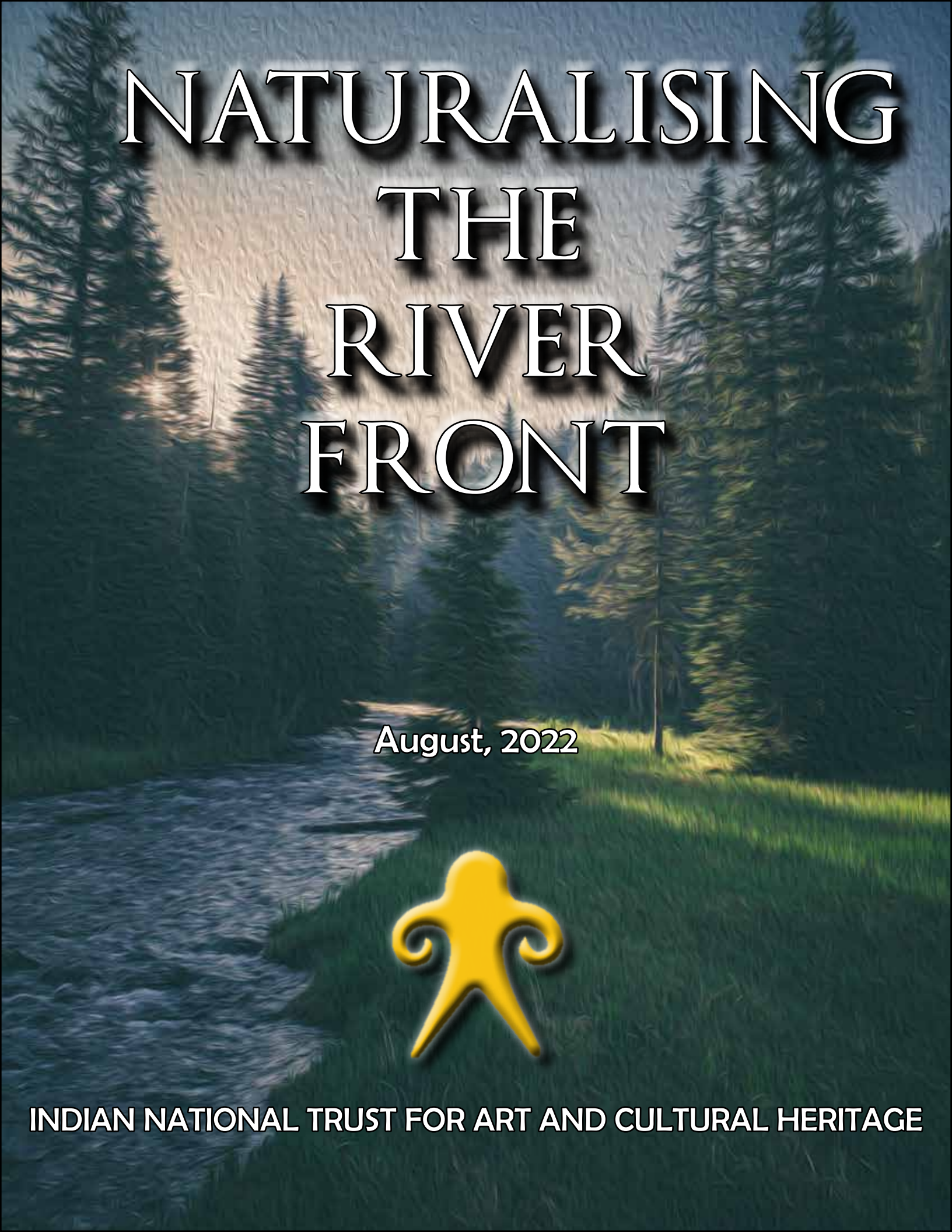

NATURALISING THE RIVER FRONT

August, 2022

INDIAN NATIONAL TRUST FOR ART AND CULTURAL HERITAGE

About INTACH :

The Indian National Trust for Art and Cultural Heritage (INTACH) was founded in 1984 in New Delhi with the vision to spearhead heritage awareness and conservation in India. Today INTACH is recognized as one of the world's largest heritage organizations, with over 220 Chapters across the Country. In the past 38 years INTACH has pioneered the conservation and preservation of our natural, built, and intangible heritage. Headquartered in New Delhi, it operates through various divisions such as Architectural Heritage, Natural Heritage, Material Heritage, Intangible Cultural Heritage, Heritage Education and Communication Services (HECS), Crafts and Community Cell, Chapters, INTACH Heritage Academy, Heritage Tourism, Listing Cell and Library, Archives and Documentation Centre.

Manu Bhatnagar is an urban and environmental planner with over 30 Years of experience in the environment sector. He heads the Natural Heritage Division of Indian National Trust for Art and Cultural Heritage (INTACH) as Principal Director. He is an alumni of Cornell University with qualifications in Regional Planning. He has worked in India and in SE Asia on diverse projects ranging from urban-regional-environmental planning to cultural documentation, river conservation, lake management, water policy, sustainable agriculture, urban biodiversity and geo-tourism.

*Image by Shivank Tanwar From Pixabay

NATURALISING THE RIVER FRONT

August, 2022

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Message From Chairman, INTACH

Today urbanization is expanding and occupying every open space within cities and on the periphery. River banks are no exception but rivers cannot be considered in isolation of their banks. The harsh texture of our cities can be mellowed with greener banks which allow ecological processes to function and provide a softer environment for urbanites in which to commune with nature.

I earnestly hope that the insights in this monograph will influence agencies involved in river front development to reorient their approach away from excessively hard river fronts to greener river banks accommodating humans and also flora and fauna.

Maj. Gen. LK Gupta [Retd]
Chairman, INTACH

Foreword

River front development is the new buzz word in the lexicon of urban local bodies. Taking up a river front sends a signal of smartness, dynamism and happening. Most river fronts, however, are celebrations of concrete with hard surfaces killing the ecological processes, habitats and niches.
But is there a way to create softer, natural river fronts where natural processes thrive, the river eco-system remains integrated, and a sense of serenity soothes and elevates the spirits of the visitor?

This monograph provides pointers to the several ways whereby concrete pavements recede and enable natural elements to come to the fore in river front development.

Manu Bhatnagar
Principal Director
Natural Heritage Division
INTACH

CONTENTS

River front : An introduction

The general impression is that river fronts are places of hard surfaces – built facades, stone or concrete walkways and steps leading to the water edge. There does not appear to be any place for natural features and hence no ecological processes as a result. Let us look at some of the ancient and modern river fronts to derive some insights.

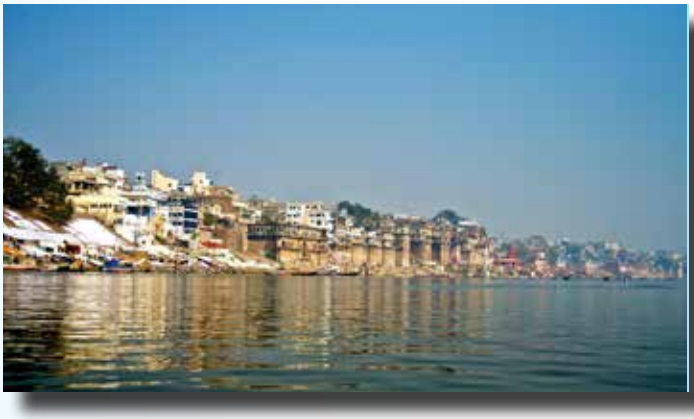


Figure 1: Ganga River Front at Varanasi

Source - Oreotikii from Pixabay

Figure 2 : Manikarnika Ghat at Varanasi

Source - D MZ from Pixabay

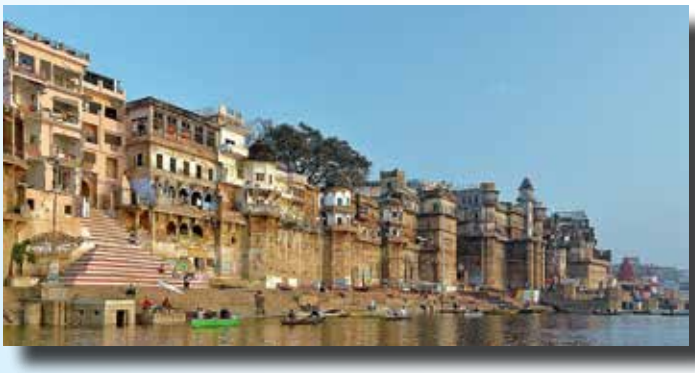


Figure 3: Varanasi Ghat

Source - Makalu from Pixabay

Figure 4: Kashi Vishwanath Corridor Under Construction

Source - desfosse from Pixabay

So what do these ghats at Varanasi tell us about eco-friendly features. In ancient times nature dominated the landscape and hence it was not essential to bring in natural features in the ghats hardscape.

Recent developments also do not show any inclination to design eco-friendly river fronts. Now let us examine some recently designed and implemented river fronts in India.

Figure 5: Assi Ghat, Varanasi
Source - By Nandanupadhyay | commons.wikimedia.org)

Figure 6: Chandi Ghat, Haridwar
Source - WAPCOS Limited Twitter

Figure 7 & 8: Sabarmati River Front, Ahmedabad - The Famous Trend Setter
Source - ahmedabadtourism.in

These river fronts are a celebration of concrete and stone with a sprinkling of regimented and manicured greens as a token gesture towards eco-friendliness. The natural shoreline/bank of the river has been completely obliterated wiping out habitats and the transition zone between water and land.

Figure 9: Patna River Front
Source - architecture.live

Figure 10: Gomti River Front, Lucknow
Source - Gomti River Front|facebook.com

What is an Eco-friendly River Front?

A VISION STATEMENT

The river will be able to support a habitat for riverine biodiversity to thrive: This is the ideal situation from an environmental point of view. This vision of the urban river management seeks to ensure healthy rivers that are able to provide an environment for diverse species of flora and fauna to flourish in their natural states.

To Enhance The Riparian Buffer Along River Banks

Rationale: A riparian buffer is a longitudinal stretch of vegetation on either bank of a river, whose significance cannot be over-emphasized. It acts as a shock absorber for the river and its aquatic ecosystem from detrimental developmental activities. The buffer zone also protects the urban area from the impact of floods. Ideally, the riparian buffer should be a continuous stretch with a width of twelve to fifteen meters. *(Rajeev R Mishra, 2020)*

In view of these constraints, it is important for cities to make optimal use of the floodplain area. One of the activities that can be considered is the development of Biodiversity Parks, which are increasingly becoming an attractive option in cities. While not protected areas they come under the classification of **OECM [Other Environmental Conservation Measures].**

A widely cited paper by *Parris et al. (2018)*, advocates the following principles for biodiversity planning in cities are summarized as :

I. **Protection:** The first principle is to identify and protect areas of high biodiversity (both current and potential) in the floodplains. It is rarely possible to recreate entire ecological communities or ecosystems once they are lost. Hence, it is often more effective to keep existing biodiverse areas than to attempt to recreate them in the future. Such areas may include patches of remnant vegetation, wetlands, natural drainage lines, or larger green spaces containing varied habitat types.

II. **Connectivity:** The second principle is to maintain or re-establish connectivity between patches of habitat to allow the movement of animals and the propagules of fungi and plants (spores, pollen and seeds) across the landscape. Such movement is important for the maintenance of genetic diversity and the long-term persistence of populations and diverse ecological communities.

III. **Construction :** The third principle is to construct ecological features that can provide habitat for a range of plant and animal species. To retain biodiversity, parks need to construct ecosystem components that enhance not just the number but also the diversity of spaces for species.

IV. **Cycles :** Water, nutrient and energy recycling are critical for sustaining ecosystem services and biodiversity. **Conversely, the ecosystem services these cycles provide (such as clean water and the removal of pollutants) depend on diverse biological communities**. As such providing features which enable existence and functioning of biological communities is important.

V. **Benevolence:** There are some obvious adverse impacts of urbanization on biodiversity, such as mass fish mortality due to polluted water, migration of birds due to air pollution, etc. However, in many cases, the negative impacts are more subtle. For example, artificial light at night can interfere with circadian rhythms, sleep patterns and navigation in animals.

Understanding the river ecology

Some understanding of relevant elements of river ecology is essential to put the above principles into practice. We begin with floodplains for that is where the river front interventions are made and let us remember that urban stretches of rivers can be kilometers wide such as the Hoogly at Kolkata or just a few meters wide such as Khan river in Indore. Let us also recall that in a monsoonal climate the flood pulse can expand the river into the floodplain but the lean season flow may be much narrower.

Floodplains are unique ecosystems at the interface between land and rivers supporting a variety of environmental processes and functions.

Figure 11 : Ganga Floodplains around Munger, Bihar

(Source - *Photo by Rajiv Sinha on indiaclimatedialogue.net*)

Floodplains are the land area adjacent to the river that include the region between the river channel and the base of the valley that experiences flooding during the season of high water discharge.

A significant feature of the floodplains are the Riparian forests.

Riparian Forests

Also known as the alluvial or floodplain forests and riparian woodland, riparian forests are the highly dynamic interface of forested or wooded area between land river or streams that are quintessential in increasing the water quality of the associated rivers or streams by acting as an interception for sediments, nutrients, pesticides, debris etc. Riparian forests are often used as a conservation measure to protect the river ecology from the impact of adjacent land use especially agriculture and construction.

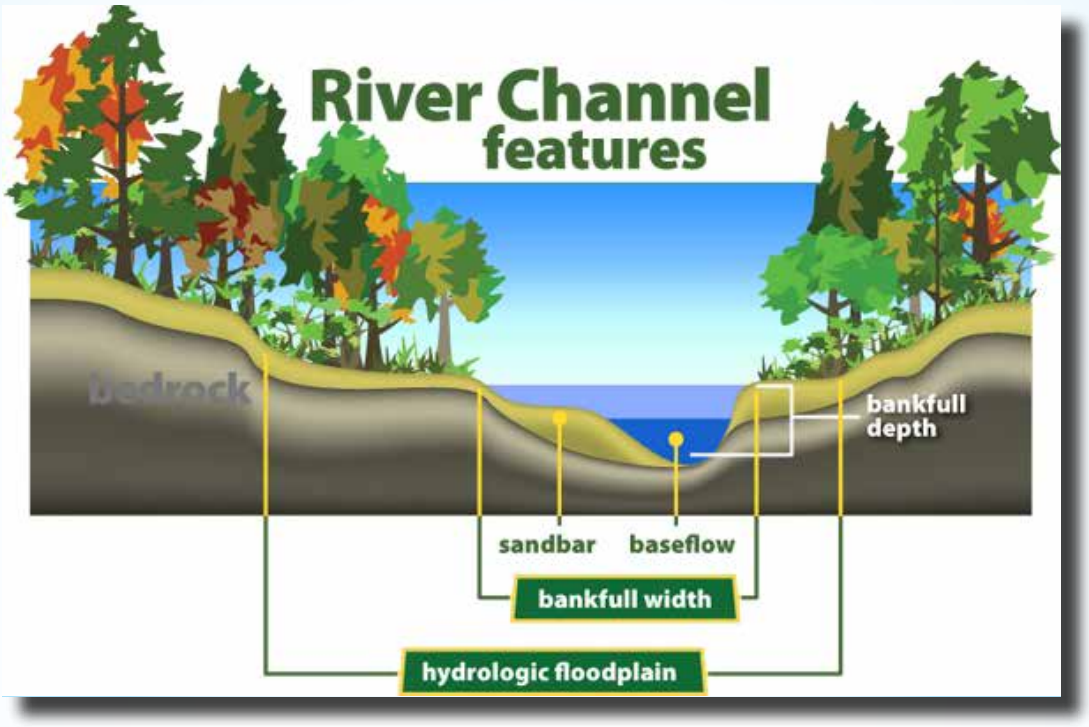


Figure 12 : River Channel Features

Source - mpwmd.net

Riparian forests act as a niche of high community diversity due to the fact that the flood events and geomorphology create heterogeneous conditions that favor species coexistence. The Riparian forests also function as a specialized and disturbance-adapted species subset. Since they are more resilient to the wet/dry periods, they showcase a local and landscape scale diversity.

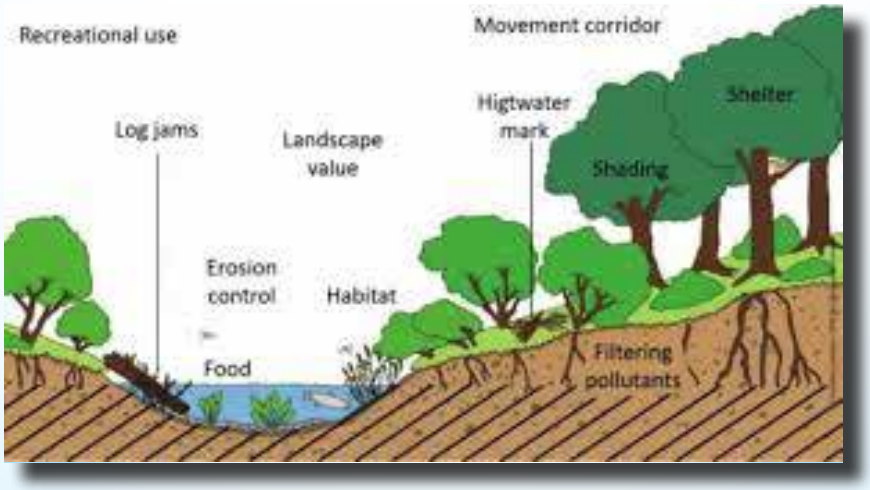


Figure 13 : Functions of Riparian Forests

Source - www.lodevoisetlarzac.fr

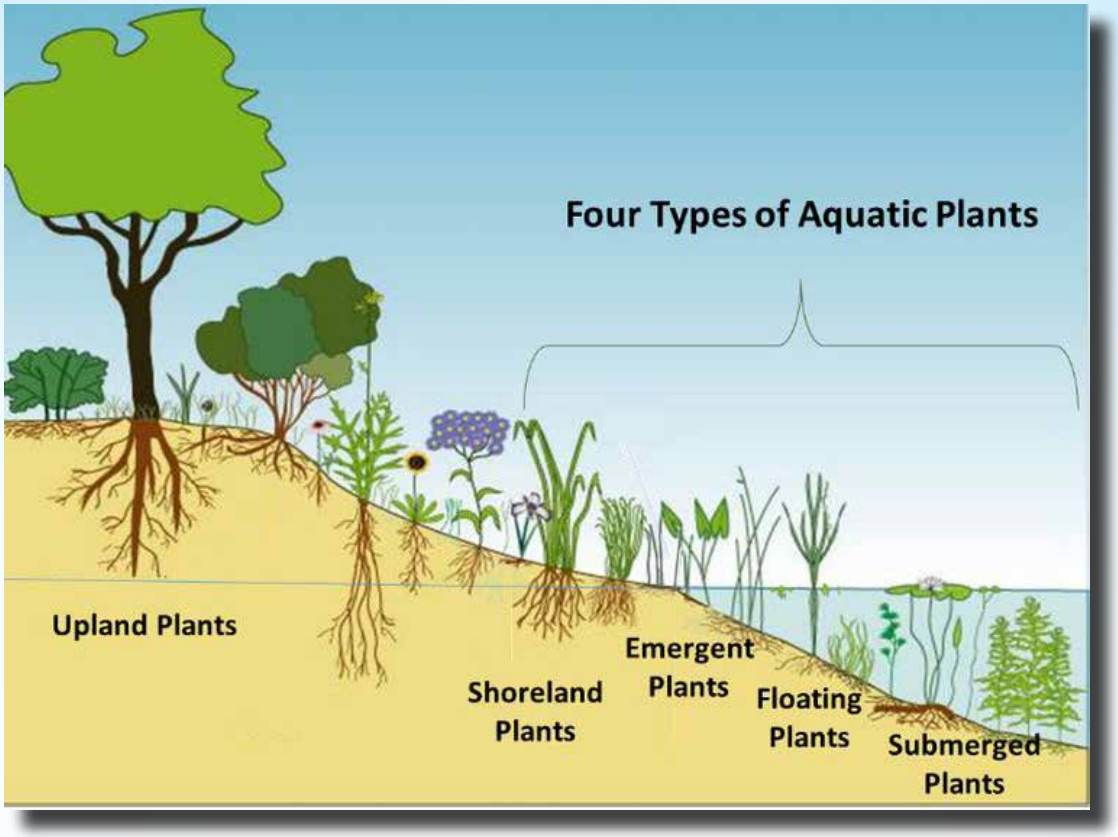


Figure 14 : High Community Diversity in Riparian Buffers

Source - www.canr.msu.edu

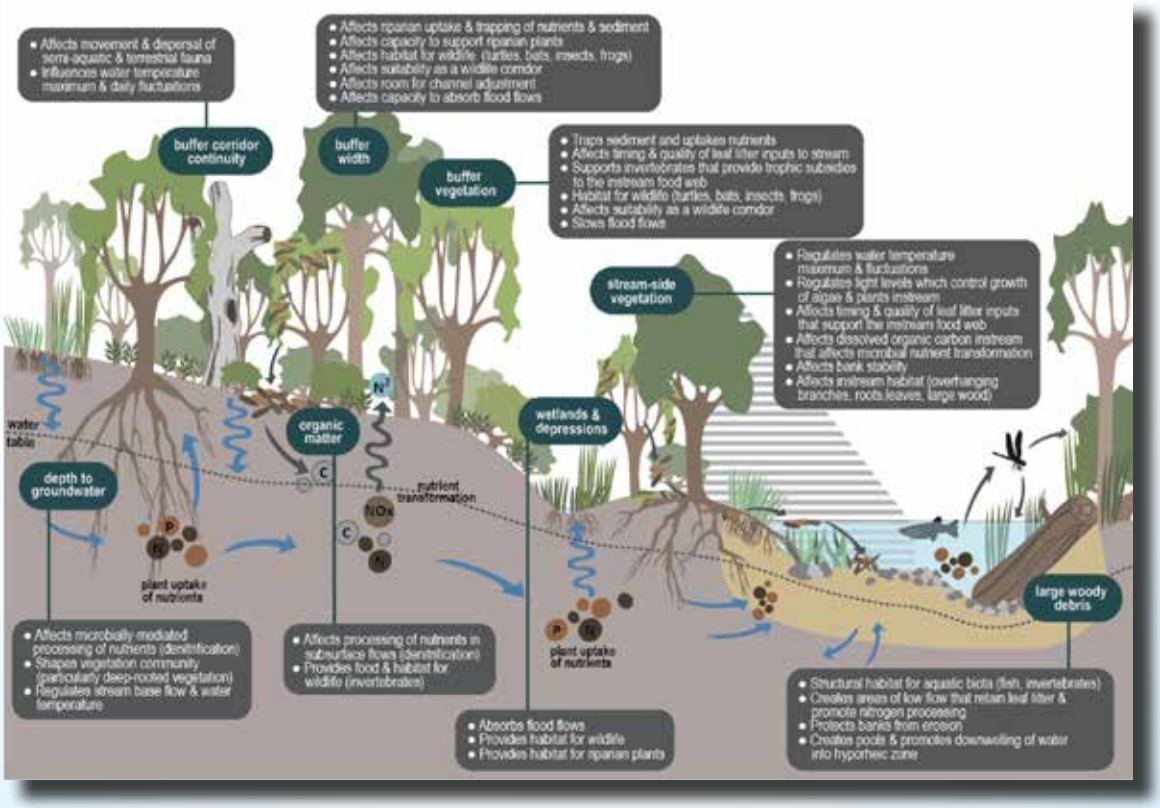


Figure 15 : Riparian Forests Supporting Biodiversity

Source - www.sariverauthority.org

Benefits and Services of Riparian Forests

I. Water related benefits

1. Erosion Control and buffering effects
2. Hydrological regulation
3. Filtering nutrients and sediments

II. Biodiversity benefits

1. Wildlife habitat and corridors
2. Quality of aquatic ecosystems

III. Agriculture and carbon-related benefits

1. Pollination and pest control
2. Retention of agrochemical pollutants
3. Carbon sequestration

IV. Cultural and social benefits

1. Recreational site for bird watchers, photographers, anglers etc
2. Provide water for multipurpose use during low flows
3. Accessible grazing land, shelter and water for livestock

Figure 16 : Avian Biodiversity

I. Riparian Forests and Water Quality

Riparian forests are quite significant in preserving the water quality, maintaining the health of the stream and controlling floods & surface runoffs which in turn benefits the entire associated ecosystems.

The riparian vegetation acts as filter and regulates the nutrient, sediment and pollutant flow into surface and groundwater. The riparian forests, by means of various mechanisms, reduce the amount of nitrogen, phosphorus and other nutrients reaching the streams, thus, preserving the water quality.

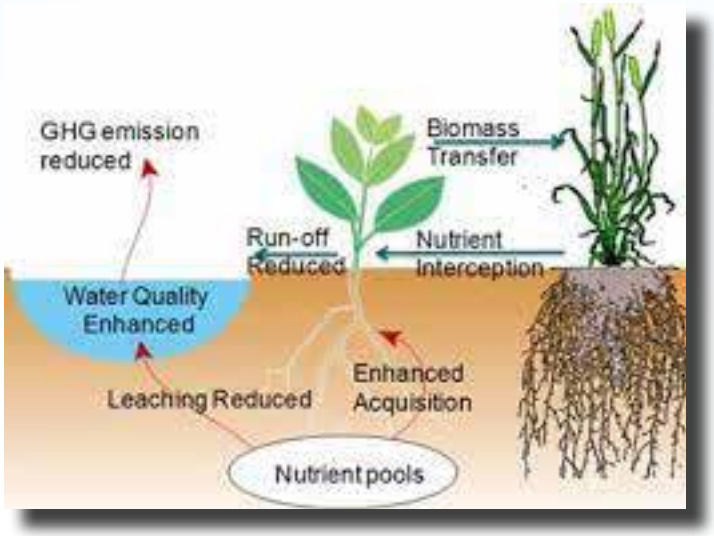


Figure 17 : Riparian Forests as Nutrient Filter (*Source - Stutter, M.I. 2012.)*

The trapped silts which are high in pollutants react with the forest soil and litter removing the agricultural nutrients by the means of biofiltration. The uptake of excess nutrients by the forest vegetation via evapotranspiration reduces the bioaccumulation.

Apart from acting as nutrient sink, filter and transformer, riparian forests prevent the infrastructural damage and wildlife harm from suspended solids by reducing the speed of water flow when it comes in contact with decaying leaves, twigs and branches, thus settling out the sediments. The roughness of the forest floor and the presence of vegetation comes handy in reducing the intensity of water flow leading to a significant reduction in the downstream flooding.

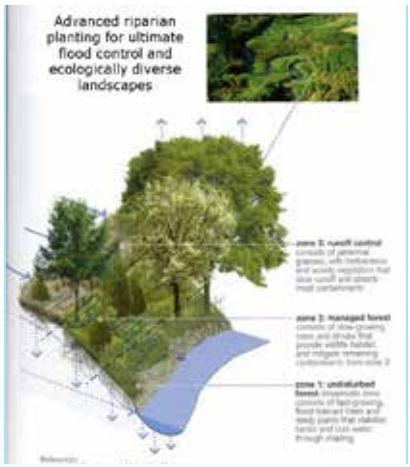


Figure 18 : Riparian Forests as Nutrient Filter, Sink and Transformer *(Source - rgsweather.com)*

II. Biodiversity, Habitat and Resource Related Benefits

It is generally seen that the riparian forests have higher species diversity due to the confluence of various habitats comprising of aquatic, semi aquatic and terrestrial organisms. The presence of the variety of micro-habitats and niches adds to the species diversity.

The riparian forests serve as a preferred habitat for many species due to the availability of water, shelter and food. The regulated temperature along with the habitat complexity and connectivity makes riparian forests a safe haven for many species.

Figure 19 : Great Indian Hornbill
Source - By varmarohit
creativecommons.org

Figure 20 : Indian Bull Frog
Source - By Danielnasika1
creativecommons.org

Figure 21 : Water Hyacinth
Source - By Dinesh Valke
creativecommons.org

In addition to the biodiversity benefits, the riparian forests also aid in nutritional resources and subsidies for the species residing. The terrestrial carbon inputs subsidize the aquatic food webs which leads to the enhanced productivity and biodiversity of both habitats. This paves the way for the export of emergent aquatic insects.

The food base of streams within riparian forests is mostly derived from the trees, but wider streams and those that lack a canopy derive the majority of their food base from algae. Biofilms can be understood as microbial consortia of autotrophs and heterotrophs, coexisting in a matrix of hydrated extracellular polymeric substances and these are most important in intermittent rivers where the importance of the water column is reduced during extended low-activity periods of the hydrological cycle. Micro-fauna also inhabit the biofilm, predating on the organisms and organic particles and contributing to its evolution and dispersal.

These two main biological components are respectively mainly algae and cyanobacteria on one side, and bacteria and fungi on the other. Biofilms therefore form a highly active biological consortium, ready to use organic and inorganic materials from the water phase, and also ready to use light or chemical energy sources.

Microorganisms

Bacteria are present in large numbers in lotic waters. Free-living forms are associated with decomposing organic material *(M.S.University of Baroda, D50510162)*, biofilm on the surfaces of rocks and vegetation, in between particles that compose the substrate, and suspended in the water column. Bacteria play a large role in energy recycling.

Diatoms are one of the main dominant groups of algae in lotic systems and have been widely used as efficient indicators of water quality.

Primary Producers

Algae, consisting of phytoplankton and periphyton, are the most significant sources of primary production in most streams and rivers. Phytoplankton float freely in the water column and thus are unable to maintain populations in fast flowing streams. They can, however, develop sizeable populations in slow moving rivers and backwaters. *(M.S.University of Baroda, D50510162)*

Insects And Other Invertebrates

Up to 90% of invertebrates in some lotic systems are insects. These species exhibit tremendous diversity and can be found occupying almost every available habitat, including the surfaces of stones, deep below the substratum or adrift in the current. Insects have developed several strategies for living in the diverse flows of lotic systems. Some avoid high current areas, inhabiting the substratum or the sheltered side of rocks. *(M.S.University of Baroda, D50510162)*

Fish and other Vertebrates

Fish are probably the best-known inhabitants of lotic systems. Continuous swimming expends a tremendous amount of energy and, therefore, fishes spend only short periods in full current. Instead, individuals remain close to the bottom or the banks, behind obstacles, and sheltered from the current, swimming in the current only to feed or change locations. Some species have adapted to living only on the system bottom, never venturing into the open water flow.

Other vertebrate taxa that inhabit lotic systems include amphibians, such as salamanders, reptiles (e.g. snakes, turtles, crocodiles and alligators) various bird species, and mammals. With the exception of a few species, these vertebrates are not tied to water as fishes are, and spend part of their time in terrestrial habitats. Many fish species are important as consumers and as prey species to the larger vertebrates mentioned above. *(M.S.University of Baroda, D50510162)*

Figure 22 : Indian Carp (Source - Image by Ralph from Pixabay)

NATURALISING THE FLOODPLAINS

Here the challenge arises that many urban river fronts have little option but to have substantial civil work interventions in the nature of walkways, ghat steps and other architectural features, lighting, manicured grass patches. Given the narrow remnant space there seems to be little scope naturalizing the floodplain. In the light of what we have just learnt let us look at some possibilities:-

I. The Riprap Edge

Boulders or large crushed stone lining of edges prevents bank erosion while providing a visually natural edge which provides habitat for several aquatic fauna and riparian flora thus enabling many ecological interactions to take place.

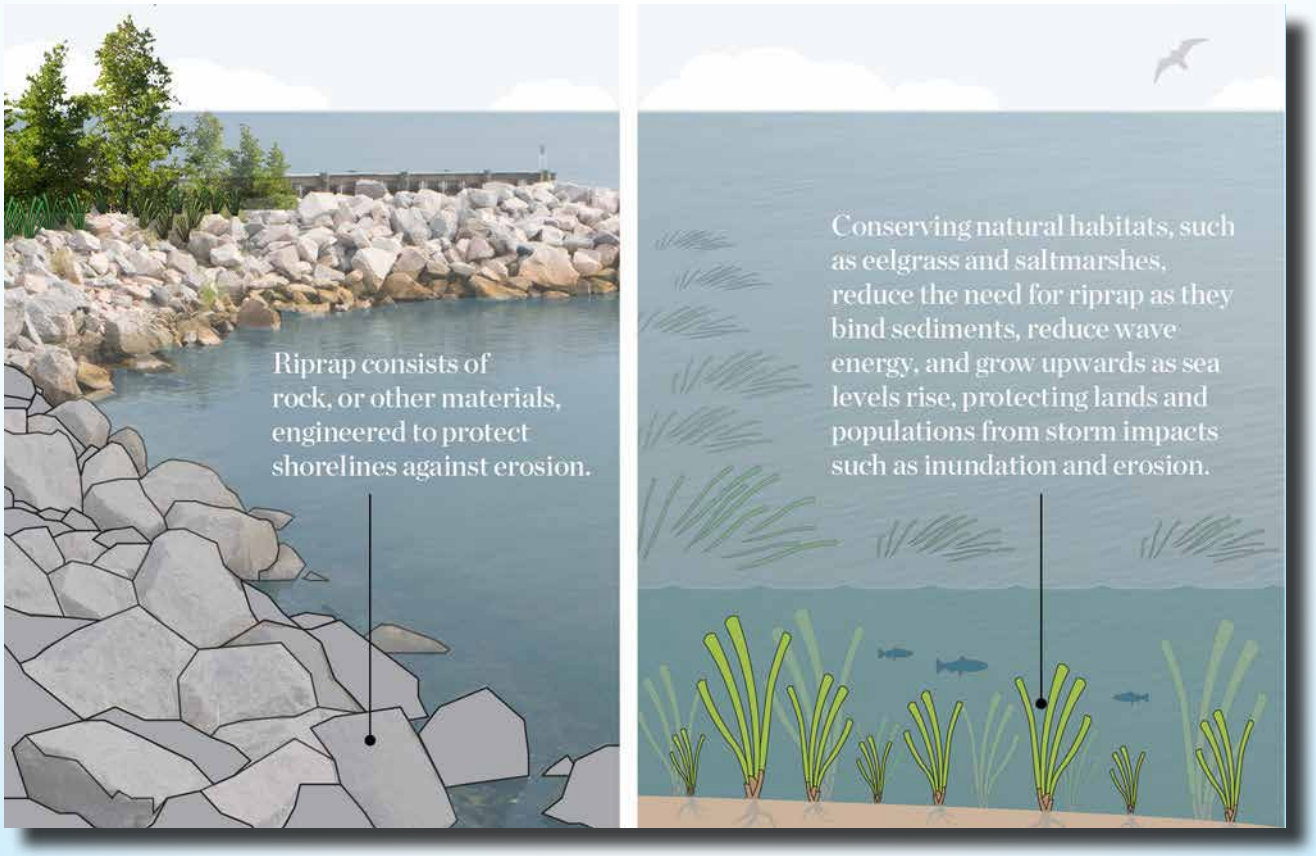


Figure 23 : Riprap Edge (Source - www.washingtonnature.org)

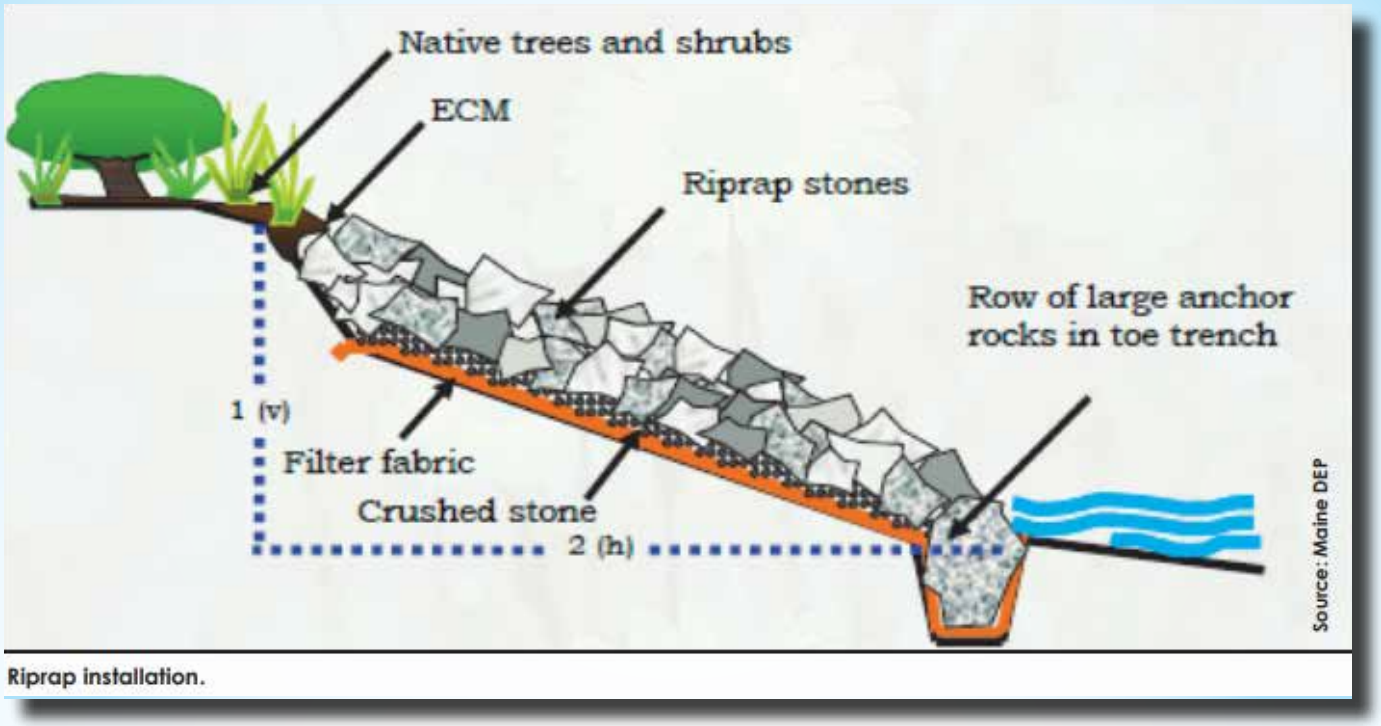


Figure 24 : Riprap Installation

Source - dec.vermont.gov

II. Introducing Riparian Grasses

Several natural riparian grasses are native to various localities. These mitigate the energy of high velocity flows while retarding soil erosion because of their extensive root network. The grasses also act as biofilters, providers of habitats not only to aquatic fauna but also to avian species and pollinators.

Figure 25 : Riparian Grass Along River Bank

Source -By krossbow|creativecommons.org

There are several species of tall riparian grasses which are highly effective in stabilizing banks while providing habitats to both micro and macro fauna.

The grasses are very economical compared to civil works or sandbags, are not swept away by floods and thus do not require annual repairs or replacement.

Figure 26 : Typha Angustifolia (Narrow Leaf Cattail)
(Source - By nature80020|creativecommons.org)

III. Trees

While, as stated earlier, tree leaves are a source of food for aquatic organisms, trees also keep the edge waters cool, particularly in narrow streams, thereby creating conducive condition for some of the aquatic fauna. Trees with large shady canopies, suitable for river edge conditions may be chosen.

Figure 27 : Tlawng River, Mizoram
(Sources - Coolcolney|creativecommons.org)

IV. Instream Landscape (The Streamscape)

Can the aesthetics of streams and rivers be improved through measures which contribute to the ecological processes within the flowing waters ? A few examples can show how.

The placement of natural stones and steps generate aeration instream and create habitats for microflora and for fauna while situating visually pleasing features which reinforce the effect of the river as a force of nature, simultaneously breaking the harsh geometry of our built spaces.

Figure 28 :- Boulders in a Stream

(Source -megamanual.geosyntec.com)

Shallow streams can have such spatial patterns of boulders bringing life to a dull stream. Steeper courses can have cascades and large boulders which the waters negotiate creating white water. Moreover, large boulders add powerful visual elements while providing habitat.

These measures not only add on to the aesthetics and filtration capacity of the stream but also serve as a habitat for many organisms that prefer these arrangements due to protection of favourable conditions.

Figure 29 : Cascades in Steeper Course of Stream

Source - By extranoise|creativecommons.org

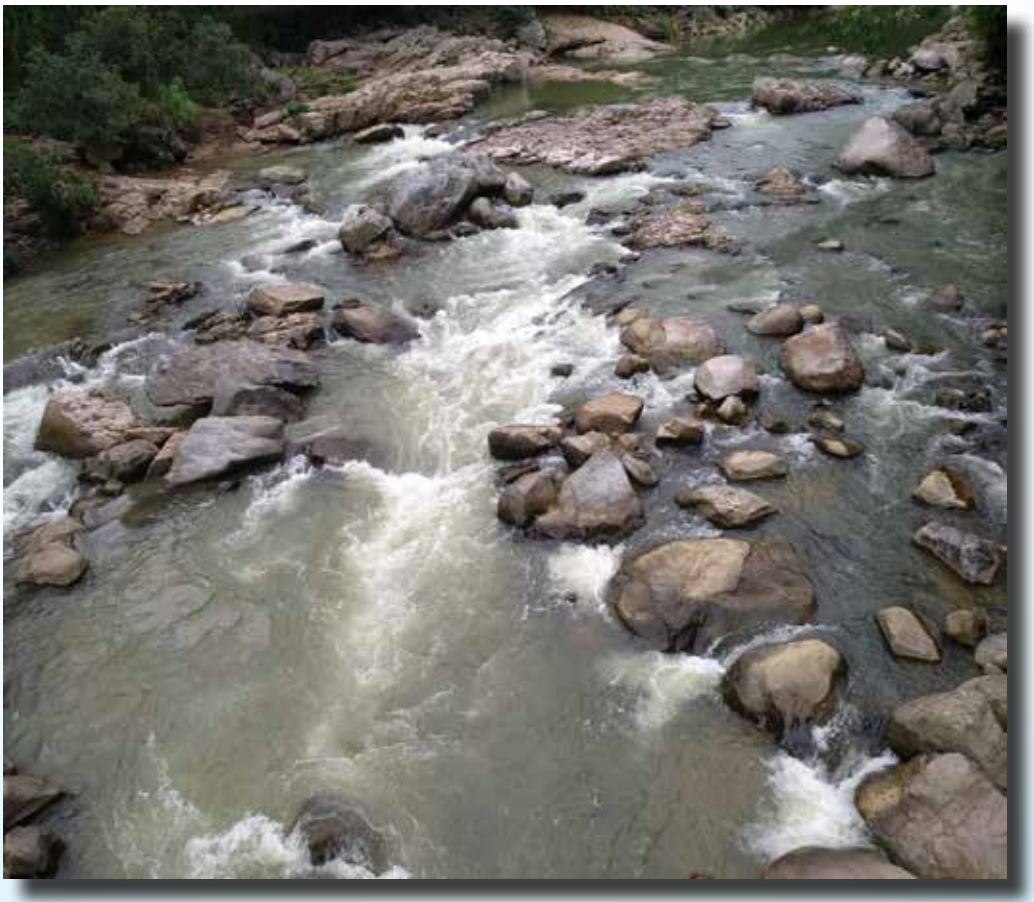


Figure 30 : Boulders are a Powerful Visual Element

V. The Opposite Bank

In most cases the opposite shore is unbuilt. Take the case of Varanasi where the left bank is the intensively built ghats which are the spiritual heart of the ancient city. But the right bank towards Ramnagar is as yet unbuilt and can have ecologically beneficial features as a compensation for the present completely hard river front of Varanasi. This is a possibility in many cities and settlements.

Figure 31 : Varanasi Satellite View *(Source - Google Earth)*

Figure 32 : Patna Satellite View *(Source - Google Earth)*

Patna – Right Bank all hardened whereas the opposite bank and even the 'diara' [island] are replete with ecological possibilities

VI. Instream Islands

In already built hardened river fronts where retrofitting is not feasible the possibility of introducing artificial islands may be examined. These could be floating as shown in Figure 33 or they can be stationary built with soil and stabilized with riprap and vegetation and geo-textiles. The islands would thus provide habitats, welcome floral and faunal elements and be soft on the eye. Alternately, if existing islands or sandbars are present the same could be landscaped with appropriate natural features as shown in Figure 34.

Figure 33 : Floating Instream Island *Source -Wikipedia*

The instream islands can be built with coir logs. Sand Bars can be vegetated and stabilized incorporating small waterbodies. These offer visual relief , habitats and eco-system processes.

Figure 34 : Emerging Riverrine Island (Ganga River Stretch Fatehpur-Unnao, UP)
Source -Abhishek Kr. Upadhyay, NHD, INTACH

VII. Light Pollution

Introduction of fancy lighting brings in the element of light pollution which interferes with the circadian rhythms of flora and fauna. Lighting plans may consider lower wattages and be oriented so as not to light up the waters.

Figure 35 : Sabarmati River Front at Night

Source - cityvillagenews.com

Figure 36 : Gomti River Front at Night

Source - Rohitgadher at r2.community.samsung.com

VIII. Retrofitting

Introduced riprap along RCC walls , transplanted mature trees, instream landscape and boulders can bring ecological processes into play even in existing situations. There is a need to soften the river front rather than emphasizing hard engineered elements.

Figure 37 : Retrofitting an Existing Urban Stream

Source -commercialdistrictadvisor.blogspot.com

THE WAY FORWARD

Patna has 3 stretches along the river. The river front in the central stretch, which is the colonial Patna, has been hard engineered as shown in Figure 9.

The following image shows the conceptual landscape proposals along the old Patliputra on an area of some 800 acres which would act as the green lungs for the dense and congested old city in spite of an ill-advised expressway intruding on elevated columns.

Figure 38 : Proposed Landscape across Ganga Floodplain (Right Bank) Patliputra, Patna

The upcoming river front at Qudesia Ghat on the Yamuna in Delhi has a 6 m wide strip of riparian grasses to stabilize the shoreline and provide ecological functions. The sand bar can be vegetated in due course.

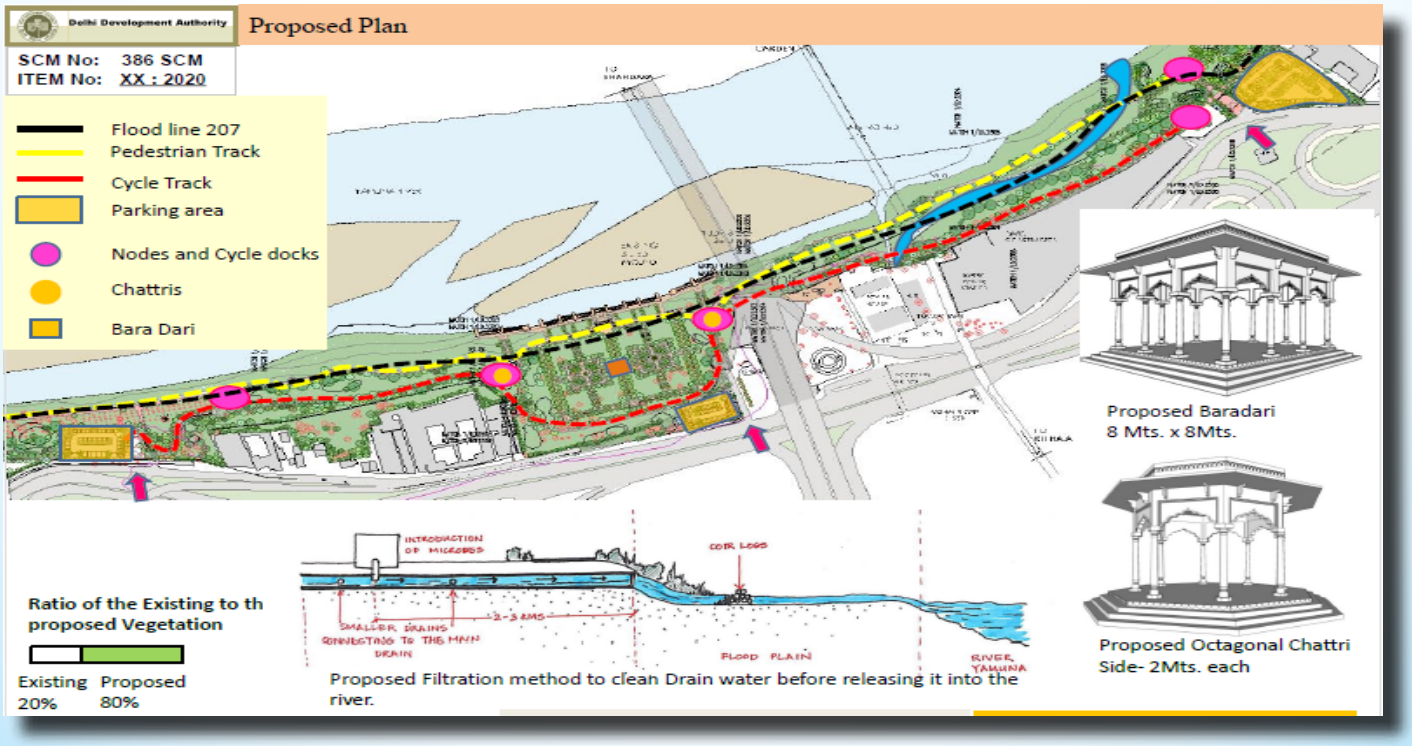


Figure 39 : Proposed Plan for Qudesia Ghat River Front, Delhi

Sita Ram's painting of Patna in 1814 shows that we only have to relearn from history (British Library)

Aligning with nature, the human spirit gets elevated.

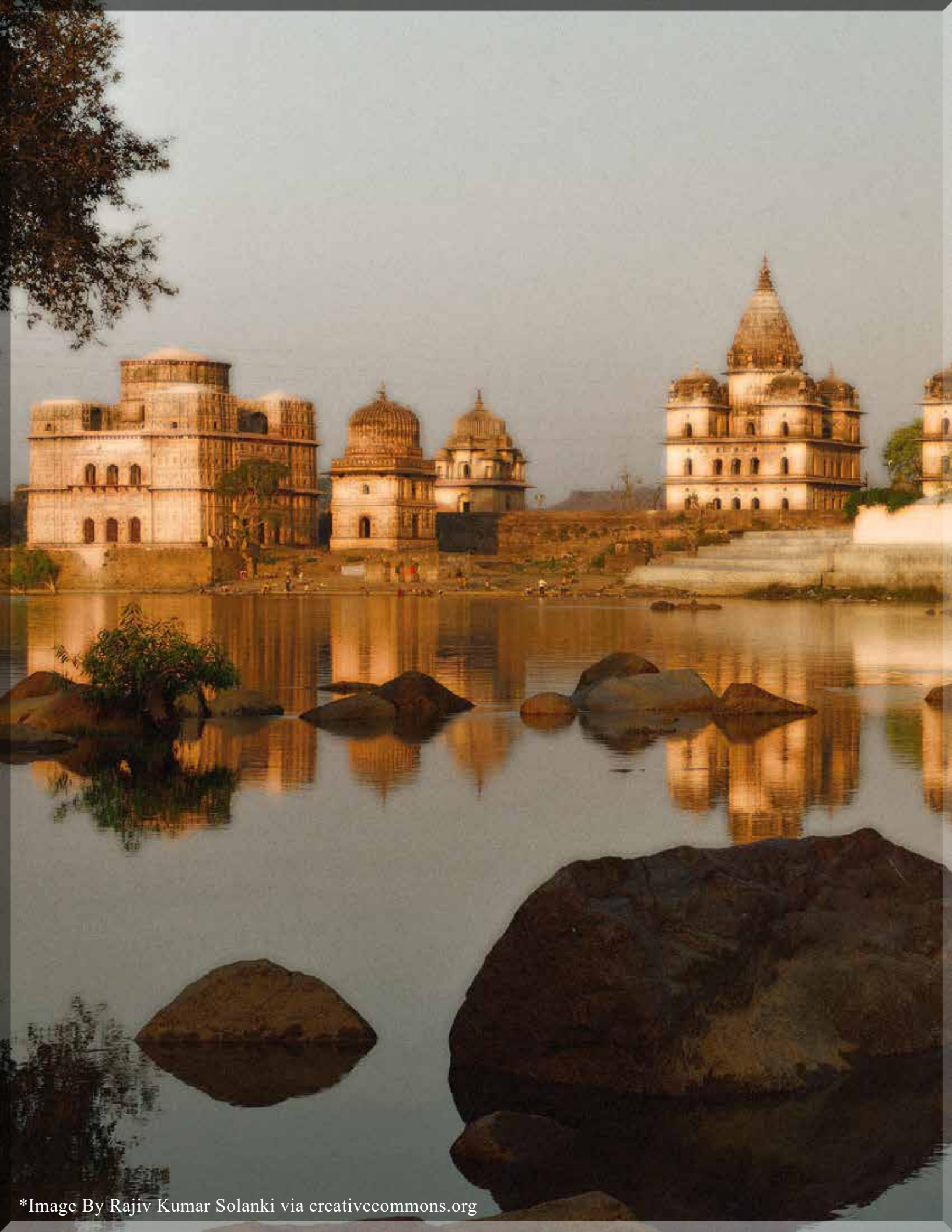
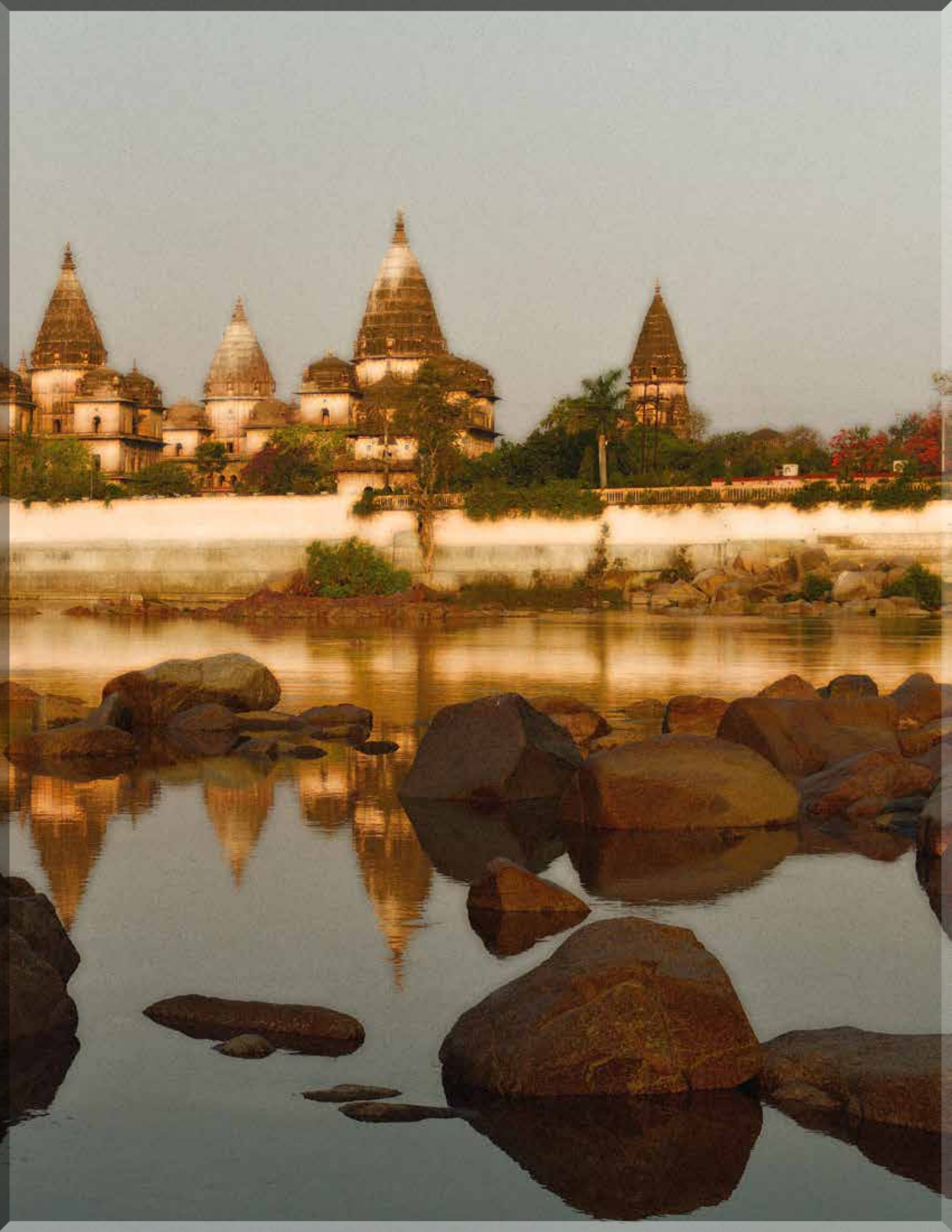


*Image By Rajiv Kumar Solanki via creativecommons.org



*Confluence of Alaknanda and Bhagirathi at Devprayag, Uttarakhand

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