	Hydrodictyaceae	-	-	8.0×10^3	-	-	-
13	*Cymbella* sp.	Cymbellaceae	-	-	-	-	8.0×10^3	-
14	*Scenedesmus* sp.	Scenedesmaceae	-	-	8.0×10^3	-	-	8.0×10^3
15	*Volvox* sp.	Volvocaceae	-	-	-	-	-	1.6×10^4
16	Zooplankton (unknown)		-	-	-	-	1.6×10^4	1.6×10^4
17	Unknown		-	-	2.4×10^4	8.0×10^3		

'-' organism not found

9. Impact and Mitigation

On the basis of literature review and analysis of the survey results, the potential impacts and mitigation for different phases of the power plant is given below.

Pre-construction Phase				
Parameter	Source	Overall Impact	Impact on dolphins	Mitigation
Ambient Air quality	Dust and gases generated from demolition works and transportation of the debris	The emitted dust from the demolishing areas will disperse to the ambient environment. The particulate matters inhaled by the human may cause respiratory problem. Moreover, the dust will fall over the leaves of the vegetation and water bodies, including rivers, near to the project site causing pollution and may affect aquatic ecosystem.	These emitted dust particles may include nitrogen, mercury compounds which may deposit on the river and accelerate etrophication. It will result in excess algae blooms which depletes oxygen levels and kills aquatic life. It will hamper the food chain and deplete fish stock which in turn will affect prey population of dolphins.	-Avoid the demolition works in the evening especially during the dry season or watering to the possible sources of fugitive emission. -Regular water spraying on the adjacent vegetation, roads andunpaved groundespecially during dry season to avoid dust. -The transportations carrying debris should be moved as soon as possible to avoid accumulation and being blown by wind. -Impact and compliance monitoring should be done as per the recommended guideline at all the sensitive locations.
Ambient Noise quality	Demolishing buildings and other structures using heavy machineries. Heavy movement of traffic and machineries.	Loud noise will affect the behavior of Ganges River Dolphins and other the nocturnal animals. Generation of impulse noise will harm the community people.	Dolphins rely on echolocation for detecting prey, communication and navigation. Noise pollution may cause trouble for them to hunt, navigate and communicate.	-The procedure of demolition should be conducted as per the guidelines. -Noise level must not exceed a set threshold. -The machines/ equipment/ vehicles

	During transportation by ships			should be turned off when not in use. -All sound-reducing devices and restrictions should be properly maintained throughout the demolition period. -Limit the hours of demolition works. -Use rubber-tired equipment rather than track equipment -Reduce the use of large cargo water vessels for the transportation of materials. -Cargo can be offloaded from ships away from the identified important dolphin areas and if possible be transported by land to the site. -Keep loading and staging areas on site within the perimeter protected by the recommended temporary noise barrier and away from the noise-sensitive sidesofsite.
Loss of vegetation	Dispersion of the dust particles during destruction of building Chop down of terrestrial vegetation	The normal photosynthesis and the transpiration process of plant will be affected due to dust particle Chop down of terrestrial	There are no direct impact	In the significant portion of the proposed power plant area green belt should be developed which will ultimately makeup the loss of carbon dioxide sequestration due to clearing of

		vegetation will reduce carbon sequestration of about 6880.480046 for 30 acres of land cover and will ultimately impact biological process and food chain as well Removal of enormous terrestrial vegetation may cause damage of habitats like mammals, reptiles etc. which may create pressure on other species.		existing vegetation and also conserve the visiting animals of the project studyarea and also beyond that area.
Water quality	Discharge of oil or other pollutants during material transportation by ship. Backfilling, food waste, plastic, papers, metal or plastic binders, solid wastes from other sources.	During pre-construction, backfilling soil and other solid wastes may leach into the surrounding water bodies which degrades the water quality, affects the fish habitats and other aquatic life.	Breathing organs of invertebrates, fish, dolphins can be clogged. Primary and secondary production of fish habitat can be reduced which will affect dolphin prey.	-For any discharge from the project site and vessels, GOB and IFC guidelines should be followed -Proper waste disposal management plan should be implemented.
Construction Phase				
Parameter	**Source**	**Overall Impact**	**Impact on dolphins**	**Mitigation**
Ambient air quality	Dust resulting from construction work and transportation of raw materials. Exhaust gas from	Operation of construction equipment and vehicles may generate PM, CO, CO_2, NOx, SOx, etc. As a result, engineers and	Emitted dust particles include nitrogen, mercury compounds which can be deposited from the plant site to water bodies. When excess mercury deposits in river it may turn into methyl	-Watering access road andconstruction site, especiallyin the dry season -Using cover sheets on trucks and open cargo water vessels

	construction machinery and vehicles used for mobilization of equipment. Air pollution arising from incineration of construction.	workers might suffer from lung diseases including shortness of breath, coughing, wheezing; chest pain; loss of appetite; tiredness due to the prolonged inhalation of dusts by the site. Particulate matter, dust will fall on the leaves, vegetation and water bodies near to the project site. Gasses in air may mix with rain and fall on waterbodies causing contamination.	mercury that affects aquatic plants, microorganisms and fish species. As a result, the food chain is affected which might have an impact on the dolphins.	for the transportation raw materials. -Regular maintenance and management of all the construction machinery andvehicles -Prohibit open burning -Impact and compliance monitoring should be done as per the recommended guideline at the sensitive location. -Reduce the use of large cargo water vessels for the transportation of materials. -Cargo can be offloaded from ships away from the identified important dolphin areas and if possible be transported by land to the site.
Ambient noise quality	Construction machinery such as pumps, generators, compressors ,pile drivers, rock drills etc. Vehicles transporting equipments and workers	Communities settled beside proposed project will be effected. Noise pollution will directly cause health hazards to the nearby residents and construction workers on the site. Loud noise will affect the behavior of Ganges River Dolphins and other the nocturnal animals.	Dolphins use echolocation for communication, navigation and finding prey. Noise pollution will effect dolphin populations, interrupt their normal behavior, way of movement, hunting behavior and driving them away from the important areas.	-Optimizing construction schedule work during daytime, especially piling work. -Using low-noise/ low vibration equipment as much as possible. -Reduce the use of large cargo water vessels for the transportation of materials.

				-Cargo can be offloaded from ships away from the identified important dolphin areas and if possible be transported by land to the site. -Roadways should be used for transportation of materialand equipments. -Route-setting and speed limit for water vessels -The machines/ equipment/ vehicles should be turned off when not in use. -Using of appropriate safety equippments (eg. ear plugs) during construction work. -Temporary noise barriers are infeasible, portable noise panels -Keep loading and staging areas on site within the perimeter protected by the recommended temporary noise barrier and away from the noise-sensitive sides of the site.
Ambient water quality	Run-off water from construction area containing pollutants. Domestic	Disposal of such harmful substances into the river water have temporary and permanent impact on fisheries.	Oil spillage from water vessels may contains heavy metals such as mercury, copper and selenium which have negative	-All the vessels must follow the inland water transport regulations of GOB as applicable -During any kind of discharges from the

	wastewater from workers. Inappropriate disposal of waste. Leakage oil and chemical materials from construction activity.	Discharge of wastewater increase the turbidity of the river which clogs breathing organ of fish habitats and leads to death.	effects on the health of dolphin population. Bio-accumulation of many of these chemicals may have adverse effects on dolphins. Prey population of dolphins might be effected.	project site and from the vessels or construction equipment during construction period, GOB and IFC guidelines should be strictly followed. -Cargo can be offloaded from ships away from the identified important dolphin areas and if possible be transported by land to the site to avoid spillage.
Waste disposal	Large amount of construction waste from construction site/transport vehicles including waste water, unused construction materials, construction debris, excavated spoils, abandoned or broken machine parts, debris, kitchen wastes from labor sheds, packaging materials, used home appliances, food waste, plastic, papers, cock sheet, cartons, metal or plastic binders, etc	Indiscriminate dumping of waste may affect surrounding aquatic species and may also lead to the spread of various diseases.	Waste containing chemicals may create imbalances in riverine ecosystems. As a result fish and aquatic plants may die, bacteria may flourish and cause disease and disrupt in the food chain which may result in decrease in prey population or adverse health effects on dolphins. Toxic algae outbreaks may cause by these imbalances that may reduce oxygen in the water, driving dolphins away from important areas. Also debris, including plastic, tarps, nets and other non-degradable objects dumped in water might trap or choke dolphins, especially young animals.	-For any discharge from the project site and vessels, GOB and IFC guidelines should be followed -Conduct separate waste collection and promote recycling and reuse. -Appropriate disposal of non-recyclable waste according to rules -Wastes generated from the construction site should be stored in appropriate bins/skips, well-covered and later buried in an approved landfill site. -All solid wastes, hazardous and non-hazardous, should be stored in designated sites prior to final disposal.

				-Proper waste disposal management plan should be implemented.
Operational Phase				
Parameter	Source	Overall Impact	Impact on dolphins	Mitigation
Ambient air quality	Oxides of Nitrogen (NOx), Oxides of Sulfur (SOx), Carbon Monoxide (CO), particulate matters may be emitted from stacks and chimneys of power plant.	Emission of exhaust gas from the stack may contribute elevated ground level concentration of CO, CO_2, NOx, particulate matter etc. at the down wind direction. The emission of SOx, NOx and PM may have significant impact on vegetation and other species. NOx, SOx, CO and PM can be washed into the river through rain. Particulate matter, dust will fall on the leaves, vegetation and water bodies near to the project site.	Emitted dust particles from the plant site include nitrogen, mercury compounds which can be deposited into the water bodies causes eutrophication and kills aquatic life. When excess mercury deposits in river it may turn into methyl mercury that affects aquatic plants, microorganisms and fish species. As a result, the whole food chain is affected and can adversely effect dolphin and dolphin prey.	-Power plant should adopt inbuilt pollution control measures like Low-NOx burner, Wet injection process etc -Cleaner fuel should be used to run the power plant -Emission from the stacks must belimited to the IFC, 2008 standard for thermal power plant. -All measures for limiting the emission of SOx, NOx and PM should be within the GOB standards and IFC guidelines -On the other hand, significant portion of greenbelt in and around the project area should be developed to improve the vegetation coverage and enhance the capacity of carbonsinking.
Ambient water quality	Thermal effluents from cooling system. Wastewater from plant process.	Discharge of wastewater, effluents and accidental spillage of oil and chemical materials into river and open water reduces the productivity of fish habitats.	Oil spillage from water vehicle contains heavy metals such as mercury, copper and selenium might have direct harmful effects on dolphins.	-Thermal effluents should be discharged far from the intake point of cooling water to reduce the impact on surrounding area. -No waste water should be

	Leakages of oil and chemical materials. Abstraction of river water. Collection of fresh water.	Water intake from the river would entrap fish, crustaceans and other aquatic organisms. Predator-prey relationship might be affected due to spread of invasive species through ballast water. Direct discharge of hot water into the river might have harmful effects on fish population.	Effects on fish population will also have adverse effects on prey of dolphins. Water extraction from river particularly during dry season for cooling and makeup process of power plant may affect aquatic ecosystem, aquatic species including dolphin and their prey.	discharged to the river without treatment. Installation of waste water treatment system by neutralization, settling and oil separation so any wastewater produced complies with wastewater standards and IFC and GOB guidelines. -Storage of oil and chemical materials in appropriate tanks with retaining walland method to prevent permeation into ground and leaching into the river. -Temporary water reservoir can be built for water storage rather than direct abstraction from river. -Drum screens need to be adopted in order to limit the entrainment of fish in the cooling water system and intakevelocities should be as low as possible
Ambient Noise quality	Noise from steam turbines generators, and pumps, etc. Transportation of power plant equipment	Hearing complexity and loss along with increased blood pressure, disturbances and discomfort to the technicians and workers and surrounding communities due to noise generated from the plant.	Transportation of power plant equipment, other materials may affects habitat quality of aquatic species due to creation of underwater noise. As dolphins rely on echolocation for detecting prey,	-Installation of low noise/low vibration type equipment -Adequate enclosure ofequipment to reduce noise -All the vessels must follow the standard of IMO, MARPOL during transportation

			communication and navigation. Noise pollution threats their survival.	of materials up to the port of delivery of foreign imported machinery and equipment. -Cargo can be offloaded from ships away from the identified important dolphin areas and if possible be transported by land to the site to avoid spillage.
Waste disposal	Waste water, waste oil, sludge and other untreated effluent. Solid waste generated from the workers living within the region such as cans, bottles and food. Hydrazine added in boiler water.	Hydrazine is a known carcinogen and a mutagen which is added in the boiler water in power plant. Workers may be exposed to hydrazine from the boiler blow down. Generation of waste may affect the fish habitats and surrounding aquatic species	Wastes may leach into nearby canal and river, affecting aquatic life. Toxic algae outbreaks may take place and reduce oxygen in the water, driving dolphins from important areas. Also debris, including plastic bags, tarps and other non-degradable objects dumped along shorelines and in coastal areas will trap or choke dolphins, especially young animals	-Waste management program consisting of -reduction, reuse, and recycling of materials -Systematic collection and protected storage -Waste disposal should be at appropriate location -Installation of wastewater treatment system by neutralization, settling and oil separation so any wastewater produced complies with wastewater standards and IFC guidelines -Hazardous waste should be treated under the related regulations.

*Source:1)DRAFT REPORT ON ENVIRONMENTALIMPACT ASSESSMENTRUPSHA 800 MW COMBINED CYCLE POWER PLANTVOLUME – I (BOOK 1 OF 2)
2) Report onEnvironmental Impact AssessmentofConstruction of Matarbari 600X2 MW Coal FiredPower Plant and Associated FacilitiesVolume 1 and 2
3)Whalesorg. (2017). *WDC, Whale and Dolphin Conservation*. Retrieved 14 December, 2017, from http://uk.whales.org/issues/pollution

10. Recommendations

From the field surveys, analysis and the results, recommendations are provided below:

- Regular long-term monitoring of dolphins following the current methodology and other wildlife should be continued during construction phase. This is important to know whether there are any effects on the dolphin population in the area. The results of the surveys that are presented in this report will act as a baseline. Long-term monitoring will also show the effectiveness of mitigation measures implemented. Regular monitoring will also help to propose conservation measures if there is a decrease in dolphin population.

- Important dolphin areas have been identified from the surveys (Map 2), where there is high concentration of dolphins, including calves. It should be ensured that these areas are disturbed as less as possible by following the mitigation measures as well as close monitoring.

- As stated in the mitigation section, it is not recommended that large cargo water vessels/Berge carrying heavy equipments for Rupsha 800 MW CCPP Project should move through the important dolphin areas. The movement of high number of large cargo water vessels will create a lot of noise. As dolphins use echolocation (a process where an animal uses calls for navigation, communication and hunting), loud noises will disrupt their normal behaviour, causing adverse effects to the dolphin population. If there is movement of large cargo vessels, specific routes will have to be identified in the areas, during specific time of the day so that disturbance is limited.

- It is recommended that the large cargo water vessels be docked in a more suitable place away from the important dolphin areas, and the materials be transported via roads to the construction sites, where applicable.

- No waste or chemicals can be discharged during O&M of Rupsha 800 MW CCPP into the river without treatment and following standard guidelines from the project site or transport vehicles.

- Mitigation measures stated in section 4 (Impact and Mitigation) should be followed to ensure that the adverse effects are mitigated and the dolphins are not harmed.

Appendix 1: Dolphin individuals recorded during the survey period

Survey season	Number of Sighting	Area (low and high tide) (km)	Encounter Rate/km in each survey
Pre-monsoon survey	70	60	1.17
First monsoon survey	50	60	0.833
Second monsoon survey	62	60	1.03
First post-monsoon survey	102	60	1.70
Total	**285**	**240**	**4.18**
Average Encounter Rate	**1.18** (the total area will be 30kmx8=240km and Encounter rate will be 284/240=1.18)		

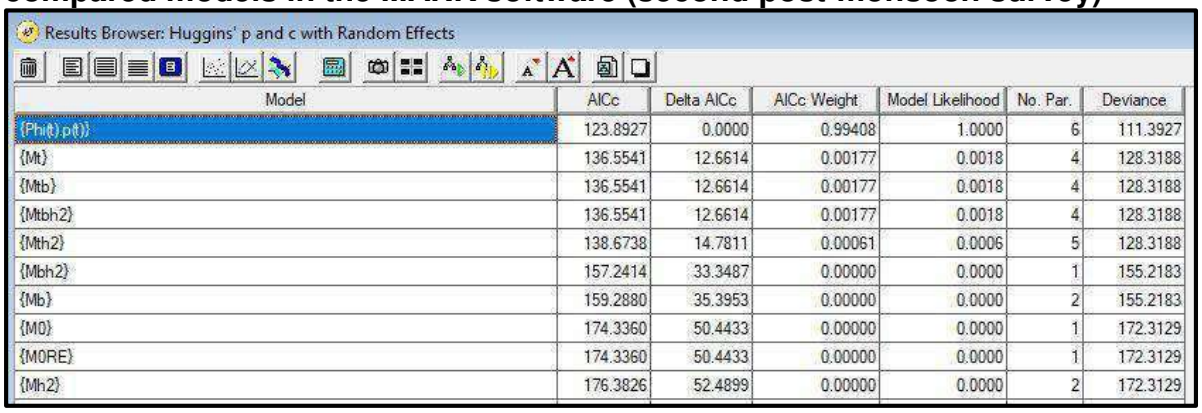
Appendix 2: Dolphin survey methodology

Teams	1. A primary observer team will be stationed on the upper deck (approximately 4.4 m above the waterline) 2. A secondary observer team will be stationed on the lower deck (c.2.3 m above the waterline) 3. The two independent observer teams will not be in visual contact and observers will be instructed to avoid alerting the other team about dolphin sightings. (Note: this will maintain the independence of results.)
Observer position	1. Three observers will stand watch at all times while "on-effort" (i.e., actively searching for dolphins along the transect line and recording effort and sighting data) 2. One will be stationed on each the port and starboard sides, searching with handheld binoculars and naked eye from the beam to about 10^0 past the bow 3. One in the centre searching by naked eye in about a 20^0 cone in front of the bow 4. The centre observer will also serve as the data recorder. Both primary and secondary teams will be comprised of the same structure.
Observer rotation	1. Observer will be rotated through the three different positions every 30 min followed by at least an hour of rest before switching teams. 2. Each team will have 3 observers. There will be a back up team who will switch positions during rotation every 30 mins.
Transect and Boat Speed	1. Transect will start from the lower part of Rupsha river and finish at upper part of Bhairab river. We will cover a total 20 km in favor of the tide. We will then move into Atairiver where we will not be in favor of the tide.

	Then we will cover the last 10 km of Atairiver. The boat speed will be controlled accordingly. 2. Boat speed will be on average 10 km/hour.
Survey Equipment	• Handheld 7 x 43 binoculars • Laser Range Finder (will be used if less than 500m) • Handheld GPS (GARMIN GPSmap62s) • Double decked boat will be used in the survey.
Sighting conditions	Every 30 min, at the location of dolphin sightings, or when there will be a significant change in sighting conditions we will record our position with a Global Positioning System and information on sighting conditions, human activities, channel width, and the distance cover along the transect line.
Channel width	Channel width will be recorded according to the sum of distance measurements to the right and left banks using a laser range finder, if less than 500 m, or the sum of estimates will be made by naked eye, if greater. We can also use satellite image to measure the channel width according to the GPS coordinates if both options are not feasible.
Sighting condition codes	Wind, glare, or rain/fog conditions will be given codes of 0, 1, or 2 corresponding to good, fair and poor respectively.
Dolphins data record	1. Species; 2. Time; 3. Radial distance to the first dolphin sighted; 4. the location of the estimated position (GPS) where the dolphins located when first observed; and 5. Group size (according to best, high and low)Specialized data sheet is attached.
Model Use	The following models will be used for analysis and estimation of population size. 1. A stratified Lincoln-Petersen model 2. Huggins conditional likelihood model 3. Horvitz-Thomson Estimator (to obtain the abundance)

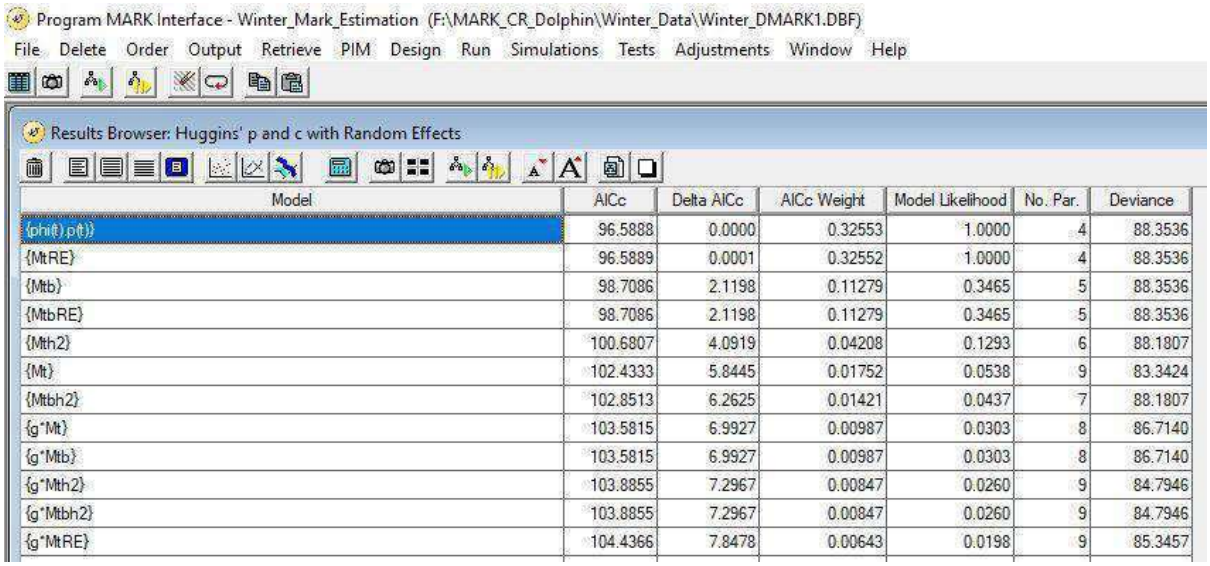
Smith et al, 1994; Smith 2000; Smith *et al.* 2006

Appendix 3:The chosen model (highlighted in blue) and the results from other compared models in the MARK software (second post-monsoon survey)


Results Browser: Huggins' p and c with Random Effects

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Par.	Deviance
{Phi(t),p(t)}	123.8927	0.0000	0.99408	1.0000	6	111.3927
{Mt}	136.5541	12.6614	0.00177	0.0018	4	128.3188
{Mtb}	136.5541	12.6614	0.00177	0.0018	4	128.3188
{Mtbh2}	136.5541	12.6614	0.00177	0.0018	4	128.3188
{Mth2}	138.6738	14.7811	0.00061	0.0006	5	128.3188
{Mbh2}	157.2414	33.3487	0.00000	0.0000	1	155.2183
{Mb}	159.2880	35.3953	0.00000	0.0000	2	155.2183
{M0}	174.3360	50.4433	0.00000	0.0000	1	172.3129
{M0RE}	174.3360	50.4433	0.00000	0.0000	1	172.3129
{Mh2}	176.3826	52.4899	0.00000	0.0000	2	172.3129

Appendix 4. The chosen model (highlighted in blue) and the results from other compared models in the MARK software (first winter survey)

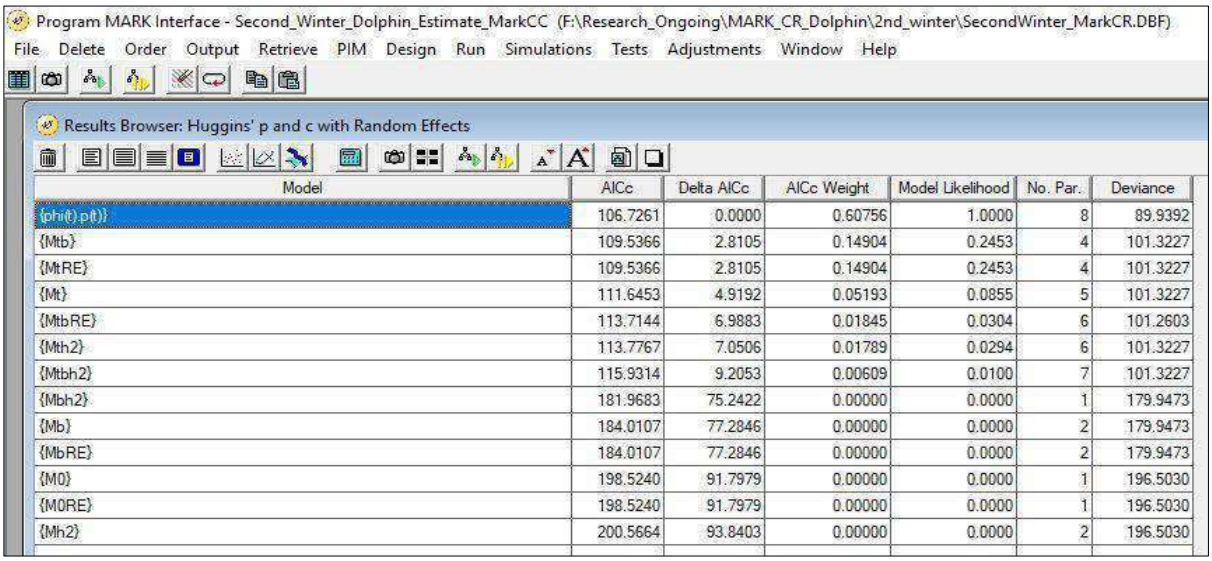

Program MARK Interface - Winter_Mark_Estimation (F:\MARK_CR_Dolphin\Winter_Data\Winter_DMARK1.DBF)

File Delete Order Output Retrieve PIM Design Run Simulations Tests Adjustments Window Help

Results Browser: Huggins' p and c with Random Effects

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Par.	Deviance
{phi(t),p(t)}	96.5888	0.0000	0.32553	1.0000	4	88.3536
{MtRE}	96.5889	0.0001	0.32552	1.0000	4	88.3536
{Mtb}	98.7086	2.1198	0.11279	0.3465	5	88.3536
{MtbRE}	98.7086	2.1198	0.11279	0.3465	5	88.3536
{Mth2}	100.6807	4.0919	0.04208	0.1293	6	88.1807
{Mt}	102.4333	5.8445	0.01752	0.0538	9	83.3424
{Mtbh2}	102.8513	6.2625	0.01421	0.0437	7	88.1807
{g*Mt}	103.5815	6.9927	0.00987	0.0303	8	86.7140
{g*Mtb}	103.5815	6.9927	0.00987	0.0303	8	86.7140
{g*Mth2}	103.8855	7.2967	0.00847	0.0260	9	84.7946
{g*Mtbh2}	103.8855	7.2967	0.00847	0.0260	9	84.7946
{g*MtRE}	104.4366	7.8478	0.00643	0.0198	9	85.3457

Appendix 5. The chosen model (highlighted in blue) and the results from other compared models in the MARK software (second winter survey)


Program MARK Interface - Second_Winter_Dolphin_Estimate_MarkCC (F:\Research_Ongoing\MARK_CR_Dolphin\2nd_winter\SecondWinter_MarkCR.DBF)

File Delete Order Output Retrieve PIM Design Run Simulations Tests Adjustments Window Help

Results Browser: Huggins' p and c with Random Effects

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Par.	Deviance
{phi(t),p(t)}	106.7261	0.0000	0.60756	1.0000	8	89.9392
{Mtb}	109.5366	2.8105	0.14904	0.2453	4	101.3227
{MtRE}	109.5366	2.8105	0.14904	0.2453	4	101.3227
{Mt}	111.6453	4.9192	0.05193	0.0855	5	101.3227
{MtbRE}	113.7144	6.9883	0.01845	0.0304	6	101.2603
{Mth2}	113.7767	7.0506	0.01789	0.0294	6	101.3227
{Mtbh2}	115.9314	9.2053	0.00609	0.0100	7	101.3227
{Mbh2}	181.9683	75.2422	0.00000	0.0000	1	179.9473
{Mb}	184.0107	77.2846	0.00000	0.0000	2	179.9473
{MbRE}	184.0107	77.2846	0.00000	0.0000	2	179.9473
{M0}	198.5240	91.7979	0.00000	0.0000	1	196.5030
{M0RE}	198.5240	91.7979	0.00000	0.0000	1	196.5030
{Mh2}	200.5664	93.8403	0.00000	0.0000	2	196.5030

Appendix 6: Mark-recapture Analysis (Second post-monsoon)

Program MARK - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017 13-Dec-2017 15:51:36 Page 001
- -

This version was compiled by GCC version 5.3.0 using the options:
-cpp -iprefix c:\tdm-gcc-64\gcc\bin\../lib/gcc/x86_64-w64-mingw32/5.3.0/ -D_MT
-U_REENTRANT -D IEEE -m64 -mtune=generic -march=x86-64 -mthreads -O2

```
   -fimplicit-none -fbounds-check -funroll-loops -ftree-vectorize
   -ffpe-summary=invalid,zero,overflow,underflow -fno-unsafe-math-optimizations
   -frounding-math -fsignaling-nans -fopenmp.

  This problem will use 4 of 4 possible threads.

 INPUT --- proc title Dolphin_Estimation;

    CPU Time in seconds for last procedure was 0.00

INPUT --- procchmatrix occasions=5 groups=2 etype=Huggins mixtures=2
 INPUT --- Nodes=101 icovar=3 ICMeansNoHisthist=300;

 INPUT ---    glabel(1)=Primary;

 INPUT ---    glabel(2)=Secondary;

 INPUT ---    time interval 1 1 1 1;

 INPUT ---       icovariatesGSizeCWidthSCon;

     Number of unique encounter histories read was 35.

     Number of individual covariates read was 3.
     Time interval lengths are all equal to 1.

     Data type number is 12
     Data type is Huggins' p and c

    CPU Time in seconds for last procedure was 0.00

Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017   13-Dec-2017 15:51:36    Page  002
Dolphin_Estimation
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  INPUT --- proc estimate link=Logitvarest=2ndPart ;
 INPUT --- model={Phi(t).p(t)};
 INPUT ---    group=1 p rows=1 cols=5 Square Time=1;
 INPUT ---    group=2 p rows=1 cols=5 Square Time=6;
 INPUT ---    group=1 c rows=1 cols=4 Square Time=11;
 INPUT ---    group=2 c rows=1 cols=4 Square Time=15;
 INPUT ---    design matrix constraints=18 covariates=18 identity;
 INPUT ---      blabel(1)=p;
 INPUT ---      blabel(2)=p;
 INPUT ---      blabel(3)=p;
 INPUT ---      blabel(4)=p;
 INPUT ---      blabel(5)=p;
 INPUT ---      blabel(6)=p;
 INPUT ---      blabel(7)=p;
 INPUT ---      blabel(8)=p;
 INPUT ---      blabel(9)=p;
 INPUT ---      blabel(10)=p;
 INPUT ---      blabel(11)=c;
 INPUT ---      blabel(12)=c;
 INPUT ---      blabel(13)=c;
 INPUT ---      blabel(14)=c;
 INPUT ---      blabel(15)=c;
```

```
 INPUT ---      blabel(16)=c;
 INPUT ---      blabel(17)=c;
 INPUT ---      blabel(18)=c;
 INPUT ---      rlabel(1)=p;
 INPUT ---      rlabel(2)=p;
 INPUT ---      rlabel(3)=p;
 INPUT ---      rlabel(4)=p;
 INPUT ---      rlabel(5)=p;
 INPUT ---      rlabel(6)=p;
 INPUT ---      rlabel(7)=p;
 INPUT ---      rlabel(8)=p;
 INPUT ---      rlabel(9)=p;
 INPUT ---      rlabel(10)=p;
 INPUT ---      rlabel(11)=c;
Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017   13-Dec-2017 15:51:36    Page  003
Dolphin_Estimation
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 INPUT ---      rlabel(12)=c;
 INPUT ---      rlabel(13)=c;
 INPUT ---      rlabel(14)=c;
 INPUT ---      rlabel(15)=c;
 INPUT ---      rlabel(16)=c;
 INPUT ---      rlabel(17)=c;
 INPUT ---      rlabel(18)=c;
 INPUT ---      dlabel(1)=Grp 1 N;
 INPUT ---      dlabel(2)=Grp 2 N;

 Link Function Used is LOGIT

 Variance Estimation Procedure Used is 2ndPart

M(t+1):
    18    17

 -2logL(saturated) = -0.0000000
 Effective Sample Size = 175

 Number of function evaluations was 43 for 18 parameters.
 Time for numerical optimization was 0.03 seconds.
 -2logL {Phi(t).p(t)} = 111.39272
 Penalty {Phi(t).p(t)} = -0.0000000
 Gradient {Phi(t).p(t)}:
  0.000000     0.000000     0.000000     0.000000     0.000000
  0.000000     0.000000     0.000000     0.000000     0.000000
  0.000000    0.6308189E-06  0.000000     0.000000    0.9427072E-06
  0.000000     0.000000     0.000000
 S Vector {Phi(t).p(t)}:
  4.235293     3.999999     3.611111     3.111111     1.764706
  1.764706    0.8827028E-07 0.8051994E-07 0.6681132E-07 0.6681059E-07
 0.6523502E-07 0.6315005E-07 0.4948998E-07 0.2262376E-07 0.1477314E-07
 0.4738380E-08 0.4026128E-08 0.1484434E-08
 Time to compute number of parameters was 0.09 seconds.
  Threshold =  0.3800000E-06     Condition index =  0.3504914E-09     New Threshold =  0.6297919E-08
 New Guessimate of Estimated Parameters {Phi(t).p(t)} = 13
 Conditioned S Vector {Phi(t).p(t)}:
```

1.000000 0.9444446 0.8526237 0.7345681 0.4166669
0.4166668 0.2084160E-07 0.1901166E-07 0.1577490E-07 0.1577473E-07
0.1540272E-07 0.1491043E-07 0.1168514E-07 0.5341724E-08 0.3488104E-08
0.1118784E-08 0.9506140E-09 0.3504914E-09
Number of Estimated Parameters {Phi(t).p(t)} = 6
DEVIANCE {Phi(t).p(t)} = 111.39272
DEVIANCE Degrees of Freedom {Phi(t).p(t)} = 29
c-hat {Phi(t).p(t)} = 3.8411282
AIC {Phi(t).p(t)} = 123.39272
AICc {Phi(t).p(t)} = 123.89272
BIC {Phi(t).p(t)} = 142.38143
Pearson Chisquare {Phi(t).p(t)} = 245.89617

LOGIT Link Function Parameters of {Phi(t).p(t)}

			95% Confidence Interval	
Parameter	Beta	Standard Error	Lower	Upper
1:p	19.442761	1698.6670	-3309.9446	3348.8301
2:p	-3.9815082	0.0000000	-3.9815082	-3.9815082
3:p	-3.9814670	0.0000000	-3.9814670	-3.9814670
4:p	-3.9815082	0.0000000	-3.9815082	-3.9815082
5:p	-3.9815082	0.0000000	-3.9815082	-3.9815082
6:p	23.996232	0.1625529E-004	23.996200	23.996264
7:p	-3.7437660	0.0000000	-3.7437660	-3.7437660
8:p	-3.7437660	0.0000000	-3.7437660	-3.7437660
9:p	-3.7437660	0.0000000	-3.7437660	-3.7437660
10:p	-3.7437833	0.0000000	-3.7437833	-3.7437833
11:c	0.9555113	0.5262348	-0.0759090	1.9869316
12:c	1.2527629	0.5669467	0.1415473	2.3639785
13:c	-0.6931474	0.5000000	-1.6731474	0.2868527
14:c	20.731936	7970.8080	-15602.052	15643.516
15:c	2.0149031	0.7527727	0.5394686	3.4903375
16:c	-0.1177833	0.4859127	-1.0701723	0.8346057
17:c	2.0149028	0.7527726	0.5394685	3.4903372
18:c	25.140963	0.0000000	25.140963	25.140963

Program MARK - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017 13-Dec-2017 15:51:36 Page 004
Dolphin_Estimation
- -

Real Function Parameters of {Phi(t).p(t)}

			95% Confidence Interval	
Parameter	Estimate	Standard Error	Lower	Upper
1:p	1.0000000	0.6112579E-005	0.9999880	1.0000120
2:p	0.0183158	0.0000000	0.0183158	0.0183158
3:p	0.0183165	0.0000000	0.0183165	0.0183165
4:p	0.0183158	0.0000000	0.0183158	0.0183158
5:p	0.0183158	0.0000000	0.0183158	0.0183158
6:p	1.0000000	0.6159766E-015	1.0000000	1.0000000
7:p	0.0231177	0.0000000	0.0231177	0.0231177
8:p	0.0231177	0.0000000	0.0231177	0.0231177
9:p	0.0231177	0.0000000	0.0231177	0.0231177
10:p	0.0231173	0.0000000	0.0231173	0.0231173

```
 11:c              0.7222222      0.1055718      0.4810319      0.8794181
 12:c              0.7777778      0.0979908      0.5353279      0.9140389
 13:c              0.3333333      0.1111111      0.1580050      0.5712255
 14:c              1.0000000      0.7902001E-005 0.9999845      1.0000155
 15:c              0.8823529      0.0781425      0.6316888      0.9704116
 16:c              0.4705882      0.1210578      0.2553703      0.6973279
 17:c              0.8823529      0.0781425      0.6316888      0.9704116
 18:c              1.0000000      0.0000000      1.0000000      1.0000000
Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017   13-Dec-2017 15:51:36    Page  005
Dolphin_Estimation
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                Estimates of Derived Parameters
             Population Estimates of {Phi(t).p(t)}
                                95% Confidence Interval
   Group     N-hat       Standard Error      Lower          Upper
---------  --------------  --------------  --------------  --------------
     1    18.000000      0.2640368E-003  18.000000      18.000184
     2    17.000000      0.2422045E-004  17.000000      17.000005

 Attempted ordering of parameters by estimatibility:
  16 13 11 12 17 15  9 10  3  5  2  4  8  7 14  6  1 18
 Beta number 18 is a singular value.

    CPU Time in seconds for last procedure was 0.14

  INPUT --- proc stop;

    CPU Time in minutes for this job was 0.00

    Time Start = 15:51:36.679   Time End = 15:51:36.810

    Wall Clock Time in minutes for this job was 0.00


        E X E C U T I O N   S U C C E S S F
```

Appendix 7: Mark-recapture Analysis (First Winter)

```
Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017   17-Jan-2018 18:17:28    Page  001
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

   This version was compiled by GCC version 5.3.0 using the options:
     -cpp -iprefix c:\tdm-gcc-64\gcc\bin\../lib/gcc/x86_64-w64-mingw32/5.3.0/ -D_MT
     -U_REENTRANT -D IEEE -m64 -mtune=generic -march=x86-64 -mthreads -O2
     -fimplicit-none -fbounds-check -funroll-loops -ftree-vectorize
     -ffpe-summary=invalid,zero,overflow,underflow -fno-unsafe-math-optimizations
     -frounding-math -fsignaling-nans -fopenmp.

   This problem will use 4 of 4 possible threads.


  INPUT --- proc title Winter_Mark_Estimation;
```

CPU Time in seconds for last procedure was 0.00

```
INPUT --- proc chmatrix occasions=5 groups=2 etype=Huggins mixtures=2
INPUT --- Nodes=101 icovar=3 ICMeansNoHisthist=300;

INPUT ---    glabel(1)=Primary;

INPUT ---    glabel(2)=Secondary;

INPUT ---    time interval 1 1 1 1;

INPUT ---       icovariatesGSizeCWidthSiteCon;
```

Number of unique encounter histories read was 35.

Number of individual covariates read was 3.
Time interval lengths are all equal to 1.

Data type number is 12
Data type is Huggins' p and c

CPU Time in seconds for last procedure was 0.00

- -

```
 INPUT --- proc estimate link=Logit varest=2ndPart ;


 INPUT --- model={phi(t).p(t)};

 INPUT ---    group=1 p rows=1 cols=5 Square Time=1;

 INPUT ---    group=2 p rows=1 cols=5 Square Time=6;

 INPUT ---    group=1 c rows=1 cols=4 Square Time=11;

 INPUT ---    group=2 c rows=1 cols=4 Square Time=15;

 INPUT ---    design matrix constraints=18 covariates=5;
 INPUT ---          1 1 0 0 0;
 INPUT ---          1 0 1 0 0;
 INPUT ---          1 0 0 1 0;
 INPUT ---          1 0 0 0 1;
 INPUT ---          1 0 0 0 0;
 INPUT ---          1 1 0 0 0;
 INPUT ---          1 0 1 0 0;
 INPUT ---          1 0 0 1 0;
 INPUT ---          1 0 0 0 1;
 INPUT ---          1 0 0 0 0;
 INPUT ---          1 0 1 0 0;
 INPUT ---          1 0 0 1 0;
 INPUT ---          1 0 0 0 1;
 INPUT ---          1 0 0 0 0;
 INPUT ---          1 0 1 0 0;
 INPUT ---          1 0 0 1 0;
 INPUT ---          1 0 0 0 1;
 INPUT ---          1 0 0 0 0;
 INPUT ---       blabel(1)=p Intercept;
 INPUT ---       blabel(2)=p Occasion 1;
 INPUT ---       blabel(3)=p Occasion 2;
 INPUT ---       blabel(4)=p Occasion 3;
 INPUT ---       blabel(5)=p Occasion 4;
 INPUT ---       rlabel(1)=p;
 INPUT ---       rlabel(2)=p;
 INPUT ---       rlabel(3)=p;
 INPUT ---       rlabel(4)=p;
 INPUT ---       rlabel(5)=p;
 INPUT ---       rlabel(6)=p;
```

- -

INPUT --- rlabel(7)=p;
INPUT --- rlabel(8)=p;
INPUT --- rlabel(9)=p;
INPUT --- rlabel(10)=p;
INPUT --- rlabel(11)=c;
INPUT --- rlabel(12)=c;
INPUT --- rlabel(13)=c;
INPUT --- rlabel(14)=c;
INPUT --- rlabel(15)=c;
INPUT --- rlabel(16)=c;
INPUT --- rlabel(17)=c;
INPUT --- rlabel(18)=c;

Link Function Used is LOGIT

Variance Estimation Procedure Used is 2ndPart

M(t+1):
19 16

-2logL(saturated) = -0.0000000
Effective Sample Size = 175

Number of function evaluations was 38 for 5 parameters.
Time for numerical optimization was 0.02 seconds.
-2logL {phi(t).p(t)} = 88.353555
Penalty {phi(t).p(t)} = -0.0000000
Gradient {phi(t).p(t)}:
0.2110236E-05 0.000000 0.000000 -0.8625427E-06 0.000000
S Vector {phi(t).p(t)}:
15.53201 3.661730 2.180378 0.5687458 0.2314120E-07
Time to compute number of parameters was 0.01 seconds.
Threshold = 0.1200000E-06 Condition index = 0.1489904E-08 New Threshold = 0.5174529E-07
New Guessimate of Estimated Parameters {phi(t).p(t)} = 4
Conditioned S Vector {phi(t).p(t)}:
1.000000 0.2357538 0.1403797 0.3661767E-01 0.1489904E-08
Number of Estimated Parameters {phi(t).p(t)} = 4
DEVIANCE {phi(t).p(t)} = 88.353555
DEVIANCE Degrees of Freedom {phi(t).p(t)} = 31
c-hat {phi(t).p(t)} = 2.8501147
AIC {phi(t).p(t)} = 96.353555
AICc {phi(t).p(t)} = 96.588849
BIC {phi(t).p(t)} = 109.01270
Pearson Chisquare {phi(t).p(t)} = 480.92057

LOGIT Link Function Parameters of {phi(t).p(t)}

Parameter	Beta	Standard Error	95% Confidence Interval Lower	Upper
1:p Intercept	2.3671248	0.6038076	1.1836620	3.5505877

2:p Occasion 1 19.296656 6573.6576 -12865.072 12903.666
3:p Occasion 2 -.1529803E-005 0.8539126 -1.6736703 1.6736672

4:p Occasion 3 -3.9426613 0.7521522 -5.4168797 -2.4684429
5:p Occasion 4 0.4362349 0.9459841 -1.4178938 2.2903637

Real Function Parameters of {phi(t).p(t)}

Parameter	Estimate	Standard Error	95% Confidence Interval Lower	Upper
1:p	1.0000000	0.2566531E-005	0.9999950	1.0000050
2:p	0.9142857	0.0473188	0.7656054	0.9720933
3:p	0.1714286	0.0637049	0.0791035	0.3325925
4:p	0.9428571	0.0392347	0.7983560	0.9856658
5:p	0.9142858	0.0473187	0.7656056	0.9720934
6:p	1.0000000	0.2566531E-005	0.9999950	1.0000050
7:p	0.9142857	0.0473188	0.7656054	0.9720933
8:p	0.1714286	0.0637049	0.0791035	0.3325925
9:p	0.9428571	0.0392347	0.7983560	0.9856658
10:p	0.9142858	0.0473187	0.7656056	0.9720934
11:c	0.9142857	0.0473188	0.7656054	0.9720933
12:c	0.1714286	0.0637049	0.0791035	0.3325925
13:c	0.9428571	0.0392347	0.7983560	0.9856658
14:c	0.9142858	0.0473187	0.7656056	0.9720934
15:c	0.9142857	0.0473188	0.7656054	0.9720933
16:c	0.1714286	0.0637049	0.0791035	0.3325925
17:c	0.9428571	0.0392347	0.7983560	0.9856658
18:c	0.9142858	0.0473187	0.7656056	0.9720934

Estimates of Derived Parameters
Population Estimates of {phi(t).p(t)}

Group	N-hat	Standard Error	95% Confidence Interval Lower	Upper
1	19.000000	0.1606274E-005	19.000000	19.000000
2	16.000000	0.1474608E-005	16.000000	16.000000

Attempted ordering of parameters by estimatibility:
1 4 3 5 2
Beta number 2 is a singular value.

CPU Time in seconds for last procedure was 0.02

```
Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017   17-Jan-2018 18:17:28    Page  005
Winter_Mark_Estimation
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  INPUT --- proc stop;
    CPU Time in minutes for this job was 0.00
    Time Start = 18:17:28.166   Time End = 18:17:28.197
    Wall Clock Time in minutes for this job was 0.00

        E X E C U T I O N   S U C C E S S F U L
```

Appendix 8: Mark-recapture Analysis (Second winter)

```
Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017    2-Feb-2018 18:27:34    Page  001
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

   This version was compiled by GCC version 5.3.0 using the options:
     -cpp -iprefix c:\tdm-gcc-64\gcc\bin\../lib/gcc/x86_64-w64-mingw32/5.3.0/ -D_MT
     -U_REENTRANT -D IEEE -m64 -mtune=generic -march=x86-64 -mthreads -O2
     -fimplicit-none -fbounds-check -funroll-loops -ftree-vectorize
     -ffpe-summary=invalid,zero,overflow,underflow -fno-unsafe-math-optimizations
     -frounding-math -fsignaling-nans -fopenmp.

   This problem will use 4 of 4 possible threads.

  INPUT --- proc title Second_Winter_Dolphin_Estimate_MarkCC;

    CPU Time in seconds for last procedure was 0.00

  INPUT --- proc chmatrix occasions=6 groups=2 etype=HugFullHet
  INPUT --- mixtures=2 Nodes=101 icovar=3 ICMeansNoHisthist=300;

  INPUT ---    glabel(1)=PrimaryTeam;

  INPUT ---    glabel(2)=SecondaryTeam;

  INPUT ---    time interval 1 1 1 1 1;

  INPUT ---       icovariatesGroupSizeChWidthSCon;

      Number of unique encounter histories read was 32.

      Number of individual covariates read was 3.
      Time interval lengths are all equal to 1.

      Data type number is 26
      Data type is Huggins' Heterogeneity pi, p, and c

     CPU Time in seconds for last procedure was 0.01

Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
gfortran(Win64) Vers. 8.2 Sep 2017    2-Feb-2018 18:27:34    Page  002
Second_Winter_Dolphin_Estimate_MarkCC
```

- -

```
INPUT --- proc estimate link=Logit varest=2ndPart ;


INPUT --- model={phi(t).p(t)};

INPUT ---   group=1 pi rows=1 cols=1 Square Constant=1;

INPUT ---   group=2 pi rows=1 cols=1 Square Constant=2;

INPUT ---   group=1 p rows=2 cols=6 Square;
INPUT ---            3  4  5  6  7  8;
INPUT ---            9 10 11 12 13 14;

INPUT ---   group=2 p rows=2 cols=6 Square;
INPUT ---           15 16 17 18 19 20;
INPUT ---           21 22 23 24 25 26;

INPUT ---   group=1 c rows=2 cols=5 Square;
INPUT ---           27 28 29 30 31;
INPUT ---           32 33 34 35 36;

INPUT ---   group=2 c rows=2 cols=5 Square;
INPUT ---           37 38 39 40 41;
INPUT ---           42 43 44 45 46;

INPUT ---   design matrix constraints=46 covariates=46 identity;
INPUT ---     blabel(1)=pi;
INPUT ---     blabel(2)=pi;
INPUT ---     blabel(3)=p;
INPUT ---     blabel(4)=p;
INPUT ---     blabel(5)=p;
INPUT ---     blabel(6)=p;
INPUT ---     blabel(7)=p;
INPUT ---     blabel(8)=p;
INPUT ---     blabel(9)=p;
INPUT ---     blabel(10)=p;
INPUT ---     blabel(11)=p;
INPUT ---     blabel(12)=p;
INPUT ---     blabel(13)=p;
INPUT ---     blabel(14)=p;
INPUT ---     blabel(15)=p;
INPUT ---     blabel(16)=p;
INPUT ---     blabel(17)=p;
```

- -

```
 INPUT ---      blabel(18)=p;
 INPUT ---      blabel(19)=p;
 INPUT ---      blabel(20)=p;
 INPUT ---      blabel(21)=p;
 INPUT ---      blabel(22)=p;
 INPUT ---      blabel(23)=p;
 INPUT ---      blabel(24)=p;
 INPUT ---      blabel(25)=p;
 INPUT ---      blabel(26)=p;
 INPUT ---      blabel(27)=c;
 INPUT ---      blabel(28)=c;
 INPUT ---      blabel(29)=c;
 INPUT ---      blabel(30)=c;
 INPUT ---      blabel(31)=c;
 INPUT ---      blabel(32)=c;
 INPUT ---      blabel(33)=c;
 INPUT ---      blabel(34)=c;
 INPUT ---      blabel(35)=c;
 INPUT ---      blabel(36)=c;
 INPUT ---      blabel(37)=c;
 INPUT ---      blabel(38)=c;
 INPUT ---      blabel(39)=c;
 INPUT ---      blabel(40)=c;
 INPUT ---      blabel(41)=c;
 INPUT ---      blabel(42)=c;
 INPUT ---      blabel(43)=c;
 INPUT ---      blabel(44)=c;
 INPUT ---      blabel(45)=c;
 INPUT ---      blabel(46)=c;
 INPUT ---      rlabel(1)=pi;
 INPUT ---      rlabel(2)=pi;
 INPUT ---      rlabel(3)=p;
 INPUT ---      rlabel(4)=p;
 INPUT ---      rlabel(5)=p;
 INPUT ---      rlabel(6)=p;
 INPUT ---      rlabel(7)=p;
 INPUT ---      rlabel(8)=p;
 INPUT ---      rlabel(9)=p;
 INPUT ---      rlabel(10)=p;
 INPUT ---      rlabel(11)=p;
 INPUT ---      rlabel(12)=p;
 INPUT ---      rlabel(13)=p;
 INPUT ---      rlabel(14)=p;
 INPUT ---      rlabel(15)=p;
 INPUT ---      rlabel(16)=p;
```

- -

INPUT --- rlabel(17)=p;
INPUT --- rlabel(18)=p;
INPUT --- rlabel(19)=p;
INPUT --- rlabel(20)=p;
INPUT --- rlabel(21)=p;
INPUT --- rlabel(22)=p;
INPUT --- rlabel(23)=p;
INPUT --- rlabel(24)=p;
INPUT --- rlabel(25)=p;
INPUT --- rlabel(26)=p;
INPUT --- rlabel(27)=c;
INPUT --- rlabel(28)=c;
INPUT --- rlabel(29)=c;
INPUT --- rlabel(30)=c;
INPUT --- rlabel(31)=c;
INPUT --- rlabel(32)=c;
INPUT --- rlabel(33)=c;
INPUT --- rlabel(34)=c;
INPUT --- rlabel(35)=c;
INPUT --- rlabel(36)=c;
INPUT --- rlabel(37)=c;
INPUT --- rlabel(38)=c;
INPUT --- rlabel(39)=c;
INPUT --- rlabel(40)=c;
INPUT --- rlabel(41)=c;
INPUT --- rlabel(42)=c;
INPUT --- rlabel(43)=c;
INPUT --- rlabel(44)=c;
INPUT --- rlabel(45)=c;
INPUT --- rlabel(46)=c;
INPUT --- dlabel(1)=Grp 1 N;
INPUT --- dlabel(2)=Grp 2 N;

Link Function Used is LOGIT

Variance Estimation Procedure Used is 2ndPart

M(t+1):
15 17

-2logL(saturated) = -0.0000000
Effective Sample Size = 192

Number of function evaluations was 43 for 46 parameters.
Time for numerical optimization was 0.16 seconds.

- -

-2logL {phi(t).p(t)} = 89.939240
Penalty {phi(t).p(t)} = -0.0000000
Gradient {phi(t).p(t)}:
-0.2969045E-05 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 -0.2842165E-05 0.000000
0.000000 0.1933445E-05-0.1050808E-05 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.7533742E-06 0.5593844E-06-0.3766871E-06 0.1678153E-05
0.000000
S Vector {phi(t).p(t)}:
3.076923 2.470588 2.470588 1.733332 1.692307
0.9411769 0.9411764 0.5000003 0.1405864E-05 0.7240347E-06
0.7130144E-06 0.4434888E-06 0.3585167E-06 0.3235718E-06 0.3178967E-06
0.3178892E-06 0.3178892E-06 0.3074423E-06 0.1496835E-06 0.1314289E-06
0.1202430E-06 0.1172966E-06 0.1171686E-06 0.6247524E-07 0.6063276E-07
0.5458477E-07 0.5458477E-07 0.5458291E-07 0.2283143E-07 0.1573467E-07
0.1169571E-08 0.1153389E-08 0.8287850E-09 0.5064499E-09 0.5064497E-09
0.4531770E-09 0.4268930E-09 0.3780729E-09 0.2005165E-09 0.1179552E-09
0.1072146E-09 0.1064020E-09 0.7240969E-10 0.3993209E-10 0.3381622E-10
0.2674458E-10
Time to compute number of parameters was 0.36 seconds.
Threshold = 0.9400000E-06 Condition index = 0.8691988E-11 New Threshold = 0.1813906E-09
New Guessimate of Estimated Parameters {phi(t).p(t)} = 33
Conditioned S Vector {phi(t).p(t)}:
1.000000 0.8029410 0.8029409 0.5633329 0.5499997
0.3058825 0.3058823 0.1625001 0.4569059E-06 0.2353113E-06
0.2317297E-06 0.1441338E-06 0.1165179E-06 0.1051608E-06 0.1033164E-06
0.1033140E-06 0.1033140E-06 0.9991875E-07 0.4864714E-07 0.4271439E-07
0.3907897E-07 0.3812139E-07 0.3807978E-07 0.2030445E-07 0.1970564E-07
0.1774005E-07 0.1774005E-07 0.1773944E-07 0.7420213E-08 0.5113768E-08
0.3801105E-09 0.3748514E-09 0.2693551E-09 0.1645962E-09 0.1645961E-09
0.1472825E-09 0.1387402E-09 0.1228737E-09 0.6516784E-10 0.3833543E-10
0.3484475E-10 0.3458064E-10 0.2353315E-10 0.1297793E-10 0.1099027E-10
0.8691988E-11
Number of Estimated Parameters {phi(t).p(t)} = 8
DEVIANCE {phi(t).p(t)} = 89.939240
DEVIANCE Degrees of Freedom {phi(t).p(t)} = 24
c-hat {phi(t).p(t)} = 3.7474683
AIC {phi(t).p(t)} = 105.93924
AICc {phi(t).p(t)} = 106.72612
BIC {phi(t).p(t)} = 131.99920
Pearson Chisquare {phi(t).p(t)} = 174.23540

LOGIT Link Function Parameters of {phi(t).p(t)}

Parameter	Beta	Standard Error	95% Confidence Interval Lower	Upper

1:pi	-1.8718031	0.7595548	-3.3605305	-0.3830757
2:pi	-41.092522	0.1341568E-005	-41.092525	-41.092519
3:p	56.564278	0.0000000	56.564278	56.564278

- -

4:p	-1.5511992	0.0000000	-1.5511992	-1.5511992
5:p	-1.5511992	0.0000000	-1.5511992	-1.5511992
6:p	-1.5512644	0.0000000	-1.5512644	-1.5512644
7:p	-1.5511992	0.0000000	-1.5511992	-1.5511992
8:p	-1.5511992	0.0000000	-1.5511992	-1.5511992
9:p	28.474750	94.454163	-156.65541	213.60491
10:p	-0.7411186	0.0000000	-0.7411186	-0.7411186
11:p	-0.7411377	0.0000000	-0.7411377	-0.7411377
12:p	-0.7413039	0.0000000	-0.7413039	-0.7413039
13:p	-0.7413039	0.0000000	-0.7413039	-0.7413039
14:p	-0.7413039	0.0000000	-0.7413039	-0.7413039
15:p	-27.652989	7.5940723	-42.537371	-12.768607
16:p	0.0571189	0.0000000	0.0571189	0.0571189
17:p	0.0571511	0.0000000	0.0571511	0.0571511
18:p	0.0571511	0.0000000	0.0571511	0.0571511
19:p	0.0571636	0.0000000	0.0571636	0.0571636
20:p	0.0571636	0.0000000	0.0571636	0.0571636
21:p	20.772807	7968.5714	-15597.627	15639.173
22:p	-0.4750927	1133.1592	-2221.4671	2220.5169
23:p	-0.4750927	1022.7672	-2005.0988	2004.1486
24:p	-0.4750927	1068.5058	-2094.7466	2093.7964
25:p	-0.4750249	1326.3821	-2600.1839	2599.2339
26:p	-0.4750249	1520.2949	-2980.2530	2979.3030
27:c	79.441290	0.0000000	79.441290	79.441290
28:c	-69.045743	0.0000000	-69.045743	-69.045743
29:c	-.2238521E-005	1.4142132	-2.7718602	2.7718557
30:c	-98.251477	0.0000000	-98.251477	-98.251477
31:c	56.783687	0.0000000	56.783687	56.783687
32:c	0.4700039	0.5700877	-0.6473680	1.5873757
33:c	-1.7047485	0.7687063	-3.2114128	-0.1980842
34:c	93.323316	0.0000000	93.323316	93.323316
35:c	59.560680	0.1258984E-005	59.560677	59.560682
36:c	28.347807	0.0000000	28.347807	28.347807
37:c	-25.485731	0.0000000	-25.485731	-25.485731
38:c	16.428773	0.0000000	16.428773	16.428773
39:c	-25.485724	0.0000000	-25.485724	-25.485724
40:c	-19.821643	0.0000000	-19.821643	-19.821643
41:c	-27.848325	0.0000000	-27.848325	-27.848325
42:c	2.7725888	1.0307764	0.7522670	4.7929107
43:c	-1.5404451	0.6362090	-2.7874148	-0.2934754
44:c	2.7725883	1.0307762	0.7522669	4.7929097
45:c	1.5404454	0.6362091	0.2934756	2.7874152
46:c	20.497756	6618.0719	-12950.923	12991.919

- -

Real Function Parameters of {phi(t).p(t)}

Parameter	Estimate	Standard Error	95% Confidence Interval Lower	Upper
1:pi	0.1333332	0.0877707	0.0335520	0.4053853
2:pi	0.1424769E-017	0.1911424E-023	0.1424765E-017	0.1424773E-017
3:p	1.0000000	0.0000000	1.0000000	1.0000000
4:p	0.1749131	0.0000000	0.1749131	0.1749131
5:p	0.1749131	0.0000000	0.1749131	0.1749131
6:p	0.1749037	0.0000000	0.1749037	0.1749037
7:p	0.1749131	0.0000000	0.1749131	0.1749131
8:p	0.1749131	0.0000000	0.1749131	0.1749131
9:p	1.0000000	0.4062477E-010	1.0000000	1.0000000
10:p	0.3227596	0.0000000	0.3227596	0.3227596
11:p	0.3227554	0.0000000	0.3227554	0.3227554
12:p	0.3227191	0.0000000	0.3227191	0.3227191
13:p	0.3227191	0.0000000	0.3227191	0.3227191
14:p	0.3227191	0.0000000	0.3227191	0.3227191
15:p	0.9782720E-012	0.7429068E-011	-.1358270E-010	0.1553925E-010
16:p	0.5142758	0.0000000	0.5142758	0.5142758
17:p	0.5142839	0.0000000	0.5142839	0.5142839
18:p	0.5142839	0.0000000	0.5142839	0.5142839
19:p	0.5142870	0.0000000	0.5142870	0.5142870
20:p	0.5142870	0.0000000	0.5142870	0.5142870
21:p	1.0000000	0.7583419E-005	0.9999851	1.0000149
22:p	0.3834116	267.88691	0.6131017E-304	1.0000000
23:p	0.3834116	241.78946	0.6131017E-304	1.0000000
24:p	0.3834116	252.60241	0.6131017E-304	1.0000000
25:p	0.3834276	313.57115	0.6131433E-304	1.0000000
26:p	0.3834276	359.41424	0.6131433E-304	1.0000000
27:c	1.0000000	0.0000000	1.0000000	1.0000000
28:c	0.1032321E-029	0.0000000	0.1032321E-029	0.1032321E-029
29:c	0.4999994	0.3535533	0.0588639	0.9411359
30:c	0.2137597E-042	0.0000000	0.2137597E-042	0.2137597E-042
31:c	1.0000000	0.0000000	1.0000000	1.0000000
32:c	0.6153847	0.1349320	0.3435829	0.8302466
33:c	0.1538461	0.1000682	0.0387385	0.4506402
34:c	1.0000000	0.0000000	1.0000000	1.0000000
35:c	1.0000000	0.0000000	1.0000000	1.0000000
36:c	1.0000000	0.0000000	1.0000000	1.0000000
37:c	0.8544520E-011	0.0000000	0.8544520E-011	0.8544520E-011
38:c	0.9999999	0.0000000	0.9999999	0.9999999
39:c	0.8544579E-011	0.0000000	0.8544579E-011	0.8544579E-011

- -

40:c	0.2463597E-008	0.0000000	0.2463597E-008	0.2463597E-008
41:c	0.8046855E-012	0.0000000	0.8046855E-012	0.8046855E-012
42:c	0.9411765	0.0570672	0.6796725	0.9917798
43:c	0.1764706	0.0924594	0.0580081	0.4271533
44:c	0.9411764	0.0570672	0.6796725	0.9917798
45:c	0.8235295	0.0924594	0.5728468	0.9419920
46:c	1.0000000	0.8292185E-005	0.9999837	1.0000163

Estimates of Derived Parameters
Population Estimates of {phi(t).p(t)}

Group	N-hat	Standard Error	95% Confidence Interval Lower	Upper
1	15.000000	0.8922051E-006	15.000000	15.000000
2	17.000000	0.3970944E-004	17.000000	17.000010

Attempted ordering of parameters by estimatibility:
32 43 45 1 33 44 42 29 24 23 22 25 26 16 18 17 20 19 14 11 12 10 13 7 8
5 4 6 46 21 38 36 40 39 37 9 15 41 2 3 31 35 28 34 27 30
Beta number 30 is a singular value.

CPU Time in seconds for last procedure was 0.53

- -

INPUT --- proc stop;

CPU Time in minutes for this job was 0.01

Time Start = 18:27:34.419 Time End = 18:27:34.925

Wall Clock Time in minutes for this job was 0.01

E X E C U T I O N S U C C E S S F U L

Appendix 9: Other wildlife recorded during the survey period

Other Animal presence			Pre-monsoon (No. of individuals)	Monsoon (No. of individuals)	Post-monsoon (No. of individuals)	Winter (Number of individuals)	National Status (IUCN Red List 2015)	Migratory/ Resident
Sl. No.	Common Name	Scientific Name						
1	Collared King Fisher	*Todiramphus chloris*	3	2			LC	R
2	White Throated King Fisher	*Halcyon smyrnensis*	4					R
3	Pied Kingfisher	*Ceryle rudis*	1	3	2	4	LC	R
4	Brahminy Kite	*Haliastur Indus*	3	17	12	2	LC	R
5	Yellow Bittern	*Ixobrychus sinensis*	1					R
6	Asian Pied Starling	*Sturnus contra*	8	9	29	2	LC	R
7	Black Kite	*Milvus migrans*	6	37	57	23	LC	R
8	Common Kingfisher	*Alcedo atthis*	3		1		LC	R
9	Greater Coucal	*Centropus sinensis*	1				LC	R
10	House Crow	*Corvus splendens*	1	65	90	55	LC	R
11	Little Cormorant	*Microcarbo niger*	16	175	50	2	LC	R
12	Jungle Crow	*Corvus levaillantii*		18	3	7	LC	R
13	Spotted Dove	*Spilopelia chinensis*		5	2	3	LC	R
14	Indian Pond Heron	*Ardeola grayii*		12	4		LC	R
15	Little Egret	*Egretta garzetta*		9	50	2	LC	R
16	Red Vented Bulbul	*Pycnonotus cafer*		9	10	1	LC	R
17	House Swift	*Apus nipalensis*		7	30		LC	R
18	Common Myna	*Acridotheres tristis*		6	2		LC	R
19	Black Drongo	*Dicrurus macrocercus*		6	6	2	LC	R
20	Sand Martin	*Riparia riparia*		6				M
21	White Wagtail	*Motacilla alba*		3	2	1	LC	M
22	Common Sandpiper	*Actitis hypoleucos*		3	18	8	LC	M

23	Palm Swift	*Cypsiurus balasiensis*		30		3	LC	R
24	Striated Heron	*Buto ridesstriata*		2			LC	R
25	Common Bittern	*Ixobrychus cinnamomeus*		2			LC	R
26	Magpie Robin	*Copsychus saularis*		1	9		LC	R
27	Chestnut Tailed Starling	*Sturnia malabarica*		2			LC	R
28	Cattle Egret	*Bubulcus ibis*		4			LC	R
29	Stork Billed Kingfisher	*Pelargopsis capensis*		1			LC	R
30	Barn Swallows	*Hirundo rustica*		7		2	LC	M
31	Gray Headed Lapwing	*Vanellus cinereus*		2			LC	R
32	Black Capped Kingfisher	*Halcyon pileata*		1				R
33	Wood sandpiper	*Tringa glareola*			1		LC	M
34	Brown headed gull	*Larus brunnicephalus*			2		LC	M
35	Baya weaver	*Ploceus philippinus*			20		LC	R
36	Black headed ibis	*Threskiornis melanocephalus*			50		VU	M
37	RufousTreepie	*Dendrocitta vagabunda*			1		LC	R
38	Rock pigeon	*Columba livia*			5		LC	R
39	Black Hooded Oriole	*Oriolus xanthornus*			1	1	LC	R
40	Great Cormorant	*Phalacrocorax carbo*			5		LC	M
41	Little Grebe	*Tachybaptus ruficollis*				1	LC	R
Total			47	444	462	119		

Appendix 10. A list of identified fish species recorded during the survey period

S. N	Common Name	Scientific Name	Monsoon	Post-monsoon	Winter	IUCN 2015 (National Status)	IUCN (Global Status)
1	Long-whiskered Catfish	*Sperata aor**	X	Ar, Rr	X	VU	LC
2	Tengara catfish	*Mystus tengara*	X	Ar, Rr	X	LC	LC
3	Fresh Water Goby	*Glossogobius giuris*	Ar	Ar	Br, Ar, Rr	LC	LC
4	Tire-track Spinyeel	*Mastacembelus armatus*	X	Ar	Ar, Rr	EN	LC
5	Bata Labeo	*Labeo bata*	Ar	Ar	Br, Ar, Rr	LC	LC
6	Sind Danio	*Devario devario*	X	Br, Ar, Rr	X	LC	LC
7	Barramundi	*Lates calcarifer*	Ar, Rr	Ar, Rr	X	NO+	
8	Freshwater shark	*Wallago attu*	Ar	Ar	X	VU	NT
9	Chola Barb	*Puntius chola*	X	Ar, Rr	Ar, Rr	LC	LC
10	Indian river shad	*Gudusia chapra*	X	Br, Ar, Rr	Br, Ar, Rr	VU	LC
11	Moonsoon River Prawn	*Macrobrachium malcomsonii*	Ar, Rr	Br, Ar, Rr	Br, Ar, Rr	LC	
12	Lanceolate goby	*Pseudapocryptes elongates*	Ar, Rr	Br, Ar, Rr	Br, Ar, Rr	LC	LC
13	Humped Featherback	*Chitala chitala**	X	Ar, Rr	Ar, Rr	EN	NT
14	Grey Featherback	*Notopterus notopterus*	X	Ar	X	VU	LC
15	Giant Snakehead	*Channa marulius**	X	X	Ar	EN	LC
16	Menoda Catfish	*Hemibagrus menoda*	Ar, Rr	Ar, Rr	Ar, Rr	NT	LC
17	Kuria labeo	*Labeo gonius*	Ar, Rr	Ar, Rr	X	NT	LC
18	Giant Freshwater Shrimp	*Macrobrachium rosenbergii*	Br, Ar	Br, Ar, Rr	Br, Ar, Rr	LC	LC
19	Gangetic Mystus	*Mystus cavasius*	Ar, Rr	Ar, Rr	Ar, Rr	NT	LC
20	River Shad	*Tenualosa ilisha*	Ar, Rr	Br, Ar, Rr	Br, Ar, Rr	LC	LC
21	Ganges River-sprat	*Corica soborna*	Br	Br	Br, Ar	LC	LC
22	Gangetic Ailia	*Ailia coila*	X	Br	Br, Ar	LC	NT
23	Canine Catfish Eel	*Plotosus canius**	X	Rr		NT	
24	Silver Needle Fish	*Xenentodon cancila*	X	Ar	Ar, Rr	LC	LC

25	Himalayan Glassy Perchlet	*Pseudambassis baculis*	Ar, Rr	Ar, Rr	Ar, Rr	NT	LC
26	Banded gourami	*Trichogaster fasciata*	X	Ar, Rr	Ar, Rr	LC	LC
27	Catla	*Catla catla**	X	Ar, Rr	Ar, Rr	LC	LC
28	Climbing Perch	*Anabas testudineus**	X	X	Ar	LC	DD
29	Rubicundus Eelgoby	*Odontamblyopus rubicundus*	X	Br, Ar, Rr	Br, Ar, Rr	LC	-
30	Mottled Nandus	*Nandus nandus*	Ar, Rr	Ar, Rr	Ar	NT	LC
31	Mrigal Carp	*Cirrhinus cirrhosus*	Rr	Ar, Rr	Ar, Rr	NT	VU
32	Mola Carplet	*Amblypharyngodon mola*	X	Ar, Rr	X	LC	LC
33	Glass barb	*Pethia guganio*	X	Br, Ar, Rr	X	LC	LC
34	Pabda catfish	*Ompok pabda*	X	X	Br, Ar	EN	NT
35	Bar-tailed Flathead	*Platycephalus indicus*	X	Ar	X	LC	DD
36	Pungas Catfish	*Pangasius pangasius*	Ar, Rr	Ar, Rr	Ar, Rr	EN	LC
37	Goldspot Mullet	*Liza parsia*	Rr	Ar, Rr	Rr	LC	
38	Gangetic Hairfin Anchovy	*Setipinna phasa*	Ar, Rr	Br, Ar, Rr	Br, Ar, Rr	LC	LC
39	Spotted Snakehead	*Channa punctatus*	X	Ar	X	LC	
40	Striped Dwarf Catfish	*Mystus vittatus*	X	Br, Ar, Rr	X	LC	LC
41	Pama Croaker	*Otolithoides pama*	Ar, Rr	Ar, Rr	Br, Ar, Rr	LC	
42	Ocellated pufferfish	*Tetraodon cutcutia*	X	Ar	Ar, Rr	LC	LC
43	Rita	*Rita rita**	X	Ar, Rr	Ar, Rr	EN	LC
44	Rohu	*Labeo rohita*	Ar, Rr	Ar, Rr	Ar, Rr	LC	LC
45	Silond catfish	*Silonia silondia*	Ar, Rr	Br, Ar, Rr	Br, Ar, Rr	LC	LC
46	Stinging Catfish	*Heteropneustes fossilis**	X	X	Ar, Rr	LC	LC
47	Snakehead Murrel	*Channa striatus**	X	Ar, Rr	Ar, Rr	LC	
48	Silver carp	*Hypophthalmichthys molitrix**	X	X	Ar, Rr		DD
49	Paradise Threadfin	*Polynemous paradiseus*	Ar, Rr	Br, Ar, Rr	Br, Ar, Rr	LC	-
50	Flathead Sillago	*Sillaginopsis panijus**	X	Ar, Rr	X	LC	-

Status code: LC-Least Concern, VU-Vulnerable, EN-Endangered, NT-Near Threatened, DD- Data Deficient, NO-Not Threatened,'+'= IUCN List 2000

N.B.: 'Br' = Present in the Bhairab River, 'Ar' = Present in the Atai River, 'Rr' = Present in the Rupsha River' X' = Absent in the River&'*' = Questionnaire survey

Appendix 11: Vegetation Survey Methodology

Sampling design and sample size

A total of 6 plots were selected in 500 m zone from the proposed power plant. The plots are equal in size (10m x 10m).

Data collection

Every individual of woody species as well as the number of herbs and shrubs was counted. The number of seedling and sapling that is regenerated naturally was recorded.

Data analysis

Density, Relative Density, Frequency and Relative Frequency is calculated by following equations.

$$1.\ \text{Density (stem/ha)} = \frac{\text{Total no. of individuals of one species in all the plots}}{\text{Plot area} \times \text{Total no. of plots studied}}$$

$$2.\ \text{Relative density (\%)} = \frac{\text{Total no. of individuals of one species in all the plots}}{\text{Total no. of plots studied}} \times 100$$

$$3.\ \text{Frequency (\%)} = \frac{\text{Total no. of plots in which the species occurs}}{\text{Total no. of plots studied}} \times 100$$

$$4.\ \text{Relative frequency (\%)} = \frac{\text{Frequency of one species}}{\text{Sum of frequency of all species}} \times 100$$