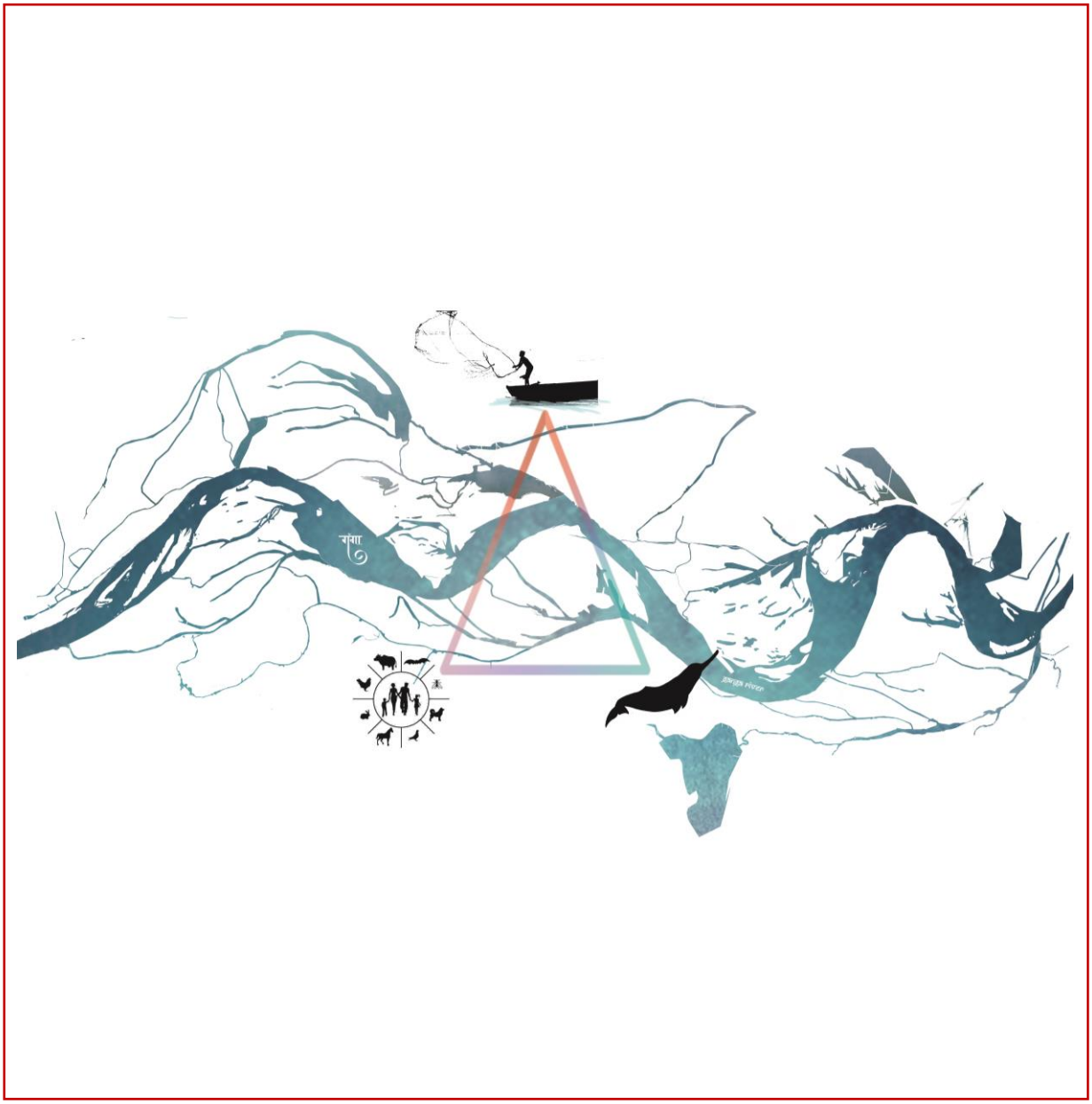
Sponsored Thesis Project Competition on

"RE-IMAGINING URBAN RIVERS"

(2021)



Project Title : The somber case of an odd triad – dolphin, man and zoonoses

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PREFACE

"***Maybe zoonoses are like animals – fighting to be the survival of the fittest trying to face the man who is devastating their homes***." – Nikitha Mallavolu

Microbial transfer have been around in this planet since time immemorial , contributing to the emergence of numerous renowned plagues, epidemics and pandemics And today almost 60 – 80% of the documented infections that affect man are of zoonotic or animal origin and this is slowly turning into a predominant cause of concern. Studies have identified the causal drivers of zoonoses to be linked with factors such as habitat fragmentation, biodiversity loss, agriculture etc. however very few studies actually have attempted to draw a link between them and the discipline of landscape architecture. Research done within the domain of veterinarian sciences, medical epidemiology etc. may have mentioned an occasional link here and there but nothing in depth or in a proper correlation as to what landscape architects can do to resolve this predicament has been explored. This research is an attempt to explore the same.

This research strives to understand how zoonotic resiliency can be achieved a riverine landscape within an urban context using the case of Vikramshila Gangetic Dolphin sanctuary, Bhagalpur, Bihar. The outcome is a prototypic design approach and framework that may be adapted into any manner of waterscapes across the nation or lay a foundation for advancements at a global scale. A cemented understanding of the fact that landscape architecture is indeed capable of curbing zoonosis at the initial phases itself is also an added and inevitable outcome of the research. However a combination of design interventions, proactive planning upon consultation with experts from various fields and policy formulations is needed for success to prevail. Mimicking the natural environment to the best possible is the core strategy to keep zoonotic spill over at bay. Strategic and prioritised calls need to be taken in addition to ecological interventions that complement the conventional interventions for attaining higher success rates.

This DPR is a comprehensive document that elucidates the past and present of Ganga River in context of Vikramshila Gangetic dolphin sanctuary in addition to providing a detailed account of how this sanctuary may be restored and conserved to its best possible glory through means of strategic design interventions, policies and guidelines. Efforts were made to consider the various aspects associated with holistic yet sustainable river sanctuary management for the benefit of both the river - its associated dynamics and biodiversity and the local community in the region. Efforts were also made to establish a consensus between the key unconventional stakeholders of this project – dolphin, man and zoonoses; each symbolic for a wider canvas. Dolphins represent the key indicator species in addition to the wide biodiversity that ensure the sustenance of Ganga river. Man refers to both the local communities that depend on the river and the occasional visitors that flock the area to perform religious acts and see the Gangetic dolphins. Incorporating the element of zoonoses into the research paradigm only assists to further explore a river sensitive development prototype that is resilient to potential pandemic or epidemic scenarios which in the light of the ongoing covid 19 global pandemic calls for an imperative need to be explored and further studied

upon. The solutions offered in this DPR when implemented shall offer an environment with resilience as its foundation for existence. The strategies covered in the DPR follow a one health approach that credits the positive health of our planet to the health of humans, animals and environment which offers multiple benefits such as increased blue – green infrastructure, enhanced quality of life, improved river health and increased awareness of man towards the existence and importance of nature and its ecosystem services. Another integral component of this DPR is an attempt at documentation of the existing research relevant to the maintenance of Vikramshila Gangetic Dolphin Sanctuary, thereby acting as a data base for future research to be based upon in this region and for similar data bases to be developed for the river in entirety.

It is anticipated that the successful implementation of each and every strategies, interventions, policies and guidelines in this DPR would be seen as a trailblazer for many similar waterscape projects to enfold at both nation and a global scale in the immediate future. On that note, I take this opportunity to thank each and every one who has been with me at various steps of the way in helping materialise the content conveyed in this DPR to the best possible form.

ACKNOWLEDGEMENT

Moving closer to the semester closure and the competition finale, this acknowledgement section stands as the final item on my checklist for the successful completion of my DPR. It is a herculean task to identify and quote every single person who has contributed to the completion of my thesis, however it is imperative to recognize on records ; of a few who did unequivocally play important roles along the way. Hence I only feel it appropriate to quote them in a roughly reverse chronologically order.

At the outset, I express my gratitude to the God Almighty, without whose unseen guidance I could never have embarked upon and complete this thesis. I am extremely grateful to my close friends formed during the course of study at SPAV for offering the third person perspective and being a pillar of support during the strenuous period. I also thank my family in addition to an array of relationships – formed on personal and professional front for their moral support, encouragement and input guidance; delivered during the casual conversations shared over this period.

Taking steps forward towards the hierarchy apex, I express my gratitude towards all the external jurors who have reviewed my work at the stage reviews and the final external review for their input was quite valuable in taking my study forward to what it is today. I further take this opportunity to thank our thesis coordinator Asst. Prof. Kapil Natawadkar whose valuable inputs have immensely contributed in directing the crux of my thesis research to stay within the paradigm of academic research limits. Yet again, I utilize this opportunity to thank the plethora of researchers whose valuable contribution to the field under which my topic lies, have cemented the very foundation of my research to take it forward in addition to the multi – faceted team and external experts at NIUA and NMCG whose critical comments helped keep me rooted to the practical aspect of design as well. A special mention to my assigned mentor from NIUA – NMCG panel – Urban River Planner Jyoti Verma who has tremendously contributed to my study through her practical comments as well as introducing me to various experts relevant to my study. I also express my gratitude to VGDS Biodiversity conservator Mr. Deepak Kumar who has immensely contributed to the thesis by sharing his knowledge of the site and its biodiversity through photographs and words.

No acknowledgement can be complete without thanking our HOD Dr. Janmejoy Gupta who along with the multi – faceted team of faculty and auxiliary staff at School Of Planning and Architecture, Vijayawada (SPAV) for the opportunity to embark on this research, in addition to the assistance offered to all the students in successfully completing the semester and therefore thesis during the hardship so formed as a result of the on-going global Covid – 19 pandemic.

At the prime and most notably, I also take this opportunity to express my sincere gratitude to my supervisor, mentor and most importantly the director of SPAV - Dr. (Prof.) Minakshi Jain for her valued suggestions, guidance, constant encouragement to keep working harder in the right direction and most importantly; for setting an environment with full freedom to create a research

that stayed true to my own. My deepest gratitude to Dr. (Prof.) Minakshi Jain (ma'am) for taking time out of her busy schedule as the director of an institute of national importance; just to ensure the needed support was always delivered, as and when required.

Thank you everyone for helping materialize my research to what it is today.

Manju Rajeev Kanchan

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VGDS – Vikramshila Gangetic Dolphin Sanctuary

FPC – Flood Pulse Concept

RCC – Riverine Continuum Concept

RPM – Riverine Productivity Model

RES – Riverine Ecosystem Synthesis

NW – National Waterway

IUCN – International Union for Conservation of Nature

CPCB – Central Pollution Control Board

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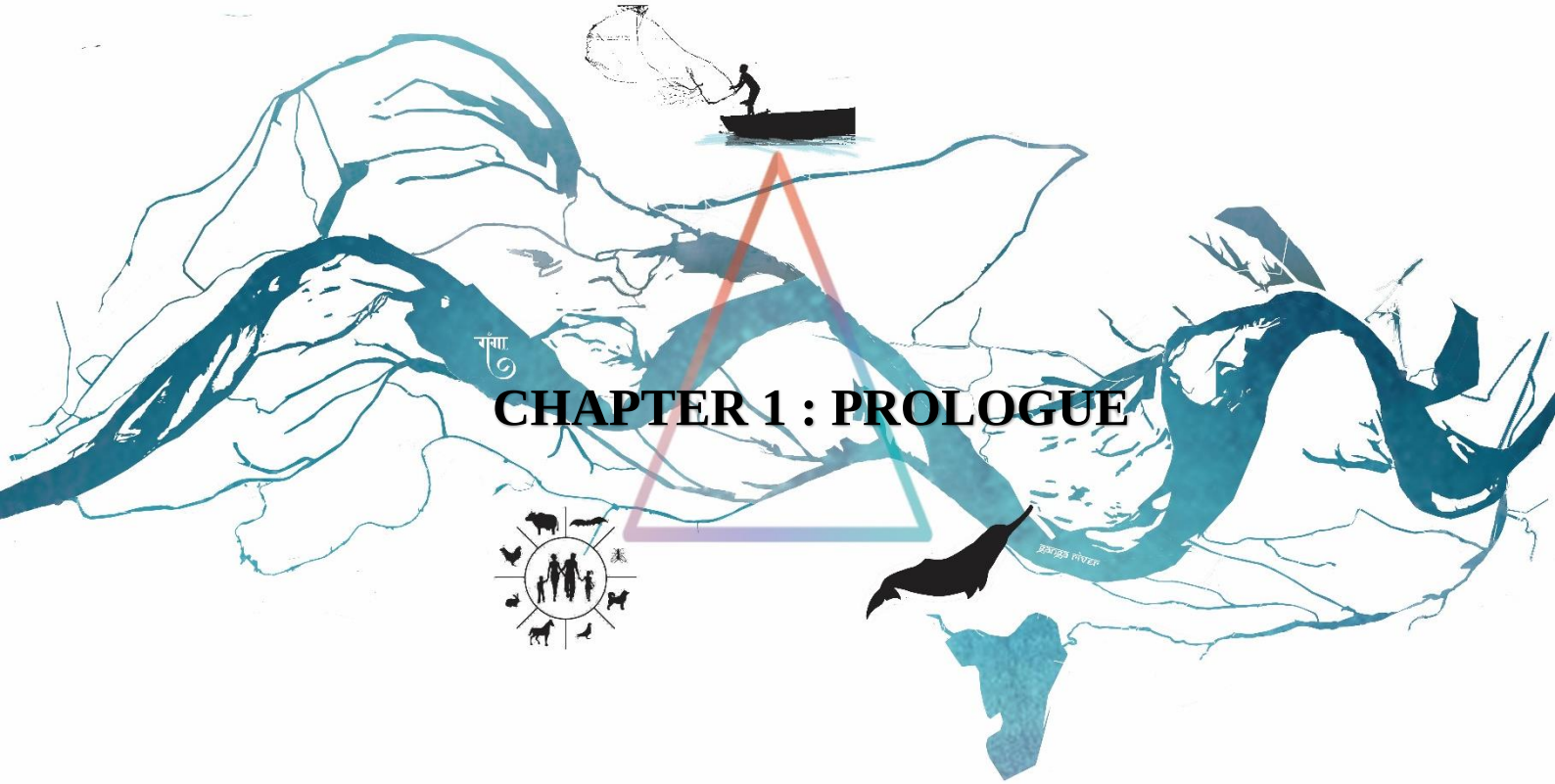

CHAPTER 1 : PROLOGUE

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1.1 PROPOSED PROJECT TITTLE

The proposed project title 'The sombre case of an odd triad - dolphin, man and zoonoses' deals with the revitalisation and revival of The Vikramshila Gangetic Dolphin Sanctuary, Bhagalpur district, Bihar. This project proposal attempts to understand and mitigate the impacts of water born zoonoses in lotic riverscapes of India using the riverine stretch of Ganga within the Vikramshila Gangetic Dolphin sanctuary (VGDS) as an example, while simultaneously developing a sanctum for the Indian Gangetic Dolphin (*Platanista gangetica*). The forlorn scenario of the degrading fisheries in Bhagalpur, the devastating attempt at survival of the Gangetic Dolphin as they try to live another day and the desperate measures the local predominant fishing community need to resort to as they end up with zero catch to meet their needs and the present zoonotic pandemic – all this played a role in helping me conjure this title. This project has also been shortlisted among the top 9 selected topics under the NMGC and NIUA jointly organised sponsored thesis project competition on '*Reimagining urban rivers*'. In accordance with the competition guidelines, the project falls under the theme 'Theme 2: Developing eco-friendly riverfront projects'.

1.2 INTRODUCTION

"The clash of human and animal interests may create friction when wild species from the peri-urban hinterland are attracted to feeding or nesting opportunities in the ever expanding suburbs." – *An excerpt from Animal cities – Beastly urban histories by Peter Atkins*

The above excerpt perfectly highlights a gist of the context that this research proposal strives to address in addition to forming one of the fundamental crux on the basis of which my dissertation proposal was developed. Zoonosis are slowly turning into a predominant issue of concern within the public health sector with studies indicating around 60–80% of the documented zoonoses to be of animal origin (***Figure 1***). Transfer of malignant zoonotic pathogens from sylvatic reservoirs into the human population is truly a rising concern; especially in the event of the ongoing pandemic.

Generic research studies identify the prominent causes of zoonotic development within the human community to be closely linked with degrading environmental status and the health of our blue – green network infrastructure as well. Studies reveal water bodies as an equivalent pathogenic reservoir for pathogens that are either endemic or reach the waters due to improper anthropogenic practices such as open defecation etc. Additional research further revealed the natural presence of human pathogens in wild fauna which usually include gregarious species such as dolphins and migratory avi - fauna that can become potential vectors of zoonoses as well.

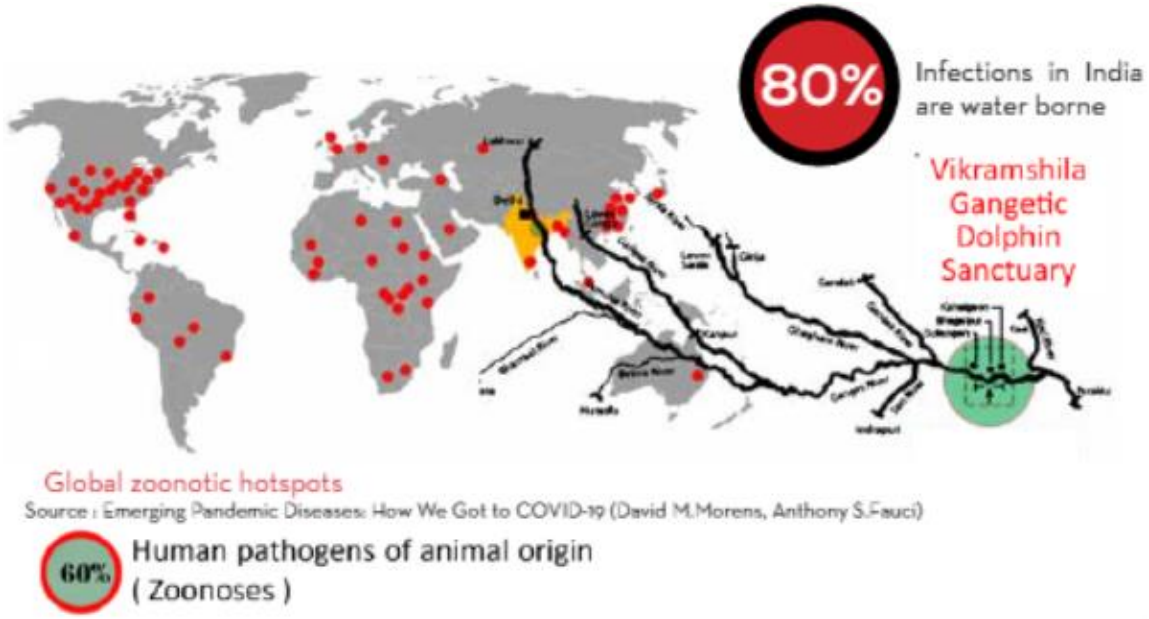

Figure 1 *- Global status of zoonoses with the proposed site in focus (Source – Adapted from Emerging Pandemic diseases – How we got to Covid19 by David M. Morens, Anthony.S.Fauci by author)*

This calls for effective monitoring and preservation of these waterbodies to prevent onward transmission to other wild, domesticated or human species via direct or indirect contact. Understanding the working of predator – prey relationships and existential food webs can help devise strategic design solutions to minimize biodiversity loss without compromising food security or development. This project strives to function as a demonstration prototypic model for maintaining zoonotic resilient and healthy water bodies within an ever developing urbanscape with an added tourism angle that ensures the safety of all stakeholders involved.

1.3 RESEARCH POSSIBILITY

The course of my dissertation titled '***Role of landscape architecture in curbing zoonoses – developing a design framework and approach***' helped me shed light on the ennumerous ways zoonoses spread into the human community. Due to a generic focus, the dissertation did not address any particular region or microsite however a drawn conclusion was that the degree of blue - green infrastructural connectivity, species richness and diversity, the extent of anthropogenic interference and interventions determined the intensity of zoonotic spillover. Which is why selecting a blue - green project site stretch subject to a plethora of natural and anthropogenic interferences in addition to being a sensitive ecosystem with a potential scope of being a pathogenic reservoir landscape offered a great potential to develop a prototypic zoonotic resilient landscape design that could be adapted to other similar ecosystems as well.

1.4 AIM

To develop a prototypic zoonotic resilient landscape where humans and fauna (both wild

and domesticated) can coexist within the same environment without fear of a pathogenic spill over.

1.5 OBJECTIVES

- To develop a design framework for dealing with eco – sensitive waterscapes within an urban environment.
- To create a safe haven for the endemic species of the region, thereby simultaneously increasing the population count of the Indian Gangetic dolphins as well.
- To design a health resilient riverine infrastructure for an ecosystem as unique and sensitive as the Ganges that exists within the layers of religion, natural sanctum and rapid urbanisation - this can further be adapted to similar riverscapes within India.
- To develop a design along the one – health approach or similar such ideologies in an attempt to draw a balance between the involved stakeholders – water (river), society (such as fishing community) and nature (Gangetic dolphin)

1.6 RESEARCH METHODOLOGY

This research strives to envision a near ideal scenario of riverine landscape design that offers an inclusive and equitable environment to all, regardless of the species diversity. This is yet another indirect outcome of developing zoonotic resilient landscapes. In order to better understand how such a massive yet critical developmental change may be brought about – this project employs a focussed research technique to achieve the best possible results within practical limits. The design methodology that is followed here has been adapted from the design approach and framework that was developed as a part of my dissertation research work which has been presented in the form of a flow chart here (***Figure 2***). Primarily a descriptive and qualitative approach in order to better influence outcome and empower change through opening a platform for future discussions and research.

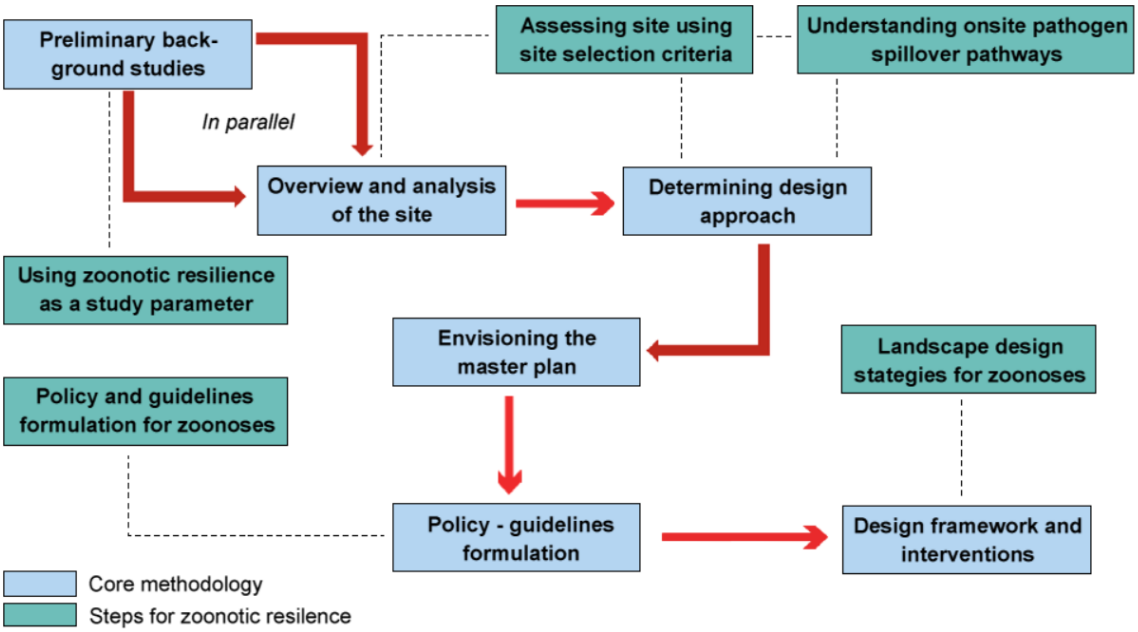

Figure 2 *- Design methodology flowchart (Source - author)*

1.7 RESEARCH QUESTIONS

- How can we develop a blue - green infrastructural riverine urban landscape, inclusive of the diverse species that exist within a habitat and holds a potential for a potential zoonotic spillover?
- How can we convert a landscape environment into a zoonotically resilient landscape?

1.8 SCOPE, FOCUS AND LIMITATIONS

Due to the large site extent and the time constraints due to it being an academic research, emphasis shall be more on the holistic master plan development. Owing to the novelty associated with the chosen topic of research, a sliver of possibility persists with respect to developing an ideal design output as this is an ongoing area of research. Additionally, owing to the above cited factors, the research shall primarily address the entire study holistically at a macroscopic level by addressing the generic and common zoonotic infections based on vector typology at a broader scale.

1.9 PROJECT BRIEF

"As a new morning unfolds with the last rays of the morning sunrise slowly caressing the earth's surface, countless greyish - pink figures - both big and small could be noticed plunging in and out of the Ganges for their joyful dip, an occasional somersault and redraw the figures in the clear water of the Ganges. A safe haven for these gentle mammals to spend their lives in pure bliss and harmony in nature; thriving in content with their families; rejoicing at every birth and mourning at every sorrow. A place where mankind can come and further experience moments of bliss and harmony away from the

daily fast paced stressful, urbane lifestyle; right in the lap of nature. A place where the religious can come and worship the Ganges and admire the work of nature as flock of birds soar past them in the clear skies."

The above description is what this thesis project shall strive to achieve. The project entitled ' The sombre case of an odd triad - dolphin, man and zoonoses' – a part live project proposal by the Central government under the Gangetic dolphin conservation project by WWF, NMCG, NIUA, and other prestigious organisations proposed an eco - touristic region that allow these species to thrive in harmony with a plethora of other floral and faunal species - both migratory, endemic, introduced etc. ; at the same time creating a perfect atmosphere for visitors to observe these majestic creatures at their natural best in addition to providing the right ambience for students and researchers to observe and study the behaviour of these mammals. On the academic front, the project shall also place a needful emphasis on how the proposed design can be zoonotically resilient, thereby generating a healthy ecosystem for both humans and other species; to be achieved via means of master plan development, policies and guidelines.

1.10 VGDS – AN OVERVIEW

Although notified in 1991, VGDS remains a protected sanctum for the Gangetic dolphins only on paper. Rampant water pollution in the waters owing to the intensive exploitation of the southern river bank of the Ganges due to increasing urbanization, inland waterway traffic, non - eco-friendly agrarian project proposals, illegal fishing, a combination of socio –economic loophole in judicial regulations and other illicit activities are a few to cite as a cause for the same. The actual extent of VGDS spans around a radius of 10km from the Ganga River edge. However keeping in mind the academic constraints, the thesis shall only deal with sanctuary core that covers a radius of 2km from the Ganga River edge (***Figure 3***).

The core of Vikramshila Gangetic dolphin sanctuary spans a distance of 60 km from Sultanganj to Kahalgaon within Bhagalpur district, Bihar at a distance of 2km from the Ganga river edge (***Figure 4***). The areal extent of the proposed site is approx. 5,000 ha (12355.27 acres).

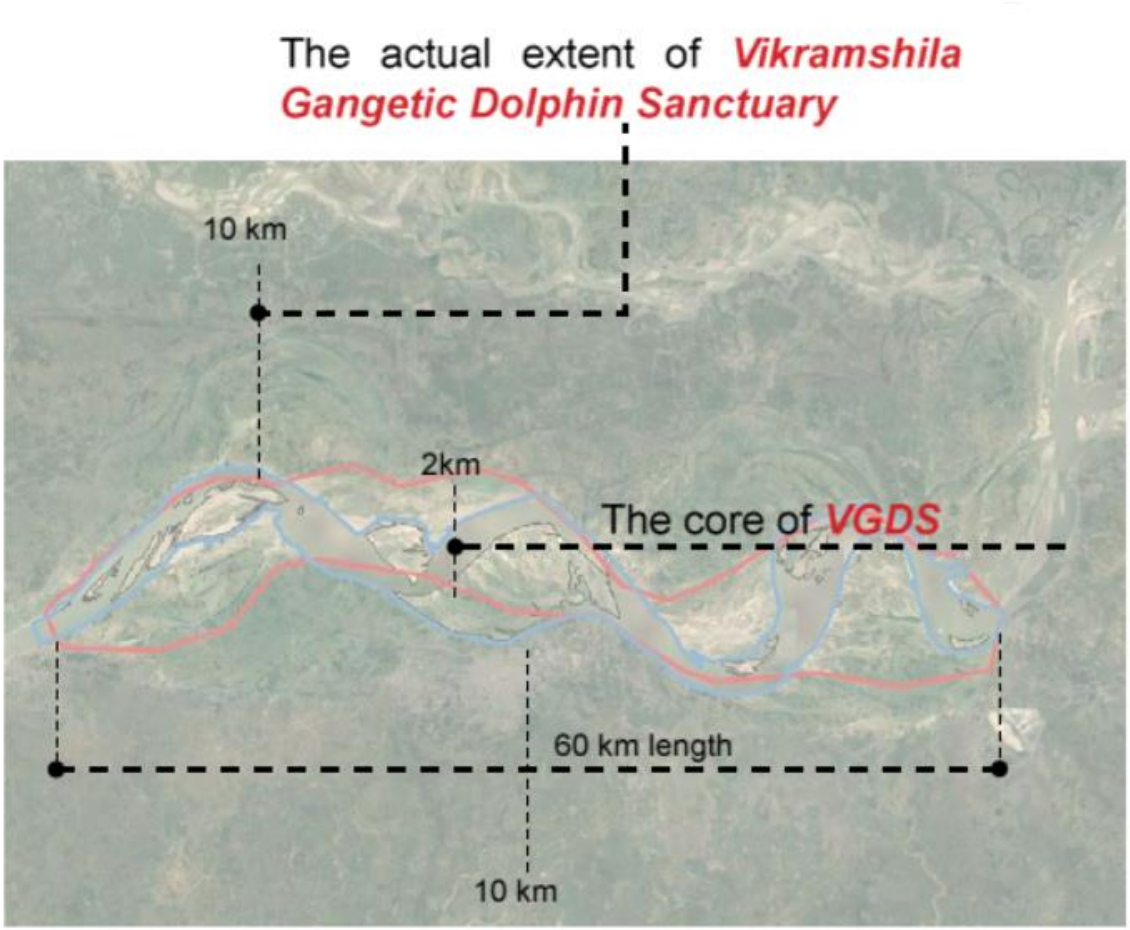

Figure 3 *- Areal extent of Vikramshila Gangetic Dolphin Sanctuary (Source – Modified by author from Google Earth, Open street maps and IBA websites)*

1.11 A ZOONOTIC PERSPECTIVE

Being gregarious occasionally, Gangetic dolphins do hold a massive scope to host potential zoonotic pathogens, thereby acting as harbinger of probable global zoonotic pandemic. Being a site where uncountable diversity of avi - fauna flock and intense urban development right close to the riverine edge, the intensity of a potential zoonotic spillover is a lot higher here. Likewise there are multiple water borne disease cases and subsequent deaths in the region already as well.

Figure 4 *– Base map showing the extent of the proposed site (Source – Adapted from Google Earth, Open Street Map and IBA, by Author)*

Additionally Gangetic dolphins are also host to human pathogens that may not be limited to *Cyclorchis campula*, *Echinochasumus andersoni*, *Anisakis simplex*, and *Contra caecum lobulatum*. This in addition to improper anthropogenic practices and inferior sewage – anti pollution infrastructure cause a zoonotic pathogen spillover into the riverine ecosystem. All this further only highlights the imperative need for extensive protection and revitalization of this dynamic and in – state – of – flux riverine landscape habitat such that not only riverine biodiversity is protected but the surrounding landscape also is zoonotic resilient keeping in mind the sacred and historic relevance of the River Ganga.

1.12 PROJECT FEASIBILITY

Despite being a notified sanctuary, the dolphin count in VGDS has drastically decreased over the years and this is a huge predicament for the health of the Gangetic riverine is closely linked to the survival and presence of the Gangetic dolphins. Moreover being social mammals that travel in group, they hold a massive potential to host potential zoonotic pathogens, thereby acting as harbinger of probable global zoonotic pandemic. The project shall provide a lot of opportunity for exploration of creating sustainably enhanced built environment in a natural dolphin habitat while ensuring that the resultant is a health and zoonotic resilient landscape.

One of the major method of achieving unified health resilient Gangetic riverscape within VGDS extent is to increase the population of Gangetic dolphin and similar such key indicator species for this will help strike a solution with respect to a majority of the problems faced by the Gangetic riverscapes. By revitalizing the river stretch, not only will the biodiversity thrive but at the same time the project shall also help the tourists and locals understand the relevance of their presence in the river.

Floodplain rivers of India such as The Gangetic Basin are socio ecological systems that support both man and a plethora of wild species including the national aquatic animal of India – Indian Gangetic dolphin (*Platonista gangetica*). However today the Indian riverscapes are competing with human interests to sustain a diverse riverine ecology as cleanly observed in the degrading quality of these rivers.

The Gangetic riverscape comprising the Ganga – Brahmaputra – Meghna river system is the main habitat of the Gangetic dolphin (*Platonista gangetica*) - a key indicator species whose presence indicate the purity of River Ganga and vice versa. Apart from occupying the apex position in the aquatic food chain (implies greater biodiversity hence healthy riverine ecosystem), downward movement of these species is another indicator of receding water during floods for the local people as well. Additionally, these beautiful blind social species are known to orient their entire life via echo- location. Upward water movement, combination of deep and shallow riverine segments are two major character traits of these river dolphin habitats. Within an overall population wavering around 4000 – 5000, these

species have been occupying the IUCN endangered list since 1996. Massive sightings along the current VGDS extent in addition to the year round dwindling dolphin count and vanishing of these species from majority of previous Gangetic dolphin hotspots have led to the establishment of the Vikramshila Gangetic Dolphin sanctuary.

Additionally the sanctuary is also home to various migratory fishes and avi – fauna as well such as red crested pochard, greater adjutant etc. However today VGDS is in a sorry condition and fails to maintain the ideal habitat needed for these dolphins owing to excessive pollution, anthropogenic interferences and intense eutrophication. It is also important that the design proposal is developed such that not only riverine biodiversity is protected but the surrounding landscape also is zoonotic resilient due to the potential scope of pathogenic spillover of the stretch into the human community owing to the sacred and historic relevance of the River Ganga.

CHAPTER 2 : LITERATURE REVIEW

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2.1 INTRODUCTION

In order to propose a viable solution that addresses the three stakeholders of concern as cited in the title, it is imperative to start from the scratch. Therefore the studies may be categorized under the following subheads:-

- Fluvial studies and dynamics
- A Gangetic perspective
- An holistic overview of zoonosis

2.2 FLUVIAL STUDIES AND DYNAMICS

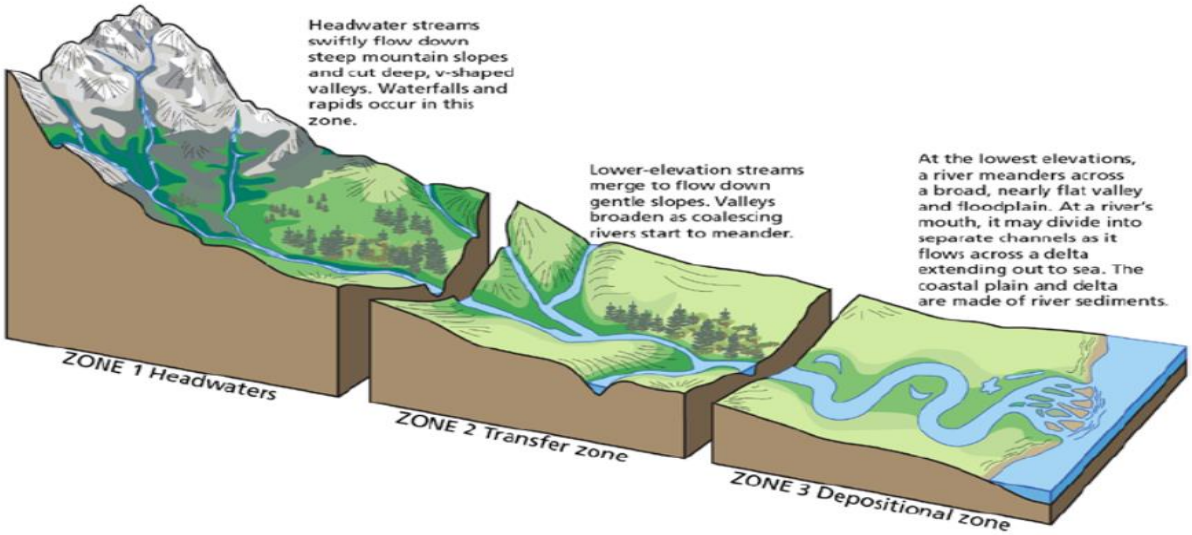


Figure 5*- Diagrammatic representation of a river from inception to culmination. (Source - https://www.nps.gov/subjects/geology/fluvial-landforms.htm)*

Rivers are one of the most dynamic natural and complex lotic freshwater systems whose uniqueness lies in their ability to connect both lotic and lentic water systems across the world in a longitudinal, latitudinal or vertical manner (***Figure 5***). Rivers are a part of the hydrological cycle that are replenished via precipitation and other sources such as groundwater, springs, and glaciers. Despite being considered major landscape features, they actually only cover around 0.1% of the land on Earth. Many civilizations are known to have flourished near river banks. Riverine ecosystems drain the surrounding landscapes through hierarchical series of fluvial channels, beginning with small headwater streams, and enlarging, ultimately, to estuaries meeting the sea. The nature and character of the resultant landscape along with its biodiversity is dependent on the fluvial flow and its pattern of flow (***Figure 6***). For all these reasons and so much more, rivers are treated as the sentinels or harbingers of what lies ahead in the destiny of our planetary sustenance.

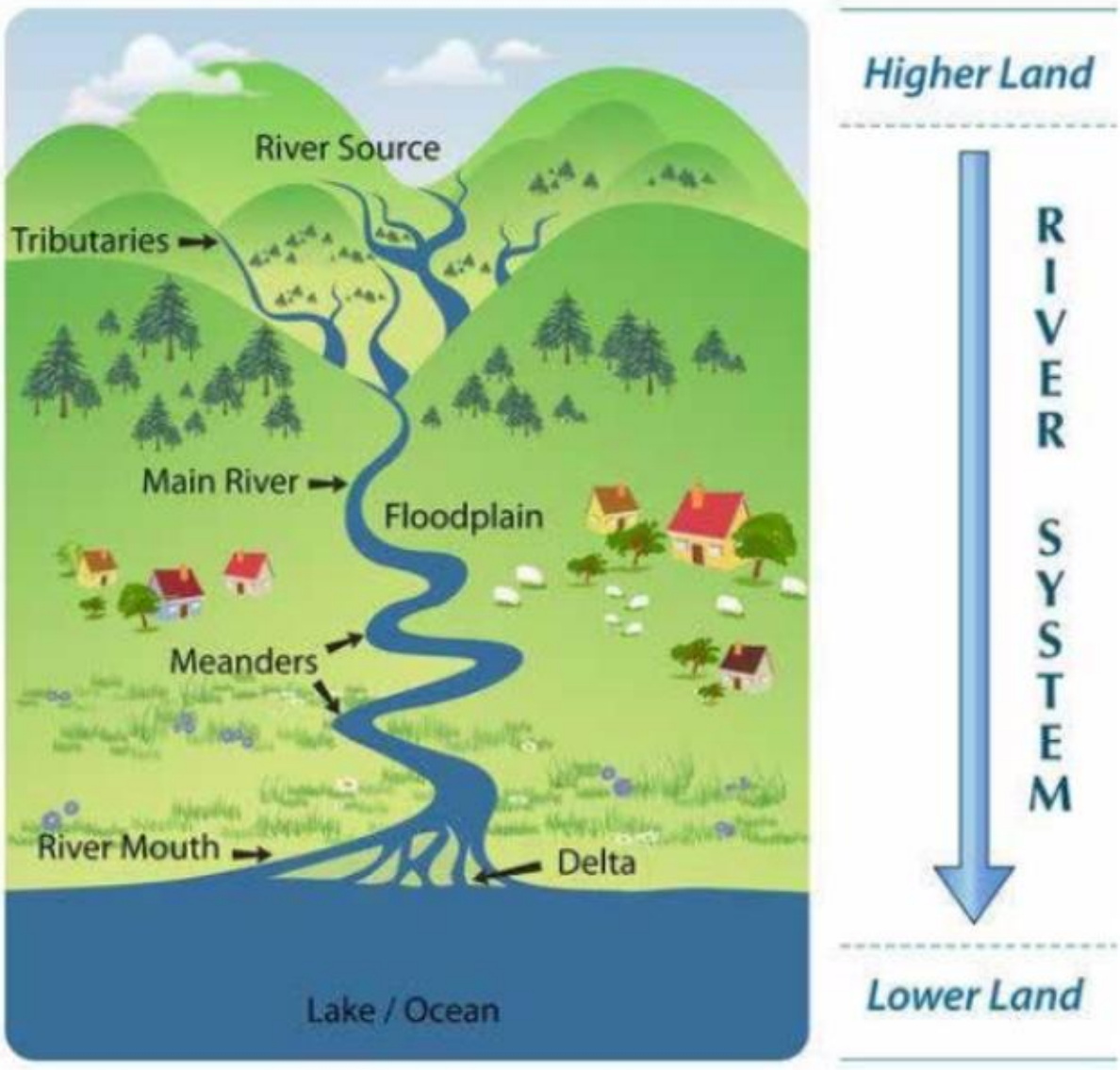


Figure 6 *- Understanding fluvial landscapes formed along the river course (Source -https://wordwall.net/en-gb/community/features-of-a-newspaper)*

2.2.1 FLOODING AND FLOODPLAINS

There are ennumerous processes that govern the health and stable functioning of a riverine ecosystem. One of the most important processes that is both essential yet potentially catastrophic in numerous instances pertaining to loss of life and property is flooding - a phenomena that involves the overflow of water from a source of body into the lands in its surrounding vicinity; often recognized as floodplains. When the lands in the vicinity of this water source is prone to frequent flooding, then these lands become known as floodplains. The cause of floods may be natural or anthropogenic. Floodplains when subject to inundation with a recurrence interval between one and two years are known as active floodplains (***Figure 7***). Unlike normal floodplains, active floodplains are extra sensitive and need to involve a careful consideration of the local ecology and landscape before performing any manner of intervention in that region as a single intervention is enough to generate a negative domino effect in the region.

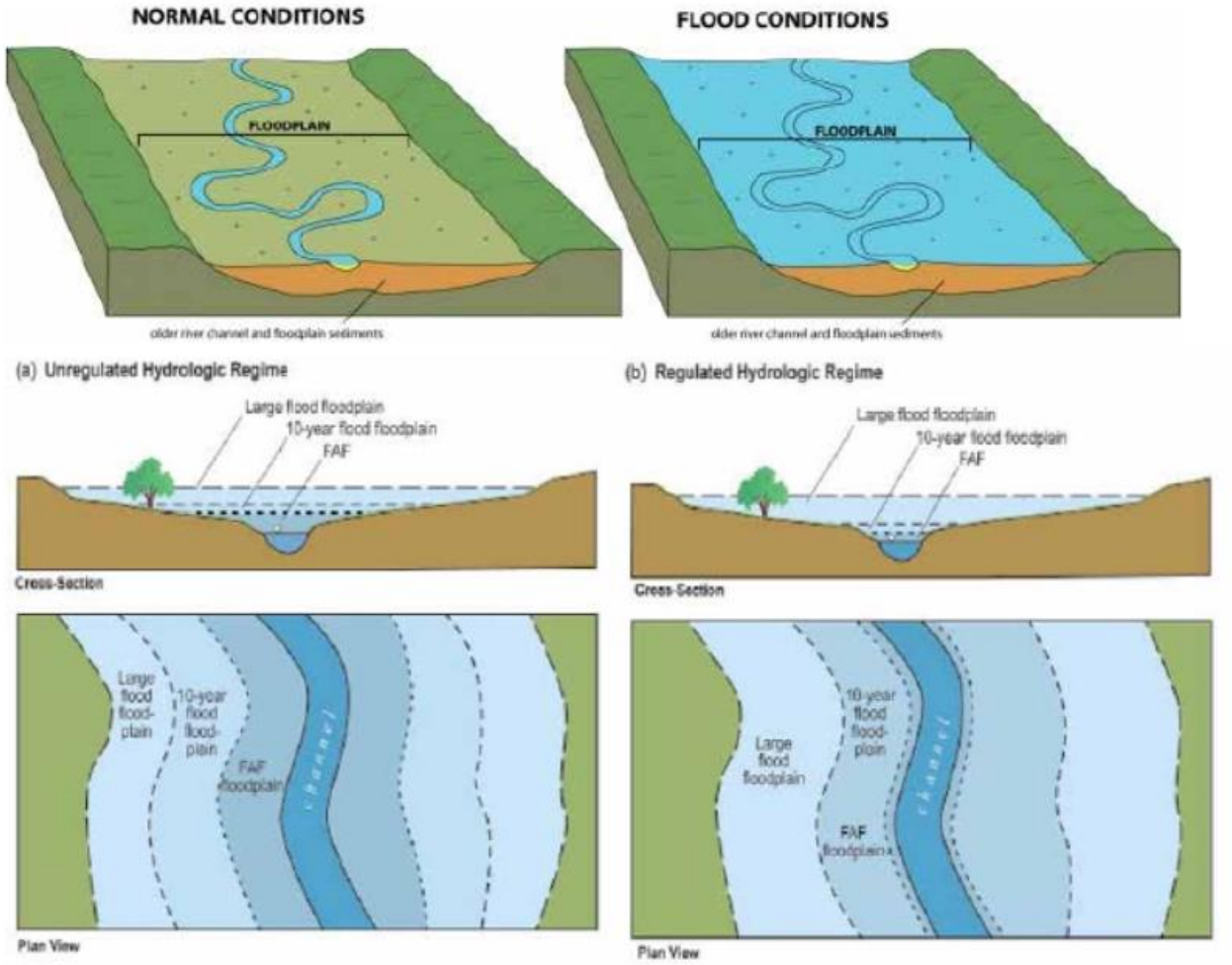


Figure 7 *- floods and floodplains (Source: Quantifying Activated Floodplains on a Lowland Regulated River: Its Application to Floodplain Restoration in the Sacramento Valley)*

The natural riparian edge of the river is also modified as a result of the floods. Levees are formed naturally as siltation and deposition occur with passage of time and floods (***Figure 8***).

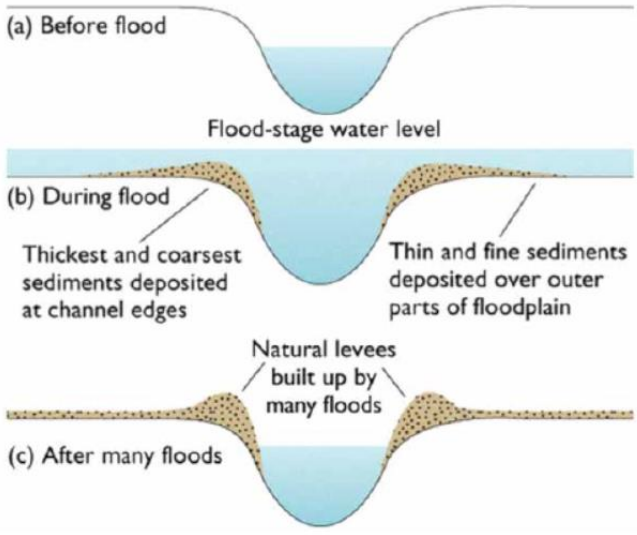


Figure 8 *- Natural levees formation (Source: https://aflam-neeeak.blogspot.com/2019/12/natural-levees-diagram.html)*

The river and its floodplains together work in unison to form an integrated system that determine the holistic health of the dependent biodiversity and green infrastructure. Hence connectivity at both physical and ecological scale is imperative for the survival of the integrated system and therefore the humans who stand codependent on this system.

2.2.2 RIVER CONCEPTS

The functioning of a river is better understood using a series of concepts developed on the basis of quantitative and qualitative studies. A few of the prominent ones have been shown here (***Figure 9***).

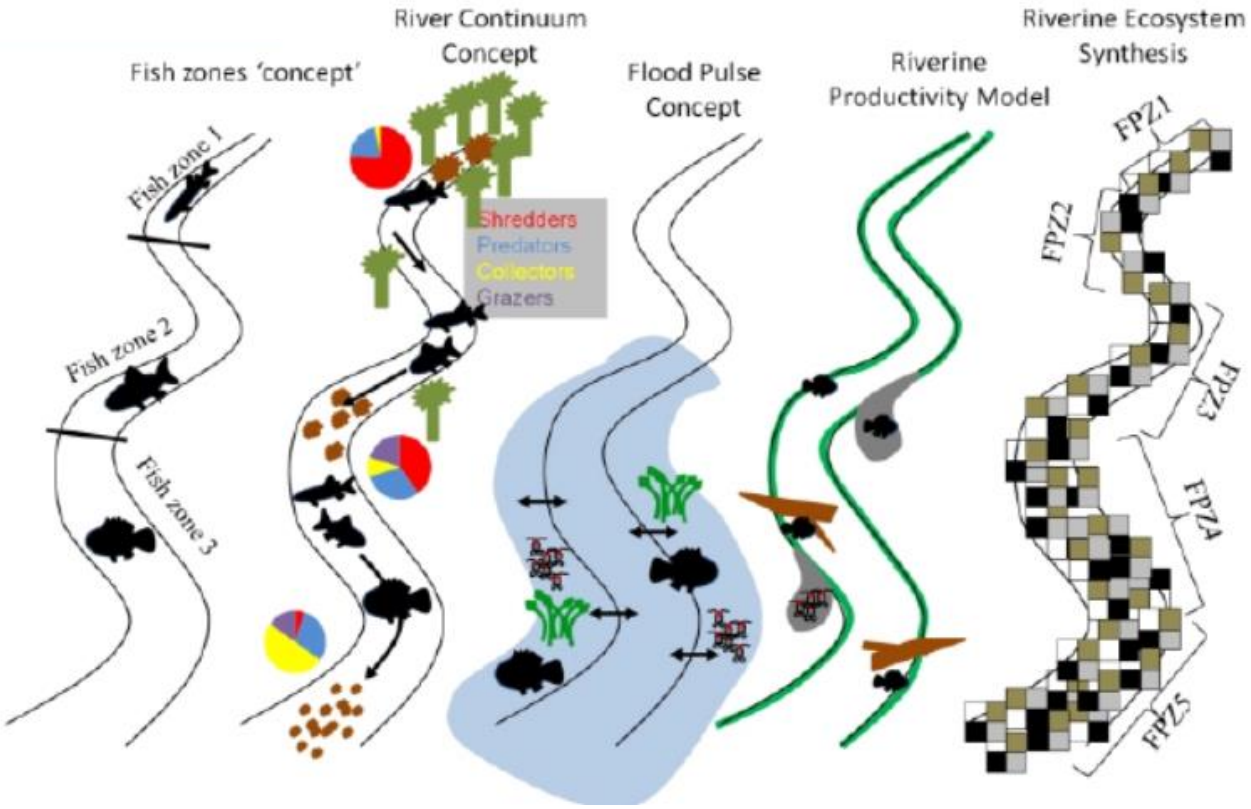


Figure 9- *Riverine ecosystem concepts (Source – Adapted from https://paulhumphriesriverecology.wordpress.com/2012/03 /05/schematicrepresentation-of-the-main-river-ecosystem-concepts)*

Out of the above depicted concepts, RES is the most advanced and relatable as it is a combination of FPC, RCC and RPM in addition to being a concept that addresses the riverine ecosystems in entirety unlike fish zone concept, RCC, FPC and RPM which talks about the river system from the perspective of a particular element. Adding an overlay of the understanding derived from these concepts to the design studies is crucial to develop a solution that is ecological sustainable in the long run.

2.3 A GANGETIC PERSPECTIVE

The stretch of the Ganges falling within the selected site of VGDS may be classified under different heads as shown here (***Figure 10***).

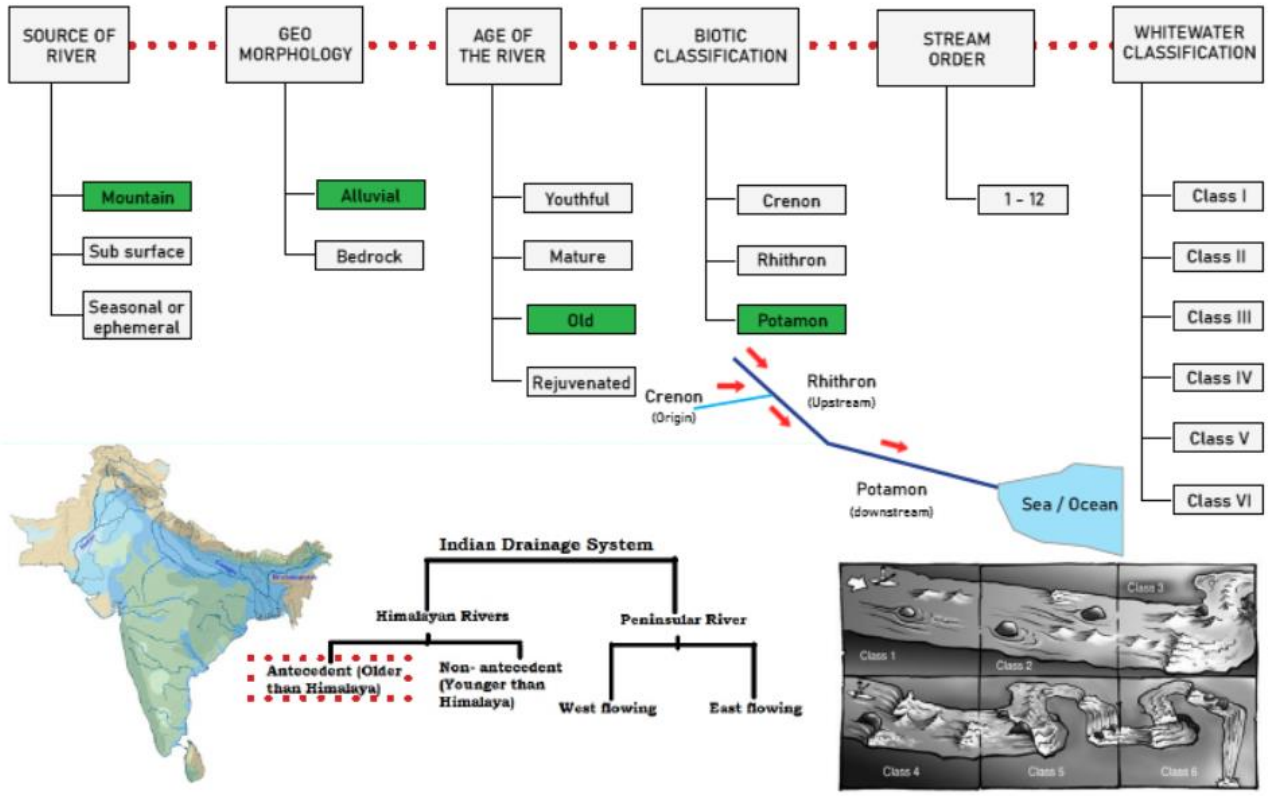


Figure 10 *- Classification status of Ganga River (Source - https://www.jagranjosh.com/general-knowledge/drainage-system-1448436362-1)*

Ganga has always been associated with the dynamic floods and its dynamic landscapes so formed as a result. The Indo-Gangetic plains are a product of intense annual floods. A foundational understanding known to all, yet recurrent year after year due to encroachments that occupy the flood pathways of the river with rampant urbanization. As long as there is room for the river to flow and express itself, no one feels the pinch. The moment that freedom of expression is compromised, people feel the pinch.

Bulk of the sediments from upstream areas in the Himalayas erode and deposit partly in the alluvial plains with a significant part in the Bay of Bengal. The Gangetic floodplains receive an annual increment of about 65 million tons of sediments whose quantity is dependent on the gradient, distance from the source area as well as the terrain geology and geomorphology.

2.3.1 GANGA NEAR VGDS

There is a reason why Indian government has personified and designated the title of 'she' to Ganga. Just like humans, Ganga too exhibits various behaviors as it flows from the Himalayas to the Bay of Bengal. The stretch of Ganga that flows within the extent of the proposed sanctuary boundary adopts a braided river character; forming a series of mid channel islands or diaras (as locally referred to) which are primarily landscapes in flux, always changing with passage of time. These diaras are separated by a series of interweaving channels or 'braids' which together form the main river channel of Ganga. In a process that continues to date, increased and fast paced flow of water

during periods of intense precipitation, these braids fuse and leave behind a network of river braids and sand - gravel islands that reveal itself with the recession of water.

To common man, this process may seem like flood however it is not. Infact this phenomena defines the very essence of what a braided river is all about. A braided river in its natural form is four-dimensional i.e. unlike other lotic water systems, this river does not stay confined within relatively stable banks and a similar width – depth range over long periods of time. Rather it is a landscape feature of flux known for changing its planform, location, channel depth and diara planforms within a short span of time. This phenomena is dependent on a variety of parameters both natural and anthropogenic.

2.3.2 BRAIDED RIVERS AND BRAIDPLAINS – FIGURING OUT DYNAMICS

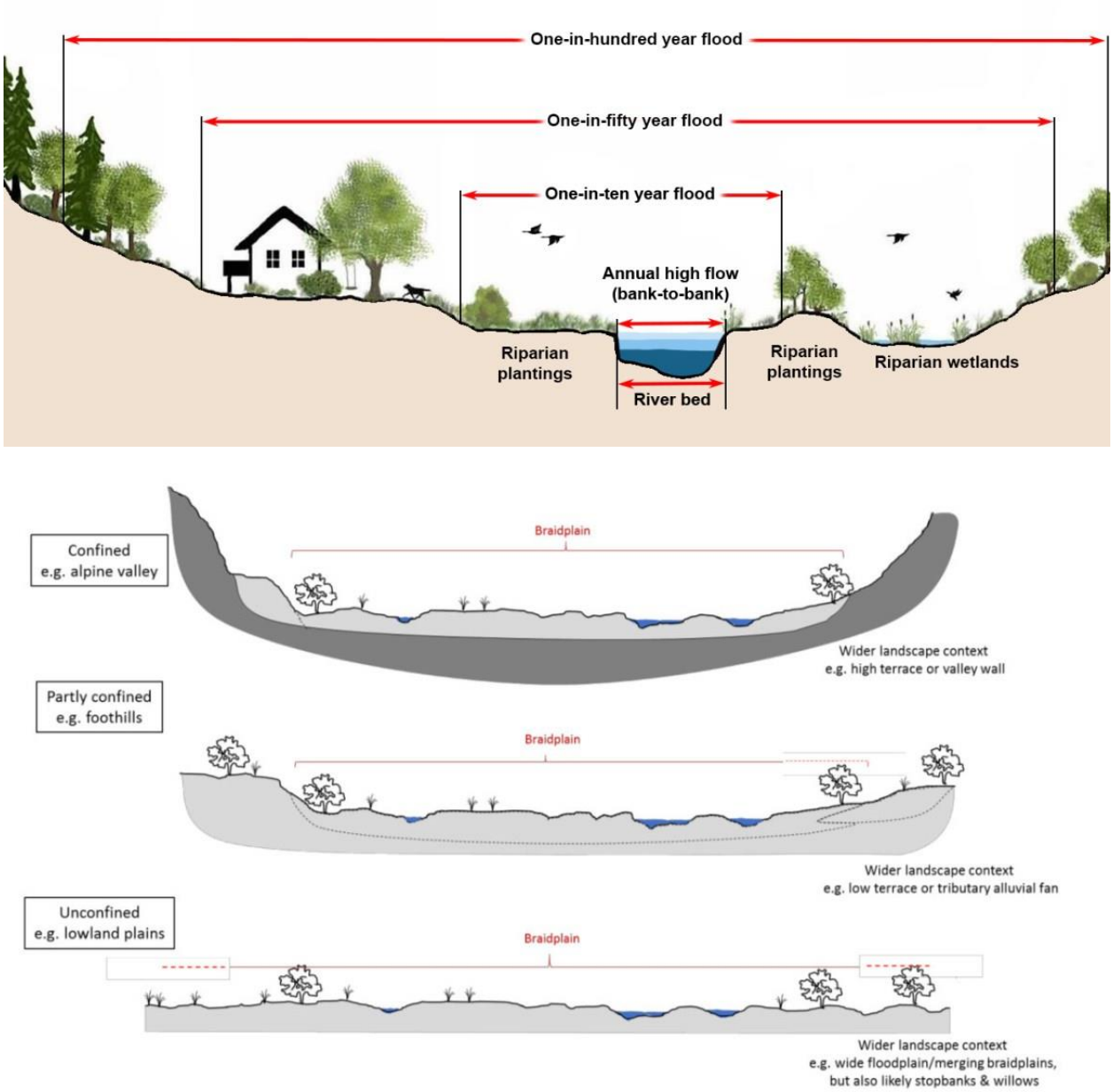


Figure 11 *- Understanding the difference between floodplains and braid plains (Source - https://braidedrivers.org/braidplains/)*

It has already been discussed in this chapter of how a floodplain is a byproduct of riverine dynamics i.e. primarily flooding. Therefore it is only natural that we interpret that braid plains too function in the similar fashion (***Figure 11***).

However that is where the catch lies in the big picture.

Each braided river is unique. It is easy to demarcate the extent of braidplains within higher elevations as they're majorly confined by glacial valleys but as the river flows onto the region of plains, there is no factor that is confining the river channel as a result of which they carelessly wander across the area thereby further complicating the regional dynamics. This behavior causes these rivers to be recognized as being wild and largely untamable owing to which they need to be looked at from a different lens and therefore provided with alternative levels of protection and conservation means.

Inorder to understand how braid plains and subsequently the rivers may be conserved, it is more imperative to understand how these plains function (***Figure 12***).

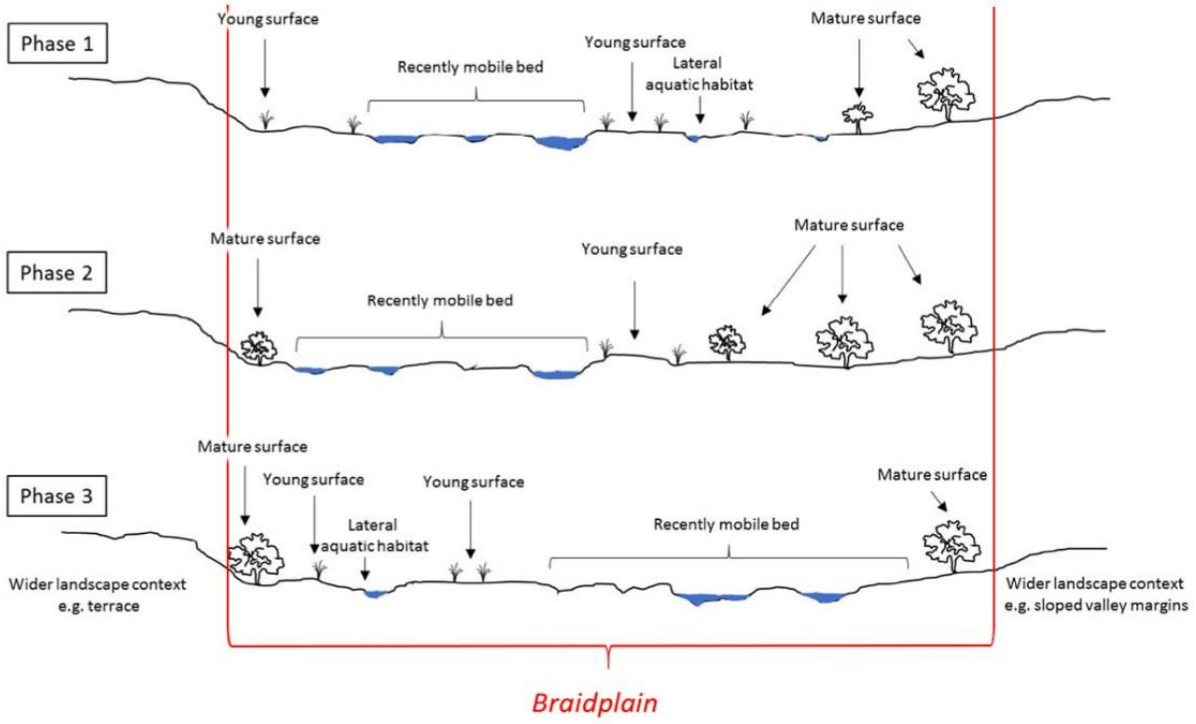


Figure 12 – *Working of braid plains (Source - https://braidedrivers.org/braidplains/)*

Due to the mobile nature of braided rivers to shift both laterally and longitudinally, figuring out the exact extents of a specific braid plains with respect to a braided river is complicated and in some cases not even possible to for a myriad of reasons. Braided river plains are unique fragile ecosystems that offer innumerous life supporting ecosystem services; some of which even act as buffer against some of the drastic impacts of climate change. Many a times, the presence of braided rivers in its natural form defines the critical infrastructure in addition to maintaining the equilibrium of its surrounding lands. Yet without a clear demarcation, braided rivers and its plains cannot be conserved or preserved in the way it ought to be as these ecosystems often succumb to a state wherein they compete against the versatile human interests and evolving anthropogenic needs. And with a lack of defined riparian boundaries, the resultant scenario is pretty obvious yet

catastrophic as the anthropogenic functions like rapid urbanization, intensive agriculture etc. slowly encroach over the very systems that offer the core ecosystem services vital to our sustenance. This destroys the equilibrium of the processes that drive the functioning of braided river ecosystems. This calls for a need to strike a balance between anthropogenic needs and conservation of these ecosensitive systems. One way of defining the areal extent of these braid plains is to look back over the course of a century as to how much space these rivers and its plains have actually occupied when devoid of any anthropogenic interventions. This can help us carve out an average extent that have to be preserved on priority basis for the healthy sustenance of the braided river ecosystems.

2.3.3 PRESENT STATUS OF URBAN RIVERS

Rivers like Ganga also hold a title of urban river as she flows through numerous towns; all of whom have become renowned and auspicious for the same cause. However these urban rivers are subject to a variety of problems (***Figure 13***). Some of them include:-

- Poor Drainage
- Alteration of natural drainage
- Intensive development and alteration of the floodplain
- Alteration of the natural river profile
- Over abstraction of water supplies
- Pollution of the river and its floodplains
- Lack of awareness and public connect
- Lack of proper river governance norms
- Loopholes in the existing river maintenance and development norms

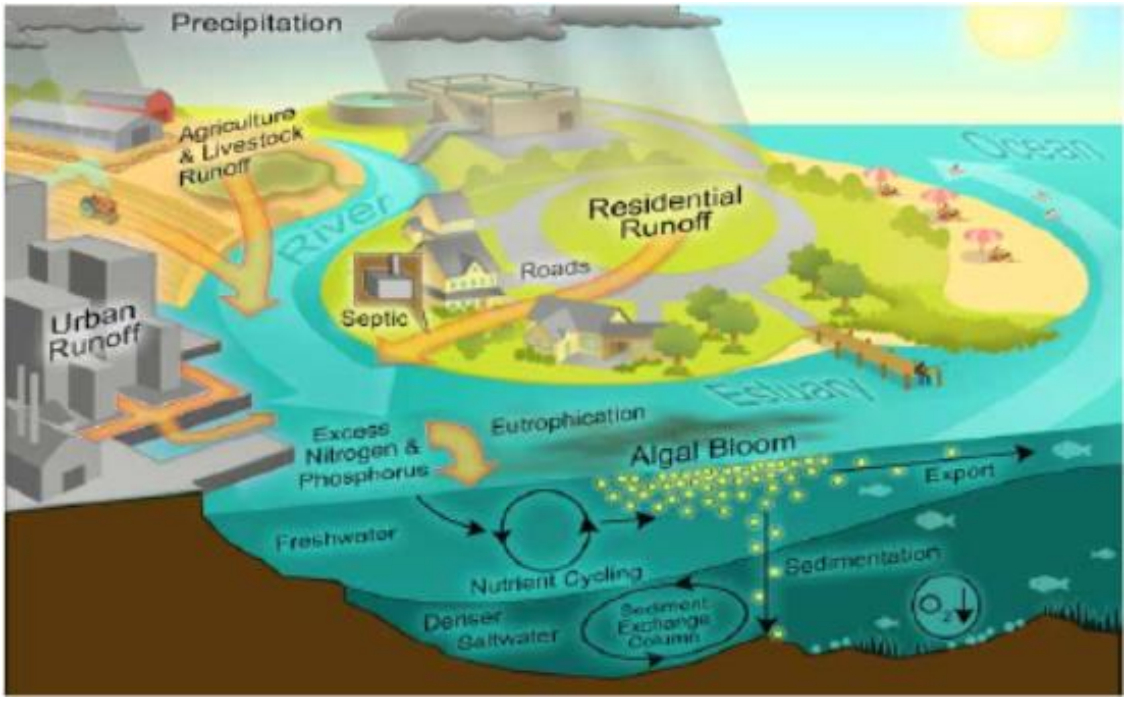


Figure 13*- River pollution cycle (Source -Assessing and managing nutrient-enhanced eutrophication in estuarine and coastal waters: Interactive effects of human and climatic perturbations - Hans W. Paerl)*

Most of the issues seen in Figure 11 may appear straightforward and easy to solve using a pre – established toolkit of techniques used in multiple similar scenarios however that is just not the case. In addition to problems, they also face a series of challenges as well in the quest to revitalizing and reviving them (***Figure 14***).

Figure 14 *- Urban river challenges (Source -Assessing and managing nutrient-enhanced eutrophication in estuarine and coastal waters: Interactive effects of human and climatic perturbations - Hans W. Paerl)*

2.4 A HOLISTIC OVERVIEW OF ZOONOSES

Any disease or infection of animal origin in humans is termed as zoonoses. Likewise when the reverse occurs, it is referred to as zooanthroponosis or reverse zoonoses (***Figure 15***).

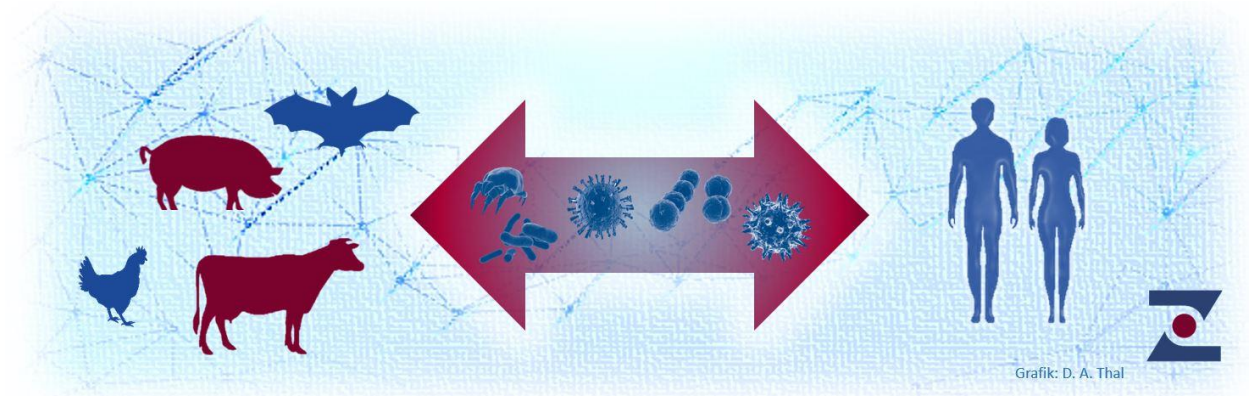


Figure 15*– Diagrammatic representation of zoonoses and zooanthroponoses (Source - https://www.zoonosen.net/zoonosenforschung/zoonose-des-monats)*

A zoonotic spillover (***Figure 16***) among the human community is a product of a multitude of factors that may be broadly classified under the following heads:-

- Climate
- Ecosystem ecology
- Changing land use
- Deforestation
- Habitat destruction and fragmentation
- Agriculture and food insecurity
- Socio- economic factors
- Landscape interventions

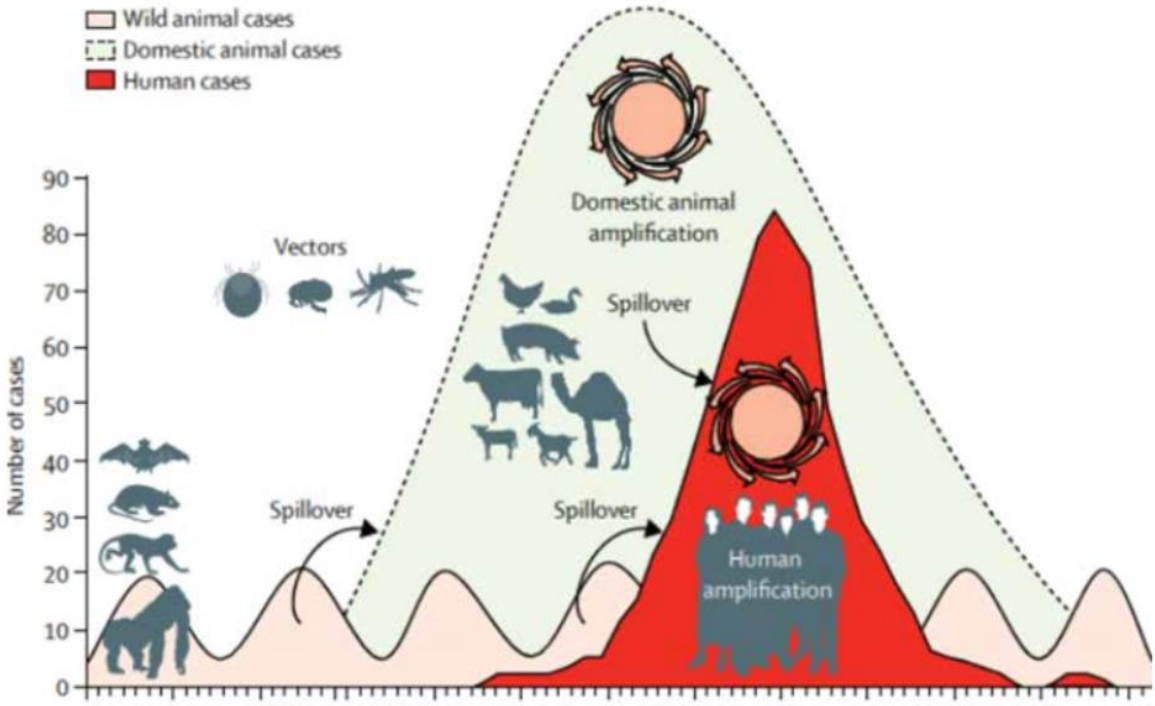


Figure 16 *– Representational graph of zoonotic spillover in humans (Source - https://www.intechopen.com/books/farm-animals-diseases-recent-omic-trends-and-new-strategies-of-treatment/metagenomics-and-diagnosis-of-zoonotic-diseases)*

The most commonly used classification parameters for zoonotic infections include:-

1) On the basis of the etiological agent:-

- Bacterial zoonoses – Eg: Anthrax, Plague, Lyme disease etc.
- Viral zoonoses – Eg: Rabies, Yellow fever, SARS, Covid19 etc.
- Rickettsial zoonoses – Eg: Q – fever, African tick-bite fever etc.
- Protozoal zoonoses – Eg: Toxoplasmosis, neosporosis etc.
- Helminthic zoonoses – Eg: lymphatic filariasis, schistosomiasis etc.
- Fungal zoonoses – Eg: Ringworm, Blastomycosis etc.
- Ectoparasites – Eg: Scabies, myiasis etc.

2) On the basis of mode of transmission:-

- Direct zoonoses – Transmission from an infected vertebrate host to a susceptible host via direct contact or through fomite or infected materials. Eg: Anthrax, Rabies etc.
- Cyclozoonoses – Diseases that require more than one vertebrate host species but no invertebrate host for the agent to complete its lifecycle. Eg: Japanese encephalitis, etc.
- Meta zoonoses – Diseases transmitted biologically by invertebrate vectors wherein the agent replicates with an extrinsic incubation period before transmission to another vertebrate host. Eg: Plague, Arbovirus infection etc.
- Saprozoonoses – Diseases transmitted by pathogens that require a vertebrate host and a non – animal biotic component such as soil, plant material etc. for the pathogenic development. Eg: Toxoplasmosis, neosporosis etc.

3) On the basis of reservoir host:-

- Anthropozoonoses – Infections transmitted from lower vertebrate animals. Eg: Plague, Q – fever etc.
- Zooanthropozoonoses – Infections transmitted from humans to lower vertebrate animals. Eg: Human TB etc.
- Amphixenoses – Infections seen in both humans and lower vertebrate animals and transmission occurs both the ways. Eg: Salmonellosis, Staphylococcosis etc.

Based on the studies carried out as part of my dissertation, landscape planning and design approach for designing a zoonotic resilient landscape can be categorized into the following categories:-

- Site selection criteria
- Design approach
- Policy level interventions
- Design guidelines

Adopting a design approach with nature oriented solutions (***Figure 17***) and ecological interventions is the ideal way to control the extent of a zoonotic spillover into the human community and prevent potential pandemics or epidemics in the future.

Figure 17*- Understanding nature based solutions (Source -IUCN)*

It is not about the number of interventions or barriers proposed to counter the issue but rather the time and space in which the favorable barriers may coincide. Likewise the nature and character of the intervention site also plays a relevant role in determining the degree of zoonotic spillover or ensuring zoonotic resiliency through means of strategic ecological interventions (***Figure 18***).

High risk sites are usually of ecosensitive nature with an areal extent of less than or equal to 0.5 acres. Such sites are a habitat for potential host vectors or was previously a home for them in addition to being renowned for past zoonotic cases in the vicinity or site. Moderate risk sites comprise a patchy habitat with high proportion of ecotones and include artificially intervened

landscape elements at a distance ≤1m from the ecotones. Occasional sightings of potential host vectors on site or vicinity is seen in this case. Low risk sites are already intervened sites.

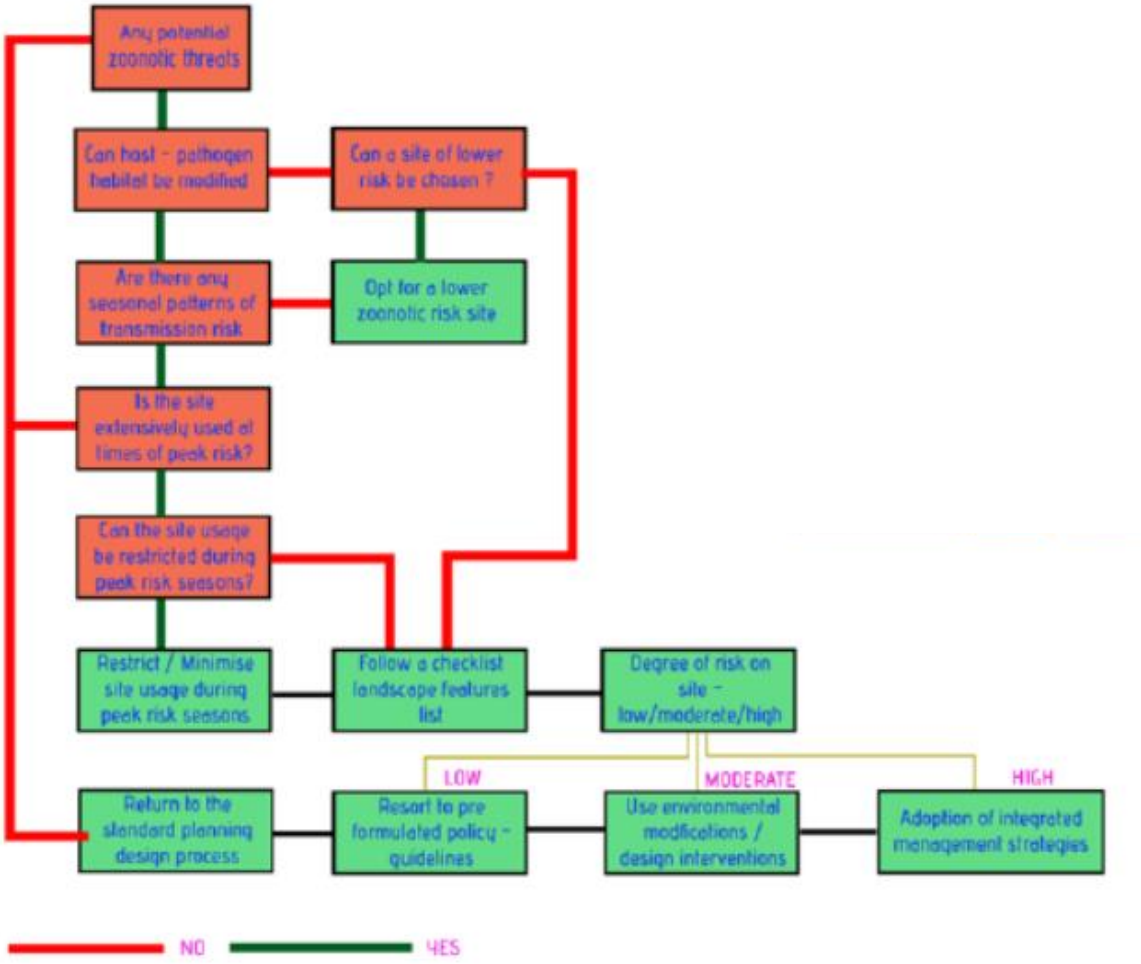


***Figure 18**- Site selection tree (Source - Modified by author from the paper - A framework for incorporating the prevention of Lyme disease)*

Therefore the key to developing a zoonotically resilient landscape lies in proposing strategic interventions to ensure that the favorable barriers do not align simultaneously in space or time (***Figure 19***).

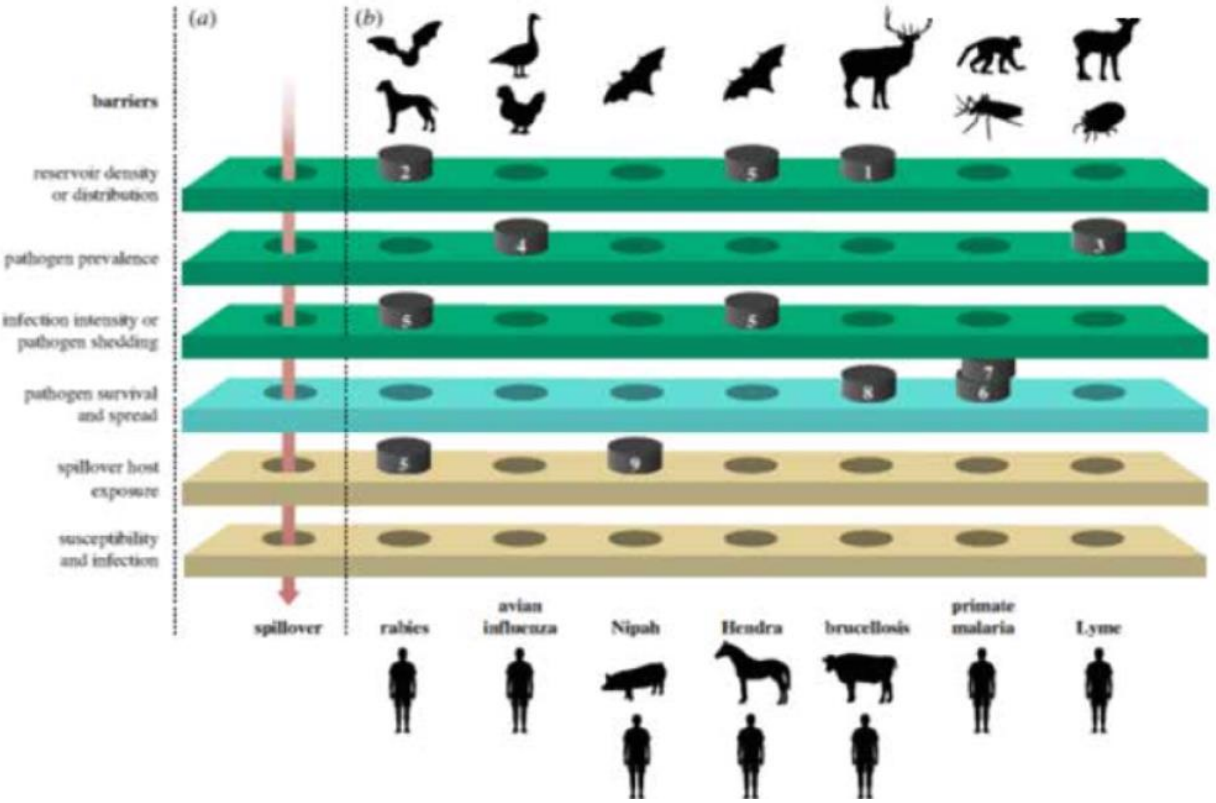
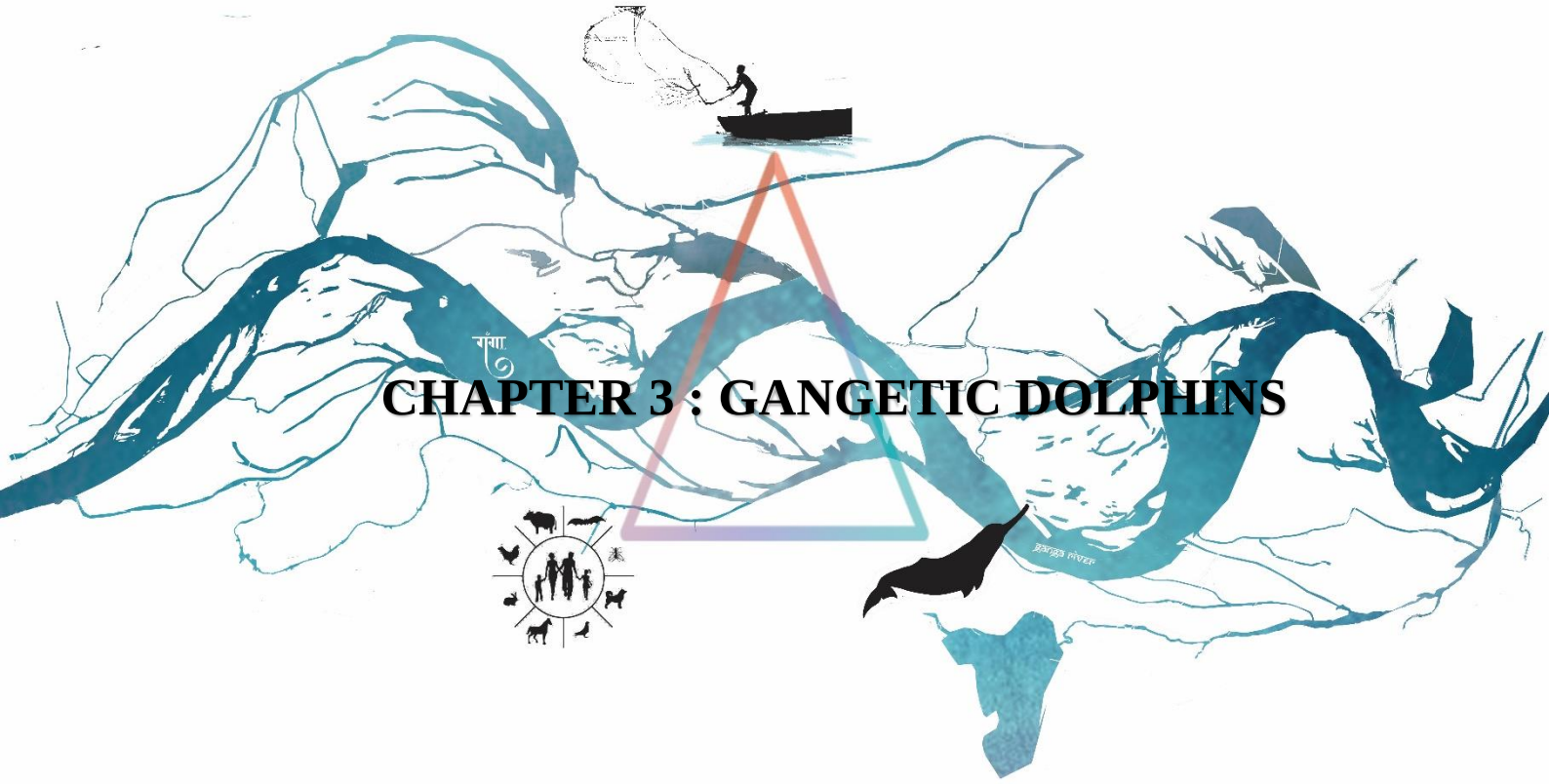


Figure 19 *- The barriers occur in reservoir hosts (green); the environment and vectors (cyan) and spillover hosts (beige). Spillover is a result of the holes in the barriers lining up in space and time. To prevent such a scenario, interventions need to be applied to reduce the hole size or prevent the holes from aligning in space and time. The black plugs blocking the holes represent ecological interventions to combat spillover. (Source – Ecological interventions to prevent and manage zoonotic pathogen spillover)*



CHAPTER 3 : GANGETIC DOLPHINS

CHAPTER 3: GANGETIC DOLPHINS

3.1 INTRODUCTION

Dolphin is the common name denoted to a set of aquatic mammals that fall within the infraorder Cetacea. There are 41 extant dolphin species of which 37 species are ocean dolphins and 4 river dolphins. Dolphins are known to live in a variety of aquatic habitats that range from open oceans, coastal waters that include bays and inlets, river basins, certain inland seas, gulfs, and in channels. The national aquatic dolphin of India – Gangetic Dolphins belong to the category of river dolphins. There are 5 river dolphins of which the Yangtze dolphin is considered functionally extinct (***Figure 20***).

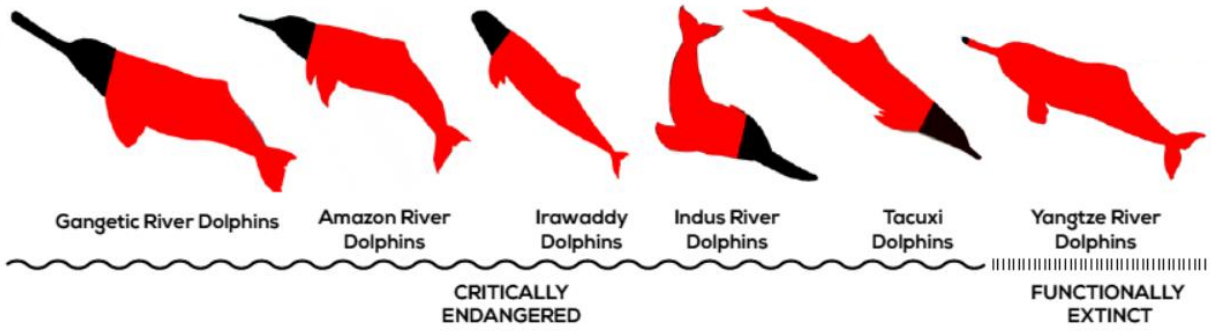


Figure 20 *- River dolphin existence status (Source - IUCN Red List)*

To date there are 2 recognised river dolphins in India (***Figure 21***).

Figure 21 *- River dolphin status in India (Source - Google)*

3.2 GANGETIC RIVER DOLPHINS

With an endangered freshwater river dolphin status, the Gangetic river dolphin (*Platonista gangetica*) is one of the two known sub species of the South Asian river dolphin known to reside in the region of the Indian subcontinent. Officially found in 1801, they primarily inhabit the Ganges and Brahmaputra rivers and their tributaries in India, Bangladesh, and Nepal. The Ganges river dolphin has been recognized by the government of India as its National Aquatic Animal.

These dolphins dwell in the freshwater river systems, mostly in plains with slow-flowing rivers. They prefer deep waters, where prey availability is high, in and around the river confluences, areas that create eddy counter currents, such as small islands, river meanders, and convergent tributaries. They have a wide variance of temperature tolerance from 8^{O} Celsius to above 33^{O} Celsius due to the vast expanses of river systems that they tend to inhabit. They inhabit depths from 3 to 9 meters (***Figure 22***). Monsoon season finds these dolphins locally migrating to - fro tributaries and larger river channels in the dry, winter season. They also move along the Bay of Bengal coast when monsoons flush freshwater out along the south eastern coast of India. The distribution range in India covers seven states namely, Assam, Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, Jharkhand and West Bengal.

Gangetic dolphins are the key indicators of a healthy Ganga riverine ecosystem in addition to being the apex predators in the freshwater food chain. Their only known predator are humans. The Ganges river dolphin are blind and survive via echolocation.

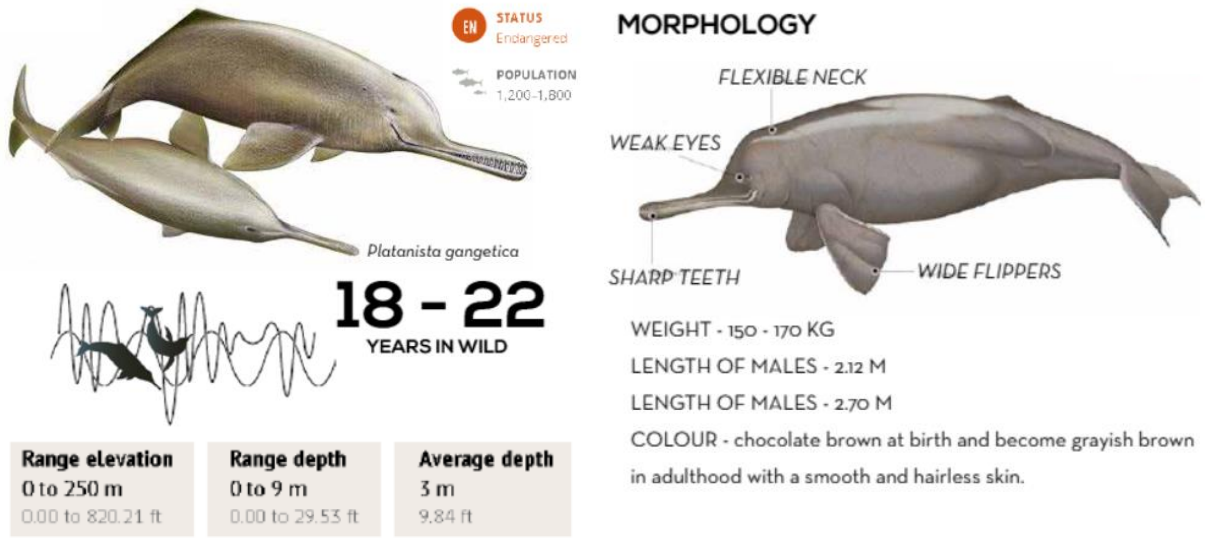


Figure 22 *- An outlook of Gangetic river dolphins (Source - https://animaldiversity.org/accounts/Platanista_gangetica/)*

3.3 GENERAL BEHAVIOUR

Some consider Ganges River dolphins semi-gregarious with a grouping of 3 – 10 individuals, especially a case in point would be at the tributary junctions where dolphin preys like schools of fishes tend to congregate. The mothers are known to support the calves until the infants are weaned. Ganges River dolphins are known to exhibit the peculiarity of swimming on one side when submerged so that its flipper trails the muddy bottom as a means to help it to find food. In captivity, measured swimming speed reached 5.4 km/hr while it is been noted as 27 km/hr in the wild. Captive animals swim and vocalize continuously over a 24 hour period, with only brief interruptions lasting a few seconds. Average dive times in the wild are between 1 minute 10 seconds and 1 minute 40 seconds. Dives in captivity are shorter than wild dive times, with the longest being 1 minute and 35 seconds.

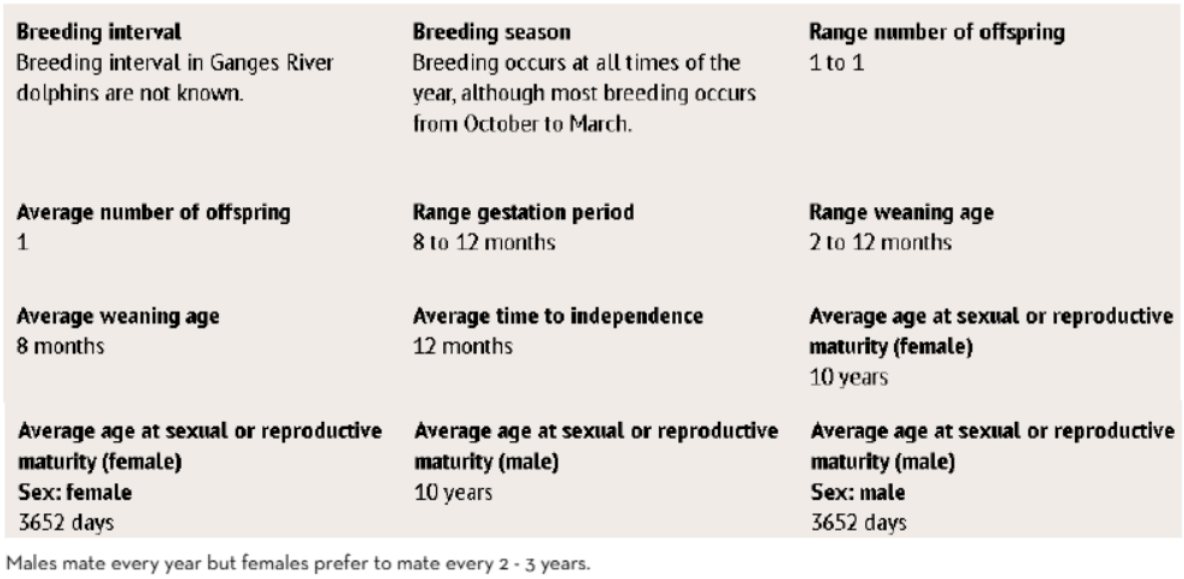


***Figure 23** - An outlook of Gangetic river dolphins reproduction and mating (Source - https://animaldiversity.org/accounts/Platanista_gangetica/)*

Apart from being top river ecosystem predators, their side swimming and a flexible neck allow them to search river bottoms to stir up hiding prey. Their formidable speed and ability to swim in shallow water allows them to chase and herd schools of fish. They feed on a variety of aquatic animals but majorly the bottom feeders such as wallago attu, crustaceans etc. They are strictly carnivorous and rely on echolocation to find hidden food in the mud and river bottom. Their mating and reproduction pattern can be observed in ***(Figure 23)***.

3.4 VOCALISATION AND COMMUNICATION

These dolphins are known to exhibit object-avoidance behaviour in both the consistently heavily murky waters and in clear water in captivity, suggesting its ability to use echo-location effectively for navigation and prey foraging. Clicks, bursts and twitters with a maximum frequency between 15 and 60 kHz are the sounds generally heard by these

species. Given the dolphin's blindness, it produces an ultrasonic sound that is echoed off other fish and water species, thereby allowing it to identify prey.

3.5 MAN – RELATIONSHIP AND THREATS

The Ganges dolphin is associated with Goddess Ganga as depiction of her vahana, the makara. However these dolphins have been adversely affected by human use of river systems in India. Generally, these animals are shy towards humans even in captivity. Their elusive nature has made them difficult subjects to study.

Historically recognised as an important as a source of oil and meat with the latter as bait to attract fish; these dolphins among all cetaceans have slowly climbed to the endangered status on the way. However use of dolphin meat as fish bait is a wrong source of information acquired by the locals as it doesn't achieve the purpose; therefore local fishermen must be educated to use other fish scraps.

With rampant urbanisation in Southern Asia, the natural habitat of Ganges River dolphins has been extensively modified and degraded. Some of the reasons include:-

- Agricultural and industrial effluent discharges
- Accumulation of heavy metals
- Dangerously high levels of arsenic in the water
- Human alterations to river systems and its natural process

Over 50 dams have been observed to affect the Ganges River dolphin count through population fragmentation and shrinking gene pools which ultimately could have a drastic impact on the future generations. The habitat expanse is now slowly getting restricted to smaller ranges. Hunting has certainly impacted the population numbers in the river systems and quite often these dolphins get caught and drown in fishing lines and nets which truly has a drastic implication on the overall count of considerable fatalities. Highly aggressive bull sharks that enter the South Asian river systems are known to attack waders and fishermen and many of these attacks on local peoples are wrongly blamed on Ganges River dolphins due to their resemblance to these sharks.

CHAPTER 4 : WHAT IS ALREADY THERE

CHAPTER 4: WHAT IS ALREADY THERE

In order to further cement the understandings covered in Chapter 3, selected case studies were studied in depth on the basis of a set of parameters. Each case study was selected on the basis of the following criteria:-

- Resemblance to site context
- Issue of flooding and its solution
- Zoonotic prevention
- River dolphin

Likewise the core focus involved finding solutions to a set of questions so that they may be further adopted in the design. They include:-

- How the issue of flooding has been resolved
- Has zoonotic prevention been carried out via means of ecological interventions
- River dolphin - presence, preservation and design influence
- How cultural & religious aspect has been addressed in equity with minimal ecological impact.
- Idea of river sanctuary and its functioning

The case studies that were finally selected include:-

- Yangtze Riverfront Park, China (***Figure 24***)
- Chongming island masterplan, China (***Figure 25***)
- Feng Riverfront Park, China (***Figure 26***)
- Ganga Riverfront development from Allahabad to Varanasi (***Figure 27***)
- National Chambal River Sanctuary, India (***Figure 28***)

The set of parameters on the basis of which the case studies were reviewed include:-

- Case type
- River type
- Extent
- Land use
- Climate
- Site issues
- Design interventions
- Impact
- Climate resilience
- Heritage preservation
- Zoonotic resilience strategies
- Dolphin status
- Visitor experience
- Best practices

Figure 24 *– Master plan of Yangtze Riverfront Park, Wuhan, China (Source – Sasaki architecture firm)*

Figure 25 *– Aerial shot of Xincusha masterplan, Chongming Island, China (Source – Sasaki architecture firm)*

Figure 26 – Master plan of Feng riverfront park, Xian, China (Source – Landzine website)

Figure 27 *– A schematic visualization of proposed development of Ghats along Ganga from Allahabad to Varanasi (Source – Morphogenesis architects)*

Figure 28 *– Aerial shot of a part of Chambal river sanctuary that lies in Rajasthan, India (Source – Google images)*

A tabulated analysis has been derived as understood from these case studies (***Table 1***).

Table 1 – Summarised analysis of case studies (Source – Author)

Selected case studies	Case type	River type	Extent	Land use	Climate
 **YANGTZE RIVERFRONT PARK** Location - Wuhan, China Urban context	Riverfront revitalization and development	Yangtze River Freshwater Mother River	503 ha (1242.94 Acres)	Mixed use urban context	Warm and temperate with significant precipitation Flooding common during monsoons
 **CHONGMING ISLAND MASTERPLAN** Location -Xincusha, Shanghai, China Urban context	Masterplan development for a riverine island	Yangtze River Freshwater Mother River	1,520 ha (3756.002 Acres)	Residential - mostly greenfield with on-going development	Oceanic climate Flooding common during monsoons
 **FENG RIVERFRONT PARK** Location - Xian, China Urban context	Riverfront revitalization and development	Feng River Freshwater Tributary of Yellow River	88 ha (217.453 Acres)	Mixed use urban context	Warm and temperate with significant precipitation Flooding common during monsoons
 **GANGA RIVERFRONT DEVELOPMENT** Location - Allahabad to Varanasi, India Urban context	Riverfront revitalization and development	Ganga River Freshwater Mother River	210 km length	Mixed use urban context	Humid semi - tropical with annual precipitation and dry spells. Monsoon Flooding common
 **NATIONAL CHAMBAL RIVER SANCTUARY** Location - UP,MP & Rajasthan, India Urban town context	River Sanctuary	Chambal River Freshwater Tributary of Yamuna River	5,40000 ha (1334369 Acres)	Mixed use urban context	Semi - arid with annual precipitation at 500 - 600mm. Flooding common during monsoons

Table 1 – Summarised analysis of case studies (Source – Author)

Site issues	Design interventions
Intense flooding Abandoned riverfront edges Lack of public open spaces Abandoned industrial areas near the river edge Degrading riverine mudflats and other biodiversity micro-habitats. Blood fluke infection threat Habitat of functionally extinct Yangtze Dolphin.	Adaptive reuse concept to revigorate abandoned industrial heritage Spatial design based on natural flooding Ecologically resilient landscapes Established snail habitat to feed on the blood fluke. Revitalization and revival of the natural mudflats. Introduced micro-habitats for local wildlife and migratory birds.
Eco sensitive & fragile river mouth ecosystem Ignored site ecological significance in previous proposal Blocked views Limited community access to significant open spaces. Restricted potential hydrological connections and wildlife movement. Habitat of functionally extinct Yangtze Dolphin. Potential for floods	Continuous public realm - Landscape network 100% public accessible riverfront edges Ecologically resilient landscapes Established and strengthened hydrological connectivities Wetland parks to bring back local wildlife Water sensitive planning and interventions to reduce saltwater intrusion, flooding, etc
Feng river banks were stripped of ecological and cultural values due to environmental degradation and intense urbanization	Reinterpreted historic river landscape and reinstating local ecologies Sponge city concept and seasonal planting Camouflaged touristic facilities to maintain the natural wildlife habitat 24 x 7 self-service smart hubs Multi - modal access systems to site Defined triple tier pedestrian walkways
Scouring of river edge Intense deforestation near lake edge River bank erosion and flooding Pollution due to dumping of part – burnt bodies into the river etc. Decreasing Gangetic Dolphin count	Floodable revamped traditional ghats Controlled spatial organization to avoid water pollution. Piers to sustain water transport up and down the river. Lifted structures for sufficient ventilation Sustainable columns Social spaces such as chaupals for cultural heritage preservation. Reforestation with resilient species
Habitat exploitation and deforestation Over - extraction of drinking water Sand mining Excessive fishing Forest resources exploitation Grazing and farming Reduced water volume due to construction of dams, barrages etc. No riparian edge Anthropogenic activities (religious etc.)	Preservation of the natural habitats. Preparation of NCS management plan - a decade - long plan that recommended a renewal of activities such as the annual survey; rear and release program for wildlife species. Designation as Ramsar and IUCN Category IV site Large scale touristic and awareness opportunities. Scientific field visit and research studies in the region.

Table 1 – Summarised analysis of case studies (Source – Author)

Selected case studies	Impacts	Climate resilience
 **YANGTZE RIVERFRONT PARK** Location - Wuhan, China Urban context	Reduced zoonotic spread of blood flukes due to snail habitat. Increased biodiversity due to versatile native and natural micro habitats. More public influx & awareness of local heritage	Natural flooding - core driver of spatial design configuration Elevated flood resilient open public spaces and built structures. Strategic site grading Placement of recreational spaces on the basis of the dispersing distances for the key wildlife species in the river basin to avoid intrusion into the primary habitats.
 **CHONGMING ISLAND MASTERPLAN** Location -Xincusha, Shanghai, China Urban context	Reduced waterlogging, salt intrusion & floods. Increased biodiversity due to native natural habitats created More open public spaces Strengthened connection to the river	Established and strengthened hydrological connectivities Water sensitive site planning and interventions such as bio - swales, green streets, canal network system and wetland park to reduce scenarios of saltwater intruision,flooding, etc.
 **FENG RIVERFRONT PARK** Location - Xian, China Urban context	Reduced floods. Increased biodiversity More public spaces Strengthened connection to the river' s historical heritage	Sponge city design concept Water storage is used for onsite irrigation, reducing water scarcity during dry seasons. Water sensitive solution which helped ensure a control of 85% of the annual runoff, reducing more than 60% NPS pollution, and reusing more than 30% of storm water onsite. Flooding and standing water issues onsite were eliminated post construction.
 **GANGA RIVERFRONT DEVELOPMENT** Location - Allahabad to Varanasi, India Urban context	More active riverfront edge. Floodable river edge. Enhanced riparian edge Reduced river pollution.	Floodable river edge. Reforestation with resilient species for reducing UHI Effect and flooding
 **NATIONAL CHAMBAL RIVER SANCTUARY** Location - UP,MP & Rajasthan, India Urban town context	Poor strategic planning has resulted in low tourist influx, illegal fishing and poaching, lack of awareness, habitat degradation and resource exploitation by locals	Retaining fragmented expanses of the natural sanctuary habitat

Table 1 – Summarised analysis of case studies (Source – Author)

Heritage preservation	Zoonotic resilient strategies	Dolphin status
Adaptive reuse concept to revive and repurpose the industrial heritage of the region. Flood resilient structures to ensure year round access to the heritage spaces.	Ecologically resilient landscapes Established snail habitat to feed on the blood fluke zoonosis vector. Strategic placement of public recreational spaces away from key wildlife species habitat to avoid public intrusion into the primary habitats.	Yangtze River Dolphin is considered functionally extinct however the design offers a good potential for the dolphins to come back and thrive
	Interconnected landscape network Ecologically resilient landscapes Established and strengthened hydrological connectivities Wetland park to bring back the local wildlife	Yangtze River Dolphin is considered to be functionally extinct however the design offers a good potential for the dolphins to come back and thrive in the region as well.
A winding corten wall with both ancient and modern scriptures for visitors to draw their own conclusions. Recreation of spaces that resemble iconic scenes from historic scriptures associated with Feng River.	Restored natural river ecologies. Camouflaged touristic facilities to maintain the natural wildlife habitat Strategic management and drainage of water onsite. Continuous landscapes	
Revamped traditional ghats Controlled spatial organization based on awareness of the chronology associated with religious activities. Flexible spaces like pop - up markets Social spaces such as chaupals		The design offers a potential for the Gangetic River Dolphin to frequent the region more often than before.
Existing traditional ghats along the river edge. Existing monuments such as forts, etc along the river edge. Flexible spaces like pop - up markets	Preservation and conservation of the natural habitats prevalent in the region.	The Gangetic River Dolphin count is dwindling lesser when compared to the other Gangetic stretches of and NCS holds perhaps the best population among the southern tributaries of Ganges.

Table 1 – Summarised analysis of case studies (Source – Author)

Selected case studies	Visitor experience	Best practices
 **YANGTZE RIVERFRONT PARK** Location - Wuhan, China Urban context	Year round riverfront access regardless of the floods due to a socially inclusive & ecologically meaningful waterfront with a strong cultural identity that embraces the Wuhan's unique philosophy derived from centuries of living alongside a dynamic river.	Adaptive reuse concept Using natural floods as core driver of spatial design configuration Animal aided design strategies
 **CHONGMING ISLAND MASTERPLAN** Location -Xincusha, Shanghai, China Urban context	The entire riverfront edge is made 100% accessible to the public with multiple green and open spaces to visit, experience the natural biodiversity and gain awareness of the same.	Continuous public access landscapes 100% public accessible riverfront edges Ecologically resilient landscapes Water sensitive site planning
 **FENG RIVERFRONT PARK** Location - Xian, China Urban context	Visitors access the site through a multi - modal transport system with 24 x 7 self-service smart hubs placed across the site. The people get to simultaeneously experience the cultural and ecological heritage associated with Feng River.	
 **GANGA RIVERFRONT DEVELOPMENT** Location - Allahabad to Varanasi, India Urban context	The religious aspect of Ganga is not compromised as the users get to carry out their activities related to religious sentiments and beliefs without major environmental impact. Additionally spaces such as chaupals create social gathering spaces which also acquaint the newer generations to the traditions and associated history as well.	
 **NATIONAL CHAMBAL RIVER SANCTUARY** Location - UP,MP & Rajasthan, India Urban town context	The wilderness values of NCS provide a scope for visitors to frequent the regions through larger- scale tourism operations such as day tours, boat trips to nesting sites or visits to view migratory birds & field visits for scientific studies. Provisions for wildlife tourism, river rafting, canoeing, adventure, religious & cultural tourism are also offered here as well.	

The tabulated inferences so understood from these case studies have been shown in (***Figure 29***).

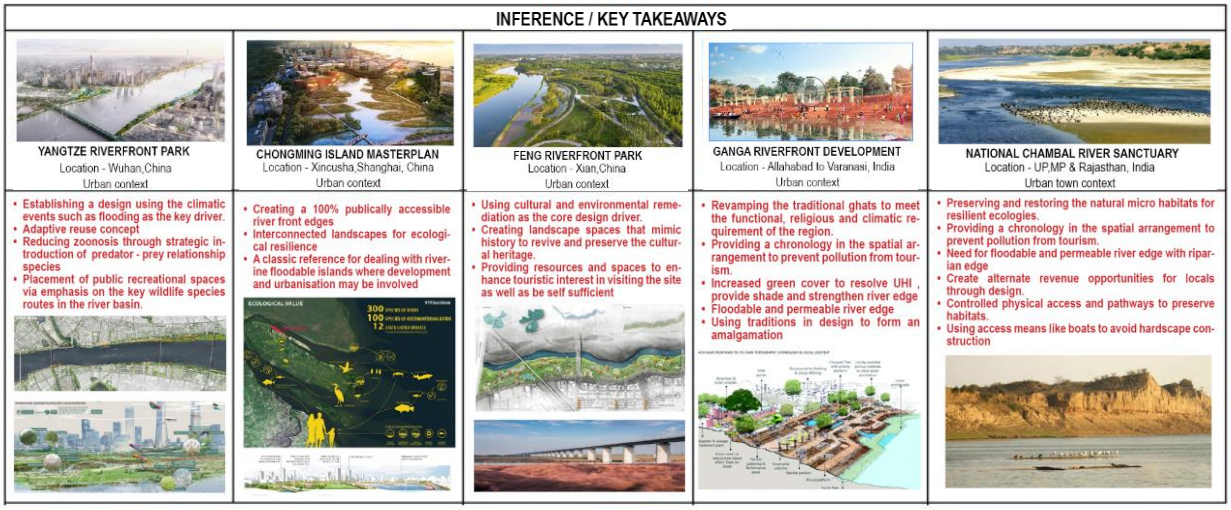


Figure 29 - Case studies inference (Source - Author)

CHAPTER 5 : LANDSCAPE OF VGDS

CHAPTER 5: LANDSCAPE OF VGDS

5.1 LOCATING THE SITE – GANGA

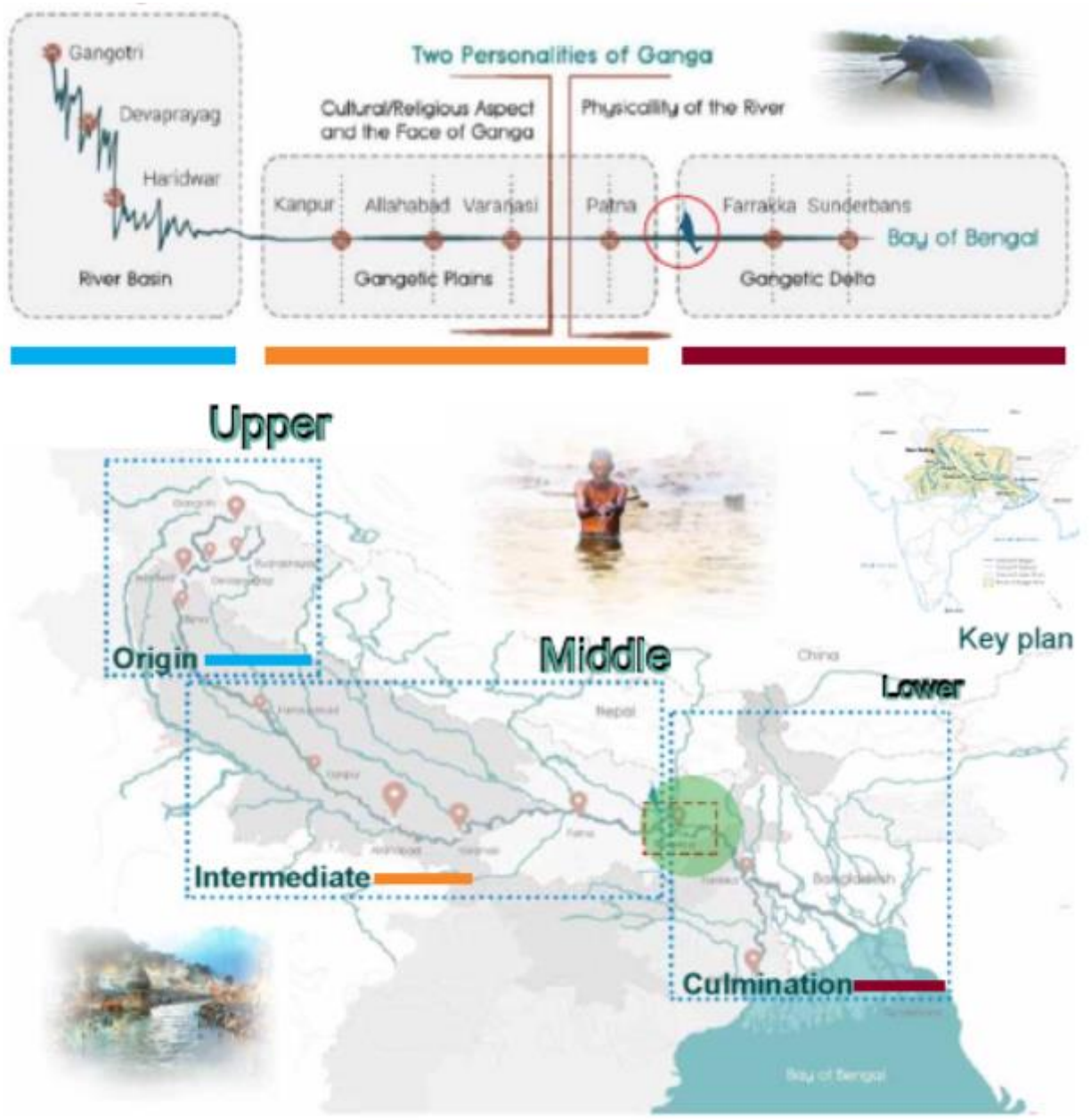


Figure 30 - Locating VGDS within the Gangetic watershed basin (Source - Adapted and modified by author from Thesis titled Architecture of Tribute: Temporality of River Ganga https://issuu.com/preetikab/docs/preetika-_thesis_report)

The Gangetic watershed basin of India may be divided into three zones of which the proposed site of VGDS core lies between the middle and the lower watershed basin (***Figure 30***). Therefore the stretch of Ganga that flows within this site may be considered to harbour a dual personality i.e. it is equally revered and feared. This dual personality drives the overall anthropogenic and natural site character. The proposed site is situated in between the intermediate and the culmination zone

as a result of which it is revered as well considered for its physicality such as flooding etc. in equal sense. The site stretch lies in a zone with a variable waterflow; that is the most polluted and largely exploited for numerous anthropogenic purposes in addition to being flood prone and largely unstable within Bihar as well.

5.1.1 LOCATING VGDS EXTENT

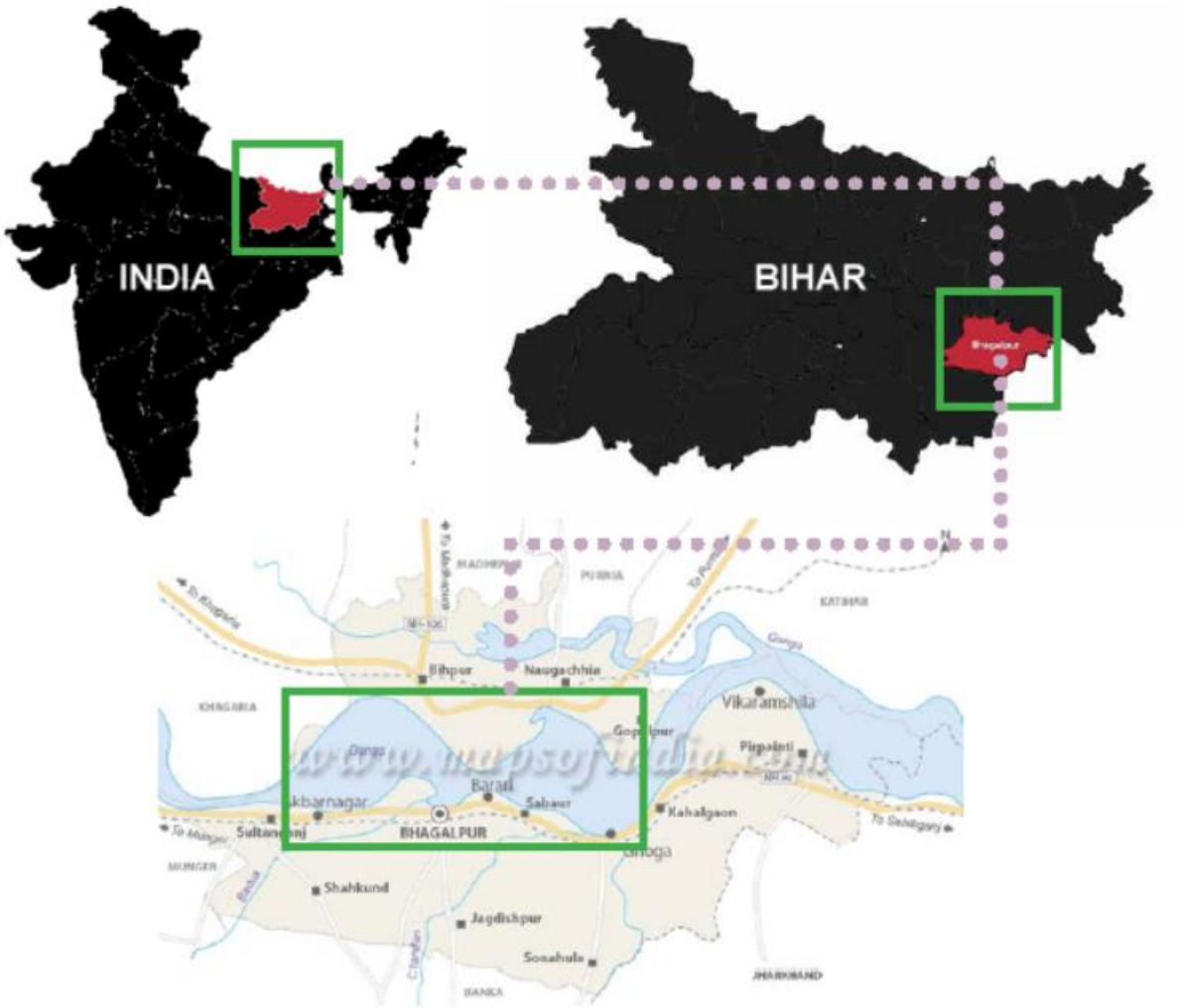


Figure 31 *- Location of VGDS in India (Source – Adapted by author)*

Situated in Bhagalpur district, Bihar, India, VGDS is a 60 km stretch of the Ganges River from Sultanganj to Kahalgaon (***Figure 31***). Notified as Vikramshila Gangetic Dolphin Sanctuary in 1991 under the provisions of Wildlife (Protection), Act 1972, it is IUCN Category IV Protected Area for the endangered Asian Gangetic dolphins and other wildlife species of which some do have endangered / threatened status. It is also an IBA (Important Bird Area) site in India as well.

Being a riverine habitat, its boundary and expanse undergo constant change due to the altering geomorphology of the Ganga River. The sanctuary has been named after the famous archaeological remains of Vikramshila University that was once a famous center of Buddhist learning across the world along with Nalanda during the Pala dynasty.

5.2 REWINDING BACK – HISTORY OF GANGA RIVER

The origin of Ganga River can be traced back to as far as the Hindu mythologies. The collision tectonics of Himalayas control the Gangetic system in addition to being responsible for the formation of Ganga Plain Foreland Basin. The Ganges, as well as its tributaries and distributaries, is constantly vulnerable to changes in its course in the delta region. The main river channel of Ganga at the entry point of Bihar dates back to around 200 years ago with a half to three-quarters of a mile width but after receiving an influx of several rivers, slowly enlarged to the size. Shifting of the bed of Ganga was continuing and in the fair season its upper end was becoming perfectly dry. A look at the evolution of the river planform around 37 years back shows that the average width of the river is around 0.25 – 3.1 km (***Figure 33***). Development is a slow progress and seems to be more concentrated at the towns of Sultanganj, Bhagalpur and Kahalgaon that lie along the right bank of the river. A major portion of the VGDS comprises of crop lands with residences which seems to have been constant for the most part to date (***Figure 32***).

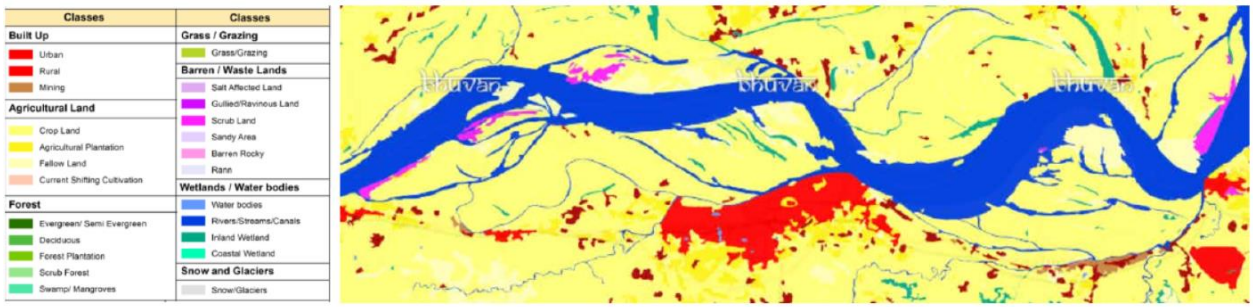


Figure 32 *- LULC map of the site for 2015-2016 (Source - Bhuvan)*

Although the major flow direction of Ganga in India is generally southeasterly, there are several places where the meandering of the river leads to a northerly flow, which is considered auspicious among Hindus - hence the term Uttarvahini Ganga.The proposed site of VGDS falls in the region of Uttarvahini Ganga which makes the towns of Bhagalpur, Sultanganj and Kahalgaon extremely auspicious.

- Sultanganj - Uttarvahini flow is for almost half km till the holy Ajgaivinath Temple.
- Bhagalpur - Uttarvahini Ganga plays a pivotal role in enhancing the already rich historic heritage of the region
- Kahalgaon - Here the Ganges is Uttarvahini for around 6 km from Kahalgaon to Bateshwar Sthan; where the Koshi and Ganges rivers merge, where Maharishi Vashistha is believed to have worshiped.

The Gangetic river stretch from Sultanganj to Kahalgaon via Bhagalpur is quite wide and deep, thereby providing an ideal habitat for the Gangetic river dolphins to thrive here; as evident in the count also. Apart from the river, various other micro - habitat environments were also present which helped a diverse variety of species to thrive in the region. However various anthropogenic influences resulted in a dwindling biodiversity count (including the Gangetic River Dolphin) which is why the region was provided with a wildlife sanctuary status.

Figure 33 *- Evolution of Ganga in VGDS from 1984 - 2021 (Source - Adapted from Google Earth by author)*

The evolution of Ganga within VGDS extent over the course of the years clearly indicate a braided river character (***Figure 34***) which is to be taken into intense consideration during master plan and design intervention formulation processes as the needful room for the river and its fluvial activities to occur need to be made.

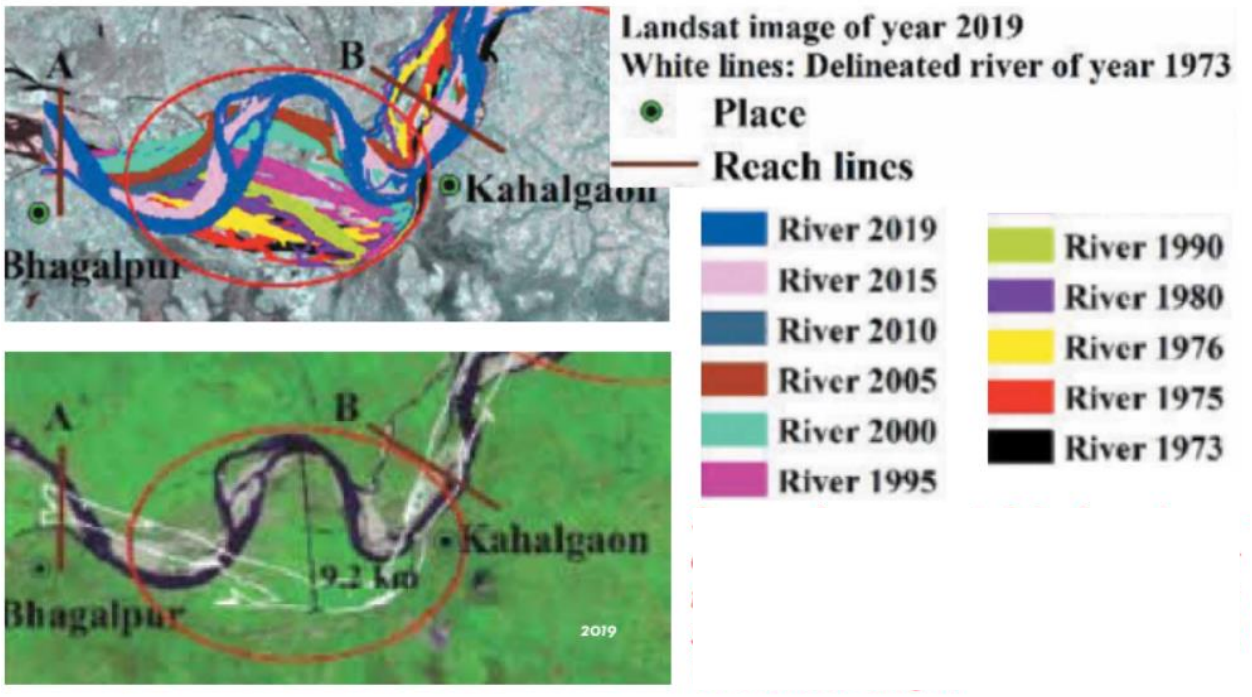


Figure 34 *– Changes in river planform within VGDS site extent from 1990 - 2019 (Source – Assessment of planform changes of the Ganga River from Bhagalpur to Farakka during 1973–2019 using satellite imagery by Chandan Raja and Vivekanand Singh)*

5.3 PHYSIOGRAPHY AND TERRAIN

The entire proposed site extent of the VGDS is composed of a variety of landforms that are formed as a result of natural ecological & hydrological processes. A major portion of the site is composed of diara lands - both old and recently formed ones in addition to chaurs, uplands and river beds (***Figure 35***).The character of each landform helps support a unique ecosystem of its own.

Despite the diversity in landforms, the proposed site extent of the VGDS lies in a low lying region which makes it extremely vulnerable to floods and excessive waterlogging as well. This makes the region extremely fertile and provides immense scope for increased groundwater level as well. The three major cities of Bhagalpur, Sultanganj and Kahalgaon are at comparatively higher region which also contributes to water flow from higher region to the lower region. (***Figure 36***). The slope at both north and south is majorly towards the river Ganga.

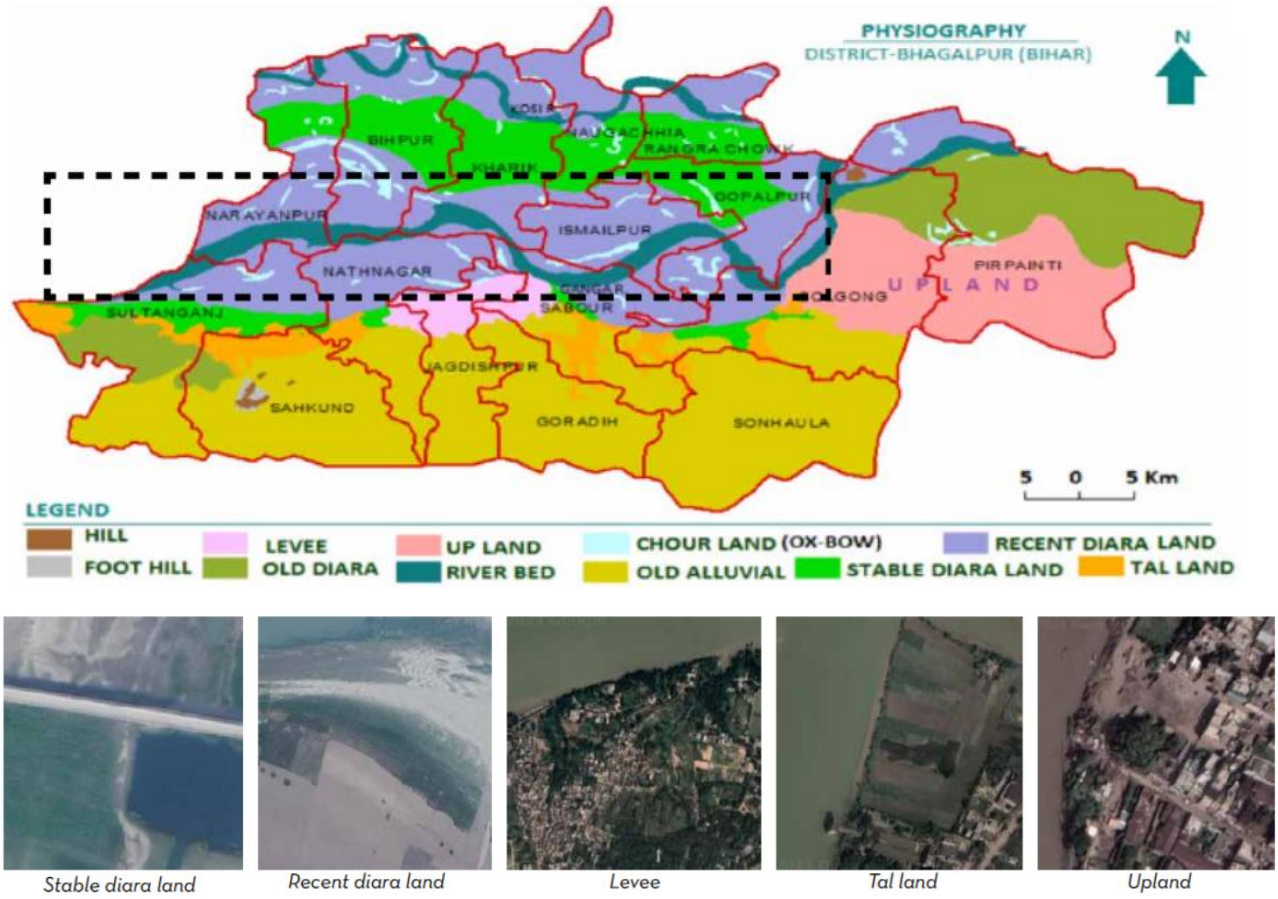


Figure 35 *- Physiography map of Bhagalpur with VGDS site extent marked (Source – Paper on Assessment of soil fertility of Tal and Diara Land: A case study of Bhagalpur district, Bihar, India)*

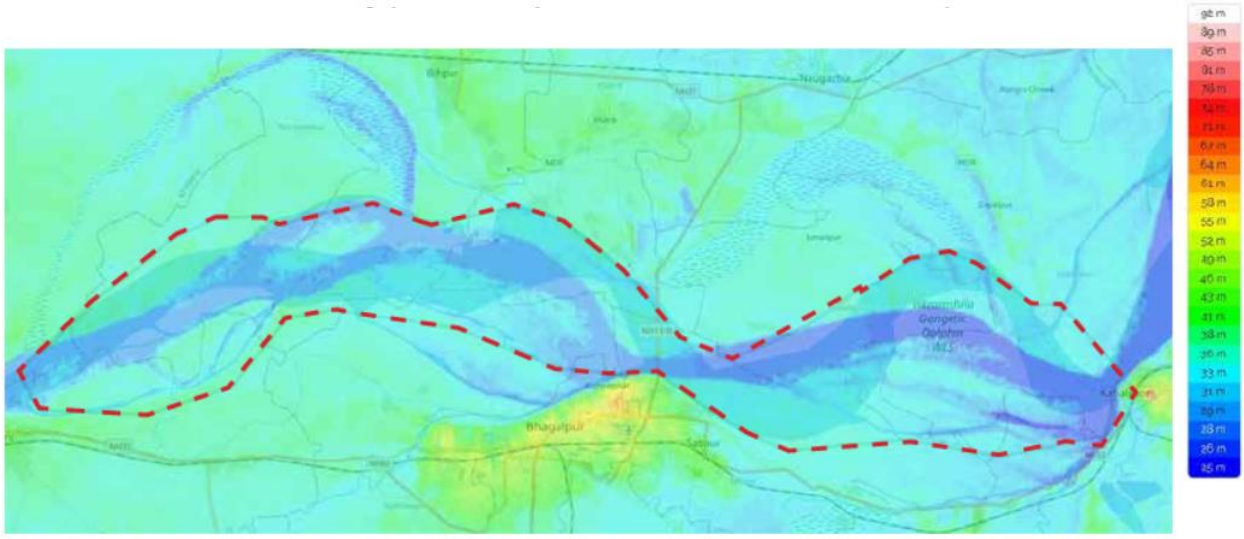


Figure 36 *- Terrain map of VGDS (Source - https://en-in.topographic-map.com/maps/es1f/Bhagalpur/)*

5.3.1 DIARA LANDS

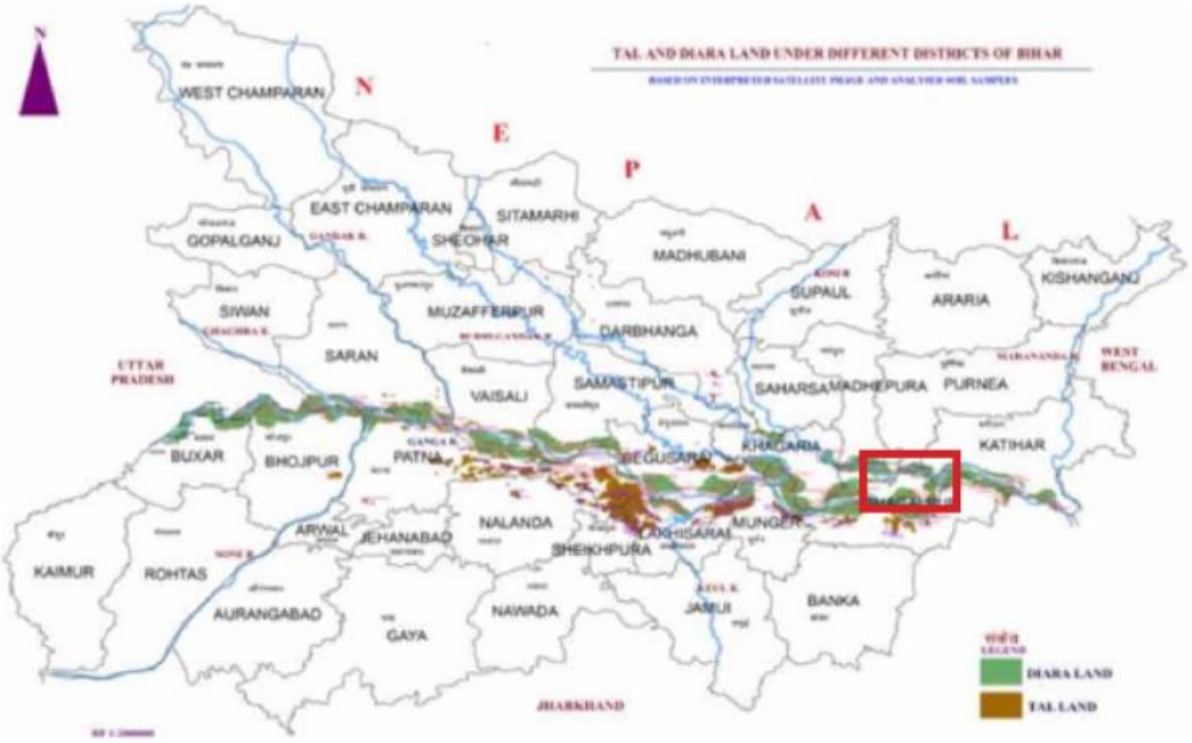


Figure 37 *- Tall and diara map of Bihar with site marked (Source - Development of Tall and Diara Land for Sustainable Agriculture in Central Bihar, India)*

The state of Bihar is primarily composed of diverse fluvial landforms with hills in certain parts (***Figure 37***).The fluvial landforms include Tall, Diaras, Chaurs, Maun etc. of which VGDS falls in a region with Tall, Diaras and Chaurs. These lands are subject to inundation for varying periods hence difficult to manage for crop production. Moreover these concepts vary from state to state and at times are used interchangeably too. These fluvial systems offer high potential for being converted into productive landscapes (fish farming etc.) as they are in a state of submergence for longer periods however they tend to lack management in general as well as do not occupy a spot in the dictionary of those who study about riverine/ fluvial systems and landforms.

Chaurs are tectonic lakes or river course remnants which are a type of floodplain wetlands but are not included in the Ramsar wetland list. Ecologically these are highly degraded systems due to excessive human intervention.

Tall lands are the natural levee of the Ganga while diara lands are the saucer shaped river floodplain under the flood plains of rivers Ganga and Ghaghara. The term 'diara' is the area on either side of rivers like Ganga which gets flooded with swelling of the rivers and is drained out with receding flood water. On the contrary 'tal' area may either be flooded through some water courses connecting the main river or even due to heavy rains and they do not drain readily with the receding of flood water (***Figure 38***).

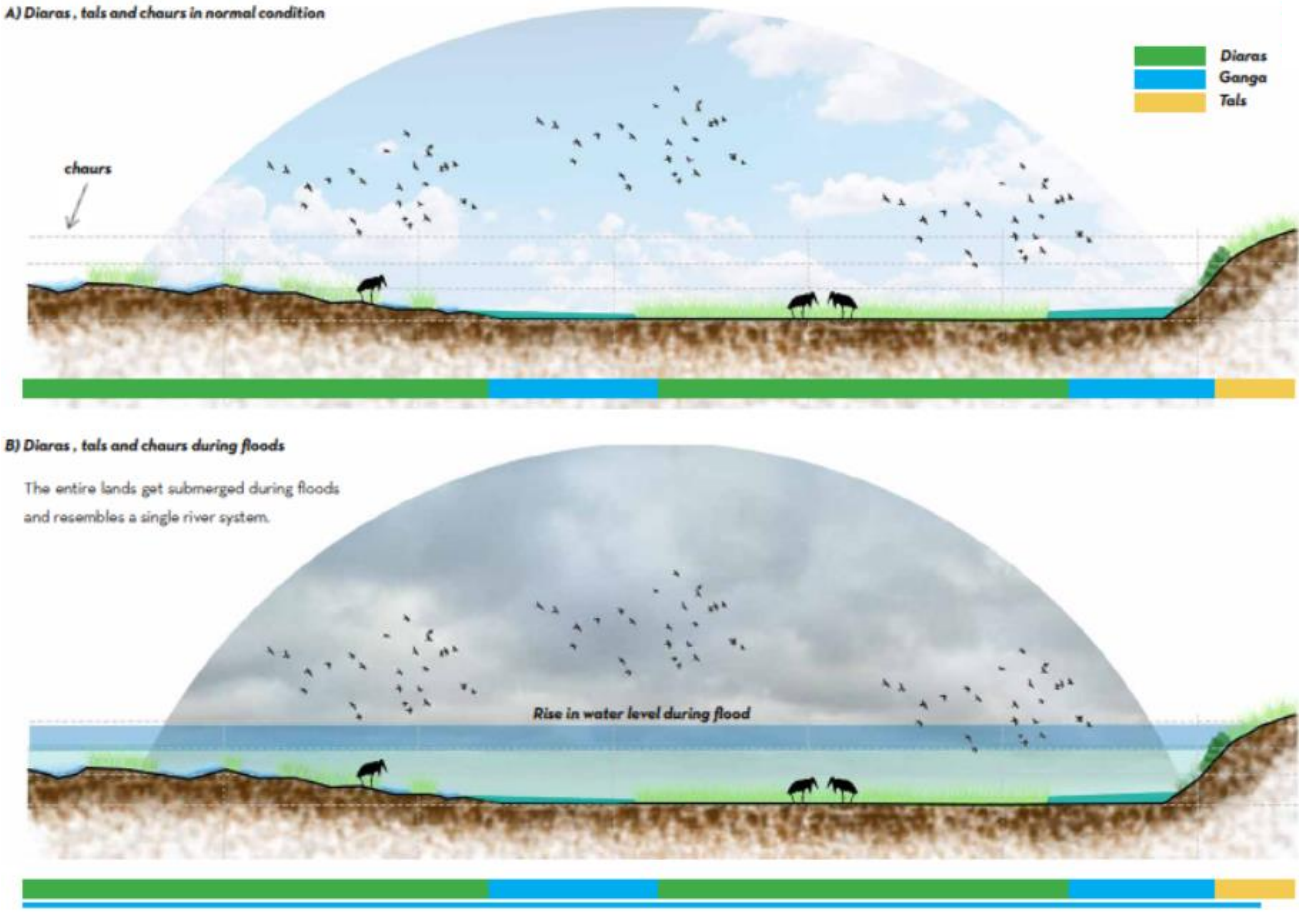


Figure 38 *- Functioning of tals, chaurs and diaras in the presence and absence of floods (Source - Author)*

Some of the most common issues these lands face include:-

- Massive macrophyte infestation due to shallow depth and lost connectivity with the river.
- Advance eutrophication resulting in swampification &colossal loss of biodiversity and fisheries.
- Increased weeds and unwanted ichytho - faunal species.
- Erratic monsoon schedules resulting in yield loss and reduced quality of the produce.
- Water logging and flooding due to continuous overflow of Ganga and famines
- Cattle grazing without any control.
- Low infiltration and water conductivity.
- River siltation and improper drainage connectivity.
- Improper and illegal constructions.

However some factors that make these lands favourable include:-

- High net return per unit area and economic returns
- Ease in irrigation.
- Low cost of cultivation.
- Less mineral requirement due to high fertility.

- Limited weed growth.
- Low cost labour facilities.
- No land ownership required.
- Income and food security of landless and marginal farmers
- Local adaptation to climate change.
- Abundant biodiversity

5.4 GEOMORPHOLOGY AND LITHOLOGY

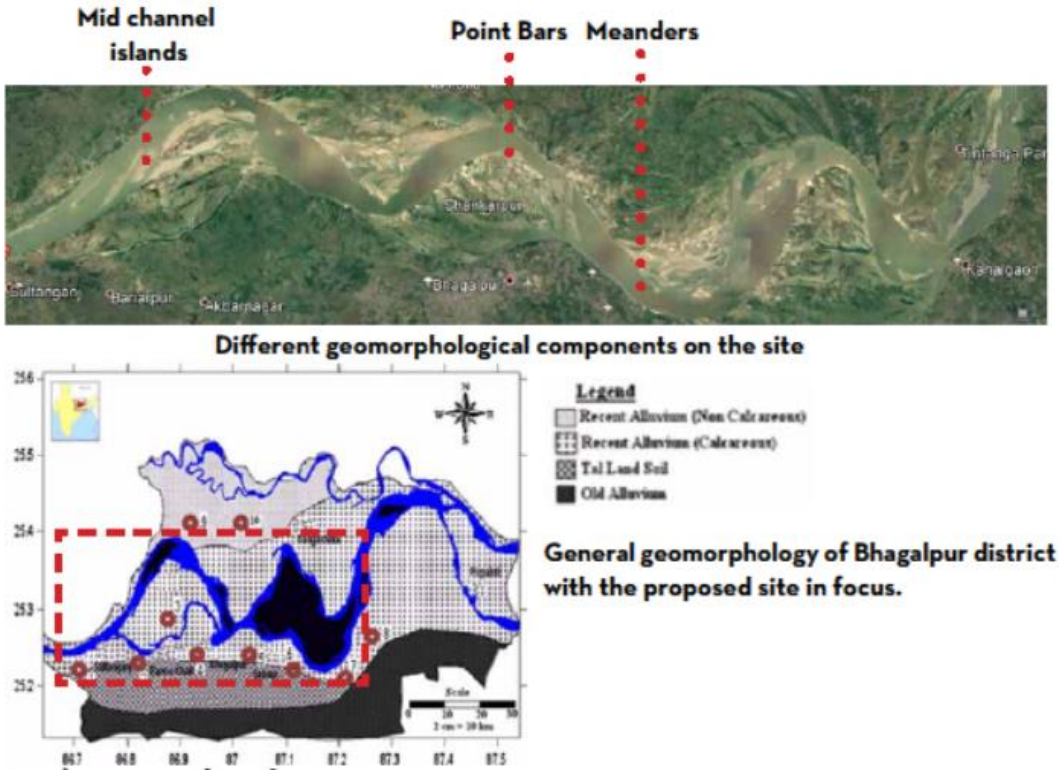
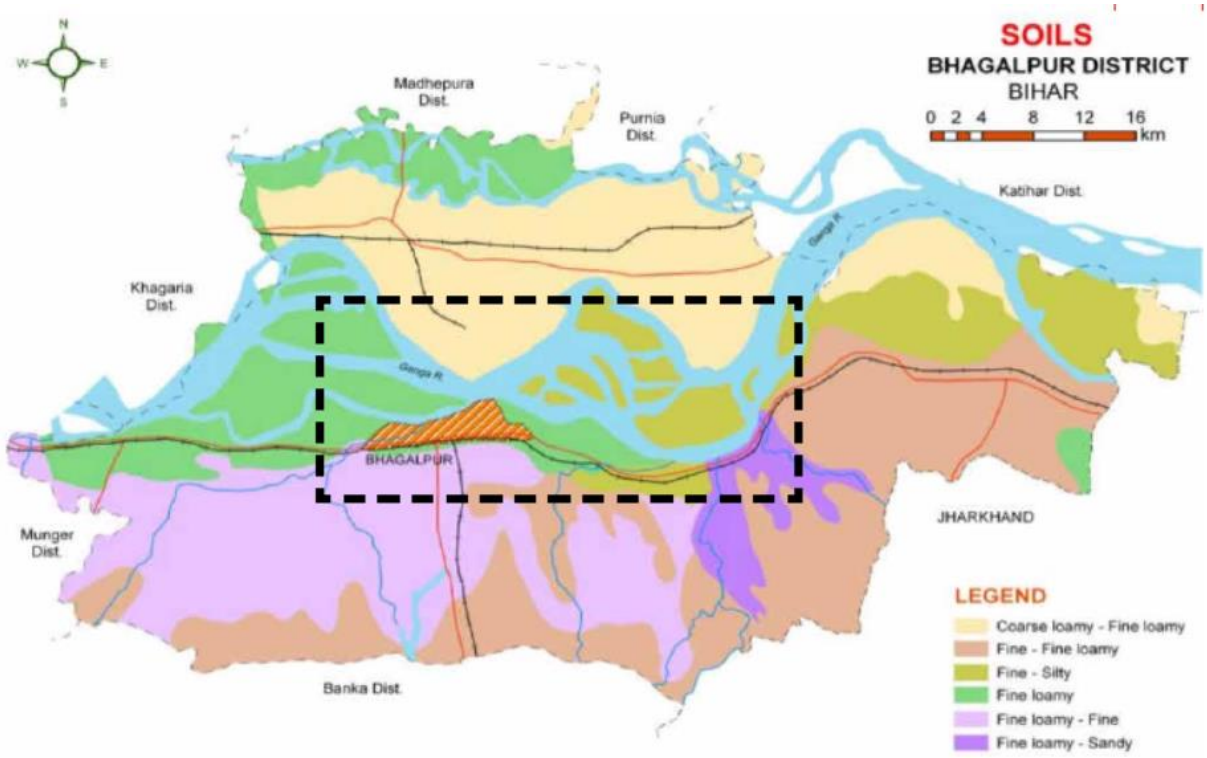


***Figure 39**- Geomorphological condition of the VGDS (Source - Adapted by author)*

Geomorphologically, the proposed site forms a part of the Mid-Ganga Foreland Basin with the regions towards the north & south of Ganga respectively forming a flat Indo-Gangetic alluvium tract while the southern part forms a marginal alluvial tract with a general elevation remaining within 45 m above mean sea level.

VGDS is a part of the Ganga–Kosi interfluve with the geomorphology of the main river channel characterized by meanders, wide straight channels, alluvial islands, point and spit bars, rocky mid-channel islands and deep countercurrent pools (***Figure 39***). The water depth ranges from 0.2 to 40 m while the channel width varies between 150 m and up to 3 km. However, in very wide channels water depths are shallow with numerous mid channel islands. The soils in the district are mainly derived from the older and newer alluvium (***Figure 40***). The pH values range from neutral to acidic and the acidity of the soil gradually increases from north to south. The soils derived from older alluvium are mainly loamy in character with moderate to heavy texture and well drained. In low lands, these are poorly drained with heavy texture. Sandy soils (Diara soils) derived from younger alluvium are light textured, well drained. These are moderate to highly fertile calcareous soils and found along the banks/course of the river Ganga.



Major Soils	Area ('000 ha)	Percentage (%) of total
Sandy Soils	20.594	13.78
Coarse Sandy Loam Soils	28.719	19.22
Fine Sandy Loam Soils	44.836	30.00
Clayey Soils	34.980	23.41
Saline/ Calcareous Soils	20.294	13.58

Figure 40 *- Soil map of Bhagalpur district with site highlighted (Source - Agriculture Contingency Plan for District: BHAGALPUR)*

5.5 FLUVIAL DYNAMICS

A river like Ganga is dynamic and complex. From inception to culmination, the river exhibits a diversity of fluvial landscapes; each unique than the other. There are ecological processes involved that establish this uniqueness. Some of the important processes that govern the geomorphology of the proposed site include siltation, flooding, aggradation and erosion. Silt and sediments are integral part of rivers as they help in creating hydro-geo-morphological complexities in the river channel in addition to being very important for the productivity and riverine biodiversity. Without suspended solids rivers cannot maintain hydro-geo-morphological complexities; essential for creating diversified micro / macro habitats for sustenance of rich and diversified biodiversity. The river bed from Bhagalpur to Farakka shows a decline in the sand contribution declines considerably with 54-69% sand and substantial increase in silt content; compensated by the nutrient flow from the basin. Sand bed is indicator of low aquatic productivity. Due to the confluence of number of tributaries water velocity in this stretch is high. The sediment load is very high and the substrate is silt over sand. The river slope is considerably reduced due to silting.

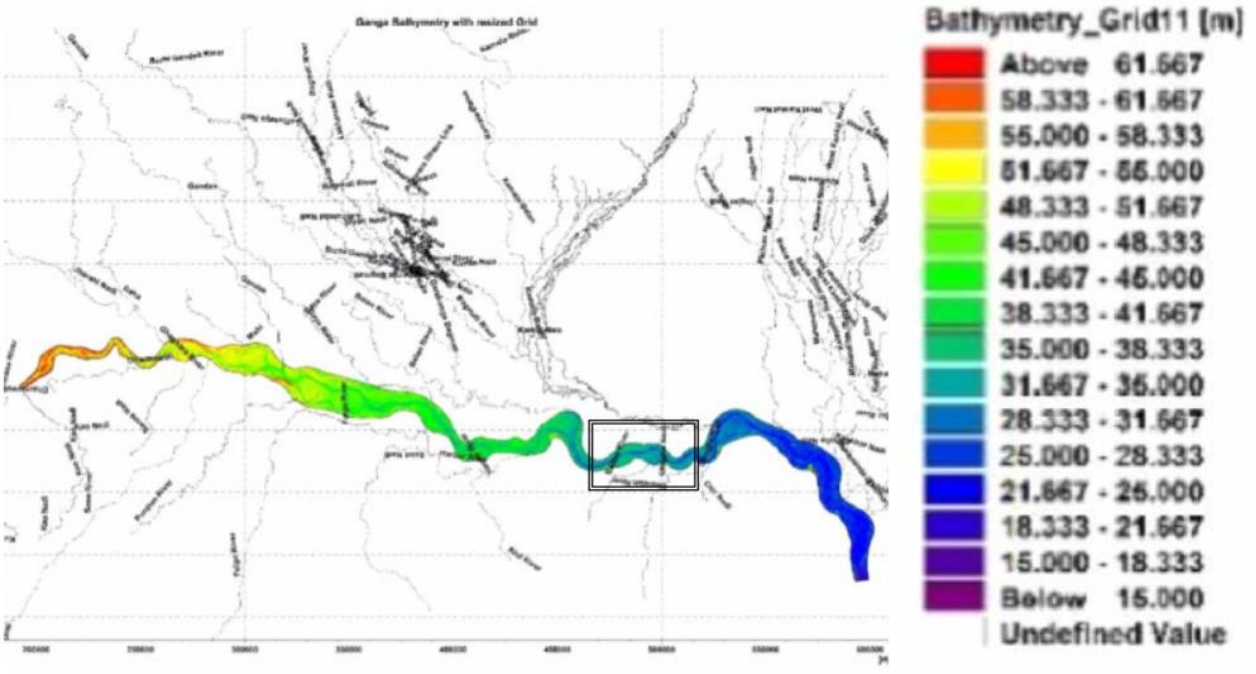


Figure 41 *- Bathymetry map of Ganga river with the proposed extent of site marked (Source - Two-dimensional morphological modelling for 600 km long Ganga in Bihar)*

The Ganga, like all rivers, does not carry just water. The river flows also include the flow of silt, nutrients and biota, the last one both upstream and downstream. E-Flow is that basic velocity needed to maintain this natural flow. There are species that thrive on the basis of this flow. The ideal e-flow is 266.42 - 289.67 metre cube per sec - the basic requisite for gangetic dolphins also. Failure to keep up this flow will lead to loss of diversity in the region through extinction deaths or migration. Apart from changing the entire ecology of the Ganga, the silt deposit in the riverbed also responsible for recurring floods. Approximately 30-35 ft. high silt deposits on the riverbed which not only reduce the water retention capacity but also results in the drying of the river or low water levels during summer despite having sufficient water (***Figure 41***).

Figure 42 *– Image on left shows the eroding river bank of Bhagalpur while the right image shows an eroding river bank within the VGDS extent at Tintanga ghat (Source - Bank shifting of river Ganga in the downstream of Bhagalpur Vikramshila Setu, Google)*

Right bank of Ganga is densely populated with 3 major towns and has many important structures. In last 10 years, the riverbank downstream Vikramshila Setu (Bhagalpur, Bihar), is shifting towards its right bank with great effect by more than 1000 m (***Figure 42***) thereby putting towns

like Bhagalpur city under risk of inundation during floods. Rate of erosion was found to be more in between 2003 & 2011 in comparison with 1988 & 2006.

5.6 HYDROLOGY AND FLOW DYNAMICS

The Bhagalpur district falls under the influence of three principal rivers – Ganga river, the Kosi River and the Ghagra River and its tributaries. Almost all the water sources in the Gangetic basin flow into this river stretch on the site and drain into the Bay of Bengal ultimately (***Figure 43***).

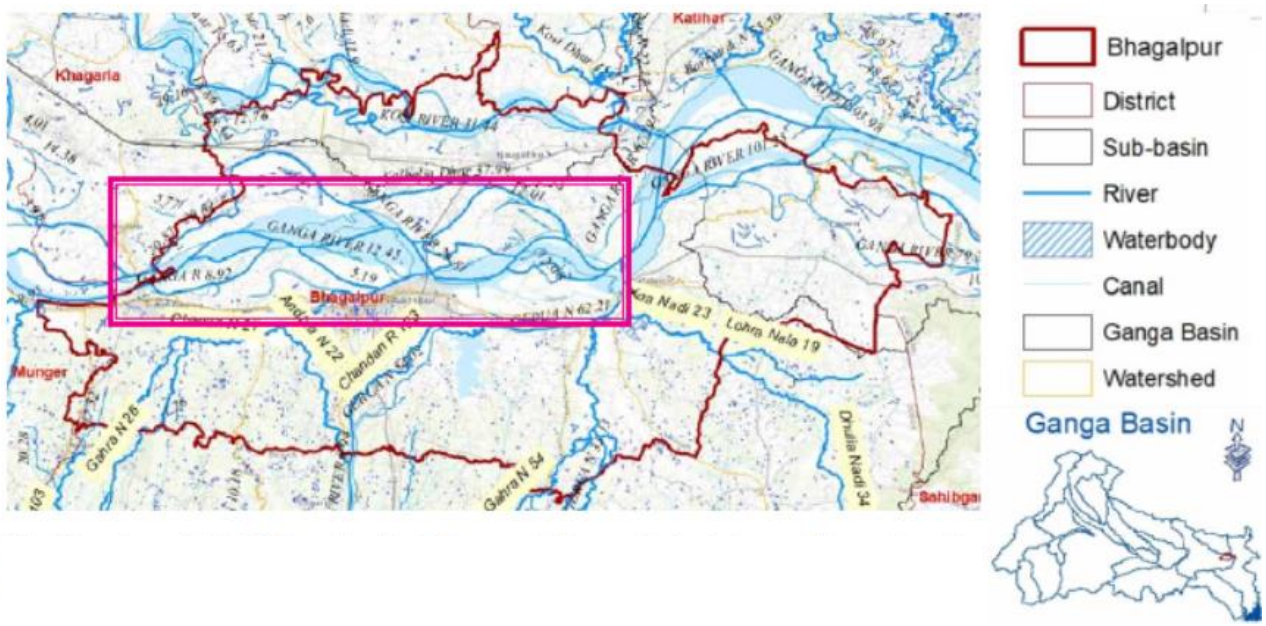


Figure 43 *- Hydrology map of Bhagalpur district with proposed site highlighted (Source - Namami Gange)*

5.7 GROUNDWATER STATUS

Age - Quaternary

Condition - Fairly thick, regionally extensive semi- confined and confined aquifer within 200 m depth and blow.

Groundwater potential - Large yield between 100 - 200 m3/hr.

The sand layers in the Quaternary Alluvium (both newer and older) form the main source of ground water in the district (***Figure 44***). Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into two categories -

- The shallow aquifers within 50 m depth.
- The deep aquifers within 50 – 200 m depth.

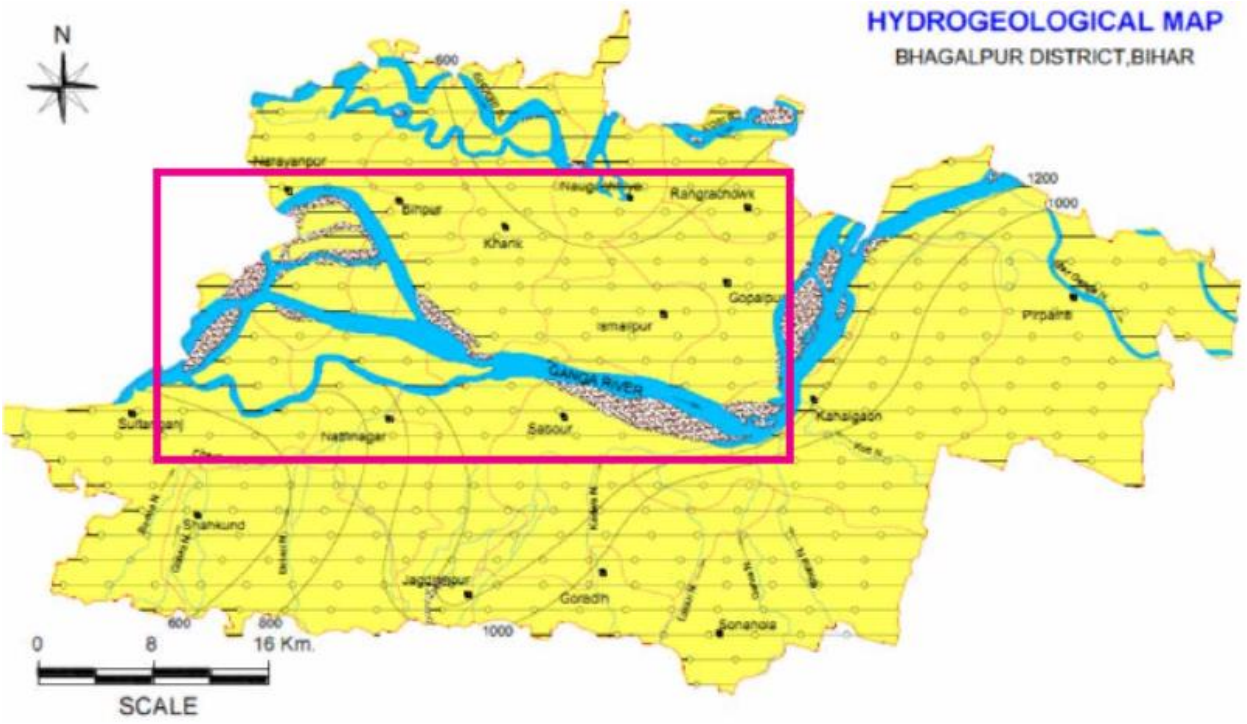


Figure 44 - Hydrogeological map of Bhagalpur district with proposed site highlighted (Source -Ground Water Information Booklet Bhagalpur District, Bihar State)

In shallow aquifers, the ground water occurs under unconfined condition and in deeper aquifers under semi-confined to confined conditions. The shallow aquifers consisting of fine to medium sand with clay, silt and kankars are the main sources of ground water in the marginal alluvial tract in the south Bhagalpur. The deeper aquifers mainly consist of sand, gravel and calcareous nodules with alternating layers of clay. The composition is not homogeneous at many places and is very often mixed with silt and little clay thereby impeding their water yielding capacity.

The ground water source is insufficient for the long term, and the current surface water source does not cater either in terms of quality or quantity. The ground water table is depleting and contaminated with fluoride and traces of arsenic (***Figure 45***). 50% of the tube wells showed Arsenic to be above the WHO health-based drinking water guideline. The towns of Sultanganj and Bhagalpur seem to be the most affected with arsenic groundwater contamination. Presence of arsenic is sporadic in hand pumps and is largely dependent on the hand pump depth and from which formation it taps water. A sudden surge in arsenic concentration in the tube wells is found between the depth range of 12 and 40 m. After 40 m there is a drastic decline in arsenic concentration. In dug wells arsenic concentration is reported as below detection limit (BDL).The maps suggest that approximately 75% of this area has no safe tube wells. This discovery of thorium which does not have a WHO health-based drinking water guideline, is a potential public health challenge

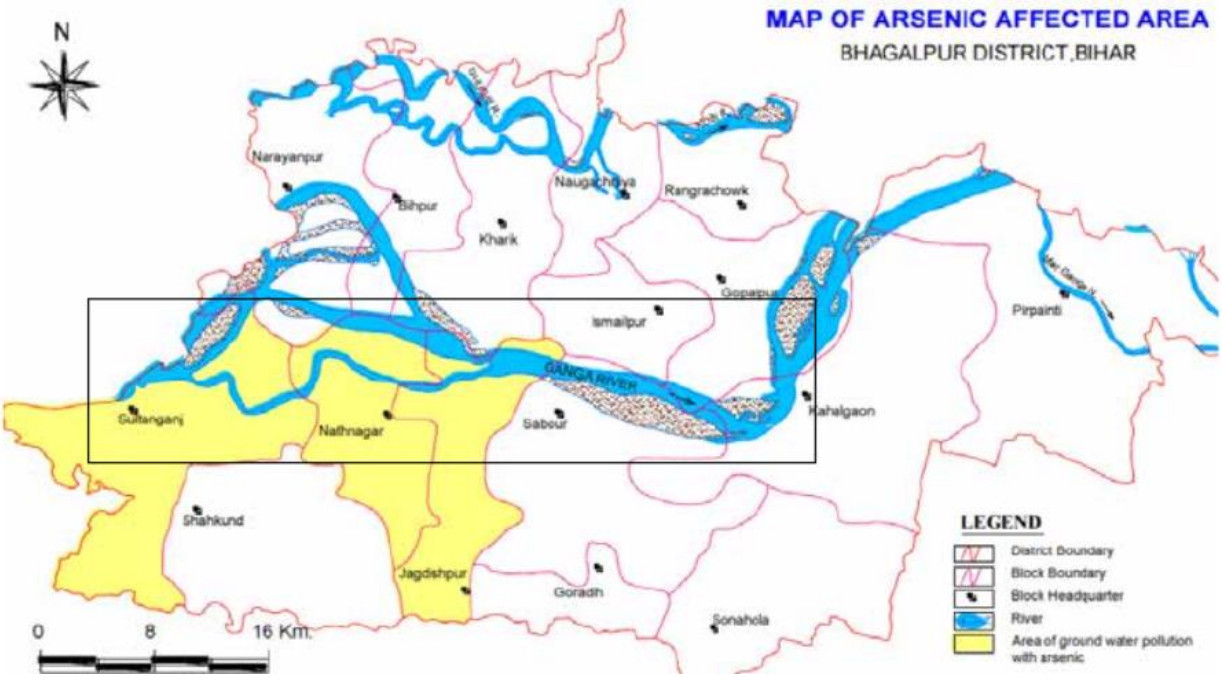


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Figure 45*-Arsenic contamination map of Bhagalpur district with proposed site highlighted (Source -Ground Water Information Booklet Bhagalpur District, Bihar State)*

5.8 RIVER WATER QUALITY

The Ganga was once renowned for its ability to retain oxygen due to high oxygen retention capabilities as it was the only river in the world which had 12 ppm of oxygen. The amount of organic waste that goes into Ganga should have already exhausted the amount of oxygen. But so far this has not happened. However the present day scenario is that the water quality in the proposed site region is not fit to drink or bathe in unless advanced treatment is carried out. This not only affects the human life but also the vast array of biodiversity thriving in the region. This is also why a shortage of drinking water persists in the region despite habitation being close to a perennial river as Ganga (***Figure 46***).

Key causes for the same include:-

- Pollution
- Improper agriculture practices
- Dumping of bodies
- Religious activities

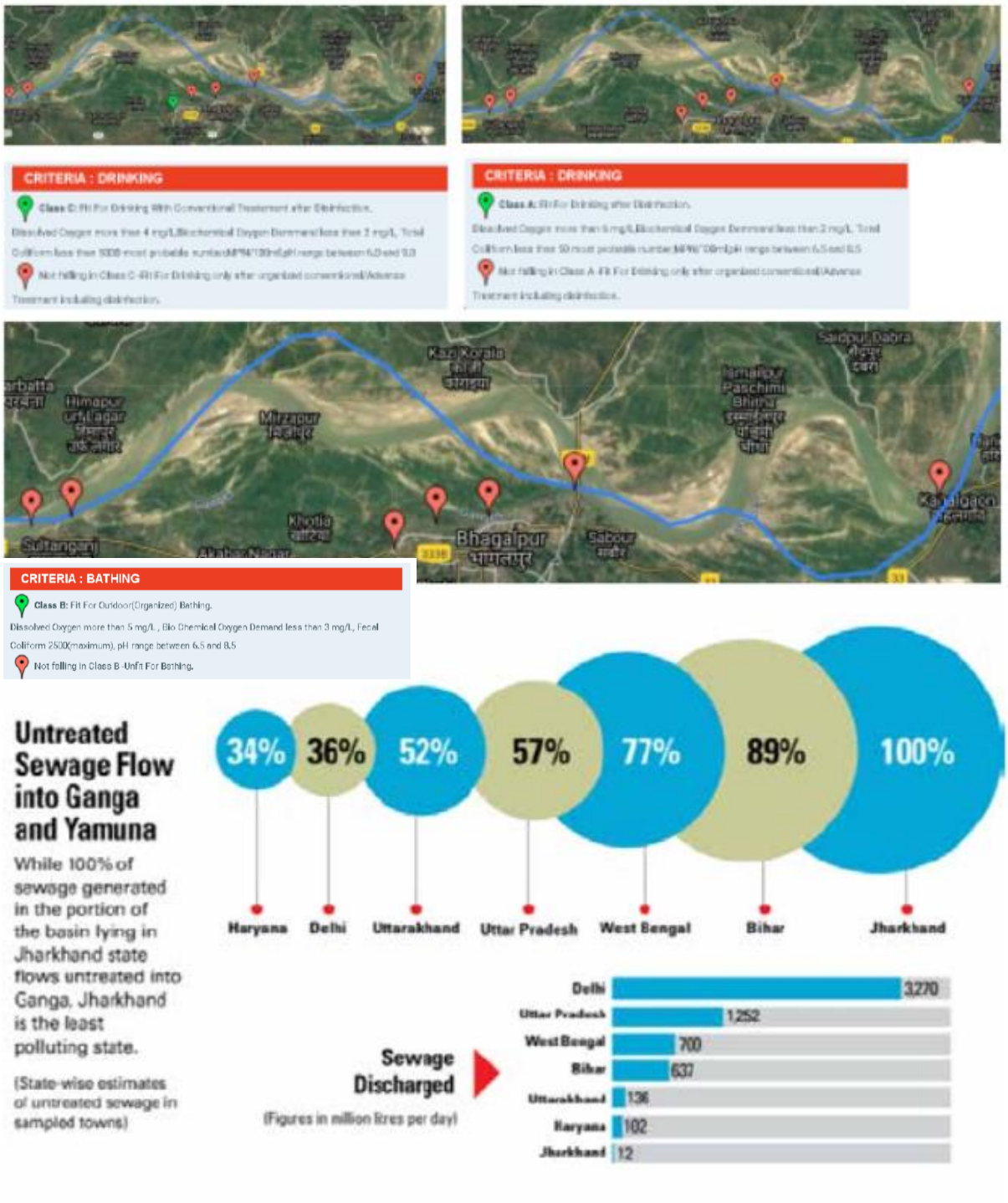


Figure 46 *- Water quality status of Ganga in the proposed site extent. Statistical data of the amount of untreated sewage discharge into Ganga clearly shows that majority of the waste influx into the region is a result of both onsite and offsite discharge upstream. (Source - Namami Gange)*

5.9 CLIMATE AND PRECIPITATION

The climate experienced here in this sanctuary area can be described as a mean between the scorching heat of the west and moist of the east (***Figure 47***). Temperatures vary from a recorded minimum of about 5–8°C in winter (December–January) up to a maximum of 45°C in high summer (May–June). There are distinctively 4 seasons here in this region:-

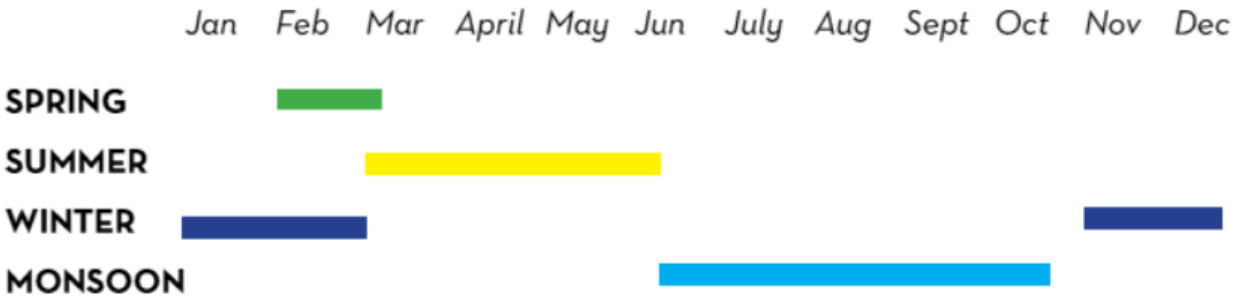


Figure 47 *– Seasons calendar for the proposed site extent (Source - Author)*

Mean Max. temperature - 31.3^{O} C

Mean Min. temp - 18.6^{O} C

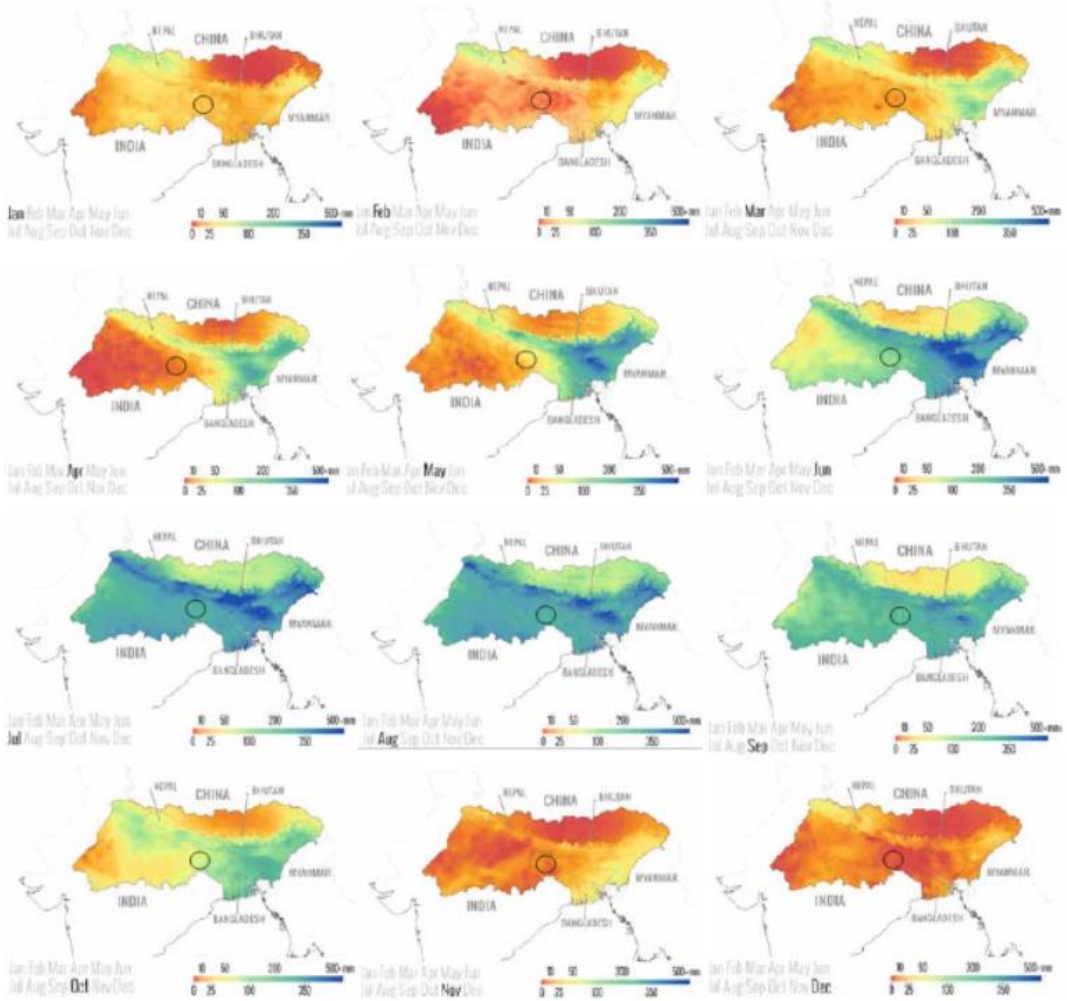


Figure 48 *– Precipitation calendar for the proposed site extent (Source - Author)*

Precipitation is in the form of rain with the southwest monsoons as the main source of rainfall in the region. The average annual rainfall for the sanctuary region as a whole is 1087.97 mm (***Figure 48***).

5.9.1 FLOOD SCENARIO

The proposed site is situated in a region that is extremely vulnerable to floods, earthquake, winds, cyclones and occasionally droughts as well (***Figure 49***). However floods top the list. The south-west monsoon (June-September) contributes 80% to 90% of the total rainfall. Intense precipitation imply higher runoff, causing most rivers to overflow and flood adjacent low lying areas connecting the flood plains. The resultant being displaced people, impacted livelihoods and loss of lives, livestock and critical infrastructure (***Figure 50***).

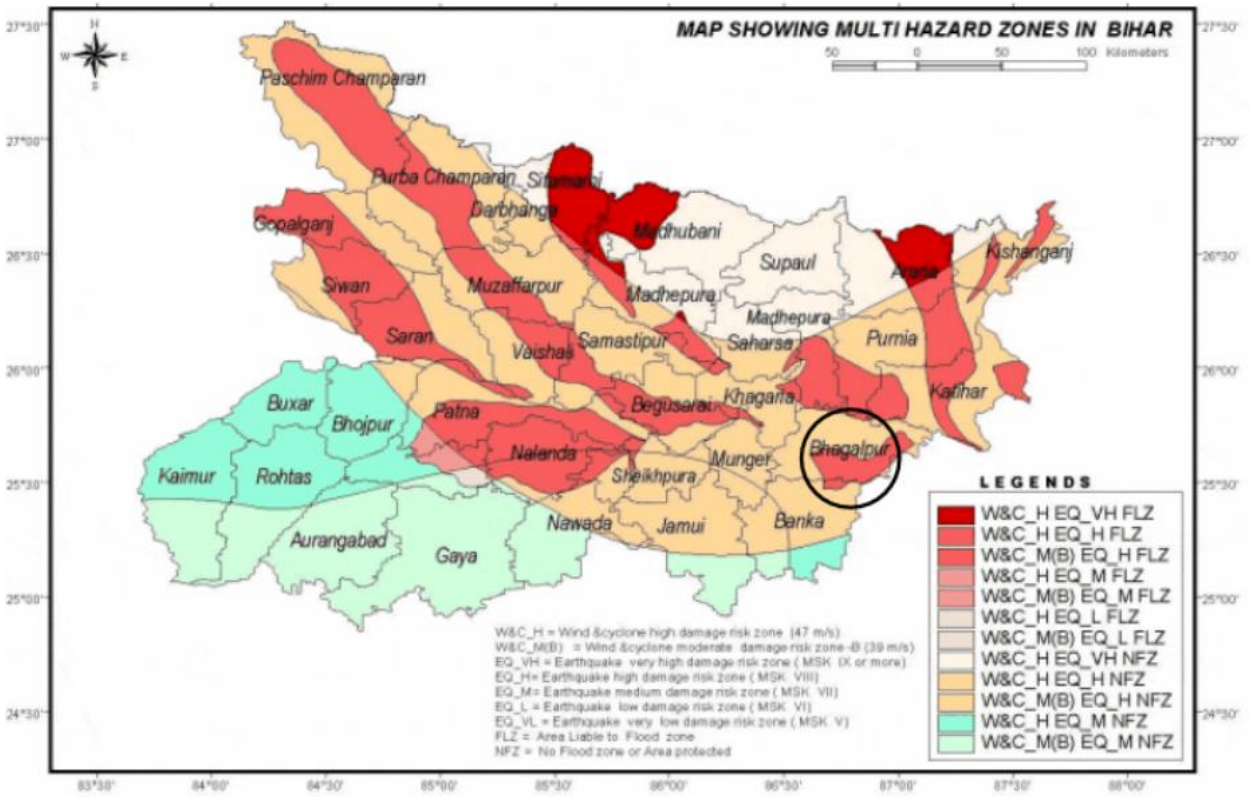


Figure 49 *– Multi hazard map of Bihar highlighting the proposed site extent (Source – Bihar State Disaster Management Authority)*

Additionally these flooding events also provided a conducive environment to the spread of water borne diseases. Also intense precipitation lead to increase in moisture buildup while consequent inundation leads to poor soil aeration conditions of flooded soils which thereby adversely affects the plant growth as well.

The stretch near Bhagalpur and Kahalgaon are gauge sites. River gauge sites are very sensitive to precipitation variability, and therefore serves as an important proxy indicator of flooding. A river is said to be in flood situation when its water level crosses the danger level (DL) at that particular site.

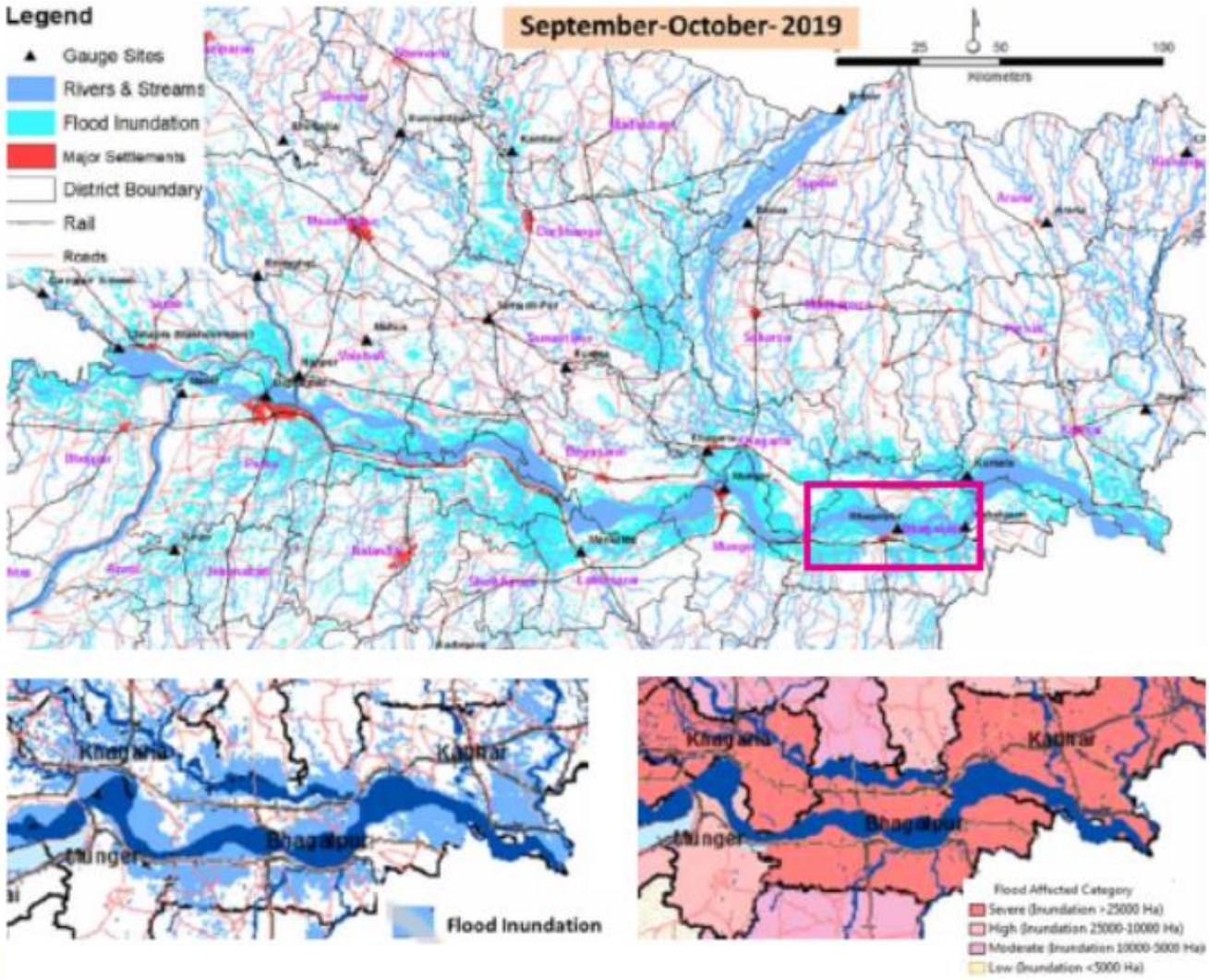


Figure 50 *- Inundation scenario of Bihar with proposed site highlighted during Sept - Oct 2019 floods (Source - Bhuvan)*

5.10 ZOONOSIS HAZARD PROFILE

The region experiences various zoonotic infections with water borne of critical ranking (***Figure 51***).Most transmission occurs through vector bites which introduces infectious agents into the bloodstream. The vectors and animal reservoirs for many of these diseases are naturally found in Bihar, hence very prominent in Bihar. Water borne diseases via contaminated drinking-water is also frequent cause of diseases such as cholera, typhoid, viral hepatitis A etc.

Vector borne

- Malaria
- Acute Encephalitis Syndrome
- Japanese Encephalitis
- Kala-azar
- Chikungunya
- Dengue

- Filaria

Enteric, Food and Waterborne Diseases

- Acute Diarrhoeal Disease
- Bacillary Dysentery
- Typhoid fever
- Cholera
- Shigellosis

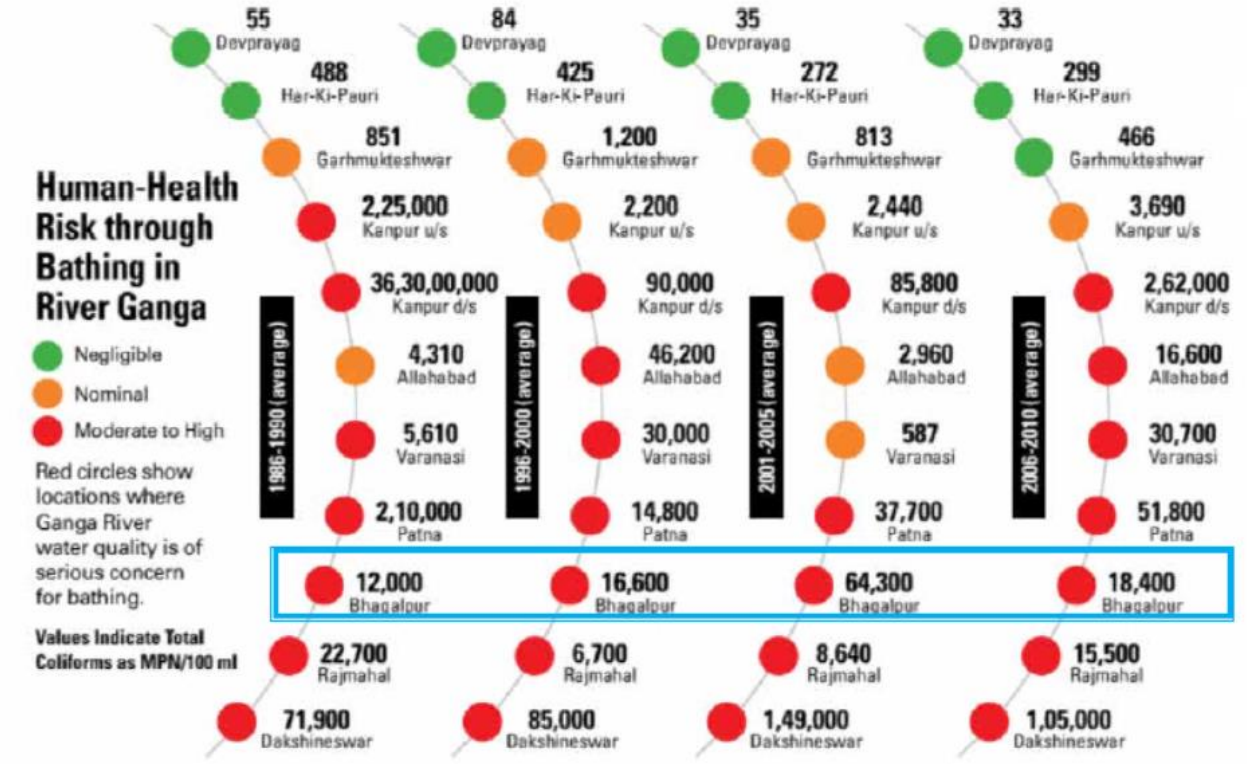


Figure 51 *– Human health risk scenario in River Ganga shows Bhagalpur at a moderate to high scenario which highlights the need for developing zoonotic resilience in the region (Source – Namami Gange)*

The impact of these disease in the region is not just limited to symptoms alone. Rather it results in a visible count of life loss every year especially with increased inundation and climate change (***Figure 52***). The major causes for increased cases are a result of both natural and anthropogenic causes. Aggravated natural phenomena as a result of carelessly thought and introduced anthropogenic interventions is the major cause of increased zoonotic cases in the region.

Table 2.49 : Epidemiological status of Malaria in 2010 and 2011 in the States Traversed by NW-1

States	Year	Population	Cases	Deaths
Bihar	2011	32928	160653	17
	2010	103230	1908	1
	2011	103483	2643	0

Sources: National Vector Borne Disease Control Programme

Table 2.50 : State-Wise Dengue Cases and Deaths in the States Traversed by NW-1

No. Sl.	State	2008		2009		2010		2011	
		Case	Death	Case	Death	Case	Death	Case	Death
1	West Bengal	1038	7	399	0	805	1	510	0
2	Jharkhand	0	0	0	0	27	0	36	0
3	Bihar	1	0	1	0	510	0	21	0
4	Uttar Pradesh	51	2	168	2	960	8	155	5

Sources: National Vector Borne Disease Control Programme

Table 2.51 : Kala-azar cases and deaths in the States Traversed by NW-1

State	2007		2008		2009		2010		2011	
	Case	Death	Case	Death	Case	Death	Case	Death	Case	Death
West Bengal	1817	9	1256	3	756	0	1482	4	1962	0
Jharkhand	4803	20	3690	5	2875	12	4305	5	5960	3
Bihar	37819	172	28489	142	20519	80	23084	95	25222	76
UP	69	1	26	0	17	1	14	0	11	1

Sources: National Vector Borne Disease Control Programme

Table 2.52 : AES/JE (Viral) Cases and Deaths (2006 – 2011) in the States Traversed by NW-1

Sl. No.	Affected States/UTs	2006		2007		2008		2009		2010		2011	
		Case	Death	Case	Death	Case	Death	Case	Death	Case	Death	Case	Death
1	Uttar Pradesh	2320	528	3024	645	3012	537	3073	556	3540	494	3490	579
2	Bihar	21	3	336	164	203	45	325	95	50	7	821	197
3	Jharkhand	0	0	0	0	0	0	0	0	18	2	303	19
4	West Bengal	0	0	16	2	58	0	0	0	70	0	714	58
	Total (India)	2871	663	4110	966	3855	684	4521	774	5167	679	8247	1169

Sources: National Vector Borne Disease Control Programme
(Japanese Encephalitis (JE), Acute Encephalitis Syndrome (AES)

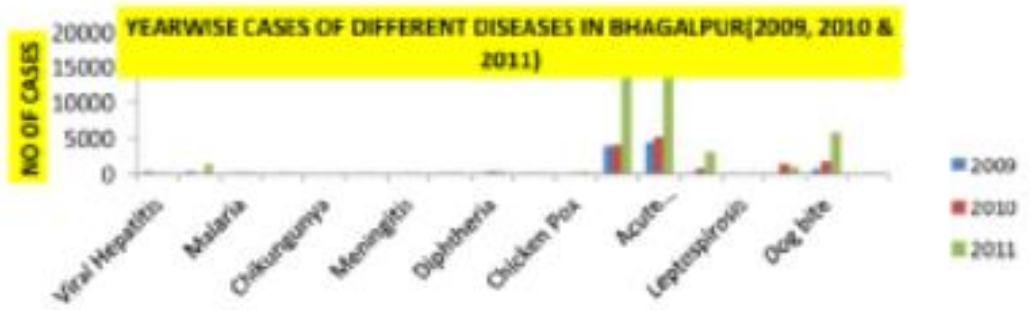


Figure 52 *– Infection cases and deaths scenario in Bihar with Bhagalpur highlighted from 2006 -2011 (Source – National Vector Borne Disease Control Programme)*

5.11 SITE ECOLOGY

The Ganga river basin is known for rich biodiversity, which sustains a diverse group of flora and fauna supporting abundant biological wealth (***Figure 53***). The Ganga ecosystem and its food-web must be viewed holistically with integrated and watershed perspectives. In fact there are species so unique to the Gangetic river system that they are found nowhere else in the world such as the Gangetic River dolphins. The faunal resources of the river Ganga can be categorized into three distinct zones of which the site falls under the middle Ganga region which also happens to be the most polluted due to anthropogenic actions.

Generic causes for declining ecology in the site region include:-

- Anthropogenic activities such as pollution
- High sensitivity to the quantitative and qualitative alteration of aquatic habits.
- Increasing population
- Change in water and land use patterns
- Irregular water flow from the reservoirs in the upper reaches.
- Irrigation canals and barrages on the Ganga decrease the water flow
- Shallow depth of the river.
- Over fishing and sand mining activities
- Habitat destruction and fragmentation
- Water abstraction for irrigation, industries and private use.
- Exotic species introduction,
- Cremation and agricultural activities etc.

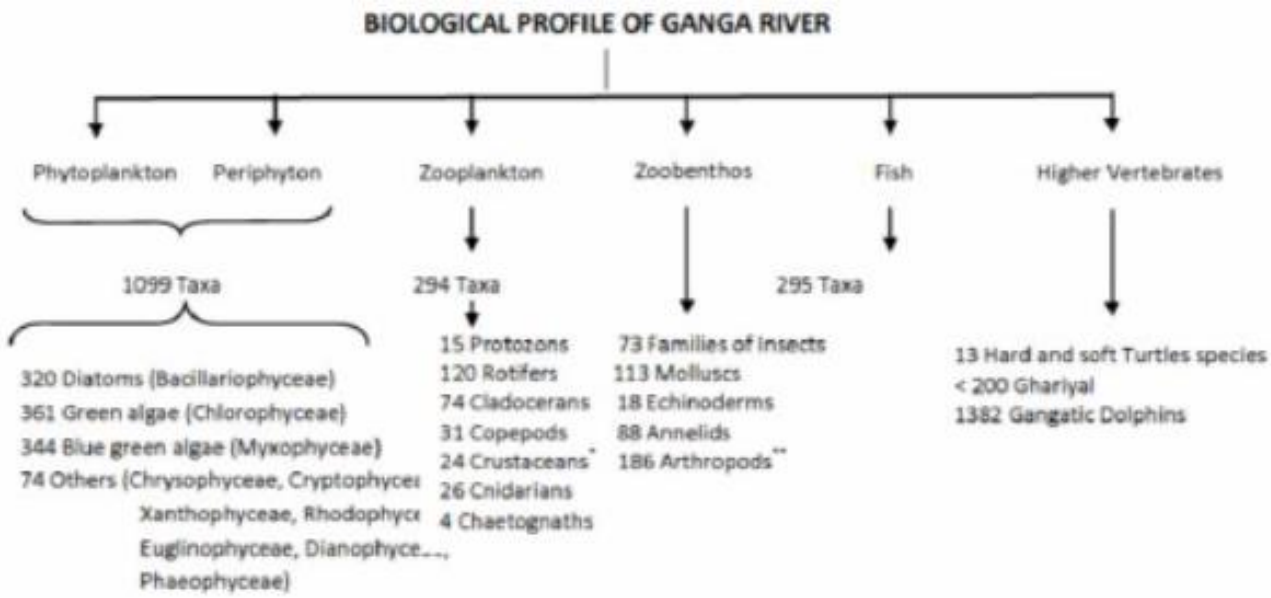


Figure 53 *– Biological profile of Ganga River (Source – Namami Gange Report on Measures for Ecological Revival of River Ganga)*

With respect to the proposed site extent, the area is renowned for a wide variety of floral species that serve different purposes in the grander ecological scheme. Some of the native species specially

the riparian variants are slowly vanishing in the region as they lose the fight to commercial agriculture crops and rapid urbanization. Some of the few notable species The Ganga river basin is known for rich biodiversity, which sustains a diverse group of flora and fauna supporting abundant biological wealth. Although an extensive list of the flora that prevails along the stretch of Ganga have been covered in the Namami Gange reports, some of the selected dominant flora that exist and used to exist within the sanctuary extent have been indicated here (***Figure 54***).

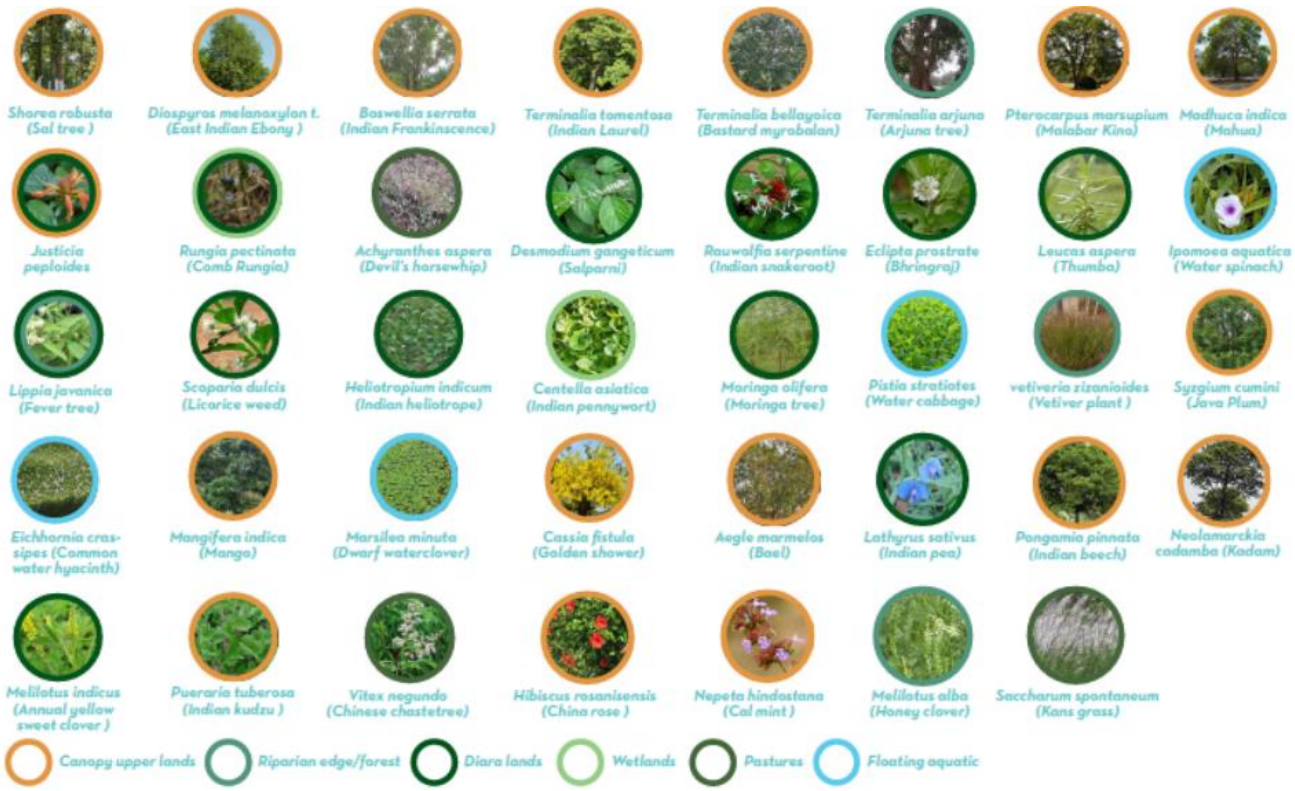


Figure 54 *– Selected onsite flora (Source - Adapted by author from Namami Gange)*

With equal fervor, the area is renowned for numerous ichthyofaunal species (***Figure 55***) for the proposed site extent is one of the major fishing areas in the region; supporting the national fisheries as well. Over the years there has been a measurable shift in the overall hydrology and river water quality as a result of which the fish catch has declined significantly while the species composition has inclined towards being more favorable for non-major carp and miscellaneous species. Introduction of exotic fishes in the name of commercial demand have led to species invasion which is why now the status of the ecology and fisheries are turning into a matter of serious concern. Decline in the overall fish count and therefore the fisheries can be amounted to a diversity of factors primarily anthropogenic in nature (***Figure 56***). Likewise climatic changes are also a matter of great concern as there are fishes heavily dependent on the seasonal changes of the river flow (***Figure 57***).

Family: subfamily[a]	Species[b]	Figure reference number[c]	Status in fisheries and reported % decline	Reported causes of decline (hypotheses)	Likelihood of hypotheses
Dasyatidae	*Pastinachus sephen* Forsskal 1775	–	R20–R45, –99	BD	High
Anguillidae	*Anguilla bengalensis* Gray 1831	–	R10–R45, –90	BD	High
Notopteridae	*Chitala chitala* Hamilton 1822	43	FY, –90	OF, DF	High
Notopteridae	*Notopterus notopterus* Pallas 1869	8	FY, –95	OF, DF	Low
Clupeidae	*Gudusia chapra* Hamilton 1822	7	FY, –75	OF, DF	High
Clupeidae	*Gonialosa manmina* Hamilton 1822	8	FY, –75	OF, DF	High
Clupeidae	*Corica soborna* Hamilton 1822	1	S, –65	DF	Moderate
Clupeidae	*Tenualosa ilisha* Hamilton 1822	33	R10–R30, –99	BD	High
Engraulidae	*Setipinna brevifilis* Valenciennes 1848	22	FY, NA	–	–
Cobitidae	*Botia dario* Hamilton 1822, *Botia lohachata* Chaudhuri 1912	–	S, –40	–	–
Nemacheilidae	*Lepidocephalichthys guntea* Hamilton 1822	–	S, –40	–	–
Danionidae: Chedrinae	*Salmostoma bacaila* Hamilton 1822, *Salmostoma phulo* Hamilton 1822	14	S, –90	OF	Moderate
Danionidae: Chedrinae	*Cabdio morar* Hamilton 1822	11	FY, –90	DF	Low
Danionidae: Chedrinae	*Securicula gora* Hamilton 1822	17	O, –99	DF	Moderate
Danionidae: Rasborinae	*Amblypharyngodon mola* Hamilton 1822	–	O, –99	–	–
Cyprinidae: Labeoninae	*Crossocheilus latius* (=*Tariqilabeo latius*) Hamilton 1822	13	S, –72.5	–	–
Cyprinidae: Labeoninae	*Labeo calbasu* Hamilton 1822	40	FY, –80	OF, DF, BD	Moderate
Cyprinidae: Labeoninae	*Gibelion catla* (=*Labeo catla*) Hamilton 1822	47	S, –75	DF, OF, BD	High
Cyprinidae: Labeoninae	*Labeo rohita* Hamilton 1822	46	S, –90	DF, OF, BD	High
Cyprinidae: Labeoninae	*Labeo gonius* Hamilton 1822	36	S, NA	–	–
Cyprinidae: Labeoninae	*Cirrhinus mrigala* Hamilton 1822	41	S, –75	DF, OF, BD	High
Cyprinidae: Labeoninae	*Bangana ariza* (=*Gymnostomus ariza*) Hamilton 1807	25	S, –50	–	–
Cyprinidae: Labeoninae	*Chagunius chagunio* Hamilton 1822	–	S, NA	–	–
Cyprinidae: Smiliogastrinae	*Systomus sarana* Hamilton 1822	26	S, NA	DF	Moderate
Cyprinidae: Smiliogastrinae	*Puntius sophore* Hamilton 1822	10	FY, –75	DF	Low
Cyprinidae: Smiliogastrinae	*Pethia conchonius* Hamilton 1822	9	FY, –75	DF	Low
Cyprinidae: Smiliogastrinae	*Osteobrama cotio* Hamilton 1822	12	S, NA	–	–
Bagridae	*Sperata aor* Hamilton 1822	39	FY, –85	OF	High
Bagridae	*Sperata seenghala* Sykes 1839	42	FY, –85	OF	Moderate
Bagridae	*Hemibagrus menoda* Hamilton 1822	35	S, –98	TH, OTH	Moderate
Bagridae	*Mystus cavasius* Hamilton 1822, *Mystus vittatus* Bloch 1794	16, 19	FY, –95	OF	Moderate
Bagridae	*Rita rita* Hamilton 1822	38	FY, –95	OF	High
Sisoridae	*Bagarius yarrelli* Sykes 1839	48	S, –70	OF	Low
Sisoridae	*Gogangra viridescens* Hamilton 1822	2	S, –75	–	–
Pangasiidae	*Pangasius pangasius* Hamilton 1822	49	R25, –95	BD	High
Siluridae	*Wallago attu* Bloch & Schneider 1801	45	FY, –50	–	–
Siluridae	*Ompok pabda* Hamilton 1822	24	S, –80	OF, DF	High
Heteropneustidae	*Heteropneustes fossilis* Bloch 1794	18	S, –99	WL	Moderate
Ailiidae	*Clupisoma garua* Hamilton 1822	15	FY, –75	–	–
Ailiidae	*Eutropiichthys vacha* Hamilton 1822, *E. murius* Hamilton 1822	21	FY, –75	–	–
Ailiidae	*Silonia silondia* Hamilton 1822	–	R10, –95	BD	Moderate
Ailiidae	*Ailia coila* Hamilton 1822	15	FY, –75	BD	Low
Horabagridae	*Pachypterus atherinoides* Bloch 1794	6	S, –70	DF, OF	High
Belonidae	*Xenentodon cancila* Hamilton 1822	20	FY, –90	BD	Moderate
Synbranchidae	*Monopterus cuchia* Hamilton 1822	–	S, NA	–	–
Mastacembelidae	*Mastacembelus armatus* Lacepede 1,800	34	S, –95	DP, OTH	Low
Mastacembelidae	*Macrognathus aral* Bloch & Schneider 1801, *M. pancalus* Hamilton 1822	30	S, –95	DP, OTH	Low
Mugilidae	*Rhinomugil corsula* Hamilton 1822	31	S, –95	DF, BD	Moderate
Mugilidae	*Sicamugil cascasia* (=*Minimugil cascasia*) Hamilton 1822	5	S, NA	DF, BD	Low
Ambassidae	*Chanda nama* Hamilton 1822, *Parambassis ranga* Hamilton 1822	3 4	FY, NA to –80	DF	Low
Sciaenidae	*Johnius coitor* Hamilton 1822, *J. gangeticus* Talwar 1991	29	S, –98	BD	Moderate
Nandidae	*Nandus nandus* Hamilton 1822	23	S, NA	–	–
Gobiidae	*Glossogobius giuris* Hamilton 1822	32	FY, –75	BD	Low
Osphronemidae	*Trichogaster fasciatus* Bloch & Schneider 1801	–	S, –75	WL	–
Channidae	*Channa marulius* Hamilton 1822	44	FY, –90	OF, DF	High
Channidae	*Channa striata* Bloch 1793	37	FY, –90	OF, DF	Low
Channidae	*Channa punctatus* Bloch 1793	–	FY, –90	OF, DF	Moderate
Tetraodontidae	*Leiodon cutcutia* Hamilton 1822	–	O, NA	–	–
Crustacea: Penaeidae	*Penaeus* spp. Fabricius 1798	–	FY, –90	DF, OF, BD	Moderate
Crustacea: Palaemonidae	*Macrobrachium* spp. Spence Bate 1868	50	R35, –99	BD	Moderate

Figure 55 *– A list of fish species in VGDS*

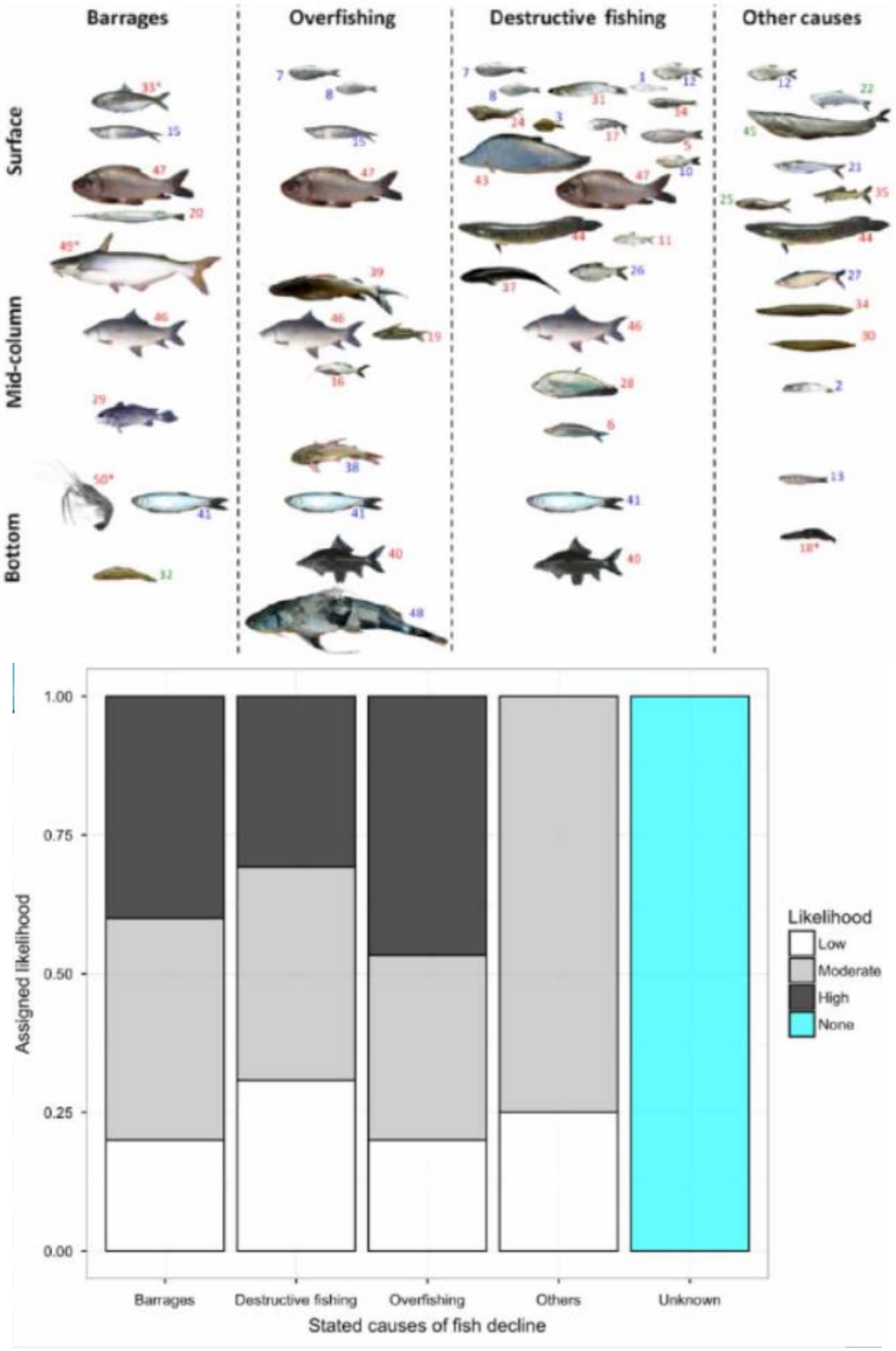


Figure 56 *– Factors responsible for fish decline (Source - - Identifying potential causes of fish declines through local ecological knowledge of fishers in the Ganga River, eastern Bihar, India)*

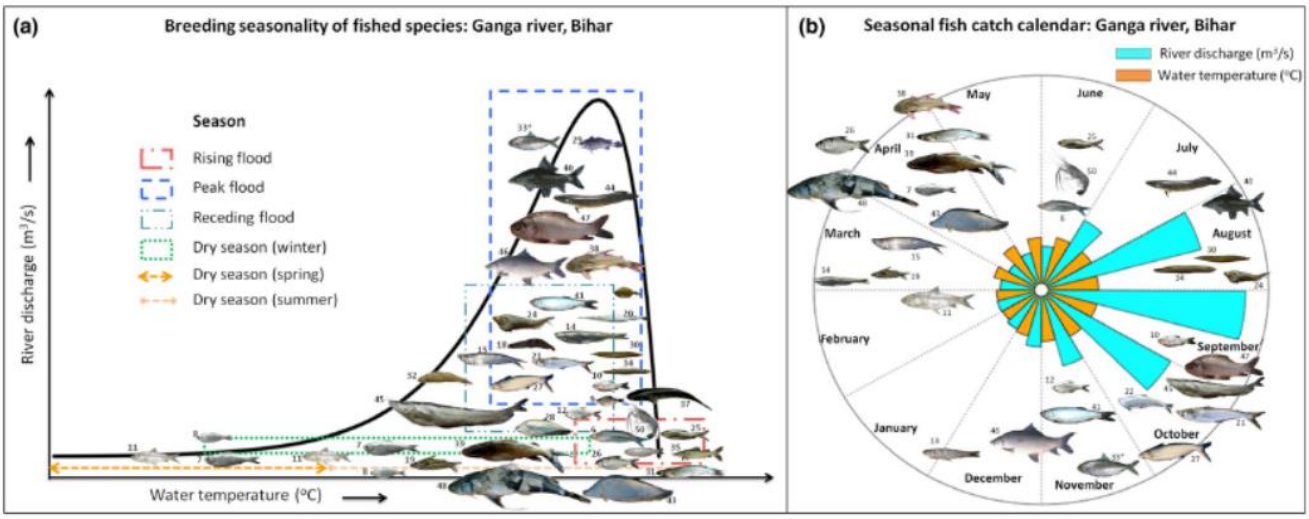


Figure 57 *– Climatic factors responsible for fish breeding (Source - - Identifying potential causes of fish declines through local ecological knowledge of fishers in the Ganga River, eastern Bihar, India)*

The site is also an IBA Category A1 - Globally threatened species. Criterion for the same is that the site is known or thought regularly to hold significant numbers of a globally threatened species. The site qualifies IBA criteria if it is known, estimated or thought to hold a population of a species categorized by the IUCN Red List as Critically Endangered, Endangered or Vulnerable.

VGDS has been selected as an IBA due to the presence of hundreds of Indian Skimmers *Rynchops albicollis*. Globally threatened species such as the Greater Adjutant *Leptoptilos dubius* and Lesser Adjutant *L. javanicus* are also present. VGDS is also rich in waders. Common Crane Grus grus, Eurasian Spoonbill *Platalea leucorodia* and various ducks are also seen here. The common dangers to the diverse avi-fauna **(*Figure 59*)** in the region can be seen in (***Figure 58***).

Threats	Description	Bird taxa affected	Locations and areas where found
Hunting and illegal killing (poaching)	Shooting of birds, poisoning, poaching, capture in large and small nets, trapping, pesticide use	Indiscriminate, but occasionally preference for waterfowl, egrets, cranes, waders, wagtails, pipits	Floodplain scrub, agricultural fallows on banks
Loss of nesting and breeding habitats	1. Erratic flow releases from upstream dams causing loss of floodplain habitat due to sudden submergence and/or erosion	Many wader species breeding on floodplain banks, such as Indian Skimmer, Little Pratincole, plovers, terns	Mid-channel alluvial deposits, islands, sand banks
	2. Encroachment of cucurbit cultivation on breeding habitats such as alluvial islands and open floodplain scrub		
	3. Loss of nesting or roosting trees due to construction of roads, highways, expansion of settlements	Adjutants and other storks	Diyara region (floodplain settlement areas), especially the north banks of Ganga and Kosi rivers
Loss of foraging habitats	Rapid encroachment and reclamation, burial of existing wetlands, channel-dredging of river silt beds	Diving ducks, some waders	Diyara region
Other factors	High levels of organic pollution, solid wastes and plastic garbage disposal, high boat traffic, cattle movement, human disturbance and transient settlements on banks	Indiscriminate effects	Widespread in the entire region

Figure 58 *– Threats to avi faunal species in the Vikramshila Gangetic Dolphin Sanctuary riverscape. (Source - An annotated bird checklist of the Vikramshila Gangetic Dolphin Sanctuary, Bhagalpur, Bihar, India, with an assessment of threats to bird conservation)*

Apart from these, key indicator species such as Gangetic river dolphins, Smooth coated otters, gharials and freshwater turtles are also known to reside in this sanctuary. This diversity in species exist due to the braided river processes that cause the natural landscape of the region to be in a state of flux which drives the habitat diversity therefore making it a paramount factor for the sustenance of numerous species that call this sanctuary their home.

Name	Habitat	Occ	Status	Trend	Notes
Fulvous Whistling-duck *Dendrocygna bicolor*	Ch, Wt	U	R, L	NA	
Lesser Whistling-duck *Dendrocygna javanica*	Ch, Wt	C	R, L	IC	2
Bar-headed Goose *Anser indicus*	Ch	U	W	DC	
Greylag Goose *Anser anser*	Ch	C	W	DC	
Common Shelduck *Tadorna tadorna*	Ch	U	W	DC	
Ruddy Shelduck *Tadorna ferruginea*	Ch, Wt	C	W	NC	1, 4
African Comb Duck *Sarkidiornis melanotos*	Ch, Wt	U	R, L	NA	2, 4
Cotton Pygmy-goose *Nettapus coromandelianus*	Wt	U	R	NC	2, 4
Marbled Teal *Marmaronetta angustirostris* (VU)	Ch	R	W	NA	
Red-crested Pochard *Netta rufina*	Ch	U	W	DC	1, 4
Common Pochard *Aythya ferina*	Ch	C	W	DC	
Ferruginous Duck *Aythya nyroca* (NT)	Ch	U	W	DC	1, 4
Tufted Duck *Aythya fuligula*	Ch	O	W	DC	1, 4
Garganey *Spatula querquedula*	Ch, Wt	C	W	DC	
Northern Shoveler *Spatula clypeata*	Ch	C	W	DC	1, 4
Falcated Duck *Mareca falcata* (NT)	Ch	R	W	NA	4
Gadwall *Mareca strepera*	Ch, Wt	O	W	DC	
Eurasian Wigeon *Mareca penelope*	Ch	O	W	DC	
Mallard *Anas platyrhynchos*	Ch	R	W	DC	1, 4
Northern Pintail *Anas acuta*	Ch	C	W	NC	1, 4
Common Teal *Anas crecca*	Ch	O	W	DC	1, 4
Little Grebe *Tachybaptus ruficollis*	Wt, Rd	C	R, L	DC	1, 2
Great Crested Grebe *Podiceps cristatus*	Ch	C	W	NC	1
Rock Dove *Columba livia*	Sc, Ag	C	R	IC	1, 2
Eurasian Collared Dove *Streptopelia decaocto*	Sc, Ag	U	R, L	NC	2
Western Spotted Dove *Spilopelia suratensis*	Sc, Ag	U	R,L	NC	1, 2
Yellow-footed Green Pigeon *Treron phoenicopterus*	Ag	R	R, M	NA	
Asian Palm Swift *Cypsiurus balasiensis*	Ag	O	R	NC	2
Little Swift *Apus affinis*	Ag	C	R, A	DC	2
Greater Coucal *Centropus sinensis*	Sc, Ag	C	R	NC	2
Western Koel *Eudynamys scolopaceus*	Sc, Aq	C	L	NC	2
Indian Cormorant *Phalacrocorax fuscicollis*	Ch, Wt	U	L, W	NA	1
Oriental Darter *Anhinga melanogaster* (NT)	Ch, Wt	O	R, L	DC	
Indian Thick-knee *Burhinus indicus*	Fl, Wt	O	R	NA	2
Pied Avocet *Recurvirostra avosetta*	Ch	U	W	DC	
Black-winged Stilt *Himantopus himantopus*	Fl, Wt	C	L,W	NC	1, 2, 5
Eurasian Golden Plover *Pluvialis apricaria*	Ch, Wt	R	W	DC	
Pacific Golden Plover *Pluvialis fulva*	Ch, Wt	O	W	DC	
Little Ringed Plover *Charadrius dubius*	Fl, Wt	C	R	NC	1, 2
Kentish Plover *Charadrius alexandrinus*	Fl, Wt	O	M	NC	3
Lesser Sandplover *Charadrius mongolus*	Fl	V	W	NA	
River Lapwing *Vanellus duvaucelii* (NT)	Ch	C	R	DC	1, 2
Red-wattled Lapwing *Vanellus indicus*	Ch, Wt	C	R	NC	1, 2, 3
Greater Painted-snipe *Rostratula benghalensis*	Wt, Rd, Ag, Sc	U	R, L	NA	2
Pheasant-tailed Jacana *Hydrophasianus chirurgus*	Wt, Rd, Ag	O	R, L	DC	2
Bronze-winged Jacana *Metopidius indicus*	Wt, Rd, Ag	O	R, L	DC	2
Whimbrel *Numenius phaeopus*	Ch	O	W	DC	
Eurasian Curlew *Numenius arquata* (NT)	Ch	C	W	NC	1
Bar-tailed Godwit *Limosa lapponica*	Ch, Wt	O	W	DC	
Black-tailed Godwit *Limosa limosa* (NT)	Ch, Wt	C	W	DC	1
Temminck's Stint *Calidris temminckii*	Fl, Wt	O	W	DC	
Dunlin *Calidris alpina*	Fl, Wt	V	W	DC	
Little Stint *Calidris minuta*	Fl, Wt	C	W	DC	1
Terek Sandpiper *Xeneus cinereus*	Wt, Fl, Sc, Ag	V	W	DC	
Common Sandpiper *Actitis hypoleucos*	Wt, Fl, Sc, Ag	C	R, L	NC	1, 2
Green Sandpiper *Tringa ochropus*	Wt, Ch	U	W	NC	2
Common Greenshank *Tringa nebularia*	Wt	C	W	NC	1
Common Redshank *Tringa totanus*	Ch, Wt	C	W	NC	
Wood Sandpiper *Tringa glareola*	Wt	O	W	DC	
Little Pratincole *Glareola lactea*	Fl, Wt	C	L, M	DC	1, 2
Indian Skimmer *Rynchops albicollis* (VU)	Ch, Fl	U	Bm, M	DC	2
Slender-billed Gull *Larus genei*	Ch	V	W	NA	
Brown-headed Gull *Larus brunnicephalus*	Ch	C	W	NC	
Black-headed Gull *Larus ridibundus*	Ch	C	W	NC	
Pallas's Gull *Larus ichthyaetus*	Ch	C	W	DC	
Sooty Tern *Onychoprion fuscatus*	Ch	V	W	NA	
Little Tern *Sternula albifrons*	Ch	C	L, M	NC	1, 2, 5
Common Gull-billed Tern *Gelochelidon nilotica*	Ch	U	L, M	NA	
Caspian Tern *Hydroprogne caspia*	Ch	C	W	NC	
Whiskered Tern *Chlidonias hybrida*	Ch, Wt	O	L, M	NC	1
River Tern *Sterna aurantia* (NT)	Ch	C	R	DC	1, 2
Common Tern *Sterna hirundo*	Ch	V	M	NA	
Black-bellied Tern *Sterna acuticauda* (EN)	Ch, Fl	C	R, M	NC	3
Spotted Owlet *Athene brama*	Ag	C	R	NC	2
Short-eared Owl *Asio flammeus*	Sc	U	R	NA	
Brown Fish Owl *Ketupa zeylonensis*	Fl, Wt, Sc	U	R	NA	
Osprey *Pandion haliaetus*	Ch, Wt	C	RL	NC	1
Black-winged Kite *Elanus caeruleus*	Ag, Sc	C	RL	NC	1, 2
Oriental Honey Buzzard *Pernis ptilorhynchus*	Fl, Sc, Ag	C	R	NC	2
Crested Serpent Eagle *Spilornis cheela*	Fl, Sc, Ag	O	R	NA	
White-rumped Vulture *Gyps bengalensis* (CR)	Fl	U	R	DC	1
Indian Spotted Eagle *Clanga hastata* (VU)	Fl	U	R, L	NA	1
Greater Spotted Eagle *Clanga clanga* (VU)	Fl	U	R, L	NA	
Tawny Eagle *Aquila rapax*	Fl, Sc	C	L, M, W	NC	
Steppe Eagle *Aquila nipalensis*	Fl, Sc	U	W	NA	
Eastern Imperial Eagle *Aquila heliaca* (VU)	Fl, Sc	V	W	NA	
Western Marsh Harrier *Circus aeruginosus*	Ch, Wt, Fl, Sc, Ag	C	W	DC	1
Hen Harrier *Circus cyaneus*	Fl, Sc, Ag	R	W	DC	
Pied Harrier *Circus melanoleucos*	Fl, Sc	U	W	DC	
Montagu's Harrier *Circus pygargus*	Fl, Sc	R	W	DC	
Shikra *Accipiter badius*	Sc, Ag	C	R	NC	1, 2
Eurasian Sparrowhawk *Accipiter nisus*	Fl, Sc, Ag	U	W	DC	
Northern Goshawk *Accipiter gentilis*	Fl, Sc	V	W	DC	
Pallas's Fish Eagle *Haliaeetus leucoryphus* (VU)	Ch	R	R, L	DC	
Brahminy Kite *Haliastur indus*	Ch, Wt	U	R, L	DC	1, 2
Black Kite *Milvus migrans*	Fl, Sc, Ag, Ch, Wt	C	R, W	IC	1, 2
White-eyed Buzzard *Butastur teesa*	Fl, Sc, Ag	C	R, L	DC	
Long-legged Buzzard *Buteo rufinus*	Fl	V	W	DC	
Upland Buzzard *Buteo hemilasius*	Fl, Sc	O	W	NC	

Name	Habitat	Occ	Status	Trend	Notes
Eastern Water Rail *Rallus indicus*	Rd, Wt	O	W	NA	
White-breasted Waterhen *Amaurornis phoenicurus*	Wt, Rd	C	R, L	NC	2
Watercock *Gallicrex cinerea*	Rd, Wt	O	R, L	NA	1, 2
Common Coot *Fulica atra*	Wt, Ch	O	M	NC	1, 2
Common Crane *Grus grus*	Fl, Wt	C	W	DC	1
Greater Adjutant *Leptoptilos dubius* (EN)	Ch, Wt, Fl, Sc	U	R	NC	1, 2
Lesser Adjutant *Leptoptilos javanicus* (VU)	Wt, CH, Fl, Sc	C	R	NC	1, 2
Painted Stork *Mycteria leucocephala* (NT)	Ch	U	L, M	NC	1
Asian Openbill *Anastomus oscitans*	Ch, Wt	C	R, L	IC	1, 2
Black Stork *Ciconia nigra*	Ch	O	W	NC	1
Asian Woollyneck *Ciconia episcopus* (VU)	Ch, Wt	C	R, L	NC	1, 2
White Stork *Ciconia ciconia*	Ch	R	W	NA	
Eurasian Spoonbill *Platalea leucorodia*	Ch	O	L, W	DC	1
Black-necked Stork *Ephippiorhynchus asiaticus* (NT)	Ch	C	R	NC	2
Black-headed Ibis *Threskiornis melanocephalus* (NT)	Wt, Fl, Sc, Ag	U	R, L	DC	1
Red-naped Ibis *Pseudibis papillosa*	Wt, Ch, Fl, Sc	C	R, L	NC	1, 2
Black Bittern *Ixobrychus flavicollis*	Wt	U	W	NC	
Black-crowned Night Heron *Nycticorax nycticorax*	Ch, Wt	C	R, L	NC	1, 2
Green-backed Heron *Butorides striata*	Ch, Wt, Rd	O	R	NC	2
Indian Pond Heron *Ardeola grayii*	Wt, Rd, Fl	C	R	IC	1, 2
Cattle Egret *Bubulcus ibis*	Wt, Rd, Fl, Sc, Ag	C	R	IC	1, 2
Grey Heron *Ardea cinerea*	Ch	C	R, L	NC	1, 2
Purple Heron *Ardea purpurea*	Wt, Rd	O	R	NA	2
Great Egret *Ardea alba*	Ch, Wt	C	R, L	NC	1, 2
Intermediate Egret *Ardea intermedia*	Ch, Wt	C	R	NC	1, 2
Little Egret *Egretta garzetta*	Ch, Wt	C	R	NC	1, 2
Dalmatian Pelican *Pelecanus crispus* (VU)	Ch	R	W	DC	
Spot-billed Pelican *Pelecanus philippensis* (NT)	Ch	V	L, M	NA	
Great White Pelican *Pelecanus onocrotalus*	Ch	U	W	DC	
Little Cormorant *Microcarbo niger*	Ch, Wt	C	R, L	IC	1, 2
Great Cormorant *Phalacrocorax carbo*	Ch	C	W	IC	1, 2
Hoopoe *Upupa epops*	Sc, Ag	C	R,L	NC	2
Asian Green Bee-eater *Merops orientalis*	Sc, Ag	C	R, L	NC	2
Chestnut-headed Bee-eater *Merops leschenaulti*	Sc, Ag	U	M	NC	3
Blue-tailed Bee-eater *Merops philippinus*	Fl, Sc, Ag	O	Bm,L	DC	2
Indian Roller *Coracias benghalensis*	Sc, Ag	C	RL	NC	1, 2
Common Kingfisher *Alcedo atthis*	Ch, Wt	C	R	DC	1, 2
Pied Kingfisher *Ceryle rudis*	Ch	C	R	NC	1, 2
White-breasted Kingfisher *Halcyon smyrnensis*	Wt, Ch, Sc, Ag	C	R	NC	1, 2
Lesser Kestrel *Falco naumanni*	Sc, Ag	O	W	DC	1
Common Kestrel *Falco tinnunculus*	Sc, Ag	C	L, W	NC	1
Red-headed Falcon *Falco chicquera* (NT)	Ag, Sc, Fl	C	R	NC	2
Peregrine Falcon *Falco peregrinus*	Fl, Sc	O	L, W	NC	1
Rose-ringed Parakeet *Psittacula krameri*	Sc, Ag	C	R	DC	2
Brown Shrike *Lanius cristatus*	Sc, Ag	O	W	DC	
Bay-backed Shrike *Lanius vittatus*	Sc, Ag	C	R, L	NC	2
Eurasian Golden Oriole *Oriolus oriolus*	Sc	O	R	NC	2
Black-hooded Oriole *Oriolus xanthornus*	Sc	O	R	NC	2
Black Drongo *Dicrurus macrocercus*	Sc, Ag	C	R	NC	1, 2
Rufous Treepie *Dendrocitta vagabunda*	Sc, Ag	C	R	NC	2
House Crow *Corvus splendens*	Sc, Fl, Wt, Ag	C	R	NC	1, 2
Large-billed Crow *Corvus macrorhynchos*	Sc, Fl, Wt, Ag	C	R	NC	1, 2
Sand Martin *Riparia riparia*	Fl, Ch	C	R, W	NC	2
Plain Martin *Riparia paludicola*	Fl, Ch	O	W	DC	2
Dusky Crag Martin *Hirundo concolor*	Fl	C	R, W	DC	
Barn Swallow *Hirundo rustica*	Fl, Ch, Ag, Sc	C	W	DC	1
Wire-tailed Swallow *Hirundo smithii*	Fl, Ch	O	R, L	DC	2
Red-rumped Swallow *Hirundo daurica*	Fl, Ch, Sc	O	R, W	DC	2
Streak-throated Swallow *Hirundo fluvicola*	Fl, Ch	O	R, L	DC	2
Singing Bushlark *Mirafra cantillans*	Sc, Ag	C	R, L	DC	2
Rufous-tailed Lark *Ammomanes phoenicura*	Sc, Ag	C	R	NC	2
Greater Short-toed Lark *Calandrella brachydactyla*	Sc, Ag	C	R, W	DC	3
Indian Short-toed Lark *Calandrella raytal*	Fl, Sc	O	R, W	DC	1, 3
Tawny Lark *Galerida deva*	Sc, Ag	O	R, L	NC	2
Oriental Skylark *Alauda gulgula*	Sc, Ag	O	W	NC	1, 2
Ashy-crowned Sparrow Lark *Eremopterix griseus*	Sc, Ag	C	R	NC	2
Zitting Cisticola *Cisticola juncidis*	Sc, Ag, Rd	U	R, L	NA	2
Plain Prinia *Prinia inornata*	Sc, Ag, Rd	U	R	NC	2
Red-vented Bulbul *Pycnonotus cafer*	Sc, Ag	C	R	IC	2
Blyth's Reed Warbler *Acrocephalus dumetorum*	Sc, Ag, Rd	O	W	NA	2
Greenish Warbler *Phylloscopus trochiloides*	Sc, Ag	O	W	NC	
Common Babbler *Turdoides caudata*	Sc, Ag, Rd	O	R, L	DC	2
Jungle Babbler *Turdoides striata*	Sc, Ag, Rd	C	R	IC	2
Common Myna *Acridotheres tristis*	Ag Wt, Sc, Fl	C	R	IC	1, 2
Bank Myna *Acridotheres ginginanus*	Ag, Wt, Ch, Sc	C	R	IC	1, 2
Chestnut-tailed Starling *Sturnus malabaricus*	Ag	U	M	NC	2
Brahminy Starling *Sturnus pagodarum*	Sc, Ag	C	R, L	IC	2
Rosy Starling *Sturnus roseus*	Ag	C	M	DC	
Asian Pied Starling *Sturnus contra*	Ag, Fl, Sc	C	R	IC	1, 2
Bluethroat *Luscinia svecica*	Fl, Sc, Rd, Ag	O	W	NA	
Oriental Magpie Robin *Copsychus saularis*	Ag, Sc	C	R	NC	2
Black Redstart *Phoenicurus ochruros*	Sc, Ag	C	W	NC	
Common Stonechat *Saxicola torquatus*	Sc, Ag	O	W	NA	
Pied Bushchat *Saxicola caprata*	Sc, Ag	C	R	NC	2
Indian Chat *Cercomela fusca*	Sc, Ag	C	R	IC	2
House Sparrow *Passer domesticus*	Sc, Ag	C	R	DC	2
Black-breasted Weaver *Ploceus benghalensis*	Sc, Ag	U	R	NA	2
Baya Weaver *Ploceus philippinus*	Sc, Ag	C	R	DC	2
Red Avadavat *Amandava amandava*	Sc, Ag, Rd	C	R	NA	2
Chestnut Munia *Lonchura atricapilla*	Sc, Ag, Rd	C	R	NA	2
White Wagtail *Motacilla alba*	Fl, Ag, Sc	C	W	NC	1
White-browed Wagtail *Motacilla maderaspatensis*	Fl, Ag, Sc	C	R	NC	1, 2
Citrine Wagtail *Motacilla citreola*	Fl, Ag, Sc	O	W	DC	1
Yellow Wagtail *Motacilla flava*	Fl, Ag, Sc	C	W	NC	
Grey Wagtail *Motacilla cinerea*	Fl, Ag, Sc	C	W	NC	
Paddyfield Pipit *Anthus rufulus*	Fl, Ag, Sc	C	R	NC	2
Long-billed Pipit *Anthus similis*	Fl, Ag, Sc	U	W	DC	
Tree Pipit *Anthus trivialis*	Fl, Ag, Sc	U	W	NC	
Olive-backed Pipit *Anthus hodgsoni*	Fl, Ag, Sc	U	W	DC	

Figure 59 *– A list of avian fauna found at Vikramshila Gangetic Dolphin Sanctuary riverscape. (Source - An annotated bird checklist of the Vikramshila Gangetic Dolphin Sanctuary, Bhagalpur, Bihar, India, with an assessment of threats to bird conservation)*

5.11.1 ECOLOGICAL HABITAT DIVERSITY

VGDS is an amalgamation of a diverse variety of habitats; each home to different kinds of species. The most dominant and recognized of these habitats along with the factors responsible for their gradual degradation have been cited in (***Table 2***):-

Table 2 – List of natural landscape habitats in VGDS (Source – Author)

S.No	Name of landscape habitat	Commonly found faunal species	Causes of extinction / degradation
1	Mid channel islands / diaras	Smooth coated otters, Greater adjundant, etc.	Practice of cucurbit cultivation,
2	Sand bars and Sand spits	Waders, Gharials,etc.	Erratic flow releases from upstream dams
3	Alluvial scrubs	Herons, egrets, cattle, dogs, etc.	Practice of cucurbit cultivation, minimal vegetation
4	Floodplain wetlands	Snails, crustaceans, molluscs, Various birds and fish species	Rapid encroachment and reclamation, high levels of organic pollution, solid wastes and plastic garbage disposal,
5	Main river channel	Gangetic dolphins, freshwater turtles, crustaceans, various fish species like Wallago Attu, Catla etc.	Rapid encroachment and reclamation of river, channel-dredging of river silt beds, high levels of organic pollution, solid wastes and plastic garbage disposal, high boat traffic, natural change in river channel course, change in river e - flow due to upstream dams and barrages erratic release.
6	Agrarian lands	Cattle, Cattle egrets, sparrows etc.	High levels of organic pollution, natural change in river channel course, change in river e - flow due to upstream dams and barrages erratic release, use of fertilizers and pesticides, selective species cropping.

5.12 ANTHROPOGENIC LAYERS OF STUDY

In addition to the ecological sensitivities, there further exists an extra layer of anthropogenic impacts that need to be considered for they too bring with it a series of problems that either impact the natural processes by impeding or aggravating them. To start with – the cultural influence of the three towns of Bhagalpur, Sultanganj and Kahalgaon that is equally superimposed on the fame associated with the sanctuary and dolphin presence in the region. The southern bank where the towns lie is accessible from various points however Vikramshila Setu Bridge is the main connectivity from the southern bank to the northern bank. Ferry is used to traverse to - fro by the locals.

River Ganga is known for its physical and spiritual sustenance with powers of healing and re-generation. It holds an immense sacred position in the Hindu religion and finds its mention in many ancient texts. Her entire course is a pilgrimage route for the millions of Hindu devotees who visit the preeminent therthas that mark her path. Apart from regular religious activities that take place along the river stretch, there are specific festivities wherein the influx of people towards the

river stretch is extremely high which when coupled with unecological practices create havoc in the ecological balance of the river and its ecosystem.

Tourism is a neglected sector in the site extent region despite the presence of several sites that attract visitors annually. Bhagalpur is not part of the tourist circuit of Bihar however it has been proposed as part of Bihar Tourism initiatives **(*Figure 60*)**.The potential has not been fully exploited and tourist infrastructure is limited. As an IBA area, VGDS region has a vast potential to promote bird tourism as it is a mosaic of ideal habitats for several migratory birds due to water-bodies, green vegetation and clean and untapped environments of Gangetic diara areas. Also from October to March, when river tourism is at the peak, big steamers carrying tourists, mostly foreigners from Calcutta visit Bhagalpur through the proposed NW-1.By improving the holistic tourism infrastructure, along with information, branding and a safe environment for tourists will help provide impetus to tourism.

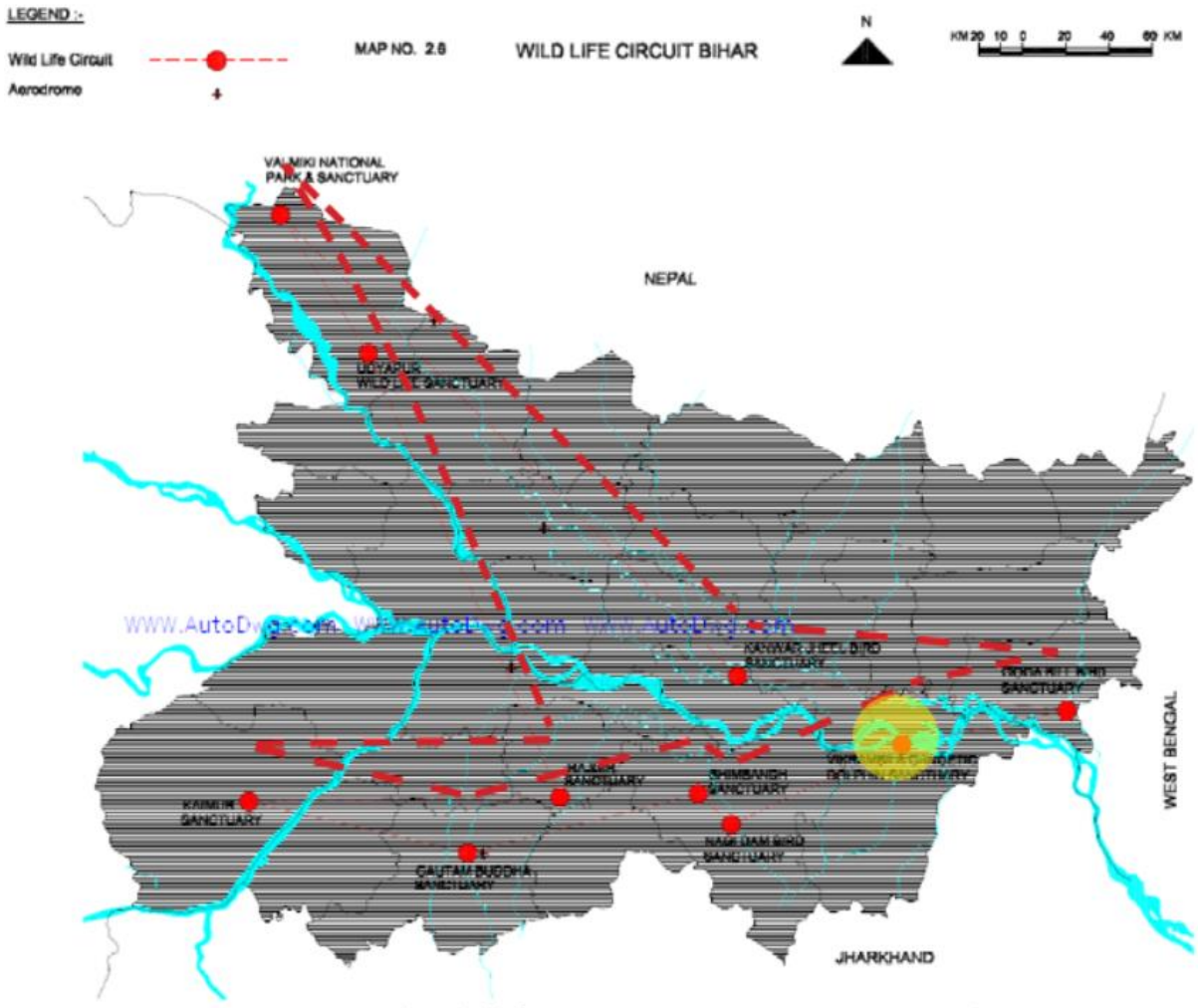


Figure 60 *– Proposed wildlife tourist circuit for Bihar (Source - Bihar Tourism Report 2003)*

5.12.1 KEY HUMAN INTERVENTIONS – REASON FOR TROUBLE IN PARADISE

Although a variety of anthropogenic factors are to be held responsible for a multitude of issues prevalent in the VGDS extent; a few of them are to be referred to in particular for they are more of structural interventions than unecological/unethical activities. Interventions of these kind in future need to proposed if and only if it is of absolute need and there is no other alternative sustainable solution These interventions include:-

VIKRAMSHILA SETU BRIDGE

The Vikramshila Setu (Bhagalpur, Bihar) is 4367 m long and is located 135 km downstream of Mokameh Bridge and 190 km downstream of Gandhi Setu Bridge, Patna. The Vikramshila Setu (***Figure 61***) is the link between national highway 80 at right bank and national highway 31 at left bank. However at the point around 3.5 km downstream of Vikramshila Setu 1100 m erosion in past 8 years (2003-2011) with respect to 720 m. Erosion in previous 18 years(1988-2006). Rate of erosion was determined more than twice. Further the excessive dredging during the construction of the bridge is also a detrimental consequence of this bridge construction.

Figure 61 *– The Vikramshila Setu, Bhagalpur, Bihar (Source – Google Maps Images)*

NTPC KAHALGAON POWER STATION

Situated around 10 km from the Kahalgaon river edge, the NTPC plant is known to discharge its effluent into the river which became a major source of concern for the fishers of Kagzi Tola in Kahalgaon (one of the largest and most active fishing centers in Bhagalpur district) through poor river water quality and therefore reduced fish count due to the same. (***Figure 62***)

Figure 62 *– The Vikramshila Setu, Bhagalpur, Bihar (Source – Google Maps Images)*

PROPOSED NATIONAL WATERWAY – 1

The stretch of main river channel of Ganga that flows within the Vikramshila Gangetic Dolphin Sanctuary extent is a part of the proposed NW-1 route in India. However when implemented it is bound to have drastic implications on a large extent of the Gangetic dolphin habitats in India including VGDS (***Figure 63***) for the biggest factor that is unknown to many – Gangetic dolphins are blind and rely on echolocation for their sustenance. NW route shall imply a safe passage for ship vessels that use SONAR as part of navigation. This can tamper with the echolocation signals emitted by these dolphins, thereby resulting in their collision with these ships and therefore deaths.

Figure 63 *– Map showing some of the prominent wildlife sanctuaries that shall be impacted as a result of NW- 1. VGDS is also one of them. (Source – The Third Pole)*

FARAKKA BARRAGE

Around 20-25 years ago, the Gangetic river basin was full with water through the year and even in mid-summer-days, the river used to maintain water level of not less than 33m. But post - 1970s (when the Farakka barrage (***Figure 64***)was built around 112km east of Bhagalpur), the river gradually changed its ecology and due to deposit of silt on its bed, the river not only changed its course but also lost its depth. Due to the Farakka barrage, the very productive fisheries of VGDS and its vicinity nearly collapsed, as the count of Hilsa and major carps declined substantially. For a structure constructed 112km away from the sanctuary, the impact cause is quite substantial which is why it is imperative to be critical of any similar interventions when it comes to ecological projects such as these.

Figure 64 *– The Farakka Barrage in Farakka, West Bengal. (Source – www.scroll.in)*

Apart from these major interventions, illegal construction and encroachments of the poor into the diara lands (both on the mainland and the mid channel islands) and near the riparian edge are also some notable factors that contribute to a degrading environment in the region.

5.13 SOCIO – ECONOMIC CONTEXT AND DEMOGRAPHICS

VGDS falls within the domain of the towns of Sultanganj, Bhagalpur and Kahalgaon which are considered recordically as 'bank districts' and the population density trend is generally recorded higher here (***Figure 65***). A probable cause for the same may be the attraction that these districts hold in terms of livelihood.

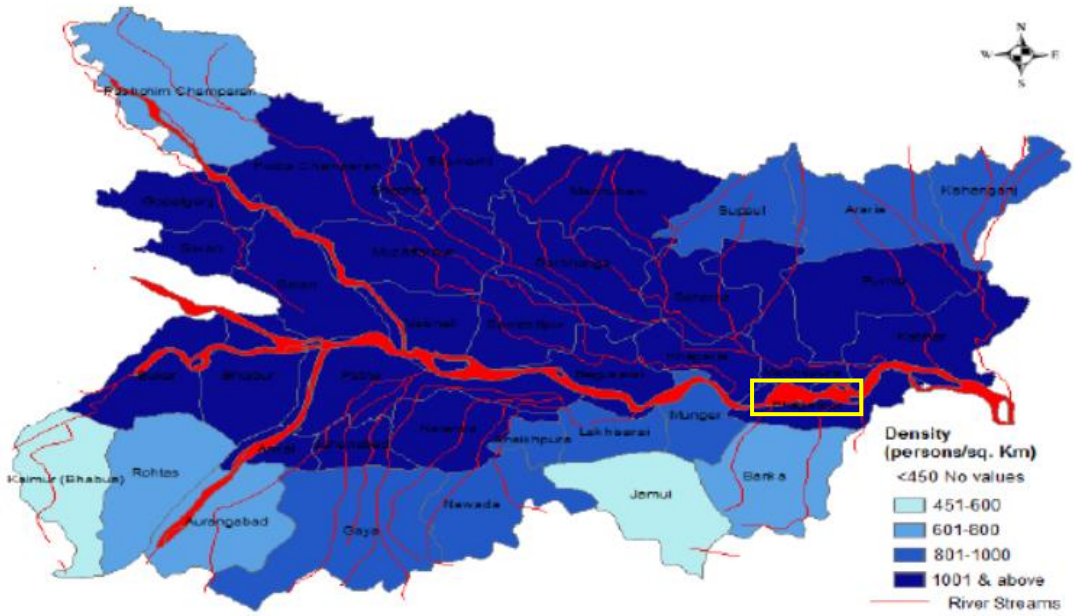


Figure 65 *– Population Density (Persons/sq. km.) across Districts of Bihar, 2011 with VGDS extent highlighted. (Source – NMCG Report on Demographic and Socio-Economic Analysis in Lower Ganga Basin)*

Statistics further show a comparatively lower sex ratio in these regions. Further it is also noted that the population with the site extent comprises more of higher caste people as lower castes prefer to stay in non-bank districts.

The overall impact of the demographic situation along with the partition of the state area into Bihar and Jharkhand caused the mineral rich portion to be transferred to the Jharkhand state, leaving behind the arable lands in the Bihar portion. Agriculture is not only the source of livelihood in the region but also it generates raw material for the agro based industries which has immense potential in the state. Next to agriculture, fishing occupies the next spot.

5.13.1 AGRICULTURE

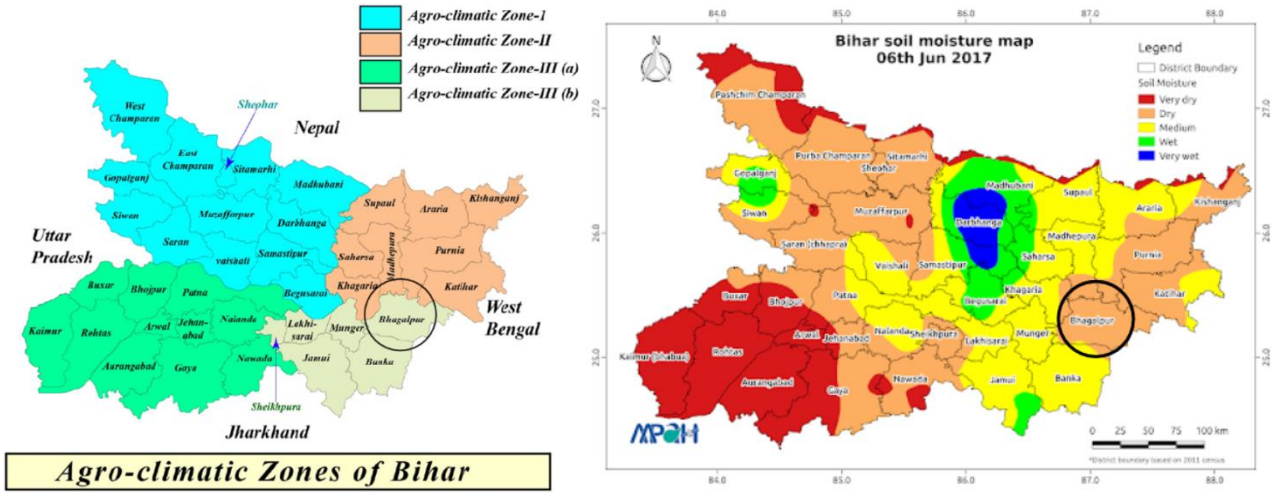


Figure 66 *– Agro climatic zone and soil moisture map of Bihar with VGDS extent (Source – https://geography4u.com/agriculture-of-bihar-bpsc/ and http://www.aapahinnovations.com/soil-moisture-map-state-bihar-2/)*

VGDS falls under Agro climatic zone – III (b) that implies a region of hot and humid nature with alluvial soil that is dry with respect to soil moisture (***Figure 66***). There are two main cropping seasons in the eastern part of India viz. kharif (June-July to September-October) and Rabi (October November to March April). Often the crops planted during June are lost due to heavy floods and farmers may be able to harvest only those crops that are planted during October-November.

Despite the immense potential the site holds for agriculture, the preference towards agriculture as a livelihood may be considered secondary to fishing which could be related to a constant lack of investment and the prevalence of old agrarian practices. Some other equally contributing factors include:-

- The nature of the land forms (***Figure 67 and 68***).
- Erratic monsoon schedules make it difficult to sow crops at appropriate time resulting in yield
- loss and reduced quality of the produce.
- Water logging and flooding due to continuous overflow of Ganga and famines
- Pest infections due to floods.

- Difficult to grow Kharif crops (July - September) as most land stays submerged. (Successful cultivation of Rabi season crop is based on residual moisture left after drainage and land freed from submergence.)
- Lack of any irrigation facilities, technologies and innovative knowledge.
- River siltation resulting in clogging of existing ways or (locally called as plan) and collapse of drainage systems.
- Choking of the natural drains (or nailas) due to inadequate capacity or non-existence of culverts below roads. Most of the existing sluice gates are nonfunctional/broken/do not exist.
- Grazing of crop by cattle without any control.
- Low infiltration and hydraulic conductivity, and occurrence of hardpan in the subsurface layer.

CLASSIFICATION OF CHAURS		
Duration of water stagnation.		
Permanent chars In existence for more than ten years.	**Semi-permanent chars** In existence for less than ten years but more than five years.	**Temporary chars** In existence for less than five years.
Inundation period.		
Chronically flooded Inundation throughout the monsoon season.	**Occasionally flood affected** Inundation for a short period due to flash flood.	**Almost flood free** Temporary inundation during high floods only.

Figure 67 *– Classification of chaurs (Source – author)*

Primarily a feature of central Bihar; VGDS stretch does have a certain percentage of tal area along the river edge on the southern bank where the towns of Sultanganj, Bhagalpur and Kahalgaon lie. It also acts as a delta to several rivers that flow into it. Tall area is best suit for monoculture which is only taken during rabi season as a result of which purpose pulses such as gram, lentil, lathyrus and pea are most common grown as rabi crops ; linseed, rai and toria are grown as mixed crop with pulse crop. In upland tall area, wheat is also grown as mixed crop with gram now-a-days while in areas with irrigation facility through tube wells, onion and another vegetable crop (ladyfinger, spongegourd etc.) However tall area suffers continuous water stagnation problem during monsoon period and improper/ lack of drainage facility delay the drainage of excess water. This tend to complicate cultivation in the winter season while cultivation of kharif season crop is not possible because during monsoon period most of the area under this region remains submerged under 4 to 6 meter deep water - the soil as such becomes unfit for cultivation owing to which the crop sowing time is delayed which further results in low productivity despite high soil fertility status. Most of the times, whole crop gets washed away from the fields ; specially in case of un unpredicted monsoon outbreak so the practice of using short duration summer crop variants was abandoned.

Diara lands despite being a highly flood risk/ prone area - these lands are utilized for agriculture. After the monsoon season, the water from the riverbeds retreats back to its channel, leaving large areas dry. Usually diara lands are available only for a short period, and landless, small and marginal farmers cultivate on these lands the seasonal vegetables and fruits. Diara farmers often resort to mixed cropping as an insurance against crop failure due to flood waters.

In the Bhagalpur district diara farmers grow/sown maize in two season first in rabi maize (October-November) and second garma maize (March-April) depends upon rains and In Rabi season also grown wheat, maize generally grown in irrigated area where as pulses like gram, pea, mustard, lentil, kalai etc. are taken in non-irrigated areas. These areas of land are generally left unused due to the austerity in management, conflicts of land ownership, difficult access and lack of overall motivation to cultivate marginal land. Such areas if managed properly can greatly contribute to the economics of the people living in and around them, as well as of the country.

CLASSIFICATION OF DIARA LANDS BASED ON

Distance from main stream		
Lower diara lands Located in the main river beds with fine sand to courses and deposits on the surface.Available for cultivation of different crops and vegetables during non-monsoon seasons (Nov/ Dec to May/June).	**Middle diara lands** Located on the river banks.The width of such lands varies considerably due to frequent inundation during rainy seasons by swelling flood waters. The depth of flooding varies considerably at different locations.	**Upper diara lands** Those lands which during the course of continuous depositions get elevated and tend to get less frequently flooded in comparison to the middle diara lands.
Precise location from main stream		
Main riverbed (Lowland diara) The actual riverbeds, which have fine sand to coarse deposits on surface, become available during December or January to June until early rains set in.	**Main Land (Medium land) Diara** Same as middle diara lands from the previous categorisation.	**Upland diaras** Same as upper diara lands from previous categorisation. For all practical purposes, these areas are not very different from the normal (non-diara) lands.

Other classifications

Riverbed diara: The lands available for cultivation on both sides of the flowing portion of the riverbed during non-monsoon season.

Riverbank diara: Strips of land available for cultivation in between riverbeds and natural levees or existing embankments.

Flood affected diara: The lands available for cultivation adjacent to unprotected reaches.

Flood prone diara: The area on both sides beyond the levees or embankments of the river.

Figure 68 *– Classification of diara lands (Source – author)*

5.13.2 FISHING

Fishery conflicts in the Ganga River in Bhagalpur district of Bihar have had a long history of over 200 years. These two centuries have witnessed three broad phases:

- Systemic oppression of local traditional fishing communities at the hands of private feudal landlords (zamindars) who also claimed private rights over the Ganga River fisheries (1790s to 1990-91)
- Ecological degradation after the construction of the Farakka barrage and the National Thermal Power Corporation Plant in Kahalgaon (1975 to 1990), and
- Criminal (mafia) control of the fisheries after 1991, following a social movement by fishers to overthrow the previous private regime.

The stretch of river from Sultanganj to Pirpainti (80 km) was privately owned by two families in Bhagalpur, who claimed that these rights were granted to them since the Mughal period. The principle of 'riparian rights' (as in English laws) was applied to the Ganga River and the banks and they came to be owned free-hold by the zamindars (known as Jalkar Zamindars or Panidars).

The Panidari system in this part of Bihar was thus the riverine counterpart of Zamindari; fortified by land tenancy acts of the British colonial administration in the 18th and 19th centuries. The Panidari control continued to increase in its brutality and coercion over the years. Fishers had to pay at least 50% of their catch to the Panidar's 'men' or often face harassment, physical assault, and threat.

Zamindari was abolished in independent India (in 1952), but the Panidari continued in the Bhagalpur district of Bihar till 1991 (Kelkar & Krishnaswamy 2014). By the mid- to late 1980s, the riverine condition had also declined substantially, following the commissioning of the Farakka Barrage in 1975 and the NTPC plant in Kahalgaon in 1992. Declines in fisheries productivity continued after the construction of the Kanpur Barrage and the Tehri dam upstream on the Ganga (by 1999). This ecological degradation, compounded with extreme oppression at the hands of the Panidars forced fishers of Kagzi Tola to lead to the Ganga Mukti Andolan, a social movement led primarily by fishers, and which succeeded in convincing the Bihar state government to end the private fisheries regime in 1991, making the fishing 'free-for-all' (essentially open-access). While this victory had symbolic importance, its actual social and ecological impact was short-lived (Kelkar 2014a). Very soon, criminals and fishing mafia came to dominate the open-access fishery, in the absence of any form of institutional control by fishing communities.

The Mallah and Nishad castes claim to be 'traditional fishing communities' (***Figure 69***) and possess traditional knowledge and continue some traditional practices in fishing.

Name of Settlement	Sub-caste	Range of Influence	Grouping patterns	Fishing effort & practices	Propensity to exit from fishery	Role in resistance	Tolerance for other fishers
KagziTola (Kahalgaon)	Banpar	Ganga River and some tributaries in Bihar, Bengal and eastern UP	Mixed groups, corporate groups, bands	Main river, localized around Kahalgaon but widespread fishing across the region	Low, shift to labour and exit known only during extreme years	Led	Low
Makkhatakiya (Naugachhia)	Nishad	Kosi, Ganga rivers	Bands	Inlets and side-channels with vegetation, ponds and floodplain wetlands	Moderate to High, shift to pond fisheries and wage labour	Supported	Usually, they are the 'other' fishers, High
Barari (Bhagalpur)	Gorhi (Mahaldar)	Barari area	Family groups	Main river, highly localized	High, many have shifted to local alternative occupations	Passive	High

Figure 69 *– A comparison of the characteristics of three Mallah fishing settlements in the Bhagalpur district indicates a gradient of differences in fishing practices and preferences (Source – Tempered Down – An article by Nachiket Kelkar and Subhasis Dey)*

The issues that the fishing community face in general include:-

- Continued decline in fisheries productivity due to ecological degradation and anthropogenic interferences.
- Internal feuds between local fishing communities resulting in lack of institutional control and focus towards the core vision of protecting the river.
- Criminals and fishing mafia dominating the open-access fishery. The mafia started operating highly destructive fishing gears such as mosquito nets (Kapda Jaal or Musahri Jaal) and river-seines (Kachaal Jal) with mesh sizes from 1 to 4 mm, which would lead to mass mortality of fish eggs, spawn, and recruits – and caused heavy destruction of fish stocks till date. The fisheries department and the forest department charged with curbing these illegal and destructive gears, have done nothing to stop this problem (for reasons related to corruption, nexuses with the mafia, and exploitation of poor fishers).
- Designation of VGDS as part of the new open-access regime which the fishers thought of as a government ploy to exert control and ban fishing from the sanctuary. Although never banned inside the sanctuary, fishing rights were never settled, and forest department staff used the opportunity to extract bribes from fishers.
- Lack of state cooperatives to manage riverine fisheries, because it had to remain 'open access' which allowed criminals to now dominate the fishers in worse ways than the Panidars had ever done.

Identifying and settling rights of these communities can help to create sustained and secure river fishing livelihoods, along with initiatives for improving their current economic & socially marginalized condition. Further this will also help ensure a healthy river ecosystem as they too can contribute in the preservation and awareness aspects of the same.

CHAPTER 6 : ACQUAINTING WITH LEGALITES

CHAPTER 6: ACQUAINTING WITH LEGALITIES

6.1 INTRODUCTION

Before proceeding forward with design and guidelines, it is imperative to take a look at the norms that are already existing or proposed with respect to the context of study at a global and local level so that the loopholes may be rectified in the newly proposed policies and guidelines.

6.2 IUCN GUIDELINES

To start with and as mentioned earlier, VGDS falls under Category IV of IUCN classification. Category IV provides a management approach used in areas that have already undergone substantial modification, necessitating protection of remaining fragments, with or without intervention. They frequently play a role in "plugging the gaps" in conservation strategies by protecting key species or habitats in ecosystems.

They could, for instance, be used to:

- Protect critically endangered populations of species that need particular management interventions to ensure their continued survival.
- Protect rare or threatened habitats including fragments of habitats and secure stepping-stones (places for migratory species to feed and rest) or breeding sites;
- Provide flexible management strategies and options in buffer zones around, or connectivity conservation corridors between, more strictly protected areas that are more acceptable to local communities and other stakeholders
- Maintain species that have become dependent on cultural landscapes where their original habitats have disappeared or been altered.

<u>Issues for consideration</u>

Many category IV protected areas exist in crowded landscapes and seascapes, where human pressure is comparatively greater, both in terms of potential illegal use and visitor pressure. These areas that rely on regular management intervention need appropriate resources from the management authority and can be relatively expensive to maintain unless management is undertaken voluntarily by local communities or other actors. Because they usually protect part of an ecosystem, successful long-term management necessitates careful monitoring and an even greater than usual emphasis on overall ecosystem approaches and compatible management in other parts of the landscape or seascape.

The project falls under inland water category and is subjected to the following complexities on grounds of protection:-

- Landscape relationship and role.
- Hydrological processes.
- Lateral connectivity.

- Groundwater-surface water interactions.
- Exogenous threats.
- Exclusion from inland water resources.
- Multiple management authorities.

Management of terrestrial protected areas could better address inland waters, for example by:

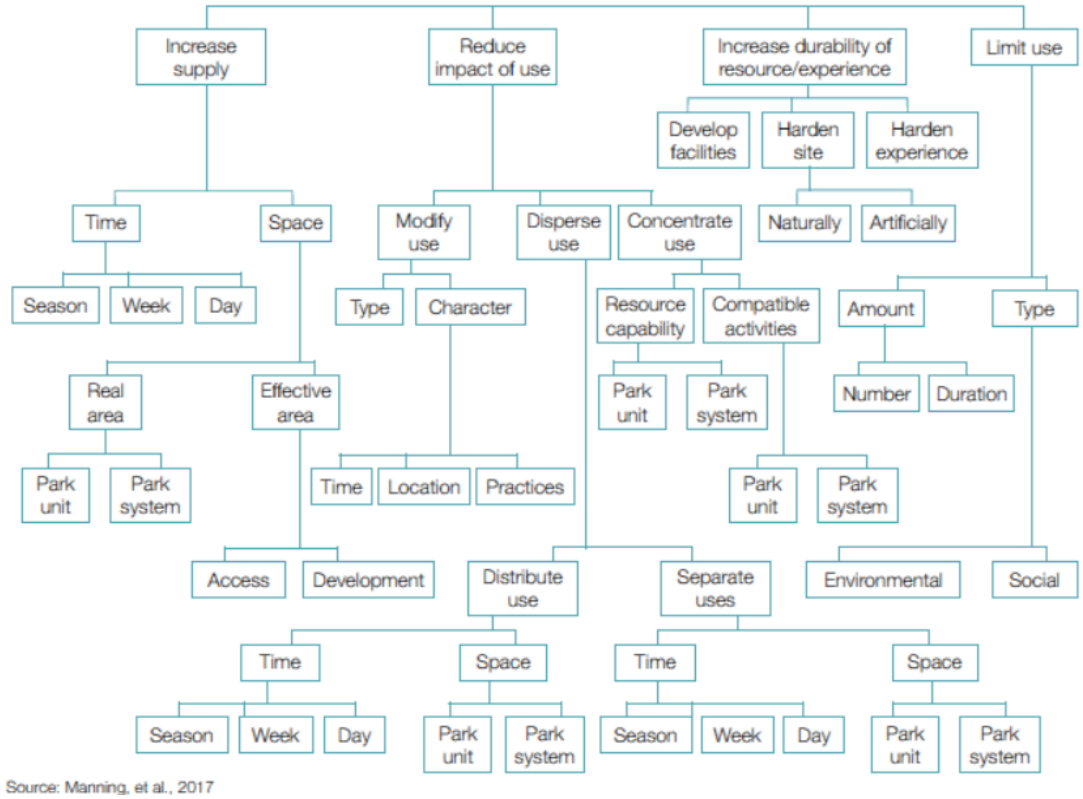
- Protecting or restoring longitudinal and lateral connectivity of stream corridors (e.g., removing barriers, reconnecting rivers with floodplains, ensuring that roads and associated infrastructure within protected areas are not fragmenting stream systems);
- Protecting native fauna (e.g., prohibiting exotic fish stocking or overfishing);
- Protecting native flora – particularly in riparian zones which may be neglected in the broader protected area;
- Managing aquatic recreational activities (e.g., restricting motorized watercraft and discharge from boats);
- Aggressively protecting water quality (e.g., careful management of point-source discharges from recreational facilities);
- Protecting headwater flows so that downstream users can enjoy the benefits of ecosystem services;
- Protecting or restoring riparian buffers both within a park and along a park's border if a river demarcates the border (and extending PA boundaries where possible using appropriate inland wetland ecosystem criteria – e.g., using catchment boundaries, not river channels, to demarcate areas);
- Special protection for sacred springs or pools that have cultural significance.

Likewise when it comes to tourism management in protected areas as VGDS, IUCN cites the following type of intervention measures (***Figure 70***) in addition to a general framework of strategies for managing tourism and visitor use in protected areas as well (***Figure 71***).

Type	Examples
Direct (Emphasis on regulation of behaviour; individual choice restricted; high degree of control)	• Increase area surveillance • Zone incompatible uses spatially or temporally (e.g. biker-only zones, hiker-only days, prohibit motor use) • Limit stays in some campsites to one night • Rotate use (e.g. open or close roads, access points, trails, campsites) • Require reservations • Assign campsites and/or travel routes to each camper group in remote areas • Limit usage via access point • Limit size of groups (e.g. number of horses, vehicles) • Limit camping to designated campsites only • Limit length of stay in area (i.e. maximum/minimum) • Restrict building campfires • Restrict fishing or hunting • Require or encourage visitors to hire guides • Impose fines
Indirect (Emphasis on influencing or modifying behaviour; individual retains freedom to choose; control less complete, more variation in use possible)	• Improve (or not) access roads, trails • Improve (or not) campsites and other concentrated-use areas • Advertise and encourage conservation of specific attributes of the area • Identify the range of recreation opportunities in surrounding area • Educate visitors about ecology and outdoor ethics • Advertise underused areas and general patterns of use • Charge entrance fee • Charge differential fees (e.g. by trail, zone, season) • Require proof of ecological knowledge and recreational activity skills

Sources: CBD, 2004; Manning, et al. 2017

Figure 70 *– Measure for tourism management in protected areas (Source – IUCN)*



Source: Manning, et al., 2017

Figure 71 *– Strategies for managing tourism and visitor use in protected areas (Source – IUCN)*

6.3 GANGA RIVER MANAGEMENT STRATEGIES

NMCG has recognized five major factors as the culprits of Ganga river degradation (***Figure 72***) on the basis of which the main objectives of Ganga river management have been identified as the following:

- Environmental flows shall be maintained in all rivers & tributaries of Ganga river system to fulfil their geological, ecological, socio-economic and cultural functions.
- Water quality in all rivers and tributaries of Ganga river system shall be consistent with their governing geological, ecological, socio-economic and cultural functions.
- Water and other aquatic resources of the Ganga river system shall be used judiciously to enable sustainable development in the entire basin.
- All existing, ongoing and planned anthropogenic activities in the basin shall be reviewed or scrutinized in a transparent, inclusive manner (with consensus of all affected people and stakeholders) for the overall health of the basin.

Figure 72 *- Causes of Ganga river degradation (Source - Vision Ganga December 2017)*

Each state has a specific strategy framework proposed on the basis of the above issues in addition to state specific issues identified. The key measures for Bihar wherein VGDS falls has been shown here (***Figure 73***).

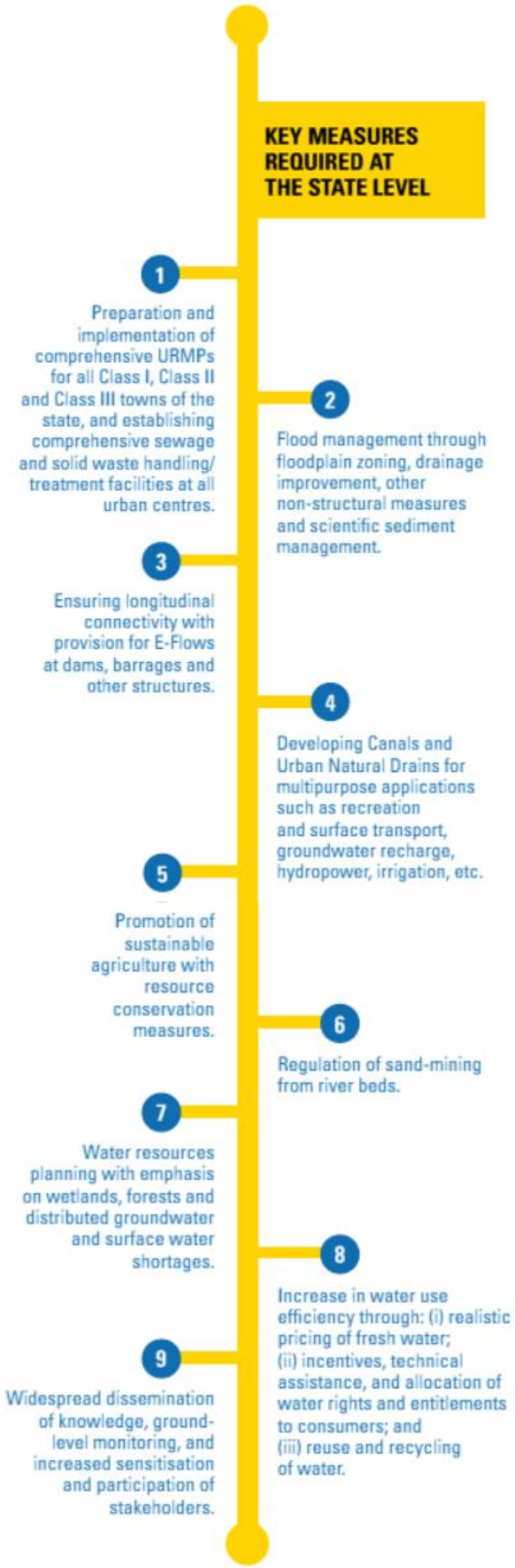


Figure 73 *– Key state level measures required for Bihar (Source - Vision Ganga December 2017)*

NMCG has also addressed the restoration aspect of various waterbodies associated with Ganga through a phase wise management strategy derived from CPCB guidelines (***Figure 74***).

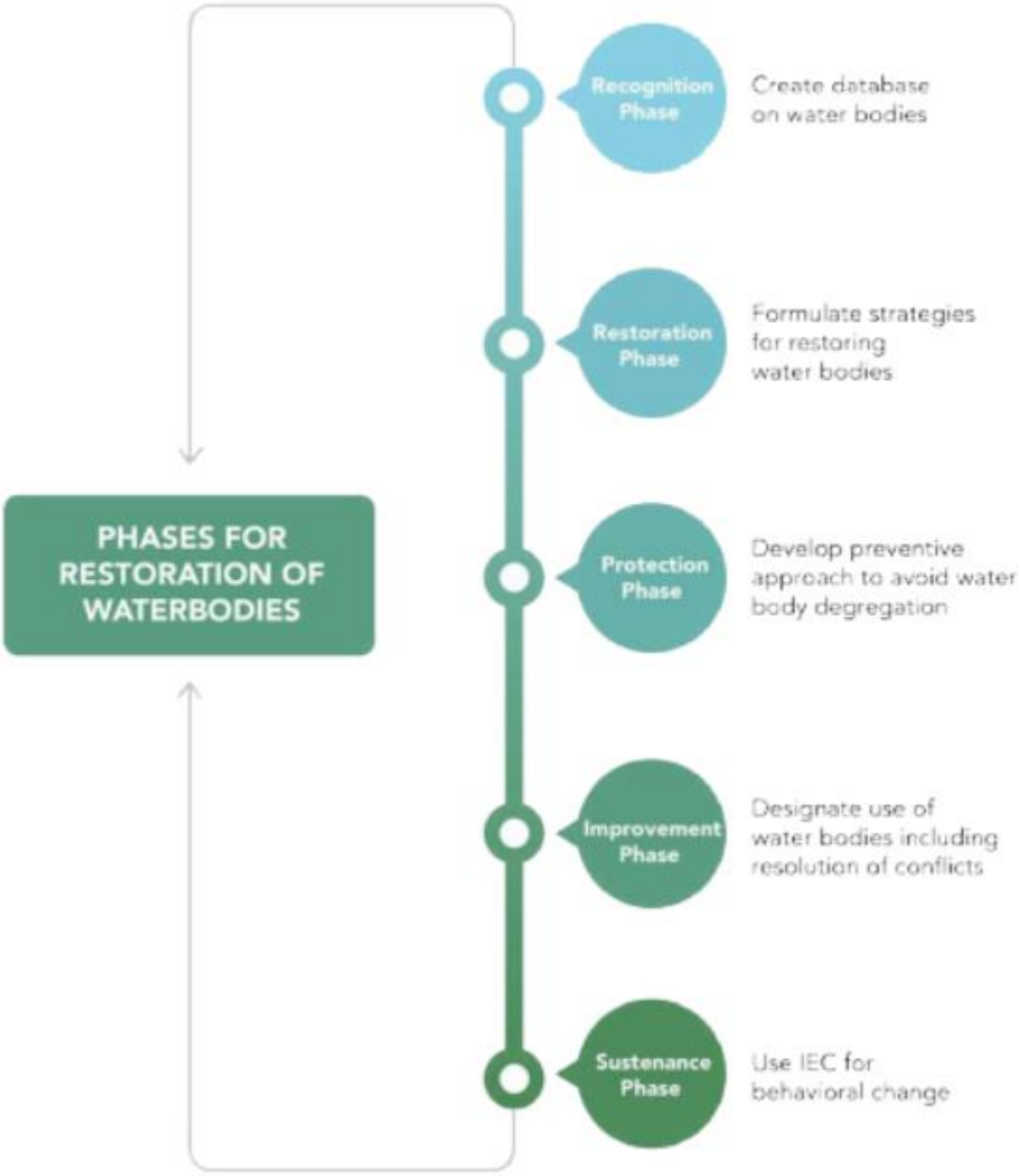


Figure 74 – Waterbodies restoration phases by CPCB (Source – NIUA – NMCG Urban River Management Framework)

Further how the goals of restoration are envisioned along with a 4 step process of ensuring restoration and treatment of waterbodies have also been discussed as well. (***Figure 75***).

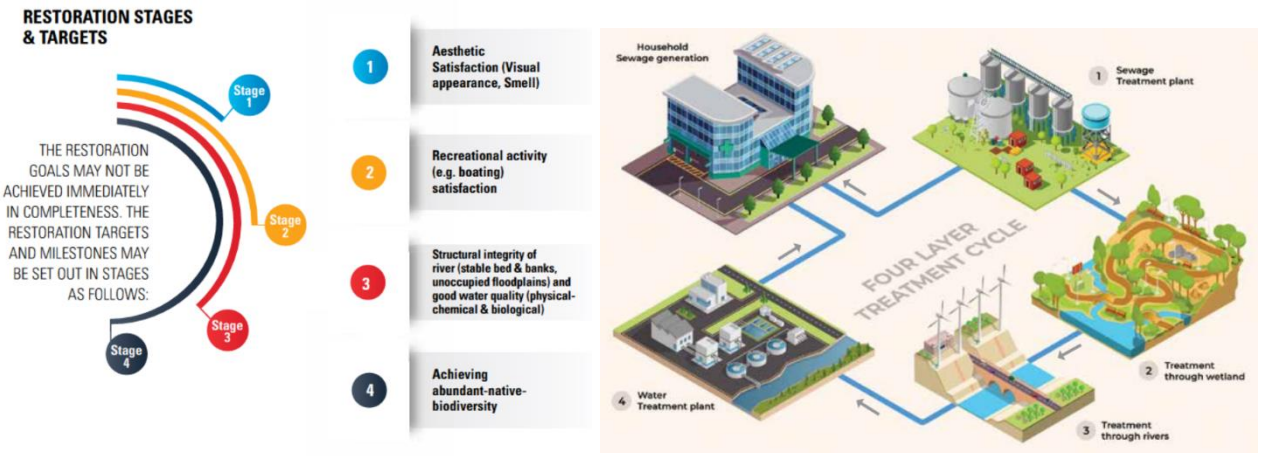


Figure 75 – Restoration and treatment perspectives (Source – River restoration and conservation December 2019)

11 parameters have been adapted from global case studies for the purpose of urban river management (***Figure 76***).

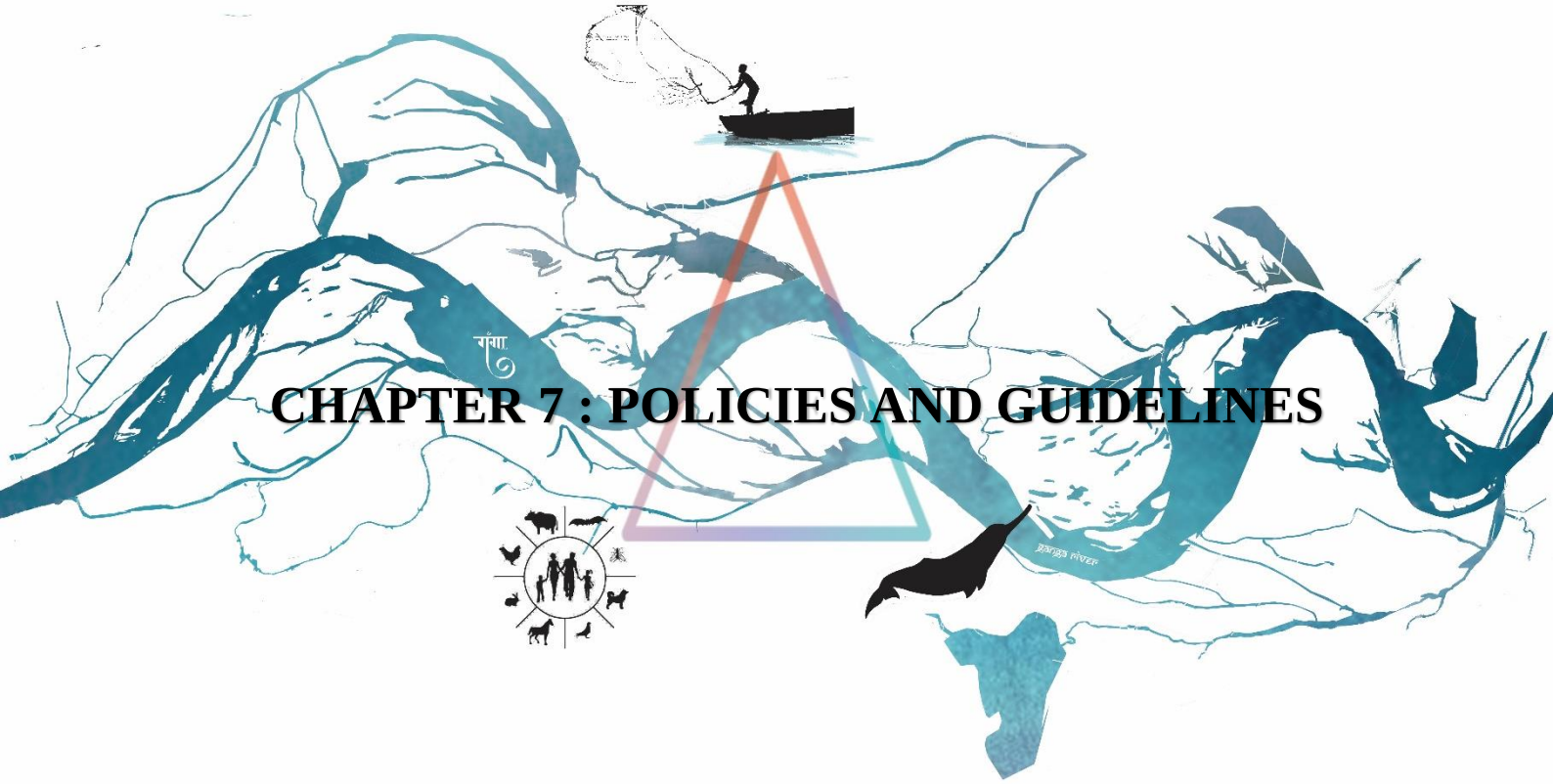
Figure 76 – Wheel of parameter for urban river management (Source – NIUA – NMCG Draft Strategic Guidelines MAINSTREAMING Urban River Management into Master Plans)

6.4 WAY FORWARD

The predicaments and issues that the proposed site extent faces can only be solved by a combination of policies and guidelines at both micro and macro level as a large number of causal factors do not even fall within the site region. There are certain issues that need to be addressed at a larger context within the overall Gangetic river basin as such if the proposed site is to thrive at its best potential. Unless the larger picture is addressed, no manner of intervention on site will solve the problems on site. Owing to academic time constraints and keeping in mind the larger picture, a few of the critical pointers are listed here below:-

- Active floodplains need to be retained devoid of any manner of construction so that the river has room to move in accordance with nature. Proper demarcation of the floodplain needs to be made and construction that caters to the sustenance & preservation of the riverine ecology may be made permissible. However they may accommodate activities that fall within the riparian rights of each individual but under strict control and ensuring that the river health is not compromised.
- Dams and barrages need to be avoided as much as possible within the larger river basin; specifically along the main river channel of Ganga. In the event of it not being possible, relocation of the dams/barrages need to be looked into as well. Alternate engineering solutions to replace or modify dams and barrages need to be researched upon.
- As long as dams and barrages are in place, the water flow needs to be regulated to meet the stipulated demands for aquatic species survival and maintenance; specifically during the dry season.
- Farakka barrage is one of the prominent factors for reducing fish species and increasing floods in this region. Alternative location of the same / measures to control the flow, modification in the engineering to permit the passage of fishes etc. need to be studied and established in immediate effect.
- Measures to regulate the intensity of pollution influx into the river channels need to be put into place such as sewage treatment plants, proper waste disposal practices etc.
- Natural flow of sediments and water from the origin of Ganga till the Bay of Bengal need to be permitted without any sort of blockage or anthropogenic interferences.
- Excessive sedimentation and siltation of the river bed need to be controlled through measures such as bank erosion control, careful grading of the river bed etc.
- The river depth needs to be maintained at a minimum of 3m all across the river. In case of practices undertaken to ensure this such as dredging etc., careful and methodological approaches need to be undertaken to ensure that the bottom feeders habitat is not destroyed or tampered.
- Effective outways to maintain the riparian rights of the locals that use the river for their daily activities should be established to avoid pollution from their usage of the river. Simultaneously measures to allow religious practices to occur in such a manner that the health of the river and its occupants is not affected.
- Over abstraction of ground water and channelization of the main river for irrigation canals need to be controlled to the best possible means. Alternate measures to save water such as rainwater harvesting and water sensitive design approaches need to be undertaken in the overall planning of the river based cities and towns.

- A predefined planting palette inclusive of hydrophilic plants to use for agriculture needs to be established so as to maximize revenue during monsoons as well.
- Construction on the mid channel islands need to be prohibited for the safety and welfare of the humans in addition to preserving the wildlife habitats.
- Commercial agriculture on the mid channel islands / diaras should be avoided or discouraged. Agriculture that supports the avi-fauna may be permitted under periodic supervision.



CHAPTER 7 : POLICIES AND GUIDELINES

CHAPTER 7: POLICIES AND GUIDELINES

7.1 INTRODUCTION

The following proposed policies and guidelines are set on the basis of two scales – one at macro – micro level while others on the basis of if its short term vs long term goals. (***Table 3***) has been structured by citing the existing policies and guidelines for a particular parameter and then retrofitting the needful policies and guidelines where not sufficient or in case a loophole may be deciphered in the existing norms. It is also to be noted that the existing policies and guidelines shall not be scraped off the list. Rather they too shall be implemented along with the new perspectives in policies and guidelines.

The following pages cover a tabulation of the proposed policies and guidelines.

Legend

- Macro level
- Micro level
- Short term goals
- Long term goals

Table 3 – Policies and guidelines to be practiced and implemented within VGDS extent (Source – Author)

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Riverine health	All class I towns, must compulsorily prepare an 'Urban River Management Plan (URMP) which addresses the following issues. • Removal of encroachments and land acquisition for riverbank beautification and related development works. • Restriction/banning of certain activities on the riverbank or in the river, viz., open defecation, disposal of solid waste, washing of clothes, wallowing of cattle, throwing of floral offerings, disposal of corpses, routine bathing (as opposed to ritual bathing), etc. • Development/restoration of the riverbank area, i.e., construction / restoration of ghats, provision of public baths and toilets, construction of walkways, parks, other public spaces, access roads, commercial establishments, etc. • Prevention of the discharge of treated and untreated sewage into the river through construction of sewers and 'nala' diversion works.	**River planform** The river stretch within the VGDS is a part of the larger river Ganga which is a braided river which is why measures to ensure that the natural river planform is maintained need to be undertaken. As 'braided rivers' are natural landscapes with hydraulical connection to the river, they should be recognised in toto, as 'braidplain'. The dynamic nature of braided rivers is to change, primarily laterally over time, a defining feature being high cumec 'freshes' fill the width of the braidplain, and active channels migrate across the braidplain (often following such events). Thus, the entire braidplain should be regarded as 'riverbed'. Tier A: Active river channels and gravels (which may or may not be weedy) Tier B: Ephemeral channels (historically active, which may be composed of ephemeral wetlands, turf lands, drylands, and weeds, and possibly built and developed structures) that are, by definition, likely to once again become active river channels following a flood and/or as excess gravels building up in the currently active channels, leading to a re-directed flow. • The expansion and contraction of the river (sedimentation, deposition, siltation and erosion processes) must follow a natural pace. • Efforts to ensure that the active floodplains are capable of performing their natural eco - hydrological processes need to be ensured. • Hydrological connections to the sanctuary river should not be blocked. • Agriculture and its associated practices should be sensitive to the natural habitats of the region and should include primarily cover crops and plants that are resilient to flooding and waterlogging	1. Land use along the river edge need to be such that it does not hinder the behaviour of the natural active flood plain. The future activities proposed should primarily be only those that are essential for the sanctuary sustenance with the exception of those already existing. 2. Varied riparian edge reinforcement targetting river bank erosion arsenic and fluoride poisoning can be developed. 3. Remediation softscape edges at the entry points of the minor channels meeting the main river such as the mixing point of Jamunia with Ganga may be provided. 4. Ample open space with no permanent structures should be provided for the river course to adapt - widen and contract naturally. 5. A series of catchment ponds,sediment basins,swales etc could be developed on the floodplains.

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Riverine health	All class I towns, must compulsorily prepare an 'Urban River Management Plan (URMP) which addresses the following issues. • Pumping and other infrastructure for conveyance of collected / diverted sewage to sewage treatment plants and construction / renovation of sewage treatment plants capable of treating the sewage to tertiary levels. • Reuse of tertiary treated sewage within the town or elsewhere for industrial, irrigation, horticultural, non potable domestic and commercial uses, groundwater recharge, etc. • Disposal of sludge generated due to sewage treatment in an acceptable manner and reuse of sludge and sludge derived products, i.e., manure, compost, etc. within the town and/or elsewhere.	**River planform** • The expansion and contraction of the river (sedimentation, deposition, siltation and erosion processes) must follow a natural pace. • Efforts to ensure that the active floodplains are capable of performing their natural eco - hydrological processes need to be ensured. • Hydrological connections to the sanctuary river should not be blocked. • Agriculture and its associated practices should be sensitive to the natural habitats of the region and should include primarily cover crops and plants that are resilient to flooding and waterlogging • Hydrological connections to the sanctuary river should not be blocked.	1. Proper segration of solid wastes and wet wastes need to be done through installation of bins etc. 2. Wastes generated from agro - aquaculture may be put to use in a cyclic sustainable manner. 3. Agriculture and its associated practices should be sensitive to the natural habitats of the region and should include primarily cover crops and plants that are resilient to flooding and waterlogging. 4. A circular model of waste generation - segregation may be adopted within the sanctuary. 5. Proper outways for depositing religious wastes should be installed. 6. No sort of farming should be carried out in the diaras as river beds should not be farmed at all, as they are, by definition 'river beds'. However farming for species sustenace may be carried out.
Gangetic river dolphins	Objective 1: Scientific Research and Monitoring Description: The whole state of Bihar lies in the Ganga basin comprising a very complex network of rivers and rivulets, with the occurrence of dolphins to be heterogenic in nature. Action Points 1. Survey and monitoring of River Ganga, especially identified 'critical stretches' annually. 2. Assessment and characterization of dolphin habitats in larger rivers, viz. Ganga, Gandak, Kosi, etc. in next three years. 3. Identification of various threats the dolphins are facing in different rivers within two years. 4. Study the movement and dispersal pattern of the Gangetic dolphin to assess its home range using modern technology in next five years. 5. Study and monitoring of bio - accumulation of toxic chemicals in dolphin tissues.	Action Points 1. A proper base map needs to be developed highlighting the crtical habitat stretches along the river planform and must be regularly updated keeping in mind the organic behaviour of the river to create landforms. 2. Measures to keep the natural river planform must be undertaken at the earliest and after every flood period.	1. The natural river planform may be strengthened using bio - engineering techniques.

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
	6. Conduct basic research on biology of the dolphin, viz. natural breeding, prey base and feeding, social behavior of the dolphin. 7. Conduct a study on mortality of river dolphin throughout the river stretch to identify the causal factors and find out remedial measures.		
Gangetic river dolphins	Objective 2: Protection of the dolphin and its habitat Description: It is important to protect the dolphin from being killed intentionally or accidentally. As maximum death of dolphins is in fishing sector, the existing fishing practices need to be reviewed and development of fishery management plan making fisheries sustainable and reducing risk to the dolphin and other aquatic wildlife. Action Points 1. Sensitizing and training the field staff of forest department for protection of Gangetic dolphins. (Regular) 2. Gather intelligence on dolphin oil fishing and identify the areas with intense dolphin oil fishing. (Within 1-2 years) 3. Sensitization of police stations and administration along the rivers to take necessary measures in case of dolphin killing. (Regular) 4. Strict enforcement of laws that prevent use of detrimental fishing methods, especially in the dolphin sanctuary. 5. Reminding the concerned government agencies from time to time to take necessary steps to reduce pollution load. 6. Government should take up the issue of declining flow with central government so that e-flow in rivers is ensured for survival of the dolphin. Objective 3: Education and awareness Description: It is essential to educate and create awareness about the importance of the dolphin as a flagship species and our National Aquatic Animal among various strata of society, viz. school and college students, fishermen, policy makers, executives, journalists etc. Action Points 1. Didactic materials for public discussion should be produced.	1. Focus on the habitat of the prey species of the dolphin need to be emphasied as this will automatically help sustain the dolphin habitats. 2. No manner of hindrance for e - flow should be developed within the sanctuary.	1. Strategies such as sediment trapping, etc in the river bed may be promoted in addition to natural river flow of sediments to renaturalise the riverbed to provide a habitat for the bottom feeders which are a major prey source for Gangetic dolphins 1. Wildlife festivals may be promoted across the sanctuary with exception of breeding seasons. 2. Signages indicating the common congregation points of the dolphins need to be highlighted. 3. Signages highlighting the basic morphology of dolphins and how they differ from the other human predators may be proposed.

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Gangetic river dolphins	Action Points 2. Education and awareness programs should be organized in schools and colleges to motivate the students to save dolphins. 3. Publicity campaigns should be organized for the common mass about the dolphin as a flagship species. 4. Publication of educational brochures in local language, radio and television programs, posters, handbills, workshops etc. should be given high priority as it may help to involve local participants. 5. Participation of traditional fising communities and other riparian communities in education and awareness program is essential for dolphin conservation. Objective 4: Livelihood securities to river dependent communities. Description: The fishing community in Bihar is very poor and is dependent on fish catch from rivers. Many of their fishing gears are detrimental to the dolphins.Some of them practice oil fishery using dolphin oil and meat as bait for the target fishes. Livelihood securities for the local stakeholders, like traditional fishing community and other river dependent communities are essential for dolphin conservation. Action Points 1. The fishing community should be encouraged to use fish scrap oil as alternative to dolphin oil . The alternative oil should be popularized through Extension Program. 2. 'Dolphin Watch' and eco-tourism program at different locations may be initiated with appropriate guidelines and environmental safeguards. The State Tourism Department may play nodal role in this exercise. It will help generate livelihoods for the local fishermen / boatmen, and help in community involvement in dolphin conservation. They should be provided financial help through 'Micro-financing' to buy good quality comfortable boats for tourists and dolphin watchers. Capacity building and skilled enhancement to such communities will be a great help to them. 3. Some of the fishermen should be encouraged to get engaged in fish-culture/ aquaculture and for this also they should be provided financial help.		1. Integrated agro - aqua farming approach may be worked out as a demonstration model within the sanctuary extent.

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Gangetic river dolphins	3. The initiative like 'Briksh Mitra' in Bihar is getting popular. Similarly, 'Dolphin Mitra' may be initiated and promoted. It will help in documenting the accidental killings of dolphin which is otherwise difficult in unorganized fishery in rivers. 4. Conduct a socio-economic survey of people's dependence on river resources and apply the results to dolphin conservation programs. 5. Education and awareness programs should be organized in schools and colleges to motivate the students to save dolphins. 6. Publicity campaigns should be organized for the common mass about the dolphin as a flagship species. 7. Publication of educational brochures in local language, radio and television programs, posters, handbills, workshops etc. should be given high priority as it may help to involve local participants. 8. Participation of traditional fishing communities and other riparian communities in education and awareness program is essential for dolphin conservation. Objective 5 : Capacity building of officials and staff. Description: The frontline and field protection staff are not well exposed to the Gangetic dolphins. They do not have adequate knowledge of biology, behavior, habitat p reference , rescue and translocation, and status survey of the dolphin. Government should deploy dedicated and interested staff for dolphin conservation. Action Points 1. The field and frontline staff interested in dolphin programs should be identified and given regular training by experts on different issues of dolphin conservation. 2. They should be taken to rivers where they can get exposure and learn about the dolphin. 3. Orientation program should be organized to motivate the staff. 4. Facilitate and support a range of research programs targeted at river dolphins in order to provide a scientific basis for conservation and management actions and capacity building.		

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Gangetic river dolphins	Objective 6: Creation / extension / strengthening of Protected Areas Description: The Gangetic dolphin moves and disperses to more than 100 km especially in floods. During other seasons also they keep on moving and dispersing, though, its home range is not known. Action Points 1. VGDS may be extended from Barjarpur to Kosi confluence. 2. There is serious need to strengthen VGDS which does not have a management plan, and dedicated well 3. trained field staff. 4. Improve links between government agencies and other stakeholders in theVGDS and involve local communities in planning stages of VGDS management. 5. Ensure enforcement of laws and regulations protecting the dolphins (and other fauna) for which the protected area was created.		
Man - locals and tourists		1. Stringent measures to ensure that healthy practices are followed within the sanctuary limits need to be in place. 2. Tourism after dusk should be avoided as much possible.	1. Waste bins segrated should be along the sanctuary extent.
Zoonosis	Most existing policies and subsequent guidelines were more inclined towards practising conventional strategies such as vaccination, periodic usage of pesticides & fertilisers etc. No particular policies and guidelines from a zoonotic point were addressed as such to date. Policies so proposed here address to the following critical parameters that predominantly contriubute to increased zoonosis in general :- • Climate • Ecosystem Ecology • Changing land use • Deforestation • Habitat destruction and fragmentation • Agriculture and food insecurity • Socio - economic factors • Landscape design interventions	1. The selection of a site near the river edge must be carried out in a systematic & meticuluous fashion based on a critical review of what the concerned landscape is capable of supporting against the backdrop of natural ecological processes. 2. The concept of coupled socio-ecological systems (SES) - an idea that views both the human and ecological systems to be inextricably linked to each other need to be applied at a regional and micro – site level. A regional level SES analysis shall not only help to identify those x- factors that lend a landscape its power of resilience or make it vulnerable to adversity but further help designate such eco - sensitive locales with controlled development or none.	1. A site level mapping of socio-ecological spaces may be carried out to ensure that the core ecologically relevant habitats are conserved while keeping the sociocultural aspects of the site intact. 2. Developing a relationship map of the predator – prey - vector – pathogen can help understand the potential impact on host – pathogen relationship. 3. Predator – prey relationship in a design project needs to be understood before intervention – manipulation of this relationship can tamper the species diversity and count.

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Zoonosis		3. Critical measures to understand the manner of zoonotic occurence, transmission and potential spillover need to be undertaken on a regular basis and a periodic surveillance of the same can help predict pandemics well in advance. 4. Landscape epidemology needs to be incorporated as an important layer in the design of landscapes similar to the proposed site. 5. Research work with respect to ecological & epidemiological information on the influence of environmental changes on zoonotic cycles need to be done. 6. Enhanced surveillance on the appearance of new spillover cases in previously zoonotic free areas, along with causes for the same need to be ensured.	4. Assessing the risk factor of a site may be carried out using a base checklist logic:- Eco sensitivity Site extent ≤0.5 acres Vector reservoir Number of zoonotic cases Artificially intervened site ≤1m from an ecotone 5. Increased understanding of the complex pathogenic life cycles and their vectors is essential for developing effective risk reducing ecosystem interventions.
Climate parameter		1. Minute checks on any plausible changes that could interact with climatic alterations capable of causing potential risks of zoonotic spillover need to be ensured. 2. Climatic models integrating ecological knowledge of important host reservoirs with near real-time climate and earth observation need to be developed to forecast probable zoonotic hazards in advance.	

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Ecosystem ecology parameter		1. Efforts to develop a scientific approach towards organizing an interconnected species rich and bio diverse blue - green infrastructure should be made. 2. Regular analysis and assessment at multiple scales based on landscape ecology framework & methods need to be conducted so as to realize the effect of government policies and regulations on the site. This is essential to prioritize the landscapes to preserve for maintenance of ecological resilience. 3. Regular evaluation of genetic diversity, animal behavior and health need to be conducted via means of case studies of various species at a global scale which will help improve our understanding of the multifactorial process that can initiate at different scales post anthropogenic disturbances. 4. Long term study sites need to be established so that researchers can catalog any sort of rare events, build awareness and collaborations over time to understand in depth the zoonotic dynamics inorder to prevent potential pandemics. 5. Integrating ecological forecast models into health planning schemes is necessary for proactively predicting risk surges including high burden zoonoses and hence subsequent solutions.	1. Selective defaunation must be avoided as much possible. 2. Techniques like zooprophylaxis and dilution effect need to be incorporated as design strategies as well for large scale projects.
Changing landuse parameter		1. Land use models that forecast potential zoonotic hazards due to changing land use need to be developed and updated on a regular basis.	1. Parts of the sanctuary extent can be deemed as demonstration sites with minimal to no human access to study natural dynamics. 2. Landuse within the sanctuary extent should not be modified and under need for modification should be such that it accomodates the needs of the ecological diversity and the natural processes before anything else.
Agriculture and food insecurity parameter		1. Sustainable agricultural practices are essential to enhance food security. 2. Alternate solutions to cultivation inorder to combat food insecurity need to be explored, researched and further innovated.	

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Deforestation parameter		1. Responsible forest management and food production is a promising solution to reduce the risk of zoonoses. 2. Long term study sites need to be established so that researchers can catalog any sort of rare events, build awareness and collaborations over time to understand in depth the zoonotic dynamics inorder to prevent potential pandemics. 3. Measures to ensure that responsible forest management practices are adopted need to be undertaken so as to reduce zoonotic risk in humans.	1. Landscape habitats such as riparian galleries etc. need to be developed to confine potential vectors or hosts to those boundaries instead of invading human habitations for resources. 2. Creating dense vegetation patches need to be reduced to avoid unintended fostering of novel pathogens into urban landscapes. 3. Maintaining landscape interconnectivity to prevent unwanted spillover. Potential routes for movement of these hosts into the human settlements (like railways, waterways, sewage systems, etc.) need to be blocked through proactive site planning and technological interventions. Simultaneously alternate movement trails for the vectors through defined landscape regions need to be developed as well. 4. The human – wildlife edge interface at the high risk zones need to have barriers in place to control the host activity. 5. The connectivity between resource rich landscape patches need to be minimized as much possible or if connected be separated by buffers to prevent spillover.
Habitat destruction and fragmentation parameter		1. Where ever possible, destruction of natural habitat and biodiversity loss must be minimized or eradicated as much possible. 2. Caution must be exercised when proposing blue-green areas in an urban context as such areas seldom support high levels of biodiversity due to its fragmented character owing to which synanthropes may be the ones that end up benefiting the most ; thereby overuling the actual intent of design proposal.	
Socio - economic parameter		1. Public health interventions and general hygienic measures in the hospitality industry and street food trade need to be enforced with stringency to minimize food borne spread of zoonoses in humans. 2. Educating and imparting awareness in people the importance of clean hygiene practices is imperative to ensure that people understand the implications of improper food processing. Including this as a part of the health protocol is even more essential to avoid the devastating impacts on economic conditions and food safety.	

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Landscape design interventions parameter		1. Proactive surveillance measures need to be put into place, specifically those areas when the human – wildlife contact is increased or can increase. 2. Public health need to be taken up as an important parametric criteria in the initial planning phases to avoid unintended spillover and associated mitigation expenditure. 3. Measures need to be undertaken to ensure that the urban blue- green infrastructure is structured to minimise the overall carrying capacity of potential vectors and subsequently the capacity of zoonotic spillover. 4. Blue infrastructure needs to be designed such that the resultant outcome is not conducive for any of the potential zoonotic vectors. 5. Increased understanding of the complex life cycles of the pathogens and their vectors is essential for developing effective risk reducing ecosystem interventions.	1. The count of predator – prey - vector – pathogen should be in balance in-order to maintain the ecosystem equilibrium through means of increased sustenance measure for the key indicator species such as Gangetic dolphins, Smooth coated otters etc. 2. Avoid planting fruit trees around site boundary or near to domesticated animal zones as they act as a beacon for potential vector hosts like bat. 3. Artificial waterbodies need to be constructed as per need and site context as larval populations densities are known to be higher when compared to natural environments. 4. Efforts must be undertaken to prevent water stagnation via introduced movement using components like pond pumps, waterfalls, fountains, aerators etc. 5. A carefully curated palette of natural predators need to be introduced into thewaterbodies – both artificial and natural to avoid unnecessary pathogenic host proliferation. 6. Increasing the holistic ecosystem complexity should also be encouraged as a means of reducing the threats of host vector proliferation. 7. Buffer strip (riparian edge) along the water bodies without anthropogenic interference need to be developed with periodic pest management.

Area of concern	Existing policies/ guidelines and drawback	Proposed policies	Proposed guidelines
Landscape design interventions parameter			8. the incline of the sides of the water body may also be done to eliminate shallow areas where sunlight reaches the bottom inorder to avoid creating suitable environment for excessive vegetation growth that can promote unwanted pathogenic growth. 9. Cautionary signages with protective detail measures need to be placed in all moderate to high risk sites. 10. Pathways need to be wide enough to avoid any potential contact with adjacent vegetation and be constructed using xeric materials or treated with desiccant. 11. Dense bushes, ground covers and heavy leaf litter need to be kept at a distance of atleast 3m away from the pathway edge. 12. Pathways should not be constructed in the high risk regions of the site and if so should be such that it may be closed during the potential vector breeding seasons. 13. The overall site layout, planting pallete, and other design aspects should ensure that it deters wildlife activity in the high activity areas.

CHAPTER 8: CONCEPTUALISATION

CHAPTER 8: CONCEPTUALISATION

8.1 INTRODUCTION

In order to derive the concept for the design proposal, the initial studies were supplemented the vision conceived by NMCG – NIUA (***Figure 77***).

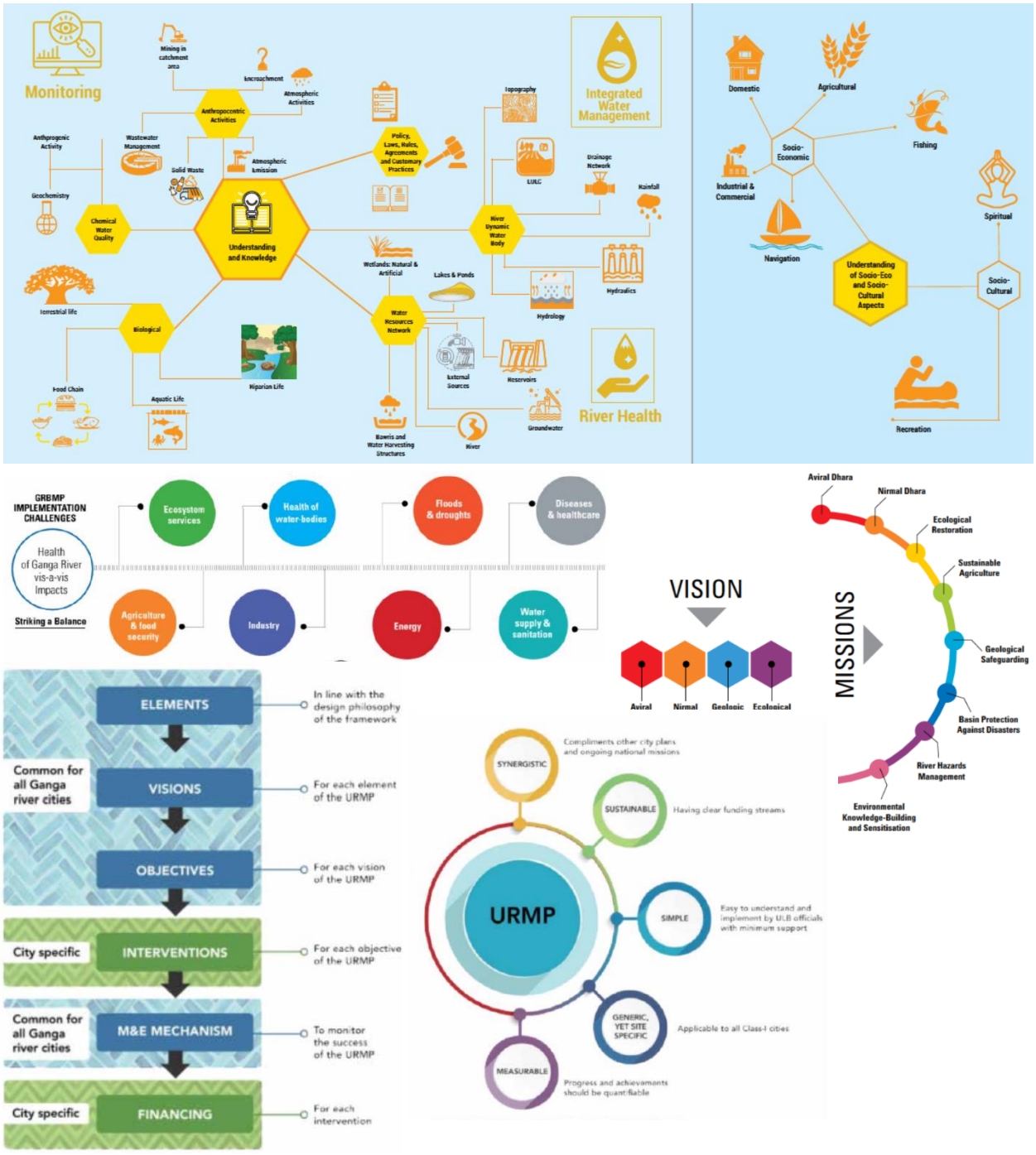


Figure 77 – A summarized pictorial representation of NMCG – NIUA vision for Ganga River (Source – NIUA – NMCG reports)

1Keeping in mind the overall vision proposed as part of the Ganga URMP Framework in addition to taking into consideration the preliminary study and analysis of VGDS site, a concept has been proposed (***Figure 78***). The details of the concept shall be covered in the next chapter.

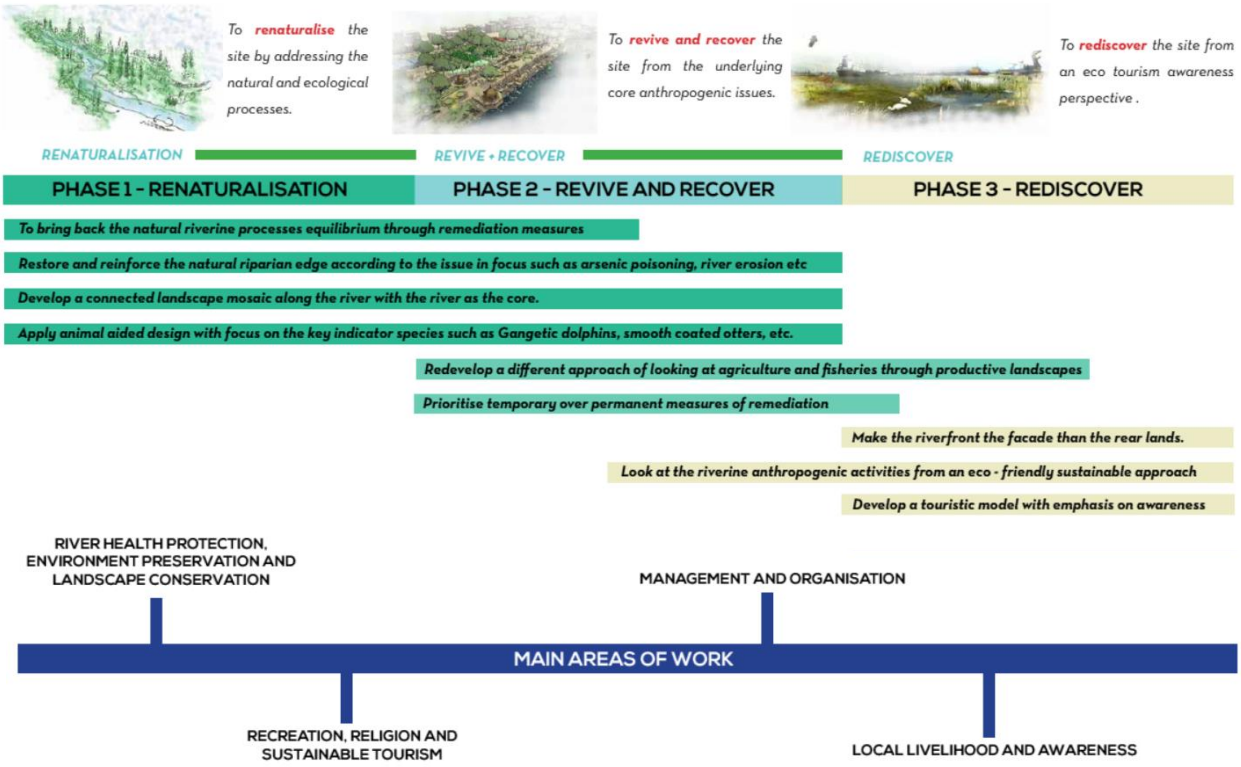


Figure 78 – Overall concept and design framework highlighting the major areas of work (Source – Author)

CHAPTER 9: DESIGN DEVELOPMENT

CHAPTER 9. DESIGN DEVELOPMENT

9.1 INTRODUCTION

The entire design proposal has been worked out in line with the 3 Rs concept (which constitute the rewilding package) as discussed earlier in Chapter 8 on the basis of which the entire master plan has been developed (***Figure 79***). The Rs include:-

- Renaturalisation
- Revive + Recover
- Rediscover

The entire design has been conceived keeping in mind the understanding that the challenges faced by the sanctuary core are an outcome of factors that occur both upstream and downstream Ganga. Hence for this proposal to work to its full extent, effective measures to resolve issues off site context need to be addressed. Therefore this proposal targets the holistic revitalization of the core region to support the key indicator species of the region as this will indirectly help ensure the habitat of the Gangetic Dolphins. Likewise certain measures have been laid forth on the basis of which the rest of the design has been developed. The success of the design is dependent on the successful implementation of those foundational policies and guidelines.

9.2 FIRST R - RENATURALISATION

Renaturalisation focuses on reverting the natural ecosystems and ecological processes of the proposed site extent. As part of renaturalisation, the following design strategies have been proposed:-

9.2.1 DESIGNATED ACTIVE FLOOD PLAIN ZONE (AFP ZONE)

Being a braided river, the natural river planform of Ganga is known to change naturally with time. The water levels are known to rise as much as 10 m with the main channel widening to 2-4 km during the monsoon season. The shallow incised river channels and exposed bank sediments are an outcome of the modern aggrading flood plain systems. Detached floodplains with sand/mud deposits in 10-15 m thick, have developed over the course of many years which at present are being extensively used to satisfy agrarian demands by local people or left as fallow lands. This has further implications on the overall regional ecology as well such as aggravated flooding, eroding river banks, etc. Establishing an activated floodplain zone spanning a distance of 3km from the main river channel of Ganga (***Figure 80***) supported by a set of special norms incorporated in the region will not only allow the river to perform its natural course of action but also ensure that the areal extent of flooding gets contained within the floodplain itself instead of spilling over into the urban areas (***Figure 81***).

Key regulations that need to be incorporated with immediate effect in the designated AFP include:-

- Relocation of existing built structures to elsewhere outside of the extent of the AFP. In the case of towns of Bhagalpur and Kahalgaon, efforts to strengthen the riparian edge and

Figure 79 – Comprehensive landscape development master plan (Source – Author)

develop continuous landscapes that lead to the main river channel shall be encouraged in those zones where relocation is not possible.

- No new construction shall be encouraged in the AFP region inclusive of the towns of Bhagalpur, Kahalgaon and Sultanganj.
- The main focus here shall be to reinstate the natural ecosystems of the region to the best possible means with minimal design interventions and more conservation.
- Use of hardscape elements shall be minimized as much possible and in case of use, it will be those of permeable and ecofriendly nature.
- Any manner of structural development in this region such as roads, bridges, built etc. shall be done unless no other alternative exists to solve the concerned issue.

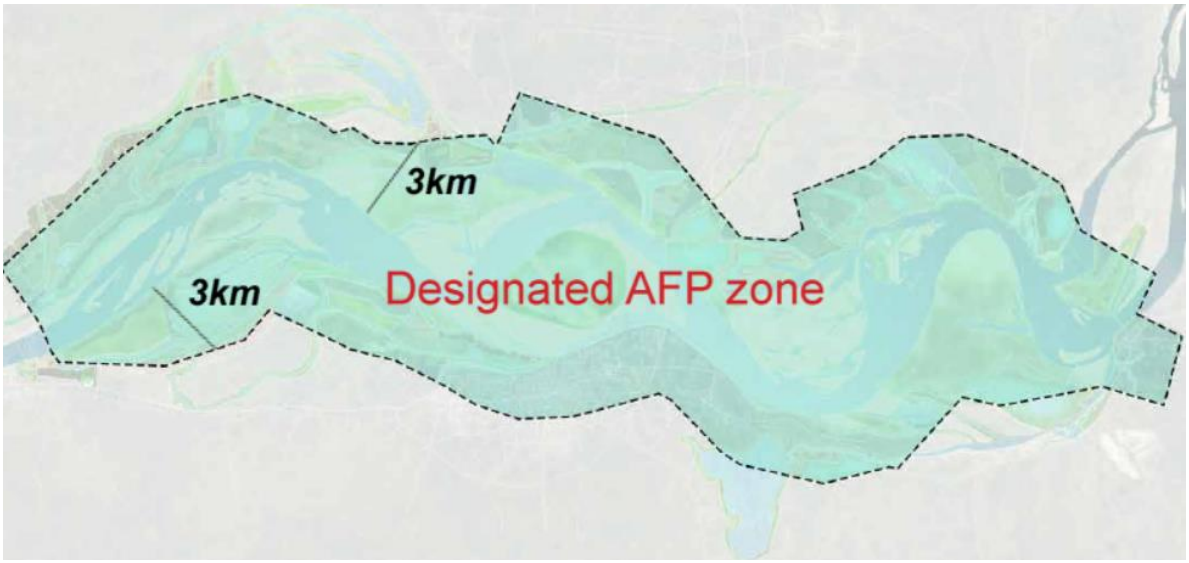


Figure 80 *– A diagram highlighting proposed AFP zone (Source - Author)*

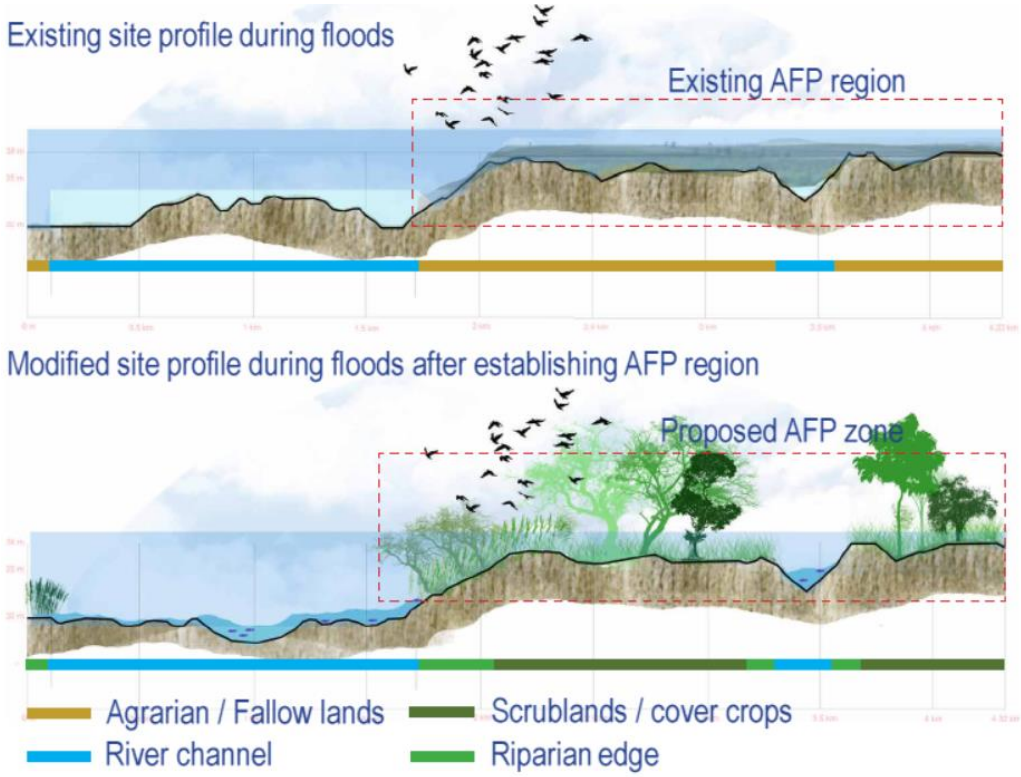


Figure 81*- A comparative profile section of how site changes after being proposed as AFP zone (Source - Author)*

9.2.2 RESTORING & DAYLIGHTING THE ORIGINAL AND EXISTING HYDROLOGICAL CONNECTIONS

Many of the old hydrological connections to the main river channel within the sanctuary core are either converted to local roads or lost to the natural processes. Occasionally here and there, they are subject to be channelized for irrigation purposes as well. This in addition to factors such as dams across the main river outside of site extent compromises the overall e-flow in addition to reducing the overall habitat area of various species as well. Therefore restoration of the old and daylighting of the existing water nexus (***Figure 82***) can help resolve this predicament which also addresses issues such as decreasing fish count, reduced habitat cover and fragmentation etc. in the larger picture.

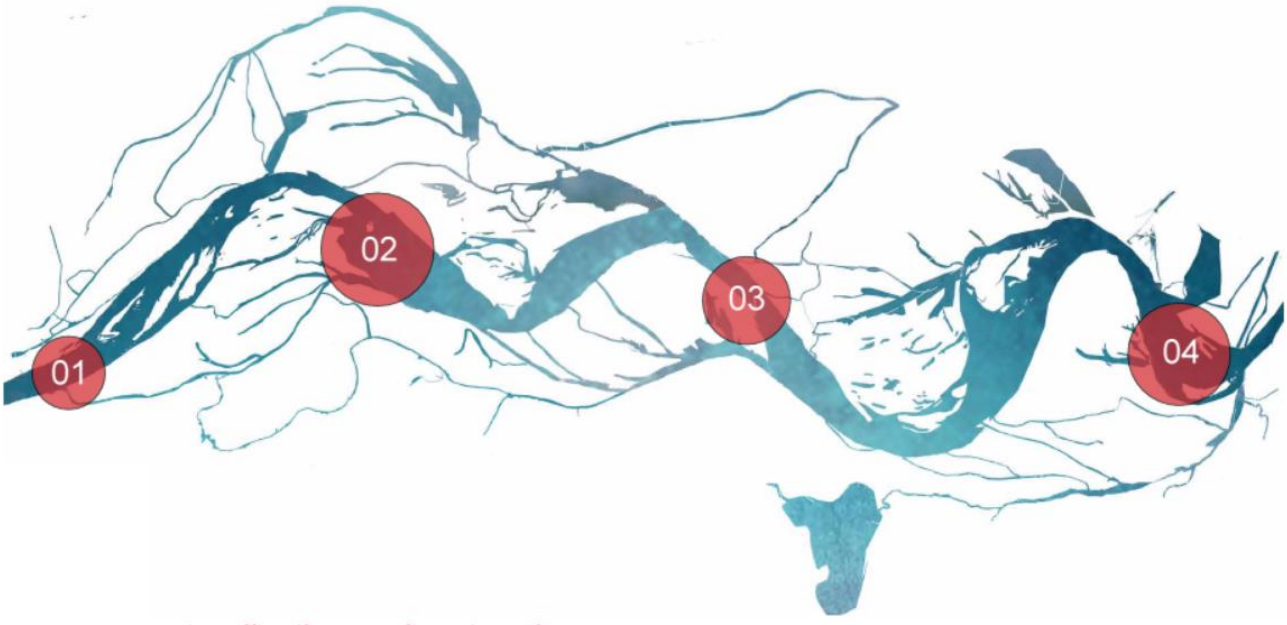


Figure 82*- A map of restored hydrological nexus in the proposed site region. (Source - Author)*

9.2.3 RIVERBED NATURALISATION AND RESTORATION

The health of a riverbed drives the rich ecological diversity to thrive in the riverine habitat. A healthy riverbed benefits a vast diversity of species in the larger food web both flora and fauna whom usually tend to form the origin of a food chain (***Figure 84***).However around 9 - 10m silt deposits are known to lie over the Gangetic riverbed within the sanctuary core; which not only compromises the natural river sediment flow but also makes it difficult for the ship vessels to traverse via the river a.k.a. NW1. Gangetic dolphins require a depth of 0 - 9m while inland ship vessels need min of 2- 3m to navigate with ease. Therefore by grading the river bed to accommodate a depth of 9m for the main channel as well as creating shallow microhabitats to accommodate the ichthyofaunal diversity, problems such as excessive siltation, ships getting stuck due to excessive dredging etc. may be resolved (***Figure 83***).

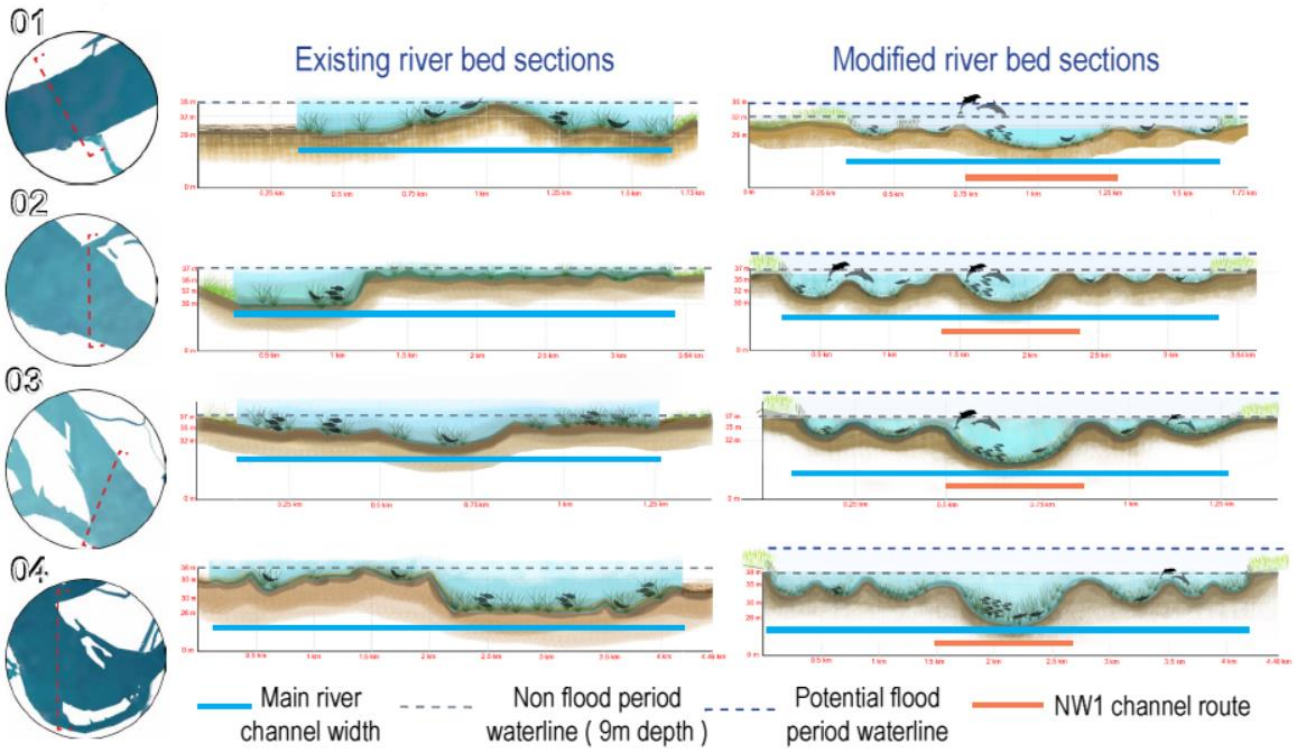


***Figure 83**- Existing vs modified riverbed sections at four points across the sanctuary extent as marked in figure 82. Riverbed naturalization has been proposed across the entire river stretch within the sanctuary core however for purpose of ease of understanding, the selected 4 points are chosen based on the bathymetry map of the region and show a major depth variation in addition to other factors which call for an immediate need to carry out restoration process at the earliest. (Source - Author)*

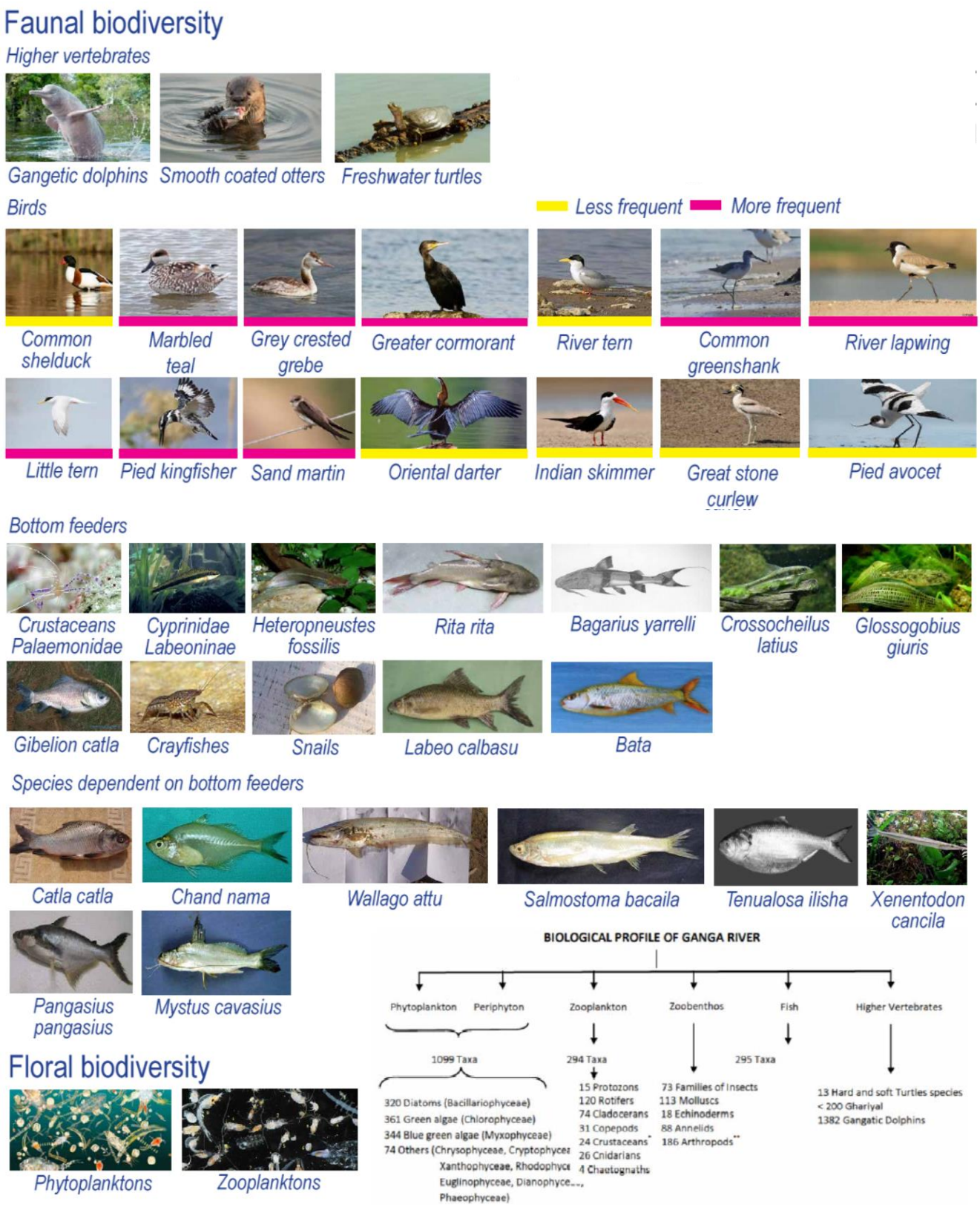


***Figure 84**- Sample biodiversity that shall benefit as result of riverbed naturalization and restoration. (Source - Author)*

9.2.4 ESTABLISHING RIPARIAN EDGES AND WILDLIFE CORRIDORS

Figure 85*- Schematic sketch of the idea of riparian corridor envisioned. (Source - Author)*

With riverfront urbanization and agriculture acting as mainstream priorities, habitat fragmentation is not a surprising outcome here. Likewise the lively fluvial processes accompanied by urban encroachment of riparian edges have resulted in eroded riparian vegetation or absent riparian corridors. Therefore continuous wildlife corridors and riparian buffers across the entire site have been proposed to combat the issues of habitat fragmentation, lack of proper habitats for species like smooth coated otters etc. to seek refuge from predators, bank edge stabilization etc. The riparian corridor pallete has also been formulated to provide phytoremediation facilities (***Figure 85***).

9.2.5 DIARAS / MID CHANNEL ISLANDS CONSERVATION

A major portion of VGDS constitute diara lands which are of more recent origin and this when coupled with the frequent flooding and excessive anthropogenic activities on these landforms (***Figure 86***).Mid channel diara islands are a product of natural fluvial process of braided rivers. By allowing them to change their morphology naturally through means of sedimentation and erosive river processes, numerous benefits such as diverse wildlife habitats, fertile lands, natural sediment flow etc. may be achieved. Further it is also imperative that these lands be preserved free of human habitation or excess anthropogenic activities that compromise the ecological health (***Figure 87***).

The changing nature of these landscapes makes it possible for the rich diversity of avian fauna to thrive in the area (***Figure 88***). The scrublands formed as a result of fallow lands and river expanse undergoing desertification act as a source of camouflage for various species from predators. Diversifying them increases the degree of cover and retains its character of flood plain as well. Proposed planting pallete for this region has been indicated here as well (***Figure 89***).

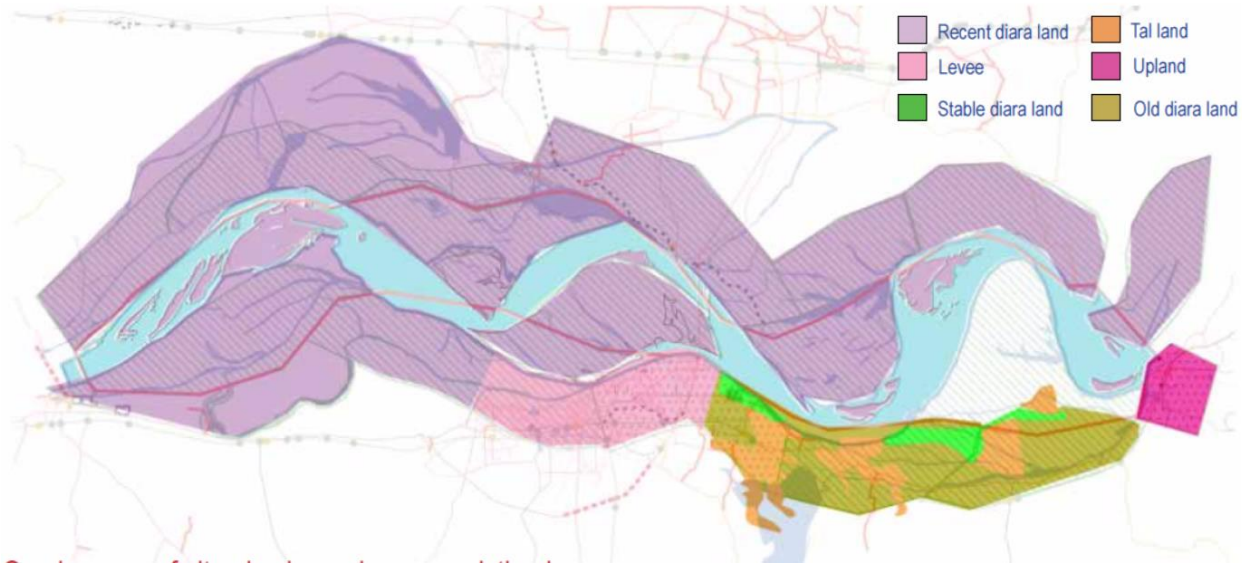


***Figure 86**- Overlay map of site physiography over existing base map. (Source - Author)*

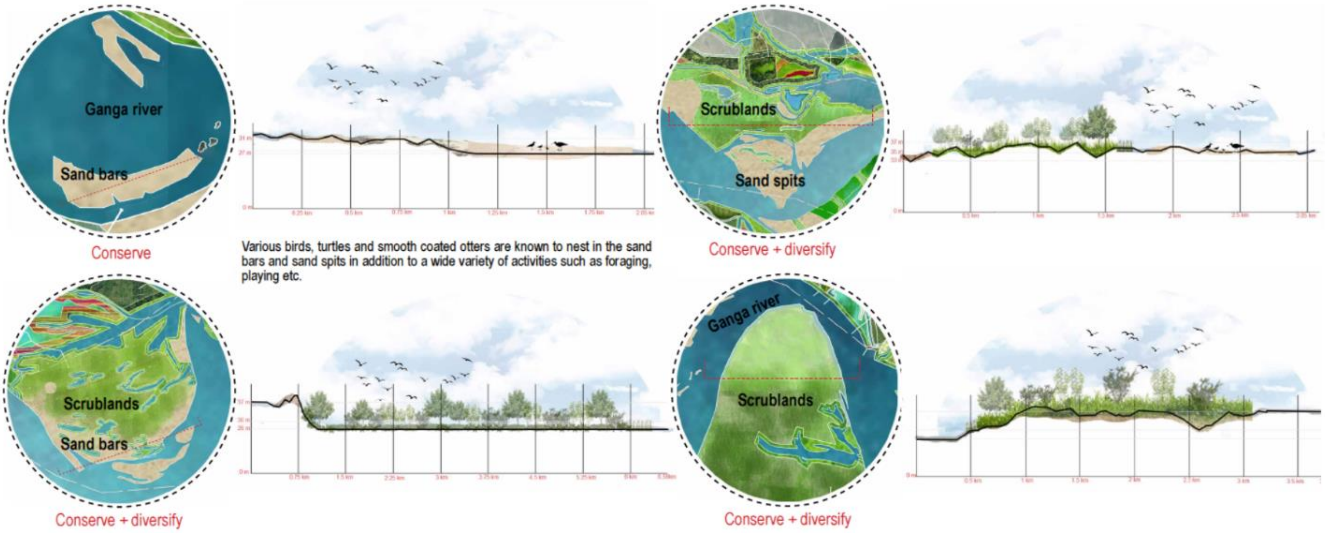


***Figure 87**- Conservation and diversification strategy for natural landscapes. (Source - Author)*

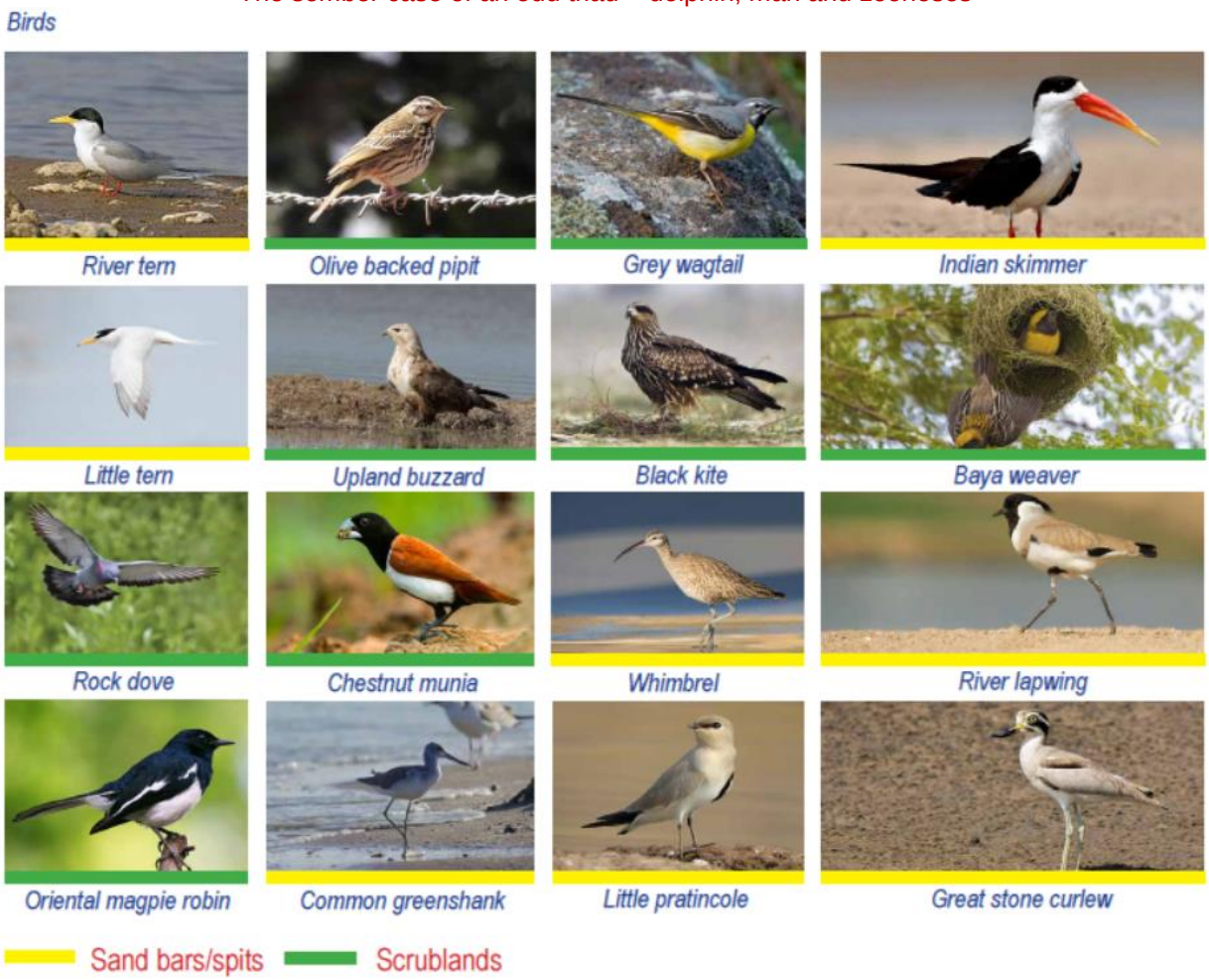


Figure 88*- Sample avian biodiversity that shall benefit as result of conservation and diversification of natural diaras. (Source - Author)*

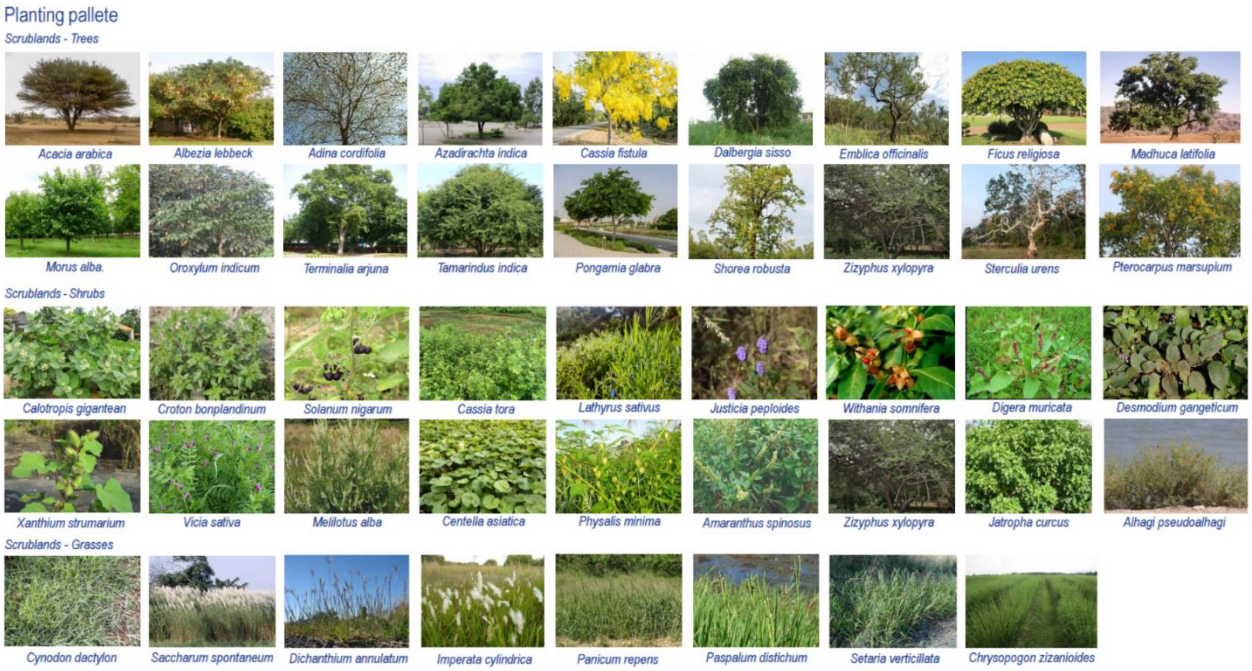


Figure 89 *– Sample planting pallete for scrublands. (Source - Author)*

9.3 SECOND R – REVIVE + RECOVER

Revive and recover deals with landscape strategies that focus on the restoring the damaged and derelict aspects of the site to its natural form. It also addressed those potential factors that may cause problems in the future as well. As part of the same, the following design strategies have been proposed:-

9.3.1 RIVER WATER PURIFICATION THROUGH COMBAT OF SOLID WASTE ACCUMULATION

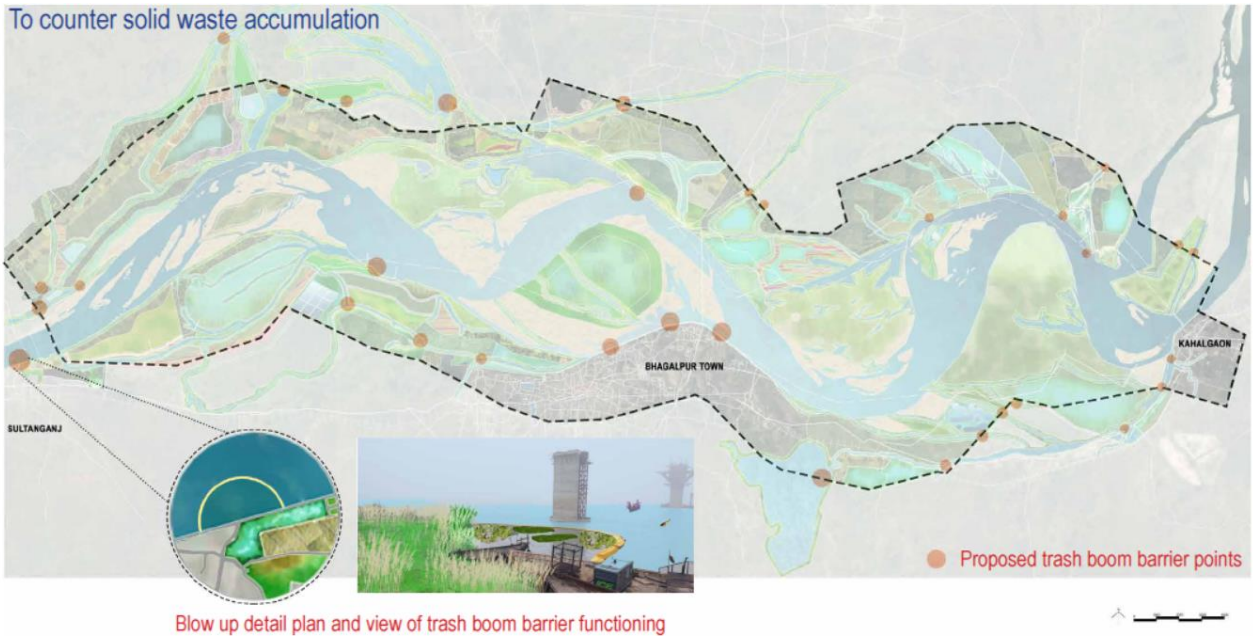


Figure 90 *– Proposed locations for trash boom barriers across the sanctuary extent with a blow up detail highlighted for the location near Sultanganj ghat, Sultanganj. (Source - Author)*

Accumulation of solid waste is a common scenario in Ganga, especially near the ghats used actively by both locals and tourists to perform religious rites or domestic activities such as washing clothes, bathing themselves and their animals etc. Inorder to control solid waste accumulation in the river and its channels, trash boom barrier devices have been proposed at the mouth of the channels that meet Ganga and at the points where in the river channels enter into the AFP region (***Figure 90***).

9.3.2 LAND REMEDIATION AND IMPROVING OVERALL WATER QUALITY THROUGH LANDSCAPES

A series of landscape design strategies such as remediation glades, phytoremediation riparian edges, wetlands etc. have been proposed across the proposed site extent to combat issues such as arsenic and fluoride poisoning etc. (***Figure 91***). The planting pallete has been carefully chosen to include hyper accumulators that can help reduce metal content in the groundwater, thereby making it pure for drinking (***Figure 92***).

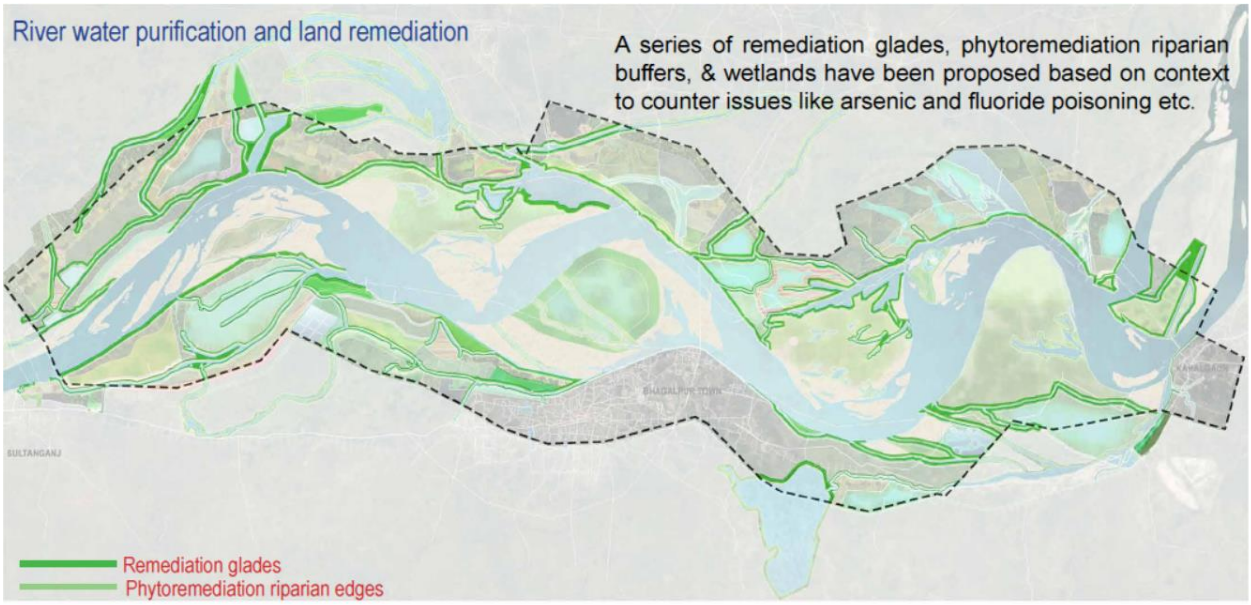


Figure 91 *– River water purification and land remediation zones across the site extent. (Source - Author)*

Figure 92 – Planting pallete for arsenic and fluoride poisoning. (Source - Author)

9.3.3 RIVER BANK STABILISATION AND SOIL CONTROL STRATEGIES

Inorder to combat the issue of eroding river edge within the sanctuary extent, a series of landscape design strategies have been inorder to be used either individually or in combination across the sanctuary core depending on the issue of concern or micro site character in that region along with a sample planting pallete (***Figure 93***).

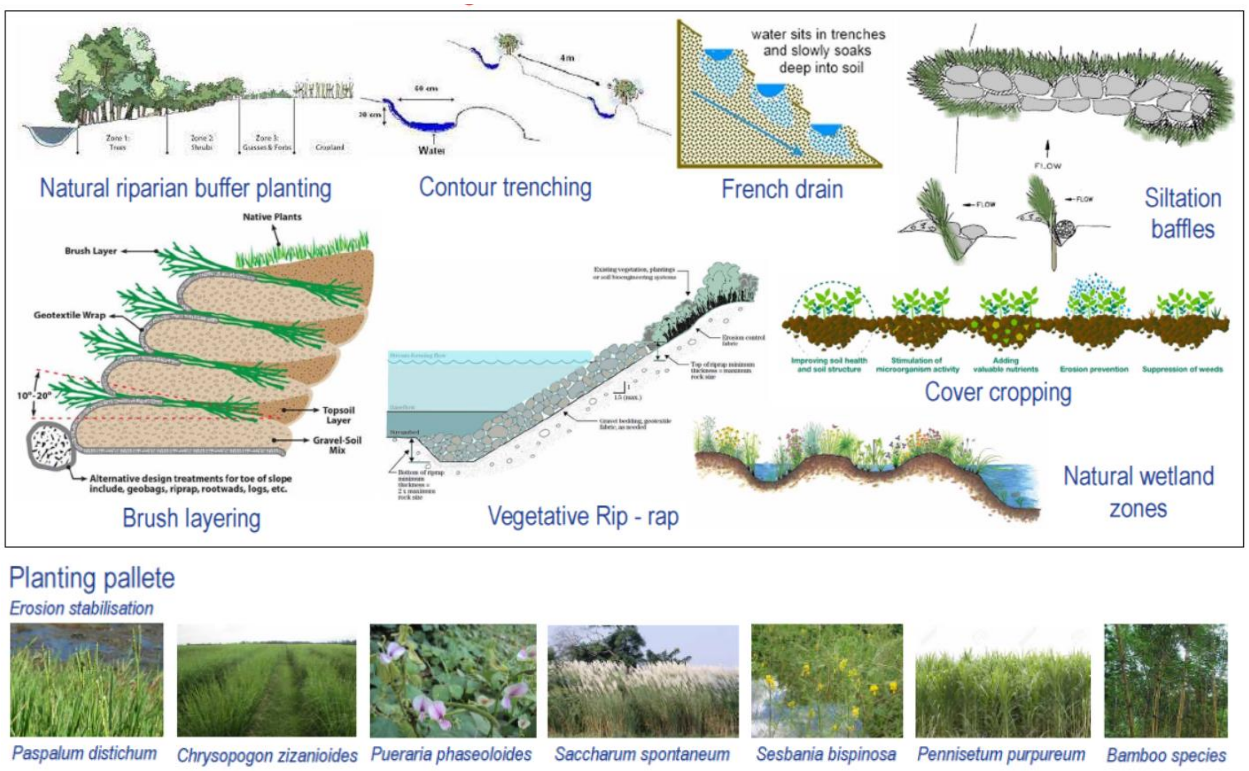


Figure 93 *– River water purification and land remediation zones across the site extent. (Source - Author)*

9.3.4 SUSTAINABLE FISHERIES

Fisheries are the heart of Bhagalpur district in general with the sanctuary core being an integral contributor to the same. However constant exploitation of the natural reservoir without giving a chance to replenish will not only generate an imbalance but at the same time, it will create a block in ensuring a stable fish catch for the local fishing community thereby depriving them of their livelihood that has been a strong part of their culture since a long time. This calls for a need to establish a decorum that is sustainable in the long run. A majority of this is possible only through effective implementation and adoption of policies and guidelines however design strategies also have an equal role to play in the same. A few of them proposed include:-

- Designating no-fishing zones (***Figure 94***).
- Creating natural hatchery ponds in the diara islands (***Figure 94***).
- Designing and restoring natural micro – habitats such as natural wetlands, shallow ponds, etc.

9.3.5 FAUNAL HABITAT MODIFICATIONS

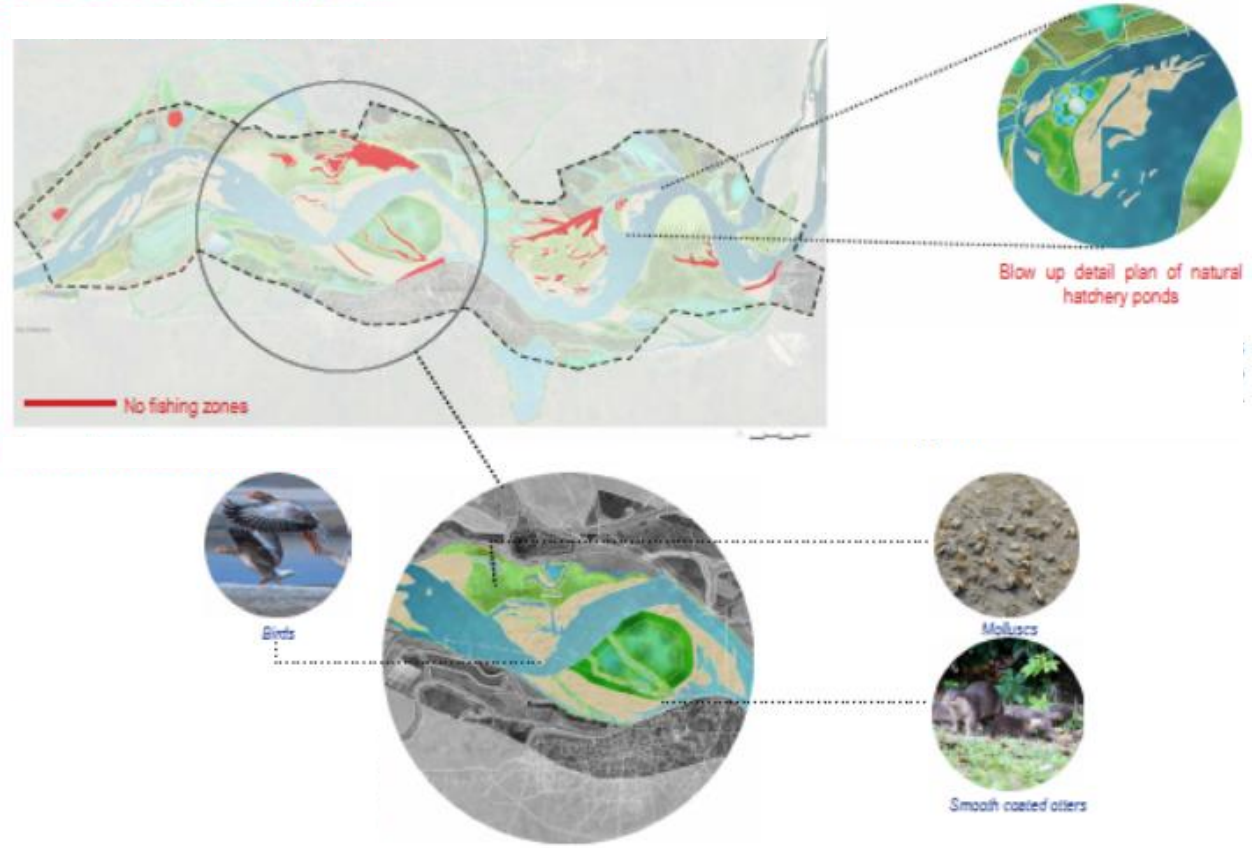


Figure 94 *– River water purification and land remediation zones across the site extent. (Source - Author)*

Despite the diversity in natural landscapes, a combination of aggravated natural processes and anthropogenic interventions, many of the natural habitats are either vanishing or compromised to an extent that many of the species are unable to use them in the way they normally would have when the habitats were devoid of excessive anthropogenic interferences. In order to tackle this issue, minor habitat modifications through strategic landscape interventions have been proposed. Some of them include:-

- Riparian and wildlife corridors (***Figure 85***).
- Alternate hideouts for aquatic species like fishes, crustaceans etc. such as natural hatchery ponds (***Figure 94***) shallow pools (***Figure 83***) etc. so that they can spawn, increase in number so that they can spill out into the river during floods. This will also ensure increased fish catch for the fishing community as well.
- Designating regions where in Gangetic dolphins are known to frolic more or where natural reservoir habitats are proposed such as meanders, mid channel islands etc. as no fishing zones to ensure an opportunity for these species to thrive in peace (***Figure 94***).

9.3.6 AGRO ECOLOGICAL LANDSCAPES

Agriculture is the pride of our nation and almost a vast proportion of the locals thriving in the region practice the same. However adopting the conventional cropping practices on the diara lands has a dire consequence here as they tend to harm the native ecology of the region as well. Use of fertilizers and pesticides pollute the lands and subsequently the river. They also increase the mineral content of the soil which further aggravates issues like arsenic poisoning etc. Further the planting of crops such as cucurbits result in habitat loss for many avian species as well. All this establishes the need for an agro ecological approach to be established in the region. (***Figure 95***).

Figure 95 – *Idea of agro – ecology concept (Source – Crop life international)*

Inorder to achieve this, the first and foremost step would be to rezone the entire agro region within the sanctuary core to suit the natural ecological scenario (***Figure 96***) followed by envisioning unique opportunities to generate revenue out of the strategic cropping pallete so proposed from an ecological perspective (***Figure 97***) such as integrated agriculture etc.

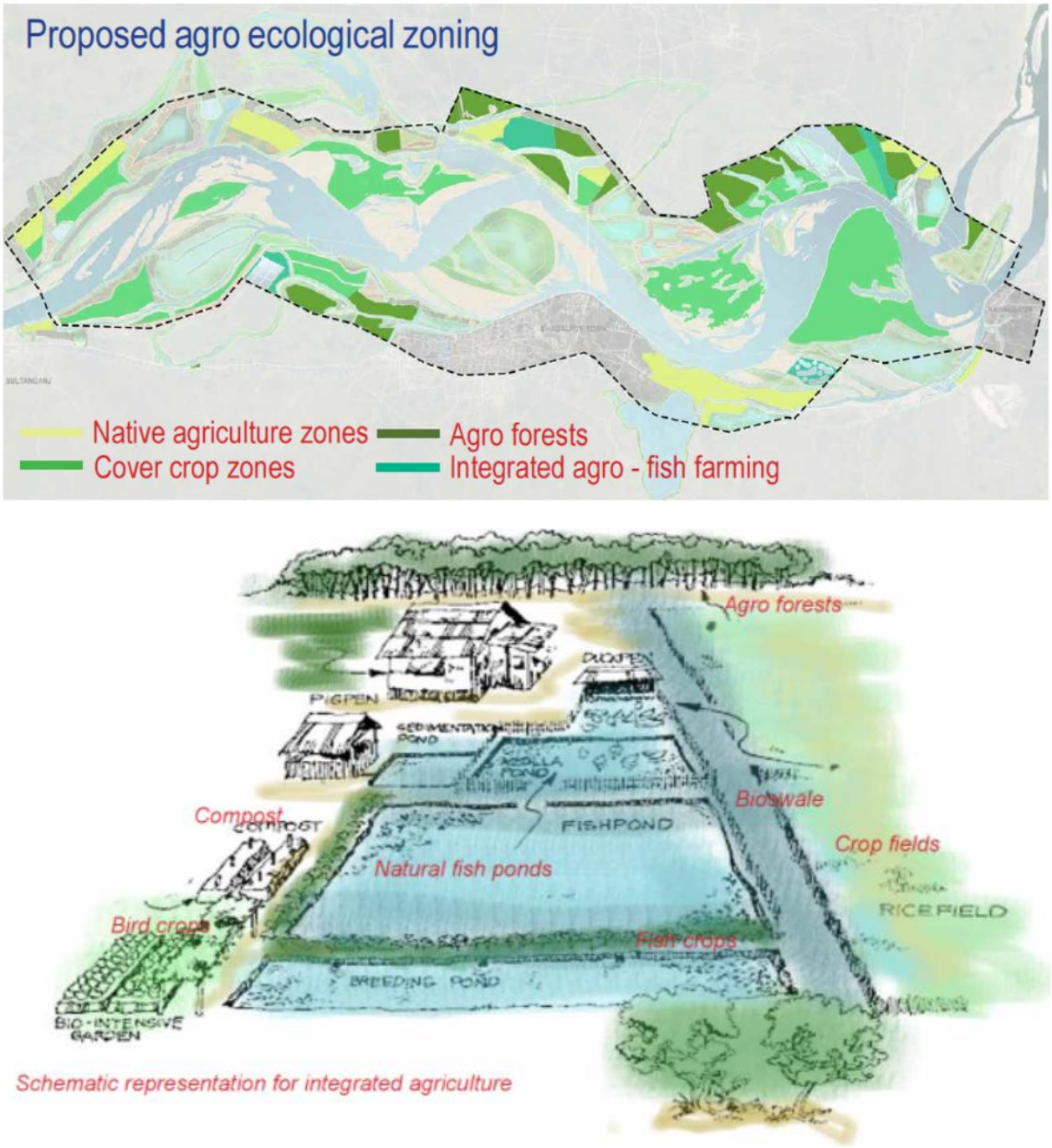


Figure 96 *– Proposed agro – ecological site zoning with a schematic representation of integrated agriculture concept (Source – Author)*

Figure 97 *– Proposed sample agro – ecological planting pallete (Source – Author)*

9.3.7 LANDSCAPE COMPONENTS FOR ZOONOTIC RESILIENCE

Although rewilding and continuous landscapes play a key role in ensuring both ecological as well as zoonotic resilience, at a micro level, few of the interventions so proposed to boost the same include urban forests, flower fields, pollinator hotels etc. (***Figure 98***). Likewise alternate faunal species and natural reservoirs of zoonotic vectors may be established as a means to redirect the mosquitoes away from humans. The details of the same shall be explored further in Chapter 11.

Figure 98 *– Schematic representations of a few strategies proposed exclusively for zoonotic resilience (Source – Author)*

9.4 THIRD R –REDISCOVER

Rediscover is all about looking at the ecosystem services that the proposed site offers to the human community through a different lens that is not only ecologically sensitive but at the same time does not compromise on the human needs. As part of the same, the following design strategies have been proposed:-

9.4.1 ECOLOGICAL PRACTICE OF RIPARIAN RIGHTS

Indian government grants riparian rights to all those who reside near the river and to those who come from afar to use the same. However the practice of riparian rights should not be at the cost of nature. This calls for a remodification of the existing river front entities to suit the human needs without compromising the faunal species and the natural landscapes (***Figure 99***).

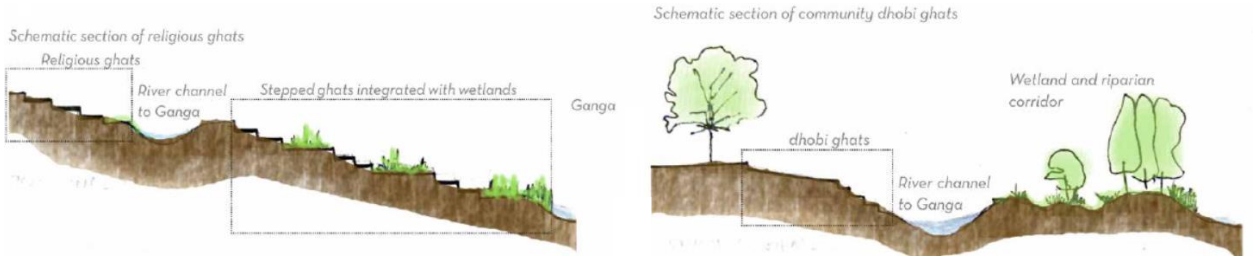


Figure 99 *– Schematic representations of how river ghats within the sanctuary core may be modified for public use (Source – Author)*

9.4.1.1 DELINEATING SITE – BARARI RIVER GHAT, BHAGALPUR

The idea of revamped riverine ghats has been put to test using Barari Ghat in Bhagalpur as an example. Barari Ghat is situated on the Bhagalpur side on the south bank of the Ganges and it is from here that Vikramshila Setu runs towards the other bank of Ganga (***Figure 100***). It is one of the largest and prominent river ghats of Bhagalpur wherein people perform their religious festive rituals, crematory rites as well as use it for a means of daily activities such as group yoga sessions etc. However intensive human activities without regard for the ecological sensitivity of the river has resulted in increased pollution specifically during festive seasons. Further absence of riparian vegetation provides an opportunity for the general public to carry out crematory rites which further hampers any potential riparian vegetative growth. Moreover there have been recurrent cases of visitors drowning near the ghat due to rampant dredging in the immediate vicinity.

Figure 100 *– Existing view of Barari Ghat, Bhagalpur being used by public with Vikramshila Setu in background (Source – VGDS biodiversity conservator Deepak Kumar)*

Keeping in mind all these, an ecologically sensitive and flood resilient design solution has been proposed that offers a multipurpose space for public to carry out their rituals while providing space for faunal activity to take place as well (***Figure 101***).

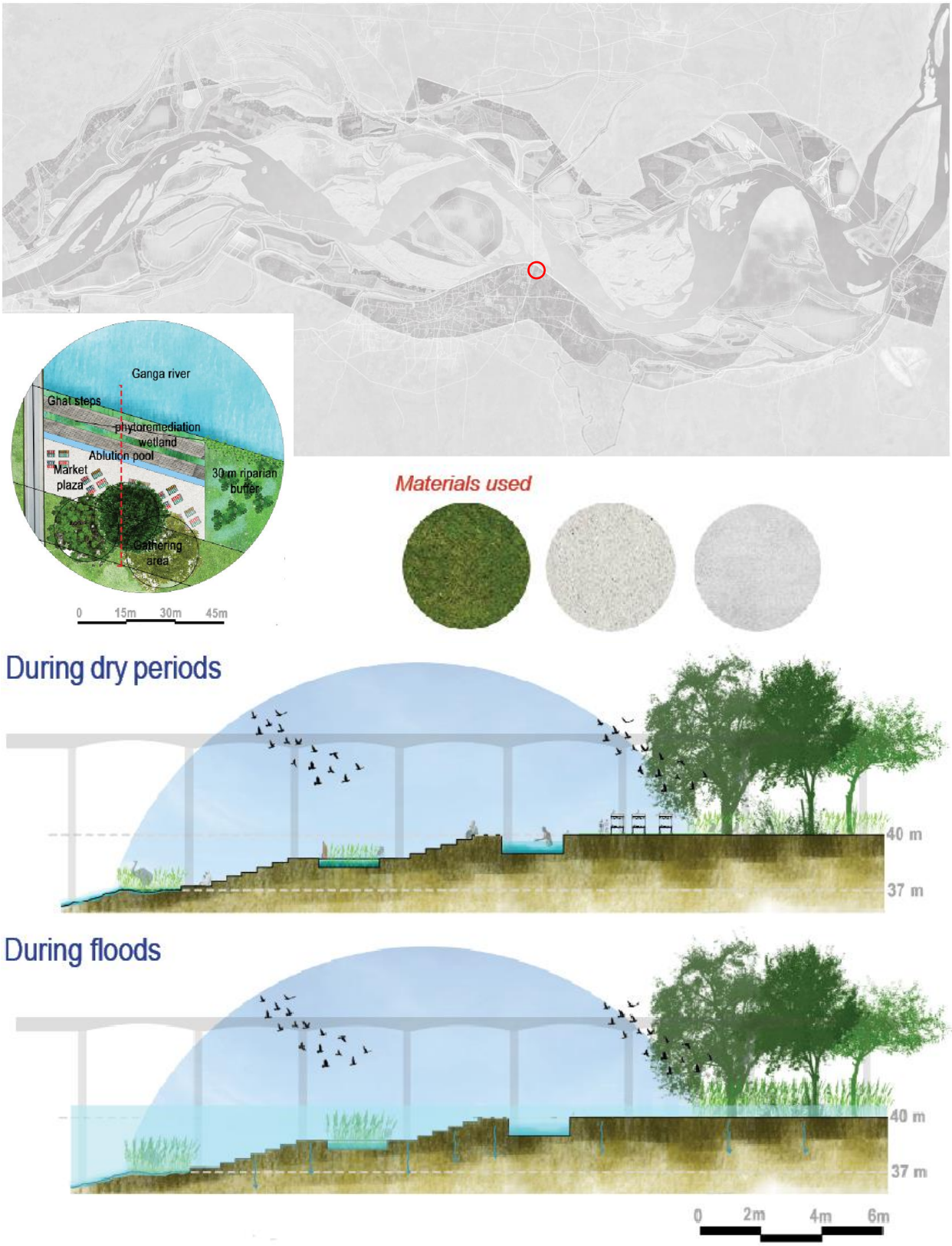


Figure 101 *– Detail plan of Barari Ghat with profile sections showing how the design is flood resilient through use of permeable materials and wetlands proposed. (Source – Author)*

9.4.2 TRAILS AND FLOATING BRIDGES

Due to the sensitivity and fragile nature of the sanctuary extent, access to the river and its adjacent landscapes have been regulated through means of trails and floating bridges (***Figure 102***).Selected areas have been proposed as access points to the main river channel and the natural landscape conservation areas while the rest is proposed to be out of bounds for general public unless granted permission by forest department. Elevated eco trails have been proposed in selected regions of the sanctuary extent for visitors to interact with the river and its biodiversity in the conservation zones. Floating bridges (***Figure 103***) have been proposed in selected zones near the preservation zones. However pathways and walkways are present for accessing the civic fronts zones as well.

Figure 102 *– Proposed master plan showing location of proposed nature trails and floating bridges across the sanctuary core extent. (Source – Author)*

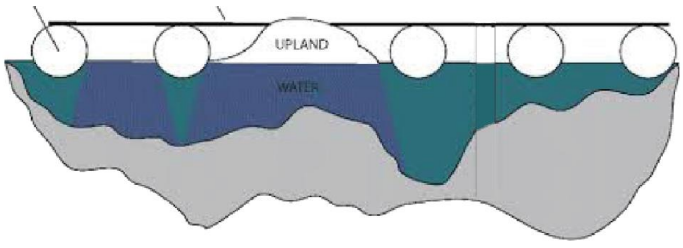


Figure 103 *– Schematic representational reference to indicate how a floating bridge maybe worked out in this context. (Source – Google images)*

9.4.2.1 DELINEATING SITE – NATURE TRAIL NEAR SULTANGANJ GANGA GHAT

An elevated nature trail traversing through diversified scrublands till the restored natural wetlands near Sultanganj Ganga ghat has been proposed for the public visiting the ghats to take in the natural landscape of the region (***Figure 104***).Similar such trails and floating bridges that extent around 2-3m into the river have been proposed at different points across the sanctuary extent for controlled and ecologically sensitive public viewing of the natural bounty (***Figure 104***).

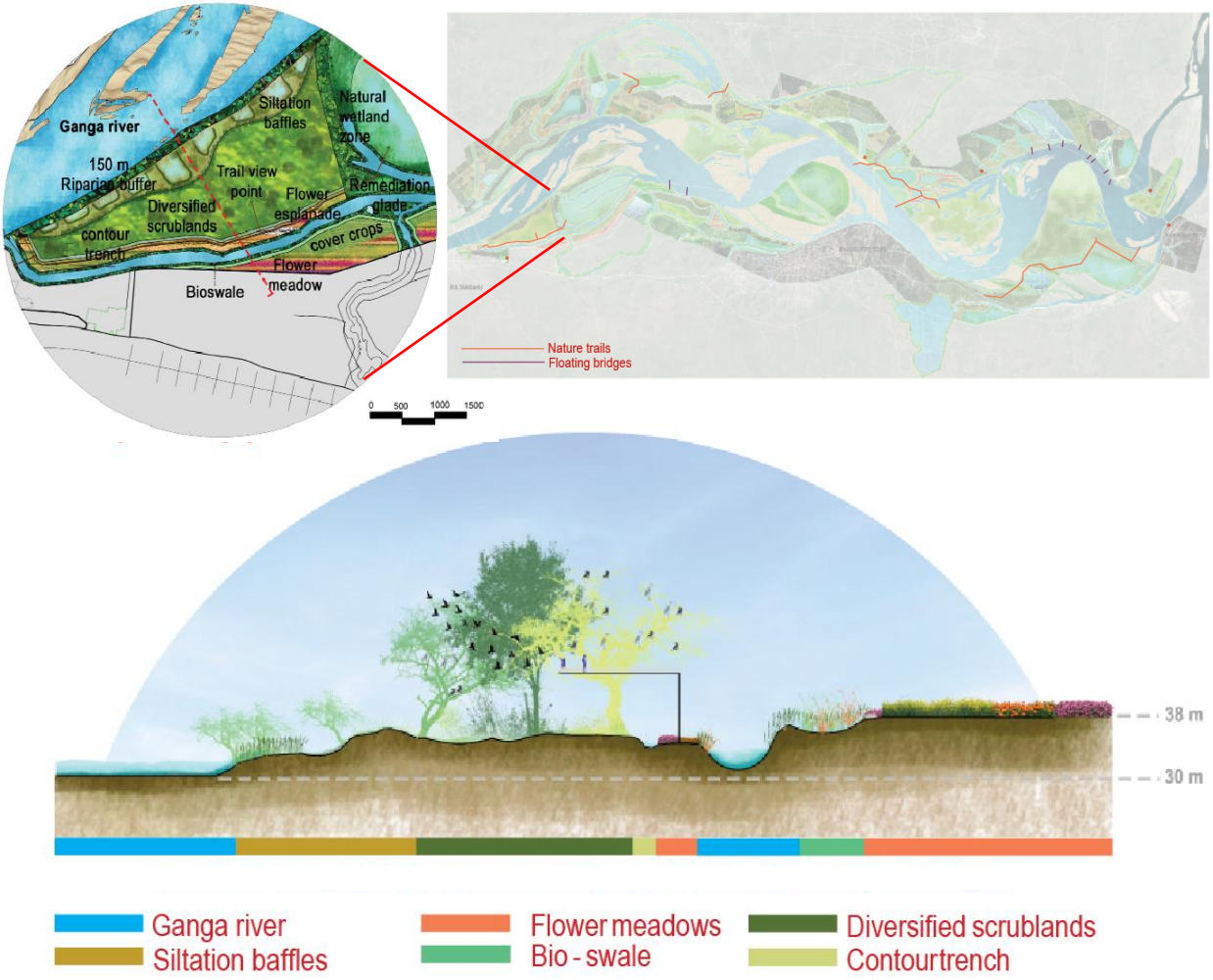


Figure 104 *– Detail plan of eco trail near Sultanganj Ganga ghat with profile section showing how the design is sensitive to the natural landscape. (Source – Author)*

9.4.3 WAYFINDING AND AWARENESS THROUGH SIGNAGES

Wayfinding is an important aspect especially in the case of a project like this owing to its sensitivities. A large portion of the locals and tourists are unaware of the diversity in the region which makes it difficult to initiate protocol measures to protect them. Therefore it is imperative to get creative, bold and explicit with signages (***Figure 105***) so that people from all walks of life and languages understand and are able to interpret them with ease.

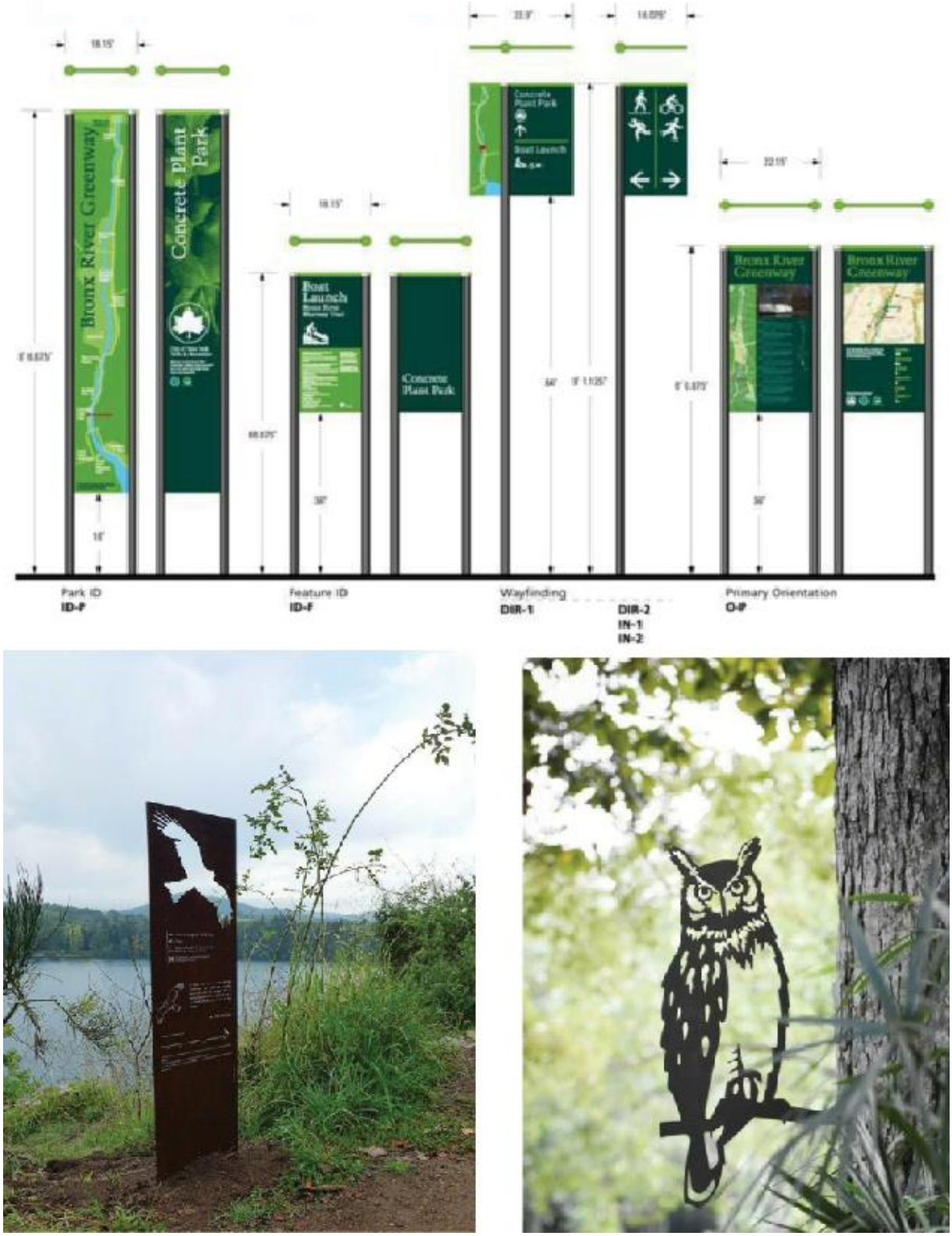


Figure 105 *– Schematic representational reference for the types of signages that may be used across the sanctuary extent. (Source – Pinterest)*

9.4.4 FERRY DOCKING

The design incorporates additional ferry docks *(***Figure 106***)* along with the existing ferry points to increase accessibility across the site extent. Keeping in mind the fragility of the site, traditional ferry is an excellent option as it is not only eco - friendly but also offers an additional source of employment to the local community in the region. By establishing a constant and regular ferry

system, the need for additional hardscape walkway access within ecosensitive region may be minimized.

Figure 106 *– Existing view of ferry being used by locals and visitors to access the banks of Ganga. (Source – VGDS biodiversity conservator Deepak Kumar)*

9.4.5 WATCHPOINTS AND LIGHTING AS PART OF SURVEILANCE

As part of surveillance, watch towers have been proposed at certain points to check illegal on-site activities. Further due to presence of wildlife activity, the overall lighting scheme needs to be limited to essential lighting ***(Figure 107)*** only which is helpful in controlling light pollution and ensure that wildlife presence is not affected as well. Thin lighting strips may be provided for both the trails and the floating bridge so that the needed visibility is retained without hampering wildlife activity in the sanctuary.

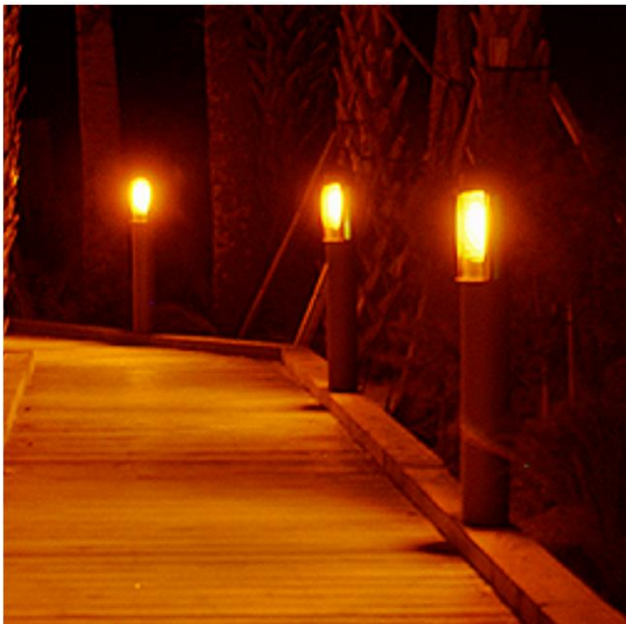
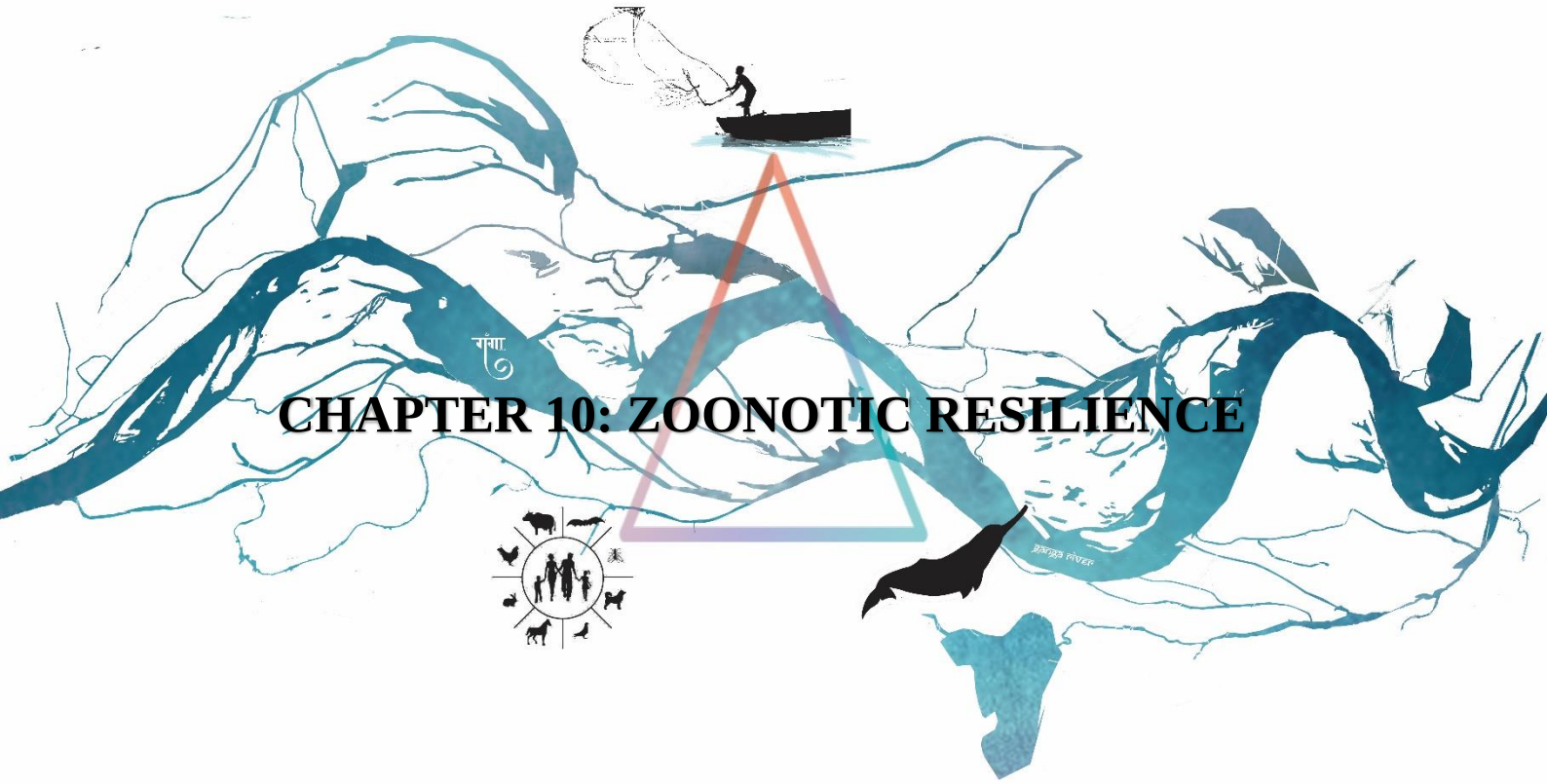


Figure 107 *– Schematic representational reference for the types of lighting that may be used across the sanctuary extent. Here strip lighting and bollard lighting has been shown. (Source – Google images)*



CHAPTER 10: ZOONOTIC RESILIENCE

CHAPTER 10. ZOONOTIC RESILIENCE

10.1 INTRODUCTION

As the conclusion approaches, it is time to return back and address the aspect of 'zoonosis' as mentioned in the thesis topic title. The report has already addressed the basics of zoonosis and the extent to which zoonosis is prevalent in the site extent as well. Although the design proposed is carried out with a penchant for ensuring a balance within the eco sensitivity associated with the site of concern, yet it is imperative to explore the extent to which zoonotic resilience has or hasn't been achieved through means of strategic design interventions. At the same time, it is also essential to understand the benefit of these interventions in the grander scheme of things.

10.2 ACHIEVING ZOONOTIC RESILIENCE

As mentioned in the previous chapter, ensuring a continuous landscape ecosystems with minimal human intervention and interferences contributes a great deal to zoonotic resiliency. However that alone is not sufficient to achieve an ideal zoonotic resilient environment as there still persists a chance for a potential zoonotic spillover as the urban towns of Bhagalpur, Kahalgaon and Sultanganj are quite close to the sanctuary core. To control this spillover, strategies like urban forests, wildlife corridors, flower fields, pollinator hotels etc. were proposed. But this too will work to an extent in the sanctuary core.

What about the urban towns then? How can accidental spillovers be controlled there then?

What needs to be understood here in this context is that more than often humans are not the primary meal option for most zoonotic vectors like mosquitoes (the dominant zoonotic vector in VGDS extent). Rather they end up as a meal due to lack of options mainly in addition to other influencing parameters. This is quite a valuable piece of information that as landscape architects and designers may exploit in the design and this is exactly what has been attempted here as well. An environment for alternate faunal species and natural reservoirs of zoonotic vectors have been established as a zooprophylaxis control strategy to redirect the mosquitoes away from humans (***Figure 108***). Likewise a planting pallete composed of species with high sugar levels can help to redirect the mosquitoes away from humans by offering another optional meal source as mosquitoes are known to feed on sugar rich plants and flowers in the absence of human presence in the region.

Further in the urban centers, it is important to plant species based on a carefully curated pallete as there are species known to be quite essential just for the mosquito lifecycle alone to be completed! Simultaneously it is important to be aware of the ecology that gets established as a result of a certain landscape environment before proposing landscapes like fragmented urban forests etc. so that sylvatic species may be avoided. Sylvatic species are infamous for being vector hosts of numerous zoonotic infections and they thrive in coexistence with human life and resources. This when supported by non – design strategies like vaccination etc. can ensure a zoonotic resilient environment.

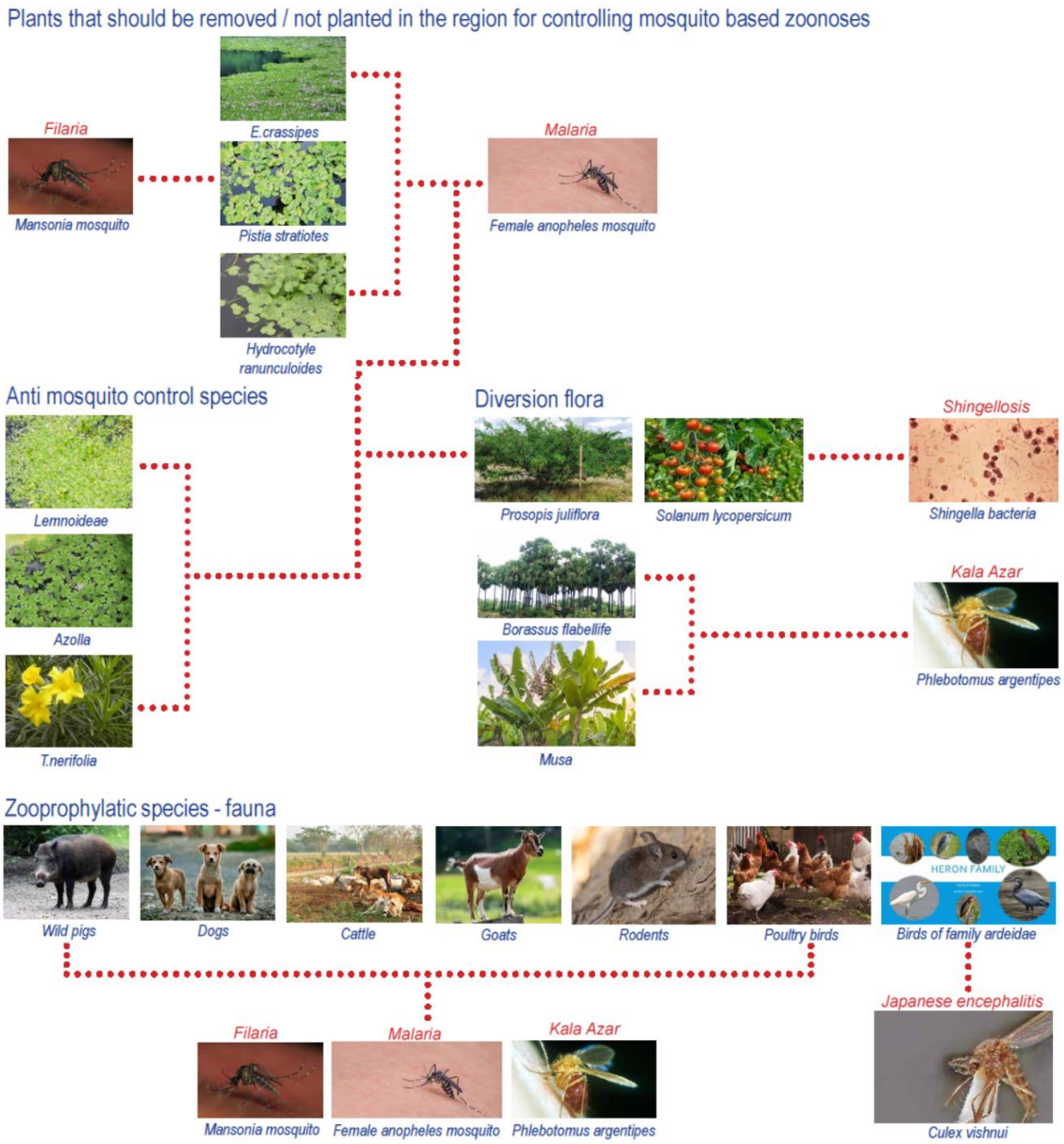


Figure 108 *– Schematic flowchart citing examples for planting and animal reservoirs to understand how zoonotic resilience may be achieved in the proposed site extent. (Source – Author)*

Inorder to ensure that most of the above cited strategies work, it is important to regulate human presence in the landscapes especially after dusk as mosquitoes are more active during those periods. Likewise human access and unnecessary involvement during breeding periods also need to be controlled to ensure the needful balance in the natural ecosystems. This has been achieved by aligning the design strategies on the basis of a design program wheel crafted on the basis of natural breeding and lifecycle periods of the key indicator species in the region like Gangetic dolphins, smooth coated otters, etc. (***Figure 109***).

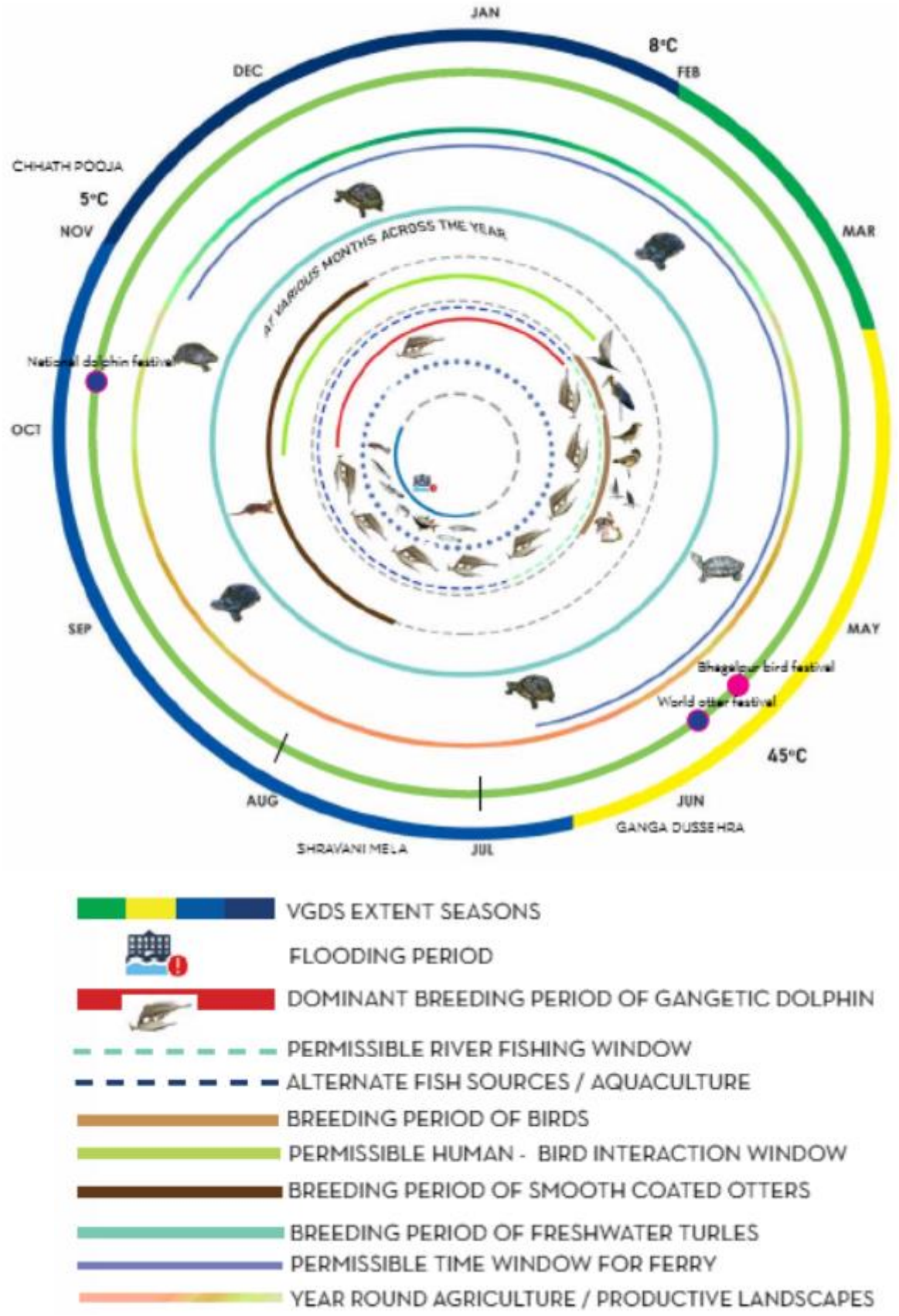
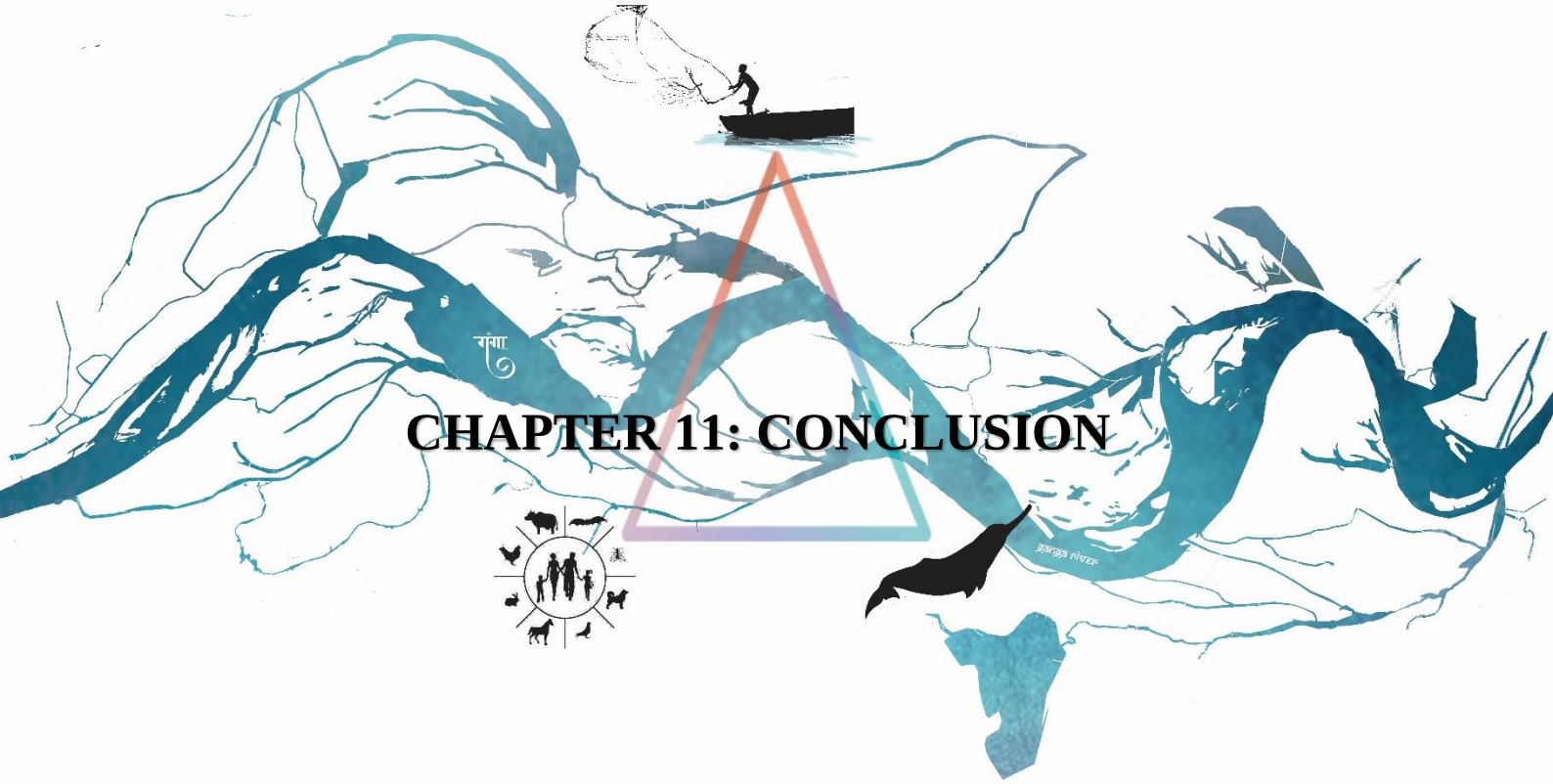


Figure 109 *– Design program wheel on an annual basis (Source – Author)*



CHAPTER 11: CONCLUSION

CHAPTER 11. CONCLUSION

"Sometimes not intervening is also landscape architecture." - By author

The above quote signifies the approach chosen so as to combat the prevailing issues of the proposed site extent. Throughout the course of the study, the aim was to explore and identify if idea of developing a zoonotically resilient landscape is possible or not with a site as dynamic as Vikramshila Gangetic Dolphin Sanctuary and it can be safe to say that it does. However it is only going to be effective if the proposals and interventions are based on input from professionals of various disciplines, supplemented with policies at a regional level. It is essential to recognize and elucidate the causal drivers of zoonoses so as to adapt the landscape epidemiology knowledge into effective public health interventions. Scanning back to the case studies, it is transparent that the zoonoses is mostly an outcome of anthropogenic drivers.

Ganga is a dynamic river with a personality that is strong, fluid and expressive as any other species might. Allowing her to express herself to the fullest is perhaps the best way to ensure that natural equilibrium is restored in the region. Ganga river adopts a braided river character from Bhagalpur (Bihar) to Jangipur (West Bengal) and it is along this stretch that VGDS lies. Braided river ecosystems are unique and fragile ecosystems whose sustenance is heavily dependent on the proper equilibrium with which the associated ecological processes such as abrasion, siltation, erosion etc. take place. Making room for the river is the ideal way to ensure the proper sustenance of the braided river ecosystem and to minimize extensive loss of life and property during floods.

The proposed study and findings are a result of a deep and intensive study of the natural ecological conditions of the VGDS site extent keeping in mind the socio- economic - cultura scenario as well. Therefore the solutions so proposed also majorly focus towards the ecological river sustenance and its associated systems and biodiversity which indirectly shall help promote a better quality of life for humans as well. This research strives to develop a prototypic design approach and framework that may be adapted into any manner of waterscapes across the nation or lay a foundation for advancements at a global scale. However a key limitation that lies in the fundamental understanding of disease emergence is the complexity involved – unknown ecology in unknown hosts. This is quite a fundamentally ecological problem that demands large scale field studies in addition to interdisciplinary collaboration between ecology and health. The spillover is an outcome of a series of barriers that a pathogen overcomes from host reservoir to human settlements. Although our knowledge about mosquitoes and other potential vectors are increasing by the day when it comes to disease ecology basics; strategies to controlling and manage the spillover in the humans is quite limited.

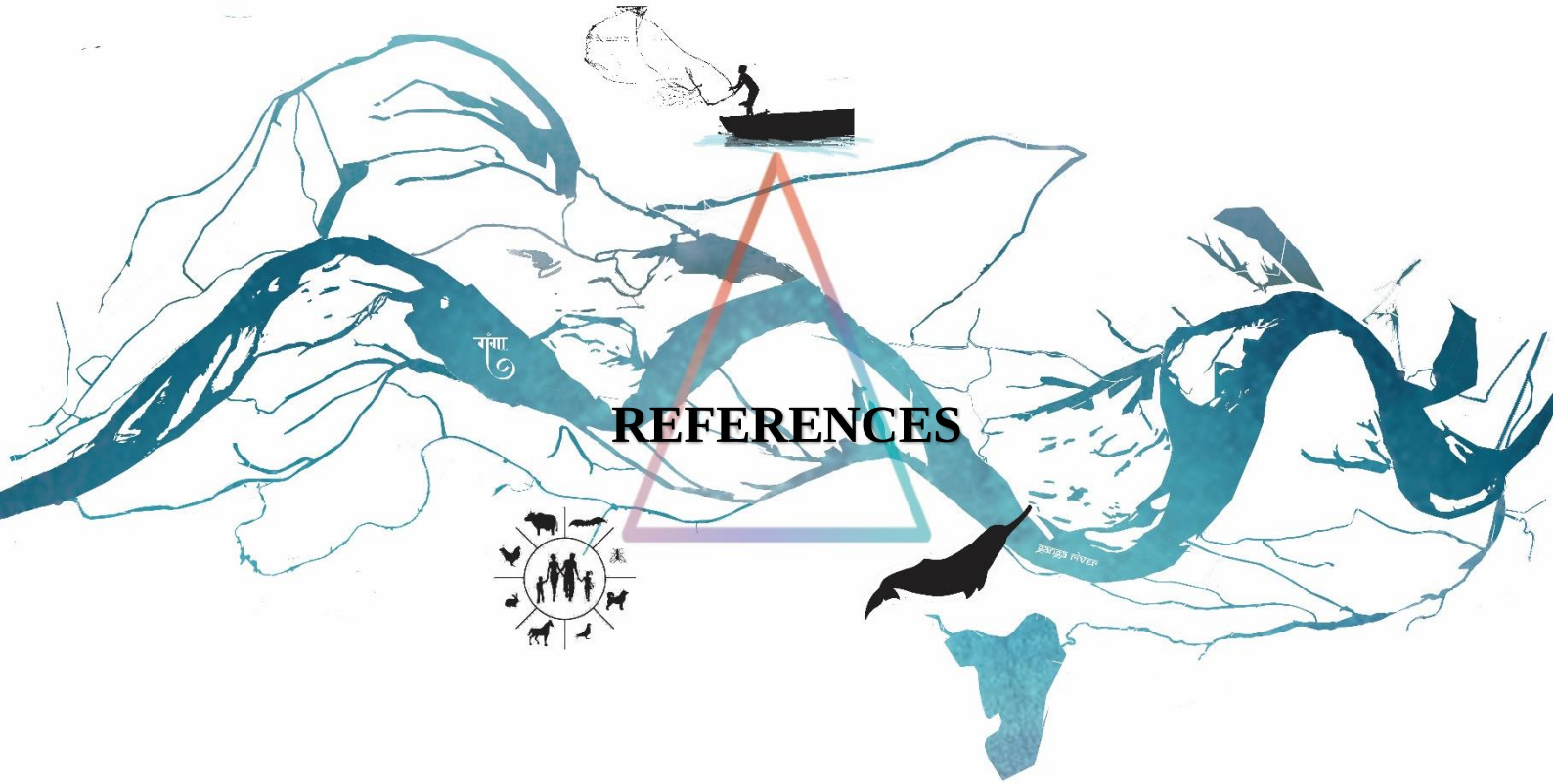
Further as discussed earlier, the stretch of Ganga that passes within VGDS extent is of braided character. Effective sustenance of such ecosystems is possible only when the natural ecological processes happen in the way it should be. Also most of the issues experienced in the proposed site

extent is a result of a multitude of activities that occur both upstream and downstream which is why if the proposed site is to truly tap into its potential, it is imperative to resolve those issues such as damming rivers, sewage influx into the rivers, construction of barrages on rivers such as Farakka barrage etc. prior to dealing with the proposed site challenges. Moreover it is now more important than ever to look at alternative solutions to existing solutions so proposed as a means to resolve current problems as for each intervention so proposed, there may be issues that may be arising somewhere outside of the intervened zone.

Last but not the least the key to protecting the Gangetic dolphins through development of a sanctum lies in the holistic revitalization of the region to support the key indicator species of the region as this will indirectly help sustain the habitat of the Gangetic Dolphins by ensuring that the factors essential for their survival such as clean river water, necessary amount of fish supply, residential areas such as river meanders etc. are present. This is a classic case of hitting multiple birds with a single stone or rather motive in this case.

Keeping the novelty associated with the research in mind, here may be a multitude of ways to achieve zoonotic resilience apart from all that proposed here in this DPR but Understanding pathogen persistence in abiotic environmental reservoirs provides scope for introducing simple interventions that operate on multiple interacting levels to manage zoonotic spillover risk in a landscape. However targeting the interface of contact can perhaps offer solutions in the most unexpected ways.

Which is why the question is how we can integrate ecology, health and a multitude of other parameters that influence a zoonotic spillover because that is way to design landscapes resilient to zoonotic attacks….



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CERTIFICATE OF COMPLETION

This is to certify that this thesis project titled "**THE SOMBER CASE OF AN ODD TRIAD – DOLPHIN, MAN AND ZOONOSES**" was carried out by Smt. **Manju Rajeev Kanchan**, a student of **Masters in Landscape Architecture**, at the**School of Planning and Architecture, Vijayawada**. Theresearch for this project was undertaken under the guidance of the afore-mentioned instituteand completed during the period of **February** to **June**.

This project was shortlisted under the *Sponsored Thesis Project Competition on "RE-IMAGINING URBAN RIVERS"* (2021) hosted by the National Institute of Urban Affairs (NIUA) and the National Mission for Clean Ganga (NMCG).

This report has been submitted by the student as a final deliverable under the competition. All parts of this research can used by any ofthe undersigning parties.

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