सत्यमेव जयते

National Mission for Clean Ganga
Ministry of Jal Shakti
Department of Water Resources, River Development & Ganga Rejuvenation
Government of India

ECOLOGY AND CONSERVATION OF DOLPHINS (CETACEANS) IN GANGA RIVER BASIN

JUNE 2021

Prepared by

cGanga
Centre for Ganga River Basin Management and Studies

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National Mission for Clean Ganga (NMCG)

NMCG is the implementation wing of National Ganga Council which was setup in October 2016 under the River Ganga Authority order 2016. Initially NMCG was registered as a society on 12th August 2011 under the Societies Registration Act 1860. It acted as implementation arm of National Ganga River Basin Authority (NGRBA) which was constituted under the provisions of the Environment (Protection) Act (EPA) 1986. NGRBA has since been dissolved with effect from the 7th October 2016, consequent to constitution of National Council for Restoration, Protection and Management of River Ganga (referred to as National Ganga Council).

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cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this it is also responsible for introducing new technologies, innovations and solutions into India.

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Acknowledgment

The document on the focal species "Dolphins" was compiled through comprehensive review on the current level of knowledge on various aspects of Dolphins and attempts to assess how current legislation and policy is affecting the species conservation and management approaches. The document was completed in June 2021 and has been finalised following a peer review process by the experts including Dr R K Sinha, Vice Chancellor, Shri Mata Vaishno Devi University, Jammu; Dr K Sivakumar, Scientist F, WII, Dehradun; Dr Sandeep Behera, Consultant Biodiversity, NMCG. Critical comments and useful suggestions made by the experts have greatly added to the work done by the members of Team cGanga. Photographs and images contributed by several people are gratefully acknowledged.

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Ecology and Conservation of Dolphins (Cetaceans) in Ganga River Basin by cGanga and NMCG

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PREFACE

National River Ganga has been at the centre of the government's multi-decadal efforts to restore and conserve degraded Indian rivers. The Ganga River Basin Management Plan (GRBMP) submitted to the National Mission for Clean Ganga (NMCG), Government of India in the year 2015 by a Consortium of 7 IITs (Indian Institute of Technology's) set a clear direction and action-framework for this purpose, but progress on its implementation was tardy, partly due to the GRBMP recommendations being broad-based strategic measures to some extent. Therefore, after the Centre for Ganga River Basin Management and Studies ("cGanga") was created through a Memorandum of Understanding between MoWR, RD&GR (now Ministry of Jal Shakti), Government of India and IIT Kanpur in April 2016, cGanga conducted many field and in-house studies as well as workshops and consultations with stakeholders, executive bodies, monitoring agencies and experts on various components of GRBMP and its implementation. Based on these activities over the past few years, a clearer understanding emerged on some of the major implementation challenges of GRBMP, especially the difficulty in restoring a very large and complex river system like River Ganga. This led to a more refined and detailed strategic implementation procedure that combines robust scientific method with a Socio-economically, culturally and administratively aligned policy framework.

One of the most important missions of GRBMP was that of Ecological Restoration. This is because it was realized during the preparation of GRBMP that the ecological health of River Ganga would be the best indicator of her wholesomeness rather than piecemeal assessment of hydrological, water quality or geomorphological characterization of the river. As a vibrant ecosystem of ancient origin, the river's biodiversity would be the most complete indicator of her overall status. It is for this reason that it was ardently hoped that GRBMP would be implemented speedily to revive the vibrant River Ganga teeming with life. And it is for the same reason that the separate compilation for each focal species is planed which not only covers the biology of the organism i.e., fish, turtle, gharial, dolphin but also its historical and current status in terms of abundance and distribution; major threats; conservation measures, formulated guidelines, current and future policies by state and central authorities and challenges for scientific understanding. The periodic monitoring of the focal species in river Ganga is necessary to decipher overall improvements or decline in the river habitat conditions within the Ganga River Basin.

This document is prepared by dedicated members of cGanga through the gathering of information taken from the peer reviewed literature and unpublished databases, Government sponsored project reports, and research findings reported in Master's and PhD dissertations, analyses and discussions with various agencies and individuals.

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Release of dolphin in its habitat, Courtesy: Sandeep Behera (NMCG)

1. INTRODUCTION

The world's most threatened mammals are freshwater Cetaceans. The river Ganga and its tributaries support a copious biological growth of rich flora and fauna including megafauna belonging to cetacean group. They constitute an upward ecological pyramid with one or more top aquatic predators such as freshwater Ganga river dolphin and other estuarine and marine Cetaceans in Ganga ecosystem. These charismatic members of Cetaceans group play an important role in ecosystem functioning, controlling community structure and promoting linkages across ecosystems (Estes et al. 1998). The Gangetic dolphins are not only an important indicator but a flagship and sentinel species for monitoring the conservation status of the large rivers in Ganga river basin (GRB) (Aggarwal et al. 2020; Gomez-Salazar et al. 2012; Sergio et al. 2008). There conservation not only protects a wider range of aquatic and threatened species but also ensures better health of our river ecosystem (Aziz 2019; Sinha et al. 2010).

South Asian river dolphin (*Platanista gangetica*) has two sub species *Platanista gangetica gangetica* (the Ganga river dolphin) and *Platanista gangetica minor* (the Indus river dolphin) (Behera 2019; Behera et al. 2013). The Ganga river dolphin, commonly known as Susu, is restricted to the Ganga, Brahamputra, Meghna, and Karnaphuli-Sangu river systems and tributaries. The mammal reported from the foot hills of the Himalaya to the limits of the tidal zone in India, Bangladesh, and Nepal (Sinha and Kannan 2014; Bashir et al. 2012). In Ganga river, freshwater dolphins also inhabits the habitat of other tributaries like Yamuna, Chambal, Ghaghra, Gandak, Rapti, Narayani, Hooghly and Kosi rivers (Braulik and Smith 2017; Choudhary et al. 2006; Smith et al. 2001; Smith and Reeves 2000; Mohan et al. 1997; Reeves and Brownell 1989; Shrestha 1989). In the lower Gangetic portion in the state of West Bengal resides some other in-stream Cetaceans which are constantly reported in the area of Sunderbans and near-shore waters of Bay of Bengal and prefer to stay in estuarine, coastal and brackish water. Irrawaddy dolphin (*Orcaella brevirostris*) is one of them and, was reported by several authors (Chowdhury et al. 2020; Kumar et al. 2019; Mallick 2011) in the lower part of Hooghly and in the upper parts of the rivers Matla, Bidyadhari, in the confluence of Raimangal and Jhilla at Bagna, Amlamati and at Sudhanyakhal. According to Mallick (2011), Indo-Pacific humpback dolphin (*Sousa chinensis*) was sighted near Sajnekhali few years back but sighting of the black finless porpoise (*Neomeris phocoenoides*) was very rare. Indo-Pacific humpback dolphin was also found in the Gomor river of Indian Sundarban during the survey between Sajnekhali Wildlife Sanctuary to Sudhanyakhali in 2008 (Saha and Palchowdhury 2008).

Cetaceans constitute an upward ecological pyramid with one or more top aquatic predators such as freshwater Ganga river dolphin and other estuarine and marine Cetaceans in Ganga ecosystem

Both (Ganga river dolphin and Irrawaddy dolphin) obligatory and facultative Cetaceans are morphologically and phylogenetically distinct (Hamilton et al. 2001) and facing non-identical threats at different scales. TIn this report information and current understanding about both focal species (Ganga river dolphin and Irrawaddy dolphin) with respect to their biology, habitat, distribution, abundance, threats, conservation and legal status is presented in the current report under subsequent sections.

- Introduction of species including its morphological characters, habitat and niche preference, breeding, food and feeding and migratory behavior.
- A global and regional (Ganga River Basin: GRB) status of focal species.
- Major threats and policy steps.
- Management and conservational challenges and measures of restoration.

2. BIOLOGY AND ECOLOGY OF CETACEANS IN GRB

Ganga River Dolphin (Platanista gangetica gangetica)

The Ganga river dolphin occurrence in Hooghly river is well documented in mythological and historical literature by William Roxburgh, Superintendent of the Botanical Garden, Calcutta in 1801 (Roxburgh 1801). The first description of the home range, morphology, and anatomy was cited by Anderson (1879) (Sinha and Kannan 2014).

The protection of the "flagship" species, Ganga river dolphin ultimately leads to the protection of other wildlife sharing common niche (Behera et al. 2019; Behera et al. 2008; Anon 2006; Choudhary et al. 2006). Ganga river dolphin has been included as a Schedule-I animal of Wildlife (Protection) Act of India (1972) and listed under "Endangered" category by IUCN (2017) (Braulik and Smith 2017). Government of India declared Ganga river dolphin a "National Aquatic Animal", during the year 2009.

Scientific classification	
Class	Mammalia
Sub-class	Eutheria
Order	Cetacea
Family	Platanistidae
Genus	*Platanista*
Species	*gangetica*
Sub-species	*gangetica*

Irrawaddy Dolphin (Orcaella brevirostris)
The history of river dolphins in India is dated back in 1852, when a specimen of Irrawaddy dolphin sighted at the harbor of Visakhapatnam on the east coast of India and was described as short-snouted porpoise by Sir Richard Owen in 1866 (Sinha 2004). These dolphins have also been observed in eastern Indian Ocean from Visakhapatnam to the deltas of Brahmaputra and Ganga rivers and in the Chilka lagoon in Orissa (Mahmud et al. 2018; Dhandapani 1992; James et al. 1989; Annandale 1915). The near- and inshore waters of western Pacific have been associated with the species habitat at near river mouths (Smith et al. 2014).

Irrawaddy dolphin is a 'facultative' river cetacean, euryhaline in nature and listed under "Endangered" or "Critically Endangered" category by International Union for Conservation of Nature (IUCN), Red List of Threatened Species based of their range within major river systems (Minton et al. 2017; Sutaria and Marsh 2011; Smith 2004; Leatherwood and Reeves 1994) and also included as a Schedule I animal under Indian Wildlife Protection Act, 1972. Subpopulations reported in the Ayeyarwady river (Smith 2004), Mahakam river (Jefferson et al. 2008), Mekong river (Smith and Beasley 2004b), Malampaya Sound (Smith and Beasley 2004a) and Songkhla lake (Smith and Beasley 2004c) are categorized as Critically Endangered.

Scientific classification	
Class	Mammalia
Sub-class	Eutheria
Order	Cetacea
Family	Delphinidae
Genus	*Orcaella*
Species	*brevirostris*

2.1 Morphological Characters

2.1.1 Ganga River Dolphin (Platanista gangetica gangetica)
The Ganga river dolphin is a well built aquatic mammal. It has a stocky body, in the middle, a long snout, broad flippers, attenuating to a narrow tail stalk behind the dorsal fin. The body has deep brown color. The adult body size range between 2.0-2.2 m (males) and 2.4-2.6 m (females) and weighs about 120 kg. The snout is long and pointed with sharp teeth on both the jaws. The sharp teeth can be seen even in the closed mouth. The eyes are vestigial as they lack a crystalline lens making it literally blind, yet able to perceive light intensity and direction. The dorsal fin is a very low triangular hump located two-thirds of the body length from the anterior end. The flippers and flukes are thin and large in relation to body size, the young ones at birth measures about 70-90 cm and weighs around 6 kg.

The most rare freshwater riverine species (Ganga river dolphin), Courtesy Shahnawaz Khan, WWF India

2.1.2 Irrawaddy Dolphin (Orcaella brevirostris)
The Irrawaddy dolphin has a blunt, bulging rounded head, flexible neck and lack a beak. It is also characterized with the forehead extending past the mouth, broad triangular, paddle-like, pectoral fins, and small, triangular dorsal fins set approximately two-thirds of the body length along the back (Koss 2012). The flippers have a convex leading edge and about one sixth of the total body length long and about half this length for the width (Smith 2009). Span of the flukes is more than one fourth the total body length, with a concave leading edge and median notch (Smith 2009). They have narrow, pointed, about 68 peg-like teeth, about 1 cm long in both the jaws. The body weight varies from 114-200 kg and the length ranges from 1.4-2.7 m. Skin coloration varies from blue to grey colouring with a lighter ventral field. The young ones at birth measures about

90-100 cm and weighs around 10-12 kg. Males are generally larger than females (Mitra and Zaman 2015). General features of Ganga river dolphin and Irrawaddy dolphin, habit and habitat preference are presented in Table 1.

Irrawaddy dolphin (*Orcaella brevirostris*)

Table 1: General habit and habitat features of *Platanista gangetica gangetica* and *Orcaella brevirostris*

Organism	*Platanista gangetica gangetica*	*Orcaella brevirostris*
Nature	Obligate fresh water riverine	Facultative, euryhaline
Maximum size	2.67 m (4 m*)	2.75 m
Water temperature	8-33 ˚C	25-31 ˚C
Current speed	Prefer eddy current; counter current associated with confluences; low current speed; deep waters located in and adjacent to channel convergences and divergences, and downstream (direction dependent upon the tide) of sharp meanders	
Substratum	Silt over sand	-
Breeding season	Jan-June	April-July
Mating	March-June	June-July
Food and feeding	Catholic feeders, bottom feeders, feed on several sp. of fishes of small size (less than 6 cm) (*Wallago attu, Bagarius* sp., *Mystus* sp., *Puntius chola, Nangra* sp.), and crustaceans	Feed on several members of carps and cat fishes (*Cirrhinus* sp., *Labeo* sp., *Xenentodon cancila, Channa* sp., *Mystus* sp. and *Arius* sp.), crustaceans, cephalopods, and fish eggs
Other requirement	Tolerate 5-35 ˚C; Ganga river dolphins are not generally known to occur in salinities greater than 10 ppt, although they have been recorded in waters as saline as 23 ppt; Animals prefer wide sinuous channels with at least two small confluences or one large confluence	Prefer wide range of habitats from fresh to marine waters, Animals in marine coastal areas inhabited in brackish to high salinity (>20 ppt) zones; prefer relatively deep pools (10-50 m) at confluences or above and below rapids
References	Jackson-Ricketts et al. 2020; *Aziz 2019; Win and Bu 2019; Smith et al. 2006; Stacey and Hvenegaard 2002; Morzer-Bruyns 1971	

2.2 Habitat and Niche

Ganga river dolphins are exclusively riverine. Relatively high densities of dolphins are found at sites where rivers join or just downstream of shallow stretches, in areas where the current is relatively weak; off the mouths of irrigation canals; and near villages and ferry routes. The 50% of dolphin sightings in the Ganga were recorded at deeper river channels at confluences (Bashir 2010). In the river basins in India, the Ganga river dolphin is present mostly in plains where the rivers run slowly. This seems to be opposite to the habitat observed in Nepal, where the dolphin can be found in relatively clear waters and rapids. In both areas, however, there is a preference for deep waters (Reyes 1991).

A rapid ecological assessment conducted in the year 2018 by the experts of Wild life Institute of India (WII), Dehradun in the main stem of river Ganga between Bijnor to Ballia, revealed that 74% of the stretch was devoid of high water depth classes, meanders and river islands

Primary habitats are characterized by an eddy countercurrent system in the main river flow caused by a fine sand/ silt point bar formed from sediment deposits of a convergent stream branch or tributary. Marginal habitats are characterized by a smaller eddy counter-current system caused by an upstream meander. Dolphins concentrate in locations of high prey availability and reduced flow (Smith 1993). South Asian river dolphins have been found in water as cold as 8 °C and as warm as 33 °C (Reeves and Brownell 1989). They often reported in the small groups of less than 10 individuals and often found alone or in pair (Jefferson et al. 2015). In the river Brahmaputra, the numbers of dolphins occurring in different depths were found to be significantly different and the highest numbers were found in depths of 4.1-6.0 m (Wakid 2009). While, Mohan et al. (1998) reported the width of the habitat for Ganga river dolphin in Kulsi river in the range 10-30 m while depth ranged during the rainy (July to August) season and dry period varied between 1.5-10 m and 0.3-8.0 m, respectively. A rapid ecological assessment conducted in the year 2018 by the experts of Wildlife Institute of India (WII), Dehradun, in the main stem of river Ganga between Bijnor to Ballia revealed that 74% of the stretch was devoid of high water depth classes, meanders and river islands (WII 2018). In the Sundarbans, mangrove forest of Bangladesh, Ganga river dolphin distribution was conditionally dependent on low salinity, high turbidity, and moderate depth during both low and high freshwater flow. Animals prefer wide sinuous channels with at least two small confluences or one large confluence (Smith et al. 2009). The diurnal dispersal, an important consideration in population assessment is reported by Sinha el al. (2010b) with vigorous and frequent surfacing, during morning and afternoon which also assumed to be their feeding time. They move far from the confluence to the quiet and deep zones with low current in the noon during the period of their low activity (Sinha el al. 2010a).

The Irrawaddy dolphins are euryhaline species found in wide range of habitats from fresh to marine waters. Little is known about the Irrawaddy dolphin habitat preferences but they are found in costal as well as estuarine areas, river deltas, lower reaches of rivers and mangrove areas. In coastal waters, it commonly occurs in areas affected by freshwater inputs and may enter the lower reaches of rivers. They prefer relatively deep pools (10-50 meters) at confluences or above and below rapids (ESI 2018). Bali and Tisen (2012) reported the presence of Irrawaddy dolphins, more than 30 km upstream from the estuaries in Rajang river with water salinity less than 10 parts per thousands (ppt). The levels of activities was reported higher in the morning and decreased during the day in the study conducted in Mekong river, Penang Island and Negros Occidental (Philippines) (Rodrguez-Vargas et al. 2019; de la Paz 2012; Stacey and Hvenegaard 2002). Group characteristics provide insights into social and ecological relationships (Stacey and Hvenegaard 2002). Smith (2009) reported the small group size of 2-6 individuals. The study related to the period of dependency, a measure of age at sexual maturity, time from one birth to the next, reproductive senescence and fecundity status of the population is required for demographic modeling (Thomas and Gulland 2017) and are lacking in the estuarine stretches of river Ganga. Also the knowledge regarding the social behaviour and life history of Irrawaddy dolphins is very scanty and a detailed study on the behavior and habitat characteristics is needed for effective conservation measures.

2.3 Breeding

Dolphins are social animals and live in small to large groups, associated with many animals like crocodiles, turtles and wetlands birds. But in adulthood they turn solitary, remain alone or at best in pairs, and may group during mating season where several males display courtship for the attention of the females (Behera and Rao 1999; Singh and Sharma 1985). Gestation period lasts 10-11 months (Reidenberg and Laitman 2009). Calving apparently can occur at any time of the year, but there may be peaks in December

The Irrawaddy dolphin seems to be an opportunistic carnivorous bottom feeder and its feeding is fully based on habitat dependent fish availability

to January and March to May. The annual birth rate of Irrawaddy dolphins in the lake of Chilika was reported one calf per year (Sarkar 2011). Newborn calves have been observed mainly in April and May. The newborns are about 0.85 m with maximum age ~30 years (Mitra and Zaman 2015). Calves are weaned within one year of birth (Jefferson et al. 2008).

The life history of Irrawaddy dolphins is little studied in the lower reaches of river Ganga. The winter as well as monsoon survey between Kolkata to Diamond harbor sighted single individuals at four locations which indicated the possibility of small year-round population in this river stretch (Chowdhury et al. 2020).

2.4 Food and Feeding

South Asian river dolphins feed on several species of small fish and invertebrates ranging from 3.5-11.8 cm. They are non-selective feeders and mostly feed at or near the bottom in morning and afternoon, echolocating and swimming on one side (Sinha 2013; Jefferson et al. 1993; Reeves and Brownell 1989). Ganga river dolphins are catholic feeders and preferred small fishes and gastropods (Sinha et al. 2010a). They show seasonal and diurnal dispersal for feeding and maintaining their territorial behavior. They aggregated near the drift fishing nets in shallow zone to capture the pray entangled/ escape from the fishing nets (Sinha et al. 2010a).

The Irrawaddy dolphin seems to be an opportunistic carnivorous bottom feeder and its feeding is fully based on habitat dependent fish availability. The diet composition of Irrawaddy dolphin constitutes small bony fish species, crustaceans, cephalopods, and fish eggs (Win and Bu 2019). The records of prey preference and food and feeding behavior in the area of Indian Sunderbans mangrove regions are very inadequate. While members of Cyprinidae, Siluridae, Pangasiidae and Bagridae constituted preferred prey for them in Mekong river system (Smith et al. 2009; Baird and Mounsouphom 1997; Marsh et al. 1989).

3. STATUS OF CETACEANS

3.1 Global Status of Ganga river dolphin and Irrawaddy dolphin

In Indian Subcontinent, Bangladesh, India, Nepal, and possibly Sikkim and Bhutan are the home range of Ganga river dolphin. Rice (1998) reported their presence at an elevation level below 250 m. The global population was estimated about 3,500 individuals throughout its distribution range in 2014 (Aziz 2019; Sinha and Kannan 2014). The detailed estimates in tributaries and in the main stem of river Ganga under GRB is presented in the subsequent section. The population assessment survey was conducted in the Brahmaputra river starting from Assam – Arunachal Pradesh border to the India – Bangladesh border in the year 1993, 2003, 2005 and 2012 revealed that the encounter range from 0.23-0.68 dolphins/km with maximum dolphin prevalence reported in 2012. The favorable conditions also prevailed in the Kulsi river before the confluence of Brahmaputra river between Marabhitha to Pas Gumi (Mohan 1989). Wakid and Braulik (2009) proposed the 30 community-based dolphin conservation habitats in Brahmaputra river between Assam – Arunachal Pradesh border to the India – Bangladesh border. The highest encounter rate was reported in the river stretch from Dhansirimukh to Tezpur because of strict protection of the river by the Kaziranga National Park. A comparative encounter rate in the river Brahmaputra, Kulsi and Subansiri is presented in Figure 1.

Geographical range of Ganga river dolphin (*Platanista gangetica gangetica*) (IUCN 2019)

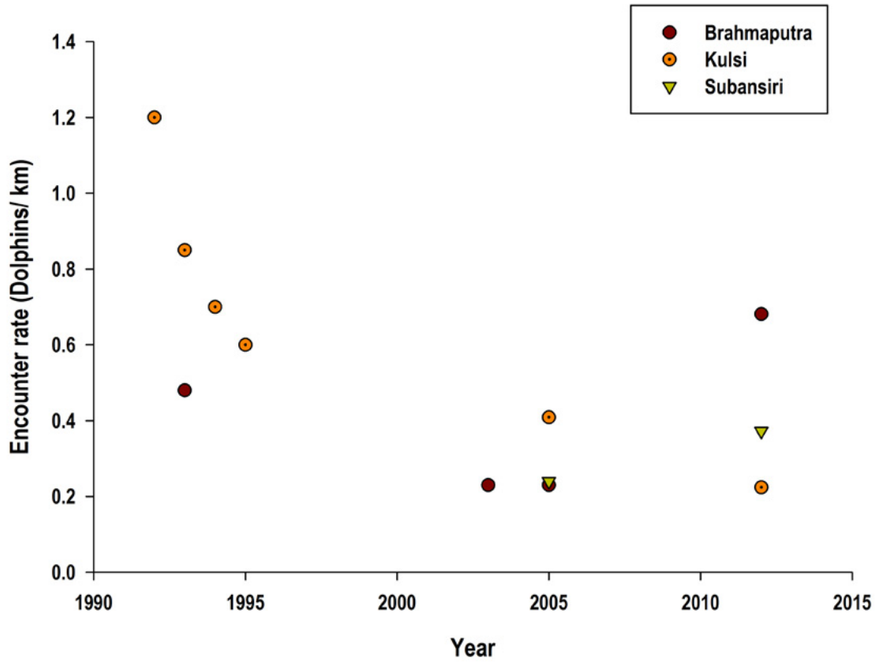
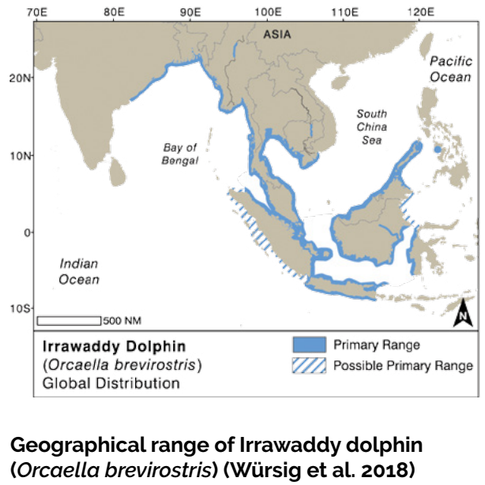


Figure 1: Status of Ganga river dolphins in river Brahamputra and tributaries
Data source: Pers. Comm. Wakid (2012); Wakid and Braulik (2009); Mohan (1989)

The most endangered among all cetacean species is facultative freshwater species, Irrawaddy dolphin patchily distributed to the estuarine, tropical, and subtropical waters of the Indo-Pacific regions from northeastern India to the Philippines (Dolar et al. 2002) and south to northern Australia (Smith 2017; Stacey and Arnold 1999; Stacey and Leatherwood 1997). The coastal and estuarine populations were reported in Borne, central islands of the Indonesian Archipelago to Palawan, Philippines and west to the Bay of Bengal. Three freshwater rivers, Ayeyarwady (formerly Irrawaddy) in Myanmar (formerly Burma), Mahakam in Indonesia, and Mekong in Cambodia and Lao People's Democratic Republic carrying freshwater populations of Irrawaddy (Aziz 2019). The Chilika Lagoon in India, Songkhla Lagoon in Thailand, and Malampaya Sound in the Philippines also having three subpopulations (Minton et al. 2017). A total of 451 Irrawaddy dolphins were sighted with an encounter rate of 0.19 dolphins/ linear km in the stretch of all navigable channels covering 1,510.4 km in Bangladesh portion of the Sundarban Mangrove forest (Smith et al. 2006). Ganga river dolphins (225 individuals) were also reported in the survey with an encounter rate of 0.47 dolphins/ linear km. Large scale dispersal up to 300-400 km to follow the pray in tributaries has been reported by Coates et al. (2003). The geographical status of Irrawaddy dolphin in the lakes and rivers is compiled in Table 2.



Geographical range of Irrawaddy dolphin (*Orcaella brevirostris*) (Würsig et al. 2018)

After the first faunistic survey (1910-1919) in Chilika by the erstwhile Indian Museum and Zoological Survey of India (ZSI) during British regime, the first account of mammalia of an Island of Chilika Lake was available that got published in 1921. Later, ZSI during its second survey (Chilika expedition) conducted during 1985-87 reported occurrence of 18 species of mammals which was, for obvious reasons, was not complete and exhaustive for the total account of the mammal fauna.....

Khan et al. (2018)

A total of 451 Irrawaddy dolphins were sighted with an encounter rate of 0.19 dolphins/ linear km in the stretch of all navigable channels covering 1,510.4 km in Bangladesh portion of the Sundarbans

Table 2: Geographical status of Irrawaddy dolphin (*Orcaella brevirostris*)

Location	Area/ Length	Reported Dolphin Population	Year	Habitat	References
Chilika Lake	1,100 km²	Min. 20	1990s	3-4 m deep channels near the lake mouth	Dhandapani (1992)
		~ 98	2002		Mohanty and Otta (2008)
		~ 162	2018		TNIE (2020)
		~ 146	2020		TNIE (2020); Beasley (2007)
Songkhla Lake	1,082 km²	~ 100	1990s	2-4 m deep section at the freshwater portion	Anderson and Kinze (1994)
		Min. 20	2000	-	Beasley et al. (2002); Beasley (2007)
		0 in 2003 ~ 15 in 2004	2003-2004	2.1-2.8 m water depth	Smith et al. (2004)
Ayeyar-wady River	2,200 km	33 to 72 dolphins reported through eight surveys	1996-2004	Deep water reaches of the river, where the depth is 40-60 fathoms; slow-moving water, area sheltered by mid-channel islands	Smith et al. (1997); Smith and Hobbs (2002); Smith (2004); Beasley (2007)
Mahakam River	800 km	100-150	Mid 1980s	Confluence point with tributaries or lake	Indonesian nature Conservation Office (Tas'an and Leatherwood 1984)
	-	68	1990s	-	Priyono (1994)
	-	33-55	1999-2002	-	Kreb (2004); Beasley (2007)
	Between Muara Kaman (about 180 km from the river mouth) and the village of Tering (about 420 km from the mouth)	89 in 2005 90 in 2007 91 in 2010 92 in 2012	2005-2012	-	Kreb (2014)
Mekong River	4,800 km	~ 200	1997	Deep pool areas at the river confluences, below or after mid-channel islands, or below rapid systems	Baird and Beasley (2005)
	-	138-178	2001-2005		Beasley (2007)
Hooghly River	96.3 km	Sighted	2013-2016	-	Mitra and Chowdhury (2018)
	123 km		2020	-	Chowdhury et al. (2020)

3.2 Status of Ganga river dolphin and Irrawaddy dolphin in GRB

Platanista gangetica gangetica, known locally as Susu, is endemic to the Indian sub-continent and reported historically in 1801 by William Roxburgh, Superintendent of the Botanical Garden, Calcutta (Roxburgh 1801) in the Hooghly river, the tidal zone of the river Ganga (Sinha and Kannan 2014; Behera et al. 2013). The historical range of distribution of *Platanista gangetica gangetica* in the main stem of river Ganga was from the foothills of Himalaya to the Bay of Bengal (Anderson 1879). The actual past records of 19th century for their abundance in the distribution range under GRB is unavailable. The historical distribution of *Platanista gangetica gangetica* in GRB is presented in Figure 2 (digitized from Anderson 1879). Historically, the dolphins were reported year-round in Yamuna river (upto Tajewala near the foothills of the Himalayas) and also at Delhi (512-km upstream of the Chambal confluence) (Anderson 1879), Sharda (upto Tanakpur) (Sinha and Sharma 2003a), Sone (upto Indrapuri barrage) (Sinha and Sharma 2003a), Ramganga (upto Moradabad) (Anderson 1879) and in the entire stretch of other major tributaries such as Ghaghara, Gandak, Kosi and Fulhar. The current distribution and population of Ganga river dolphins is also reported by several workers in not only in different segments of Ganga river and its tributaries but also in Brahmaputra river system and Sundarbans delta (Chowdhury et al. 2020; Mitra and Chowdhury 2018; Pers. Comm. Behera S.; Singh and Rao 2012; WWF-Nepal 2006; Sinha and Sharma 2003b; WWF-India Unpublished work). Once believed to be in the tens of thousands their number has gradually reduced to four to five thousand with a further decline to a mere 1,800 individuals in all the tributaries of its distribution (Bashir et al. 2007, 2010; Behera et al. 2008; Behera 1995; Jones 1982; Anderson 1879). The estimated population based on the survey conducted during 1994 to 2014, in the main stem of river Ganga and its tributaries was nearly 2,850 dolphins in GRB (Sinha and Kannan 2014). The temporal variation in the encounter rate of Ganga river dolphin in the main stem of river Ganga from Haridwar to Farakka Feeder canal is presented in Figure 3.

The Vikramshila

Ganga Dolphin had 154 dolphins in the year 2017, as per the estimates from the survey conducted by the researchers from Ashoka Trust for Research on Ecology and Environment (ATREE), Bangalore and Wild Life Institute of India (WII) Dehradun

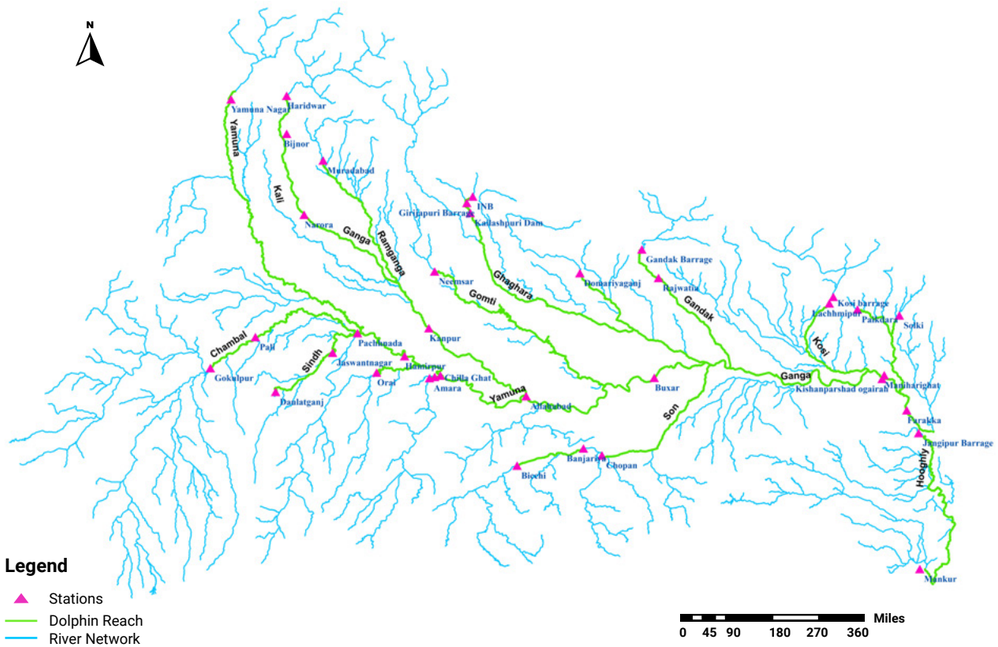


Figure 2: Historical distribution range of Ganga river dolphin in GRB

Source: digitized from Anderson (1879)

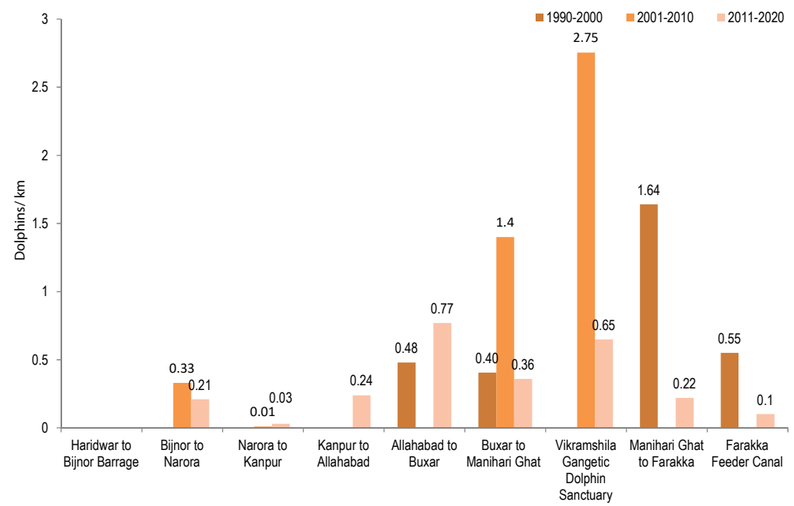


Figure 3: Temporal variation in the encounter rate of Ganga river dolphin in the main stem of river Ganga

Data source: Pers. Comm. Behera S.; WWF-India Unpublished work; WII (2018); Bashir et al. (2010); Kelkar et al. (2010); Sinha et al. (2000); Sinha (1999)

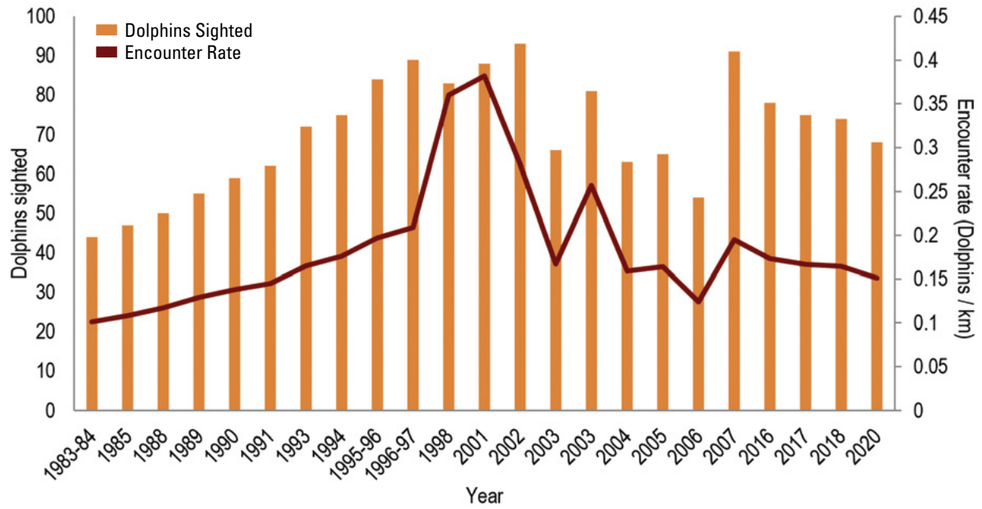


Figure 4: Temporal pattern of encounter rate of Ganga river dolphin in the National Chambal Sanctuary

Data source: Yadav (2020); Choudhary et al. (2012); Taigor (2008)

In many tributaries, the population facing severe anthropogenic pressure and is fragmented. The animals maintaining their population by congregating themselves in and/ or near the protected areas of the tributaries as well as main stem of the river Ganga, and a comparatively high encounter rate was reported in these sites i.e., Ramsar from Brijghat to Narora, National Chambal Sanctuary, Vikramshila Gangetic Dolphin Sanctuary and Sundarban Biosphere Reserve. The temporal patterns in terms of encounter rate of Ganga river dolphin in the protected area of National Chambal Sanctuary, in the main stem of the other tributaries and in Gandak main stem are shown in Figure 4, 5 and 6, respectively

The encounter rate in Ramsar site (between Bijnor to Narora) and Vikramshila Gangetic Dolphin Sanctuary are presented in Figure 3. The Vikramshila Gangetic Dolphin had 154 dolphins in the year 2017, as per the estimates from the survey conducted by the researchers from Ashoka Trust for Research on Ecology and Environment (ATREE), Bangalore and Wild Life Institute of India (WII) Dehradun (Khan 2018). The report also revealed the declining trend of dolphin population in the stretch and that is possibly due to the dredging activities and the noise pollution created by large ship propellers. These activities enhanced manifold in recent years due to the declaration of the stretch of the Ganga from Varanasi to Haldia in West Bengal 'National Waterway Number 1' by Government of India. The decline in the dolphin population even in the protected zone is matter of concern, which should be addressed in the proper way in the

novel plan "Project Dolphin" launched by Government of India for conservation of river and marine dolphins in the year 2020. It is also important to mention that little is known about the behavioral and acoustic responses, auditory masking, and potential effect of similar stress response of Ganga river dophin in the GRB system.

The reported data for tributaries of GRB clearly revealed the loss of a significant proportion of dolphin habitat due to the loss of longitudinal connectivity in dry season, a decrease in prey fishes due to intense fishing (Bashir et al., 2010), illegal poaching (Choudhury 2013), sediment deposition owing to high embankments (Smith et al., 1998) and habitat destruction and fragmentation (Dudgeon 2000; Reeves et al. 1991). The direct and indirect drivers for the reduction of the dolphin population in GRB are addressed in details in the subsequent section. The current distribution range of the Ganga river dolphin in the middle and lower middle stretches of the Ganga river and its tributaries is also depicted in the Figure 7. Encounter rates in the main stem of river Ganga between Allahabad and Farakka barrage were recorded higher in different time frame analysis.

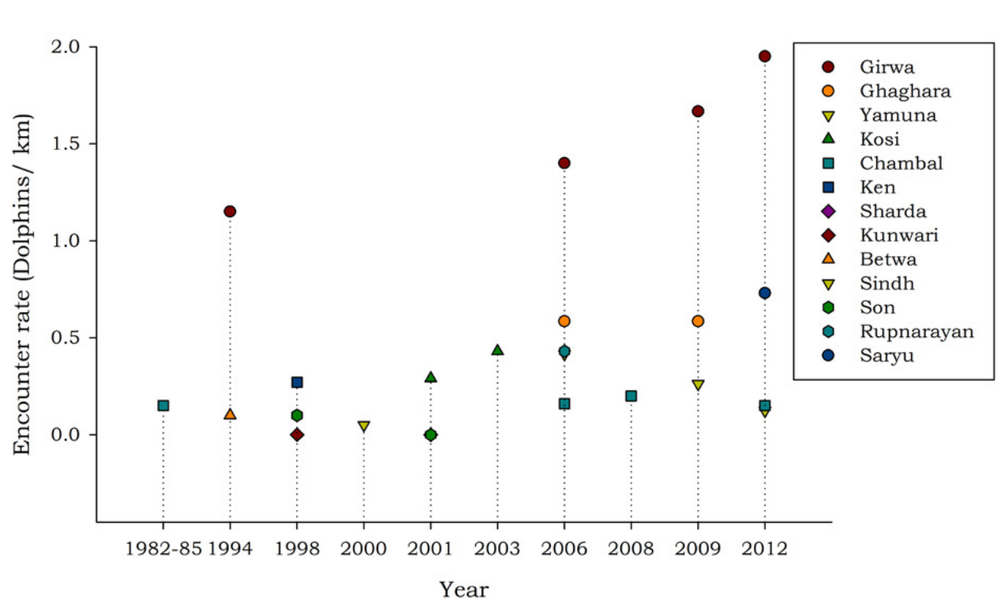


Figure 5: Encounter rate (dolphins km^{-1}) for Ganga river dolphin in various river channels of GRB

Data source: Pers. Comm. Behera S.; WWF-India Unpublished work; Singh and Rao (2012); WWF-Nepal (2006); Sinha and Sharma (2003b); Sinha et al. (2000)

The data of dolphins encounter rate has been adopted and reproduced using the statistics of the published literatures, personal communications, web articles and scientific reports. The collection of data for tributaries from various sources have either been discontinued or fragmented. Data perusal reveals that the encounter rate (Dolphins/ km) in the Girwa river is highest for all the reported years followed by Gandak in the year 2010 (Figure 5 and 6).

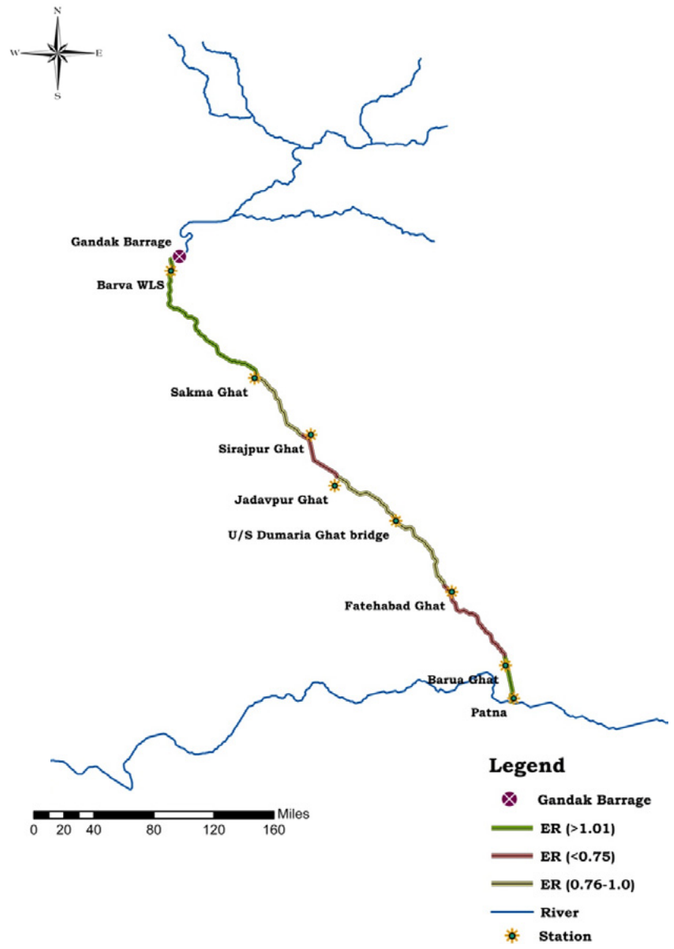


Figure 6: Ganga river dolphin encounter rate in main channel of river Gandak in the year 2008-10

Data source: Sharma (2013); Choudhary et al. (2012)

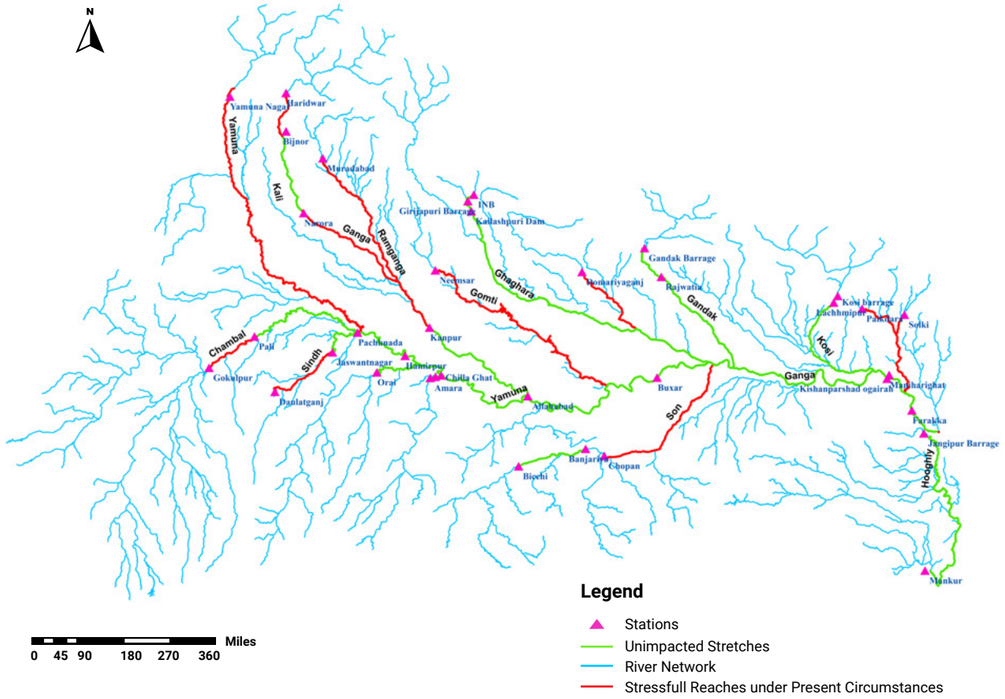


Figure 7: The current distribution pattern of Ganga river dolphin in GRB

In case of lower parts of GRB in the Indian territory of Sundarbans, the literature reveals the presence of Ganga river dolphin and Irrawaddy dolphin, but detailed study regarding the status, distribution or abundance of these cetaceans is prerequisite for their conservation (Manjrekar and Prabu 2013). The waterways of Sundarbans Reserved Forest in Bangladesh are the only places where the sharing of the common habitat is reported most often for both the cetaceans (Mitra and Chowdhury 2018). Fluctuations in temperature and salinity of different water bodies have an a special impact on the distribution of cetaceans (Baumgartner and Mate 2005). Mitra and Chowdhury (2018) also confirm the change in the distribution range of *Platanista gangetica* and *Orcaella brevirostris* in the Indian part of the Sundarbans. The study reveals the gradual disappearance of *Platanista gangetica* from the Indian territory of Sundarbans due to change in the habitat and in the presence of assorted limiting factors. The change in the habitat due to the spatio-temporal variation in the salinity value of past 30 years in three sectors of Indian Sundarbans was studied by Mitra and Zaman (2015). The results revealed that the salinity decreased in the western as well as eastern sectors of the Sundarbans while the central sector shown a reverse picture. The rise of the salinity in the central sector is predicted to be 36 psu after a period of 30 years which will significantly impact the distribution range of *Platanista gangetica* and *Orcaella brevirostris* (Figure 8). The loss of the upstream freshwater connectivity of 5 rivers (Saptamukhi, Thakuran, Matla, Gosaba, and Harinbhanga) is one of the reasons behind the change in the

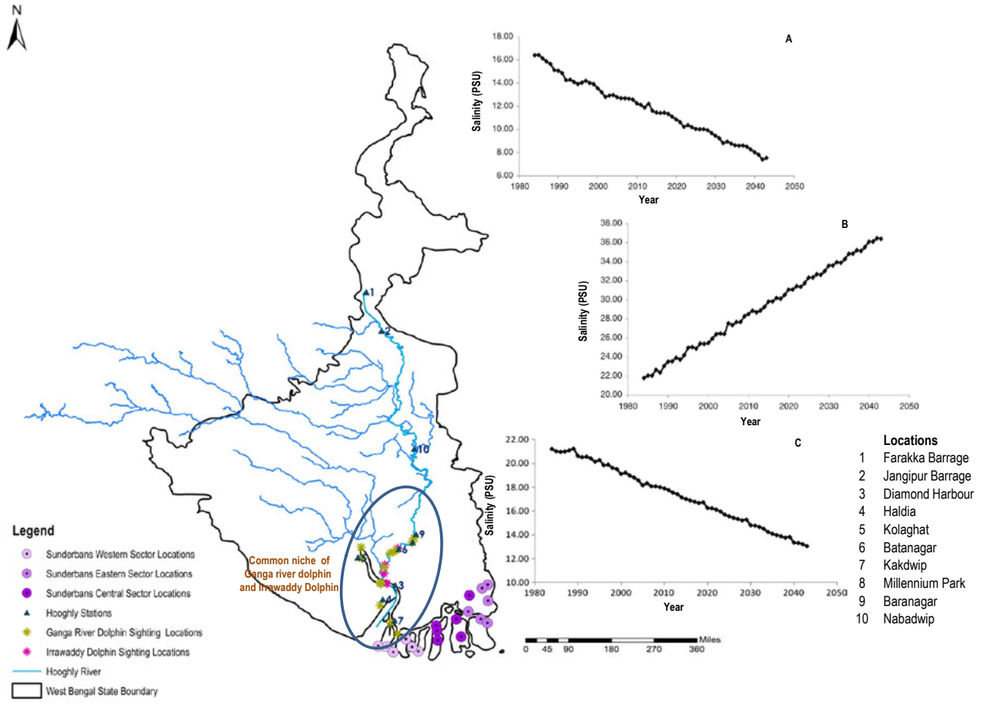


Figure 8: Distribution of Ganga river dolphin and Irrawaddy dolphin in the common niche in lower stretches of Hooghly and salinity profile of eastern (A), central (B) and western (C) sectors of Indian Sundarbans

Data source: Chowdhury et al. (2020); Mitra and Chowdhury (2018); salinity trends are adopted from Mitra and Zaman (2015)

salinity pattern in central sector. *Orcaella brevirostris* is sighted in 2014 and 2016 by Mitra and Chowdhury (2018). The salinity levels of western, central and eastern zones of Sundarbans were <1.0-19 ppt, 9.0-24.6 ppt, 5.0-24 ppt, respectively (Mitra and Chowdhury 2018). They also reported the consistent encounter rate of dolphins at the estuarine mouth of Ganga in all seasons where hypo (<1 ppt) and moderate (1-10 ppt) saline water prevailed. Close monitoring of the dolphins (*Platanista gangetica* and *Orcaella brevirostris*) behavior, status, distribution, hotspots and their existing and historical habitats in the fresh as well as in estuarine zone of Hooghly and Sundarbans is required for long term conservation of the species.

4. MAJOR THREATS AND POLICY STEPS

Low flows in dry period and loss of longitudinal connectivity

Dams and barrages have altered the natural flow regimes by impacting the hydrology (changing low flow regime and reduce peak flows and change the interannual flow variability), geomorphology and aquatic ecosystem (Mailhot et al. 2018). Studies have speculated that dam and barrages influence the Ganga river dolphin habitat occupancy by not only reducing water depth and velocity but also altering water flow and channel width (Sinha and Kannan 2014; Bashir et al. 2012a). In the study conducted by Bharti et al. (2011) on environmental flows revealed that dams and canals on the Ganga have also changed the timings of extreme flow events which altered the in-stream and floodplain ecological processes. The impact of water depth on the abundance of dolphins have been reported by Sinha and Sharma (2003a), Kelkar et al. (2010), Choudhary et al. (2012) and Paudel et al. (2015).

Choudhary et al. (2012) reported the minimum mid-channel depth requirement for dolphin adults (5.2 m) and mother-calf pairs (2.2 m to 2.4 m). Wakid (2009) stated that the most likely preferred water depth for dolphins is between 4.1 m and 6 m. Recent publication on eco-biology of Ganga river dolphins between Varanasi to Farakka indicated that the resting depth preference between 3 m to 9 m and temperature preference range of 15 to 25 ˚C (Joshi et al. 2018). These depth preferences are not easy to maintain and is among the most important threat in the entire GRB in dry season due to the “discontinuities” in the river continuum produced by existing dams and barrages.

In the main channel of river Ganga, Bhimgoda barrage, Bijnor barrage, Narora barrage, Lavkush barrage and Farakka barrage in the upper, middle and lower Ganga catchment respectively, significantly alter the natural sediment flow dynamics of the system and compromises habitat suitability. The connectivity between tributaries and

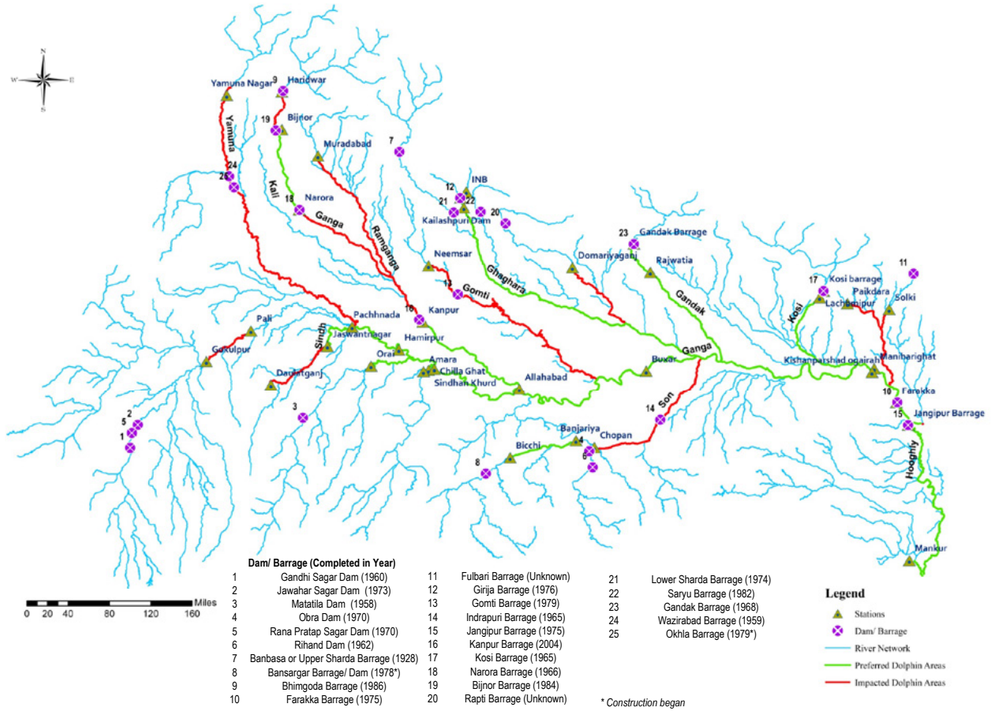


Figure 9: The impacted flow regime of river Ganga and tributaries due to the construction of dams and barrages over the last 8-9 decades
Data source: Reeves (2000)

the main channel of Ganga-Brahmaputra systems is hampered severely during the dry season from October to April and the dispersal in the tributaries is only possible during rainy season. They may become isolated in pools and river branches during the dry season (Reeves and Brownell 1989). The reduction in the flows, modification in the habitat downstream to these barrages and obstacles for longitudinal exchanges along the river Ganga and its tributaries are some of the major concerning factors responsible for declining the number of dolphins. The success of the ongoing and proposed dolphin conservation programs in GRB and in other riverine systems is based on the effective water management policy. A minimum flow of water in the river must be allowed even during the lean season for the survival and dispersal of the dolphin population. The institutional and/ or civil monitoring of flow regimes at the local level

in the entire basin in mainly dry season is desired to ensure the natural flows in the entire system. The dams and barrages constructed over the last 8-9 decades, which substantially limit he river space available for dolphins in GRB is illustrated in Figure 9.

Decline of prey base

Ganga river dolphins forage on the fishes inhabited in shallow river systems. Almost all the rivers in GRB are subjected to the shift in catch composition of local fisheries. The non-selective fishing practices in certain areas are also responsible for alteration in the food source for dolphins. The change in the composition of the fishes in the system ultimately alter the prey availability prospects and it directly or indirectly poses serious threat to the dolphin population (IPPC 2007; Sinha 2004; Ghosh et al. 1982). The habitat alteration due to the depletion of abundance and diversity of planktonic and benthic forms (Gremion et al. 2004) is induced manifolds due to the release of noxious pollutants directly into the many stretches in the rivers in GRB, which ultimately affect the prey availability for dolphin population (Bashir 2010). It was recommended to use the scientifically defensible framework for protection of freshwater ecosystem from anthropogenic pollution.

Fish stocks over-exploitation and application of non-selective fishing practices should be regulated. The natural breeding and nursery grounds should be protected by maintaining the river space. The floodplain mapping should be done using the GIS and hydraulic modeling to maintain the prey availability in all the seasons.

Direct killing and incidental capture/ entanglement in fishing nets

The freshwater Cetaceans are susceptible to direct conflicts with human beings for water and food resources and facing many associated threats (Reeves and Leatherwood 1994). The decline in the population of dolphins in various states under GRB is due to the age old practices such as the intentional killing for oil, for bait (used dolphins decomposed flesh as a bait to catch the scavenger fish of comparably high prices i.e., *Clupisoma garua*), for entrails and for meat (Bairagi 1999; Dhandpani 1992; Anderson 1879; Motwani and Srivastava 1961). The intentional killing of local migrants was also reported in the transition monsoonal period at the confluence point of the tributaries (Choudhary et al. 2006). The proper identification of the communities engaged in poaching is essential and legal actions through strict laws by the concerned authorities should enforce prohibition of such deliberate killing. The regular awareness program among the fishers should be executed at the regional scale to explain the negative consequences of such catching activities. The program should be assisted by awareness campaign for entire spectrum of communities to convey necessity of dolphin conservation and the existing rules and regulations related to dolphins prohibited actions. The awareness campaign for the use of low price alternative products such as fish scraps oil, shark oil and sardine oil (Sinha 2002; Mohan and Kunhi 1996), should be conducted and the products made available to the communities using dolphin oil and entrails to attract fish.

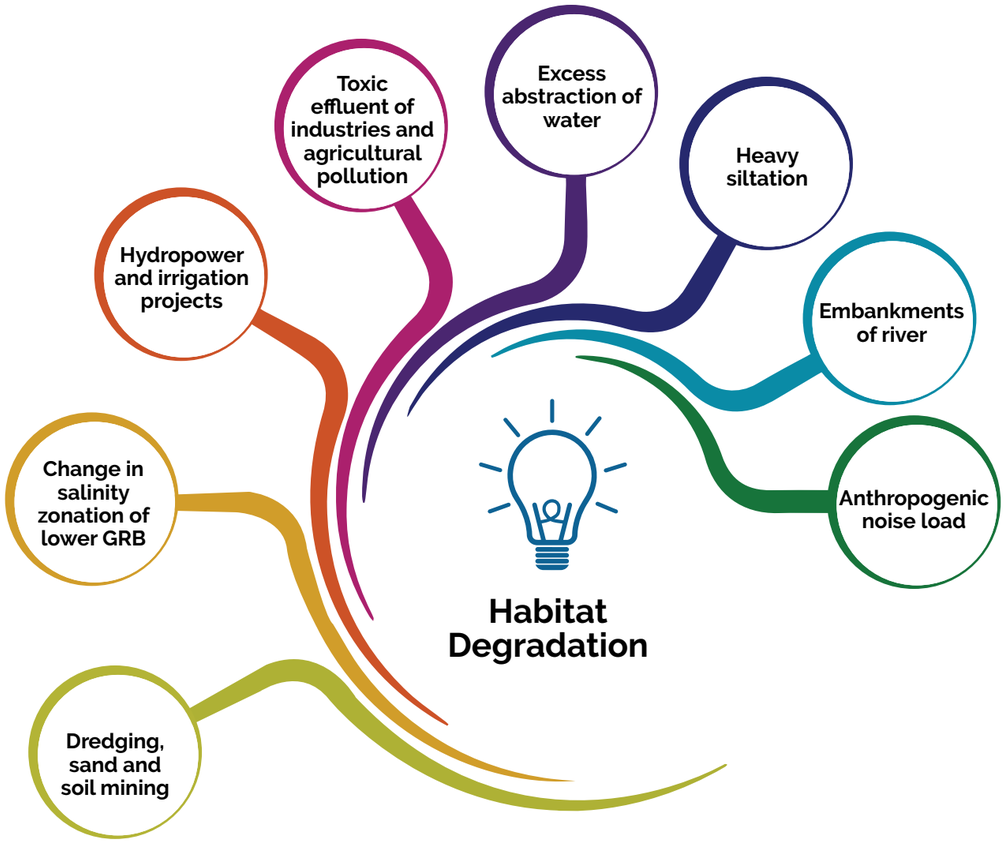
In almost all the years in the dry season, the dolphin by-catch mortality increases due to incidentally captured in gill nets (Beasley et al. 2002; Stacey and Leatherwood 1997). Authors engaged in monitoring the stretches of GRB heighten the similar actions (Paudel and Koprowski 2020; Sinha et al. 2010a; Choudhary et al. 2006; Sinha and Sharma 2003a). The fishing gears/ non-selective fishing methods (e.g. monofilament plastic gillnets and electricity) and practices, should be monitored and regulated by State Fishery Department. The alternative employment for gillnet fishermen should be provided. The gillnet-free zones in the basin should be marked and established. The fishers should also be advised to use the traditional fishing methods more frequently to manage the fisheries sustainable.

Habitat degradation

Habitats of the freshwater Cetaceans are continuously depleting due to human actions and in order to minimize the adverse impact, river management policies and conservation initiatives are desired to ensure the ecological integrity of the system. In 2016, the proposal of 'National Waterways Act' by the Government of India initiating the construction of National Waterway 1 or NW1 to transport passengers and cargo from the eastern seaport of Haldia (West Bengal, India) to Varanasi (Uttar Pradesh, India), about 1,360 km inland which also is an overlapping habitat for river dolphins and the 90% of the endangered dolphin population has the potential to wipe out from the dolphin habitats. The commissioning of the projects has to be critically reconsidered for various hydrological and ecological functions of river (Aggarwal et al. 2020). Multiple habitat variables contribute to varying degrees of impacts in the basin and are addressed underneath which threaten the survival of river dolphins over the past few decades.

Dredging, sand and soil mining

Dredging (capital dredging or maintenance dredging) and mining (sand, soil and gravel) can have significant direct and/or indirect impacts on aquatic life. The detrimental impacts and risk of the associated activities are linked with its intensity and duration and is also evaluated on the basis of tolerance threshold to the various stressors for riverine organisms including dolphins (Wenger et al. 2017; Browne et al. 2015; Erftemeijer and Lewis 2006). These anthropogenic activities maladjusted the food chain of the aquatic ecosystem by disrupting the primary trophic status.



A rigorous scientific study is lacking in GRB to access the impact associated with dredging and mining-related stressors, impact of suspended and contaminated sediment on all aquatic ecosystems in various life stages of associated organisms. The equilibrium between the developmental activities and proper risk management measures for adequate protection of keystone species is prerequisite for maintaining the ecological sustainability.

Change in salinity zonation of lower GRB

Habitat with low salinity, moderate depth and high turbidity favor Ganga river dolphin (Smith et al. 2009). The potential attributes for extirpation of the Ganga river dolphin from Indian Sundarbans are reduced freshwater discharge, elevated sedimentation and swelling salinity (TNIE 2019). Low flow during dry season due to the construction of Farakka barrage causes an increase in salinity intrusion further upstream in the estuary (Akter et al. 2016). The change in the salinity pattern in the Indian part of the estuary are affecting more to *Orcaella brevirostris* than the *Platanista gangetica* (Mitra and Chowdhury 2018). The Sundarbans Mangrove forest of south-western part of Bangladesh experienced similar change in the salinity levels from 27-27.5 ppt to 29.5-30 ppt which altered the regional ecosystems drastically (Hussain et al. 2012). In the current scenario more in-depth study is required to access the impact of barrage management on dolphin's ecology and behavior as it seems to be one of the most critical factors to decide the home range of these organisms in the estuaries.

Hydropower and irrigation projects

The engineering structures for hydropower and irrigation projects often fragment cetacean populations in entire GRB. All these dams and barrages block the movement of dolphins and other aquatic mega-fauna and create small subpopulations. Dolphin's population was isolated into four subpopulations in the main stem of river Ganga earlier in 1975, 1966 and 1984 due to the commissioning of Farakka barrage, the lower Ganga barrage at Narora and the middle Ganga barrage at Bijnor. After the extirpation of dolphins above Bijnor, the main stem of river Ganga having three subpopulations (Sinha per. com). These hydraulic structures also altered the environmental complexity in the upstream and downstream of the river channel leading to the reduction in the environmental suitability for aquatic life. The literature also reveals that due to the high water velocity and turbulence often found within the barrage gates, it would be difficult for the animals to move up-stream and lead to the downstream migratory attrition of upstream sub-population (Braulik et al. 2014; Reeves 1991; Reeves et al. 1991). The unidirectional movement of dolphins and low dry season river discharge in the stretches lead to the species extirpation. The conservation of the species requires maintenance of the habitat which warrants the future water development planning and projects to allocate funds to mitigate the harmful effects of the planned project.

Toxic effluent of industries and agricultural activities

The unregulated influx of industrial and municipal waste into the river is an important driver for extinction of the dolphins in most of the riverine systems of developing countries including GRB. The industrial and domestic pollutants altered the mesohabitats characteristics that lead to the change in the ecological interactions. The effect of these pollutants not only alters the food web of the

The regulated flow of river Ganga in lower Himalayan region at Rishikesh

system but their implication can also be visualized in the form of morphological abnormalities in dolphins such as skin lesions, reproductive and immunological disorder (NOAA 2018; Than 2013; Acevedo-Whitehouse and Duffus 2009; Van Bressem et al. 2009; Colborn and Smolen 1996). To protect and conserve the ecological integrity of the rivers, a stronger enforcement of environmental compliance is prerequisite for an effective water management policy. A more pragmatic approach is desired to find out the regional solutions for water pollution and to maintain the balance between conservation of natural resources and economic development.

The application of noxious chemicals and pesticides in agricultural practices near the main channel of the river and in the flood plains may seriously threaten the ecosystem sustainability. Some of the applied chemicals posed acute and/ or chronic risks to the living forms in the streams. The adverse effects of the agricultural pollutants on Ganga river dolphin were also reported. The application of higher level of agricultural

pollutants such as DDT and PCB's in the floodplain area was reported as one of the potential driver for reducing the dolphin abundance (Senthilkumar et al. 1999). The pesticides such as HCH, aldrin, heptachlor, DDT and endosulphan were reported from the samples collected from the river water from different regions in the middle Ganga stretch from Devprayag to Bhagalpur (Agarwal et al. 2015). HCHs were most frequently detected in mountainous stretch; endosulfans were prominent in UP stretch while in Bihar stretch aldrin group of pesticides were prominent (Agarwal et al. 2015). In the middle Ganga stretch between Kachlaghat to Kanpur, a local extirpation of the dolphins due to pollution was reported by Behera et al. (2013). Kannan et al. (2005) also reported the organic pollutants such as Organochlorine pesticides, Polychlorinated biphenyls (PCB's) and Polybrominated diphenyl ethers (PBDEs) in the tissue of Chilika lake Irrawaddy dolphins. The appropriate mitigation measures such as appropriate buffer zone between the agricultural field and water body should be adopted to reduce the risk of these noxious chemicals.

Excess abstraction of water

The river discharge generally declining from year to year due to the increasing demand of irrigated agriculture, higher demand of water in the cities along the rivers. The change in land use pattern of the basin leads to the alterations in river ecology. Higher surface water abstraction leads to the alteration in the extent of river and riparian wetland habitat, sediment deposition, and water temperature and change in water chemistry impacts the river biota significantly (Wooster 2016; Baker et al., 2010; Dewson et al., 2007). The abundance of the dolphin is positively associated with channel depth, width and its quality. The low dry season river discharge directly and indirectly impacts the river dolphins by reducing the physical space available to them and declines the fish prey (Xenopoulos and Lodge 2006; Nilsson et al. 2005). Water abstraction not only exacerbates the chances of negative human interactions but also alters hydrological regime which ultimately diminishes the carrying capacity of the river and ability to support large numbers of aquatic megafauna (Braulik et al. 2014). The environmental flow and impact assessments studies could be the primary drivers for restoration and conservation of dolphin habitat and to maintain a balance between economical practices and ecological processes.

Heavy siltation

Heavy siltation in the major rivers in GRB degrades the habitat for dolphins which need high scale plantation in the catchment area. Both the poor soil conservation techniques and

deforestation are responsible to enhance the soil erosion in the rivers which lead to the loss of the spawning and breeding grounds. The detailed study conducted on fish, a prey for dolphins, revealed that siltation heavily impacted spawning grounds, cause behavioural changes in spawning fish, decrease in fecundity and increase in egg mortality, reduction in larval growth and development rate and survival of larval fish (Srivastav et al. 2019). All these alterations ultimately lead to decrease in the prey availability and forces the dolphins to explore another niche for their survival. Substantial research is required on siltation rates, nutrient enrichment, textural deformities and their direct or indirect impact on the entire natural ecosystem. Comprehensive international policy and legislation should be executed to reduce the potential risks associated due to the heavy siltation from transboundary rivers such as Kosi, Gandak and Ghaghara.

Embankments of river

River embankments destroy the lateral connectivity of rivers to its riparian zone ultimately leading to the habitat loss for terrestrial and aquatic floral and faunal species. Riparian (buffer zone as well as buffer strip) as well as wetlands should be protected through appropriate legislative framework for managing range of functions and services. An appropriate buffer mapping and designing is a prerequisite for conservation of native fishes in river Ganga which leads to the habitat conservation and restoration for dolphins.

Government of India initiated the construction of National Waterway 1 or NW1 in Varanasi (Uttar Pradesh, India)

Anthropogenic noise load

Cetaceans populations are acoustically reliant animals and is directly impacted by anthropogenic noise produced through commercial and tourist boat traffic. These animals utilize sound for detecting prey, navigating, and communicating (Todd et al. 2015). The emitted acoustic signals are of low frequency and are prone to interference from similar low-frequency noise produced by ship engines (Dunlop 2016; Weilgart 2007). Boat movements in the streams, a causative factor for severe injury are sometimes responsible for dolphins killing. Their operations modify the geomorphologic and hydraulic attributes of the river. Many information gaps exist in the knowledge regarding the impact of boat trafficking on dolphin behaviour in the rivers of GRB. A balance between economy related to dolphin-watching tourism, commercial navigation and safeguarding habitat availability for dolphins is mandatory in a way that would neutralize the negative impacts in the form of only short-term behavioural alterations.

5. MANAGEMENT AND CONSERVATION MEASURES

1. The closed monitoring of river dolphins and their habitats is prerequisite for assessing the impact of short and long term conservation measures. Local level monitoring units “Dolphins Rakshak” should be formed to work in coordination with national and international NGOs, State Forest Department, State Fisheries Department and other Scientific Institutes to form a dolphin conservation network for close monitoring of dolphins status, identification of important dolphin habitats and its suitability, impact of anthropogenic activities on the dolphin behavior, spontaneous information dissemination and simultaneous actions.
2. Long-term research oriented biomonitoring program covering detailed scientific study on cetaceans in GRB should be financially supported which not only enhance the knowledge in scientific community but also dispersed awareness within stakeholders and local communities. Education and training should be at higher priority at the regional level to increase the number of trained people engaged in dolphin conservation.
3. Local fishers should encourage adopting traditional fishing practices that leads to dissuade the non-selective fishing

methods used by non-local contractors as soon as they get the fishing rights from regional governments.

4. States should follow the "Guidelines for implementing Wetlands (Conservation and Management) Rules, 2017" formulated by "Ministry of Environment, Forest and Climate Change, Government Of India" for aquatic and semi-aquatic biodiversity conservation.
5. The status of dolphins sub-population in the tributaries of river Ganga is still alarming and these areas be investigated more systematically than has been done to date. Local people should be encourage for community based conservation program to prevent the large scale ecological destruction by involving in regular 'local ecological surveillance' as they share the common interest for resources.
6. Multi-task water diplomacy covering the transboundary approach using environmental component of the South Asian Association for Regional Cooperation (SAARC) should be developed to link among national and international agencies for conserving river dolphin populations (Yasuda et al. 2017).
7. Government of Bangladesh in 2012 declared three Wildlife Sanctuaries for the protection of freshwater dolphins in the eastern Sundarbans, where both the species (Ganga river dolphins and Irrawaddy dolphins) co-occur most often (Thomas and Gulland, 2017). Similar habitat need to be identified and designated as hotspots in the 38% of the "Sundarbans National Park" area that lies in the Indian territory.
8. Multi-species conservation program should be formalized for the protection and conservation

5.1 Key actions for dolphins conservation recommended under "The Conservation Action Plan for the Gangetic dolphin 2010-2020" (Sinha et al. 2010) and Project Dolphin 2020

- Initiating state-wise Gangetic dolphin population status surveys and threat assessment
- Setting up of protected areas for the Gangetic dolphin
- Capacity building for Gangetic Dolphin conservation and management and promotion of the Participatory Management' of these secured habitats with help of local communities
- Minimising fisheries interface and incidental capture of river dolphins
- Prevention, mitigation and restoration of impacts on dolphin habitats from developmental projects
- Safeguarding dolphin populations and habitats through scientifically robust monitoring program
- Develop and implement the river conservation management framework to maintain the connectivity among populations
- Community involvement in river dolphin conservation and management
- Identification and mitigation of direct and indirect threats to survival of dolphin populations through:

a. Bycatch and poaching reduction with a programme that incentivize the dolphin conservation to local communities i.e. via dolphin tourism, stock enhancement of commercially important native fishes, etc.
b. Understanding and minimising the effect of vessel traffic
c. Monitoring and control of pollution levels
d. Reduction of unsustainable fishery practices
e. Ensuring ecologically safe habitat modification practices including the e-flows
f. Monitoring and controlling the spread of diseases
g. Management of invasive species in GRB
h. Riparian (buffer zone as well as buffer strip) as well as wetlands should be protected through appropriate legislative framework for managing range of functions and services

- Promote awareness through outreach and education and enhance livelihoods and well-being of dependent communities through:

a. Evaluation and integration of inter-sectoral policies to achieve maximum benefit to conservation and people dependent on river
b. Community engagement, sensitisation of stakeholders through awareness activities, education on alternate livelihood options and ecotourism models

- Rescue and rehabilitation of Gangetic dolphin
- Enhance national, regional and international cooperation on dolphin research and conservation

5.2 Glimpse of the existing and proposed conservation initiatives

The limited informational crisis associated with species habitat is always a bottleneck in the conservation of any focal species. A successful conservation action plan for the keystone species such as Ganga river dolphins and other Cetaceans requires the integration of multiple factors (social, economic and political). The inclusion of demographic, genetic, behavioural, ecological and systematic knowledge with the management and conservation approach of an endangered species is prerequisite for an effective and auspicious on-the-ground conservation.

SIGNIFICANT ACTIONS AND MILESTONES BY THE INDIA GOVERNMENT AND CONCERN STATES

- Chilika lake declared as a Ramsar site in 1981 for the conservation of Irrawaddy dolphins.
- Conservation programs were launched after the declaration of Ganga river dolphin *(Platanista gangetica gangetica)* as "National Aquatic Animal" on 5th October 2009 with a formal notification by MoEF on 10th May 2010.
- The action plan for the conservation of the Gangetic dolphin was prepared by a working group of three members "Dr RK Sinha, Dr Sandeep Behera and Dr BC Choudhary" and submitted to National Ganga River Basin Authority, Ministry of Environment and Forests, GoI in November, 2010.
- A scientific compilation written in a lucid manner and aptly illustrated on Gangetic river dolphin by Dr RK Sinha, was published by "Department of Environment and Forest, Government of Bihar, Patna" in 2013.
- A decade after the declaration of Ganga river dolphin *(Platanista gangetica gangetica)* as "National Aquatic Animal" a stronger impetus by Indian governmental authorities leads to the announcement of 10-year 'Project Dolphin' in the line of Project Tiger and Project Elephant, for the conservation

and protection of not only the Ganga river dolphins but also ocean and estuarine population of dolphins by Hon'ble Prime Minister on 15th August 2020. The project dolphin will be planning to execute in cooperation and support with Ministries/ Departments/ Scientific Organizations/ Civil Society Organizations etc.

- The National Mission for Clean Ganga with Wildlife Institute of India, Dehradun and State Forest Department launched "My Ganga My Dolphin" campaign at six sites across river Ganga in the states of Uttar Pradesh, Bihar and West Bengal on 6th October 2020, to link the tourism with dolphin's conservation.

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