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Impact of oil well blowout at Baghjan oil field, Assam and resulting oil spill, on surrounding landscape

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1 Executive Summary

The oil spill due to blow out of well number 5 of Baghjan on 27th May, 2020 and subsequent fire on 9th June, 2020 destroyed about 60-70 ha of area around the site. The oil spread out not only on land, but also dispersed into the surrounding rivers and wetlands. The loud noise due to the explosion can be heard as far as 12 km and beyond, making the area extremely unhealthy for

Figure 1.1 Landscape of Tinsukia and Dibrugarh districts. Protected areas in the vicinity are highlighted

humans and wildlife. The affected area is biodiversity rich and one of the important remaining refuge for several endangered and range restricted species.

Site survey and review of existing information from the surrounding landscape, which includes Dibru-Saikhowa National Park and Maguri-Motapung wetlands, indicates that the area harbours around 40 species of mammals, 450 species of birds, 104 species of fish, 11 species of chelonians, 18 species of lizards and 23 species of snakes, 165 species of butterflies and 680 plant species (Figure 1.1). The wetland and river in the area are also a critical lifeline for the surrounding communities. During the on-site survey a dead dolphin, several carcasses of dead fishes, herpetofauna and many species of insects were encountered. The oil spill has caused mortality and wilting of many plant species, and has severely affected the health of forests and grassland. There is a coating of oil film on the vegetation, the beel, riverfront, as well as on many species of river fauna, birds and mammals, in the impacted area. There is a leakage of hazardous and toxic chemicals, which is dangerous to life in general, and this toxicity is known to persist in aquatic and soil system for long, leading to prolonged ill effects on all life forms, including humans. Even after seven weeks of the incident, the leakage into the system continues, with no signs of containment. Sampling of water, sediments, dead organisms, vegetation and faunal survey indicates a wide ranging impact. We conducted impact study phase 1 from 29th May to 7th July, 2020.

Landscape fragility

The Brahmaputra and Ganges floodplain landscape is unique in its morphology and fragility, and is responsible for shaping the unique community of plants and animals evolved in this system like one horned rhinoceros, barasingha, wild buffalo, hog deer, pygmy hog, Bengal florican, white winged duck, marsh babbler, parrot bill, Ganges river dolphin, Asian small clawed otter, fish such as *Chitala chitala, Eutropiilchthys murius*, and many more. **The landscape is fragile and is engineered by flooding.** The dynamic nature of wetland create mosaics of habitat which are in perpetual flux. In India as well as world over, there are only handful of Protected Areas where this system and unique biodiversity is surviving, amongst them Dibru-Saikhowa National Park and Kaziranga-Orang National Park tops the list. Other Protected Areas like Manas (Assam), Valmiki (Bihar), Dudhwa and Hastinapur (Uttar Pradesh) have lost most of these aspects. ***The landscape is vulnerable to earthquakes and occasionally large earthquakes, which cause large scale changes and damage.*** We mapped changes in river courses and landscape from 1985 to 2020. ***River courses were found to shift to a maximum of 240 metres/annum, and an especially high shift rate is recorded in Tinsukia and Dibrugarh districts,*** as several rivers here have confluence with Brahmaputra (Figure 1.2). It is this dynamic riverscape changes which ensure long term survival of species adopted to

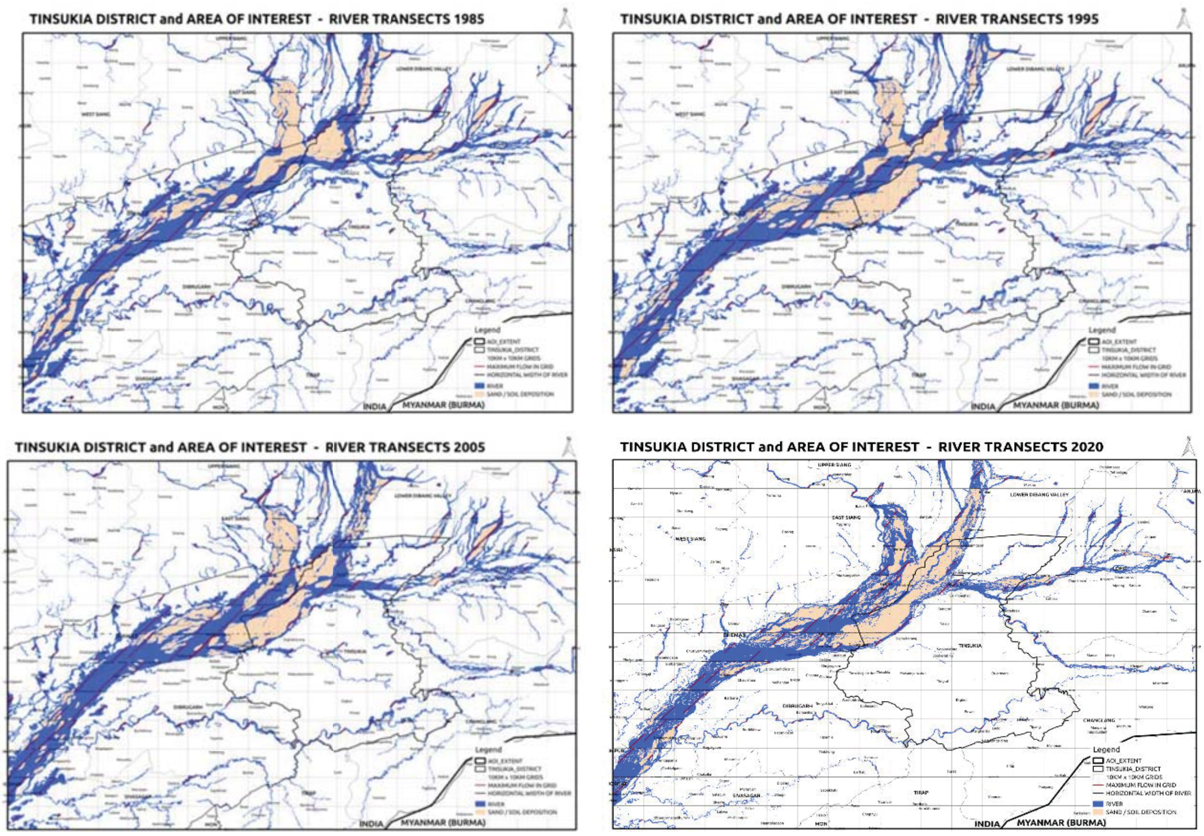

Figure 1.2 Change in river courses from 1985 to 2020 around Dibru-Saikhowa Biosphere Reserve

grassland-woodland succession, where longevity of site is not ensured but existence of grassland and swamps are ensured within landscape – shifting mosaic (Figure 2.1). Seismic data downloaded from IRIS and Earthquake tracker websites show that 15% of earthquakes are above 5 M and rest are of 3-4 M. Narula etal (2000) and Borghain et al (2016) defined 6 thrusts in this area indicating seismic vulnerability. *This seismosity, coupled with dynamic nature of the river systems make the landscape extremely fragile. Any changes to geomorphology will have far reaching consequences. Therefore, drilling for oil, and laying of oil pipelines needs to be evaluated keeping these concerns in mind.*

Contamination of air water and terrestrial system

Large amount of oil and associated pollutants were discharged in the system. We measured Nitrogen, Sulphur dioxide, Carbon monoxide and HCOH (formaldehyde) in the environment surrounding the well blow site using remote sensing data. **NO_2 has shown 16 % increase** on 27^{th} May (on the day of the spill), which is highest recorded in our data time window (1st May to 10th July). **SO_2 (Sulphur dioxide) levels spiked on 28^{th} May**, (a day after the oil spill) **and highest recorded on 9^{th} June** (on the dayof the blow out), 2020 and then subsided. HCHO (Formaldehyde) also show spike on 28th May, 9th June and highest on 21st June and CO (Carbon monoxide) levels does not show much changes before and after blow out. The **burnt out area is**

mapped as 65-70 ha which includes crop fields, grasslands and swamps. There was visible oil spill (oil and sediment) on 16th June, 2020 down stream of well.

Water and sediment pollution

The quality of water was assesed by measuring the essential physiological parameters such as pH, **Dissolved Oxygen (DO),** Total Dissolved Solids (TDS), Conductivity, Specific Conductance Temperature and PAHs pollutants. The dissolved oxygen value for Brahmaputra is reported to be 7.23 mg/l and maximum being 10.92 mg/l. We sampled **when levels of DO were at their peak, and the levels of DO ranged from 0.94 mg/l to 7.35 mg/l in all samples, which is lower than minimum recorded value of Brahmaputra and barely above CPCB class A limits. DO level declined from the day of blowout, till our last sampling session on 22nd June 2020. Maguri-Motapung beel is worst affected and large scale death of aquatic fauna was observed.** The concentration of PAHs (16 types analysed) in water of Lohit, Dibru and Maguri-Motapung ranged from 0.21 to 691.31 µg/L. The concentration was highest in Maguri-Motapung, followed by Dibru and Lohit rivers. **The carcinogenic PAHs** (ΣCPAH, sum of BaA, BbF, BkF, BaP, InP, and DbA) were also detected. It was found that ΣPAH **concentrations in the present study were significantly higher than other studies in India** (ranging from 6.0 – 143.2 µg/L (Malik et al, 2008, Chakraborty et al, 2014) **and other part of the world** (0.02 to 1.27 µg/L) (Brindha and Elango, 2013). The PAHs in soil and sediment samples ranged from 37.6 to 395.8 µg/Kg in comparison to other accidents in the world (96 to 2674 µg/Kg) (Yancheshmeh et al, 2014, Zeng et al, 2016).

In fish tissue samples the PAHs detected range between 104.3 to 7829.6 µg/Kg. **The highest concentration was observed in fishes collected from Maguri-Motapung wetland.** Among the detected PAHs in fish samples, Acenaphthene, Fluorene and Phenanthrene constituted the 95% of the total detected concentration. **The total PAHs concentration reported in fish samples appears to be 10 - 100 fold higher than the earlier reported concentration in India** (Dhananjayan and Muralidharan, 2012) **and other parts of the world** ranging from 0.53 – 1064 µg/Kg (Zabik et al, 1996; Akpambang et al, 2009 Levengood et al, 2011; Huang et al, 2014). **The impact is significant and will have long term effect, as many of these pollutants will leach into the ground and contaminate ground water.** Long term restorative efforts are needed for cleaning up these pollutants.

From the results of the study it can be concluded that Maguri-Motapung beel was severely damaged and polluted with respect to level of Dissolved Oxygen (DO), and total petroleum hydrocarbons. Also, we should worry about the long-term impacts of the oil spill in such a biodiversity rich environment and important wetland area for water birds. The lifeline is not only biodiversity but also the livelihood of local communities.

Figure 1.3 Dead Ganges river dolphin found in Maguri-Motapung beel of Tinsukia.

Sound pollution - terrestrial and underwater

Sound plays important role for life on earth. Communication, resource use, predation, survival all have reliance on sound and thus evolution have shaped various life form to use different spectrum of sound. When sound become noise it is detrimental for living being, from modulating behaviour to causing serious injury and death. To measure environment noise level in and around the oil well explosion site, as well as underwater, we used a portable digital field recorder Tascam DR-100 (TASCAM Inc.) along with a Cetacean Research™ C57 hydrophone. We found that the sound level (dB weighted) was 96.48dB along Lohit river at a distance of 0.48 km and 112.68 dB on land at 0.1 km. We predicted the noise level with distance from the oil explosion point using the inverse square law that assumes equal sound propagation in all direction in an ideal condition. The predicted noise level from oil explosion point to 12 km ranges from 113 to 70db respectively (Figure 1.4). This level of noise will adversely impact mammals, birds and insects, from disorientation to health issues. Animals would be stressed, as they have to communicate at higher decibels.

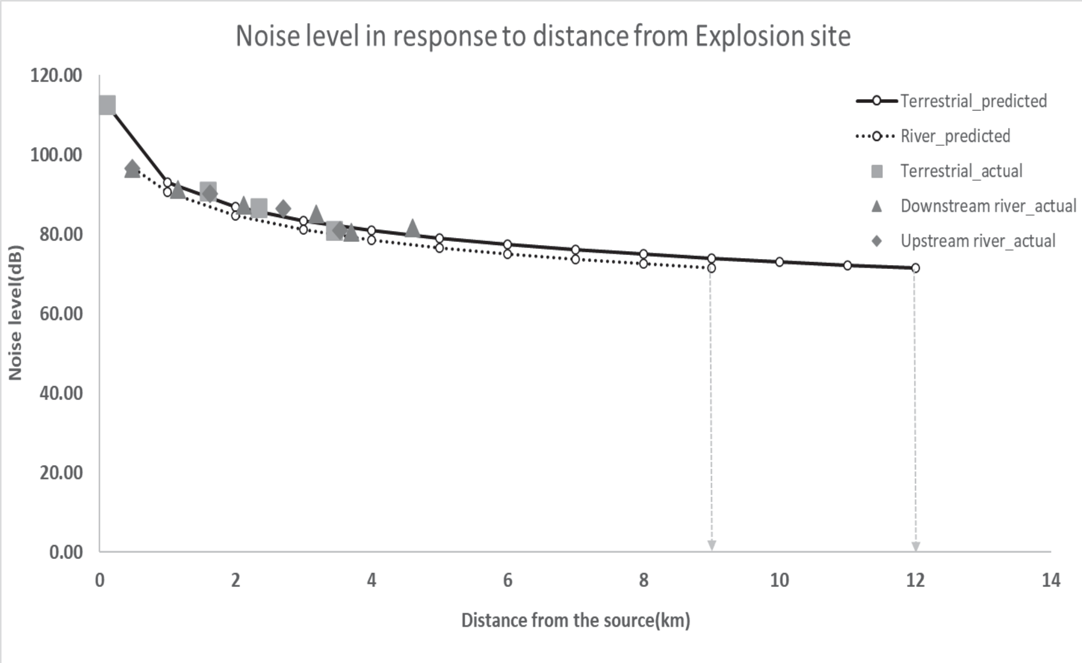

*Figure 1.4 Noise level with response to distance from the explosion site; *gray colour arrows show the distance at which the 70dB industrial zone threshold is achieved*

For humans sound level upto to 60db is the most comfortable. Noise above 70 dB over a prolonged period may damage hearing (Centers for Disease Control and Prevention, 2019). The standard limits set by WHO and CPCB ranges from 40 db (silence zone) to 65 db (Commercial zone). The noise level in 12 km radius of 70db or above made environment not suitable for the normal life for prolonged period as it may result in hearing loss and many other ailments. This level will also affect most of the birds and mammal species. The under water sound ranges from 5 Hz to 92 kHz (majority between 5 to 100 Hz) with pressure level ranging from 127 to 135 db. Most of the Ganges river dolphin communication happens in the range of 40 to 90 kHz.

Ganges river dolphin status

Survey was conducted in the month of May and June, 2020 to assess the status of dolphins. Passive acoustic monitoring (PAM) devices were used to understand occurrence and activity pattern of dolphins. A total of 54.15 hrs of acoustic data was recorded and analysed from three sites. We compared the abundance estimates with our earlier work in February 2020. In February, the encounter rate of Ganges river dolphin was 4.5/10 km, which was reduced to 1.5/10 km in May and by June it was 0.48/km indicating 89% decline in use of this area between February and June (Figure 1.5). One dolphin was found dead in Maguri-Motapung area due to oil poisoning (Figure 1.3). We recorded dolphin presence in Lohit and Dibru rivers, but no recording was detected of dolphin sound in Maguri-Motapung area, which was most impacted site. Moderate and small size tributaries plays important role during monsoon as many dolphins move in these tributaries for refuge during monsoon.

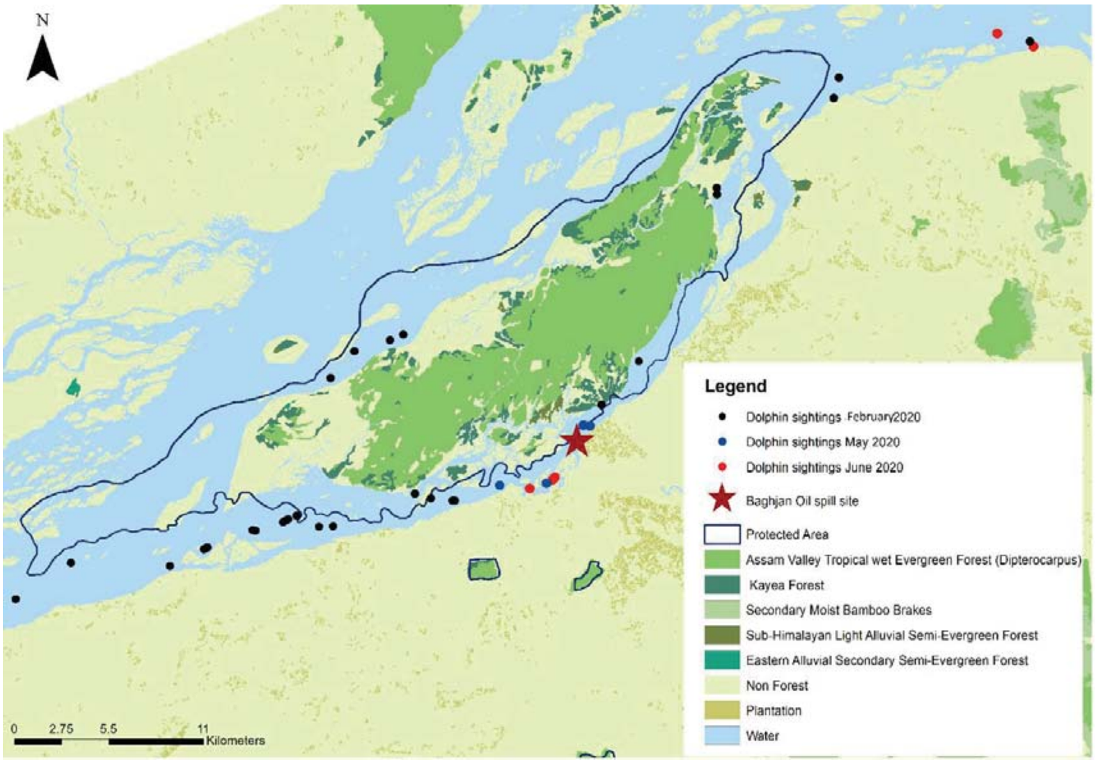

Figure 1.5 Baghjan oil spill site and dolphin sightings recorded during different temporal surveys.

Bird richness:

This area is famous for the presence of a large number of Critically Endangered and species of conservation concern. A total of 450 species of birds have been listed (Choudhury 2006, 2007; Das 2006, Rahmani 2016). A cumulative effort of 11 km was surveyed (Figure 1.6). Data from ebird was downloaded and used to draw comparisons between earlier occurrence reports at locations that fall within our sampling grid and current occurrence. **Bird species richness increases with increase in distance from oil spill site.**

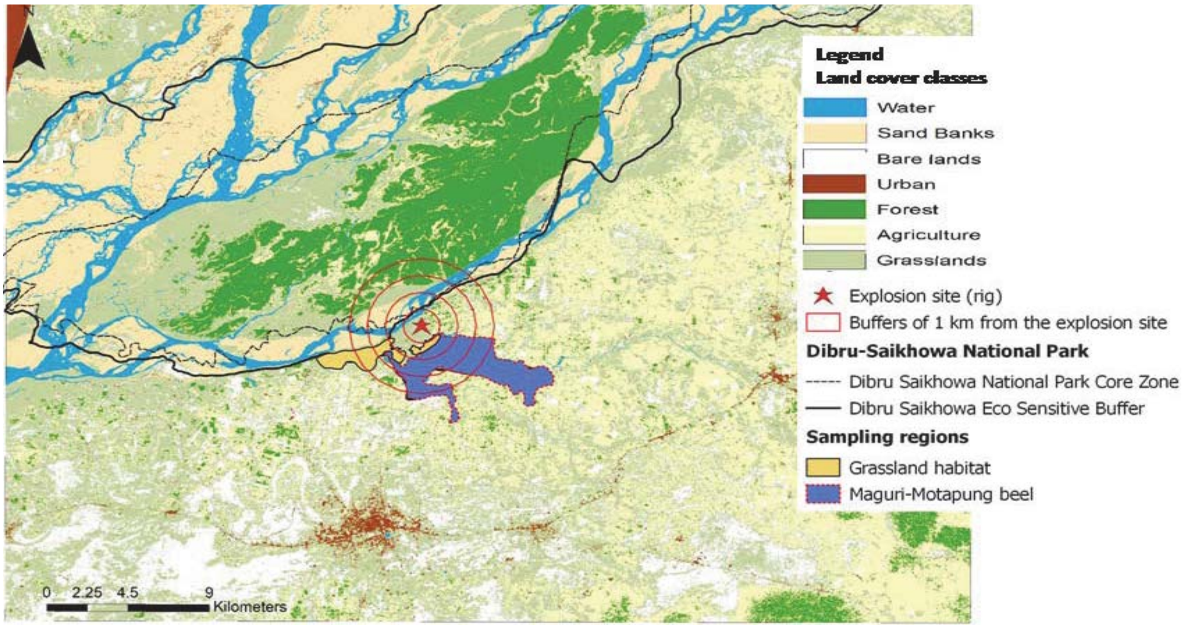

Figure 1.6 Sampling zones for impact on biodiversity up to 5 km, centered on oil blowout site

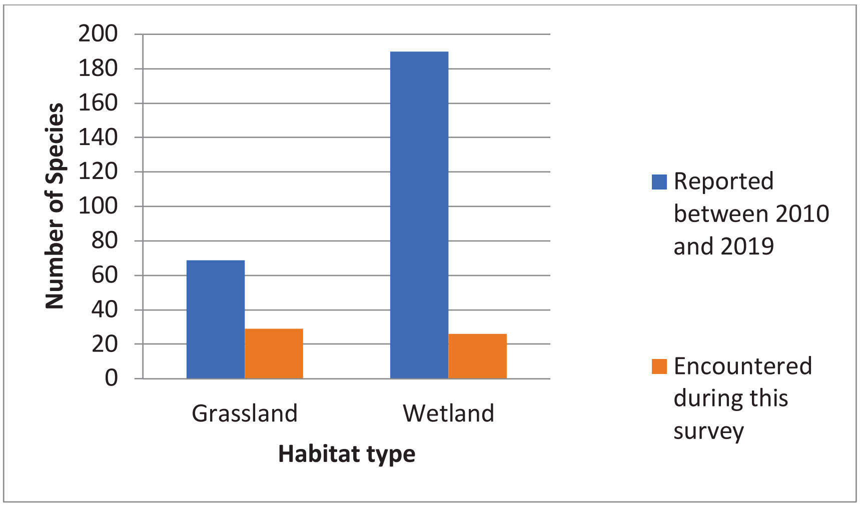

Figure 1.7 Comparison of resident species encountered in the explosion site before (from 2010-2019 from e-bird) and after well blow out (during this survey).

The bird data was compared with resident birds reported by birders on eBird (69 species in grassland and 190 species in wetland) with our surveys (28 in grassland and 28 in wetland) at the same surveyed sites. **The decline in richness is evident in grassland (59%) and wetland (85%)** (Figure 1.7). Survey team also recorded few abandoned nests at impact site. Its likely that birds are also sprayed with oil spill as oil has been seen covering the vegetation in more than a 2 km radius. **Both oil spill as well as intense sound** seems to be responsible for reduction in bird species richness and abundance.The effects of oil spill on birds are well known from many oil spills around the world from past. The overall effect of oil pollution on aquatic bird populations must be examined from two points of view: (1) the disastrous effects of oil spills and (2) the sub-lethal and indirect effects of chronic exposure to low levels of hydrocarbons in the environment (Szaro, 1976).

Fish richness

This area is reported to have 104 species of fishes (Kalita, 2016). A total of 8 sites were sampled with gill net and cast net. 25 species of fishes belonging to 9 families was recorded. Cyprinidae family was found to be the most dominant family with 13 species. **The overall richness and abundance of fishes declines with decrease in dissolved oxygen at different sites, which inturn was a result of the oil spill.** There is significant difference between low and high DO level with species richness and abundance of fishes.

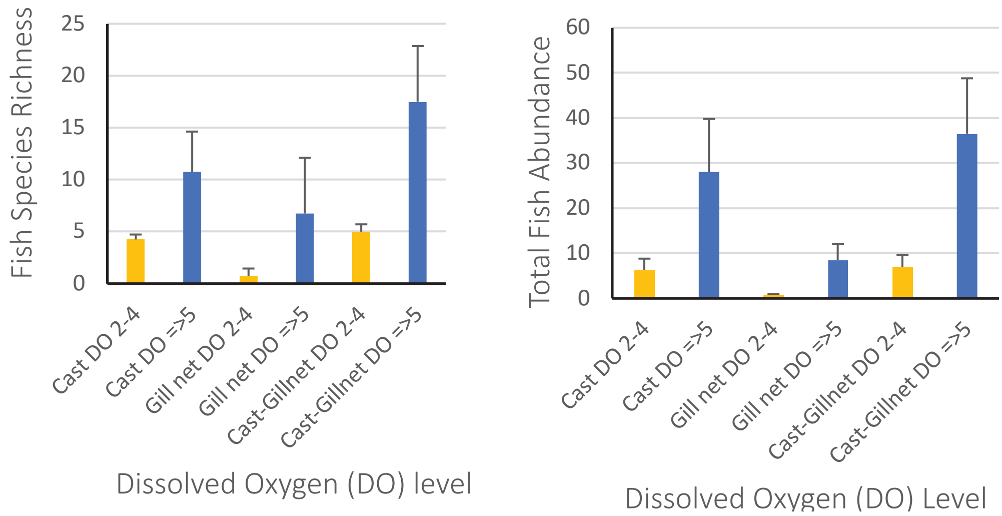

Figure 1.8 Fish species richness and abundance in two categories of water quality pertaining to Dissolve Oxygen (DO) level between 2-4 mg/l and above

Richness declines by 71 % and abundance by 81% between poor and good DO sites (Figure 1.8). **DO levels are low in areas of oil contamination.** We have seen fishes having visible symptoms on body due to oil toxicity, like loss of scales, decolouration, bleeding and excess mucous secretion. Large number of species have shown signs of oil impact (Figure 1.9 & Figure 1.10) *Cirrhinus reba, Banagana dero, Labeo bata, Labeo calbasu, Sperata aor, Sperata seengala, Channa marulius, Channa punctatus, and* Eutropiichthys *vacha* has high economic value in market and fishes like *Puntius sophore, Puntius chola, Pethia gelius, Salmophasia bacaila, Baralius barna, Mystus vittatus, Xenetodon cancila, Anabus testudineus, and Parambassis ranga* are ornamentally important fishes. **The abundance of these species was found to be significantly less in Dibru river and Maguri-Motapung beel, likely due to the mortality and avoidance of high toxic areas due to oil spill.**

During our survey, maximum mortality of adult fishes had occurred in stagnant pools, as there is slow exchange of water and most of the fishes prefer stagnant pools during breeding period.

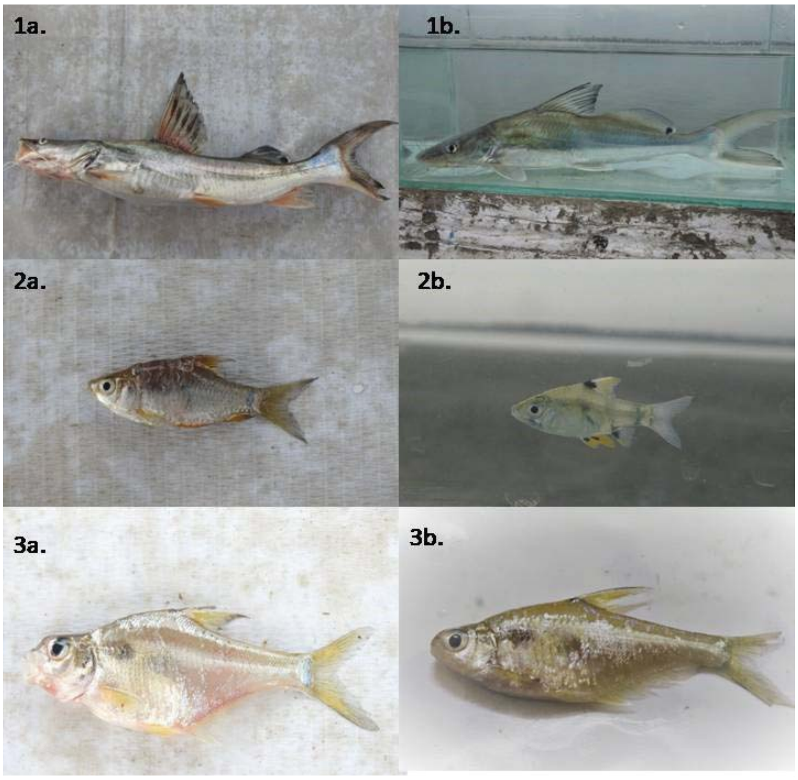

Figure 1.9 Pictures of normal and affected fishes: 1a)Spereta seengahala, 2a)Petha gelius, 3a) Osteobarma cotio shows effect of toxicity on body of fish which were collected from Maguri Motapung beel and Dibru river, Image 1b) Spereta seengahala, 2b)Petha gelius, 3b)Osteobarma cotio are normal fishes which were captured during survey carried out in Kaziranga National Park in February 2020.

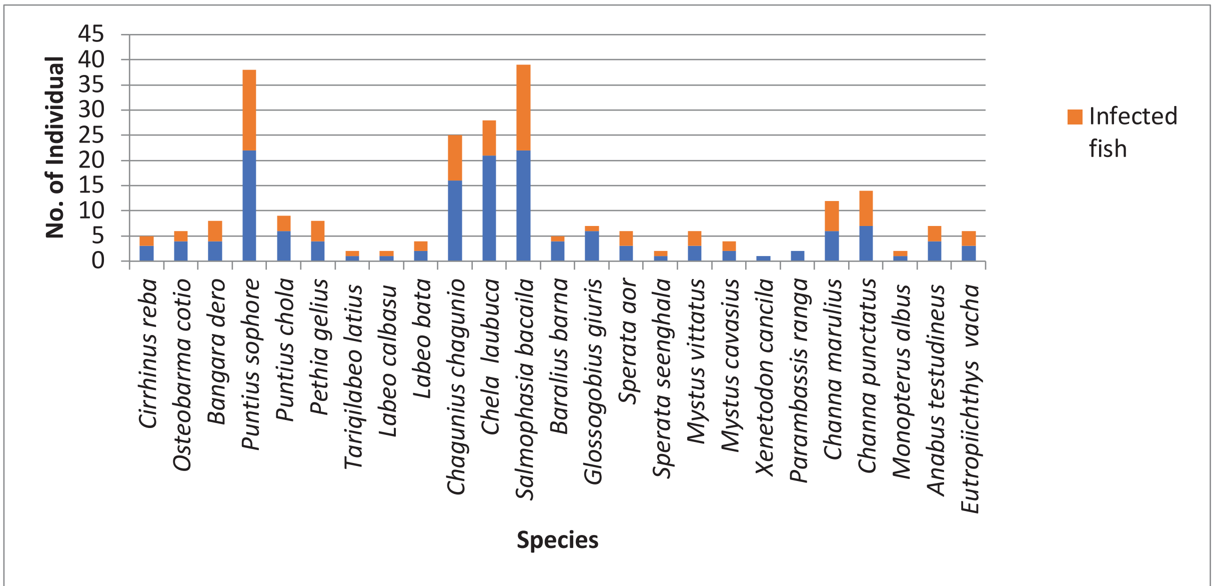

Figure 1.10 Percentage of individual infected fishes captured from Maguri-Motapung beel and Dibru river.

Butterflies and odonates richness

A total of 96 individuals belonging to 41 species of butterflies and 34 individuals of 13 species of odonates were sighted. Close to accident sites less insect species were found. The species richness at sites close to well saturated much faster, while site at 5 km has not saturated with current sampling (Figure 1.11)

Species richness and abundance of butterflies increases with distance from well blow out site indicating impact of oil spill.

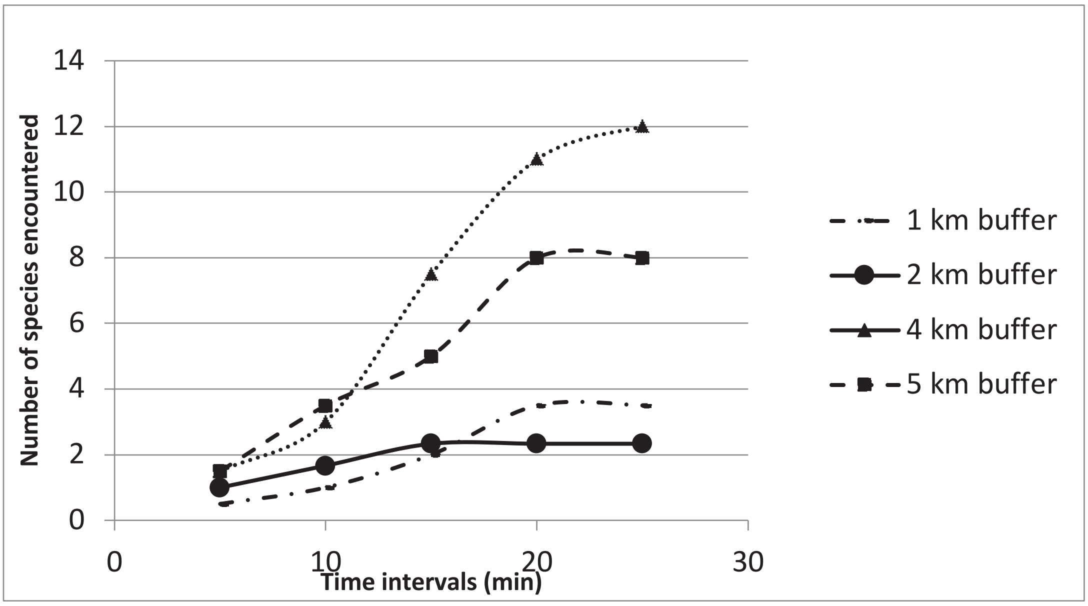

Figure 1.11 Species and number of butterflies encountered at varying distances from the explosion site at 5 minute intervals

Direct exposure to oil is known to negatively affect insects by altering different functions such as feeding and oviposition behaviour, gas exchange, cuticle permeability and cell membrane structural and functional destruction (Beattie et al.1995; Mensah et al. 1995; Bogran et al. 2006).

Herpetofauna

This area is reported to have 17 amphibians, 13, turtle, 11 snakes and 8 lizard species. The survey was restricted to day time as flooding and lockdown of site after fire created sampling issues and thus it should be considered as partial. Work is underway and will be completed depending upon flooding scenario in this area. The checklist of Ahmed and Das (2020) provides what will be expected in this area.

Nine species of reptiles were recorded by us. **The lack of any encounters of tadpoles in the multiple water pools that were encountered in the grids, despite being breeding season for many species, is a great concern.** There was a direct impacts of explosion burn down at least in 500 m, and impacts of oil spill seems to be the likely cause for reduced encounter of species. We have found live herpetofauna from 500 m up to 6 km from the oil well explosion site and carcasses at 400 m and 6 km.

People

We have not carried out any work on socio-economics and health impacts on humans. The oil well blow out definitely seems to have impacted the physical and economic health of local communities (Rishu Kalantri 2020, thelogicalindian.com). The contaminants will have long term impact and need appropriate mitigation measures.

Issues with operation of Gas and oil wells

There are **two major issues** with companies operating oil and gas wells in Assam, **a) Management of oil spills from their wells, and b) emergency response readiness and effectiveness in terms of major accidents.** The oil leakage is a chronic problem and leaching of oil in water and underground have ecological and health cost, as has been observed in the case of several wells across Eastern Assam. As far as major accidents like well blowout in Assam is concerned, **the entire focus seems to be on closure of well and no restorative process is put in place for remediation of effect of oil in terrestrial or aquatic system, it is left to nature to heal herself.**

Two oil well blow outs earlier occurred in Assam, Dikom and Naharkatia-Deohal, and we seemed to have not learned any lessons. We are unable to obtain any meaningful information about restoration of areas surrounding earlier well blow outs. This seems to be the same in the case of the blowout at Baghjan, with no effort to engage experts for remediation due to oil spill. **The site inspection by NBWL Standing committee report stated "*We are deeply distressed that OIL, as a leading public sector company, instead of serving as a beacon for environmental compliance to others in the industry, appears to have evaded environmental norms*"** (Madhusudhan & Bindra, 2013). The report also highlighted development of mitigation plan in case of incidences such as the one that has just happened. OIL does not have any information on their website nor have they provided information about their emergency plans as to how to deal with leaks and blowouts and restoration plans in case of oil spill despite our request for this information.

Conclusion

The evaluation of landscape and biodiversity indicate large-scale impact of oil spill on flora and fauna. Our evaluations and results point out to a substantially high level of PAHs pollutants, some of which are carcinogenic, being present in the system. We also recorded excessive noise level, which is detrimental to animal and human health. While the impact of sound may be taken care after plugging, the effect of PAHs will remain in the system for a long time. Decline in Ganges dolphin use of this area, as well as one dolphin mortality, death of fishes, insects, herpetofauna, birds and impact on health of most of the animals observed, are related to oil spill and well blowout. There is a substantial decline in the biodiversity of the area, resulting in an unsuitable habitat for aquatic and terrestrial life, which is clearly visibile in the mortalities observed. Humans in this area are also impacted. To counter the decline observed in mammals, birds, insects and herpetofauna, it will take time and substantial restorative efforts to regain former diversity levels. Vegetation in large area is also observed to be sprayed with oil due to blow out and has impacted the landscape in its entirety. Given the fragility and seismicity of the landscape, the impact of the oil blow out, and importance along with the uniqueness of biodiversity existing in the area, following needs to be done for safeguarding this landscape:

1) The potential of oil blow out and oil spill like disaster like this a reality and therefore such oil wells in the vicinity of Dibru-Saikhowa National park and IBA complex (Maguri and Motapung, Poba Reserve Forest, Kobo chapori, Amarpur chapori and) will be detrimental to the conservation value of this unique ecosystem. Due consideration needs to be given to this threat for future development.

2) More than 25 wells (Dibru-Saikhowa ESZ notification) are planned and almost same number exist in this conservation complex/s (Dibru-Saikhowa National Park, Bherjan Wildlife Sanctuary, Padumani Wildlife Sanctuary and Borajan Wildlife Sanctuary, Important Bird Areas (IBA) Poba Reserve Forest, Kobo chapori, Amarpur chapori and Maguri and Motapung, Dihing-Patkai Wildlife Sanctuary) needs to be re-evaluated for their cumulative impact on biodiversity value of this landscape.

3) Safety audit for all other wells currently operating or planned need to be done. Risk management study need to be done to ensure appropriate risk mitigation strategies.Detail management plan needs to be developed for safety measures and dealing with oil leakage.

4) Observing the ecological disaster caused by this incident, the proposed oil exploration and development in Mechaki, Mechaki extension, Baghjan and Tinsukia Extension PML (MoEFCC EC dated 9th April, 2020) needs to be reaassesed, since this is the habitat of Critically Endangered species of this region.

5) OIL should have dedicated team and advanced training of their personnel to deal with emergencies arising out of leakage, blow out and any other accidents which is possible due to extraction, transportation and storage of highly volatile and risky chemicals.

6) Adequate finances should be for all restorative work in Wildlife areas Protected or otherwise and compensate local people for their losses. There should be annual payment to Forest Department for restoration and subsequently for management of this conservation complex. Adequate consultation by Forest Department should be done to involve experts in the field of Oil spill remediation and restoration.

7) A long term study should be initiated to understand the long-term impact of this oil spill and blowout impact on the ecology and environment of Maguri-Motapung beel and Dibru-Saikhowa National Park as well as on the health and socio-economic conditions of local communities around the affected areas. Impact of the oil spill on the livelihood of local communities especially on ecotourism based on Maguri-Motapung beel and Dibru-Saikhowa National Park needs to be assessed.

8) Restoration will be long-term process and appropriate committee should be formed to develop, monitor and guide the process.

2 Context

A blow out of oil well occurred on 27th May 2020, at the Baghjan oil field of Oil India Limited in Assam (Figure 2.1), which caught fire on 9th June 2020. The oil and gas leaked into the system and still continues to do so (mid July, 2020). It has severely impacted wildlife, its habiat and humans. Study was undertaken to asses the damage to biodiversity and integrity of the ecosystem.The area is biodiversity rich, having several protected areas and important biodiversity hotspots in its surrounding, Dibru-Saikhowa National Park, Bherjan Wildlife Sanctuary, Padumani Wildlife Sanctuary and Borajan Wildlife Sanctuary. Important Bird Areas (IBA) include Poba Reserve Forest, Kobo chapori Proposed Reserve Forest, Amarpur chapori and Maguri and Motapung beel (Figure 2.1) .

Accident occured close to the Dibru-Saikhowa National Park and Maguri-Motapung Beel. Dibru-Saikhowa National Park is 340 km^2 and the Biosphere reserve (DSBR) spans over 425 km^2. This is located in the Tinsukia and Dibrugarh districts of Assam. This area has recorded at least 40 mammals, 450 species of birds, 104 fish species 165 butterfly species and 680 plant species, 11 species of chelonians, 18 species of lizards and 23 species of snakes (Dibru Saikhowa Management Plan,Choudhury 2006, 2007; Das 2006, Maduhusudan and Bindra, 2013, Kalita, 2016). The area harbours tiger, elephant, wild buffalo, leopard, hoolock gibbon, capped langur, slow loris, Gangetic river dolphin, amongst others. The birds of conservation concern like Bengal Florican, White winged duck. Slender-billed vulture, White-rumped vulture, Baer's Pochard White-bellied Heron, Adjutant storks, Yellow-breasted Bunting, Harriers, Swamp Francolin, Pale-capped Pigeon, Bristled Grassbird, Marsh Babbler, Jerdon's Babbler, Black-breasted Parrotbill, Yellow Weaver, Oriental Darter, Black-necked Stork, Ferruginous Duck, Red-breasted Parakeet, Blyth's Kingfisher, Great Pied Hornbill, Spot-billed Pelican and, Rufous-vented Prinia (Choudhury 2006, 2007; Rahmani et al. 2016; Bhatta et al 2016) occur in this area. Among herpetofauna, it is home to the critically endangered Black Soft-shell Turtle, Narrow headed Soft-shell Turtle, Assam Roofed Turtle Indian Flapshell Turtle, Water Monitor lizard, Indian Roofed Turtle, Burmese Rock Pythonand several species of range-restricted frogs (Ahmed & Das, 2020). Good population of Ganges river dolphin occur in the rivers, mainly in Lohit and Siang River surrounding Dibru-Saikhowa National Park. Maguri-Motapung beel is one of the major wetlands in Tinsukia District of Assam, which encompasses ~10 km^2 area, and is also severely impacted by the oil spill. While the species found in this area largely overlaps with Dibru Saikhowa National Park, until date 294 species of birds have been recorded from this area, and is as an Important Bird Area. Thousands of migratory bird visit the wetland in winter. The first record of species like Baikal Bush Warbler and

Figure 2.1 Landscape of Tinsukia and Dibrugarh districts. Protected areas in the vicinity are highlighted

White-browed Crane are also from this area, highlighting the need to conserve IBA (D Gogoi, pers.comm & eBird). A similar incident occurred at the OIL well in Dikom in 2005, which took almost a month to contain and that too with the help of international agency Boots & Coots Well Control Inc (Naqvi, 2020). **The site inspection by NBWL Standing committee report stated "*We are deeply distressed that OIL, as a leading public sector company, instead of serving as a beacon for environmental compliance to others in the industry, appears to have evaded environmental norms*"** (Madhusudhan & Bindra, 2013). The report also highlighted development of mitigation plan in case of incidences such as the one that has just happened. There seems to be no clear information on the mitigation plan as suggested by the site inspection report. DFO-Tinsukia, Wildlife Division, has written to OIL seeking clarification on mitigation plan (DFO–Tinsukia Wildlife Division, pers comm). It is important to note that the present spill has not stopped and is still polluting and contaminating the surrounding areas. A similar incident in the Kalamazoo river, USA took several years and millions of dollars to contain.

The current oil spill occurred in an area that is bordered by protected areas, rivers and important wetlands and Important Bird Area, which are the lifeline of not only biodiversity but also the livelihood of local communities. Having occurred in the monsoon season, the extent of impact due to the spread of toxic hazardous gases and chemicals through air and water has spread far more than the usual area of impact, causing large-scale damage. People in the area have reported **severe breathing difficulty, headaches and nausea.Noise pollution was big irritant causing severae unease and health issues. Even our survey team has suffered from the same symptoms, and experienced heavy presence of oil and chemicals in the environment and intolerable noise.** The sound can be heard even about 10-12 km away from the place of accident. The smell of oil permeates the entire landscape, with plants covered with layers of oil due to continuous leakage till now. There is seepage of oil to the nearby wetland and other water bodies adjacent to Baghjan (D Gogoi, pers comm.).

Oil well blow out spews a wide range of chemicals in air, water and ground, contaminating the impact zone and surroundings. The hydrocarbon component comprises of large number of organic compounds, many of which are hazardous when released into the environment, for e.g. Polycyclic aromatic hydrocarbons (PAHs) amongst others. The distressing aspect of these compounds is their property of persistence and toxicity (Liu et al. 2020). These carcinogenic compounds get widely distributed in water, soil, sediment and air, and as they do not get photochemically and biologically oxidised or decomposed, their accumulation in these systems is very high (Zhao et al. 2017; Gundlach 2017; Guzzella and De Paolis 1994). Some of the effects of this type of contamination has been reported to be hypothermia, skin and eye irritation, indigestion, dehydration, impaired reproduction and/or pneumonia in many taxa (Environmental Protection Authority, 1993). These toxic chemicals persist in the environment in particulate matter and sediments, and when environmental condition changes, they are again released into water, leading to secondary pollution and long term toxicity in these areas, which is a worrying scenario for all life forms, including humans.

Adding to the concerns is the high seismic nature of this area, where the oil wells are operating. The whole region has been subjected to frequent changes in morphology owing to recurrent earthquakes. These earthquakes are known to have caused extensive landslides and ground fissuring, amongst other effects to morphology. The region is known to have experienced several high magnitude earthquakes within a short period. Thrusts, faults and folds are a common characteristic of the region, exacerbating the concerns of oil drilling in the region, where sediments and rocks of the region have been experiencing compressive forces (Borgohain et al. 2016).

3 Landscape Fraglity

The Brahmaputra and Ganges floodplain landscape is unique and this uniqueness has shaped the biotic community that have evolved in adaptation to this landscape, like the one horned rhinoceros, barasingha, wild buffalo, hog deer, pygmy hog, Bengal florican, white winged , marsh babbler, parrot bill, Ganges dolphin, Asian small clawed otter, fish such as Chitala chitala, Eutropiilchthys murius, and many others. This landscape is particularly fragile and is engineered by flooding. The dynamic nature of wetland creates mosaics of habitat which are in perpetual flux. In India as well as world over, there are only handful of Protected Areas where this system and unique biodiversity is surviving, amongst them Dibru-Saikhowa and Kaziranga-Orang tops the list. Other Protected Areas like Manas (Assam), Valmiki (Bihar), Dudhwa and Hastinapur (Uttar Pradesh) have lost most of these aspects. This landscape is also vulnerable to earthquakes, with many fault lines and occasionally large earthquakes, causing changes and large scale damage. We mapped changes in river courses and landscape from 1985 to 2020. River courses are known to shift to a maximum 0f 240 m/annum, and an especially high shift rate is recorded in Tinsukia and Dibrugarh districts, as several rivers have confluence with Brahmaputra here. This high rate of change causes a shifting mosaic of grassland and swamps, where the habitat at a particular site is not ensured, but due to constant change, the habitat exists within the landscape. It is this dynamic riverscape changes which ensure long term survival of species adapted to grassland-woodland succession. Seismic data downloaded from IRIS and Earthquake tracker websites show that 15% of earthquakes are above 5 M and rest are of 3-4 M. Narula etal (2000) and Borgohain et al (2016) defined 6 thrusts in this area, indicating seismic vulnerability. This seismosity, coupled with dynamic nature of the river systems make the landscape extremely fragile, and any changes to geomorphology having far reaching consequences. Therefore, drilling for oil, and laying of oil pipelines needs to be evaluated keeping these concerns in mind.

3.1 Introduction

Fragility and resilience of a landscape are interconnected and it is difficult to completely tease them apart. In this particular context, fragility is more relevant as it proves to be an important critera on which we need to evaluate the changes in landscape, either natural or manmade. Fragility of a landscape defines the outcome of any action for all the elements within it i.e., wildlife and humans, their interaction and subsequent effects. This section addresses the larger conservation context, and how incidents like oil blowout and large scale developmental planning without regard to ecology make a system fragile and robs it from the inherent capability of resilience, leading to disastrous consequences.

Understanding the landscape fragility is especially crucial in the plains of Assam, as it is prone to earthquakes, and the rivers flowing through this landscape are extremely dynamic, carrying heavy sediment loads, making this landscape even more delicate. The Assam valley is a result of several tonnes of deposition of sediment brought in by the rivers Brahmaputra and Barak (Baro and Kumar, 2017). According to Angelier and Baruah (2009), the thickness of the sediment reaches 5 km from the ground surface. Below this heavy deposit of sediments lie several active tectonic faults which have been the source faults of past earthquakes (Baro and Kumar, 2017). These features make the Assam plain rivers vulnerable to change. Avulsion is a common geomorphic process responsible for course changes with many rivers of the Ganga–Brahmaputra plain (Borgohain et al 2016). Dibrugarh has 21.34% of forest cover and Tinsukia about 41.76 % cover (Forest Survey of India, 2019)(Figure 2.1). These districts have a mosaic of habitat comprising of Salix Swamp Forest, Wet and Dry grasslands, Tropical Moist Deciduous, Tropical Semi-evergreen, Evergreen Forests and Cropfilds-Orchards (Rahmani et al. 2016).

3.2 River Morphology

Measuring change

Geomorphology helps in understanding the relationship between river forms and processes, water and sediment fluxes, ecosystem and habitat relationships. Owing to the dynamic nature of rivers in the region, the changes in the tributaries of Brahmaputra, as well as main stream Brahmaputra river, in and around Dibru Saikhowa National Park, at the site of oil spill was estimated using time series land cover data. This helps in visualizing the changes in river morphology. These quantifiable changes in river are used to derive braiding index to locate zones which are prone to further change. Also channel displacement rate is calculated in these zones. This data along with land cover changes is used to understand the changes in river morphology. For detailed methodology, see Section 9.1& 9.3.

River course has undergone lot of changes around Dibru-Saikhowa national park. Sand bars have shown considerable changes in this part of the river and so the braiding index also is seen changing from 1985 to 2019-20. This continuous change in braiding index signifies the ever changing river morphology. Braiding index helps correlating the geology with land cover changes to understand the morphology of changes and the possibilities of future changes (see Section 9.3)

TINSUKIA DISTRICT and AREA OF INTEREST - GEOMORPHOLOGY

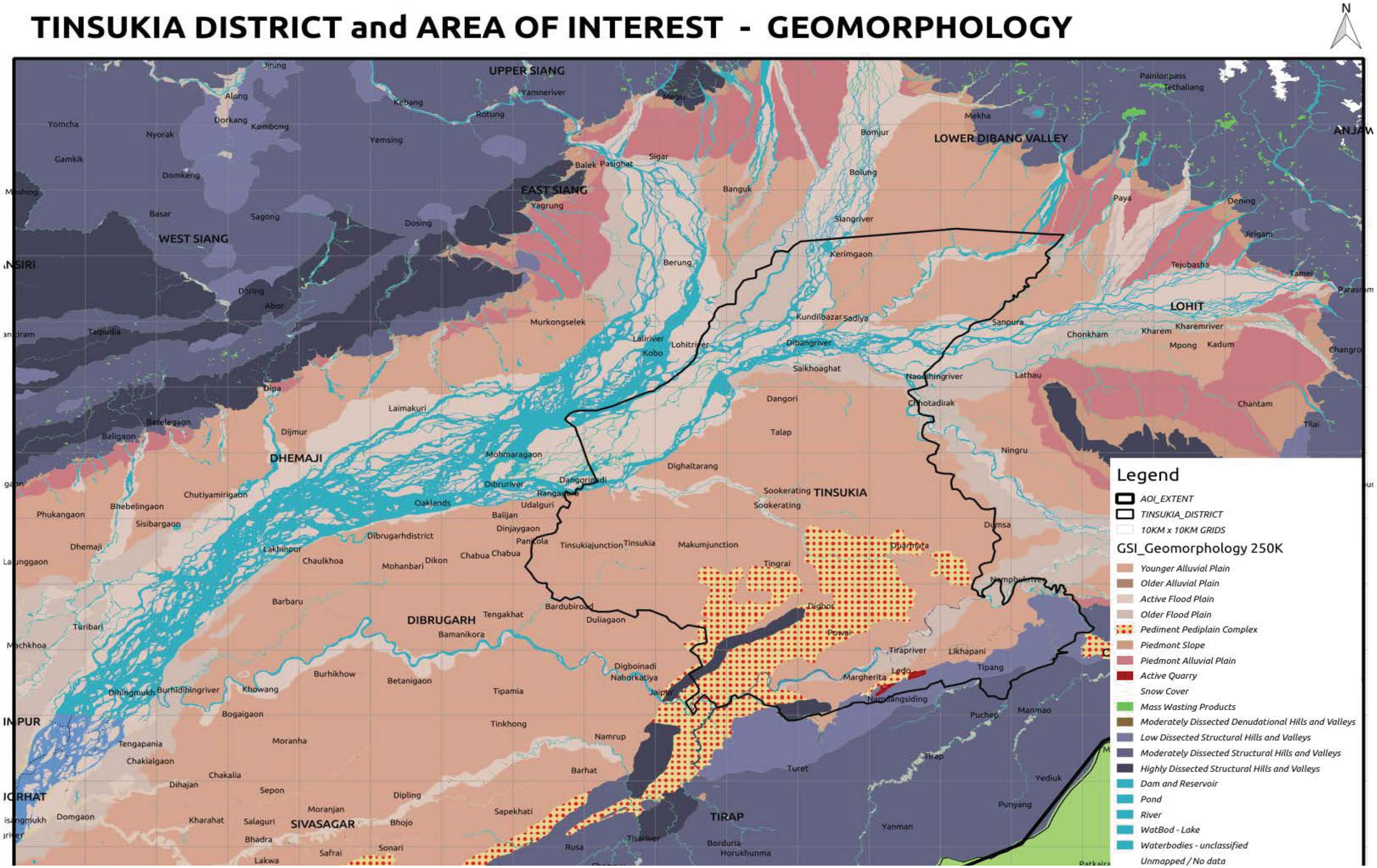

Figure 3.1 Geomorphology of eastern Assam

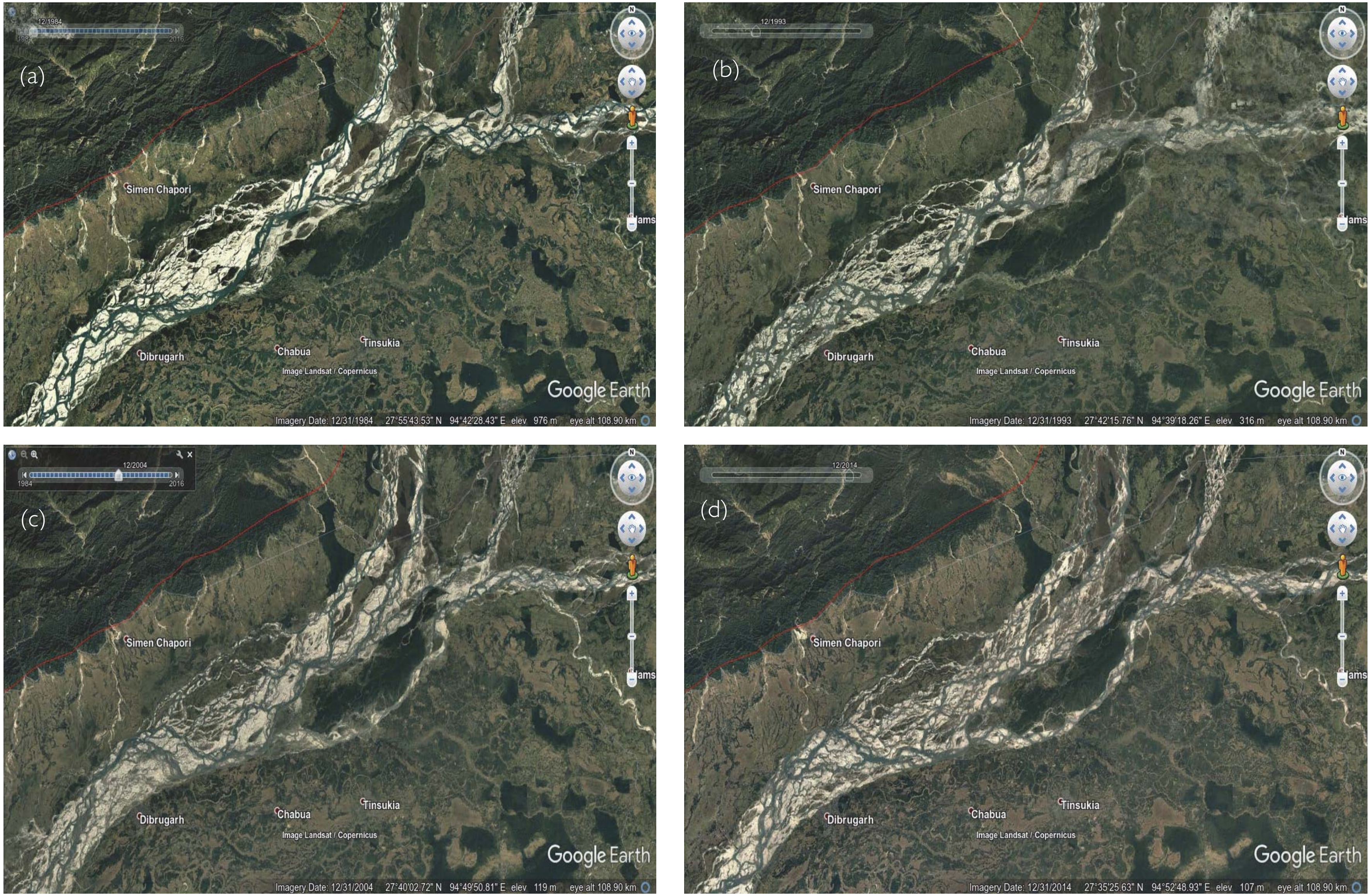

Figure 3.2: Google Earth images indicating the changes in landscape around Dibru-Saikhowa Biosphere Reserve: a) 1984, b)1993, c)2004, d)2014

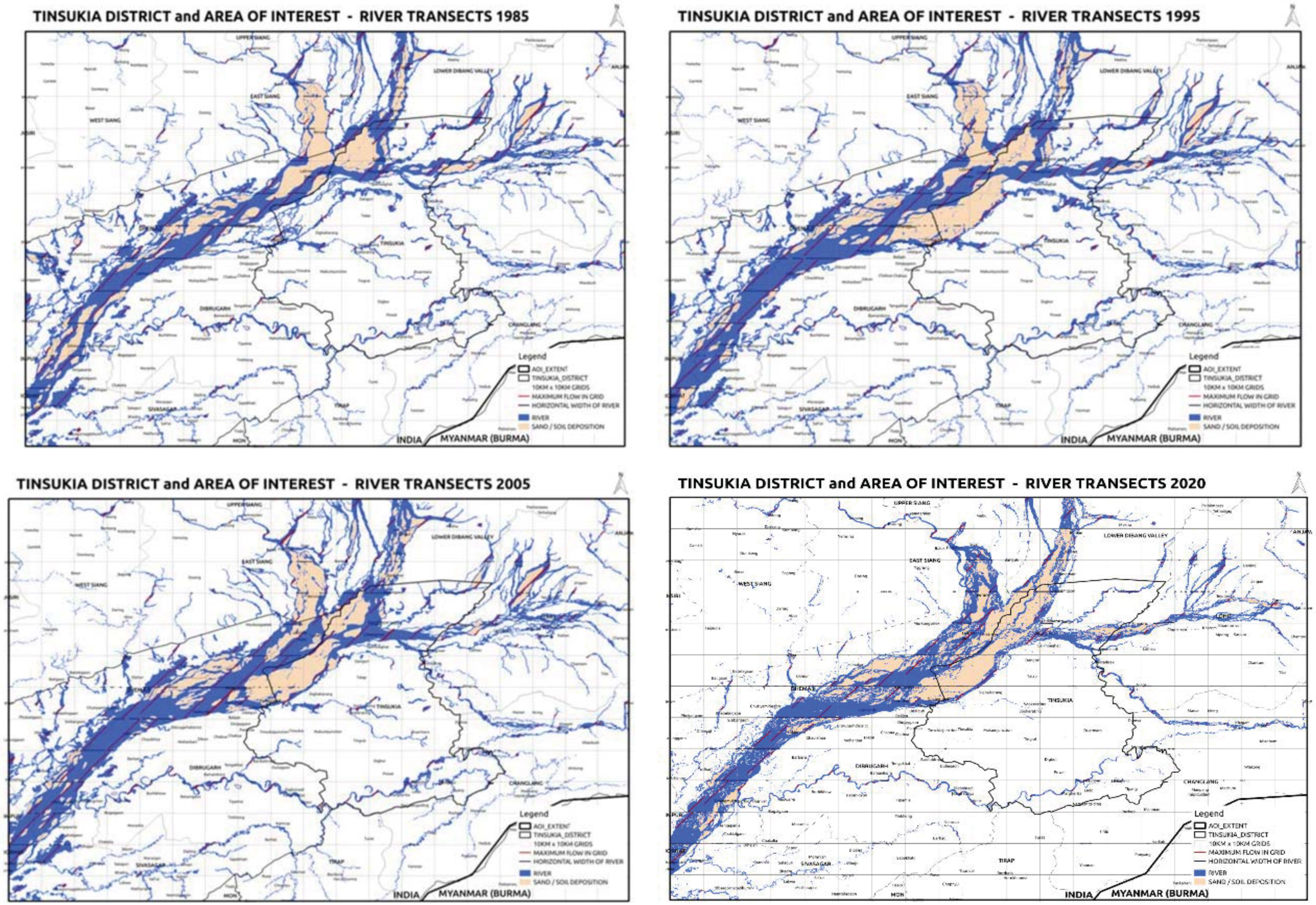

Figure 3.3 Change in river courses from 1985 to 2020 around Dibru-Saikhowa Biosphere Reserve

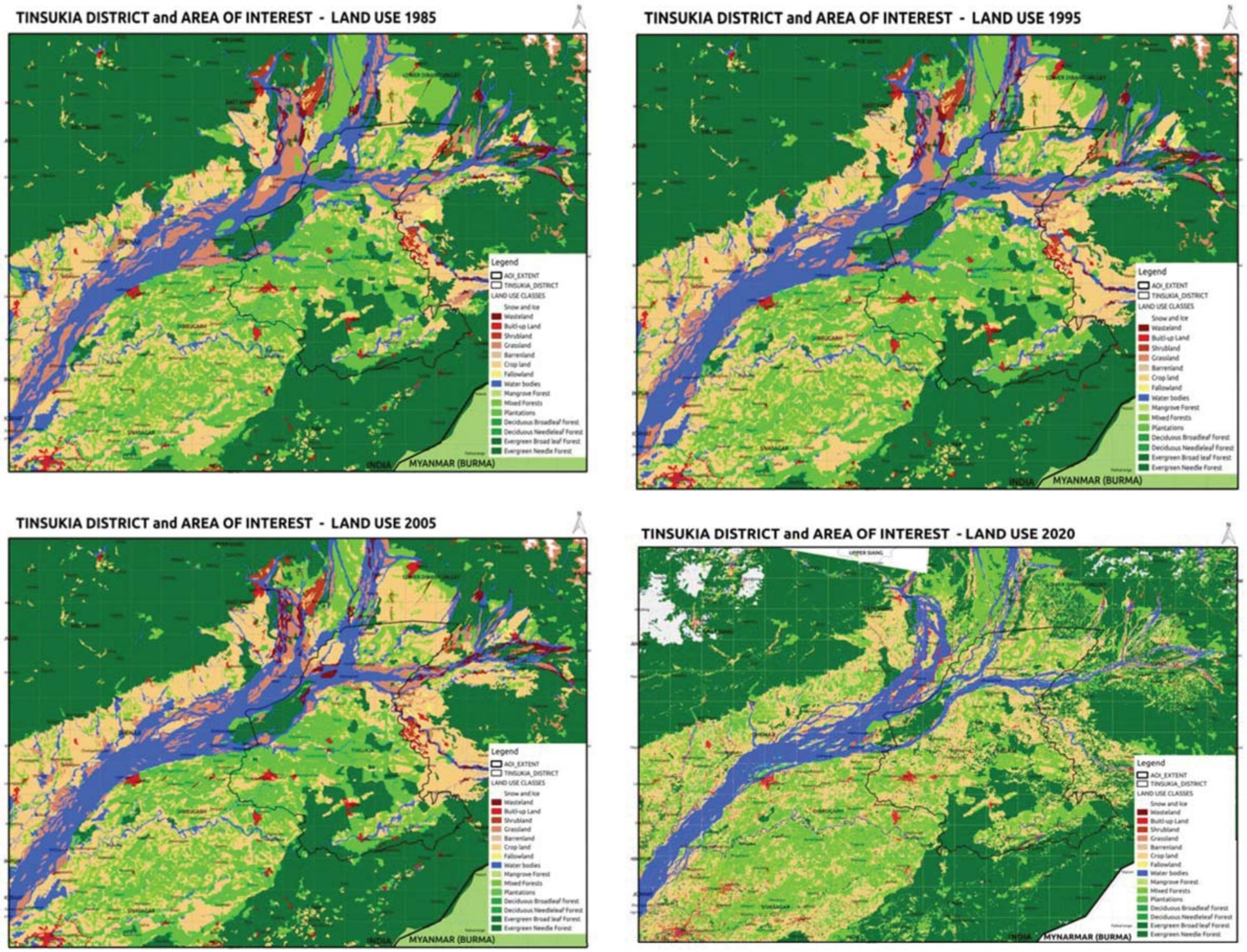

Figure 3.4 Landcover changes around Dibru-Saikhowa National Park, Dibrugarh and Tinsukia district - data derived from Landsat and LISS satellites

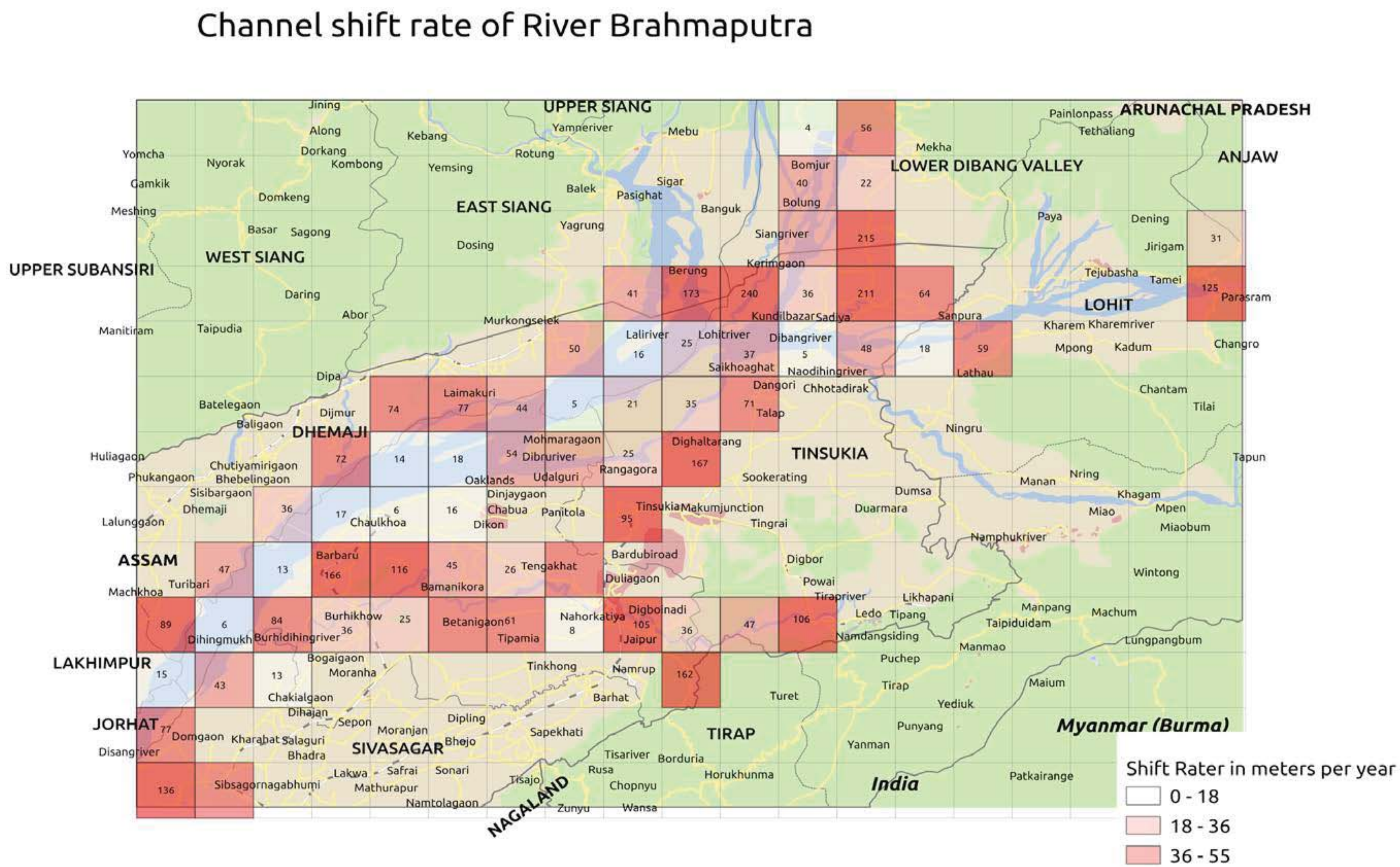

Figure 3.5 **Channel braiding index and shift rate from 1985 to 2020**

The area is composed with rocks of sedimentary origin, of these Sandstones, Shales and Unstable sand, silt and clays are found in majority. Erosion of sedimentary rock-masses along river-flows resulted in island-like formations, leading to changes in river-dynamics. In the area around Tinsukia district surface water is consistently increasing from 1985. River course widened along alluvial plains and floodplains. River braiding index is maximum along unstable clays, sand and silt deposited along river course. Flood of 1988 caused change in the course of Lohit river, it started flowing in Dongri river course and by 1995 completely captured it (Borgohain et al 2016)

Tinsukia and Dibrugarh districts have unique system of fluctuating grassland, scrubland and forest, which has disappeared from most of the Brahmaputra and Ganga flood plains. This shifting mosaic creates a unique habitat features crucial for survival of endangered fauna in the landscape like, Wild buffalo, Bengal florican, Parrot bills, White winged duck, Swamp francolin, Prinia, Babblers and many other species. This flooding process and change in landscape (Figure 3.2, Figure 3.4, & Figure 3.5) means that habitat of a species within a landscape is ensured but its exact location is not. With development happening all around Protected Areas in Tinsukia and Dibrigarh will alter the flow pattern and affect this dynamic process which is evident in these maps (Figure 3.5). There is a 14 percent increase in urbanization as well.

The proposed oil well operation in Dibru-Saikhowa will compromise this landscape. The landscape is very dynamic and intervention to change the area for development will have long term consequences on biodiversity of this area.

3.3 Seismic activity

Seismic activity in this region is extracted from IRIS(www.iris.edu) and Earthquake tracker (www.earthquaketrack.com) websites who operate on international data available from monitoring stations.

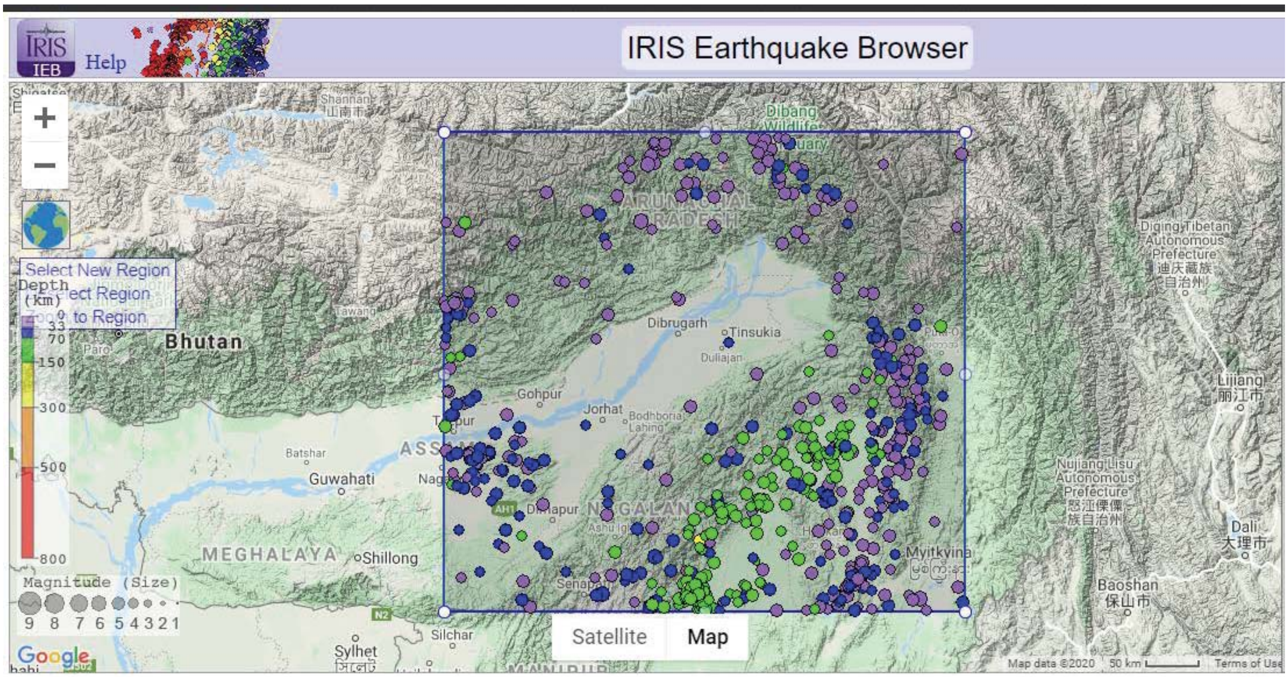

Figure 3.6 In Eastern Assam 586 Earthquake events were recorded from 1970 to July 8th 2020(Source: http://ds.iris.edu/ieb, extracted July 2020)

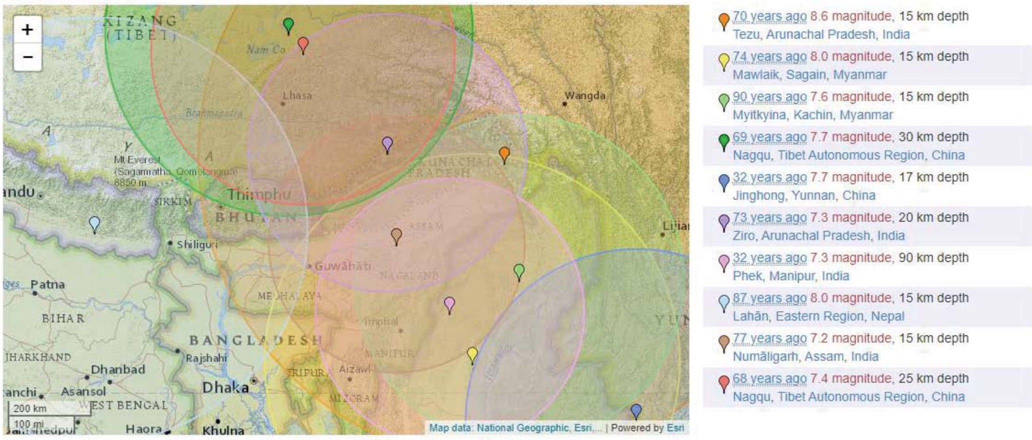

Figure 3.7 Zone of influence of some of the major earthquakes (7or above magnitude) (Source: www.earthquaketrack.com, extracted July 2020)

Assam is vulnerable to earthquakes, 586 events were recorded (Figure 3.6 & Figure 3.7) in areas of upper Assam and surroundings. Eighty five percent earthquakes in this region were of 3-4 magnitude and rest 15% above 5 magnitude. The Northeast India region is one of the most active zones in the world; having rifts- Himalayan arc to the north and the Indo-Burmese arc to the east of the region (Figure 3.8).

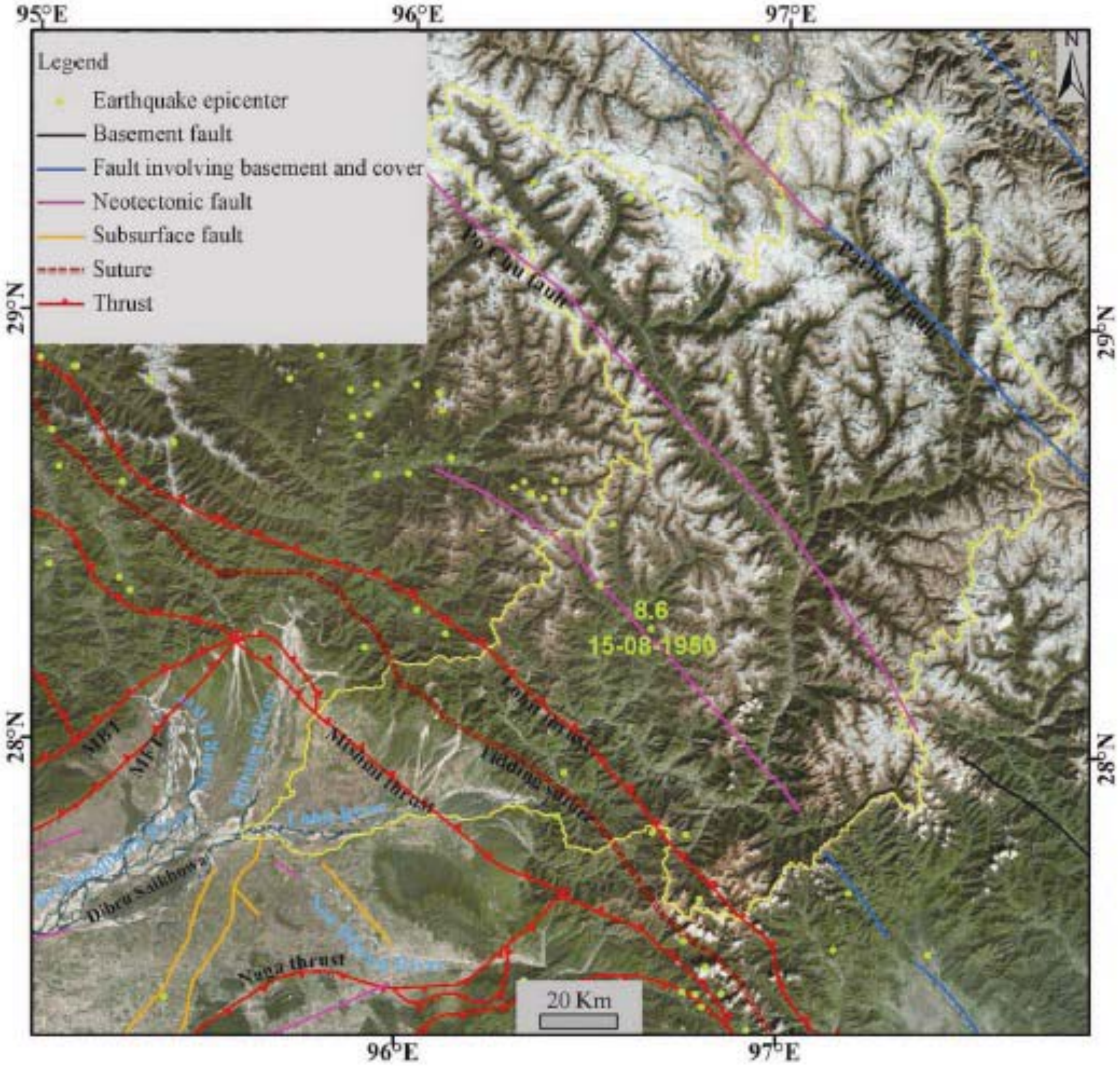

Figure 3.8 Tectonic map of the area around Dibru-Saikhowa Biosphere Reserve. Thrusts Defined by Narula et al (20000) and Borghain et al (2016) in this area are MBT (Main Boundary Thrust), MFT (Main Frontal Thrust), Mishmi Thrust, Tidding Suture, Lohit Thrust and Naga Thrust.

Thrusts Defined by Narula et al (2000) and Borghain et al (2016) in this area are MBT (Main Boundary Thrust), MFT (Main Frontal Thrust), Mishmi Thrust, Tidding Suture, Lohit Thrust and Naga Thrust. All these makes this region very vulnerable. The region produced two great earthquakes (M> 8.0) and about 20 large earthquakes (7.0>M>8.0) since 1897. The Shillong Plateau was the source area for the 1897 great earthquake M 8.7, and the Assam Syntaxis zone for the 1950 great earthquake M 8.6. Several large earthquakes occurred along the Indo-Burma ranges (CSIR-NIST, 2015).

This seismosity, coupled with dynamic nature of the river systems make the landscape extremely fragile. Any changes to geomorphology will have far reaching consequences. Therefore, drilling for oil, and laying of oil pipelines needs to be evaluated keeping these concerns in mind.

4 Contamination of air, water and terrestrial system

Large amount of oil and associated pollutants were discharged in the system. We have assessed the contamination using Sentinel satellite data We measured Nitrogen, Sulphur dioxide, Carbon monoxide and HCOH (formaldehyde) in the environment surrounding the well blow site. NO_2 has shown 16 % increase on 27th May which is highest recorded in our data time window (1st May to 10th July). SO_2 (Sulphur dioxide) levels spiked on 28thMay, and higest recorded on 9th June 2020. and then subsided. HCHO (Formaldehyde) also show spike on 28th May, 9th June and highest on 21st June and CO (Carbon monoxide) levels does not show much changes before and after blow out.The burnt out area is mapped as 65-70 ha which includes crop fields, grasslands and swamps. SAR Sentinel1 data was used to map the oil on river and wetlands, there was visible oil spill (oil and sediment) on 16th June 2020 down stream of well and also an increase in temperature in the water surrounding the blowout.

Oil well blowout at oil well #5 of the Baghjan Oil Fields of Oil India Limited on 27th May, 2020 has resulted in an estimated oil spill in more than 2 km radii from the oil rig, there are anecdovtal records of much larger radius of spread (Bhattacharya, 2020). An explosion occurred on 9th June, 2020 further burnt the surrounding area completely (Bhattacharya, 2020) (Figure 4.1, Figure 4.2, & Figure 4.3), with charring seen at least a km away from the rig. A survey conducted by the Wildlife Institute of India close to the rig (500 m), post explosion, found carcasses of many fishes, snakes, insects apart from a dolphin calf that was found dead in the surrounding wetland, Maguri-Motapung beel.

Figure 4.1 Satellite image before oil well blow out, the impact area is in red square.

Figure 4.3: Satellite image after oil well blow out, the impact area is in red square

Figure 4.2 Surrounding landscape burnt from the explosion of the oil well blowout along with the resulting oil spill (Photo: Sachin Bharali).

For assessing the impact of oil spill on the pollution levels we have taken 10km radius from oil spilling source near Bhagjan, Assam (Latitude:27.6003, Longitude:95.379). In this 10km radius change from the values of pollution levels observed in May to June 2020 are recorded. To measure the pollution levels European Space Association's Sentinel 5 precursor satellite is used. In this particular case, to understand the impact of oil spill blow out Nitrogen dioxide, Carbon monoxide(CO), Sulphur Dioxide (SO2) and HCHO (formaldehyde) product is measured. For detailed methodology, see Section 9.4

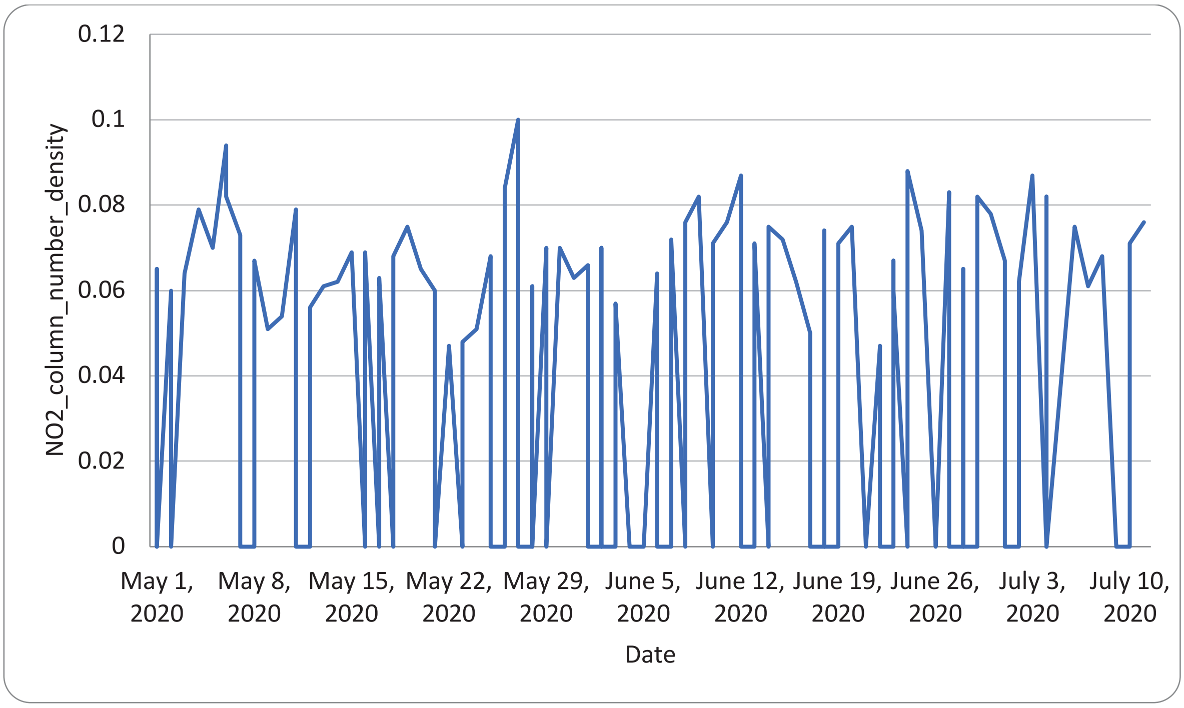

Figure 4.4 Nitrogen dioxide changes in Bahgjan,Assam

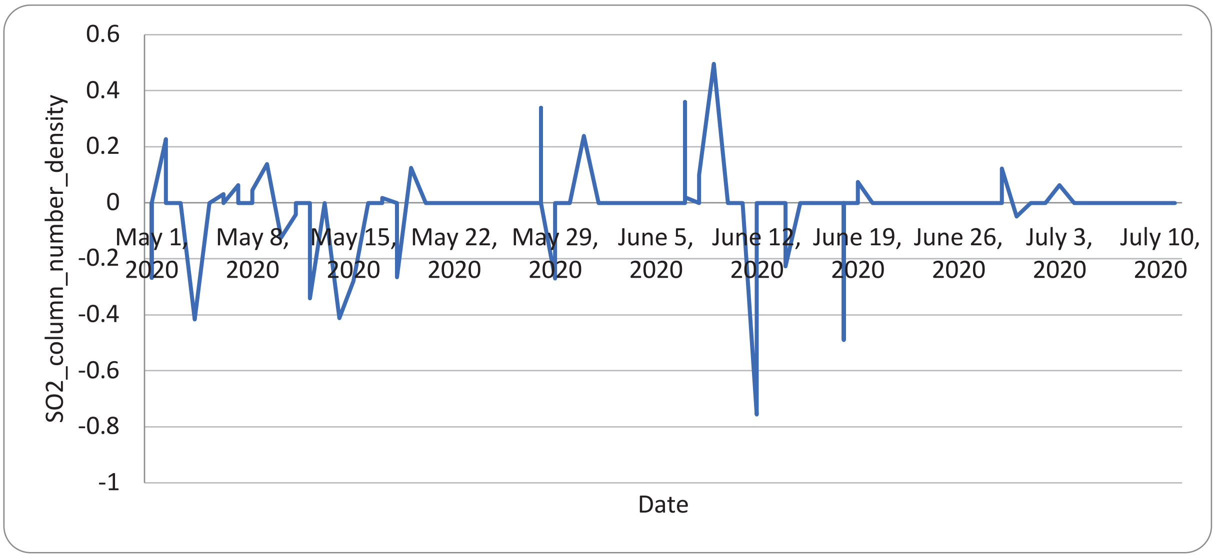

Figure 4.5 Sulphur Dioxide changes in Bahgjan,Assam

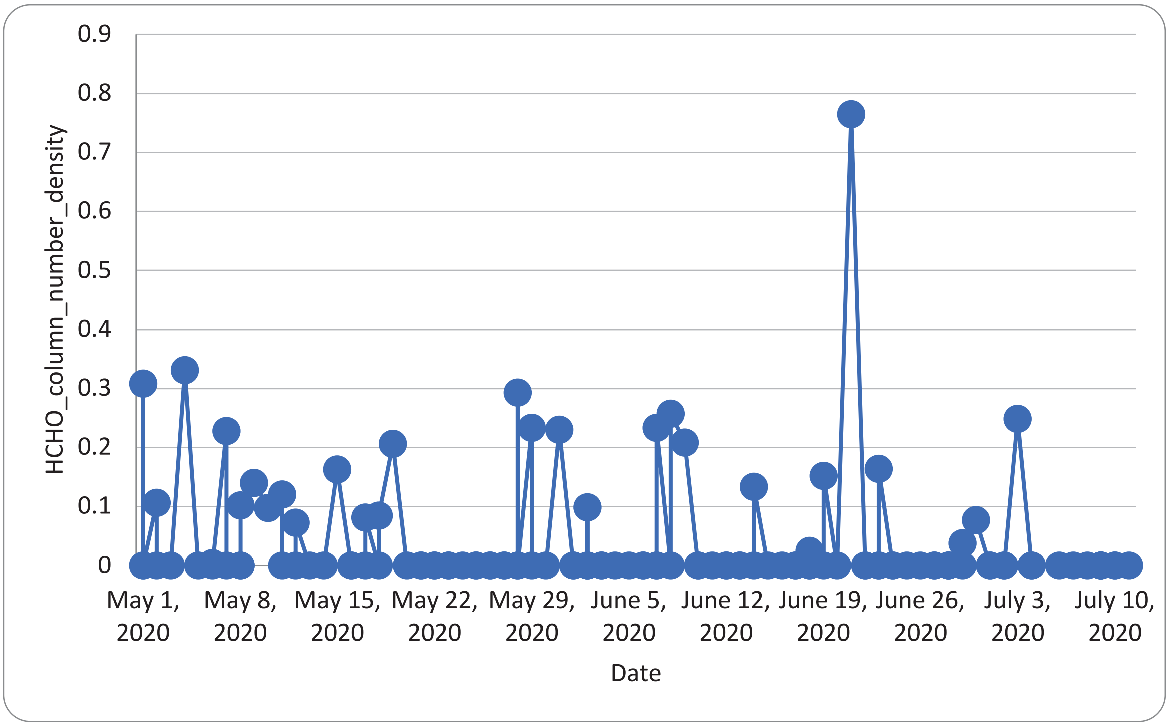

Figure 4.6 CHOH fluctuions in May and June in and around oil well blow out site.

NO2 has shown 16 % increase on 27th May which is highest recorded in our data time window (1st May to 10th July) (Figure 4.4). SO2 (Sulphur dioxide) levels spiked on 28th May (no data for 27thMay), and higest recorded for 9th June 2020. and then subsided. HCHO (Formaldehyde) also showed spike on 28th May, 9th June and highest on 21st June (Figure 4.6). CO (Carbon monoxide) levels does not show much changes before and after blow out. The gaseous coulumns are created by complex processes and air circulation and rain modify their presence, as well as the presence of clouds during this time make interpretation difficult. Preliminary information indicate some correlational changes with blow out and fire. Work is in progress and needs further evaluation.

4.1 Impact on land surface temperature

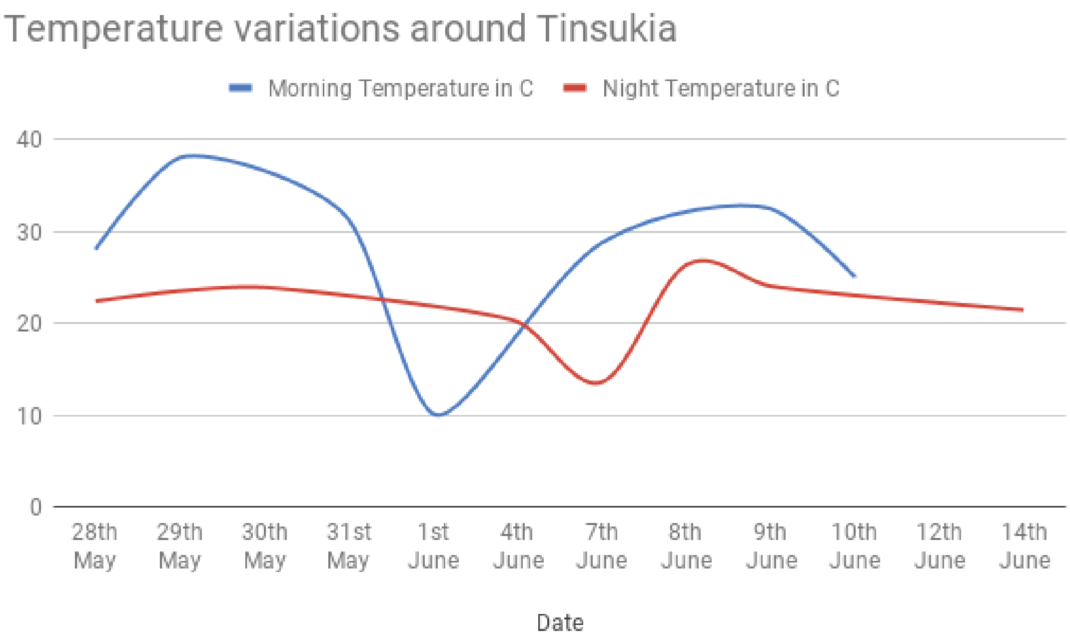

Figure 4.7 Temperature profile around Baghjan well blowout site.

There was a spike in surface temperature on 28th May and June 8th and 9th (Figure 4.7). Though the temperature is lower than the levels in May, the spike might be induced by well fire.

4.2 River and Wetland Pollution mapping

The oil spill is hazardous for water and land pollution, impact depends upon nature of water body and topography of the land. Oil and its complex ingredients float on surface, get mixed or settle on bottom, even mid column water flow is reported all this depends on the density of componds. As shown in the images, on 23rd May the islands and water in Lohit and Maguri-Motapung beel were showing no signs of oil pollution (Figure 4.8). After the blow out on 27th May, images from 16th June (Figure 4.9) show oil on water. The upstream of the oil spill has vegetation intact the oil deposits are largely downstream from the site.

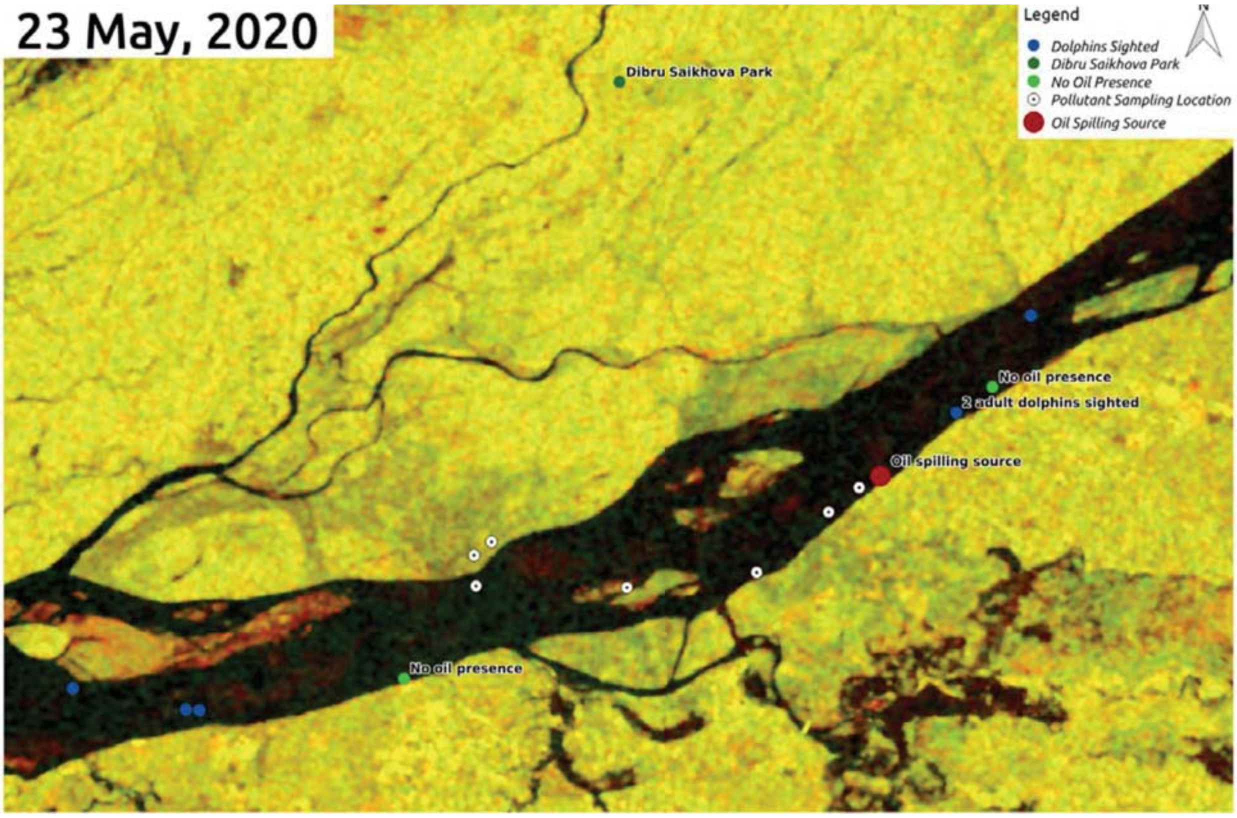

Figure 4.8: No Visible oil pollution on 23rd May at Maguri Motapung beel

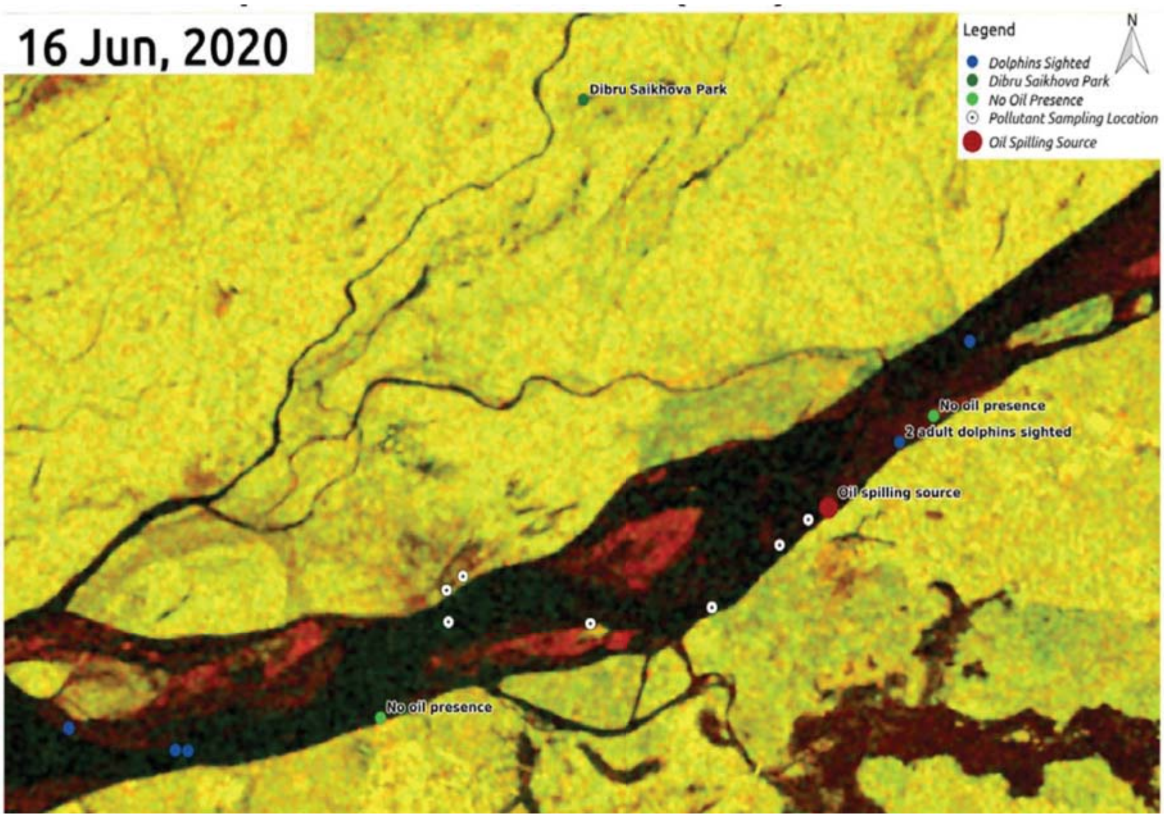

Figure 4.9: 16th June satellite imagery shows oil contamination on vegetation and water – after blow out on 9th June.

5 Water quality assessment of Lohit river, Dibru river and Motapung—Maguri beel

Oil began leaking out of the well with blowout. The quality of water was assesed through measuring the essential physiological parameters such as pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Conductivity, Specific Conductance Temperature and Polycyclic Aromatic Hydrocarbons (PAHs) pollutants. Ground sampling of 31 samples (water, soil and tissue of dead animals) from accident site and surrounding areas was done. PAHs content in water, sediment and fish tissues was analysed by using Gas Chromatography (GC-FID) and validated and confirmed by GC-MS/MS.

The dissolved oxygen value for Brahmaputra is normally reported to be 7.23 mg/l and maximum being 10.92. Our sampling peak time for DO was ranging from 0.94 mg/l to 7.35 mg/l in all samples, which is lower than minimum recorded value of Brahmaputra and barely above CPCB class A limits. DO level consistently declined from the day of blowout till our last sampling session on 22nd June, 2020. ***Maguri-Motapung beel was found to be the worst affected****, with large scale death of aquatic fauna. The concentration of PAHs (16 types analysed) in water of Lohit, Dibru and Magui-Motapung ranged from 0.21 to 691.31 µg/L. The concentration was highest in Maguri-Motapung, followed by Dibru and Lohit rivers.* ***The carcinogenic PAHs*** *(ΣCPAH, sum of BaA, BbF, BkF, BaP, InP, and DbA) were also detected.Iit was found that ΣPAH* ***concentrations in the present study were significantly higher than other studies*** *in India (ranging from 6.0 – 143.2 µg/L (Malik et al, 2008, Chakraborty et al, 2014) and other part of the world (0.02 to 1.27 µg/L) (Brindha and Elango, 2013). The PAHs in soil and sediment samples ranged from 37.6 to 395.8 µg/Kg in comparison to other accidents in the world (96 to 2674 µg/Kg) (Macias-Zamora et al, 2002, Yancheshmeh et al, 2014, Zeng et al, 2016).*

In fish tissue samples the PAHs detected range between 104.3 to 7829.6 µg/Kg. The highest concentration was observed in fishes collected from Maguri-Motapung wetland. Among the detected PAHs in fish samples, Acenaphthene, Fluorene and Phenanthrene constituted the 95% of the total detected concentration. ***The total PAHs concentration reported in fish samples appears to be 10 - 100 fold higher than the earlier reported concentration in India*** *(Dhananjayan and Muralidharan, 2012)* ***and other parts of the world*** ranging from *0.53 – 1064 µg/Kg (Zabik et al, 1996; Akpambang et al, 2009 Levengood et al, 2011; Huang et al, 2014).* ***The impact is highly significant and will have long term effect as many of these pollutants will leach into the ground and contaminate ground water****. Had* *it not been the flood time the impact would have been far more disastrous. Long term restorative efforts are needed for cleaning up these pollutants.*

From the results of the study it can be concluded that Motapung-Maguri beel was severely damaged and polluted as regards to DO values, and total petroleum hydrocarbons. Also, we should worry about the long-term impacts of the oil spill in such pristine environment and important wetland area for water birds. This is a lifeline not only for biodiversity but also for the livelihood of local communities.

5.1 Introduction

Oil began leaking out of the well on evening of blowout in river and wetlands along with the mixture of gases and sound pollution. The leak continued uncontrolled from the well till date (15^{th} July 2020). Blowout and subsequent fire expose the entire locality and surroundings to range of pollutants, chemicals, gases and sound. Petrochemicals ae complex chemical compounds and exposure to them have both lethal and sub-lethal effects on the flora and fauna (Snyder et al, 2015; Venn-Watson et al, 2015; Paruk et al, 2014). Petroleum discharged on water spreads quickly to cover large areas with a layer of oil varying from micro-meters to centi-meters thick. Some oils, especially heavy crudes and refined products, sink and move below the surface or along the bottom of the water body. Wave action and water currents mix the oil with water and produce either an oil-in-water emulsion or a water-in-oil emulsion. Polycyclic aromatic hydrocarbons (PAHs), which make up a substantial portion of many fossil fuels, including crude oil, oil shales, and tar sands are considered the most toxic component of oil (Albers and Loughlin, 2003; Finch et al., 2011; Vidal et al., 2011). As a group of organic toxic compounds, PAHs have been listed as priority pollutants by both the US Environmental Protection Agency and the European Union. Since PAHs are resistant to degradation and can bio-accumulate though the food chain, they may pose considerable threats to ecosystems over a long period (Wu et al, 2011). Due to their lipophilicity, persistence, and high toxicity, PAHs are difficult to be washed-off, and particularly in aquatic environments, they tend to get adsorbed on particulate matters and remain adsorbed for long periods. Their lipophilic nature enables them to cross biological membranes and accumulate in organisms, causing considerable damage. PAHs are toxic, carcinogenic, and mutagenic to all organisms, including humans (Nacci et al, 2002; Armstrong et al, 2004). The metabolites of PAHs may bind to proteins and DNA, which causes biochemical disruption and cell damage in animals and cancer in human (Armstrong et al, 2004). Also causing a number of adverse effects to aquatic organisms, including endocrine alteration (Meador et al., 2006), growth reduction (Christiansen et al, 1995), DNA damage (Caliani et al., 2009) and malformations of embryos and larvae (Carls et al., 2008).

Since the oil blowout, a study has been conducted to determine the fate of the released oil and its toxicological impact on the ecosystem of Maguri-Motapung wetland, Dibru and Lohit river.

Carcasses of many species like Ganges river dolphin, fishes, insects, and herpeto-fauna were collected from areas around the oil well (Figure 5.1). To study the effect of oil, we aimed to investigate the presence, concentrations, and ecological risk of Polycyclic aromatic hydrocarbons (PAHs) in the natural gas leakage in water and sediment samples collected from Lohit river, Dibru river and Maguri-Motapung beel and also fish samples collected from Maguri Motapung beel and Lohit river. The primary objective of this study was to estimate the overall toxic effect of 16 PAHs in the aquatic ecosystem of the impacted area, for more details on the PAHs and sampling, see Section 9.7. To assess the presence and extent of oil spill, the contaminated water and sediment samples were collected from the sites (Figure 5.2) at intervals of 1 km. The quality of water was

Figure 5.1: a.Dead fish specimen;b.presence of oil in water near rig area; c. water sample collected from nearby area d. Plant affected by oil

determined by measuring the essential physiochemical parameters such as pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Conductivity, Specific Conductance Temperature and PAH's pollutants.

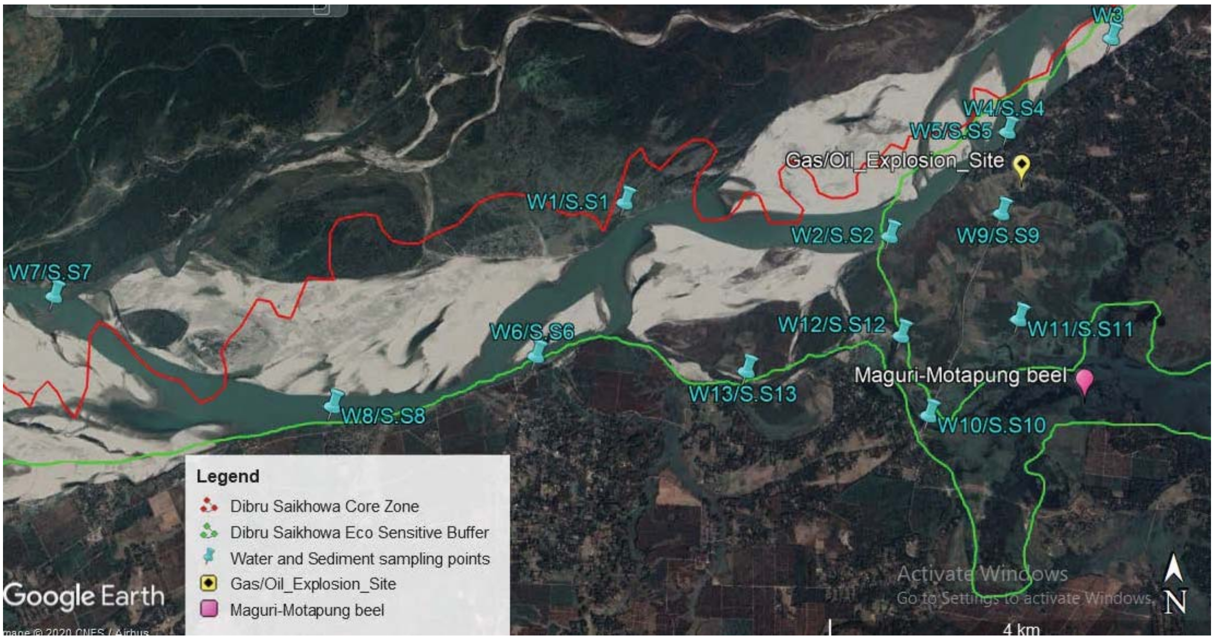

Figure 5.2 Study area map indicating all samplings points assessed before fire

Physiochemical parameters were measured at each of the sampling points in Lohit river (Figure 5.2) sampling points from W1 to W!3) (Table 5-1). The Dissolved oxygen (DO) of the river varies with time and season, depending upon the species of phytoplanktons present, light penetration (Tripathi et al., 1991; Das et al., 2013), nutrient availability, temperature, salinity, water movement, partial pressure of atmospheric oxygen in contact with the water, thickness of the surface film and the bio-depletion rates (Ifelebuegu et al. 2017)). It is an important limnological parameter that indicates the level of water quality and organic pollution in the water body (Wetzel and Likens, 2006, Khatoon et al., 2013).

5.2 Water quality

Sampling in May, 2020 just after well blow out indicates Dissolved oxygen (DO) in Lohit river had an average value of 6.8±0.59mg/l, with minimum recorded at point W6 (5.74±0.21mg/l) and maximum at W7 (7.35±0.01mg/l) (Table 5-1). Value of Dissolved oxygen (DO) at sampling point upstream from gas explosion site (W3) is 6.81±0.08 mg/l. Flooding and high wind flow helped to disperse oily layer and maintain oxygen level, but some oil may sink to the bottom too. The Dibru river connected to Maguri-Motapung beel and Lohit river, two sites were sampled (W12 and W13). The measured Dissolved oxygen (DO) values are 5.29±0.15mg/l and 5.65±0.28 mg/l respectively. The average value recorded as 5.4±0.28mg/l. (Table 5-1). The minimum DO recorded for Brahmaputra was 7.23 mg/l and maximum being 10.92 mg/l, the optimal time DO was 8.63 mg/l (Central Water Commission, 2019). The value at all sites are lower than lowest reported limits for Brahmaputra. The DO varies with time of day, this data was collected during 12 to 16 Hrs the peak time for DO level.

At locations closer to the source, many dead fish were found during sampling in Maguri-Motapung beel because the level of Dissolved oxygen (DO) in the water influences the survival of fauna dependent on it. In Maguri-Motapung beel, the average Dissolved Oxygen (DO) was 1.4±1.23 mg/l, minimum was recorded at point W9 (0.94±0.31mg/l) which was very close to the explosion site and maximum value was recorded at W10 (1.74±1.30mg/l)l (Table 5-1). The measured values are far below the permissible limits given by CPCB (6mg/l). Sampling in June 2020, indicate lower DO values in all sites sampled (Table 5-2). There was a visible layer on surface of water, and vegetation around the rig after well fire. We sampled four points in Dibru river after explosion. The average Dissolved oxygen(DO) in the Dibru river had reduced further in comparison to pre fire sampling (May 2020) and is much lower than the permissible limits (Table 5-2). Measured value of Dissolved oxygen(DO) in Dibru river kept decreasing as we moved towards the Maguri beel indicating much poorer condition of beel and heavy oil pollution. A number of fishes had also died in Maguri beel due to non-availability of oxygen and accumulation of oil in gills. Oil slick formed on water surface hinders aeration of the water as it interferes with the absorption of atmospheric oxygen. This is the reason of such low value of Dissolved oxygen (DO) in Dibru river when sampled after the explosion. The oil film gradually diminishes with time as it readily adsorbs suspended particulate matter and sinks to form sludge on the river bed (McCauley 1966). Hydrocarbons bioaccumulate in organisms such as aquatic plants, fish, and invertebrates (Anyakora and Coker, 2007). Values of Dissolved oxygen(DO) does not showed much variation in Lohit river because of the dilution and dispersion of oil due to flood. All other values (TDS, Sp. Conductance, Conductivity) did not show variations after the explosion.The oxygen balance of beel may be affected by presence of oil layer that hinders aeration of the water. Large quantities of oil were found in the water although the oil film never completely covered the surface. Oil spill not only cause acute injury and mortality of organisms which are directly exposed at the source point, but also those organisms that are present in and around the affected area (Simcik et al., 1996; Anyakora et al., 2008; Pérez et al., 2008).

Water **temperature** is important parameter which determines the rate of oil decomposition, sedimentation, and sludge formation. Most rapid oxidation of hydrocarbons occurs at temperatures ranging between 15 and 35°C (Zobell, 1963). The minimum temperature was recorded at point W1 (21.97±0.40°C) and maximum at point W9 (29.07±0.70°C) (Table 5-1). Low water temperatures reduce sedimentation rates markedly while high water temperatures increase them, resulting in the disappearance of emulsified oil from the water with an accompanying increase in oil in the sludge (McCauley, 1966).

The quality of the **Total Dissolved Solids** (TDS) is in general proportional to the degree of pollution. The detected mean value of TDS in all sampling points remained within the permissible limits given by BIS and WHO (Table 5-1). Changes in the pH will cause some of the solutes to precipitate or will affect the solubility of the suspended matter (Das et al., 2012). PAHs are hydrophobic molecules and are found mainly associated with suspended particulate matter in water. They tend to accumulate in sediments over time. Consequently, sediments are major sinks for PAHs and can also act as secondary sources of contamination in aquatic systems (Hylland, 2006). Value at all the sampling points were measured and location W9 showed the highest TDS (151.65±45.21mg/l) (Table 5-1), indicating highest value at source of pollution, at the sampled point that was closest to the source of pollution.

Water conductivity measures the water's ability to carry an electric current. It is related to the total dissolved salts or ions in the water and the general chemical richness of the freshwater samples examined. W9 had the highest value (233.32±69.55µs/cm) relative to all the samples collected.

Table 5-1 Water quality parameters at the sampling points, post oil well blowout

Parameters	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	BIS (2009) / CPCB Acceptable limit	WHO (2011) Desirable limit
Temperature(°C)	21.96 ±0.40	23.13 ±0.06	25.30 ±0.42	23.9± 0.14	23.07 ±0.06	24.27 ±0.05	23.30 ±0.00	23.13 ±0.08	29.07 ±0.70	25.50 ±0.43	24.54 ±0.60	23.85 ±0.05	23.21 ±0.11	-	-
DO (mg/L)	7.21 ±0.09	6.98 ±0.15	6.81 ±0.08	6.88 ±0.34	6.96 ±0.00	5.74 ±0.21	7.35 ±0.01	6.83 ±0.03	0.94 ±0.31	1.74 ±1.30	1.12 ±1.11	5.29 ±0.15	5.65 ±0.28	6	-
Sp. Conductance (µS/cm)	116.83±12.87	112.9 ±1.04	107.75 ±1.34	112.6 ±1.13	121.43 ±0.06	99.19 ±0.16	135.67 ±0.08	111.17 ±0.05	233.32 ±69.55	114.06 ±29.38	135.07 ±15.59	102.46 ±0.16	99.18± 3.96	-	-
Conductivity (µS/cm)	109.7± 11.17	108.63 ±0.84	108.30 ±0.42	110.05 ±0.78	116.7± 0.10	97.73± 0.14	131.03 ±0.05	107.02 ±0.10	251.37± 72.07	115.04± 28.82	133.89± 15.91	100.14 ±0.10	95.64± 3.96	750	750
TDS (mg/L)	75.93 ±8.40	73.39 ±0.66	70.03 ±0.86	73.18 ±0.76	78.94 ±0.04	64.48±0.11	88.19 ±0.04	72.26 ±0.02	151.65 ±45.21	74.14 ±19.09	87.80 ±10.14	66.60 ±0.11	64.47 ±2.57	500	600

Table 5-2 Essential water quality parameters at each sampling point after explosion at the site

Date	Location	Temperature (°C)	DO (mg/L)	Sp. Conductance (µS/cm)	Conductivity (µS/cm)	TDS (mg/L)
20-06-2020	Lohit River	22.89±0.69	7±0.14	93.4±2.28	89.46±3.42	60.7±1.48
22-06-2020	Dibru River	22.37±0.23	7.07±0.074	92.3±27.13	87.41±25.68	59.99±17.63
22-06-2020	Dibru River	25.4±0.03	4.97±0.27	91.75±0.49	92.47±0.48	59.64±0.32
22-06-2020	Dibru River	25.83±0.05	4.71±0.37	89.06±10.14	90.58±10.32	57.89±6.59
22-06-2020	Dibru River	29.2±0.01	2.39±0.35	79.18±0.05	85.81±0.03	51.46±0.02

5.3 Concentration of PAHs in surface water

The concentrations and detection frequencies of PAHs in the water samples collected from the Lohit river, Maguri-Motapung wetland and Dibru river are summarized in Table 5-3. In all the samples analysed, the overall ΣPAH (all 16 PAHs) ranged from 0.21 to 691.31 µg/L with a mean concentration of 31.11 µg/L. The surface water samples were divided into three sampling locations (Lohit river, Maguri-Motapung wetland and Dibru river) based on the oil spill exposure. The ΣPAH range was detected highest in the Maguri-Motapung wetland (0.21 - 691.31 µg/L), followed by Dibru river (0.24 - 7.28 µg/L) and Lohit river (0.22 - 0.29 µg/L).The carcinogenic PAHs (ΣCPAH, sum of BaA, BbF, BkF, BaP, InP, and DbA) were also detected in the range of 0.27 to 14.82 µg/L with an average of 5.28 µg/L.

We collected the available data on ΣPAH concentrations in surface water from previously published literature. After reviewing the earlier reports, it was found that ΣPAH concentrations in the present study were significantly higher than other studies in Indian surface water ranging from 6.0 – 84.21 µg/L in Gomti river, Lucknow (Malik et al, 2008), Below Detectable Limit – 31 µg/L in river Ganges and Brahmaputra (Chakraborty et al, 2014), 95.2 – 143.2 µg/L in ground water of Chennai (Brindha and Elango, 2013), and other part of the world including 0.05 – 1.27 µg/L in Tianjin river, China (Shi et al, 2005), 0.02 – 0.49 µg/L in Yellow river, China (Wang et al, 2008), 0.01 – 0.43 µg/L in Mississippi river, USA (Mitra and Bianchi, 2003), 0.005 – 0.01 µg/L in

Brisbane river, Australia (Shaw et al, 2004), 0.005 – 0.26 μg/L in Poyang lake, China (Zhi et al, 2015).

5.4 Concentration of PAHs among sediment samples

Out of 16 PAHs, only 3 PAHs were detected in single sediment sample (S.S-9) collected from the Maguri-Motapung wetland which was the maximum impacted area from the Oil blowout. The concentration of ΣPAHs in S.S-9 sample ranged from 37.6 to 395.8 μg/Kg with a mean concentration of 195.23 μg/Kg (Table 5-4Table 5-5). The ΣPAHs concentration reported in sediment sample from Maguri-Motapung wetland appears to be middle level compared with similar wetlands in other part of the world ranging from 371 – 2530 μg/Kg in Taihu Lake, China (Zeng et al, 2016), 212.0 – 2674 μg/Kg in Anzali wetland, Iran (Yancheshmeh et al, 2014), 96 μg/Kg in Todos Santos Bay wetland, Mexico (Macias-Zamora et al, 2002), 36.5 – 1031.8 μg/Kg in lower reaches of Shiwuli river, China (Wu et al, 2019).

5.5 Concentration of PAHs among Fish Species

Concentration of individual PAHs among fish species collected from the Maguri-Motapung wetland and Lohit river are listed in Table 5-5. Elevated level of ΣPAHs and ΣCPAHs in the fish samples was detected in ranges of 104.3 to 7829.6 μg/Kg and 145.1 to 169.3 μg/Kg, respectively. The highest concentration of ΣPAH was detected in the fish samples collected from the Maguri-Motapung wetland. The total sum of ΣPAH in different fish species were recorded as 11467.9 μg/Kg (*Mystus Vittatus*), followed by 11378.1 μg/Kg (*Channa orientalis*), 10877.7 μg/Kg (*Rasbora daniconus*) and 10721.0 μg/Kg (*Puntius Sophore*). No ΣPAHs concentration was detected in the *Eutropiichthys vacha* collected from Lohit river. Among the detected PAHs in fish samples, Acenaphthene, Fluorene and Phenanthrene constituted the 95% of the total detected concentration.

The total PAHs concentration reported in fish samples collected from Maguri-Motapung wetland appears to be 10 - 100 fold higher than the earlier reported concentration in India (17.43 – 70.44 μg/Kg) (Dhananjayan and Muralidharan, 2012) and other part of the world ranging from 26.8 – 104.1 μg/Kg in Western Nigeria (Akpambang et al, 2009), 0.73 – 17.04 μg/Kg in Portugal (Ramalhosa et al, 2009), 23.83 – 79.74 μg/Kg in Turkey (Basak et al, 2010), 39.6 – 247.0 μg/Kg in Kuwait (Alomirah et al, 2009), 2.5 – 9.4 μg/Kg in different marine fishes in Catalonia, Spain (Llobet et al, 2006), 15 – 118 μg/Kg in marine fish, China (Cheung et al, 2007) Lake Michigan, USA (0.53 – 1064 μg/Kg) (Zabik et al, 1996; Levengood et al, 2011; Huang et al, 2014).

Table 5-3 Concentration (µg/Kg) of PAHs among water samples collected from the Lohit river, Maguri-Motapung Wetlands and Dibru river.

	Lohit River								Maguri-Motapung Wetland			Dibru River
PAHs	**W-1**	**W-2**	**W-3**	**W-4**	**W-5**	**W-6**	**W-7**	**W-8**	**W-9**	**W-10**	**W-11**	**W-12**
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	**22.62**	**0.26**	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	**174.6**	**2.61**	**0.21**	**0.80**
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	**691.31**	ND	**2.80**	**7.28**
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	**13.33**	**0.42**	ND	**0.45**
Pyrene	**0.22**	ND	ND	ND	ND	**0.23**	ND	ND	**6.12**	**0.31**	ND	**0.56**
Benz[a]anthracene	ND	ND	ND	ND	ND	BQL	ND	BQL	**6.61**	BQL	BQL	BQL

Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	**9.97**	**0.38**	BQL	**0.36**
Benzo[b]fluoranthene	ND	ND	ND	ND	ND	**0.29**	ND	**0.27**	**9.18**	**0.33**	**0.27**	**0.52**
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz[a]pyrene	ND	ND	ND	ND	ND	BQL	ND	BQL	**7.17**	BQL	BQL	BQL
Dibenzo[a,h]anthracene	ND	ND	ND	ND	ND	BQL	ND	ND	**14.82**	ND	ND	ND
Benzo[g,h,i]perylene	ND	ND	ND	ND	ND	BQL	ND	BQL	**8.34**	BQL	BQL	**0.24**
Indeno[1,2,3-cd] pyrene	ND	ND	ND	ND	ND	BQL	ND	BQL	**12.82**	ND	BQL	BQL

ND – Not Detected, BQL – Below Quantifiable Limit

Table 5-4 Concentration (µg/L) of PAHs among sediment samples collected from the Lohit river, Maguri-Motapung Wetlands and Dibru river.

	Lohit River								Maguri-Motapung Wetland			Dibru River
PAHs	**S.S-1**	**S.S-2**	**S.S-3**	**S.S-4**	**S.S-5**	**S.S-6**	**S.S-7**	**S.S-8**	**S.S-9**	**S.S-10**	**S.S-11**	**S.S-12**
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	**37.60**	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	**152.30**	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	**395.8**	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz[a]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz[a]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo[a,h]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd] pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND – Not Detected

Table 5-5 Concentration (μg/Kg) of PAHs among fish collected from the Maguri-Motapung wetland and Lohit river.

PAHs	***Puntius sophore****	***Mystus vittatus****	***Channa orientals****	***Rasbora daniconus****	***Eutropiichthys vacha*#**
Naphthalene	ND	ND	**104.3**	**166.9**	ND
Acenaphthylene	ND	ND	ND	**129.6**	ND
Acenaphthene	**475.5**	**566.1**	**821.5**	**1500.9**	ND
Fluorene	**2779.4**	**3131.8**	**2829.9**	**7829.6**	ND
Phenanthrene	**7466.1**	**7770.0**	**7002.7**	**200.1**	ND
Anthracene	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	**0.178.9**	**347.4**	ND
Pyrene	ND	ND	**136.5**	**317.7**	ND
Benz[a]anthracene	ND	ND	**169.3**	**145.1**	ND
Chrysene	ND	ND	**135.0**	**240.4**	ND
Benzo[b]fluoranthene	ND	ND	ND	ND	ND

Benzo[k]fluoranthene	ND	ND	ND	ND	ND
Benz[a]pyrene	ND	ND	ND	ND	ND
Dibenzo[a,h]anthracene	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ND	ND	ND	ND	ND
Indeno[1,2,3-cd] pyrene	ND	ND	ND	ND	ND

***** fish collected from Maguri-Motapung Wetland**,** # fish collected from Lohit river, ND – Not Detected

The post-mortem report provided by DFO-Tinsukia Wildlife Division, of the Ganges dolphin carcass found in the Maguri-Motapung wetland was observed to be in accordance with the previously reported effect of PAHs on mammals (Appendix 12). The observations included extensive haemorrhages in gastrointestinal tract, haemorrhages and edema in lungs, haemorrhages and ventricular damages in heart, haemorrhages in stomach, intestinal lumen and liver parenchyma, congestion in kidney and brain. The post-mortem report suggested the probable cause of death of the dolphin could be inhalation or ingestion of toxic substance leading to hypoxia. DeGuise et al, (2017) in their study on dolphins exposed to oil at Barataria Bay, Louisiana, also reported the similar health effects such as adrenal and lung abnormalities in dolphins that stranded and died within the oil spill footprint. Specifically, dolphins post oil spill had a prevalence of thin adrenal gland cortices, severe pneumonia, and primary bacterial pneumonia. The study supported the conclusion that exposure to petroleum products from oil spill led to adrenal and lung disease in dolphins and contributed to the observed increase in dolphin mortalities.

5.6 Risk valuation of PAHs in aquatic ecosystem

Risk valuation of PAHs is subjected to two laboratory derived factors: a) median lethal dose (LD50), a statistically derived single oral dose of a compound that will cause 50 % mortality of the test population; b) the median lethal concentration (LC50), concentration of a substance in the diet that is expected to lead to 50 % mortality of the test population. Many PAHs are acutely toxic to aquatic organisms at very low doses. The sensitivities of fish to Acenaphthene, Fluorene, Phenantherene and Benza[a]anthracene was observed to be greater than other detected PAHs in the fish tissues. A recent compilation of lethal concentration (LC50s) for the different aquatic organisms obtained from USEPA ECOSAR software tool (USEPA, 2012) have been listed in Table 5-6

The obtained results with significantly higher levels of PAHs in water and fish samples indicate an increased level of toxicological impact on various wildlife species. As mentioned inTable 5-6, the concentration of PAHs in the water and fish samples are found to be several times higher than the LC50 concentration. The observed levels of PAHs in the present study is reported to have severe impacts on fishes, plant and microbes, birds, reptiles, amphibians and mammals. Petroleum can adversely affect organisms by physical action (smothering, reduced light), habitat modification (altered pH, decreased dissolved oxygen, decreased food availability), and toxic action. Large discharges of petroleum are most likely to produce notable effects from physical action and habitat modification. The mechanism of toxicity is reported to cause interference with cellular membrane function and enzyme systems associated with the membrane (Neff, 1985). The resulting biochemical disruptions and cell damage lead to mutations, developmental malformations, tumours, and cancer (Eisler, 2000; Santodonato et al, 1981). The PAHs affects different organisms at different level and in different ways based on their physical, chemical and biological functions.

Table 5-6 The Acute Toxicity Level (LC50) of PAHs in some of the aquatic species (USEPA, 2012).

PAHs	Abb.	Fish	Daphnid	Green Algae	Mysid	Water	Fish
		96 h	**48 h**	**96 h**	**96 h**	**Max. detected concentration**	
		LC50	**LC50**	**EC50**	**LC50**	**Present Study**	
Naphthalene	Nap	9390	5940	6910	4010	-	166.9
Acenaphthylene	Acpy	2280	1550	2420	5000	-	129.6
Acenaphthene	Acp	1480	1030	1740	327	22.62	1500.9
Fluorene	Fl	2110	1450	2330	511	174.6	7829.6
Phenanthrene	Phe	1150	810	1470	220	691.31	7770
Anthracene	AnT	1150	810	1470	220	-	-
Fluoranthene	Flu	390	290	660	50	13.33	347.4
Pyrene	Pyr	390	290	660	50	6.12	317.7
Benz[a]anthracene	BaA	129	101	290	11	6.61	169.3
Chrysene	Chr	130	100	290	11	9.97	240.4
Benzo[b]fluoranthene	BbF	42	35	125	2.5	9.18	-

Benzo[k]fluoranthene	BkF	42	35	125		2.5	ND	-
Benzo[a]pyrene	BaP	42	35	125		2.5	7.17	-
Dibenz[a,h]anthracene	DbA	14	12	54		0.55	14.82	-
Benzo[g,h,i]perylene	BghiP	14	12	54		0.55	8.34	-
Indeno[1,2,3-cd]pyrene	InP	14	12	54		0.55	12.82	-

The highest detected PAHs (Acenaphthene, Fluorene and Phenanthrene) in water and fish sample have high toxic effect on the aquatic environment. Acenaphthene damages the DNA of cells and affects endocrine activity. A bigger concern is the potential for acenaphthene to build up in aquatic sediments, which could pose a risk to organisms that dwell in or near the bottom of lakes and rivers. Effect of fluorene studied on fingerling bluegills showed that 62 μg/L adversely affected their ability to capture prey, 120 μg/L reduced growth, and 1000 μg/L increased their vulnerability to predation. Fluorene, at concentrations well below its solubility and at levels that could realistically occur in the environment, represents a potential hazard to aquatic organisms (Finger et al, 1985). In animal studies, exposure to fluorene affected the blood system and spleen (USEPA, 2002). Ninty three percent mortality was observed in the embryo of rainbow trout administrated with the phenanthrene (85 μg/L) self-explained its toxicity for fishes (Black et al, 1983).

5.6.1 Plants and Microbes

Reports of the effects of petroleum spills or discharges on plants and microbes contain accounts of injury or death of freshwater wetland vegetation (Burk, 1977; Baca et al., 1985); enhanced or reduced biomass and photosynthetic activity of phytoplankton communities (Johansson et al, 1980; Shailaja, 1988); genetic effects on terrestrial plants (Klekowski, 1994); and microbial community changes and increases in numbers of microbes (Braddock et al, 1995; Megharaj, 2000). Lethal and sublethal effects are caused by contact with oil or dissolved oil, systemic uptake of oil compounds, blockage of air exchange through surface pores, and possibly by chemical and physical alteration of soil and water, such as depletion of oxygen and nitrogen, pH change, and decreased light penetration. Individual PAHs, at low concentrations (5 to 100 ppb) can stimulate or inhibit growth and cell division in aquatic bacteria and algae. At high concentrations (0.2 to 10 ppm) the same PAHs interfere with cell division of bacteria and cell division and photosynthesis of algae and macrophytes; they can also cause death (Neff, 1985; Eisler, 2000).

5.6.2 Fish

Heavy exposure to petroleum in adult and juvenile fish through ingestion of contaminated food or water can lead to their death. Petroleum concentrations (total petroleum hydrocarbons) in water of less than 500 μg/L during long-term exposure (Woodward et al, 1983). Sublethal effects begin at concentrations of less than 500 μg/L and include changes in heart and respiratory rates, gill structural damage, enlarged liver, reduced growth, fin erosion, corticosteriod stress response, immunosuppression, impaired reproduction, increased external and decreased internal parasite burdens, behavioral responses, and a variety of biochemical, blood, and cellular changes (Barnett and Toews, 1978; Malins and Hodfins, 1981; Thomas and Budiantara, 1995; Kuehn, 1995; Gregg et al, 1997; Khan, 1999; (Collier et al, 2013; Vinget et al, 2016). Eggs and larvae can suffer adverse effects, including death, when exposed to concentrations of petroleum in water ranging from less than 1 μg/L (total PAHs) up to 500 μg/L (total PAHs or total petroleum hydrocarbons) (Marty, 1997; Heintz et al, 1999; Carls et al, 1999). Effects of oil on eggs and larvae include death of embryos and larvae, abnormal development, reduced growth, premature and delayed hatching of eggs, DNA alterations, and other cellular abnormalities (Malins and Hodgins, 1981; Brown, 1996; Marty, 1997; Heintz et al, 1999; Carls et al, 1999)

5.6.3 Reptiles and Amphibians

Carcass of various species of reptiles and amphibians were found at the site of blowout. Earlier studies have also reported death and sub lethal effects of PAHs such as grossly inflated lungs, fatty livers, and abnormal behaviour in Bullfrog tadpoles (McGrath and Alexander, 1979). Sensitivity of the amphibian larvae to oil is reported to be slightly less, but it can cause reduced growth or reduced food (algae) densities and could prevent metamorphosis of green frogs at high exposure (Mahaney, 1994; Lefcort, 1997)

5.6.4 Birds

Birds have also been reported to be affected by petroleum through external oiling, ingestion, egg oiling, and habitat changes. External oiling disrupts feather structure, causes matting of feathers, and produces eye and skin irritation. Death often results from drowning (Vermeer and Vermeer, 1975; Tseng, 1993; Jenssen et al, 1994) Birds that spend much of their time in the water, such as alcids (Alcidae), waterfowl (Anatidae) are the most vulnerable to surface oil. Petroleum can be ingested through feather preening, consumption of contaminated food or water, and inhalation of fumes from evaporating oil. Ingestion of oil is seldom lethal, but it can cause many debilitating sublethal effects that promote death from other causes, including starvation, disease, and predation. Effects include gastrointestinal irritation, pneumonia, dehydration, red blood cell damage, impaired osmoregulation, immune system suppression, hormonal imbalance, inhibited reproduction, retarded growth, and abnormal parental behaviour (Eppley, 1992; Jenssen, 1994; Fowler et al, 1995; Walton, 1997). Petroleum spilled in avian habitats can have immediate and long-term effects on birds. Fumes from evaporating oil, a shortage of food, and clean-up activities can reduce use of an affected area (Parsons, 1994; Day, 1997).

5.6.5 Mammals

The metabolism and effects of some PAHs have been well documented in laboratory rodents and domestic mammals but poorly documented in wild mammals. Target organs for PAH toxic action are skin, small intestine, kidney, and mammary gland; tissues of the hematopoietic, lymphoid, and immune systems; and gametic tissue. Aquatic mammals are long-lived and have relatively large amounts of body fat (necessary for energy storage, thermoregulation, etc.), placing them at significant risk for accumulating lipophilic organic contaminants. This makes aquatic mammals both vulnerable to and sensitive indicators of acute and chronic exposure to recalcitrant contaminants. Chronic effects may impair reproductive performance, immune function, or even survival for individuals and, if widespread, affect the status of a population and community (NRC 2003). Evidence suggests that chronic and/or acute exposure to oil may lead to a range of ailments and conditions including skin irritation, conjunctivitis, hepatic and hypothalamic lesions, hepatic necrosis, cancer, and poor survival of offspring (Engelhardt 1982, Martineau et al. 1994, Loughlin et al. 1996, Peterson et al. 2003). Inhalation exposures are a concern for any air-breathing organisms (e.g. sea turtles, mammals, birds, humans) near the oil spilled surface. Cetaceans breathing just above the air/water interface would likely be more consistently exposed to the highest concentrations of surface oil droplets, than either birds or humans. Large mammals may also ingest prey that has oil or its metabolites in their tissues. Inhalation of evaporating oil is a potential respiratory problem for mammals near or in contact with large quantities of unweathered oil. Some of the previously described disorders are thought to be caused by hypothermia, shock, and stress rather than direct toxic action; distinguishing between the two types of causes can be difficult. Similarly, the unique cetacean physiological and anatomical adaptations for respiratory efficiency associated with diving would increase the impacts of oil inhalation and aspiration (Takeshita et al, 2017).

6 Sound pollution from the oil well blowout

Noise levels upto 5 km from oil blow out, on surface and under water, was measured. Sound plays important role for life on earth. Communication, resource use, predation, survival all have reliance on sound and thus evolution have shaped various life form to use different spectrum of sound. When sound become noise it is detrimental for living being, from modulating behaviour to causing serious injury and death. To measure environment noise level in and around the oil well explosion site, we used a portable digital field recorder Tascam DR-100 (TASCAM Inc.). Sound recording was done along Lohit river 4 km upstream to 5km down stream from well blow out site and on land upto 4km.

We found that the sound level (dB weighted) was 96.48dB along Lohit river at a distance of 0.48 km and 112.68 dB on land. The predicted noise level from oil explosion point upto 12 km ranges from 113 to 70db (Figure 5). For humans sound level upto to 60db is the most comfortable. Noise above 70 dB over a prolonged period may damage hearing (Centers for Disease Control and Prevention, 2019).The standard limits set by WHO and CPCPB ranges from 40 db (silence zone) to 65 db (Commercial zone). The noise level in 12 km radius of 70db or above made environment not suitable for the normal life for prolonged period as it may result in hearing loss and many other ailments. This level will also affect most of the birds and mammal species. The under water sound ranges from 5 Hz to 92 kHz (majority between 5 to 100 Hz) with pressure level ranging from 127 to 135 db. Most of the Ganges dolphin communication happens in the range of 40 to 90 kHz.

6.1 Surface noise monitoring

To measure environment noise level in and around the oil well explosion site, we used a portable digital field recorder Tascam DR-100 (TASCAM Inc.). Sound level in the surrounding environment was recorded along the river Lohit on 3rd July, and in and around the explosion site (rig area) at the oil fields on 4th July, 2020.

Along the Lohit river, sound level recording was done up to 5 km downstream (to Guijan ghat) and 4 km upstream from the oil explosion site. Along this 9 km stretch, recording was carried out every 500 m - 1 km. Around the rig area on land, sound level recording was done for up to 4 km distance from the explosion site, once every 1- 2 km. With the recordings, a spectrogram was generated to visualize the spectrum of frequencies (i.e. the amount of energy in the sound at each frequency) of the signal (Figure 6.1).

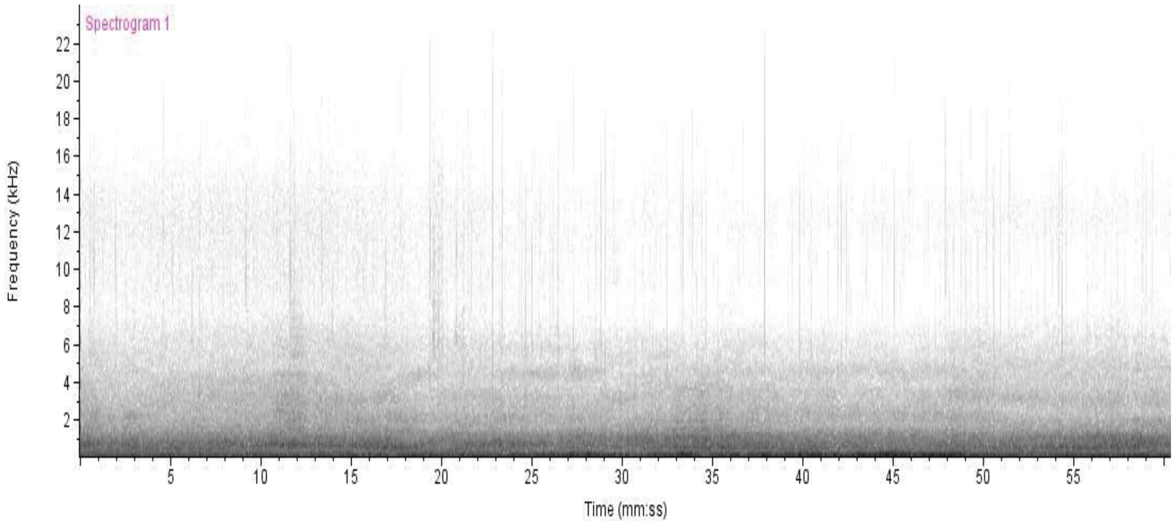

Figure 6.1 A representative spectrogram of environmental noise. Horizontal axis represents time, and the vertical axis represents frequency. The amplitude is a third dimension of a particular frequency at a particular time and is represented by the intensity of the colour.

For each of our 13 sound recordings, we selected the required sound clip on the spectrogram from Raven software and measured average power and peak power. For detailed methodology, see Section 9.8

While the extent of frequency range audible by young people lies between 20 to 20,000 Hz, human ears are most sensitive to hear between 500 Hz and 6,000 Hz, than any frequency beyond these limits. The conventions used here to denote these terms are as follows, LA= A-weighted power, LAeq= equivalent A weighted power, LAmax= maximum A weighted power. LA is synonymous with dBA and dB(A) and is often written as LA = xdB. The standard thresholds of environment noise as per WHO guidelines are in Appendix 13.

From the recordings obtained by us, we found that the peak power at 0.48km from spill site is **150.2dB** along the Lohit River and at 0.1 km, the peak power was **163.2 dB** on the land (Table 6-1 & Table 6-2). Both of these go beyond the environment noise usually found (Figure 6.2).

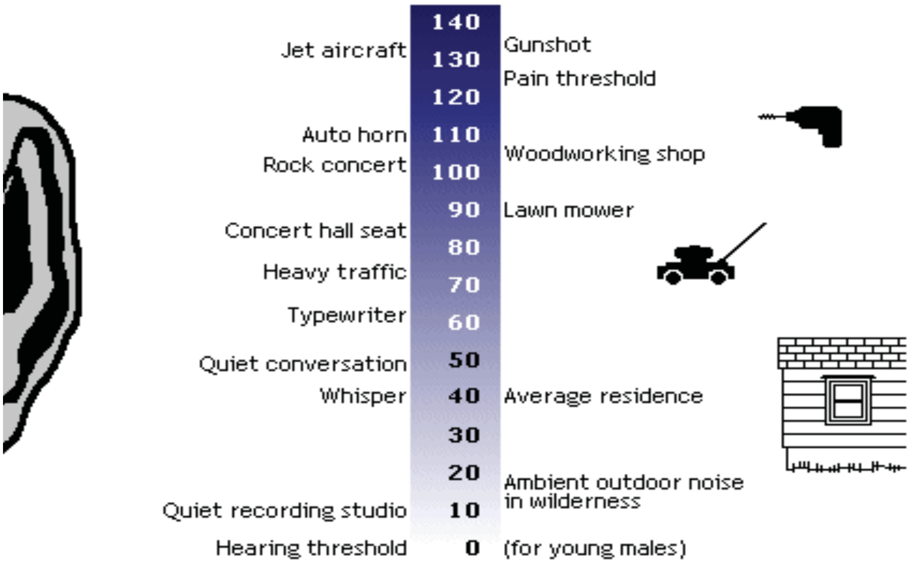

Figure 6.2 Sound levels of common sounds in air re 20 µPa. (© University of Rhode island)

Table 6-1 Summary of the noise level recordings at various distance from the oil explosion site in Baghjan along Lohit river.

Sl.no	Aerial Distance from spill (From River Lohit)	Gain	avg power (dB)	peak power (dB)	dB(A)
1	**0.48**	**10**	**116.5**	**150.2**	**96.48**
2	1.15	10	111.2	146.1	91.18
3	1.62	10	110.1	144.2	90.08
4	2.12	10	107.3	140.5	87.28
5	2.7	10	106.5	141.1	86.48
6	3.18	10	105.2	139.1	85.18
7	3.53	10	100.9	134.4	80.88
8	3.7	10	100.6	134.6	80.58
9	4.6	10	101.7	133.9	81.68

Table 6-2 Summary of the noise level recordings at various distance from the oil explosion site in Baghjan in the rig area on land

Sl.no	Aerial Distance from spill (Explosion site)	Gain	avg power (dB)	peak power (dB)	dB(A)
1	**0.1**	**10**	**132.7**	**163.2**	**112.68**
2	1.59	10	110.9	144.8	90.88
3	2.34	10	106.6	140.8	86.58
4	3.45	10	101	136.6	80.98

Table 6-3 Centre pollution control Board (CPCB) permissible limits for noise level

Area code	Category of area/zone	Limits In dB(A) LAeq*	
		Day Time	Night Time
A	Industrial zone	75	70
B	Commercial zone	65	55
C	Residential zone	55	45
D	Silence zone	50	40

We found that the sound level (dB weighted) was 96.48dB(A) along Lohit river at a distance of 0.48 km and 112.68 dB(A) on land at 0.1 km. From our study, we predicted the noise level with increase in distance from the oil explosion point using the inverse square law that assumes equal sound propagation in all direction in an ideal condition. We have seen that in both upstream and downstream in the Lohit river up to 9-10 km radius from the oil explosion point the noise level was higher than 70db. In the terrestrial habitat (oil explosion site) the 70db Limit was found to be in a Radius of 12 kilometre. Up to 60db is the most comfortable sound level for Humans. Noise above 70 dB over a prolonged period of time may start to damage hearing (CDC), with the standard limits set by WHO (Appendix I3) and CPCB (Table 6-3), which was almost near the limit for a big public event such as ceremonies, festivals and entertainment events and far exceeds the night time limit for industrial zone area. This makes the environment not suitable for the normal life for prolonged period as it may result in hearing loss.

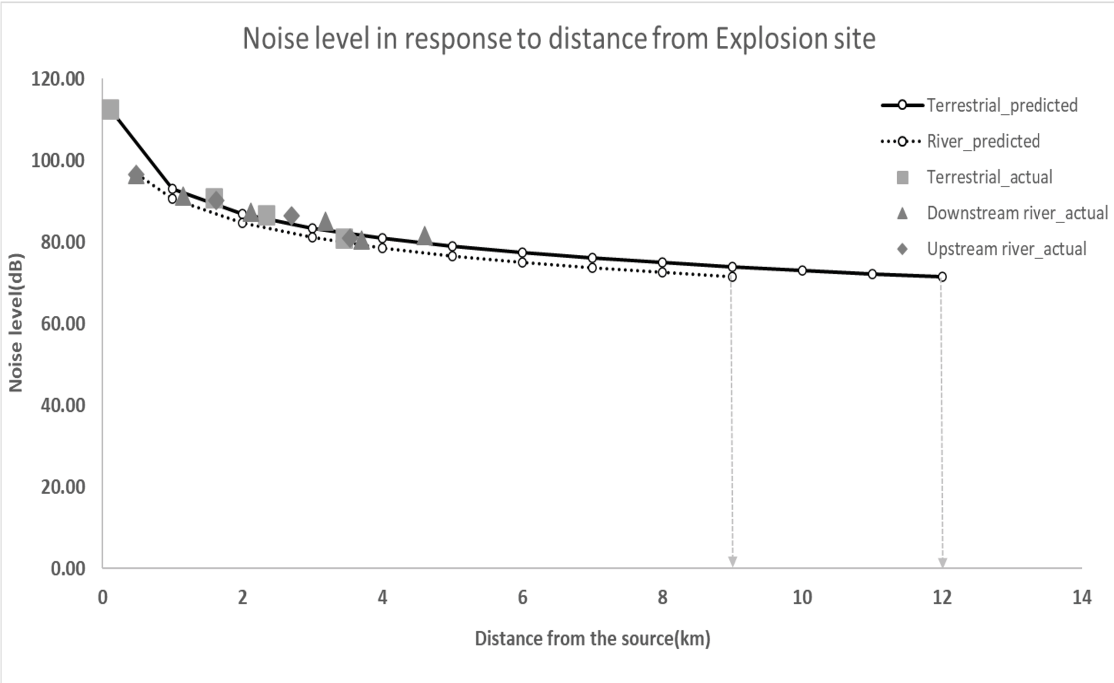

Figure 6.3 Noise level with response to distance from the explosion site.
** Gray colour arrow show the distance at which 70dB industrial zone threshold is achieved*

On river the dampening of sound is less due to negligible obstruction compared to on land where structure impede and reverberate (Figure 6.3) This will cause high stress level for the Humans settled nearby as its higher than the normal norms prescribed by both WHO and CPCB (Also see Appendix 13I & Table 6-3). Noise beyond a threshold is a threat to wildlife as well.

6.2 Underwater noise monitoring

Passive acoustic monitoring (PAM) device (The Cetacean Research™ C57 hydrophone series) along with the portable digital field recorder Tascam DR-100 (TASCAM Inc.) were used to monitor underwater sound in June 2020. They were deployed at 500m intervals of the river to get a sound profile. Sound level in the underwater environment was recorded along the river Lohit on 3rd July, 2020. Along the Lohit river, underwater recording was done 7 km downstream (to Guijan ghat) and 4 km upstream from the oil explosion site. Along this 11 km stretch, recording was carried out within every 500m - 1 km. For detailed methodology, see Section 9.9. Man-made noise has the potential to induce a stress response in aquatic fauna changing there physiological, hormonal, and behavior response. (Wright et al., 2007). Typical Sound Pressure Levels for various sources is given in Table 6-4.

Table 6-4 Typical Sound Pressure Levels for various sources by National Oceanic and Atmospheric Administration(NOAA)

The amplitude of Example Sounds	In Air	In Water
	(dB re 20µPa @ 1m)	(dB re 1µPa @ 1m)
Threshold of hearing	0 dB	--
Whisper at 1 meter	20 dB	--
Normal conversation	60 dB	--
Painful to the human ear	130 dB	--
Jet engine	140 dB	--
Blue whale	--	165 dB
Earthquake	--	210 dB
Supertanker	128 dB (example conversion)	190 dB

At 3.53 km upstream of the lohit river the mean SPL level was 128.7 dB. While at downstream around 6.51km the mean SPL was 127.9 dB .The loudest noise was recorded at 0.48 km from the oil explosion site with a mean SPL of 135 dB noises (Table 6-5).The noise levels from the sound files were within a frequency bands upto 92kHz and Majority of sound lies between 5 to 100 Hz (Figure 6.4).

Table 6-5 Mean SPL at various points in the upstream of river Lohit from the oil explosion site

Sl.No	Aerial Distance from spill (Explosion site)	Mean SPL
1	3.53	128.7
2	2.7	130
3	1.62	127.1
4	0.96	133.3
5	0.48	135

Table 6-6 The mean SPL at various points in the downstream of river Lohit from the oil explosion site.

Sl.No	Aerial Distance from spill (Explosion site)	Mean SPL
1	0.48	135
2	1.15	134.5
3	2.12	114.8
5	3.18	135.3
5	3.7	124.2
6	4.6	121
7	5.55	113.2
8	6.51	127.9

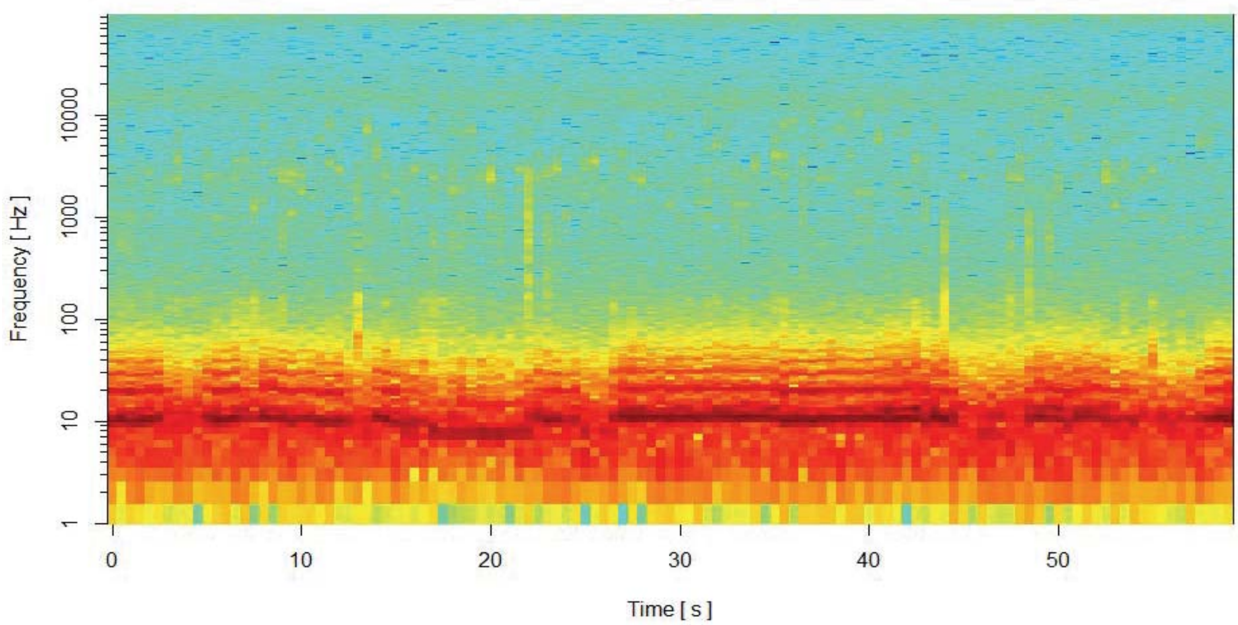

Figure 6.4 Power Spectral Density (PSD) view in the spectrogram

From the spectrogram of the underwater sound at 0.48 km from the oil explosion site the mean SPL was found to be at 135 dB re 1 μPa. The underwater sound level is found to be within normal limits, but any continuous emission of anthropogenic noise can lead to degradation of the aquatic environment which will in turn affect the aquatic life (Table 6-7)

Table 6-7 ***Effects of Human-Generated Sound on aquatic biodiversity (Rako-Gospic and Picciulin, 2019)***

Species	**Physiological Effects**	**Hearing Loss and Masking**	**Behavioral and Acoustic Response**
Fish	Increased cortisol; hematological responses	Damage to inner ear sensory cells; reduced auditory sensitivity; increase in vocalization rate	Startle response, deep diving; changes in group cohesion; reduced foraging performance; changes in antipredator responses; reduced ability to maintain their territory; modifications of foraging habits, increase defensive acts
Molluscs	Reduced embryos development and increased mortality of hatched larvae; developmental delays of larvae	Injury in statocysts	Alarm responses (such as ink ejection in squid) and changes in swimming patterns and vertical position
Crustaceans	Variations in hemolymphatic parameters; increase in the metabolism	Currently unknown	Latency to a predator threat
Marine mammals	Hormonal changes; increased heart rate; suppression of immunity; higher oxygen consumption; hypoxia; fat and heart emboli	Damage to ears (degeneration of sensory and hair cells, cochlea and auditory nerve), PTS, TTS associated to higher mortality; shifts in vocalization frequency, increased vocalization rate; increased call duration, cessation of vocalization	Changes in diving behavior, movement speed and orientation; changes in vocalization and group cohesion, habitat displacements; shifts of migration routes

7 Biodiversity Survey

Dolphins: *Compared to an earlier survey in February where the encounter rate of Ganges dolphin was 4.5/10 km, it was reduced to 1.5/10 km in May and by June it was 0.48/km, indicating 89% decline in use of this area. One dolphin was found dead in Maguri-Motapung area most likely due to oil poisoning. We recorded dolphin presence in Lohit and Dibru rivers but no recording was made of dolphin sound in Maguri-Motapung area which was most impacted site.*

Bird richness: *This area is famous for Black-breasted Parrotbill, Marsh Babbler, White-winged Duck, Bengal Florican, Jerdon's Bushchat and Swamp Grass babbler. A total of 450 species of birds have been listed (Choudhury 2006, 2007; Das 2006, Rahmani 2016). This area has six Critically Endangered, six Endangered, 12 Vulnerable, and 16 Near Threatened species of birds (Rahmani, Islam and Kasambe, 2016). The habitat in the affected area is segregated into Grassland and wetland. Data from ebird was downloaded and used to draw comparisons between earlier occurrence reports at locations that fall within our sampling grid and current occurrence. Bird species richness increases with increase in distance from oil spill site. The bird data was compared with resident birds reported by birders on eBird. The decline in richness is evident in grassland (59%) and wetland (85%). Survey team has recorded abandoned nest at impact site. The effects of oil spill on birds are well known from many oil spills around the world from past. The overall effect of oil pollution on aquatic bird populations must be examined from two points of view: (1) the disastrous effects of oil spills and (2) the sub-lethal and indirect effects of chronic exposure to low levels of hydrocarbons in the environment (Szaro, 1976).*

Fish richness: *Dibru-Saikhowa National Park part is reported to have 104 species of fishes. The sampling was carried out with gill net and cast net at a total of eight sites. We have recorded about 25 species of fishes belonging to 9 families. Cyprinidae family was found to be the most dominant family with 13 species. The overall richness and abundance of fishes declines with decrease in dissolved oxygen at different sites. We have seen fishes having visible symptoms on body due to oil toxicity. During our survey, maximum mortality of adult fishes had occurred in stagnant pools, as there is slow exchange of water and most of the fishes prefer stagnant pools during breeding period. Cirrhinus reba, Banagana dero, Labeo bata, Labeo calbasu, Sperata aor, Sperata seengala, Channa marulius, Channa punctatus, Eutropiichthys vacha has high economic value in market and fishes like Puntius sophore,* Puntius chola, Pethia gelius, Salmophasia bacaila, Baralius barna, Mystus vittatus, Xenetodon cancila, Anabus testudineus, and Parambassis ranga *are ornamentally important fishes. The abundance of these species was found to be very less in Dibru river and Maguri- Motapung beel, likely due to the mortality or and avoiding high toxic areas due to oil spill.*

Butterflies and odonates richness: *A total of 96 individuals belonging to 41 species of butterflies and 34 individuals of 13 species of odonates were sighted. Species richness and abundance of butterflies increases distance from well blow out site. Our survey team has found carcasses of burnt odonates as well as live ones with oil film on wings. Direct exposure to oil is known to negatively affect insects by altering different functions such as feeding and oviposition behaviour, gas exchange, cuticle permeability and cell membrane structural and functional destruction (Beattie et al.1995; Mensah et al. 1995; Bogran et al. 2006).*

Herpetofauna: *The survey was restricted to day as flooding and lockdown of site after fire created night sampling issues and thus it should be considered as partial. Work is underway and will be completed depending upon flooding scenario in this area. The checklist of Ahmed and Das (2020) provides what will be expected in this area. Nine species of reptiles were recorded by us. The lack of any encounters of tadpoles in the multiple water pools that were encountered in the grids, despite being breeding season for many species, is a great concern. Though this time of the year in a flood-prone season makes it difficult to discern whether the cause of apparent wipe out of herpetofauna is floods or the explosion, the direct impacts of explosion through burn down is certain for at least 500 m, and impacts of oil spill remains a crucial component to answer. We have found live herpetofauna from 500 m up to 6 km from the oil well explosion site and carcasses at 400 m to 6 km.*

People: *We have not done any work on socio-economics and health impacts on humans. The oil well blow out had economic and health impact on humans (Rishu Kalantri 2020, thelogicalindian.com). The contaminants will have long term impact and need appropriate mitigation measures.*

Given that the maximum impact area was Dibru-Saikhowa National Park and Maguri-Motapung Wetland, we started with our preliminary reconnaissance survey to assess the impact on flora and fauna in the surrounding region. The animal sampling were carried out since 29th May 2020, to 10th July 2020.

7.1 Monitoring of Ganges River Dolphin (Platanista gangetica gangetica)

Earlier studies on cetacean (which includes whales, dolphins and porpoises) health due to exposure to oil spills has reported lung injuries (Stabenau et al. 2006); physical injuries to the respiratory tract by irritating tissues/membranes during aspiration of liquid oil deposited on the blowhole (Gentina et al. 2001). These resulted into moderate to severe lung diseases causing pneumonia, lung abscesses, pulmonary infections and adrenal toxicity (Schwacke et al. 2013, Venn-Watson et al. 2015). On the other hand, ingestion of petroleum oil while foraging on oil-contaminated prey resulted into deposition of petroleum hydrocarbons at highest level in blubber followed by liver and other tissues (Geraci and St. Aubin 1982, Engel'hardt 1983). However, another important aspect of effect of oil spill on cetacean is their ranging patterns and habitat use. Experimental results reported from captive dolphins has demonstrated their ability to detect slick oil conditions and avoid entering those areas consistently (Geraci et al., 1983; St Aubin et al., 1985). While in wild, although they are capable of detecting slick and mousse oil conditions, it was observed that eventually they enter those zones with some initial hesitations (Smultea and Würsig, 1995). This was suggested as multi- year site fidelity to small home ranges in dolphins (Wells et al. 1987, Wells et al. 2017) where they continuously access the area despite of having noxious stimuli to oil. The strong impulse for migration, which is an important event of life history of cetaceans, remained unaffected with the presence of oil on their way (Evans 1982). In both of these cases, the chance of continuous exposure of the animal to the toxicity of petroleum hydrocarbon product increases, which can remain in the area for longer duration (Wells et al. 2017, Mullin et al. 2017).

This study was conducted between May and July, 2020, to understand the changes in distribution pattern of Ganges dolphin in Lohit- Dibru stretch of Brahmaputra due to the recent oil spill and blowout of oil well that happened in the month of May, 2020 in that area. The affected Maguri-Motapung Beel, has connectivity with the Lohit river, through Dibru river, stretch which is also a potential habitat of Ganges dolphins. Two temporal surveys were carried out in the Lohit-Dibru River. The first survey was conducted (post oil spill and before oil well explosion) in the month of May 2020 covering a 32 km stretch with the blowout site as centre. The second survey was conducted during June 2020 in a 62km stretch of Lohit River (Figure 7.1). The distribution was then compared with previous years surveys conducted in this area in the month of February, from 2012-2020.

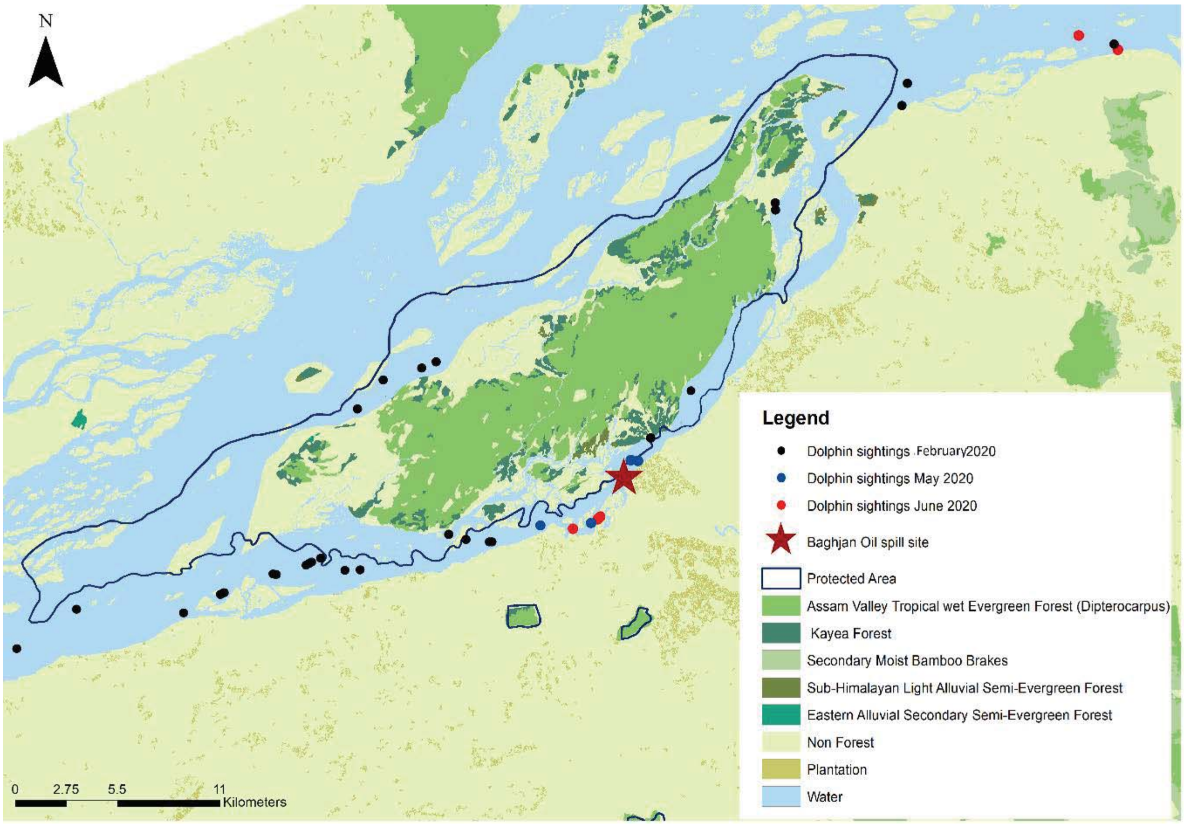

Figure 7.1 Baghjan oil spill site and dolphin sightings recorded during different temporal surveys.

As per the survey done in February 2020, before the oil spill accident happened, the dolphin encounter rate was 4.5 per 10km. In the same stretch, after oil spill, the encounter rate was 1.5 per 10 km (Table 7-1). This indicates a decline in use of the habitat by dolphin after oil spill.

Table 7-1 ***Estimates before and after oil spill within a 20km stretch of affected zone of the Brahmaputra River***

Estimates	Feb, 2020	May, 2020
N-Hat	9.0	5.0
SD	0.61	0.01
UCI	10.0	5.02
LCI	8.0	4.98
Total effort	20	32
Encounter rate per 10 km	4.50	1.50

In June 2020 survey, we estimated a significantly lower encounter rate (0.48/ 10km stretch) in the Lohit River (from Bhupen Hazarika Setu to Siang-Lohit confluence at Balijan), which shows 89% reduction (Table 7-2). While the previous surveys were carried out during low water (winter) season, this particular survey was conducted during high water (monsoon) season. The distribution pattern changes during monsoon as they are reported to move towards tributaries to escape increasing water levels in the river main stem (Kasuya and Haque, 1972). In Dibru river, 5 dolphins were sighted in a 4 km stretch. But it is unlikely that the number solely declined at this level in Lohit River due to migration. A decline in dolphin population solely due to increase in water level is more likely to happen on northern side of Dibru-Saikhowa, in larger channel of Brahmaputra, than in Lohit River.

Table 7-2 Estimates of Ganges dolphin population during previous surveys in Lohit- Dibru stretch of Brahmaputra River.

Estimates	Lohit 2012	Lohit 2018	Lohit Feb 2020	Lohit Jun 2020
N-Hat	23	34	28	3
Sd	2	2.39	3.00	0.01
UCI	26	39	33	3
LCI	19	29	23	3
Total stretch length	94	70	70	62
Encounter rate per 10 km	1.76	3.62	2.64	0.48

Figure 7.2 Dead Ganges river dolphin found in Maguri-Motapung beel of Tinsukia.

Dolphin death in Maguri-Motapung beel is more likely caused by oil pollution, (Figure 7.2) as all symptoms reported indicate effect of oil pollution on mammals. The observations as reported in the post-mortem report included extensive haemorrhages in gastrointestinal tract, haemorrhages and edema in lungs, haemorrhages and ventricular damages in heart, haemorrhages in stomach, intestinal lumen and liver parenchyma, congestion in kidney and brain, all indicative of severe and suddent stress by external factors.

7.2 Acoustic monitoring of dolphins

Passive acoustic monitoring (PAM) devices were used to understand occurrence and activity pattern of dolphins. C-PODs are one such underwater acoustic loggers meant for cetaceans. CPODs were deployed in river Lohit, Dibru and Maguri-Matapung beel. In Lohit River the C-POD was deployed at Guijan ghat area and in Dibru river the deployment was carried out at the confluence point of the river from 17th - 18th June 2020 and 23rd-24th June 2020, respectively. A total of 54.15 hrs of acoustic data was recorded and analysed. Multiple dolphin surfacing's were observed in the deployment area during and after the deployment and also during the surveys carried out at the river. One CPOD was deployed inside Maguri-Motapung beel area on 6th July, 2020 for 7 hrs and 15 min.

During our study period there was no detection of dolphins in our passive acoustic monitoring device (CPOD) which indicate the absence of dolphin inside the beel area during the study period. But the Maguri-Motapung beel area during the study period. But (a) the presence of dolphin in the Dibru river confluence area which was around 1.5 km downstream to the deployment site at Maguri-Motapung beel, (b) secondary information from the villagers of sighting of dolphins in beel area and (c) rescue location of dolphin carcass suggests that the beel area is frequently using by dolphins during high water periods.

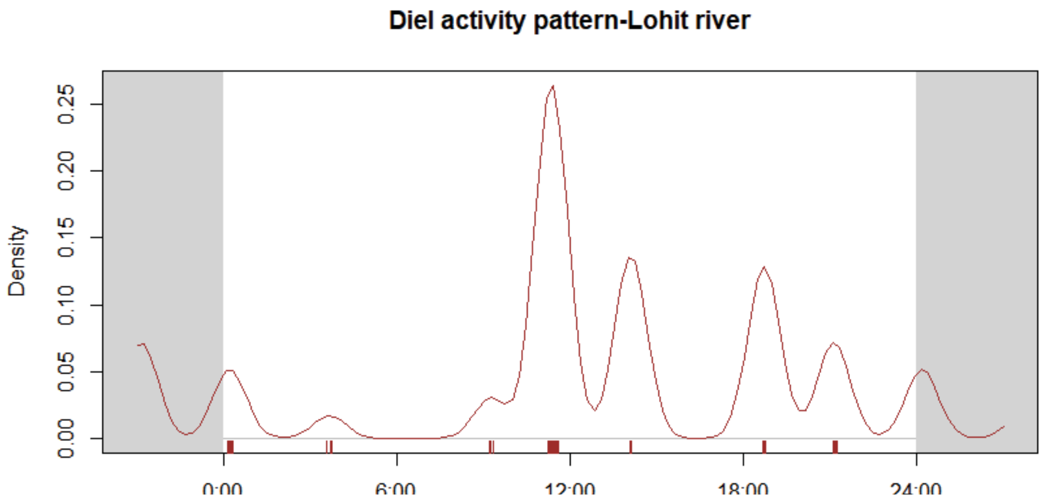

Figure 7.3 Density plot of diel activity patterns of Ganges river dolphins in Lohit river

The diel activity pattern drawn using the number of clicks detected per minute in the dolphin train shows that the dolphins are actively found in both the river Lohit and Dibru. In Lohit, recording shows sparse detections of dolphins. In Dibru, recording had more dolphin click detection than Lohit suggesting more active use of Dibru river than Lohit. The dolphins were found to be using the Dibru river throughout the day with less detection in the morning hours (Figure 7.3 & Figure 7.4). The most dominant frequency (maximum energy peak) was found to be 57.31±16.01kHz in Dibru river and 56.77±11.67 kHz in Lohit river (Figure 7.6) The highest frequency usage was found in Dibru river followed by Lohit river. The frequency shows a trimodal frequency pattern. The average sound pressure level was 54.93±47.94 Pa in Lohit river, 77.10±53.31 Pa in Dibru river. (Figure 7.7). The maximum SPL usage by Ganges river dolphin in Dibru river was 255 Pa and in Lohit river was 254 Pa. The number of click trains were found to be more in Dibru river than lohit river (Figure 7.8).

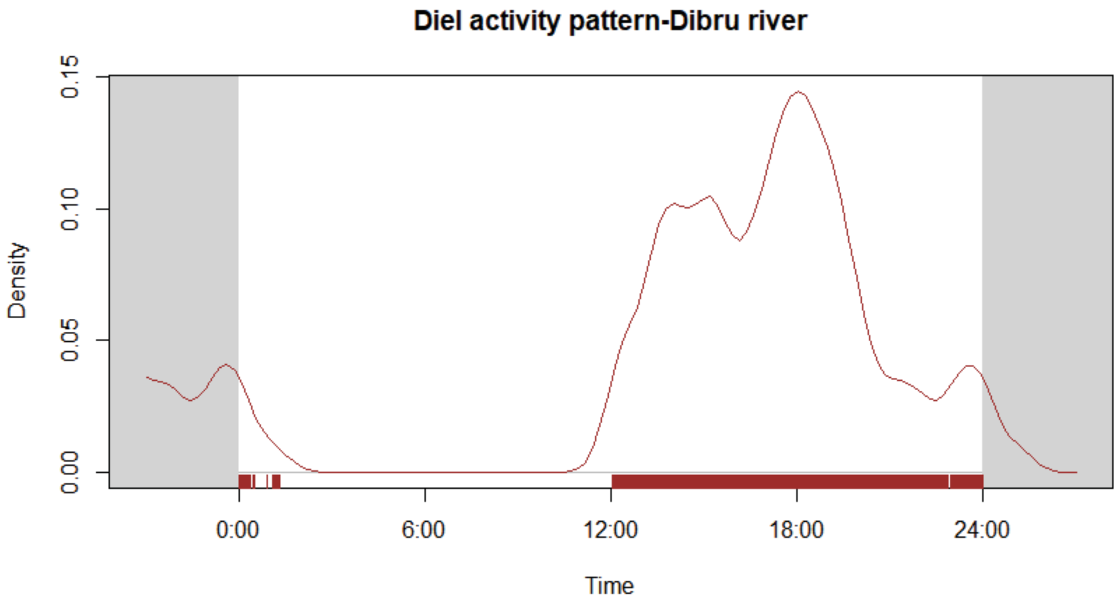

Figure 7.4 Density plot of diel activity patterns of Ganges river dolphins in Lohit river

Figure 7.5 Map showing the of the location of CPOD deployment at River Lohit and Dibru area and Maguri-Motapung Beel area

The dolphins were also found using the confluence area (Dibru river deployment area) almost throughout the day (Figure 7.3). The deployment site being a confluence, with a linkage with

Maguri-Mtapung beel, make water nutrient rich attracting more fishes and in turn attracting river dolphins (Figure 7.5). Also, the Dibru river acts as a safe haven for Ganges river dolphins during the flood season with periodic migration of the dolphin into this tributary during the monsoon periods. The river Lohit is connected with Maguri beel wetland area through Dibru river. Any ecological impact in the Dibru and Lohit river or the beel will pose a major threat to the population of dolphins in this area.

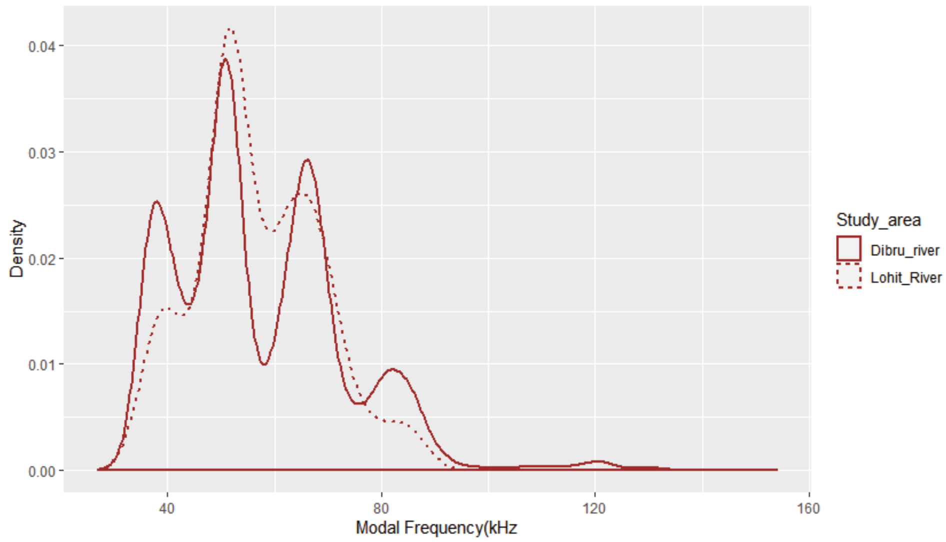

Figure 7.6 Density plot of frequency usage of Ganges river dolphin in Lohit and Dibru river

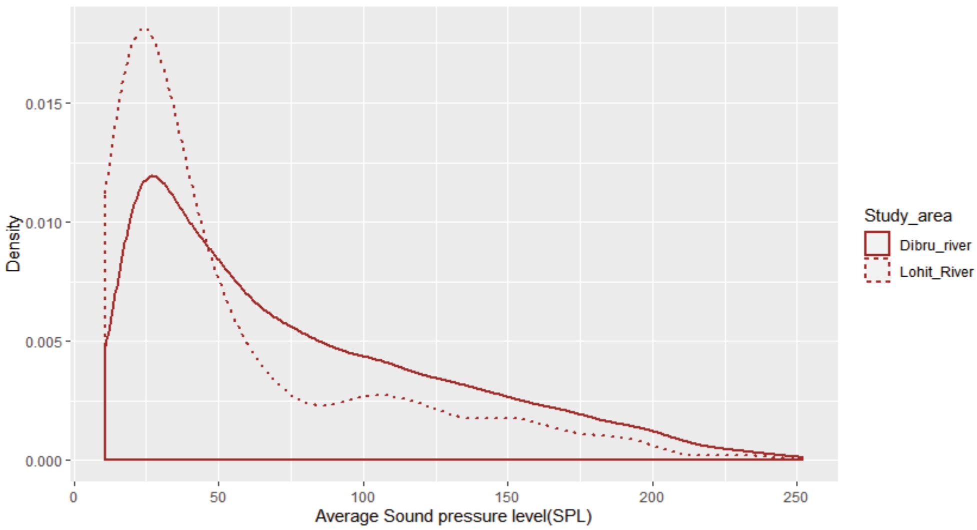

Figure 7.7 Density plot of average sound pressure level (SPL) usage of Ganges river dolphin in Lohit and Dibru river

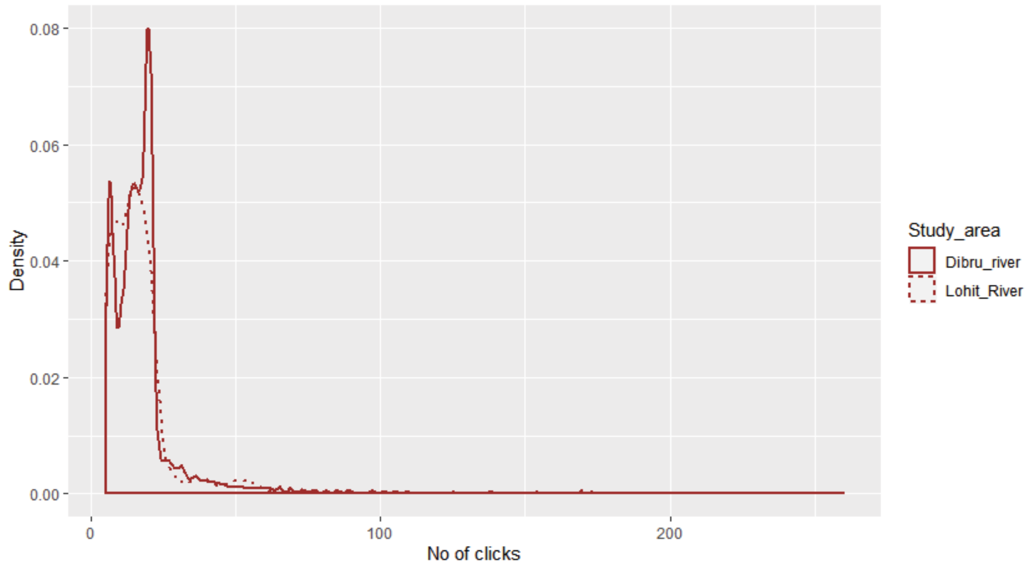

Figure 7.8 ***Density plot of number of clicks per train usage by Ganges river dolphin in Lohit and Dibru river***

7.3 Birds

The habitat in the affected area was segregated into Grassland and wetland. Transects were walked in the grassland regions and boat transects were carried out in the wetland area between 09:00h – 14:00h. A cumulative effort of 3.48 km transect was carried out in the grasslands falling at distances of 1, 2, 4 and 5 km from the explosion site. The cumulative effort surveyed in the beel (wetland) area was 11 km.

Data from ebird was downloaded and used to draw comparisons between earlier occurrence reports at locations that fall within our sampling grid and current occurrence. Available data in our sampling regions (from 2010 onwards) are arranged according to sampled grid in Grassland and wetland. As the data had replicates of multiple days in the same locations we calculated the average of individuals sighted for each species. Incidental sightings of nest locations were recorded with its microhabitat observed.A total of 45 Species with 447 individuals were recorded in affected area (both grassland and wetland) including 213 individuals of 28 species (Appendix 4) in grassland patches (Table 7-3) and 234 individuals of 28 species in wetland area (Appendix 5 & Table 7-3). Apart from this, ouside the survey, Chestnut-capped babbler, Gray-throated martin, Cinnamon Bittern and Asian Palm swift were also encountered around the beel area.

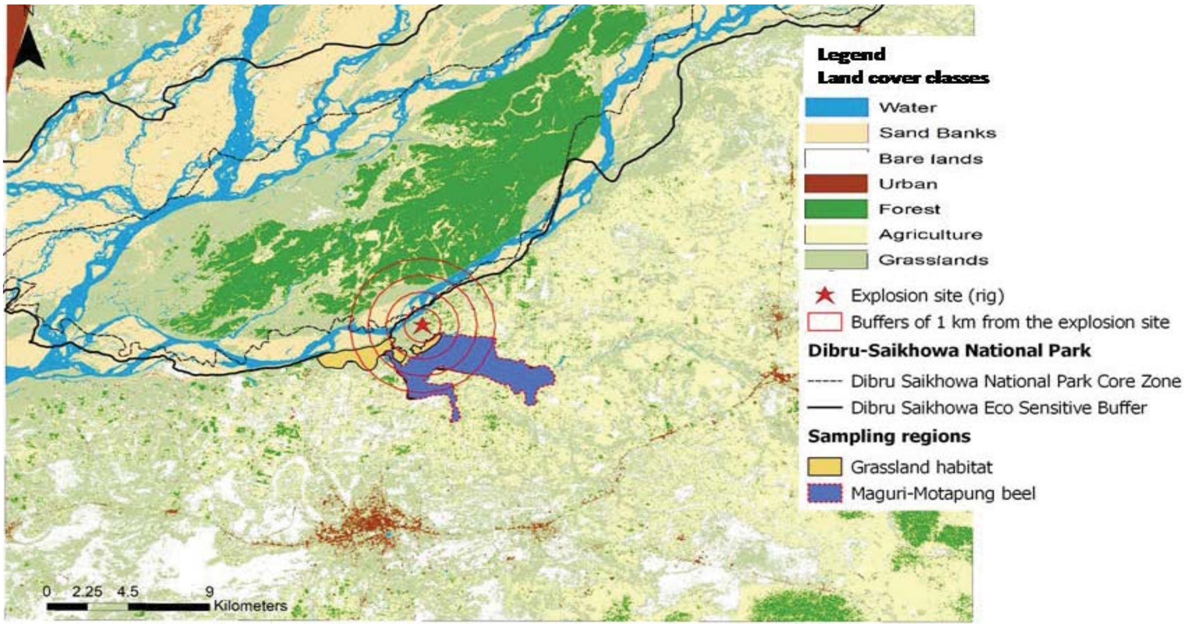

Figure 7.9 Sampling regions, concentric circles of 1km from Baghjan well no.5 (accident site).

At 1, 2, 4 and 5 km distance from the oil spill site bird species richness show increasing trend (Table 6-4 & Figure 7.10). Species accumulation curve for sampling regions (grid wise) for both habitat types are prepared with reference to the sighting time of bird species at every five minutes interval. The curve shows that the sampling effort of 70 minutes in the beel region is sufficient to achieve the asymptote for species curve. Sites close to well blowout indicate saturation of species faster in comparison to site 5 km away, indicating impact of oil spill on birds, birds seem to have left the area.

Table 7-3 Effort and counts of species obtained during the survey period in comparison to data available from e-bird

			Sighted by us	
Habitat type	Distance from spill (km)	Effort (km)	Number of Species	Number of Individuals
Grassland	1	0.9	11	49
Grassland	2	1.38	13	60
Grassland	4	0.4	8	32
Grassland	5	0.8	17	72
Wetland	Maguri-motapung	11	26	234

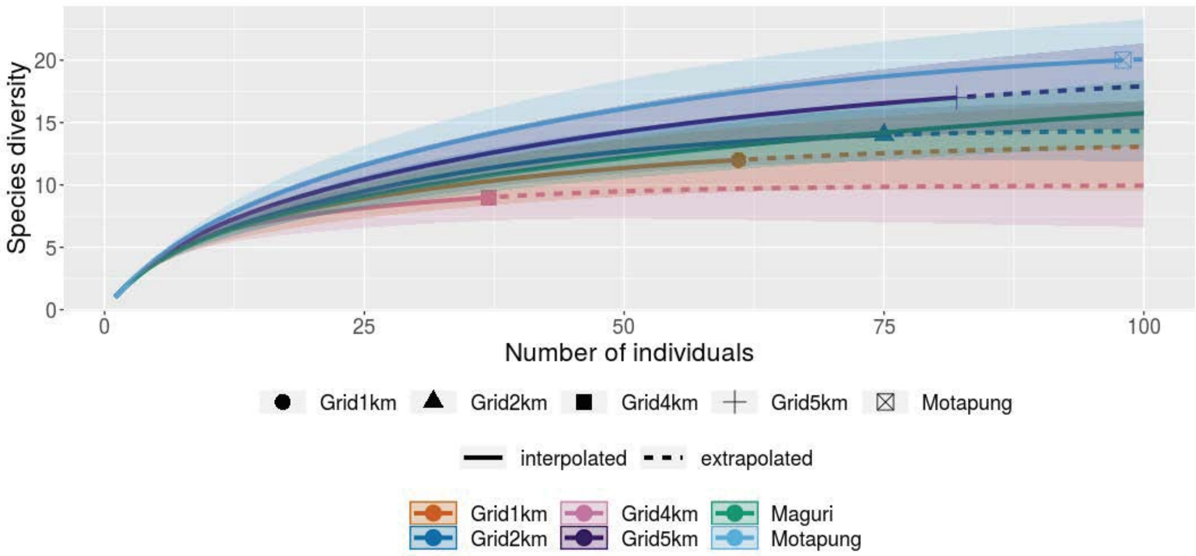

Figure 7.10 Species accumulation curve for grassland at different distances (1,2,4,5 km buffer) and wetland (Ma)

Comparison with e-bird data

A total of 335 species were recorded in the affected area (both wetland and grassland together) according to e-bird data (2010-2020). Among which, a total of 94 species are recorded in the patches of grassland that was surveyed by us. 69 species of them are resident whereas 1 is summer migrant and 21 are winter migrant (Appendix 2). 335 species of birds are recorded in Maguri-Motapung beel area according to eBird data, of which 190 are resident, 7 are summer migrant and 125 are winter migrant (Appendix 3). Collation of e-bird data across months since 2010 show that independent checklists (n=10) generated have recorded 50 bird species or less in the grassland area in the month of April and May (Figure 7.11). Plots of month wise across the year visitation bias as there are fewer checklists in May, June, July and September. However, an average close to 158 individual birds are recorded during the month of April (Figure 7.12). In the grassland patches near explosion site, we sighted 28 species of birds (Appendix 4) and 28 wetland species were sighted by us (Appendix 5) (Figure 7.15). During our survey, some of the threatened resident species, namely, Marsh babbler, Jerdon's babbler, Swamp Grass Babbler and Black-breasted Parrotbill were not encountered. The comparison indicates the birds are not ustilizing the affected sites. The decline in richness is evident in grassland (59%) and wetland (85%). Survey team has recorded few abandoned nest at impact site. Its likely that birds are also sprayed with oil spill as oil has been seen covering the vegetation in more than 2 km radius. Both oil spill as well as intense sound seems to be responsible for reduction in bird species richness and abundance.

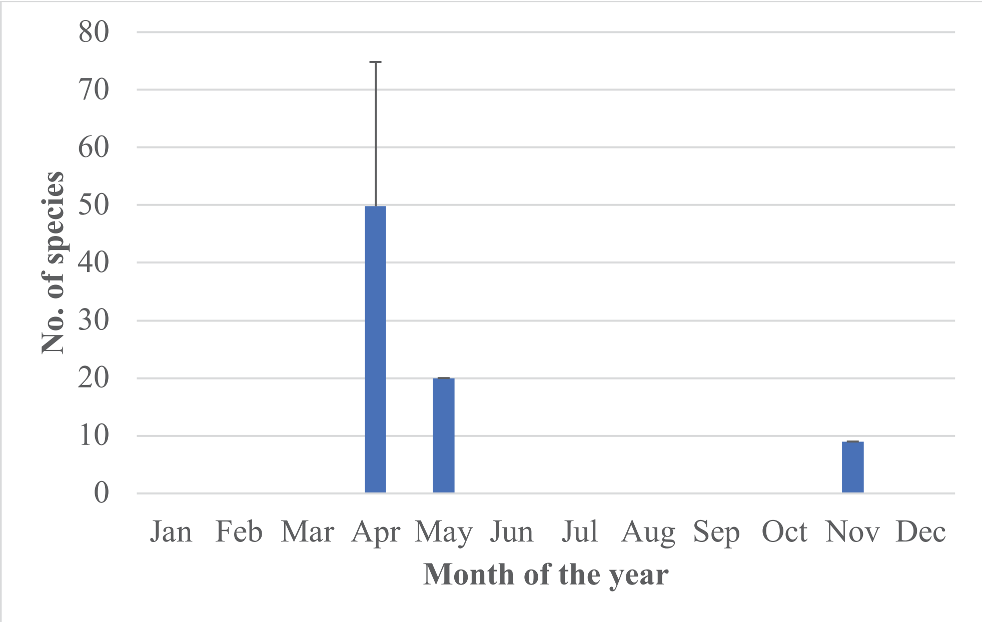

Figure 7.11 Graph showing monthly records of species richness across different months in the grassland region (checklists =10, since 2010, source: eBird)

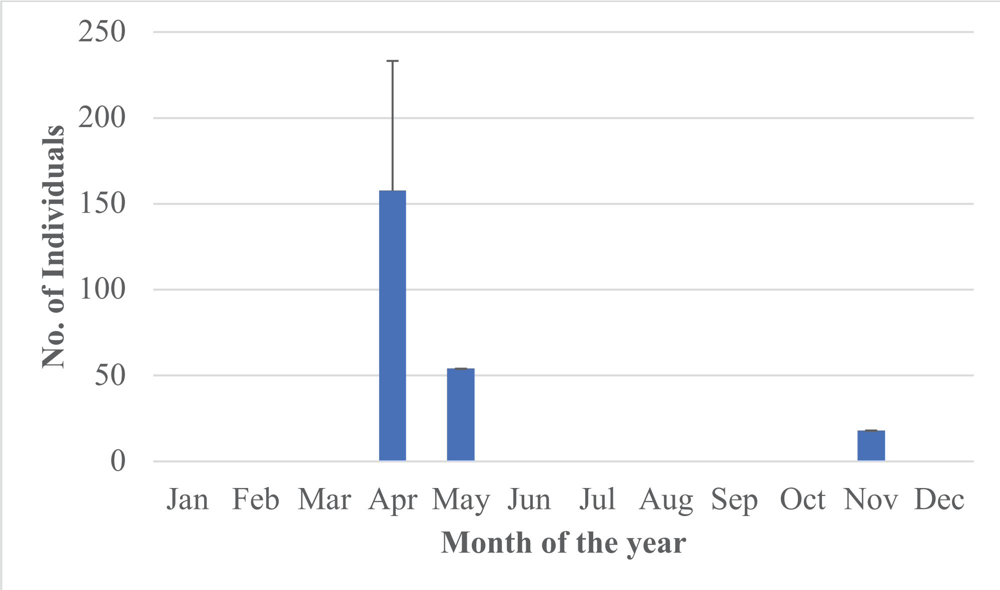

Figure 7.12 Graph showing monthly records of species abundance across different months in the grassland region (checklists =10, since 2010, source: eBird).

In the wetland area (Maguri-Motapung beel), highest of 44 species are recorded during the month of February followed by close to 43 species in March and January. An average close to 40 species of birds is recorded in the wetland area since 2010 in the month of May (Figure 7.13). Average of 263 individuals is recorded in the area in the month of April and 104 individuals in the month of May (Figure 7.14).

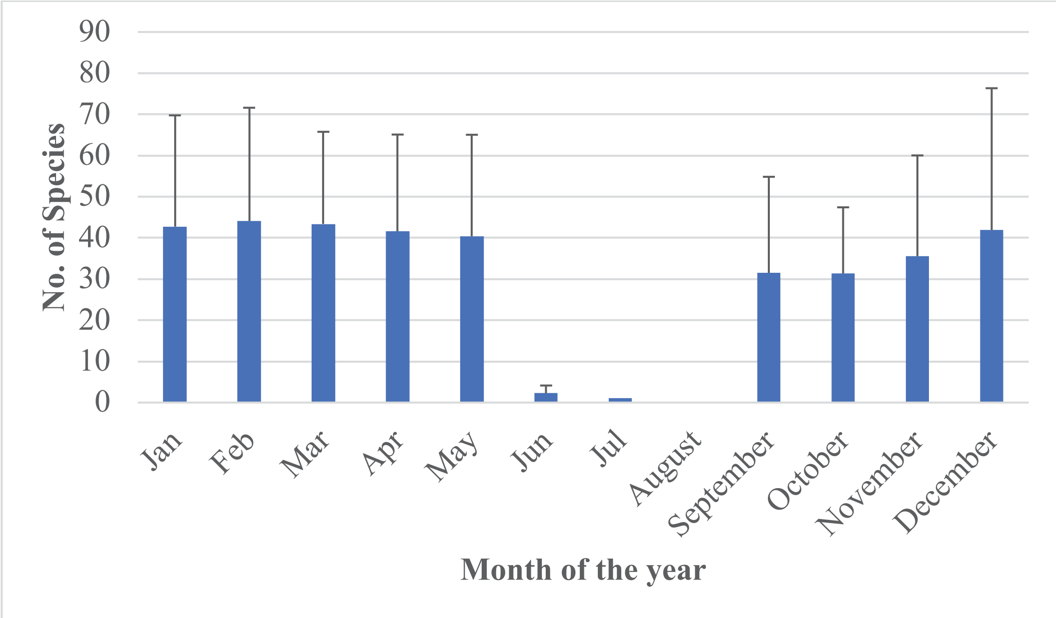

Figure 7.13 Graph showing monthly records of species richness across different months in the wetland region (checklists =421, since 2010, source: eBird)

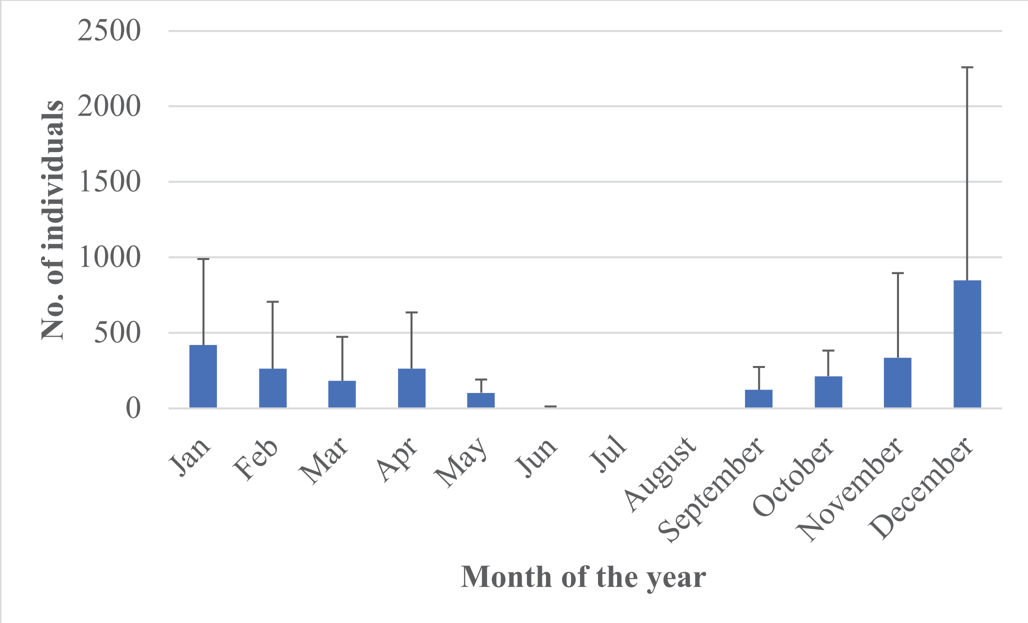

Figure 7.14 Graph showing monthly records of species abundance across different months in the wetland region (checklists =421, since 2010, source: eBird).

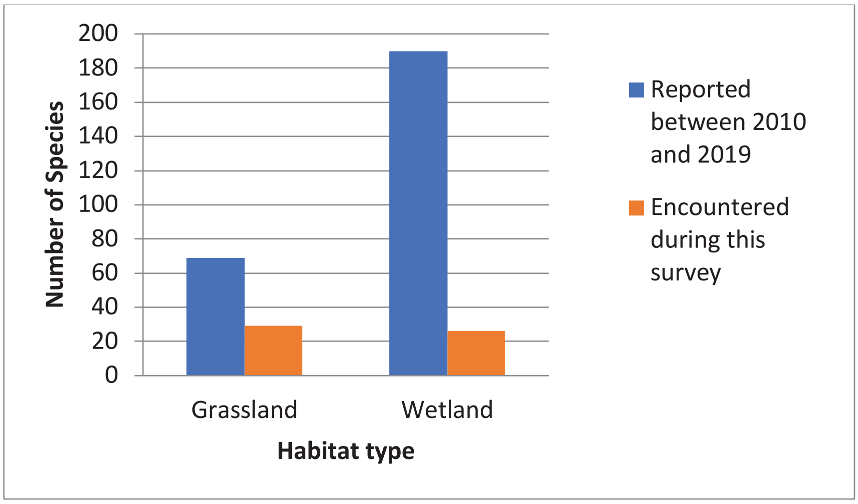

Figure 7.15 Comparison of resident species encountered in the explosion site before (from 2010-2019 from e-bird) and after explosion (during this survey).

This region is potentially also a breeding or a nesting ground for many species. During the survey, active as well as abandoned bird nests were observed and recorded (Table 7-4).

Table 7-4 Incidental sightings of nests were recorded in the sampling area in 3 locations in different microhabitats.

Sl. No.	Nest	Habitat	Location		Status
			Lat	Long	
1.	Unknown 1	*Bombax ceiba*	27.578236	95.348284	Abandoned
2.	Unknown 2	*Bombax ceiba*	27.587683	95.383187	Abandoned
3.	Red-wattled lapwing	Short grassland	27.585737	95.37803	Active (3 eggs)

Threatened wetland bird species such as Darter (Near threatened), Lesser White Fronted Goose (Endangered), Ferruginous Pochard (Near threatened), Baer's Pochard (Critically endangered) are recorded from the area. Threatened grassland species such as Marsh Babbler (Vulnerable, Restricted range), Jerdon's Babbler (Vulnerable), Swamp Grass Babbler (Endangered, restricted range) and Black Breasted Parrotbill (Vulnerable, Restricted range) are also recorded from the concerned area. Also, other threatened species like Slender-billed vulture (Critically endangered), White-rumped vulture (Critically endangered) and Swamp francolin (Vulnerable) have been reported from here (Das and Hatibaruah, 2014).

The effects of oil spill on birds are well known from many oil spills around the world from past. The overall effect of oil pollution on aquatic bird populations must be examined from two points of view: (1) the disastrous effects of oil spills and (2) the sub-lethal and indirect effects of chronic exposure to low levels of hydrocarbons in the environment (Szaro, 1976).

In a short-term study of the gulf war oil spill in 1991; during the first months more than 30,000 wintering birds were killed by oil-fouling. This represents from 22 % to more than 50 % of the regional populations of different species. Records indicate that most waders had dispersed from the affected intertidal habitats and that at least a proportion of the oil-fouled waders survived (Symens & Suhaibani, 1994).

As the sampling area is an Eco Sensitive Zone and is a suitable habitat for more than 450 species of resident and migratory birds and harbors 700 – 20000 individuals, this kind of oil explosion can be disastrous for biodiversity. A total of 56 Species with 447 individuals were recorded during sampling in affected area. The oil in the water and soil in the area might definitely harm the species we found in the area. Moreover, the temperature of the fire and the high sound level in and around the location can be very harmful for any species. The area holds many rare species of birds also which should be taken in consideration as in 2014 Baikal bush warbler (*Locustella davidi*) was recorded in Maguri beel which was its first record in India. It is also breeding season for many birds and other species and their habitat should be in suitable condition. We found 3 nests in our sampling region in different habitats. Such oil spill and fire might destroy these nests and breeding grounds for birds and other fauna. Comparison with resident birds reported on eBird with our checklists indicate severae decline in use of grasslands and wetlands (Figure 7.15).

In long term study of the Exxon Valdez oil spill it was found that species richness was significantly lower in the year of the oil spill for the same season even 1-2 year later, especially in heavily oiled bays (Wiens, Crist, Day, Murphy, & Hayward, 1996). Species richness of several guilds of birds feeding on or close to the shoreline was negatively related to initial oiling level (Wiens et al., 1996). The richness of a guild of winter visitant and resident species showed the greatest negative association with initial oiling. In winters, maguri beel also provides shelter and food to many migratory birds every year. 309 species of birds were recorded in the affected area only in the month of November, December, January, February and March according to Ebird data. In a short-term case study on Peregrine Falcons after Prestige oil spill it was found that loss of clutches during the incubation period increased significantly and was correlated with the loss of females. The polycyclic aromatic hydrocarbon concentrations in the eggs, collected from five nests after they were deserted, ranged from 21.20 ng/g to 461.08 ng/g, values which are high enough to cause the death of the embryos and poisoning of adult birds (Zuberogoitia et al., 2006).

On examining trends of marine birds in the oiled and unoiled areas it was found that most taxa for which injury was previously demonstrated were not recovering (Lance, Irons, Kendall, & McDonald, 2001; McKnight et al., 2006). In a case study it was found that even after 10 years harlequin duck population had not recovered (Esler et al., 2002). Similar status was seen for the common scoter after the Sea Empress oil spill (Banks et al., 2008) were population fail to recover after a decade. Guillemots populations remained depressed at oil spilled sites (Golet et al., 2002). The reason for lack of recovery may be related to persistent oil remaining in the environment

(Lance et al., 2001). After the Prestige oil spill reproductive performance of Kentish plover was lowered by reducing egg quality. Due to petroleum oil toxicosis. Microscopically, hemosiderin deposits, related to cachexia and/or hemolytic anemia, were observed in those birds harboring oil in the intestine (Balseiro et al., 2005). Migratory birds affected by the oil spill experienced long term flight impairment and delayed arrival to breeding, wintering, or crucial stopover sites and subsequently suffered reductions in survival and reproductive success (Perez, Moye, Cacela, Dean, & Pritsos, 2017).

7.4 Fishes

Brahmaputra river sytem is rich in fish species due to diverse habitats, 229 species have been reported, majority of the species belong to the order Cypriniformes (114 species), followed by Siluriformes (57 species) and Perciformis (29 specie). One hundred and four species of fishes are reported from Tinsukia-Dibrugarh area (Kalita, 2016).

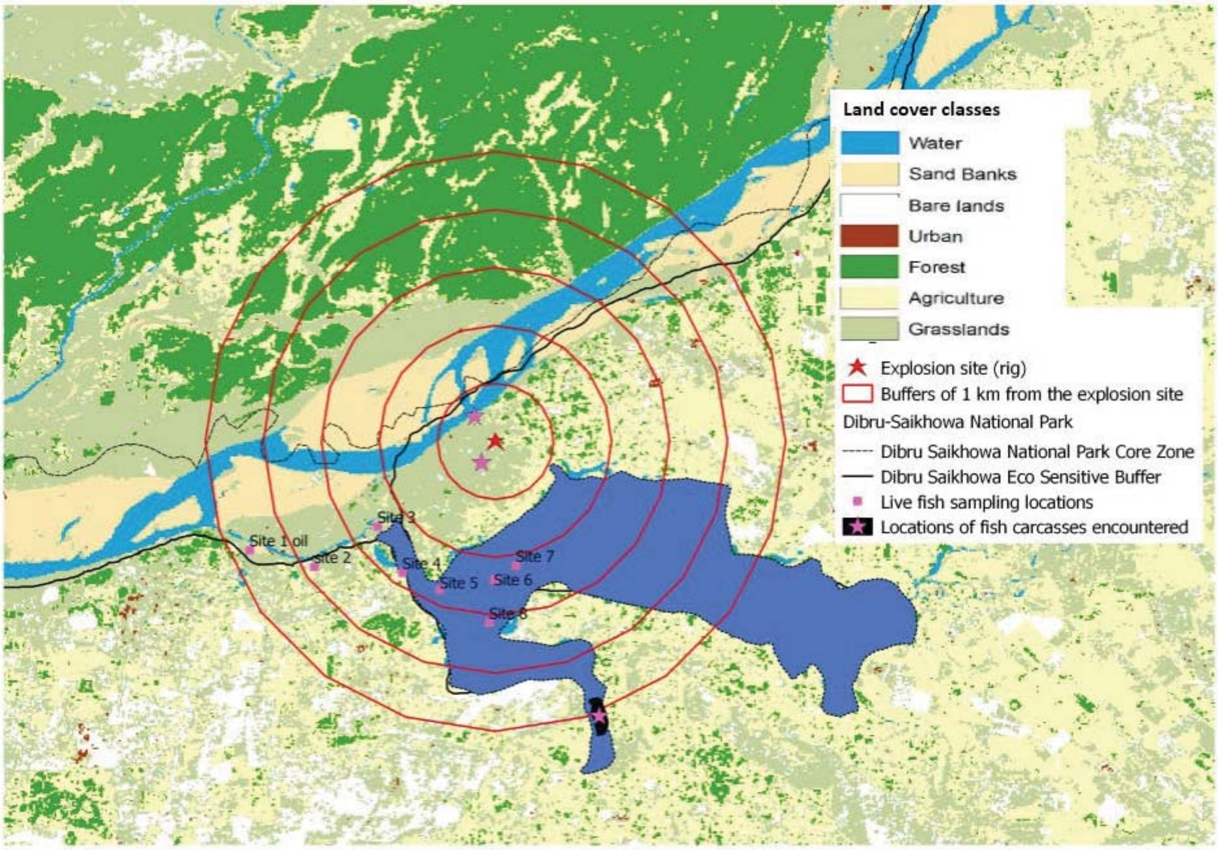

Figure 7.16 Showing Sampling sites in Dibru river and Maguri-Motapung Beel and sites where fish mortality was collected.

We have recorded about 25 species of fishes belonging to 9 families. Cyprinidae family was found to be the most dominant family with 13 species.

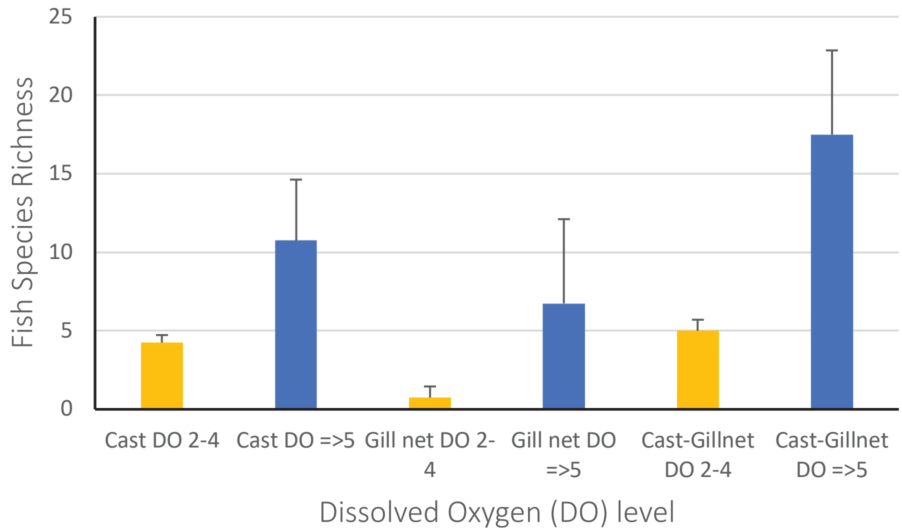

Figure 7.17 Fish species richness in two categories of Dissolved Oxygen (DO), DO between 2-4 mg/l and DO equal or more than 5 mg/l.

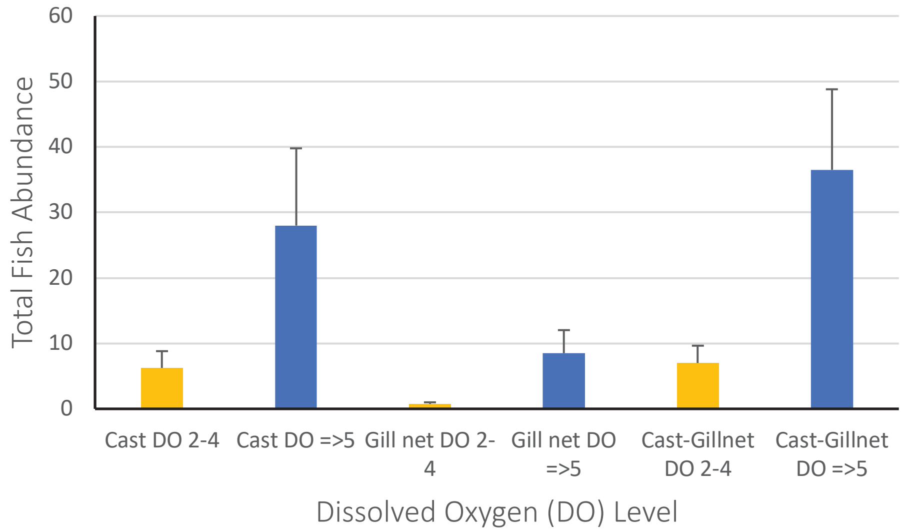

Figure 7.18 Fish species richness in two categories of Dissolved Oxygen (DO), DO between 2-4 and DO equal or more than 5

Site 1, 2, 3 (Figure 7.16) are have high abundance of fishes as they are far from oil spill sites (2 to 4 km) compared to Site 4,5,6,7,8 which are stagnant pools or slow moving water and are near wetland of Maguri beel where toxicity level is high.

These sites also have different DO levels. Fish species richness (Figure 7.17) and abundance (Figure 7.18) significantly differ in poor (DO= 2-4) and better (DO=>5) sites. Richness declines by 71 % and abundance by 81% between poor and good DO sites. DO level differs due to oil contamination.

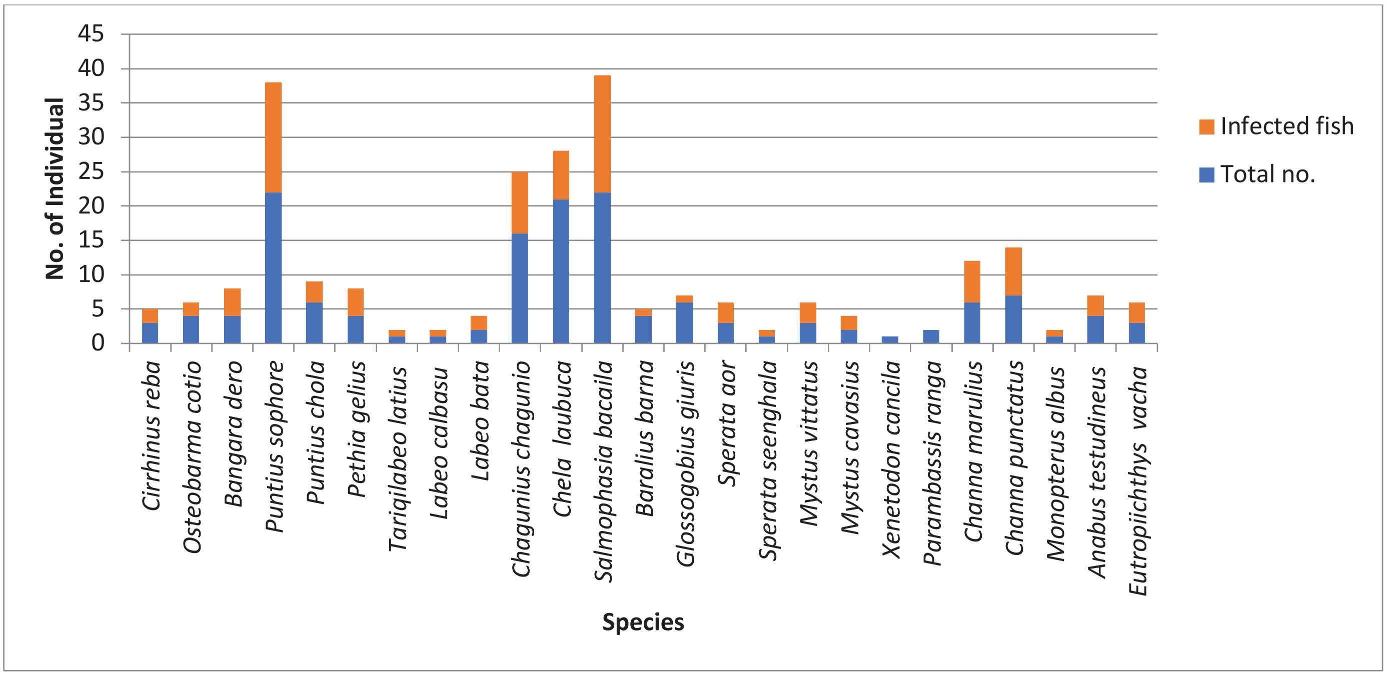

Figure 7.19 Percentage of normal and affected fishes captured from Maguri-Motapung beel and Dibru river.

Puntius sophore, Chagunius chagunio, Chela laubuca, Salmophasia bacaila, Spereta aor, Mystus vittatus, Channa punctatus, Channa marulius, shows high infection in fishes due to increase in toxicity and increase in heavy metals in water due to oil explosion in Dibru river and Maguri Motapung beel (Figure 7.19).

The breeding season of fishes in north-east India is from April to July and during breeding season fishes migrate uphill of the stream for breeding and therefore a significant amount of fishes were potentially affected due to explosion and continue to be affected due to the uncontained oil leak. The type of oil and the timing of the release influence the severity of oil's effects on fish. Light oils and petroleum products can cause acute toxicity in fish. Mortality in aquatic life occurs due to increased pressure, toxicity and temperature rapidly in the immediate environment. We have encountered about 30 carcasses of fish in water bodies around the explosion site. Personal communications from the locals there have suggested that there were many more dead fish earlier after the oil well blowout and they have either washed out due to flood or fished out.

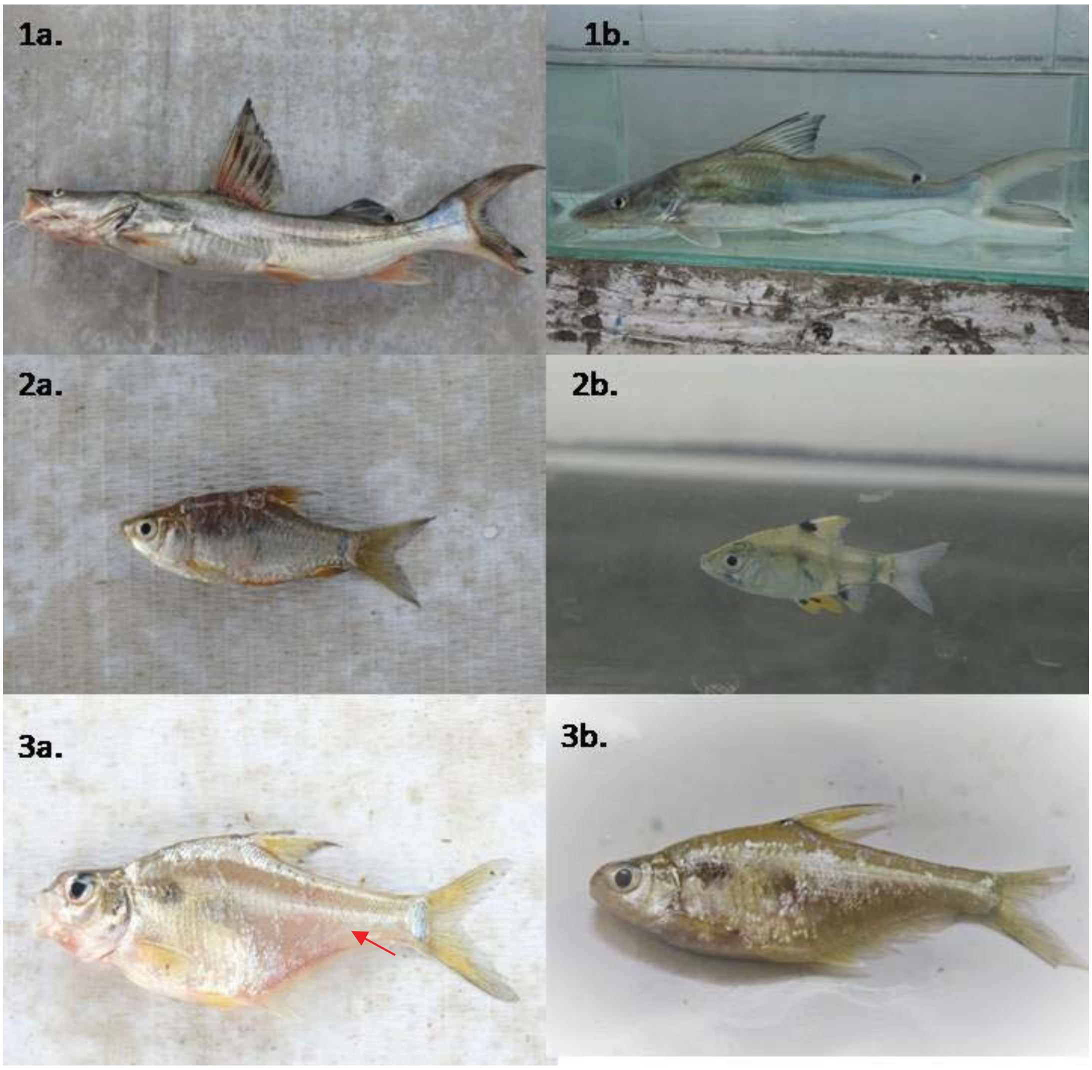

Figure 7.20 Images- Photographs of affected and normal fishes: 1a)Spereta seengahala, 2a)Petha gelius, 3a) Osteobarma cotio shows effect of toxicity on body of fish which were collected from Maguri Motapung beel and Dibru river, Image 1b) Spereta seengahala, 2b)Petha gelius, 3b)Osteobarma cotio are normal fishes which were captured during survey carried out in Kaziranga National Park in February 2020.

Fishes show some visible specific symptoms on body due to presence of toxicity or heavy metals in water. Fishes secrets excess amount of mucus on body for protection and breathing purpose due to decreased in oxygen level in water, their body colour becomes pale and/or losses their body scales which further leads to bleeding through body (Figure 7.20). Due to increase in toxicity or increase in heavy metals in water body there are few immediate effects which can also be observed i.e mortality of eggs, juveniles and fingerlings stages. During our survey, maximum mortality of adult fishes had occurred in stagnant pools (Figure 7.21), as there is slow exchange of water and most of the fishes prefer stagnant pools during breeding period. Immediate loss of riverine habitat seem to have occurred due to oil and petroleum spillage. Long-term studies have reported genetic damage to embryos resulting in morphological abnormalities which can affect ability to swim, feed, avoid predators and migrate (Incardona 2011).

Figure 7.21 Carasses of (clockwise from upper left) 1.Channa punctatus, 2. Monopterus albus (eel), 3. Puntius sophore found at regions in and around the Maguri-Motapung beel

7.5 Long term effects on aquatic life from oil spill

As per our findings PAHs (Polycyclic Aromatic Hydrocarbons) are released from oil films and droplets at progressively slower rates with an increasing molecular weight, leading to greater persistence of larger PAHs. Polycyclic Aromatic Hydrocarbons (PAH) can be a slow-acting poison, and has toxic effects. The presence of PAH in water body increases heavy metal and toxicity which leads to loss of habitat and primary productivity (phytoplankton and zooplankton).

Cirrhinus reba, Banagana dero, Labeo bata, Labeo calbasu, Sperata aor, Sperata seengala, Channa marulius, Channa punctatus, Eutropiichthys vacha has high economic value in market and fishes like *Puntius sophore, Puntius chola, Pethia gelius, Salmophasia bacaila, Baralius barna, Mystus vittatus, Xenetodon cancila, Anabus testudineus, and Parambassis ranga* are ornamentally important fishes. The abundance of these species was found to be very less in Dibru river and Maguri- Motapung beel, likely due to avoiding high toxic areas or due to the mortality that was caused by the oil spill.

The oil well blowout has certainly caused loss of riverine habitat in its surrounding regions, caused considerable mortality in fishes and livelihood of people and could have long-term impacts as well.

The type of oil and the timing of the release influence the severity of oil's effects on fish. Fish eggs and larvae are, in general, more vulnerable to oil spills than adult fish, partly due to their intrinsically higher sensitivity to oil toxicity, even to short (2 – 24 hour) exposures to 50 μg/L of the water soluble fraction of crude oil (Føyn and Serigstad 1989). Long-term exposure of fish embryos to weathered oil (3- to 5-ringed PAHs) at ppb concentrations has population consequences through indirect effects on growth, deformities, and behavior with long-term consequences on mortality and reproduction (Charles H. Peterson et al.,2003). The Exxon Valdez spill had long-lasting ecosystem impacts on neritic and pelagic habitats in Prince William Sound, causing increased mortality in developing pink salmon for several years after the spill (Rice et al., 2001).

Research spanning the past two decades has revealed a common form of injury among teleost embryos exposed to crude oil. Cardiotoxicity is generally the most sensitive phenotype, and this is primarily evident as fluid accumulation (oedema) in the pericardial space or yolk sac. This loss of circulatory function and corresponding change in morphology has been documented for several different crude oils, including Alaska North Slope, Mesa light, Iranian heavy, and Bass Strait (Couillard, 2002; Incardona et al., 2005; Jung et al., 2013; Pollino and Holdway, 2002) across a range of freshwater and marine species, including mummichog (*Fundulus heteroclitus* (Couillard, 2002)), zebrafish (Danio rerio (Carls et al., 2008; Incardona et al., 2005)), rainbowfish (*Melanotaenia fluviatilis* (Pollino and Holdway, 2002)), pink salmon (*Oncorhynchus gorbuscha* (Marty et al., 1997b)), and Pacific herring (*Clupea pallasi* (Carls et al., 1999; Incardona et al., 2009)). Many of the gross morphological features of the crude oil cardiac toxicity syndrome can be attributed to secondary consequences of reduced circulatory function or heart failure (Incardona et al., 2004). Chronic toxicity and stress may also reduce fecundity and survival through increased susceptibility to predation, parasite infestation, and zoonotic diseases. The frequency of a single symptom does not necessarily reflect the effects of oil on the organism, so the cumulative effects of all symptoms of toxicity must be considered in evaluating acute and chronic effects of oil on fish (Heintz et al., 2000). Contaminant exposure can make a spawning site unavailable for multiple generations if the oil is detectable by the fish. (Cheung et al., 2009).

The overall impact of oil spill recorded following impacts; mortality of eggs and immature stages, effects on organs, tissues and gills, physiological dysfunction, stress and altered respiration, irregular or reduced heart rate, fluid accumulation, effect on swimming, feeding, reproductive and migratory behaviours genetic damage to embryos resulting in morphological abnormalities, displacement of individuals or portions of a population from preferred habitat (Nahrgang et al., 2010; Boertmann, Mosbech, and Johansen, 1998; Jonsson et al., 2010; Pearson, Woodruff, and Sugarman, 1984). Pinto, Pearson, and Anderson, 1984; Moles and Wade, 2001; Heintz et al., 2000; Christiansen and George, 1995; Mahon, Addison, and Willis, 1987; Ott, Peterson, and Rice, 2001; Rice et al., 2000; Carls, Harris, and Rice, 2004; Short et al., 2004; Peterson et al., 2003)

7.6 Butterflies and odonates

For butterfly sampling a team of one observer and a recorder surveyed the designated grid for a pre-determined time of 20 minutes between 0900h to 1400h. Between two spatial sets of the time-constrained survey, a checklist of species sighted was generated at a point between the two spatial sets. A time constrained survey of three spatially independent sets of 20 minutes each were carried out in one of the grids (2 km from the rig, short-tall grassland interspersed with water puddles) for sampling odonates. The dragonflies and damselflies were photographed in the field and sometimes caught with a net and released without harming the individual after identification. A checklist was generated of species encountered between the spatial sets.

A total of 96 individuals belonging to 41 species of butterflies have been sighted from both the time constrained survey and the checklist generated at the sampled point (Appendix 7). The number of individuals sighted appears to linearly increase from the site of explosion until 5 km in the regions sampled (Figure 7.22). Species accumulation curve for 5 mins show that grids closer to the explosion site saturated earlier than the grids away from the explosion site (Figure 7.23). The habitats of all the grids sampled were similar; grids at 1km, 2km, 4km and 5km were short grassland, short-tall grassland, tall grassland-shrubland and short grassland-Agriculture, respectively. Our survey team has found carcasses of burnt odonates as well as live ones with oil film on wings

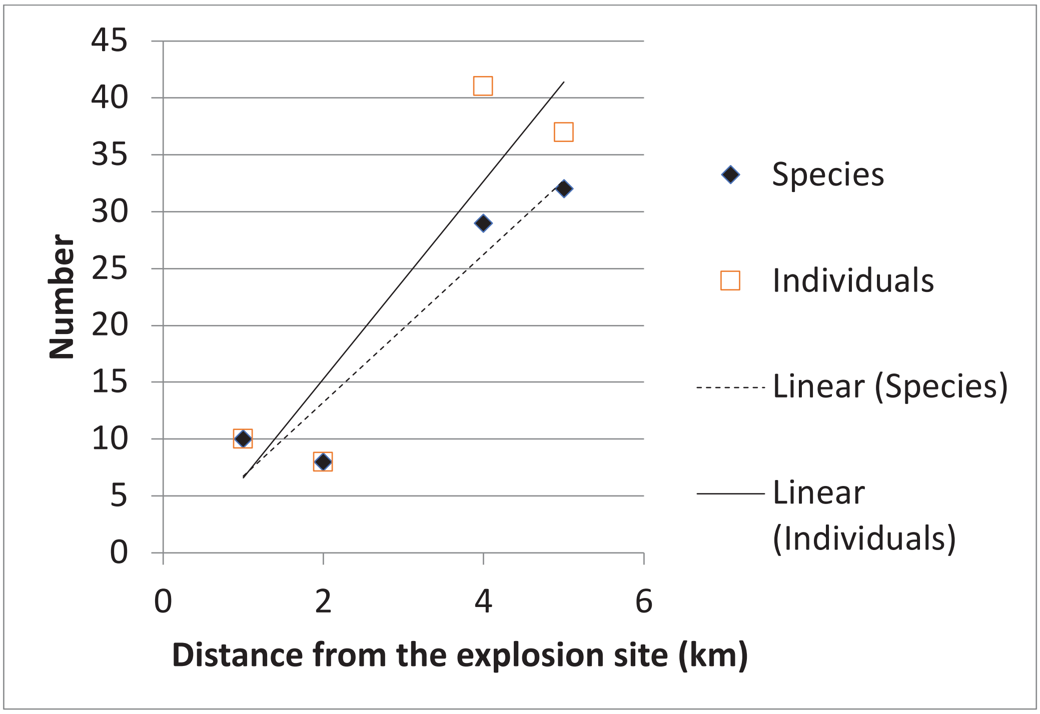

Figure 7.22 Species and number of butterflies encountered at varying distances from the explosion site

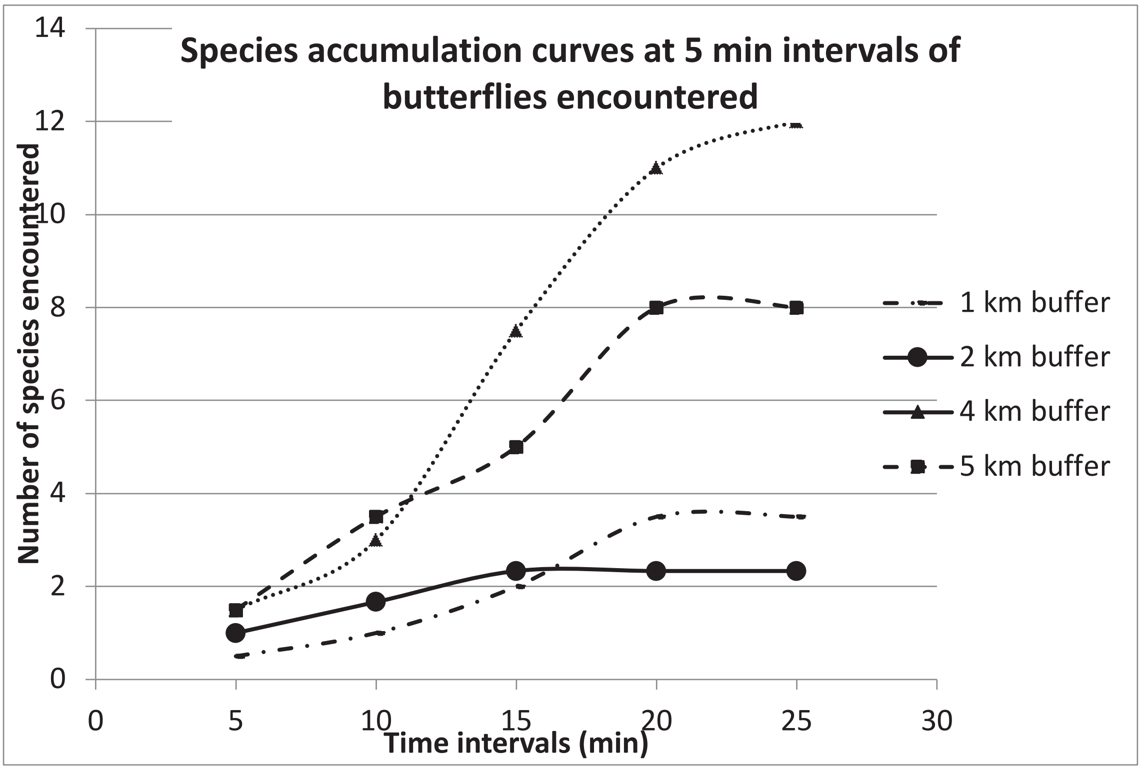

Figure 7.23 Species and number of butterflies encountered at varying distances from the explosion site at 5 minute intervals

A total of 34 individuals of 13 species of odonates were sighted during the survey (Appendix 8), and the IUCN status of all the species are Least Concern. Personal observations on field revealed the presence of oil film on wings of green marsh hawk and ditch jewel dragonfly and a carcass of a scarlet skimmer species with oil film on wings (Figure 7.24) were found.

The butterflies are very sensitive to minute changes in the ecosystem. Though the studies on impacts of oil spill on butterflies have been highly neglected, it may have direct or indirect effects on the population of butterflies. Different species prefer specific plant species as their host plants. The blowout and explosion resulted in severe damage to the vegetation of surrounding area including several host plants of butterflies. This may affect the oviposition, larval and pupal stages of butterflies. We also encountered several dead specimens of butterflies during our survey. In the area we surveyed, three species which are protected under Schedule II of the Wildlife (Protection) Act, 1972, are found, shows the importance of the area for butterfly conservation. However, to know the extent of effect of the incident on butterflies and their host plants short term and long-term impact assessment studies are needed in the area.

Figure 7.24 Carcass of scarlet skimmer with visible coating of oil on the wings

The dragonfly and damselfly spend the larval stages in water. A minute change in the water bodies can have effects on the eggs and larva of dragonflies and damselflies. Due to oil deposition in water the eggs, larva and nymphs will get damaged, therefore effecting the odonate population in the area. Meland et.al. (2019) found the damage of DNA in dragonfly nymph in the roadside ponds where sedimentation of polycyclic aromatic hydrocarbons (PAHs), alkylated PAHs and metals were encountered. Again, due to low DO level in the water bodies in the area the prey population of the odonates like fish fingerlings, tadpoles and other aquatic insects got affected. However, to understand the extent of impacts of the blowout and explosion both short term and long term impact assessment studies are needed.

The number of studies dealing with the effects of oil spill on insects are very low. The adverse impacts of petroleum and petroleum-derived substances on terrestrial insects and spiders have been confirmed in a few studies (Blakely et al. 2002; Rusin and Gospodarek 2016). Direct exposure to oil is known to negatively affect insects by altering different functions such as feeding and oviposition behaviour, gas exchange, cuticle permeability and cell membrane structural and functional destruction (Beattie et al.1995; Mensah et al. 1995; Bogran et al. 2006). The successful use of crude oil sprays in traditional integrated pest management programme to control butterfly and moth (Beattie et al. 1995, Mensah et al. 1995) indicates the potential of the negative effect that oil spills can have on Lepidoptera in contaminated areas. There is much that we don't know about the extent of effect oil spills can have on butterflies which warrants short term and long term impact assessment studies.

7.7 Herpetofauna

A time-constrained area search method was employed for sampling herpetofauna in each of the four grids (1 km, 2 km, 4 km and 5 km) for a pre-determined time of one hour. The sampling was carried out by active searches underneath logs, leaf litters etc. for presence of animals by 1-2 independent observers within the grid. The searches will be targeting potential regions for encountering common herpetofaunal group, namely skinks, agamids, geckos, snakes, chelonians, frogs and toads. This area has reported to have 17 amphibian, 13 turtle, 11 snakes and 8 lizard species (Appendix 9, 10 & 11)

A cumulative effort of 5.5 km was carried out in the four grids actively searching for the presence of any herpetofauna of any life stages. A total of 4 individuals of house geckos (*Hemidactylus* sp.) were found in one of the grids, herpetofauna were not encountered in any of the other grids. However, supplementary observations (opportunistic) of 9 species of reptiles were encountered in other locations (Figure 7.25 & Appendix 10 & 11). The microhabitat of all the herpetofauna found, including those found in the grid was human-habitation that had not burnt (Figure 7.25). Reports of *Euphlyctis cyanophlyctis* (Common skittering frog) in beel in 2018 is reported (iNaturalist, 2018). Though this one is a common species widely distributed across waters of different quality, not an individual was found in the regions sampled. A species thought to be extinct in wild was also rescued in a tea estate close by, the black soft-shell turtle *Nilssonia nigricans* (news report by Mubina Akhtar, 2020). There are also reports of the river banks of Dibru-Saikhowa National Park harbouring endangered species of turtles and also possibly their breeding. Some of these include the endangered *Chitra indica* (Gray, 1831), an endangered and a rarely sighted species, *Nilsonnia gangeticus* (Cuvier, 1825), a vulnerable and a frequently traded species, *Cuora amboinensis* (Daudin, 1802), a vulnerable and a declining species with this National Park being one of the strong holds of the wild population, *Cyclemys gemeli* Fritz, Guicking, Auer, Sommer, Wink and Hundsdorfer, 2008, *Pangshura tecta* (Gray, 1831), *Pangshura tentoria* (Gray, 1834), a not evaluated and a poorly known species, *Pangshura sylhetensis* (Jerdon, 1870), an endangered and a protected species and *Melanochelys tricarinata* (Blyth, 1856), a vulnerable species whose populations are restricted to protected areas (Ahmed and Das, 2010).

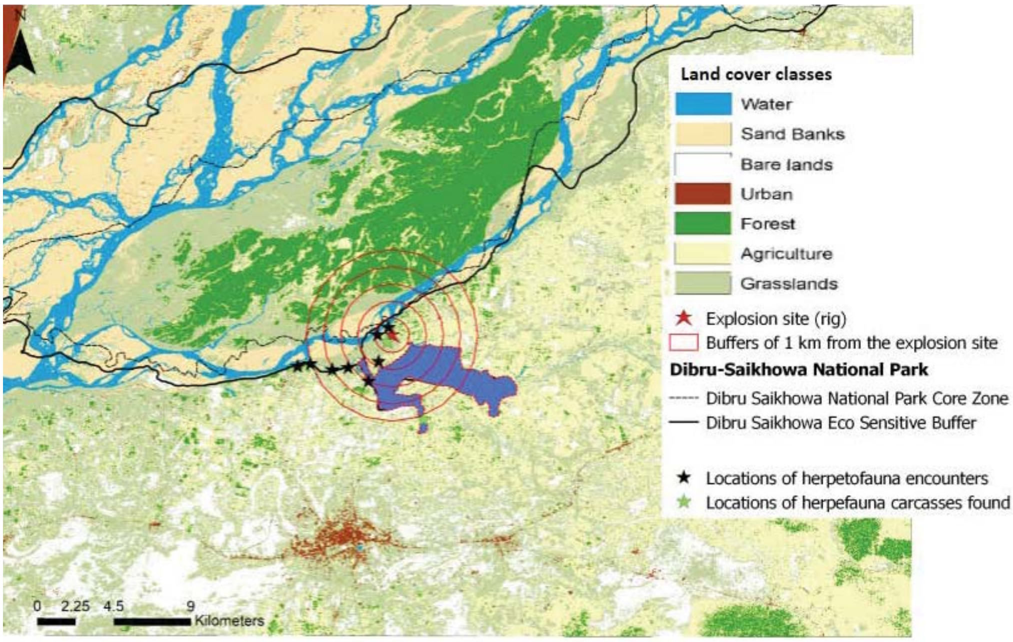

Figure 7.25 Location of herpetofauna opportunistic encounters (both live and carcasses) during the survey period (02/06/2020 – 07/07/2020) (details of the herpetofauna are given in Appendix 9, 10 & 11)

We have found live herpetofauna from 500 m, up to 6 km from the oil well explosion site and carcasses at 400 m to 6 km; the former was found burnt while the latter drowned due to reasons unknown. The lack of any encounters of tadpoles in the multiple water pools that were encountered in the grids, despite being breeding season for many species, is a great concern. Though this time of the year in a flood-prone season makes it difficult to discern whether the cause of apparent wipe out of herpetofauna is floods or the explosion, the direct impacts of explosion through burn down is certain for at least 500 m, and impacts of oil spill remains a crucial component to answer. The survey was restricted to daylight only as flooding and lockdown of site after fire created night sampling issues. The checklist is partial and list of Ahmad and Das (2020, Appendix 10 & 11) provides what will be expected in this area.

Besides, the extent of damage, oil spill can have both short term and long term impacts on herpetofauna. On 9th December 2014, a severe oil spill incident that occurred in the mangrove ecosystems of Sundarbans and caused death of several water monitors (Mijanur and Iliazovic, 2016). Evidences of PAH (polycyclic aromatic hydrocarbons), have been found in the gut, liver and kidney of sea snakes suggesting possibilities of PAHs being circulated in the marine food chain (Mote et al., 2015). Similarly, toxics can slow tadpole response times or swimming ability, making them more vulnerable to predators and less able to find food. Contaminants can also interfere with sexual development, reproduction, and thyroid functioning, which may cause tadpoles to grow but not undergo metamorphosis. They can also impair immune functions, making tadpoles or juvenile frogs more vulnerable to disease (Sparling et al., 2010). Amphibians are one of the sensitive taxa, especially their skin with many also having cutaneous respiration. Any oil film that covers the skin is likely to cause a reduction in their respiration rates. Similarly, reptiles already suffer from lack of large scale data (40 % remain not evaluated by the IUCN with 16% of the evaluated ones stand as Data Deficient, IUCN, 2017) and communal myths and illegal trade that threaten their lives across India. There are few habitats where the diversity and populations of herpetofauna can flourish. Preserving these habitats is imperative to retaining our biodiversity value. Dibru-Saikhowa Biosphere Reserve that includes the core zone of the National Park and the Maguri-Motapung beel is recognized for the same purpose. Any potential hazards in this region threatens one of the strong holds of population of at least 9 species of chelonians (turtles and tortoises; Ahmed and Das, 2010), among the 42 species of reptiles and 17 species of amphibians that inhabit this region (Nongmaithem et al., 2016)(Appendix 9, 10 & 11). This sums up to one twelfth of reptilian species found in India. We suggest considering abatement of hazards that will potentially threaten the efforts that are being made to conserve the biodiversity in these regions. This holds true especially for oil well blowout, though at times accidental and at times due to negligence of appropriate hazard management strategies that not only have a short term impact but a long term and a far reaching impact. Flood prone regions, like our region of interest, the Dibru-Saikhowa Biosphere Reserve, could spread the oil spill at far distances through the running water that can have a devastating impact kilometers away from the actual site of oil well blowout.

7.8 People

We have not done any work on socio-economics and health impacts on humans. The oil well blow out had economic and health impact on humans (Rishu Kalantri 2020, thelogicalindian.com). The contaminants will have long term impact on human heath, which need to be assessed properly and need appropriate mitigation measures.

8 Conclusion

The area around the spill over is of high biodiversity value. The spill has resulted in mass mortality and severely impacting the environmental condition resulting in debilitating conditions for species to survive. The toxic fumes and oil coating has universally affected flora and fauna. The contaminants and oil continue to be released in surrounding areas and immediate steps are needed to contain this spill over. The toxins released are known to have long-term persistence in soils and sediments, which will not only affect current life conditions, but due to sustained release over a long period, pose a serious health risk for a longer term.

There are two major issues with companies operating oil and gas wells in Assam, a) Management of oil spills from their wells, and b) emergency response readiness and effectiveness in terms of major accidents. The oil leakage is a chronic problem and leaching of oil in water and underground have ecological and health cost. As has been observed in the case of several wells across Eastern Assam. As far as major accidents like well blowout in Assam the entire focus is on closure of well and no restorative process is put in place for remediation of effect of oil in terrestrial or aquatic system.

Two oil well blow outs earlier occurred in Assam, Dikom (Gogoi et al., 2007) and Naharkatia-Deohal (Lahiri et al., 2012).. We are unable to get any meaningful information about restoration of surrounding area. Same looks like the case in Baghjan with no effort to engage experts for remediation due to oil spill. OIL does not have any information on their website nor they provided information about their emergency plans as to how to deal with leaks and blowouts and restoration plans in case of oil spill

The evaluation of landscape and biodiversity indicate large-scale impact of oil spill on flora and fauna. Our evaluation indicates much higher level of PAHs pollutants some of which are carcinogenic are in the ecosystem. Excessive noise level, produced by the blowout is detrimental to animal and human health. Impact of sound may be taken care after plugging. Effect of PAHs are going to be there in ecosystem for long term. Decline in Ganges dolphin use of this area, as well as death of one dolphin, mortality of fishes, insects, herpetofauna, birds and impact on health of most of the animals are related to oil spill and well blowout.Humans in this area are also impacted. Decline in mammals, birds, insects and herpetofauna will take time and restorative efforts are needed to regain to former diversity levels. Vegetation in large area is sprayed with oil due to blow out and have impacted the landscape.

Given the fragility and seismicity of the landscape, the impact of the oil blow out, and importance along with the uniqueness of biodiversity existing in the area, following needs to be done for safeguarding this landscape:

1) The potential of oil blow out and oil spill like disaster like this a reality and therefore such oil wells in the vicinity of Dibru-Saikhowa National park and IBA complex (Maguri and Motapung, Poba Reserve Forest, Kobo chapori, Amarpur chapori and) will be detrimental to the conservation value of this unique ecosystem. Due consideration needs to be given to this threat for future development.
2) More than 25 wells (Dibru-Saikhowa ESZ notification) are planned and almost same number exist in this conservation complex/s (Dibru-Saikhowa National Park, Bherjan Wildlife Sanctuary, Padumani Wildlife Sanctuary and Borajan Wildlife Sanctuary, Important Bird Areas (IBA) Poba Reserve Forest, Kobo chapori, Amarpur chapori and Maguri and Motapung, Dihing-Patkai Wildlife Sanctuary) needs to be re-evaluated for their cumulative impact on biodiversity value of this landscape.
3) Safety audit for all other wells currently operating or planned need to be done. Risk management study need to be done to ensure appropriate risk mitigation strategies.Detail management plan needs to be developed for safety measures and dealing with oil leakage.
4) Observing the ecological disaster caused by this incident, the proposed oil exploration and development in Mechaki, Mechaki extension, Baghjan and Tinsukia Extension PML (MoEFCC EC dated 9th April, 2020) needs to be reaassesed, since this is the habitat of Critically Endangered species of this region.
5) OIL should have dedicated team and advanced training of their personnel to deal with emergencies arising out of leakage, blow out and any other accidents which is possible due to extraction, transportation and storage of highly volatile and risky chemicals.
6) Adequate finances should be for all restorative work in Wildlife areas Protected or otherwise and compensate local people for their losses. There should be annual payment to Forest Department for restoration and subsequently for management of this conservation complex. Adequate consultation by Forest Department should be done to involve experts in the field of Oil spill remediation and restoration.
7) A long term study should be initiated to understand the long-term impact of this oil spill and blowout impact on the ecology and environment of Maguri-Motapung beel and Dibru-Saikhowa National Park as well as on the health and socio-economic conditions of local communities

around the affected areas. Impact of the oil spill on the livelihood of local communities especially on ecotourism based on Maguri-Motapung beel and Dibru-Saikhowa National Park needs to be assessed.

8) Restoration will be long-term process and appropriate committee should be formed to develop, monitor and guide the process.

9 Methods in detail

9.1 Measuring change: River morphology

Geomorphology helps in understanding the relationship between river forms and processes, water and sediment fluxes, ecosystem and habitat relationships. This data along with land cover changes is used to understand the changes in river morphology. Due to changes in the rivers this national park has become an island (Figure 2.1). River transects were done to asses change in sand deposition rates. As the river morphology changes have occurred around 1993 to 2005 the study considers landcover data from the years 1985,1995, 2005 and 2019-20 to measure these quantitatively.

Land use and land cover (LULC) have 19-classes,sourced from Earth Data repository DAAC. These datasets are for India and are of time periods 1985, 1995, 2005, 2019-20. These maps were derived using Landsat 4 and 5 Thematic Mapper (TM) for 1985, Enhanced Thematic Mapper Plus (ETM+), and Multispectral (MSS) data for 1995, India Remote Sensing satellites (IRS) data for 2005 and 2019-20. The data were classified according to the International Geosphere-Biosphere Programme (IGBP) classification scheme. In this study we aggregated 19 classes into 4 classes as we are looking for changes in river morphology, Waterbodies, Vegetation, Urban and other.

9.2 Channel shift rate:

From the land cover maps all the surface water bodies are extracted and channels are separated from this data and then for each time period channel shift rate is calculated using the formula given below.

$$rate = \forall i \in (1, n)\ (w\,1 \cap g\,i\,,\ w\,2 \cap g\,i\,)/(t\,2 - t\,1\,)$$

where g is the set of grids, t represents the time and w represents the surface water.

The area is divided into grids and for each grid channel shift rate is calculated. Displacement is calculated from the shift of channel from one time period to another. It is observed that the shift rates are more towards the Himalayan foothills and are ranging from 0 to 240 per year. To understand the impact of sand deposits we have integrated this information with geological information to derive braiding index.

9.3 Braiding index

The Brahmaputra River flows along the alluvial valley as a wide braided river. Braiding also happens in tributaries of Brahmaputra in Assam plains. The width of the river varies with time along its course. The braiding intensity of this river is estimated using the braiding index (BI) of Brice (1964). River width is extracted from land cover data. River transects are done to assses sand bars formed along the river and then the ratio of that with the length of the river is found to derive the braiding index.

Also it is observed that channel width has a positive correlation with braiding index and so there is an increase in the index value with the increase in channel width.

$$\text{Braiding index} = 2\,(Li)/L, \text{ Where}$$

Li = sum of the length of the braid bars and islands in a particular segment of the river

L = length of the course of the river in that particular segment.

The river transects are done for every grid to understand the silt deposits and water flow. This output is used in deriving the braiding index across the region.

9.4 Measuring pollution levels using geospatial methods

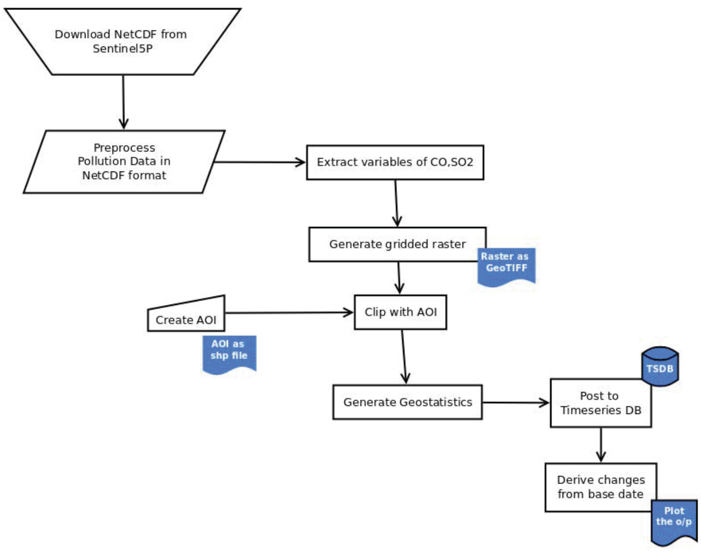

Figure 9.1 Flow diagram shows the process of deriving the geostatistics for the pollution levels.

To measure the pollution levels European Space Association's Sentinel 5 precursor satellite is used (Figure 9.1). This satellite is specifically launched to monitor air quality with high temporal resolution. There are several products available in Sentinel 5P mission to understand and quantitatively assess air quality. NO_2, SO_2, CH_4, CO are all available for different scenarios. In this particular case to understand the impact of oil spill blow out Carbon monoxide(CO), Sulphur Dioxide (SO_2) and HCHO (formaldehyde) product is used.TROPOMI instrument gives product at a spatial resolution of 7 km by 3.5 km which is fairly good to estimate impact of pollution at regional level. This data is accessed from sentinel Copernicus openhub. The data comes in NetCDF format and SNAP tool of ESA is used to convert the product to a raster to extract the required information. Data before the blow out and after the blow out are taken to check the levels in Tinsukia. Extraction at small scale is challenging interms of picking localized changes.

Pollution level is calculated using following formula

$$P(t) = \forall\ g \epsilon G, max(DN(\cap_i^n \quad (g_i \cap bbox)))$$

Where P(t) = pollution at time t

G = set of raster grids and bbox is the referenced envelope of the area of interest. In this case study we have used EPSG:4326 for map projections.

Once pollution level is calculated, percentage change is calculated using the formula below

$$\delta_t = 100 * (P(t) - P(1)/P(1))$$

These delta values are plotted to observe the variations in CO and SO_2 levels.

9.5 Impact on land surface temperature

Landsat and MODIS LST product is used to make some observations.Both morning and night temperatures are captured by MODIS Aqua and Terra satellites which provide better picture of the variations.

9.6 River and Wetland Pollution mapping

For mapping oil pollution Sentinel 1 SAR was used (Ozigis et al 2018) as it can penetrate clouds and detect changes in the land surfaces.

9.7 Pollution – water quality

The primary objective of this study was to estimate the overall toxic effect of 16 PAHs compounds [Naphthalene (NaP), Acenaphthylene (Acpy), Acenaphthene (Acp), Fluorene (Fl), Phenanthrene (Phe), Anthracene (Ant), Fluoranthene (Flu), Pyrene (Pyr), Benz[a]anthracene (BaA), Chrysene (Chr), Benzo[b]fluoranthene (BbF), Benzo[k]fluoranthene (BkF), Benz[a]pyrene (BaP), Dibenzo[a,h]anthracene (DbA), Benzo[g,h,i]perylene (BghiP), Indeno[1,2,3-cd] pyrene (InP)] in the aquatic ecosystem of the impacted area.

A detailed sampling was conducted to evaluate the impact of oil blowout and a total of 29 samples, including water (n – 12), sediments (n – 12) and fishes (n – 5) were collected from the highly impacted area of the Maguri-Motapung wetland, Dibru and Lohit river. The blubber sample (n - 2) of endangered Gangetic dolphin was also collected from the carcass of dolphin found in Maguri-Motapung wetland. Water samples (1 lit) at each sampling point were collected into pre-cleaned sterilized amber HDPE (High Density Polyethylene) bottles from the Maguri-Motapung wetland and from the main channel of Lohit and Dibru rivers. Waterbed sediments (100 gm) were grabbed in sampling container from the bottom and banks of the river and wetlands where fine-textured substrate had accumulated. Dead fish samples (n - 5) of five different species, namely *Mystus Vittatus, Channa orientalis, Rasbora daniconus, Puntius Sophore* and *Eutropiichthys vacha* were collected from the two sites (Maguri—Motapung wetland and Lohit river). After sampling, all collected samples (water, sediment, fish & blubber) were immediately stored in an ice-chest at 4°C and transported to the Shriram Institute of Industrial Research, New Delhi (accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL), a constituent board of Quality Council of India (QCI) as per ISO/IEC: 17025 in the field of testing) for laboratory analysis. PAHs content in water, sediment and fish tissues was analysed by using Gas Chromatography (GC-FID) and validated and confirmed by GC-MS/MS.

To assess the presence and extent of oil spill, the contaminated water and sediment samples were collected from the sites (Figure 9.2) at intervals of 1 km. Along with sample collection, water quality was also assessed at the same points. Testing the quality of water is an important part of environmental monitoring (Ritabrata, 2018). The results obtained from our study were compared with guidelines values (permissible limits) which is standardized by BIS (Bureau of Indian standards,1991) CPCB (IS 2296:1992) and WHO (World Health Organisation, 2011). The quality of water can be determined through measuring the essential physiological parameters such as pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Conductivity, Specific Conductance Temperature and PAH's pollutants. Except chemical pollutants all parameters were measured with the help of a YSI Professional Digital Sampling System (Pro-DSS- USA). The instrument was programmed to log the data for every 3 minutes in Lohit river and for every 5 seconds in Dibru river and Maguri-Motapung beel. The raw data was stored in the logger of the instrument which was later retrieved using KorDss software and Data Manager software respectively, for statistical analysis.

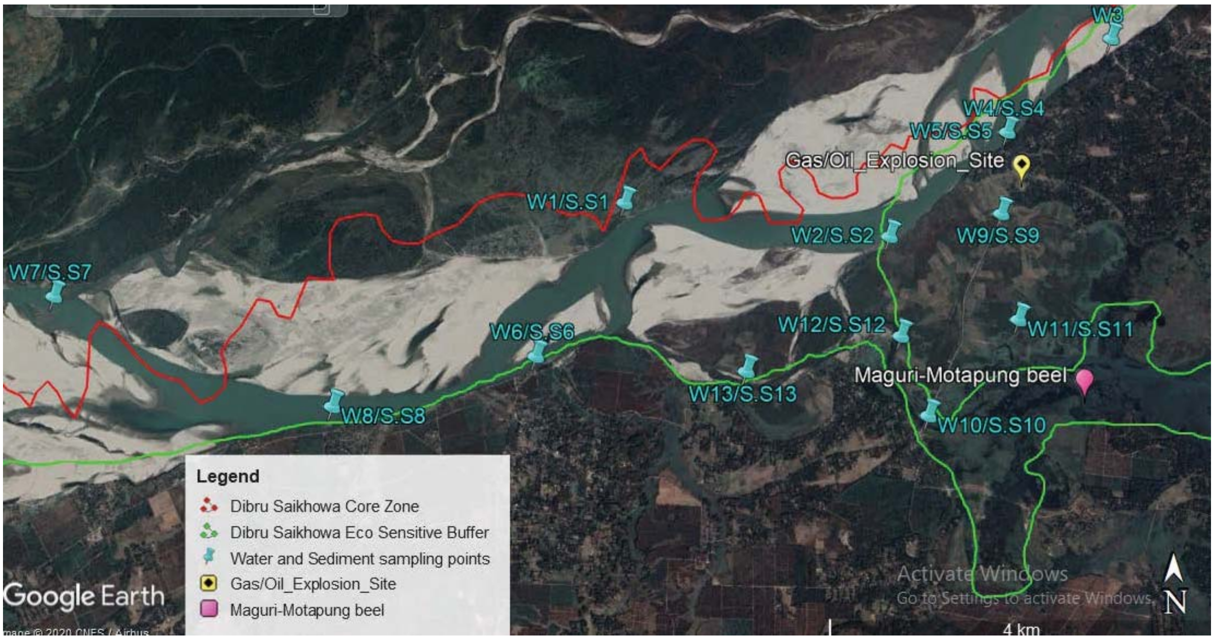

Figure 9.2 Study area map indicating all samplings points assessed before explosion

Physiochemical parameters were measured at each of the sampling points in Lohit river. sampling points from W1 toW8). The Dissolved oxygen (DO) of the river vary with time and season, depending upon the species of phytoplanktons present, light penetration (Tripathi et al., 1991; Das et al., 2013), nutrient availability, temperature, salinity, water movement, partial pressure of atmospheric oxygen in contact with the water, thickness of the surface film and the bio-depletion rates (Ifelebuegu et al. 2017)). It is an important limnological parameter that indicates the level of water quality and organic pollution in the water body (Wetzel and Likens, 2006, Khatoon et al., 2013).

9.8 Sound pollution:

The ambient noise was recorded at a sampling rate of 48 kHz. The strength of the signals obtained were optimized by adjusting and noting down the gain, as it is an important parameter while recording the sounds using microphone; low gain misses quieter sounds and high gain saturates the recording.

A total of 13 soundwave files were obtained and analysed using Raven Pro 1.5 software (The Cornell Lab). With the recordings, a spectrogram was generated to visualize the spectrum of frequencies (i.e. the amount of energy in the sound at each frequency) of the signal.

For each of our 13 sound recordings, we selected the required sound clip on the spectrogram from Raven software and measured the following

a) Average Power: In a grayscale spectrogram, it is the value of the power spectrum (the power spectral density of a single column of spectrogram values) averaged over the frequency extent of the selection. The values of the power spectrum are summed between the lower and upper frequency bounds of the selection, and the result is divided by the number of frequency bins in the selection.

Units: dB.

b) Maximum/peak power: In a selection it is the power at the darkest point in the selection. Units: dB re 1 dimensionless sample unit.

From the power and frequency values obtained, we converted the dB reference level to A-weighted dB levels in RStudio. A-weighted dB filter is a psycho-acoustical measure that that converts the sound level into a human subjective measure. The full frequency range for young people is 20 to 20,000 Hz, and between 500 Hz and 6,000 Hz human ears are more sensitive than that to lower or higher frequencies. The conventions used here to denote these terms are as follows, LA= A-weighted power, LAeq= equivalent A weighted power, LAmax= maximum A weighted power. LA is synonymous with dBA and dB(A) and is often written as LA = xdB.

9.9 Underwater noise monitoring

Passive acoustic monitoring (PAM) device (The Cetacean Research™ C57 hydrophone series) along with the portable digital field recorder Tascam DR-100 (TASCAM Inc.) were used to monitor underwater sound in July 2020. They were deployed at 500m intervals of the river to get a sound profile. The sampling rate (the number of samples per unit taken from a continuous signal to make a discrete or digital signal) was 192kHz, and the gain was set at 5 to get recordings without saturating the file. The analysis was done for 12 records in RStudio after calibrating for hydrophone sensitivity at that particular gain to get the absolute measure to draw comparison spatially. Each recording was 1 minute long, adding up to a total of 12 minutes.

9.10 Dolphin monitoring

Independent double observer method was followed for the Ganges dolphin surveys (Smith, 2006). In double-platform independent observer surveys, sighting data from each platform represents an independent capture occasion, were used in a two-sample capture-recapture framework for estimation of population abundance along with estimates of capture probabilities and precision. We used Chapman's unbiased estimator (Chapman, 1951) to obtain an estimate of the number of dolphins.

$$\hat{\mathrm{N}} = \left(\frac{(\mathrm{n_p} + 1) \times (\mathrm{n_s} + 1)}{\mathrm{m_{ps}} + 1}\right) - 1$$

Where,

$\widehat{\mathrm{N}_c}$= population size estimate

n_p = number of animals sighted by the primary observer team

n_s = number of animals sighted by the secondary observer team

m_{ps} = number of animals sighted by both teams (matches or recaptures)

The probability of detection is estimated as m_{ps}/n_p, m_{ps}/n_s

The associated variance V_c is given by (Seber 1970):

$$V_c = \frac{(\mathrm{n_p} + 1) \times (\mathrm{n_s} + 1) \times (\mathrm{n_p} - \mathrm{m_{ps}}) \times (\mathrm{n_s} - \mathrm{m_{ps}})}{(m_{ps} + 1)^2 \times (m_{ps} + 2)}$$

The upper and lower ranges of the 95% confidence interval were calculated as

$$95\%\ \mathrm{CI} = \widehat{\mathrm{N}_c} \pm (1.96 \times \mathrm{SD})$$

9.11 Acoustic monitoring of dolphins

Passive acoustic monitoring (PAM) devices were used to understand occurrence and activity pattern of dolphins. C-PODs are one such underwater acoustic loggers meant for cetaceans, that have a single hydrophone with a frequency range of 20 to 160 kHz. The data are logged on to a memory card and retrieved using the C-POD software. Dolphin clicks are separated from other ambient noise using the in-built function in the software, the KERNON classifier. The automated classifier segregates all acoustic recordings into 'NBHF' (narrow band high frequency), 'Other Cetacean' (which includes river dolphin), 'Sonar' and 'Unclassified'. The classifier also classifies the click trains to 'high', 'moderate', 'low' or 'doubtful' clicks, where 'high' indicates click trains that have a ≥75% likelihood of being dolphins. To reduce false positives, we used only 'high' and 'moderate' quality click trains of river dolphins. The CPODs were moored with the required weight and buoys to aid in maintaining the hydrophone in the 30-50% of the water column. This aids in reducing sediment noise and surface noise and optimizes capturing cetacean sounds.

9.12 Biodiversity methods

The survey was done from May, to July 2020. Survey for all these taxa was carried out in grids identified within the concentric circles around well blow out site (Fig 9.3)

Bird:

The habitat in the affected area is segregated into Grassland and wetland. Transects were walked in the grassland regions and boat transects were carried out in the wetland area between 09:00h – 14:00h. A cumulative effort of 3.48 km transect was carried out in the grasslands falling at distances of 1, 2, 4 and 5 km from the explosion site. A cumulative effort of 11 km was in the beel (wetland) area. Data from ebird was downloaded and used to draw comparisons between earlier occurrence reports at locations that fall within our sampling grid and current occurrence. Available data in our sampling regions (from 2010 onwards) are arranged according to sampled grid in Grassland and wetland.

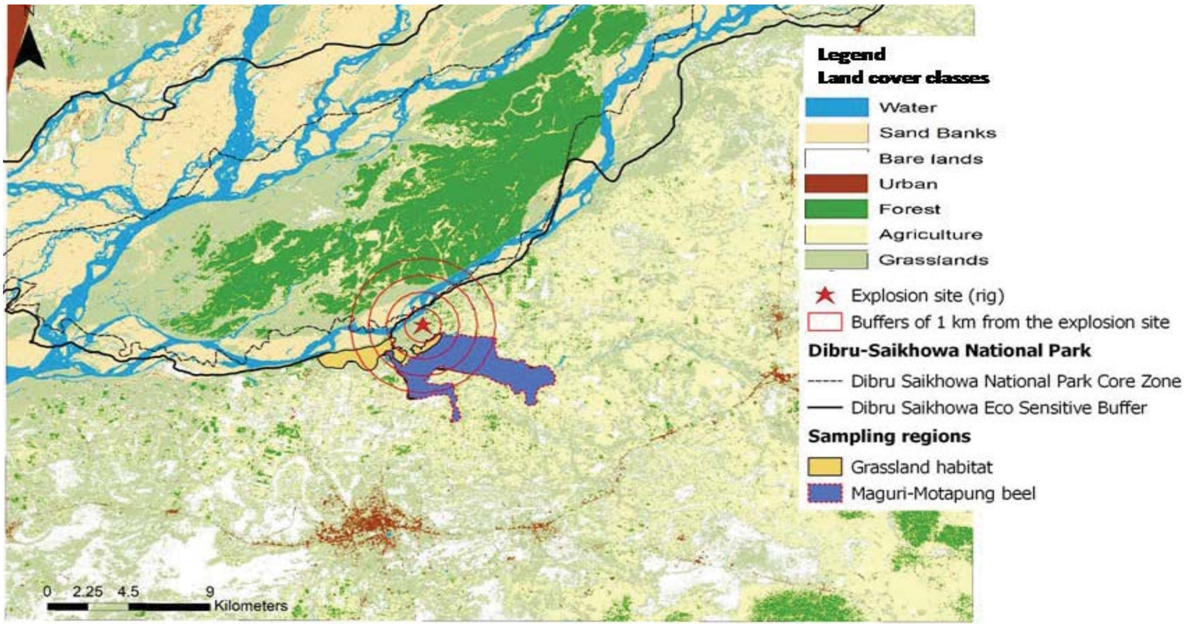

Figure 9.3 Sampling regions, concentric circles of 1km from Baghjan well no.5 (accident site).

Fish: The sampling was carried out with (1.75x1.75 cm, 3.75x3.75 cm, 5x5 cm, 10x10 cm) mesh size of gill net and (0.25x0.25 cm) mesh size of cast net were used for sampling. Gill net was deployed for 60 mins and cast net was cast for 10 times on each site (Table 9.1). The sampling was done after 1.5-2kms of interval. Fishes caught in the net were photographed, weighed and morphometry was recorded for analysis. We followed published taxonomic keys to identify species (K. C. Jayaram 2010) and online identification keys like the Fish base (www.fishbase.org), (Frose and Pauly 2000). Species were then assigned to their threatened status following the IUCN red list category. The helath status of fishes caught was also assessed. Dead fishes were collected for effect of pollutants.

Table 9-1 Types of nets used and the effort invested in Maguri-Motapung Beel and Dibru for fish sampling.

Nets	Mesh Size	Length	Effort per site	Total effort
Cast net	0.25 x 0.25 cm	3 m	10 trails	80 trails
Gill net-1	1.75 x 1.75 cm	100 m	1 hr	8 hrs
Gill net-2	3.75 x 3.75 cm	100 m	1 hr	8 hrs

Gill net-3	**5×5 cm**	**100 m**	**1 hr**	**8 hrs**
Gill net-4	**10 x 10 cm**	**100 m**	**1 hr**	**8 hrs**

Butterflies and Odonates: A team of one observer and a recorder surveyed the designated grid for a pre-determined time of 20 minutes between 0900h to 1400h. Between two spatial sets of the time-constrained survey, a checklist of species sighted was generated at a point between the two spatial sets. A time constrained survey of three spatially independent sets of 20 minutes each were carried out in one of the grids (2 km from the rig, short-tall grassland interspersed with water puddles) for sampling odonates. The dragonflies and damselflies were photographed in the field and sometimes caught with a net and released without harming the individual after identification. A checklist was generated of species encountered between the spatial sets.

Herpetofauna:

A time-constrained area search method was employed for sampling herpetofauna in each of the four grids (1 km, 2 km, 4 km and 5 km) for a pre-determined time of one hour. The sampling was carried out by active searches underneath logs, leaf litters etc. for presence of animals by 1-2 independent observers within the grid. The searches will be targeting potential regions for encountering common herpetofaunal group, namely skinks, agamids, geckos, snakes, chelonians, frogs and toads. This area has reported to have 17 amphibian, 13, turtle, 11 snakes and 8 lizard species. A cumulative effort of 5.5 km was carried out in the four grids actively searching for the presence of any herpetofauna of any life stages. Sampling was done only during day time, so the list is partial. The checklist of the area (Ahmed and Das, 2010) will be used to assess the probable species present in the area

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11 Appendix 1 – Burned area visualisation

Google Earth engine is used to generate cloud free Sentinel 2 images to observe the burned area.

```
var roi = ee.Geometry.Point([95.37898, 27.60028]).buffer(5000);
/**
 * Function to mask clouds using the Sentinel-2 QA band
 * @param {ee.Image} image Sentinel-2 image
 * @return {ee.Image} cloud masked Sentinel-2 image
 */
function maskS2clouds(image) {
  var qa = image.select('QA60');
  // Bits 10 and 11 are clouds and cirrus, respectively.
  var cloudBitMask = 1 << 10;
  var cirrusBitMask = 1 << 11;
  // Both flags should be set to zero, indicating clear conditions.
  var mask = qa.bitwiseAnd(cloudBitMask).eq(0)
            .and(qa.bitwiseAnd(cirrusBitMask).eq(0));
  return image.updateMask(mask).divide(10000);
}
var dataset1 = ee.ImageCollection('COPERNICUS/S2_SR')
            .filterDate('2020-05-01', '2020-05-31')
            // Pre-filter to get less cloudy granules.
            .filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE',20))
            .map(maskS2clouds);
var dataset2 = ee.ImageCollection('COPERNICUS/S2_SR')
            .filterDate('2020-06-1', '2020-06-30')
            // Pre-filter to get less cloudy granules.
            .filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE',20))
            .map(maskS2clouds);
var visualization = {
  min: 0.0,
  max: 0.3,
  bands: ['B4', 'B3', 'B2'],
};
Map.setCenter(95.37898, 27.60028, 15);
Map.addLayer(dataset1.mean().clip(roi), visualization, 'May'); Map.addLayer(dataset2.mean().clip(roi
```

12 Appendix 2 Checklists of birds recorded earlier from the grasslands (same grids we sampled) collected from eBird site.

S.no.	VernacularName	Scientific Name	Resident/ Migratory
1	Black-faced Bunting	*Emberiza spodocephala* Pallas, 1776	Winter
2	Red-wattled ng	*Vanellus indicus* (Boddaert, 1783)	Resident
3	Thick-billed Warbler	*Arundinax aedon*	Winter
4	Chestnut-tailed Starling	*Sturnia malabarica* (Gmelin, 1789)	Resident
5	Indochinese Roller	*Coracias affinis* McClelland, 1840	Resident
6	Red-vented Bulbul	*Pycnonotus cafer* (Linnaeus, 1766)	Resident
7	Tickell's Leaf Warbler	*Phylloscopus affinis* (Tickell, 1833)	Winter
8	Green Imperial-Pigeon	*Ducula aenea* (Linnaeus, 1766)	Resident
9	Siberian Stonechat	*Saxicola maurus* (Pallas, 1773)	not found
10	Lesser Whistling-Duck	*Dendrocygna javanica* (Horsfield, 1821)	Resident
11	Greater Painted-Snipe	*Rostratula benghalensis* (Linnaeus, 1758)	Resident
12	Striated Grassbird	*Megalurus palustris* Horsfield, 1821	Resident
13	Jerdon's Babbler	*Chrysomma altirostre* Jerdon, 1862	Resident
14	Zitting Cisticola	*Cisticola juncidis* (Rafinesque, 1810)	Resident
15	Great Myna	*Acridotheres grandis* Moore, 1858	Resident
16	Lesser Coucal	*Centropus bengalensis* (Gmelin, 1788)	Resident

17	Marsh Babbler	*Pellorneum palustre* Gould, 1872	Resident
18	Citrine Wagtail	*Motacilla citreola* Pallas, 1776	Winter
19	Cinnamon Bittern	*Ixobrychus cinnamomeus* (Gmelin, 1789)	Resident
20	Jungle Myna	*Acridotheres fuscus* (Wagler, 1827)	Resident
21	Greater Coucal	*Centropus sinensis* (Stephens, 1815)	Resident
22	Yellow Bittern	*Ixobrychus sinensis*	Resident
23	Paddyfield Pipit	*Anthus rufulus* Vieillot, 1818	Resident
24	Indian Spot-billed Duck	*Anas poecilorhyncha* Forster, 1781	Resident
25	Little Cormorant	*Microcarbo niger* (Vieillot, 1817)	Resident
26	Yellow-bellied Prinia	*Prinia flaviventris* (Delessert, 1840)	Resident
27	Black Drongo	*Dicrurus macrocercus* Vieillot, 1817	Resident
28	Common Myna	*Acridotheres tristis* (Linnaeus, 1766)	Resident
29	Plain Prinia	*Prinia inornata* Sykes, 1832	Resident
30	Rufous Treepie	*Dendrocitta vagabunda* (Latham, 1790)	Resident
31	Bristled Grassbird	*Chaetornis striata*	Winter
32	Bluethroat	*Luscinia svecica* (Linnaeus, 1758)	Winter
33	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	Resident
34	White Wagtail	*Motacilla alba* Linnaeus, 1758	Winter
35	Gray-headed Swamphen	*Porphyrio poliocephalus* (Latham, 1801)	Resident
36	Spotted Bush Warbler	*Locustella thoracica* (Blyth, 1845)	Winter
37	Barn Swallow	*Hirundo rustica* Linnaeus, 1758	Winter

38	Gray-throated Martin	*Riparia chinensis* (J.E.Gray, 1830)	not found
39	Brown Boobook	*Ninox scutulata* (Raffles, 1822)	Resident
40	Swamp Francolin	*Francolinus gularis* (Temminck, 1815)	Resident
41	Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)	Resident
42	Common Tailorbird	*Orthotomus sutorius* (Pennant, 1769)	Resident
43	Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766)	Resident
44	Black-winged Kite	*Elanus caeruleus* (Desfontaines, 1789)	Resident
45	Chestnut-capped Babbler	*Timalia pileata* Horsfield, 1821	Resident
46	Black Kite	*Milvus migrans* (Boddaert, 1783)	Resident
47	Eurasian Tree Sparrow	*Passer montanus* (Linnaeus, 1758)	Resident
48	Clamorous Reed Warbler	*Acrocephalus stentoreus* (Hemprich & Ehrenberg, 1833)	Resident
49	Dusky Warbler	*Phylloscopus fuscatus* (Blyth, 1842)	Winter
50	Gray Heron	*Ardea cinerea* Linnaeus, 1758	Resident
51	White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	Resident
52	Chinese Rubythroat	*Calliope tschebaiewi*	not found
53	White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	Resident
54	Asian Pied Starling	*Gracupica contra* (Linnaeus, 1758)	Resident
55	Black-hooded Oriole	*Oriolus xanthornus* (Linnaeus, 1758)	Resident
56	Barred Buttonquail	*Turnix suscitator*	Resident
57	Black-crowned Night-Heron	*Nycticorax nycticorax* (Linnaeus, 1758)	Resident

58	Asian Koel	*Eudynamys scolopaceus*	Resident
59	Bengal Bushlark	*Mirafra assamica* Horsfield, 1840	Resident
60	Aberrant Bush Warbler	*Horornis flavolivaceus* (Blyth, 1845)	Winter
61	Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	Resident
62	Asian Openbill	*Anastomus oscitans* (Boddaert, 1783)	Resident
63	Purple Heron	*Ardea purpurea* Linnaeus, 1766	Resident
64	Rosy Pipit	*Anthus roseatus* Blyth, 1847	Winter
65	Spotted Dove	*Streptopelia chinensis* (Scopoli, 1786)	Resident
66	Rose-ringed Parakeet	*Psittacula krameri* (Scopoli, 1769)	Resident
67	Oriental Magpie-Robin	*Copsychus saularis* (Linnaeus, 1758)	Resident
68	Gray Wagtail	*Motacilla cinerea* Tunstall, 1771	Winter
69	Indian Cuckoo	*Cuculus micropterus*	Summer
70	Great Egret	*Ardea alba* Linnaeus, 1758	Resident
71	Eurasian Hoopoe	*Upupa epops* Linnaeus, 1758	Resident
72	House Crow	*Corvus splendens* Vieillot, 1817	Resident
73	Baya Weaver	*Ploceus philippinus* (Linnaeus, 1766)	Resident
74	Oriental Turtle-Dove	*Streptopelia orientalis* (Latham, 1790)	Resident
75	Temminck's Stint	*Calidris temminckii* (Leisler, 1812)	Winter
76	Oriental Skylark	*Alauda gulgula* Franklin, 1831	Resident
77	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	Resident
78	Striated Babbler	*Turdoides earlei* (Blyth, 1844)	Resident

79	Paddyfield Warbler	*Acrocephalus agricola* (Jerdon, 1845)	Winter
80	Striated Heron	*Butorides striata* (Linnaeus, 1758)	Resident
81	Smoky Warbler	*Phylloscopus fuligiventer* (Hodgson, 1845)	Winter
82	Red-whiskered Bulbul	*Pycnonotus jocosus* (Linnaeus, 1758)	Resident
83	Little Ringed Plover	*Charadrius dubius* Scopoli, 1786	Resident
84	Russet Bush Warbler	*Locustella mandelli* (W.E.Brooks, 1875)	Resident
85	Ruddy Shelduck	*Tadorna ferruginea* (Pallas, 1764)	Winter
86	Indian Pond-Heron	*Ardeola grayii* (Sykes, 1832)	Resident
87	Large-billed Crow	*Corvus macrorhynchos* Wagler, 1827	Resident
88	Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)	Resident
89	Common Sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)	Winter
90	Green Sandpiper	*Tringa ochropus* Linnaeus, 1758	Winter
91	Blue-throated Barbet	*Psilopogon asiaticus*	Resident
92	Gray-breasted Prinia	*Prinia hodgsonii* Blyth, 1844	Resident
93	Common Greenshank	*Tringa nebularia* (Gunnerus, 1767)	Winter
94	Western Yellow Wagtail	*Motacilla flava* Linnaeus, 1758	Winter

13 Appendix 3 Checklists of birds recorded earlier from the wetland area (Maguri-Motapung Beel)(same grids we sampled) collected from eBird

Sno	VernacularName	Scientific Name	Resident/ Migratory
1	Falcated Duck	Mareca falcata	Winter
2	Citrine Wagtail	Motacilla citreola Pallas, 1776	Winter
3	Indian Pond-Heron	Ardeola grayii (Sykes, 1832)	Resident
4	Eastern Spot-billed Duck	Anas zonorhyncha Swinhoe, 1866	?
5	Great Egret	Ardea alba Linnaeus, 1758	Resident
6	Purple Heron	Ardea purpurea Linnaeus, 1766	Resident
7	Chinese Rubythroat	Calliope tschebaiewi	not found
8	Pheasant-tailed Jacana	Hydrophasianus chirurgus (Scopoli, 1786)	Resident
9	Bluethroat	Luscinia svecica (Linnaeus, 1758)	Winter
10	Striated Babbler	Turdoides earlei (Blyth, 1844)	Resident
11	Plain Prinia	Prinia inornata Sykes, 1832	Resident
12	Cattle Egret	Bubulcus ibis (Linnaeus, 1758)	Resident
13	Eurasian Coot	Fulica atra Linnaeus, 1758	Resident
14	Ferruginous Duck	Aythya nyroca (Guldenstadt, 1770)	Winter
15	Bar-headed Goose	Anser indicus (Latham, 1790)	Winter
16	Eurasian Wigeon	Mareca penelope (Linnaeus, 1758)	Winter
17	Asian Openbill	Anastomus oscitans (Boddaert, 1783)	Resident
18	Northern Lapwing	Vanellus vanellus (Linnaeus, 1758)	Winter

19	Little Grebe	Tachybaptus ruficollis (Pallas, 1764)	Resident
20	Wood Sandpiper	Tringa glareola Linnaeus, 1758	Winter
21	Western Yellow Wagtail	Motacilla flava Linnaeus, 1758	Winter
22	Graylag Goose	Anser anser (Linnaeus, 1758)	Winter
23	Gray-backed Shrike	Lanius tephronotus (Vigors, 1831)	Winter
24	Asian Pied Starling	Gracupica contra (Linnaeus, 1758)	Resident
25	Green-winged Teal	Anas crecca Linnaeus, 1758	Winter
26	Red Collared-Dove	Streptopelia tranquebarica	Resident
27	Mallard	Anas platyrhynchos Linnaeus, 1758	Winter
28	Great Myna	Acridotheres grandis Moore, 1858	Resident
29	Little Cormorant	Microcarbo niger (Vieillot, 1817)	Resident
30	Jungle Myna	Acridotheres fuscus (Wagler, 1827)	Resident
31	Watercock	Gallicrex cinerea (Gmelin, 1789)	Resident
32	Black-faced Bunting	Emberiza spodocephala Pallas, 1776	Winter
33	Siberian Stonechat	Saxicola maurus (Pallas, 1773)	not found
34	Long-tailed Shrike	Lanius schach Linnaeus, 1758	Winter
35	Gadwall	Mareca strepera (Linnaeus, 1758)	Winter
36	Eurasian Marsh-Harrier	Circus aeruginosus (Linnaeus, 1758)	Winter
37	Eurasian Wryneck	Jynx torquilla Linnaeus, 1758	Winter
38	Bronze-winged Jacana	Metopidius indicus (Latham, 1790)	Resident
39	Little Egret	Egretta garzetta (Linnaeus, 1766)	Resident
40	Ruddy Shelduck	Tadorna ferruginea (Pallas, 1764)	Winter

41	Red-crested Pochard	Netta rufina (Pallas, 1773)	Winter
42	Northern Shoveler	Spatula clypeata (Linnaeus, 1758)	Winter
43	Glossy Ibis	Plegadis falcinellus (Linnaeus, 1766)	Resident
44	Swamp Francolin	Francolinus gularis (Temminck, 1815)	Resident
45	House Crow	Corvus splendens Vieillot, 1817	Resident
46	Eurasian Moorhen	Gallinula chloropus (Linnaeus, 1758)	Resident
47	White Wagtail	Motacilla alba Linnaeus, 1758	Winter
48	Green Imperial-Pigeon	Ducula aenea (Linnaeus, 1766)	Resident
49	Pin-tailed Snipe	Gallinago stenura (Bonaparte, 1831)	Winter
50	Rosy Pipit	Anthus roseatus Blyth, 1847	Winter
51	Smoky Warbler	Phylloscopus fuligiventer (Hodgson, 1845)	Winter
52	Bengal Bushlark	Mirafra assamica Horsfield, 1840	Resident
53	Common Sandpiper	Actitis hypoleucos (Linnaeus, 1758)	Winter
54	Montagu's Harrier	Circus pygargus (Linnaeus, 1758)	Winter
55	White-breasted Waterhen	Amaurornis phoenicurus (Pennant, 1769)	Resident
56	Large-billed Crow	Corvus macrorhynchos Wagler, 1827	Resident
57	Black-winged Kite	Elanus caeruleus (Desfontaines, 1789)	Resident
58	Jerdon's Babbler	Chrysomma altirostre Jerdon, 1862	Resident
59	Swamp Grass Babbler	Laticilla cinerascens (Walden, 1874)	not found
60	Striated Heron	Butorides striata (Linnaeus, 1758)	Resident
61	Black Drongo	Dicrurus macrocercus Vieillot, 1817	Resident

62	Fulvous Whistling-Duck	Dendrocygna bicolor (Vieillot, 1816)	Resident
63	House Sparrow	Passer domesticus (Linnaeus, 1758)	Resident
64	Garganey	Spatula querquedula (Linnaeus, 1758)	Winter
65	Lesser Adjutant	Leptoptilos javanicus (Horsfield, 1821)	Resident
66	Indian Spot-billed Duck	Anas poecilorhyncha Forster, 1781	Resident
67	Ruddy-breasted Crake	Zapornia fusca	Resident
68	Eurasian Tree Sparrow	Passer montanus (Linnaeus, 1758)	Resident
69	Rufous Treepie	Dendrocitta vagabunda (Latham, 1790)	Resident
70	Crimson Sunbird	Aethopyga siparaja (Raffles, 1822)	Resident
71	Black-crowned Night-Heron	Nycticorax nycticorax (Linnaeus, 1758)	Resident
72	Pale Sand Martin	Riparia diluta (Sharpe & Wyatt, 1893)	?
73	Northern Pintail	Anas acuta Linnaeus, 1758	Winter
74	Striated Grassbird	Megalurus palustris Horsfield, 1821	Resident
75	Common Myna	Acridotheres tristis (Linnaeus, 1766)	Resident
76	Brown-cheeked Rail	Rallus indicus Blyth, 1849	Winter
77	Black Redstart	Phoenicurus ochruros (S.G.Gmelin, 1774)	Autumn/Spring
78	Gray-headed Swamphen	Porphyrio poliocephalus (Latham, 1801)	Resident
79	Spotted Dove	Streptopelia chinensis (Scopoli, 1786)	Resident
80	Green Sandpiper	Tringa ochropus Linnaeus, 1758	Winter
81	Common Hawk-Cuckoo	Hierococcyx varius	Resident

82	Red-wattled Lapwing	Vanellus indicus (Boddaert, 1783)	Resident
83	Himalayan Griffon	Gyps himalayensis Hume, 1869	Winter
84	Chestnut-capped Babbler	Timalia pileata Horsfield, 1821	Resident
85	Slender-billed Vulture	Gyps tenuirostris G.R.Gray, 1844	Resident
86	Chestnut-eared Bunting	Emberiza fucata	Winter
87	Yellow Bittern	Ixobrychus sinensis	Resident
88	Common Pochard	Aythya ferina (Linnaeus, 1758)	Winter
89	Paddyfield Warbler	Acrocephalus agricola (Jerdon, 1845)	Winter
90	Dusky Warbler	Phylloscopus fuscatus (Blyth, 1842)	Winter
91	Hen Harrier	Circus cyaneus (Linnaeus, 1766)	Winter
92	Common Kingfisher	Alcedo atthis (Linnaeus, 1758)	Resident
93	Ashy Woodswallow	Artamus fuscus Vieillot, 1817	Resident
94	Gray Wagtail	Motacilla cinerea Tunstall, 1771	Winter
95	Spotted Bush Warbler	Locustella thoracica (Blyth, 1845)	Winter
96	Pied Harrier	Circus melanoleucos (Pennant, 1769)	Winter
97	Pied Kingfisher	Ceryle rudis (Linnaeus, 1758)	Resident
98	Chestnut Munia	Lonchura atricapilla (Vieillot, 1807)	Resident
99	Little Ringed Plover	Charadrius dubius Scopoli, 1786	Resident
100	Lesser Whistling-Duck	Dendrocygna javanica (Horsfield, 1821)	Resident
101	Stork-billed Kingfisher	Pelargopsis capensis (Linnaeus, 1766)	Resident
102	Oriental Honey-buzzard	Pernis ptilorhynchus (Temminck, 1821)	Resident

103	Asian Palm-Swift	Cypsiurus balasiensis (J.E.Gray, 1829)	Resident
104	Clamorous Reed Warbler	Acrocephalus stentoreus (Hemprich & Ehrenberg, 1833)	Resident
105	Golden-headed Cisticola	Cisticola exilis (Vigors & Horsfield, 1827)	Resident
106	Barn Swallow	Hirundo rustica Linnaeus, 1758	Winter
107	Tickell's Leaf Warbler	Phylloscopus affinis (Tickell, 1833)	Winter
108	Marsh Sandpiper	Tringa stagnatilis (Bechstein, 1803)	Winter
109	Oriental Scops-Owl	Otus sunia (Hodgson, 1836)	Resident
110	Marsh Babbler	Pellorneum palustre Gould, 1872	Resident
111	River Tern	Sterna aurantia J.E.Gray, 1831	Resident
112	Baikal Teal	Sibirionetta formosa (Georgi, 1775)	Winter
113	Collared Scops-Owl	Otus lettia (Hodgson, 1836)	Resident
114	Paddyfield Pipit	Anthus rufulus Vieillot, 1818	Resident
115	Richard's Pipit	Anthus richardi Vieillot, 1818	Winter
116	Red-vented Bulbul	Pycnonotus cafer (Linnaeus, 1766)	Resident
117	Black-winged Stilt	Himantopus himantopus (Linnaeus, 1758)	Resident
118	Tufted Duck	Aythya fuligula (Linnaeus, 1758)	Winter
119	Brown Boobook	Ninox scutulata (Raffles, 1822)	Resident
120	Oriental Darter	Anhinga melanogaster Pennant, 1769	Resident
121	Red-whiskered Bulbul	Pycnonotus jocosus (Linnaeus, 1758)	Resident
122	Gray Heron	Ardea cinerea Linnaeus, 1758	Resident

123	Temminck's Stint	Calidris temminckii (Leisler, 1812)	Winter
124	Shikra	Accipiter badius (Gmelin, 1788)	Resident
125	Baya Weaver	Ploceus philippinus (Linnaeus, 1766)	Resident
126	Yellow-bellied Prinia	Prinia flaviventris (Delessert, 1840)	Resident
127	Intermediate Egret	Ardea intermedia Wagler, 1827	Resident
128	Eurasian Sparrowhawk	Accipiter nisus (Linnaeus, 1758)	Resident
129	Whiskered Tern	Chlidonias hybrida	Winter
130	Great Cormorant	Phalacrocorax carbo (Linnaeus, 1758)	Winter
131	Common Tailorbird	Orthotomus sutorius (Pennant, 1769)	Resident
132	Oriental Magpie-Robin	Copsychus saularis (Linnaeus, 1758)	Resident
133	Cotton Pygmy-Goose	Nettapus coromandelianus (Gmelin, 1789)	Resident
134	Oriental Skylark	Alauda gulgula Franklin, 1831	Resident
135	Zitting Cisticola	Cisticola juncidis (Rafinesque, 1810)	Resident
136	Baikal Bush Warbler	Locustella davidi (La Touche, 1923)	?
137	Common Snipe	Gallinago gallinago (Linnaeus, 1758)	Winter
138	Kentish Plover	Charadrius alexandrinus Linnaeus, 1758	Winter
139	Asian Barred Owlet	Glaucidium cuculoides (Vigors, 1831)	Resident
140	Himalayan Shortwing	Brachypteryx cruralis	not found
141	Cinereous Tit	Parus cinereus Vieillot, 1818	Resident
142	Black Stork	Ciconia nigra (Linnaeus, 1758)	Winter
143	White-rumped Vulture	Gyps bengalensis (Gmelin, 1788)	Resident

144	White-throated Kingfisher	Halcyon smyrnensis (Linnaeus, 1758)	Resident
145	Blunt-winged Warbler	Acrocephalus concinens (Swinhoe, 1870)	Resident
146	Large Cuckooshrike	Coracina macei (Lesson, 1831)	Resident
147	Yellow-footed Green-Pigeon	Treron phoenicopterus (Latham, 1790)	Resident
148	Small Pratincole	Glareola lactea Temminck, 1820	Resident
149	Scarlet-backed Flowerpecker	Dicaeum cruentatum (Linnaeus, 1758)	Resident
150	Greater Coucal	Centropus sinensis (Stephens, 1815)	Resident
151	Common Redshank	Tringa totanus (Linnaeus, 1758)	Winter
152	Chestnut-tailed Starling	Sturnia malabarica (Gmelin, 1789)	Resident
153	Eurasian Curlew	Numenius arquata (Linnaeus, 1758)	Winter
154	Siberian Rubythroat	Calliope calliope (Pallas, 1776)	Winter
155	Olive-backed Pipit	Anthus hodgsoni Richmond, 1907	Winter
156	Gray Bushchat	Saxicola ferreus J.E.Gray & G.R.Gray, 1847	Winter
157	Pallas's Grasshopper-Warbler	Locustella certhiola (Pallas, 1811)	Winter
158	Mountain Tailorbird	Phyllergates cuculatus	Resident
159	Pacific Golden-Plover	Pluvialis fulva (Gmelin, 1789)	Winter
160	Cinnamon Bittern	Ixobrychus cinnamomeus (Gmelin, 1789)	Resident
161	Indochinese Roller	Coracias affinis McClelland, 1840	Resident
162	Peregrine Falcon	Falco peregrinus Tunstall, 1771	Winter
163	Abbott's Babbler	Malacocincla abbotti	Resident

164	Blue-throated Barbet	Psilopogon asiaticus	Resident
165	Common Shelduck	Tadorna tadorna (Linnaeus, 1758)	Winter
166	Gray-throated Martin	Riparia chinensis (J.E.Gray, 1830)	not found
167	Aberrant Bush Warbler	Horornis flavolivaceus (Blyth, 1845)	Winter
168	White-browed Wagtail	Motacilla maderaspatensis Gmelin, 1789	Winter
169	Long-billed Plover	Charadrius placidus J.E.Gray & G.R.Gray, 1863	Winter
170	Rose-ringed Parakeet	Psittacula krameri (Scopoli, 1769)	Resident
171	Greater Painted-Snipe	Rostratula benghalensis (Linnaeus, 1758)	Resident
172	European Starling	Sturnus vulgaris Linnaeus, 1758	Winter
173	Blyth's Reed Warbler	Acrocephalus dumetorum Blyth, 1849	Winter
174	Lineated Barbet	Psilopogon lineatus	Resident
175	Eurasian Collared-Dove	Streptopelia decaocto (Frivaldszky, 1838)	Resident
176	Common Greenshank	Tringa nebularia (Gunnerus, 1767)	Winter
177	Blyth's Pipit	Anthus godlewskii (Taczanowski, 1876)	Winter
178	Eurasian Kestrel	Falco tinnunculus Linnaeus, 1758	Winter
179	Rock Pigeon	Columba livia Gmelin, 1789	Resident
180	Gray-headed Lapwing	Vanellus cinereus (Blyth, 1842)	Winter
181	Red-necked Falcon	Falco chicquera Daudin, 1800	Resident
182	Bronzed Drongo	Dicrurus aeneus Vieillot, 1817	Resident

183	Lesser Coucal	Centropus bengalensis (Gmelin, 1788)	Resident
184	Black-hooded Oriole	Oriolus xanthornus (Linnaeus, 1758)	Resident
185	Great Crested Grebe	Podiceps cristatus (Linnaeus, 1758)	Winter
186	Little Stint	Calidris minuta (Leisler, 1812)	Winter
187	Jungle Babbler	Turdoides striata (Dumont, 1823)	Resident
188	Common Crane	Grus grus (Linnaeus, 1758)	Winter
189	Great Eared-Nightjar	Lyncornis macrotis	Summer
190	Taiga Flycatcher	Ficedula albicilla (Pallas, 1811)	Winter
191	Bank Myna	Acridotheres ginginianus (Latham, 1790)	Resident
192	Gray-breasted Prinia	Prinia hodgsonii Blyth, 1844	Resident
193	Baillon's Crake	Zapornia pusilla (Pallas, 1776)	Winter
194	Blue Whistling-Thrush	Myophonus caeruleus	Winter
195	Streaked Weaver	Ploceus manyar (Horsfield, 1821)	Resident
196	Black-headed Gull	Chroicocephalus ridibundus (Linnaeus, 1766)	Winter
197	Water Rail	Rallus aquaticus Linnaeus, 1758	Winter
198	Black Kite	Milvus migrans (Boddaert, 1783)	Resident
199	Red-rumped Swallow	Cecropis daurica (Laxmann, 1769)	Winter
200	Russet Bush Warbler	Locustella mandelli (W.E.Brooks, 1875)	Resident
201	Common Hill Myna	Gracula religiosa Linnaeus, 1758	Resident
202	Chestnut-crowned Bush Warbler	Cettia major (Moore, 1854)	Summer

203	Oriental Turtle-Dove	Streptopelia orientalis (Latham, 1790)	Resident
204	Brown Crake	Zapornia akool	Resident
205	Ashy Prinia	Prinia socialis Sykes, 1832	Resident
206	Brown Shrike	Lanius cristatus Linnaeus, 1758	Winter
207	Jack Snipe	Lymnocryptes minimus (Brunnich, 1764)	Winter
208	Asian Koel	Eudynamys scolopaceus	Resident
209	Greater Spotted Eagle	Clanga clanga (Pallas, 1811)	Winter
210	Graceful Prinia	Prinia gracilis (Lichtenstein, 1823)	Resident
211	Coppersmith Barbet	Psilopogon haemacephalus (M├╝ller, 1776)	Resident
212	Streak-throated Woodpecker	Picus xanthopygaeus (J.E.Gray & G.R.Gray, 1847)	Resident
213	Spot-billed Pelican	Pelecanus philippensis Gmelin, 1789	Resident
214	Thick-billed Warbler	Arundinax aedon	Winter
215	Red-breasted Parakeet	Psittacula alexandri (Linnaeus, 1758)	Resident
216	Baer's Pochard	Aythya baeri (Radde, 1863)	Winter
217	Hair-crested Drongo	Dicrurus hottentottus (Linnaeus, 1766)	Resident
218	Gray-headed Canary-Flycatcher	Culicicapa ceylonensis (Swainson, 1820)	Winter
219	Indian White-eye	Zosterops palpebrosus (Temminck, 1824)	Resident
220	Alexandrine Parakeet	Psittacula eupatria (Linnaeus, 1766)	Resident
221	Black-breasted Parrotbill	Paradoxornis flavirostris Gould, 1836	Resident

222	White-tailed Robin	Myiomela leucura (Hodgson, 1845)	Resident
223	Alpine Swift	Apus melba (Linnaeus, 1758)	Winter
224	Oriental Pied-Hornbill	Anthracoceros albirostris (Shaw, 1808)	Resident
225	Little Pied Flycatcher	Ficedula westermanni (Sharpe, 1888)	Resident
226	Black-necked Stork	Ephippiorhynchus asiaticus (Latham, 1790)	Resident
227	White-rumped Munia	Lonchura striata (Linnaeus, 1766)	Resident
228	Pallas's Gull	Ichthyaetus ichthyaetus (Pallas, 1773)	Winter
229	Little Bunting	Emberiza pusilla Pallas, 1776	Winter
230	River Lapwing	Vanellus duvaucelii (Lesson, 1826)	Resident
231	Spotted Owlet	Athene brama (Temminck, 1821)	Resident
232	Oriental Pratincole	Glareola maldivarum J.R.Forster, 1795	Resident
233	Black-headed Ibis	Threskiornis melanocephalus (Latham, 1790)	?
234	Sand Lark	Alaudala raytal	Resident
235	Little Spiderhunter	Arachnothera longirostra (Latham, 1790)	Resident
236	Crested Serpent-Eagle	Spilornis cheela (Latham, 1790)	Resident
237	Brown-headed Gull	Chroicocephalus brunnicephalus (Jerdon, 1840)	Winter
238	Blue-tailed Bee-eater	Merops philippinus Linnaeus, 1766	Summer
239	House Swift	Apus nipalensis (Hodgson, 1837)	Resident
240	Eurasian Spoonbill	Platalea leucorodia Linnaeus, 1758	Resident
241	Eurasian Hoopoe	Upupa epops Linnaeus, 1758	Resident

242	Bristled Grassbird	Chaetornis striata (Jerdon, 1841)	?
243	Osprey	Pandion haliaetus (Linnaeus, 1758)	Winter
244	Rufescent Prinia	Prinia rufescens Blyth, 1847	Resident
245	Nepal House-Martin	Delichon nipalense Moore, 1854	Resident
246	Striated Prinia	Prinia crinigera Hodgson, 1836	Resident
247	Scaly-breasted Munia	Lonchura punctulata (Linnaeus, 1758)	Resident
248	Blue-breasted Quail	Synoicus chinensis (Linnaeus, 1766)	Resident
249	Laggar Falcon	Falco jugger J.E.Gray, 1834	Resident
250	Eastern Yellow Wagtail	Motacilla tschutschensis Gmelin, 1789	Winter
251	Red Knot	Calidris canutus (Linnaeus, 1758)	Winter
252	White-throated Needletail	Hirundapus caudacutus (Latham, 1802)	Summer
253	Brown-backed Needletail	Hirundapus giganteus (Temminck, 1825)	Resident
254	Bank Swallow	Riparia riparia (Linnaeus, 1758)	?
255	Green Bee-eater	Merops orientalis Latham, 1801	Resident
256	Whistler's Warbler	Phylloscopus whistleri	Winter
257	Black-rumpedFlameback	Dinopium benghalense	Resident
258	Red Avadavat	Amandava amandava (Linnaeus, 1758)	Resident
259	Pygmy Flycatcher	Ficedula hodgsoni (F.Moore, 1854)	Winter
260	White-rumpedShama	Copsychus malabaricus	Resident
261	Indian Cuckoo	Cuculus micropterus Gould, 1838	Summer
262	Crested Bunting	Emberiza lathami J.E.Gray, 1831	Resident

263	Common Iora	Aegithina tiphia (Linnaeus, 1758)	Resident
264	Hodgson's Redstart	Phoenicurus hodgsoni (Moore, 1854)	Winter
265	Slaty-breasted Rail	Lewinia G.R.Gray, 1855	Resident
266	Small Niltava	Niltava macgrigoriae (Burton, 1836)	Winter
267	Steppe Eagle	Aquila nipalensis Hodgson, 1833	Winter
268	Black-tailed Godwit	Limosa limosa (Linnaeus, 1758)	Winter
269	Ruff	Calidris pugnax (Linnaeus, 1758)	Winter
270	Smew	Mergellus albellus (Linnaeus, 1758)	Winter
271	Chestnut-crowned Warbler	Phylloscopus castaniceps	Winter
272	Black Bittern	Ixobrychus flavicollis (Latham, 1790)	Winter
273	Himalayan Swiftlet	Aerodramus brevirostris (Horsfield, 1840)	Resident
274	Scarlet Minivet	Pericrocotus speciosus (Latham, 1790)	Resident
275	Greater Racket-tailed Drongo	Dicrurus paradiseus (Linnaeus, 1766)	Resident
276	Eastern Marsh-Harrier	Circus spilonotus Kaup, 1847	Winter
277	Barred Buttonquail	Turnix suscitator (Gmelin, 1789)	Resident
278	White-tailed Eagle	Haliaeetus albicilla (Linnaeus, 1758)	Winter
279	Black-browed Reed Warbler	Acrocephalus bistrigiceps Swinhoe, 1860	Winter
280	Russet Sparrow	Passer cinnamomeus	Winter
281	Collared Owlet	Glaucidium brodiei (Burton, 1836)	Resident
282	Golden-fronted Leafbird	Chloropsis aurifrons (Temminck, 1829)	Resident

283	Striated Swallow	Cecropis striolata (Schlegel, 1844)	Resident
284	Pin-striped Tit-Babbler	Mixornis gularis	Resident
285	Crested Goshawk	Accipiter trivirgatus (Temminck, 1824)	Resident
286	Dunlin	Calidris alpina (Linnaeus, 1758)	Winter
287	Spotted Redshank	Tringa erythropus (Pallas, 1764)	Winter
288	Pied Bushchat	Saxicola caprata (Linnaeus, 1766)	Winter
289	Blue-eared Barbet	Psilopogon duvaucelii	Resident
290	Plaintive Cuckoo	Cacomantis merulinus (Scopoli, 1786)	Resident
291	Pallas's Fish-Eagle	Haliaeetus leucoryphus (Pallas, 1771)	Resident
292	Amur Falcon	Falco amurensis Radde, 1863	Winter
293	Ashy Drongo	Dicrurus leucophaeus Vieillot, 1817	Resident
294	Puff-throated Babbler	Pellorneum ruficeps Swainson, 1832	Resident
295	Spot-winged Starling	Saroglossa spiloptera (Vigors, 1831)	Resident
296	Green-billed Malkoha	Phaenicophaeus tristis (Lesson, 1830)	Resident
297	Vernal Hanging-Parrot	Loriculus vernalis (Sparrman, 1787)	Resident
298	White-eyed Buzzard	Butastur teesa (Franklin, 1831)	Resident
299	Greater Scaup	Aythya marila (Linnaeus, 1761)	Winter
300	Striated Bulbul	Pycnonotus striatus (Blyth, 1842)	Resident
301	Eurasian Griffon	Gyps fulvus (Hablizl, 1783)	Winter
302	Daurian Redstart	Phoenicurus auroreus (Pallas, 1776)	Winter
303	White-browed Crake	Amaurornis cinerea (Vieillot, 1819)	not found
304	Purple Sunbird	Cinnyris asiaticus (Latham, 1790)	Resident

305	Changeable Hawk-Eagle	Nisaetus cirrhatus (Gmelin, 1788)	Resident
306	Gray-sided Bush Warbler	Cettia brunnifrons (Hodgson, 1845)	Winter
307	Eurasian Hobby	Falco subbuteo Linnaeus, 1758	Winter
308	Plain Flowerpecker	Dicaeum minullum Swinhoe, 1870	Resident
309	Greenish Warbler	Phylloscopus trochiloides (Sundevall, 1837)	Winter
310	Blue-eared Kingfisher	Alcedo meninting Horsfield, 1821	Resident
311	Gray Treepie	Dendrocitta formosae Swinhoe, 1863	Resident
312	Large Hawk-Cuckoo	Hierococcyx sparverioides	Summer
313	Black-breasted Weaver	Ploceus benghalensis (Linnaeus, 1758)	Resident
314	Painted Stork	Mycteria leucocephala (Pennant, 1769)	Winter
315	Dollarbird	Eurystomus orientalis (Linnaeus, 1766)	Resident
316	Pied Avocet	Recurvirostra avosetta Linnaeus, 1758	Winter
317	Lesser Sand-Plover	Charadrius mongolus Pallas, 1776	Winter
318	White-tailed Stonechat	Saxicola leucurus (Blyth, 1847)	Resident
319	Short-eared Owl	Asio flammeus (Pontoppidan, 1763)	Winter
320	Black-throated Prinia	Prinia atrogularis (Moore, 1854)	Resident
321	Indian Golden Oriole	Oriolus kundoo Sykes, 1832	?
322	Lesser Cuckoo	Cuculus poliocephalus Latham, 1790	Summer
323	Black-crested Bulbul	Rubigula Blyth, 1845	Resident
324	Yellow-vented Flowerpecker	Dicaeum chrysorrheum Temminck, 1829	Resident

325	Crested Kingfisher	Megaceryle lugubris (Temminck, 1834)	Resident
326	Yellow-browed Warbler	Phylloscopus inornatus (Blyth, 1842)	Winter
327	Black Bulbul	Hypsipetes leucocephalus (Gmelin, 1789)	Resident
328	Barred Cuckoo-Dove	Macropygia unchall (Wagler, 1827)	Resident
329	Rufous-capped Babbler	Cyanoderma ruficeps	Resident
330	White-throated Bulbul	Alophoixus flaveolus (Gould, 1836)	Resident
331	Rufous-bellied Niltava	Niltava sundara Hodgson, 1837	Winter
332	Slaty-bellied Tesia	Tesia olivea (McClelland, 1840)	Winter
333	Gray-cheeked Warbler	Phylloscopus poliogenys	Winter
334	Greater Yellownape	Chrysophlegma flavinucha	Resident
335	Blyth's Leaf Warbler	Phylloscopus reguloides (Blyth, 1842)	Winter

14 Appendix 4 Checklist of birds recorded by us in grassland

Sl. No.	Common Name	Scientific Name
1	Asian Palm-Swift	*Cypsiurus balasiensis* (J.E.Gray, 1829)
2	Asian Pied Starling	*Gracupica contra* (Linnaeus, 1758)
3	Barn Swallow	*Hirundo rustica* Linnaeus, 1758
4	Black Drongo	*Dicrurus macrocercus* Vieillot, 1817
5	Black-winged Kite	*Elanus caeruleus* (Desfontaines, 1789)
6	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790)
7	Bush lark	*Mirafra assamica*
8	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)
9	Chestnut-capped Babbler	*Timalia pileata (Call heard)*
10	Common Myna	*Acridotheres tristis* (Linnaeus, 1766)
11	Common Tailorbird	*Orthotomus sutorius* (Pennant, 1769)
12	Cotton Pygmy-Goose	*Nettapus coromandelianus* (Gmelin, 1789)
13	Fulvus Whistling Duck	*Dendrocygna bicolor*
14	Indochinese Roller	*Coracias affinis* McClelland, 1840
15	Intermediate Egret	*Ardea intermedia* Wagler, 1827
16	Large-billed Crow	*Corvus macrorhynchos* Wagler, 1827
17	Lesser Whistling-Duck	*Dendrocygna javanica* (Horsfield, 1821)
18	Little Cormorant	*Microcarbo niger* (Vieillot, 1817)
29	Little Egret	*Egretta garzetta* (Linnaeus, 1766)
20	Common Myna	*Acridotheres tristis*
21	Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)
22	Red-vented Bulbul	*Pycnonotus cafer* (Linnaeus, 1766)
23	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)
24	Rufous Treepie	*Dendrocitta vagabunda* (Latham, 1790)
25	Spotted Dove	*Streptopelia chinensis* (Scopoli, 1786)
26	Striated Babbler	*Turdoides earlei* (Blyth, 1844)
27	Striated Heron	*Butorides striata*
28	White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)

15 Appendix 5 Checklist of birds recorded by us in wetland (Maguri-Motapung Beel)

S.No.	Scientific name	Common Name
1	Asian Palm-Swift	*Cypsiurus balasiensis*
2	Barn Swallow	*Hirundo rustica* Linnaeus, 1758
3	Black Drongo	*Dicrurus macrocercus* Vieillot, 1817
4	Black-winged Kite	*Elanus caeruleus* (Desfontaines, 1789)
5	Blue Tailed Bee Eater	*Merops philippinus*
6	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790)
7	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)
8	Cinnamon Bittern	*Ixobrychus cinnamomeus*
9	Cotton Pygmy-Goose	*Nettapus coromandelianus* (Gmelin, 1789)
10	Gray-throated Martin	*Riparia chinensis*
11	Great Egret	*Ardea alba* Linnaeus, 1758
12	Intermediate Egret	*Ardea intermedia* Wagler, 1827
13	Jungle Myna	*Acridotheres fuscus* (Wagler, 1827)
14	Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)
15	Lesser Whistling-Duck	*Dendrocygna javanica* (Horsfield, 1821)
16	Little Cormorant	*Microcarbo niger* (Vieillot, 1817)
17	Little Egret	*Egretta garzetta* (Linnaeus, 1766)
18	Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)
19	Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)
20	Indian Pond-Heron	*Ardeola grayii* (Sykes, 1832)
21	Gray-headed Swamphen	*Porphyrio poliocephalus* (Latham, 1801)
22	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)
23	Shikra	*Accipiter badius* (Gmelin, 1788)
24	Indian Spot-billed Duck	*Anas poecilorhyncha* Forster, 1781
25	White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)
26	Yellow-bellied Prinia	*Prinia flaviventris* (Delessert, 1840)
27	Yellow Bittern	*Ixobrychus sinensis*
28	Zitting Cisticola	*Cisticola juncidis* (Rafinesque, 1810)

16 Appendix 6 Checklist of fishes captured from Dibru River and Maguri – Motapung Beel

Family	*Scientific name*	Common name	IUCN status	No. of Individual capture
Cyprinidae	*Cirrhinus reba* (Day 1878)	Reba carp	LC	4
	Osteobrama cotio (Hamiltion 1822)		LC	7
	Bangara dero (Hamiltion 1822)	Kalabans	LC	1
	Puntius sophore (Hamiltion 1822)	Spot fin swamp barb	LC	6
	Puntius chola(Hamiltion 1822)	Chola barb	LC	2
	Pethia gelius (Hamiltion, 1822)	Golden dwarf barb	LC	4
	Tariqilabeo latius (Hamiltion, 1822)	Gangetic latia	LC	1
	Labeo calbasu (Hamiltion 1822)	Calbasu	LC	3
	Labeo bata (Hamiltion, 1822)	Bata labeo	LC	2
	Chagunius chagunio (Hamiltion, 1822)		LC	1
	Salmophasia bacaila (Hamiltion, 1822)	Large razorbelly minnow	LC	16
	Chela laubuca (Hamiltion, 1822)	Indian glass fish	LC	21
	Baralius barna(Hamiltion, 1822)	Barna baril	LC	7
Gobiidae	*Glossogobius giuris* (Hamiltion, 1822)	Tank gobi	LC	3
Bagridae	*Sperata aor* (Hamiltion, 1822)	Long-whiskered catfish	LC	1
	Sperata seenghala (Sykes, 1839)	Gaint river catfish	LC	1
	Mystus vittatus (Bloch 1794)	Striped dwarf catfish	LC	6
	Mystus cavasius (Hamiltion, 1822)	Gangetic mystus	LC	2
Belonidae	*Xenetodon cancila* (Hamiltion, 1822)	Freshwater garfish	LC	1
Ambassidae	*Parambassis ranga* (Hamiltion 1822)	Indian glassy fish	LC	1
Channidae	*Channa marulius* (Hamiltion 1822)	Gaint snake head	LC	6
	Channa punctatus (Hamiltion 1822)	Spotted snake head	LC	4
Synbranchidae	*Monopterus albus* (Zuiew 1793)	Rice swamp eel	LC	1

17 Appendix 7 List of species of Butterflies sighted during the survey

Scientific Name	Common Name	IUCN status	IWPA Status
Family Papilionidae			
Papilio nephelus	Yellow Helen	Not Evaluated	
Graphium sarpedon	Common Bluebottle	Not Evaluated	
Papilio demoleus	Lime	Not Evaluated	
Graphium agamemnon	Tailed Jay	Not Evaluated	
Papilio memnon	Great Mormon	Not Evaluated	
Troides aeacus	Golden Birdwing	Least Concern	
Papilio castor	Common Raven	Not Evaluated	
Family Nymphalidae			
Ypthima baldus	Common Fivering	Not Evaluated	
Neptis hylas	Common Sailer	Not Evaluated	
Junonia atlites	Grey Pansy	Not Evaluated	
Mycalesis perseus	Common Bushbrown	Not Evaluated	
Ariadne merione	Common Castor	Not Evaluated	
Cethosia cyane	Leopard Lacewing	Not Evaluated	
Parantica aglea	Glassy Tiger	Not Evaluated	
Ariadne ariadne	Angled Castor	Not Evaluated	
Danaus genutia	Common Tiger	Not Evaluated	
Euploea core	Common Indian Crow	Least Concern	

Junonia almana	Peacock Pansy	Least Concern	
Tirumala limniace	Blue Tiger	Not Evaluated	
Euthalia aconthea	Baron	Not Evaluated	
Athyma perius	Common Sergeant	Not Evaluated	
Hypolimnas bolina	Great Eggfly	Not Evaluated	
Danaus chrysippus	Plain Tiger	Not Evaluated	
Tanaecia lepidea	Grey Count	Not Evaluated	Schedule II
Tirumala septentrionis	Dark blue tiger		
Melanitis leda	Common Evening Brown	Not Evaluated	
Family Lycaenidae			
Castalius rosimon	Common Pierrot	Not Evaluated	
Jamides celeno	Common Cerulean	Not Evaluated	
Hypolycaena erylus	Common Tit	Not Evaluated	
Surendra quercetorum	Common Acacia Blue	Not Evaluated	
Prosotas nora	Common Lineblue	Not Evaluated	
Apharitis lilacinus	Lilac Silverline		Schedule II
Anthene lycaenina	Pointed Ciliate Blue	Not Evaluated	Schedule II
Chilades lajus	Lime Blue	Not Evaluated	
Family Riodinidae			
Zemeros flegyas	Punchinello	Not Evaluated	
Family Hesperiidae			
Aeromachus pygmaeus	Pygmy Scrub Hopper	Not Evaluated	

Ampittia dioscorides	Bush Hopper	Not Evaluated	
Family Pieridae			
Eurema blanda	Three Spot grass yellow	Not Evaluated	
Catopsilia pomona	Common Emigrant	Not Evaluated	
Eurema brigitta	Small Grass Yellow	Least Concern	
Delias descombesi	Redspot Jezebel	Not Evaluated	

18 Appendix 8 List of species of odonates sighted during the survey

Scientific Name	**Common Name**	**IUCN status**
Orthetrum sabina	Green marsh hawk	Least Concern
Camacinia gigantea	Giant forest skimmer	Least Concern
Diplacodes nebulosa	Black tipped ground skimmer	Least Concern
Brachythemis contaminata	Ditch Jewel	Least Concern
Ictinogomphus sp.1	Club tail	Least Concern
Rhyothemis variegata	Common picture wing	Least Concern
Acisoma panorpoides	Trumpet tail	Least Concern
Crocothemis servilia	Scarlet skimmer	Least Concern
Ictinogomphus sp.2	Club tail	Least Concern
Neurothemis tullia	Pied paddy skimmer	Least Concern
Burmagomphus sp.	Club tail	Least Concern
Pseudagrion sp.	Dart	Least Concern
Ceriagrion coromandelianum	Coromandel Marsh Dart	Least Concern

19 Appendix 9 List of herpetofaunal species encountered during the survey period

Date of encounter	Scientific Name	Common Name	Microhabitat	Status	Distance to the explosion site (km)
30/05/2020	*Rhabdophis subminiatus* (SCHLEGEL, 1837)	Red-necked keelback	Water puddle along river Lohit	Live	0.50
30/05/2020	*Varanus salvator* (LAURENTI, 1768)	Common Water Monitor	Forest along river Lohit	Live	0.75
02/06/2020	*Fowlea piscator* (SCHNEIDER, 1799)	Checkered Keelback	Grassland	Carcass	0.43
22/06/2020	*Fowlea piscator* (SCHNEIDER, 1799)	Checkered Keelback	River	Live	2.96
23/06/2020	*Ptyas mucosa* (LINNAEUS, 1758)	Oriental Ratsnake	Human Habitation	Live	5.19
23/06/2020	*Calotes versicolor* (DAUDIN, 1802)	Common Garden Lizard	Human habitation	Live	5.19
03/07/2020	*Hemidactylus frenatus* DUMÉRIL & BIBRON, 1836	Common House Gecko	Human habitation	Live (4)	3.70
04/07/2020	*Boiga siamensis* NUTAPHAND, 1971	Eyed Cat Snake	Human habitation	Live	5.19

04/07/2020	*Duttaphrynus melanostictus* (Schneider, 1799)	Asian Common Toad	Human habitation	Live	5.19
05/07/2020	*Hemidactylus frenatus* DUMÉRIL & BIBRON, 1836	Common House Gecko	Human habitation	Live (2)	1.69
06/07/2020	*Calotes versicolor* (DAUDIN, 1802)	Common Garden Lizard	Human habitation	Live	2.95
06/07/2020	*Fowlea piscator* (SCHNEIDER, 1799)	Checkered Keelback	River	Live	4.56
06/07/2020	*Fowlea piscator* (SCHNEIDER, 1799)	Checkered Keelback	Wetland	Carcass	5.16
09/07/2020	*Euphlyctis cyanophlyctis* (Schneider, 1799)	Common skittering frog	Human habitation	Live (2 individuals)	5.19

20 Appendix 10 List of herpetofauna found in this area

	Species	Common name	Locality Records	Status	Reference
	TURTLES				
1.	*Nilssonia gangetica* (Cuvier 1825)	Gangetic Softshell Turtle	Laika	Vulnerable	Choudhury (1995)
2.	*Nilssonia nigricans* (Anderson, 1875)	Black Soft-shell Turtle	Dibrugarh	Critical	Paschang and Gemel (2002)
3.	*Nilssonia hurum* (Gray, 1831)	Peacock Soft-shell	Dibru-Saikhowa National Park	Vulnerable	Choudhury (1998)
4.	*Chitra indica* (Gray, 1831)	Narrow headed Soft-shell Turtle	Dibru-Saikhowa National Park	Endangered	Choudhury (1998)
5.	*Lissemys punctata* (Bonnaterre, 1789)	Indian Flapshell Turtle	Maguri Beel	Schedule I	Pers. Obs. (Dr. Abhijit Das, 2009)
6.	*Pangshura sylhetensis* Jerdon, 1870	Assam Roofed Turtle	Dibru-Saikhowa National Park	Endangered	Choudhury (1998)
7.	*Pangshura tentoria* (Gray, 1834)	Indian Tent Turtle	Baluchar, Saikhowaghat,	Not Evaluated	Ahmed and Das (2010), Choudhury (1995)

			Rohmonia, Guijan		
8.	*Pangshura tecta* (Gray, 1831)	Indian Roofed Turtle	Dibru Nallah	Schedule I	Ahmed and Das (2010)
9.	*Pangshura smithii* (Gray, 1863)	Brown Roofed Turtle	Saikhowaghat	Not Evaluated	Choudhury (1995)
10.	*Geoclemys hamiltonii* (Gray, 1831)	Pond Turtle	Kaloumi Camp	Vulnerable	Pers. Obs. (Dr. Abhijit Das, 2009)
11.	*Cyclemys gemeli* Fritz, Guicking, Auer, Sommer, Wink & Hundsdorfer, 2008	Assam Leaf Turtle	Guijan, Rohmoria	Not Evaluated	Choudhury (1995)
12.	*Cuora amboinensis* (Daudin, 1802)	Malayan Box Turtle	Dibru-Saikhowa National Park	Vulnerable	Choudhury (1995)
13.	*Melanochelys tricarinata* (Blyth, 1856)	Tricarinate Turtle	Dibru-Saikhowa National Park	Endangered	Ahmed and Das (2010)
	LIZARDS				
1.	*Calotes versicolor* (Daudin, 1802)	Indian Garden Lizard	Dibru-Saikhowa National Park, Baghjan	Not Evaluated	Mathur (2018), Bhagjan confirmed by Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)

2.	*Eutropis macularia* (Blyth, 1853)	Bronze Grass or Little Sun Skink	Dibru-Saikhowa National Park, Baghjan	Not Evaluated	Mathur (2018), Bhagjan confirmed by Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)
3.	*Eutropis multifasciata* (Kuhl, 1820)	Many-lined Grass Skink	Dibru-Saikhowa National Park, Baghjan	Least Concerned	Mathur (2018), Bhagjan confirmed by Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)
4.	*Gekko qecko* (Linnaeus, 1758)	Tokay Gecko	Dibru-Saikhowa National Park, Baghjan	Not Evaluated	Mathur (2018), Bhagjan confirmed by Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)
5.	*Hemidactylus frenatus* Duméril & Bibron, 1836	Asian House Gecko	Dibru-Saikhowa National Park, Baghjan	Least Concerned	Mathur (2018), Bhagjan confirmed by Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)
6.	*Lygosoma albopunctatum* (Gray, 1846)	White spotted Supple Skink	Dibru-Saikhowa National Park, Baghjan	Not Evaluated	Mathur (2018), Bhagjan confirmed by Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)
7.	*Varanus bengalensis* (Daudin, 1802)	Bengal Monitor	Dibru-Saikhowa	Schedule I	Mathur (2018), Bhagjan confirmed by Pers. Comm.

			National Park, Baghjan		(Dr. Firoz Ahmed, Aaranyak, Assam)
8.	*Varanus salvator* (Laurenti, 1768)	Water Monitor	Guijan, Dibru-Saikhowa National Park	Schedule I	Choudhury (1998)
	SNAKES				
1.	*Python bivittatus* Kuhl, 1820	Burmese Rock Python	Laika, kaloumi	Schedule I	Pers. Obs. (Dr. Abhijit Das, 2009)
2.	*Pareas monticola* (Cantor 1839)	Assam Snail Eater	Dibru-Saikhowa National Park	Schedule IV	Pers. Obs. (Dr. Abhijit Das, 2009)
3.	*Dendrelaphis pictus* (Gmelin, 1789)	Painted Bronzeback Tree Snake	Dibru-Saikhowa National Park	Not Evaluated	Mathur (2018)
4.	*Enhydris enhydris* (Schneider, 1799)	Smooth Water Snake	Maguri Beel	Schedule IV	Pers. Obs. (Dr. Abhijit Das, 2009)
5.	*Fowlea piscator* (Schneider, 1799)	Checkered Keelback	Kalumi	Schedule II	Pers. Obs. (Dr. Abhijit Das, 2009)
6.	*Xenochrophis cerasogaster* (Cantor, 1839)	Glossy Bellied Mash Snake	Maguri Beel	Schedule IV	Pers. Obs. (Dr. Abhijit Das, 2009)
7.	*Rhabdophis subminiatus*(Schlegel, 1837)	Red Necked Keelback	Laika, Dodhia	Schedule IV	Pers. Obs. (Dr. Abhijit Das, 2009)

8.	*Oligodon albocinctus*(Cantor, 1839)	White-Barred Kukri Snake	Dibru-Saikhowa National Park	Not Evaluated	Mathur (2018)
9.	*Ophiophagus hannah*(Cantor, 1836)	King Cobra	Guijan, Dibru-Saikhowa National Park	Schedule II	Pers. Obs. (Dr. Abhijit Das, 2009), Choudhury (1998)
10.	*Bungarus fasciatus* (Schneider, 1801)	Banded Krait	Guijan, Koloumi	Schedule IV	Pers. Obs. (Dr. Abhijit Das, 2009)
11.	*Bungarus niger* Wall, 1908		Dibrugarh and Sadiya, Sibsagar	Not Evaluated	Das (2018)
	AMPHIBIANS				
1.	*Duttaphrynus melanostictus (Schneider, 1799)*	Asian Common Toad	Dibru-Saikhowa National Park, Baghjan	Least Concerned	Mathur (2018), Bhagjan confirmed by Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)
2.	*Hoplobatrachus crassus* (Jerdon, 1854)	Jerdon's Bull Frog	Laika	Schedule IV	Das and Sengupta (2009)
3.	*Hoplobatrachus tigerinus*(Daudin, 1802)	Indian Bull Frog	Maguri Beel	Schedule IV	Das and Sengupta (2009)
4.	*Fejervarya pierrei*(Dubois, 1975)	Pierre's Cricket Frog	Guijan	Not Evaluated	Das and Sengupta (2009)
5.	*Euphlyctis cyanophlyctis*(Schneider, 1799)	Skittering Frog	Maguri Beel, Koloumi	Schedule IV	Das and Sengupta (2009)

6.	*Hydrophylax leptoglossa* (Anderson, 1871)	Assam Forest Frog	Guijan	Schedule IV	Das and Sengupta (2009)
7.	*Humerana humeralis*(Boulenger, 1887)	Bhamo Frog	Dibru-Saikhowa National Park	Schedule IV	Das and Sengupta (2009)
8.	*Hylarana tytleri* Theobald, 1868	Leaf Frog	Koloumi Camp	Not Evaluated	Das and Sengupta (2009)
9.	*Chiromentis simus* (Annandale, 1915)	Annandale's Pigmy Tree Frog	Dibru-Saikhowa National Park	Least Concerned	Das and Sengupta (2009)
10.	*Philautus vittatus* (Boulenger, 1887)	Two Striped	Dodhia village	Least Concerned	Das and Sengupta (2009)
11.	*Rhacophorus bipunctatus* Ahl, 1927	Twin Spotted Tree Frog	Dibru-Saikhowa National Park	Least Concerned	Das and Sengupta (2009)
12.	*Rhacophorus smaragdinus* Blyth, 1852	Large Tree Frog	Dibru-Saikhowa National Park	Least Concerned	Das and Sengupta (2009)
13.	*Polypedates teraiensis* (Dubois, 1987)	Terai tree frog	Laika, Dodhia	Least Concerned	Das and Sengupta (2009)
14.	*Uperodon globulosus*(Gunther, 1864)	Indian Balloon Frog	Guijan	Least Concerned	Das and Sengupta (2009)
15.	*Hylarana taipehensis* (Van Denburgh, 1909)	Taipeh Frog	Dibru-Saikhowa	Least Concerned	Mathur (2018), Bhagjan confirmed by Pers. Comm.

			National Park, Baghjan		(Dr. Firoz Ahmed, Aaranyak, Assam)
16.	*Microhyla ornata* (Dumeril and Bibron, 1841)	Ornamented Pygmy Frog	Dibru-Saikhowa National Park, Baghjan	Least Concerned	Mathur (2018), Bhagjan confirmed by Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)
17.	*Minervarya syhadrensis* (Annandale, 1919)	Southern Cricket Frog	Baghjan	Least Concerned	Pers. Comm. (Dr. Firoz Ahmed, Aaranyak, Assam)

21 Appendix 11 Checklist of Herpetofauna (Source: Ahmed & Das, 2020)

Wetland associated Herpetofauna

in Dibru- Saikhowa National Park, Assam

Species	Common name	Locality Records	Status	Reference
TURTLES				
Nilssonia gangeticus	Gangetic Softshell Turtle	Laika	Vulnerable	Choudhury (1995)
Nilssonia nigricans	Black Soft-shell Turtle	Dibrugarh	Critical	Paschang and Gemel (2002)

Nilssonia hurum	Peacock Soft-shell	Dibru-Saikhowa National Park	Vulnerable	Choudhury (1998)
Chitra indica	Narrow headed Soft-shell Turtle	Dibru-Saikhowa National Park	Endangered	Choudhury (1998)
Lissemys punctata andersoni	Indian Flapshell Turtle	Maguri Beel	Schedule I	Das (2009)
Pangshura sylhetensis	Assam Roofed Turtle	Dibru-Saikhowa National Park	Endangered	Choudhury (1998)
Pangshura tentoria	Indian Tent Turtle	Baluchar, Saikhowaghat, Rohmonia, Guijan	Not Evaluated	Ahmed and Das (2010), Choudhury (1995)
Pangshura tecta	Indian Roofed Turtle	Dibru Nallah	Schedule I	Ahmed and Das (2010)
Pangshura smithii	Brown Roofed Turtle	Saikhowaghat	Not Evaluated	Choudhury (1995)
Geoclemys hamiltonii	Pond Turtle	Kaloumi Camp	Vulnerable	Das (2009)
Cyclemys gemeli	Assam Leaf Turtle	Guijan, Rohmoria	Not Evaluated	Choudhury (1995)
Cuora amboinensis	Malayan Box Turtle	Dibru-Saikhowa National Park	Vulnerable	Choudhury (1995)
Melanochelys tricarinata	Tricarinate Turtle	Dibru-Saikhowa National Park		Ahmed and Das (2010)

LIZARDS				
Varanus salvator	Water Monitor	Guijan, Dibrusaikhowa National Park	Schedule I	Choudhury (1998)
Species	**Common name**	**Locality Records**	**Status**	**Reference**

SNAKES				
Python bivittatus	Burmese Rock Python	Laika, kaloumi	Schedule I	Das (2009)
Pareas monticola	Assam Snail Eater	Dibru-Saikhowa National Park	Schedule IV	Das (2009)
Enhydris enhydris	Smooth Water Snake	Maguri Beel	Schedule IV	Das (2009)
Fowlea piscator	Checkered Keelback	Kalumi	Schedule II	Das (2009)
Xenochrophis cerasogaster	Glossy Bellied Mash Snake	Maguri Beel	Schedule IV	Das (2009)
Rhabdophis subminiatus	Red Necked Keelback	Laika, Dodhia	Schedule IV	Das (2009)
Ophiophagus hannah	King Cobra	Guijan, Dibrusaikhowa National Park	Schedule II	Das (2009), Choudhury (1998)
Bungarus fasciatus	Banded Krait	Guijan, Koloumi	Schedule IV	Das (2009)
AMPHIBIANS				
Hoplobatrachus crassus	Jerdon's Bull Frog	Laika	Schedule IV	Das and Sengupta (2009)
Hoplobatrachus tigerinus	Indian Bull Frog	Maguri Beel	Schedule IV	Das and Sengupta (2009)
Fejervarya pierrei	Pierre's Cricket Frog	Guijan	Not Evaluated	Das and Sengupta (2009)
Euphlyctis cyanophlyctis	Skittering Frog	Maguri Beel, Koloumi	Schedule IV	Das and Sengupta (2009)
Hydrophylax leptoglossa	Assam Forest Frog	Guijan	Schedule IV	Das and Sengupta (2009)

Humerana humeralis	Bhamo Frog	Dibru-Saikhowa National Park	Schedule IV	Das and Sengupta (2009)
Hylarana tytleri	Leaf Frog	Koloumi Camp	Not Evaluated	Das and Sengupta (2009)
Species	**Common name**	**Locality Records**	**Status**	**Reference**
Chiromentis simus	Pigmy Tree Frog	Dibru-Saikhowa National Park	Least Concerned	Das and Sengupta (2009)
Feihyla vittatus	Two Striped Pigmy Tree Frog	Dodhia village	Least Concerned	Das and Sengupta (2009)
Rhacophorus bipunctatus	Twin Spotted Tree Frog	Dibru-Saikhowa National Park	Least Concerned	Das and Sengupta (2009)
Rhacophorus smaragdinus	Large Tree Frog	Dibru-Saikhowa National Park	Least Concerned	Das and Sengupta (2009)
Polypedates teraiensis	Terai tree frog	Laika, Dodhia	Least Concerned	Das and Sengupta (2009)
Uperodon globulosus	Indian Balloon Frog	Guijan	Least Concerned	Das and Sengupta (2009)

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22 Appendix 12 Post Mortem report of Ganges River Dolphin

MVD/F-13/2020/04 Dated: 12/06/2020

To

The Range Forest Officer

Guijan WL range

Guijan, Tinsukia-Assam

Subject: Regarding submission of Post mortem Report of Gangetic River Dolphin (<u>Platanista gangetica</u>) on 29-05-2020

(Ref: **Letter No. GWL/7©/2020/130 and dated on 29-05-2020**)

Sir,

In reference to the subject cited above hereby would like to inform you that as per your request for Post Mortem Examination by letter no. GWL/7©/2020/130 dated on 29-05-2020 , we have jointly carried out the post mortem examination along with Veterinary Surgeon of Mobile Veterinary Service-Eastern Assam ,Wildlife Trust Of India at my State Veterinary Dispensary , Tinsukia ,Govt. Of Assam on 29-05-2020 .

Hereby submitting the Post mortem Report for your kind consideration and necessary action.

Attached herewith: PM Report of Gangetic River Dolphin.

Thanking you.

Yours sincerely

Date: 12/6/2020

Place: Tinsukia

12/6/2020
(Dr. Khanin Changmai)
Wildlife Trust of India
Veterinary Surgeon
Mobile Veterinary Service - Eastern Assam
Regn. No. 006665 (VCI)

Smita
12/6/20
Dr. P. C. Dutta
Vety Officer
Mobile Vety. Dispensary
TINSUKIA
Mobile No-9435136478

RECORD OF NECROPSY EXAMINATION

NAME OF PROTECTED AREA/ZOO Maguri Beel

NAME OF SPECIES with scientific name Gangetic River dolphin (Platanista gangetica)

AGE (approx) 2 months SEX Male AMBIENT TEMPERATURE in 'C' (at the time of acquisition)

DATE OF NECROPSY 29/05/2020 DATE AND TIME OF DEATH (estimated) 24-48 hours old carcass

TIME OF ACQUISITION OF CARCASS........ TIME OF DISPOSAL OF CARCASS 30/05/2020

GPS LOCATION AT PLACE OF DEATH & PLACE OF NECROPSY (If different)
N 27°34'22.15"/E 95°22'8.34" and N 27°29'33"/E 95°21'42"

AREA DESCRIPTION (topography, water source etc.)
Area is Maguri Beel Motapung area, carcass found in waterbody of the Beel

I. HISTORY OF DEATH

1. Brief History: The gangetic river dolphin was found dead in Maguri Beel water just below the Maguribeel Bridge
2. Observation of the surroundings: ....
3. Other relevant information: There was a gas well blowout incident at Baghjan - BGR-05 well as per information given by local people and forest staff on 27/05/2020

II. EXTERNAL EXAMINATION

PHYSICAL CONDITION: Normal * Fat * Thin * Emaciated * RIGOR MORTIS NO

SUPERFICIAL LYMPH GLANDS: NO

MUCOUS-MEMBRANE........

NATURAL ORFICES NAD

BODY WEIGHT in kg (approx) 6.510 kg

BODY LENGTH in cm 89 cm
(nose to tip of tail)

TAIL LENGTH in cm........
(base of tail to tip of tail)

HEIGHT AT WITHERS in cm........

CHEST GIRTH in cm........

STATE OF CARCASS: Fresh * Refrigerated * Deep Frozen * Decomposed * Incomplete *

STATE OF DECOMPOSITION: Fresh * Bloated * Active decay * Advanced decay *

DESCRIPTION OF WOUNDS/INJURIES. If any No

OTHER REMARKABLE OBSERVATIONS, if any No

Vital Measurements (whichever applicable):-

Rt. FORE FOOT-PAD GIRTH & LENGTH X BREADTH in cm (carnivores): N/A

LENGTH OF CANINE TEETH in cm (carnivores): Upper Right........ Upper Left........ Lower Left........ Lower Right........

Rt. FORE FOOT-PAD CIRCUMFERENCE in cm (elephant) N/A

LENGTH & CIRCUMFERENCE (at base) OF BOTH TUSK/TUSH in cm (elephant) N/A

OTHERS (Length of Antler/Horn, Length & circumference of Rhinoceros Horn, etc.) N/A

Death SL No........

Horn SL No........

III. INTERNAL EXAMINATION

A. SKIN, SUBCUTENIOUS TISSUE & MUSCLES:		Outer skin layer got removed
B. BODY CAVATIES: 1. POSITION OF VISCERAL ORGANS 2. PERITONEAL CAVITY 3. PLEURAL CAVITY AND PLEURA		NAD
C. RESPIRATORY SYSTEM: 1. LARYNX 2. TRACHEA 3. BRONCHI AND BRONCHIOLES 4. LUNGS (Appearance, colour & consistency) 5. LYMPH GLANDS 6. DIAPHRAGM		NAD Lungs shows haemorrhages and edematous NAD
D. HEPATIC SYSTEM: 1. LIVER (Appearance) 2. LIVER TISSUE 3. GALL BLADDER & DUCTS 4. LYMPH GLANDS		Shows haemorrhages on its parenchyma NAD
E. CIRCULATORY & LYMPHATIC SYSTEM: 1. PERICARDIAL SAC 2. HEART MUSCLE 3. HEART CHAMBERS 4. LARGE BLOOD VESSELS 5. SMALL BLOOD VESSELS (Mesenteric) 6. SPLEEN (Appearance, size, colour) 7. SPLENIC TISSUE		shows haemorrhages → Presence of clotted blood observed Haemorrhages observed
F. DIGESTIVE TRACT: 1. PHARNYX 2. ESOPHAGUS		NAD
3. STOMACC (Simple)	i. Cardiac zone ii. Fundus iii. Pylorus	Haemorrhages observed
(compound)	i. Rumen ii. Reticulum iii. Omasum iv. Abomasum	
4. SMALL INTESTINE	i. Duodenum ii. Jejunum iii. Ileum	Haemorrhages observed

5. LARGE INTENSTINES	i. Caecum ii. Colon iii. Rectum	Haemorrhages and congestion observed
6. LYMPH GLANDS (Mesenteric)		NAD
G. UROGENTIAL ORGANS 1. KIDNEYS (Colour and appearance) 2. URINARY BLADDER		Congestion NAD
3. REPRODUCTIVE ORGANS	i. Testes/penis/Glands ii. Ovary/Uterus/Vagina	NAD
H. ADRENALS:		NAD
I. HEAD: 1. BUCCAL & NASAL CAVITIES 2. TONGUE 3. BRAIN & SPINAL CORD		Pale in colour → Pale in colour → congestion
J. SKELETON		

IV. SUMMARY OF MAJOR FINDINGS

1. Heart shows haemorrhages and ventricular damage
2. Lungs shows haemorrhags and edema
3. Stomach, intestinal lumen shows haemorrhage
4. Brain shows congestion

SL No.	Sample	Preservative used	Examination required	Laboratory address
1	Heart	Salt sol[n] 10%, Formalin	Toxic gaseous/	1) Directorate of
2	Liver	and in Ice	hydrocarbon agent	Forensic Science.
3	Lungs	- do -	Viral and Bacterial	2) NERDDL, Khanapara
4	Kidney	- do -	agents, Patho-histo-	
5	Stomach with Content	- do -	logical and Anatomy	3) College of Veterinary
6	Intestine with Content	- do -		Science,
7	Heart Blood	in EDTA		Pathology and
8				Anatomy
9				
10				

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V. PROVISIONAL DIAGNOSIS

As per Postmortem examination, there are changes observed in lungs, heart, liver, kidney, Brain and gastro intestinal tract. Considering the involvement of vital organs and extensive haemorrhages in Gastro-intestinal tract death may be due inhalation or ingestion of substance of toxic origin leading to hypoxia and death. This is only a tentative conclusion on cause of death. For any confirmatory and differential diagnosis further advanced laboratory Test must be done by competent authority.

Place State veterinary Dispy. Tinsukia
Date 12/06/2020

1. Signature [signature]
Dr. P. C. Dutta
Vety Officer
Mobile Vety. Dispensary
TINSUKIA
Mobile No-9435136478

Veterinarian's name Dr. Pradip Ch. Dutta.

Designation Vety. officer (Mobile) Tinsukia

2. Signature [signature]

Veterinarian's name (Dr. Khanin Changmai)

Designation Veterinary Surgeon /Asst. Manager
Wildlife Trust of India
Veterinary Surgeon
Mobile Veterinary Service - Eastern Assam
Regn. No. 006665 (VCI) / 2102 (AVC)

Note: Attach a rough sketch of the area duly signed by the competent authority

23 Appendix 13 World Health Organization (WHO) Guidelines for noise based on the lowest levels of noise that affect health

Specific Environment	Time Base (hours)	Critical health effect(s)	Standard limits as per WHO guidelines	
			LAeq [dB]	LAmax, fast [dB]
Outdoor living area	16	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	50 55	-
Dwelling, indoors, Inside bedrooms	16	Speech intelligibility and moderate annoyance, daytime and evening Sleep disturbance, night-time	35 30	-
Outside bedrooms	8	Sleep disturbance, window open (outdoor Values)	45	60
School class rooms and pre-schools, indoors	During class	Speech intelligibility, disturbance of information extraction, message communication	35	-
Pre-school bedrooms, indoors	Sleeping time	Sleep disturbance	30	45
School, playground outdoor	During play	Annoyance (external source)	55	-

Hospital, ward rooms, indoors	8 16	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	40 -
Hospitals, treatment rooms, indoors	-	Interference with rest and recovery	As low as possible	-
Industrial, commercial, shopping and traffic areas, indoors and outdoors	24	Hearing impairment	70	110
Ceremonies, festivals and entertainment events	4	Hearing impairment (patrons:<5 times/year)	100	110
Public addresses, indoors and outdoors	1	Hearing impairment	85	110
Music through headphones/earphones	1	Hearing impairment (free-field value)	85 (under headphones, adapted to free-field values)	110
Impulse sounds from toys, fireworks and firearms	-	Hearing impairment (adults) Hearing impairment (children)	-	120-140 (peak sound pressure (not LAmax, fast), measured 100 mm from the ear)

Outdoors in parkland and conservation areas		Disruption of tranquillity	existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low	

-- End of Report --