REJUVENATION OF NAG RIVER CORRIDOR, IN NAGPUR CITY

MASTER OF LANDSCAPE ARCHITECTURE

Anchal Naresh Agrawal
2014MLA003

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL
NEELBAD ROAD, BHAURI, BHOPAL – 462030

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REJUVENATION OF NAG RIVER CORRIDOR, IN NAGPUR CITY

A DESIGN THESIS

Submitted
In partial fulfillment of the requirements for the award of the degree of

MASTER OF LANDSCAPE ARCHITECTURE

By

Anchal Naresh Agrawal
2014MLA003

Under the Guidance of
Thesis Committee

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL
NEELBAD ROAD, BHAURI, BHOPAL – 462030
DECLARATION

MAY 2016

I **Anchal Naresh Agrawal** , Scholar No. **2014MLA003** hereby declare that the thesis entitled **Rejuvenation of Nag River Corridor, In Nagpur City,** submitted by me in partial fulfillment for the award of Master of Landscape Architecture, in School of Planning and Architecture Bhopal, India, is a record of bonafide work carried out by me. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

24/05/2016 Anchal Naresh Agrawal

Certificate

This is to certify that the declaration of **Anchal Naresh Agrawal** is true to the best of my knowledge and that the student has worked for one semester in preparing this thesis.

RECOMMENDED

Thesis Committee

ACCEPTED

Ar. Savita Raje
Professor and Coordinator
Head
Master of Landscape

Dr. Rachna Khare
Head
Department of Architecture

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This thesis is only the beginning of my journey.

Anchal Naresh Agrawal

SUMMARY

Throughout ages rivers have given birth to human settlements and civilizations; with several great cities across the world map being located at rivers junctions and according to their proximity to the river. Rivers had great economic-political utility, for they provided convenience of transport of goods and people, and as gateways to the city. They have also given birth to unique cultures and played important in the rituals and customs of its region's religion. They also played important role in the morphology of the settlement, with important and ordinary structures planned and situated in accordance with their proximity to the river. Thus River edges were not merely boundary lines between the human settlement and the water body but have played important ecological, social, economic and aesthetic roles.

This importance drastically reduced with the oncoming of Industrial Revolution and advancement in technology, their importance in economic and social life of the city declined. Over time, urban rivers became undesirable, and even detested places. Indian rivers are faced with many such problems of pollution, drastic reduction in their widths, loss of catchment areas, giving a shoddy image to the cityscape, etc. Fortunately in recent years, the rivers have once become important part of urban planning. And the approaches to rejuvenate these dying rivers have ranged from taking them as important city artifacts to utilizing their economic potential again.

Nag River of Nagpur city has been taken as a case for exploration of the topic. The city has three watersheds running parallel to each other within the city limits, and has three rivers flowing in each watershed. The extent and nature of urbanization is unique for each of the three watershed regions and each of them present different challenges and opportunities. Central zone is most historic and has dense in population while the other two are new.

The study involved understanding of the behavior and characteristics of the streams. Parallel to this, study of how each of these are impacted upon by the surrounding human activities. Primary focus was an examination of different sources of pollution (Nallahs, storm water drains, sewage systems) and their causes. Besides,

documentation of existing flora fauna along the river edge, building- use, and land use was undertaken.

The method for study was collection of data through primary and secondary means. The primary means were photo documentation, interviews, field visits, site surveys and observations while secondary data was collected from a number of departments such as NMC, NEERI, through published documents such as City Sanitation plan, City Development Plan, Environmental Status Report the dynamic of the city was understood and interviews with the officials. After Gathering the drainage maps and sewerage maps for the city, the mechanism and network of streams were understood.

After analysis, the rejuvenation strategies were developed which is demonstrated through a master plan for the river and also through guidelines at macro level. Wherein, potential areas were identified for design interventions along the fluvial corridor. Strategies adopted for river rejuvenation were : protection of river by study of its historical context and key learnings from past - how the river has interacted with human life; creating a healthy ecological system by restoring its natural from , purification of water before it is channelized into the river ,etc.; and balancing the urban development and the existing human habitat through a number of strategies such as development guidelines , stitching of the human habitat with the river by creating an open space network, public realm along its edges, etc.

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1. Introduction:

1.1. Background

Nagpur is a city in the central part of India in Maharashtra State. Nagpur district is located between 21°45' N to 20°30' N and 78°15' E to 79°45' E. The adjoining districts are Bhandara on the east, Chandrapur on the south, Amravati and Wardha on the west and in the north shares the boundary with Madhya Pradesh. The Nagpur district is located in the Deccan Plateau region of Maharashtra. The city is practically located at the geographical centre of India. In fact the zero milestone of India is in this city.

Bakth Buland Shah, the founder of Nagpur city, decided to start the settlement along the river in early 18th century. The expansion took place on both sides of the Nag River.

The Nag River:

Rivers are sacred and people refer to them as mothers, but today most urban rivers are converting into a sewage nallahs. There is no sewage treatment and nor proper solid waste disposal. Same is the case with Nagpur's Nag River. People actually better know it as Nag nallah.

A tributary of the Kanhan which rises in the hills to the west of Nagpur and flows in a serpentine course past Nagpur City, joining the main river at Saongi in the east of the District.

The river probably derives its name (Nag, a cobra) from its sinuous course, and in turn gives a name to the city. According to Dr. B. R. Ambedkar people of Nagpur belong to Nag Dynasty, who were followers of the Buddha. And, so the river and city is named as Nagpur.

The River's origin was contradictory, but now confirmed that Nag river origins to a hillock situated near Lava village, and not from a lake called Ambazari, which is located to the west of the City (Ref Fig. 1).

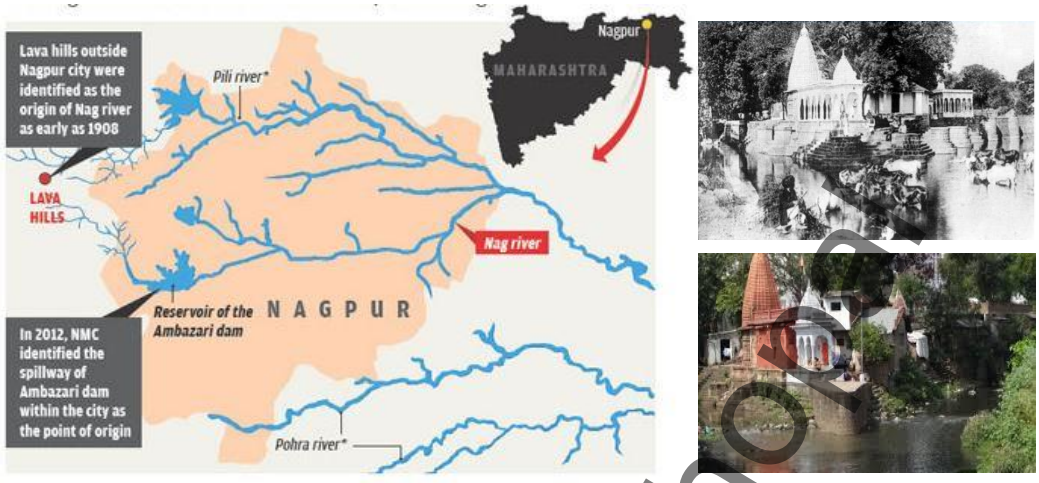


Fig 1: The Sangam or river junction temple, Nag river Nagpur (Source: Pradhyumna Sahastrabhojanee, Ecocity Foundation, *Tributaries of the Nag)

1.2. Need of the Project:

Due to rapid urbanization during the past 50 years the city has increased use of water which has increased generation of sewage. Settlement has been along the river. Resulting wastewater is not being treated adequately thereby resulting in discharge of untreated waste water into the rivers and causing:

i) Deterioration of quality of receiving water and

ii) Disturbing the eco system.

Urban population of the city is about 2,497,870 (as per 2011 census). Water supply to the City is about 520 MLD and sewage generation is around 420 MLD. Nagpur Municipal Corporation (NMC) has inadequate infrastructure to collect and treat the entire sewage generated from the city. Civic bodies have not been in a position to develop adequate environmental infrastructure for protection of environment resulting in increased pressure of environmental degradation primarily due to discharge of untreated / partially treated into the Nag River. The river is polluted and the water is unfit for any use.

It needs to be mentioned that, Environment Department, Govt. of Maharashtra has given a status of notified river to Nag river Classification of water of Nag River Basins / Sub-Basin by Environment Department, Government of Maharashtra. Notification is reproduced below.

Environment Department, Government of Maharashtra has classified 20 main rivers & their sub basins in A- I, A-II, A-III & A-IV on their best designated use.

Sr No.	Name of the River	Strech of A-I class	A-II class	A - IV Class
1.	Nag River	---	Origin to Ambazari Lake	Ambazari Lake are Confluence with Kanhan River
2.	Pioli River	---	Origin Lake Gorewada Tank	Gorewada Tank to Confluence with Nag River

Table 1: Classification of water of Nag River Basins / Sub-Basin by Environment Department, Government of Maharashtra (Source: Nag River Basin Action Plan, prepared By Maharashtra Pollution Control Board Regional Office, Nagpur May-2011)

Total length of Nag River is 16.50 Km up to the city limit. Its width ranges from 12 to 40 m and depth varies from 2 to 4.5 m. Total length of Nag River up to the confluence with Kanhan River at Agargaon is about 68 Km.

Today the source of water for the river is only sewage. Besides, industrial waste also flows into the river.

Nagpur is attempting to become Eco city and aiming at high degree of self-sustainability, so it becomes important to take care of its natural resources and use them judiciously.

Therefore, it is the need of the day to try to restore the status of water in the rivers along with its wholesomeness as per the best designated use. Rejuvenation of the river becomes important because of city's rich history associated with it, and its origin is here. If the toxins are removed before the water enters into any other source, the further loss of biodiversity will be tackled.

1.3. Aim

To make a landscape proposal for restoring the lost identity of Nag river. Rejuvenation of the river as a public open space**.**

1.4. Objective

- To understand the catchment of the river and topographical analysis.
- To identify the challenges to the urban stream.

- To understand the existing land use and rivers role in the masterplan of the city.
- To determine peoples negotiation with water, through tangible and intangible activities along the river edge.
- To determine the historical and culturally significant spaces around the urban stream.
- To identify the potential of the fluvial corridor for public access/ no public access.
- To improve and rejuvenate spatial quality around the river through landscape design**.**

1.5. Methodology

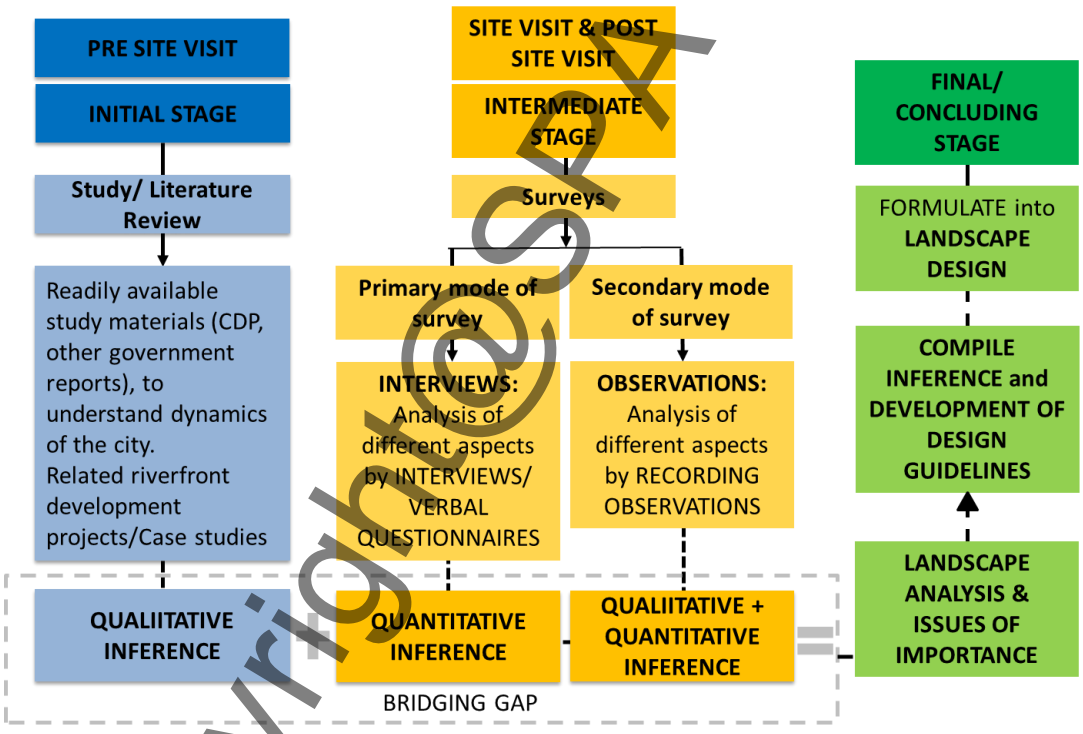


Table 2: Frame work for methodology

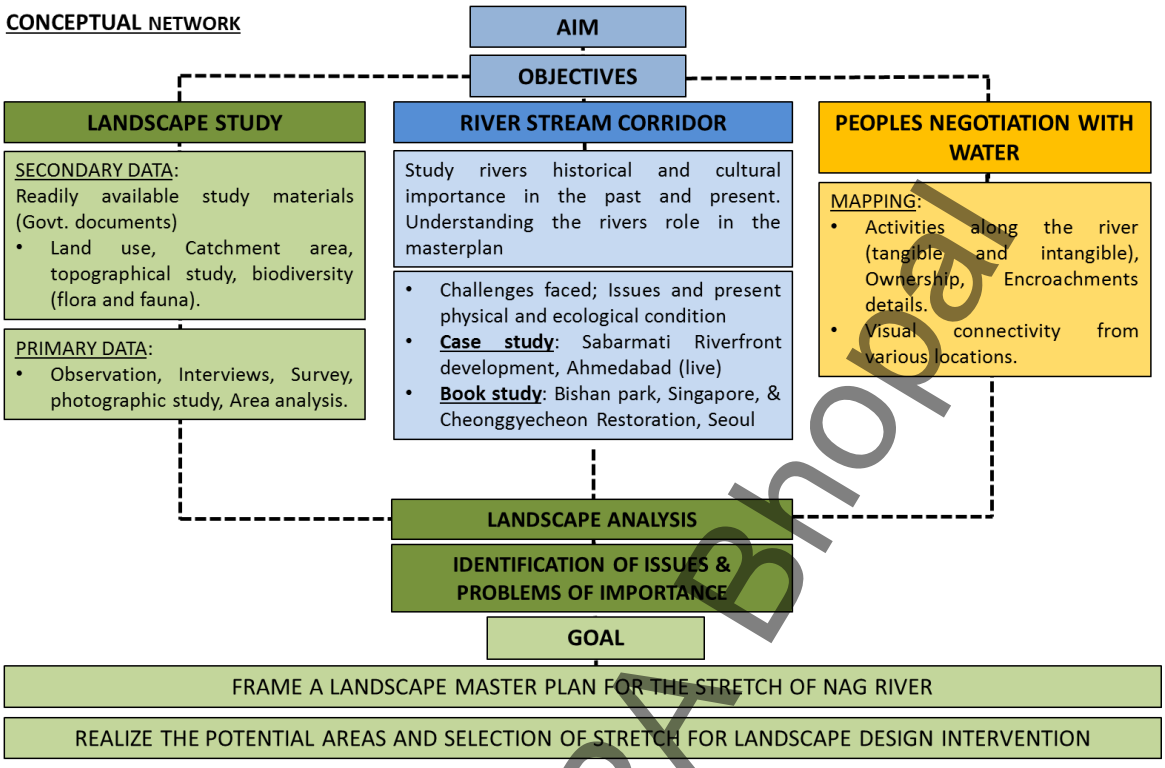


Table 3: Conceptual network/ methodology for site study

1.6. Scope & Limitation

Study and analyse full stretch of river (within Nagpur Municipal limits). Prepare a master plan for a part of the urban stream (upper, mid, or lower stream).

Landscape design intervention will be limited to potential area as a sample, as the river is 16.5km within city limits. Proposal of the full stretch would be out of scope. Would limit to immediate influence area.

2. Literature review

2.1. Understanding Rivers, Watersheds and stream orders

Watershed *:* A watershed is the land area Drained by a particular stream or river. All human habitats fall in watersheds and depend upon it. (Riley).To begin learning about a local stream, river one has to become familiar with the watershed they run through and the history that comes with them. (Riley).The differences between streams, brooks, creeks, gulches, washes and rivers are difficult to measure and quantify which mostly loosely defined terms. And these have so far been denoted to Represent cultural and regional customs more than they define or standardize a geographic feature. The definition of a creek or stream is dependent on the definition of its watershed (Riley).A drainage network is formed when smaller streams join to form larger streams. Thus, larger watersheds constituted by joining of smaller watersheds.

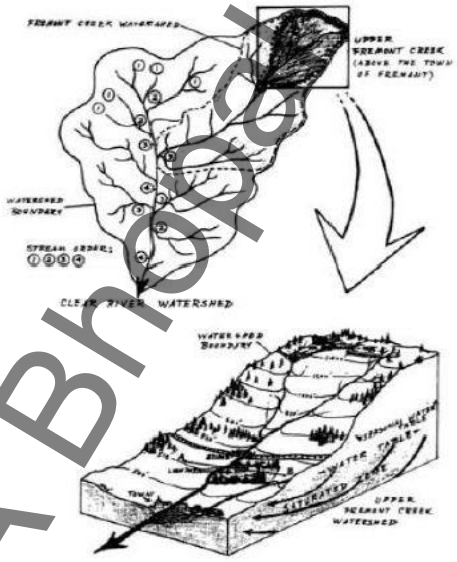


Fig 2.1. Watershed and stream order (Source: The Federal Interagency Stream Restoration Working Group, 2001)

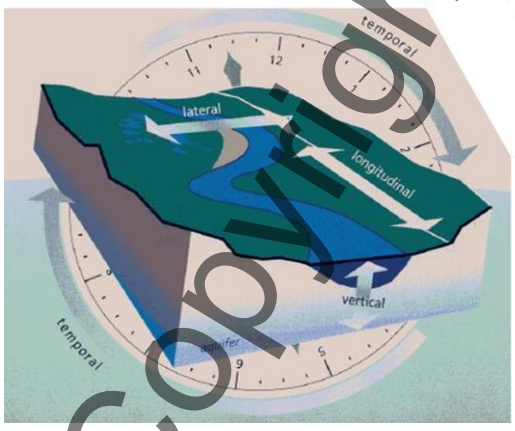


Fig 2.2.. Dimensions of the stream corridor. (Source: The Federal Interagency Stream Restoration Working Group)

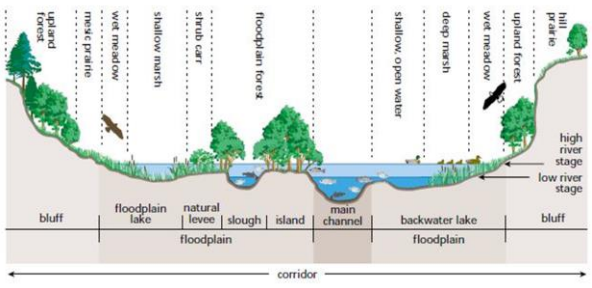


Fig. 2.3. Cross section of the river corridor . (Source: Sparks, Bioscience, vol.45, American Institute of Bbiological Science)

Stream Orders*:* The different channels draining these watersheds can be designated by the no. of tributaries they have or by their order. A first order stream channel has no tributaries, when two first order streams join; they create a second-order stream. When two second order streams join they create a third order stream and so on. A stream is designated by its order; therefore a concept of the size of the drainage area concerned can be easily arrived at.

Fig. 2.4. Stream Order
Source : (The Federal Interagency Stream Restoration Working Group, Stream corridor restoration principles, processes and practices, 2001.

Floodplains*:* The floor of most stream valleys is relatively flat. This is because over time the stream moves back and forth across the valley floor in a process called lateral migration. In addition, periodic flooding causes sediments to move longitudinally and to be deposited on the valley floor near the channel. These two processes continually modify the floodplain. Through time the channel reworks the entire valley floor. As the channel migrates, it maintains the same average size and shape if conditions upstream remain constant and the channel stays in equilibrium. (The Federal Interagency Stream Restoration Working Group, 2001)

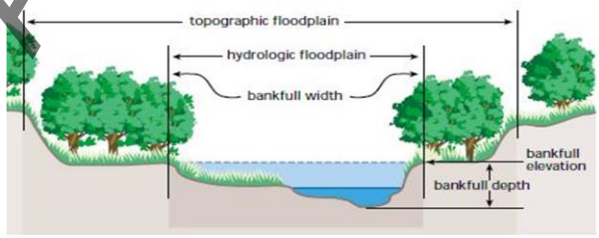


Fig. 2.5. Channel cross section
(Source : The Federal Interagency Stream Restoration Working Group, Stream corridor restoration principles, processes and practices, 2001).

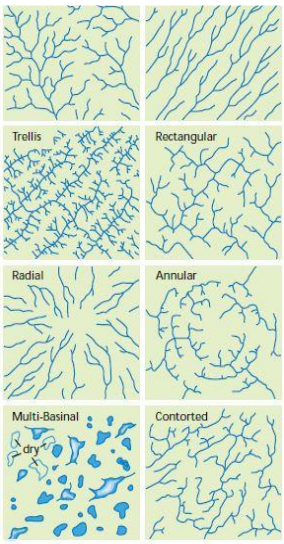


Fig. 2.6. Water drainage patterns
Source : A.D. Howard, 1967, American Association Of Petroleum Geologists

There are two types of floodplains:

Hydrologic floodplain*:* The land adjacent to the base flow channel residing below bank full elevation. Not every stream corridor has a hydrologic floodplain.

Topographic floodplain*:* The land adjacent to the channel including the hydrologic floodplain and other lands up to an elevation based on the elevation reached by a flood peak of a given frequency (for example, the 100-year floodplain). 100-year and 500-year floodplains are commonly used in the development of planning and regulation standards.

2.2. River Rejuvenation

Introduction to Rejuvenation: Rejuvenation is distinct from restoration which involves reclaiming and recreation of its original natural form and flow, in the sense that it may also involve giving it a new identity. In urban areas rejuvenation may involve complicated compromises and agreements to establish the objectives based on natural history and human settlement history that has shaped the current land uses and ecological systems. (Riley) Ecological and urban settlement needs can be balanced, which is self-sustaining and improves upon the existing site conditions, with appropriate landscaping measures. The measures generally involves bringing in a biologically diverse aquatic life which has nutrients, algae, proper temperature and other chemical parameters. Reclaiming the physical feature of river or a stream, with streamside trees and shrubs, the channel with its natural width and depth, pools, riffles and meanders. (Riley)

Rejuvenation through landscaping means to can create new environments that provide sanctuary, adventure, symbolism, recreation, entertainment and sustenance. It's used to mitigate for land use changes such as building of freeway, offices, parking lots, housing developments and of water projects. Landscaping is also the revegetation of stream banks so that they do not collapse under high velocity of flows but continue to work as a component in a dynamic system in which meandering, aggradations and degradation of the channel occur in balance. (Riley)

2.3. Need:

1. Urbanization has affected:

- The physical process of river growth
- Modified stream structure
- Influenced the function of the river systems

2. More than 60% of the rivers in the world have experienced high level of human modification

3. Urbanization causes river degradation due to the amount of impervious surface area which causes

- Increased erosion, Channel destabilization and
- Widening of stream
- Leading to loss of Habitat from channelization
- Excessive sedimentation etc.

4. The impact of urbanization on the water body/ river can best studied under four categories:

Hydrology: The bank full flooding (or the condition of the flow that fills up the channel) occurs much more frequently in highly urbanized areas and has the potential to be extremely erosive and damaging to the natural morphology of the stream.

Geomorphology: The impact of urbanization on geomorphology of the river is as follows:

Stream widening & erosion; Reduced fish passage; Degradation of habitat structure; Decreased channel stability etc.

Water Quality

Habitat

Fig. 2.7. Stream (Source : Web)

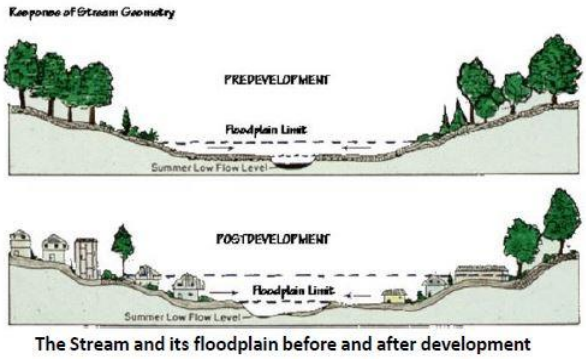


Fig. 2.8. Water drainage patterns (Source : The Federal Interagency Stream Restoration Working Group, Stream corridor restoration principles, processes and practices, 2001).

2.4. Ecological Perspective

McHarg, Ian L. in his seminal book *Design with Nature* (1969), instead of the conventional "rule" and "design" has proposed for a balanced co-habitation of humans and nature from an ecological-scientific perspective. The present environment crisis is a consequence of neglect and abuse of the nature's laws and its mechanisms and will aggravate the situation in future if the status quo continues. McHarg argues the design should respond sensitively to the natural conditions, ecological conditions and reduce humans' interference, all design schemes and plans should be an integration of history, physical, and biological development processes, which is dynamic and a process of nature evolution. Before design, he has emphasized the need to understand the inner mechanisms of these before we make decisions on how to utilize the nature resources. For such an approach would raises lands social value, besides being an effective and optimum utilization of land. The design must take into account the layout character, natural resources, the natural evolution process, local natural resource styles, etc. these must then favored and optimized through the design proposal.
Of particular note are the series of methods about land resources category, valuation and classification that he has developed.

2.5. Socio-Cultural Perspective

Rivers have been defined and perceived in myriad of ways, viz, as natural resource, a geographical feature of a region, as a mother, as a goddess, etc. For Urban Planners and engineers it has strictly a utilitarian value which should needs to be channelized into the sea and which may have economic potential too; on the other hand it may have spiritual and cultural significance for local indigenous communities living alongside the river. Kuntala Lahiri-Dutt in her paper People, Power and Rivers: Experiences from the Damodar River, India (2003) highlights the various notions and beliefs held by different actors and stakeholders and how their notions guide their attitudes and actions towards the river. The paper focuses on how attitudes of planning and administrative bodies in post-colonial India towards rivers, with their development agendas has not only polarized issues of anti-dam vs pro-dam, global vs local, traditional vs developmentalist but also marginalized the hitherto local and indigenous

communities who had rivers as an important part of their daily lives and held socio-cultural significance. Taking case of Damodar River of eastern India to show how state-control of rivers and their interventions can conflict with localites and has ultimately created social inequalities. Of particular note, her observations of how various notions and attitudes held towards a river, affects its ecological health, size and shape and its relationship with humans. They are not just material resources but also have symbolical meanings and have socio-cultural significance; and how the latter can help in bringing back the significance to rivers.

2.6. **On the Riverfront** – Sriganesh Rajendaran

The author tells that the sensorial contact with water is much desired notion of a riverfront. He then talks about the river and city relationship from the past till date. Talking about the visual connection, the author writes in context of lateral portion of the river. If the river is narrow then the connection is strong both visually and physically, as could be seen in the case of Paris (Seine), Chicago (Chicago), etc.

Instead for perceiving rivers as societal discontinuity, it should be seen as a continuum of voids or open spaces in the urban fabric.
The city's relationship with its river changes or alters with time. And the major climatic and tectonic events or manmade obstacle may disturb the river's course over a short time causing river to completely disappear or leave the traces of its flow. The width of the river has a strong influence on the scale of the river corridor, the riverfront and its uses and relation to the opposite bank. Private land uses along the river are an impediment to continuous access. Sabarmati riverfront: As a seasonal river Sabarmati is a large void, potentially capable of linking the open spaces on its opposite banks.

He concludes by saying that its time that we ask our rivers what their essential nature of riverfront should be. It's time the relation between the river and the city is rekindled with affection and longing.

3. Case study:

3.1. Sabarmati River Front Development, Ahmedabad

3.1.1. Project summary

Location: Ahmedabad, India; Length: 10.4 km;

Fig 3.1: Sabarmati Riverfront Ahmedabad (Source: http://2.bp.blogspot.com/)

The River Sabarmati flows from north to south splitting Ahmedabad into almost two equal parts, served as a water source and provided almost no formal recreational space for the city (Ref Fig.3). As the city has grown, the Sabarmati River had been abused and neglected. Increased pollution was posing a major health and environmental hazard to the city. Encroachment on the banks was also seen.

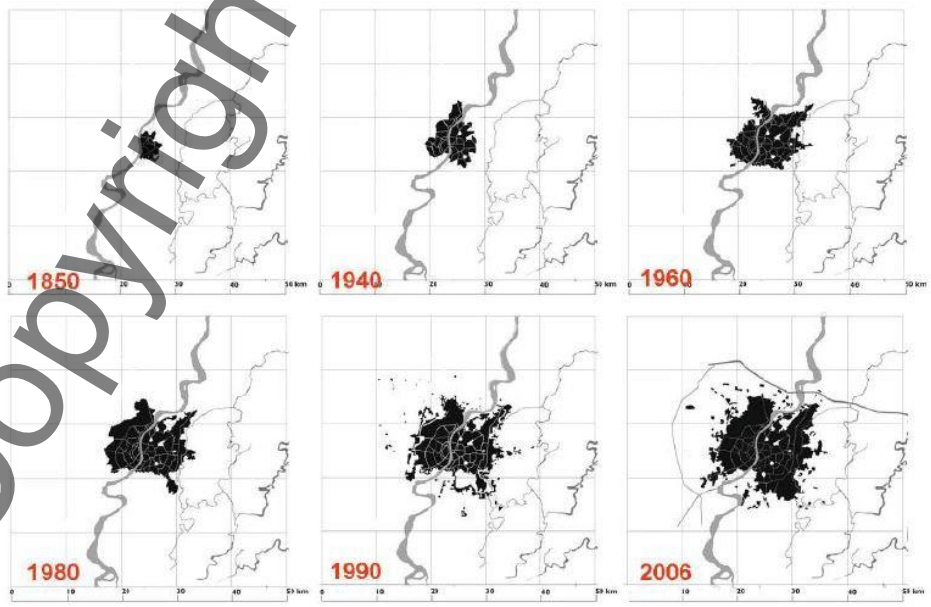


Fig 3.2: Sabarmati and the growth of Ahmedabad city (Source: SRFD Project for Urban Mobility 261114- Mr. Jagdish)

The examples clearly illustrate how the river has added vibrancy to the urban landscape of Ahmedabad with its open spaces, walkways, well-designed gardens along with activities which contribute to economic growth.

The project dealt with sensitive issues like slum rehabilitation, relocation of an age old natural market and a Dhobi Ghats with élan. The project has connected the river and people, again directly through its Ghats.

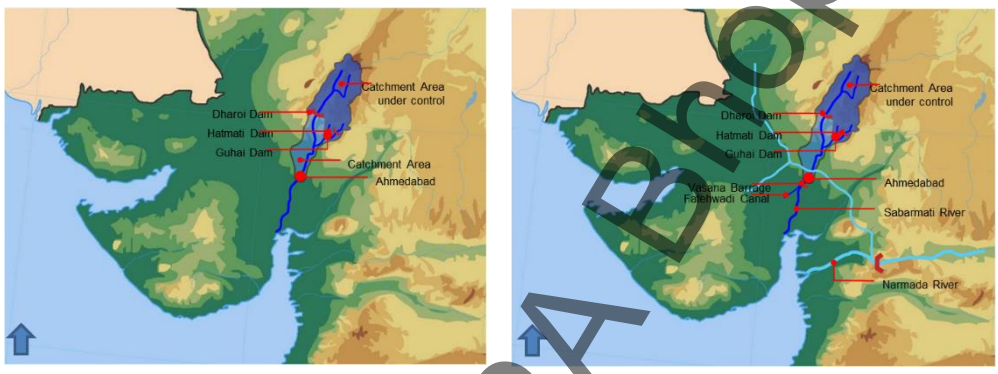


Fig 3.3: Catchment of Sabarmati River; Sabarmati River & Narmada River's Connection (Source: SRFD Project for Urban Mobility 261114- Mr. Jagdish)

Sabarmati is a seasonal river, water is channeled into the river from Narmada canal, which intersects the river upstream from Ahmedabad and is retained in the river using the Vasna Barrage which is located downstream (Ref Fig.4).

Sabarmati Riverfront development Corporation Limited (SRFDCL) was launched in May 1997 by the Ahmedabad Municipal Corporation (AMC) under Section 149(3) of the Indian Companies Act, 1956.

A Special Purpose Vehicle model (a legal entity created solely to serve a particular function) was used to avoid the delays associated with municipal decision-making. On Built maintain operate and Transfer (BMOT) basis.

Land ownership: River bed land which was originally held by the Govt. of Gujarat, was transferred to the AMC, which in turn granted development rights to SRFDCL for this reclaimed land.

3.1.2. Issues & Concerns pertaining to Sabarmati River Bed which are similar to NAG River Bed

1. FLOOD HAZARD:
10,000 slum household adjacent to the river can get washed away. Several low lying areas are flood prone.

FLOOD HAZARD SOLUTION:
Embankments would have 50cm wide and 9.545m high diaphragm walls below the river bed level constructed on both the banks designed to provide protection against flood

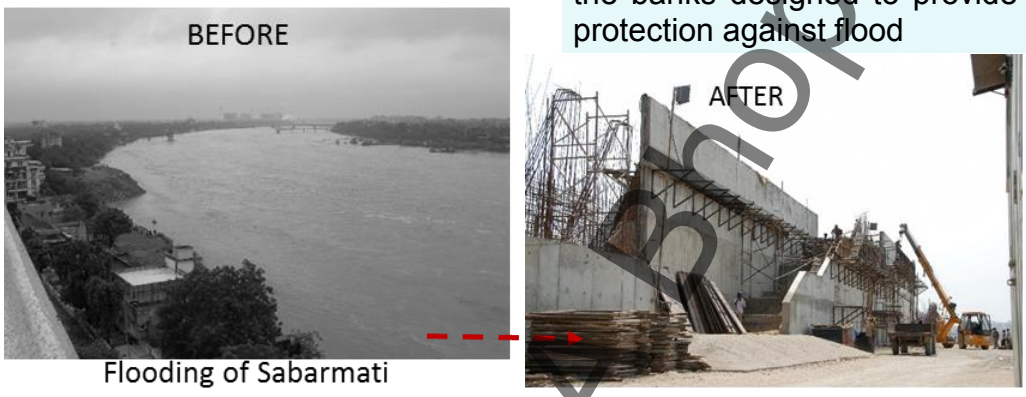


Fig 3.4: Before and after pictures of Flood hazards & solutions at Sabarmati River (Source: SRFD Project for Urban Mobility 261114- Mr. Jagdish)

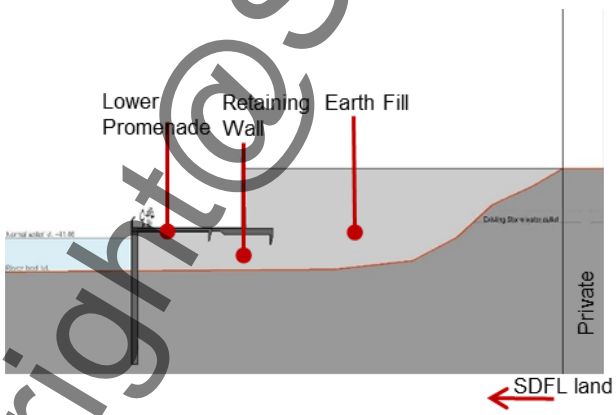


Fig 3.5: The Construction Process– Retaining Wall and Earth Fill

2) SEWAGE FLOW INTO THE RIVER:
A number of storm water drains discharge the waste water into the river (many of them are illegal)
27 such discharge points were detected along the river basin.
These had to be extended to a main line to divert this discharge.

Proposed to lay trunk sewer parallel to the riverside roads East River Drive and West River with extensions from the drain points
Terminates at STP near Vasana Barrage.
Total cost estimated Rs 5.75 crores.
Length: West bank: 12.3km, East bank: 15km

Sewerage Inceptor Sewage Line Being Built

Fig 3.6: Before and after pictures of sewage flow into the river & solutions at Sabarmati River (Source: SRFD Project for Urban Mobility 261114- Mr. Jagdish)

Fig 3.7: SW Drainage Outfalls Along 10.4km stretch (Source: SRFD feasibility report)

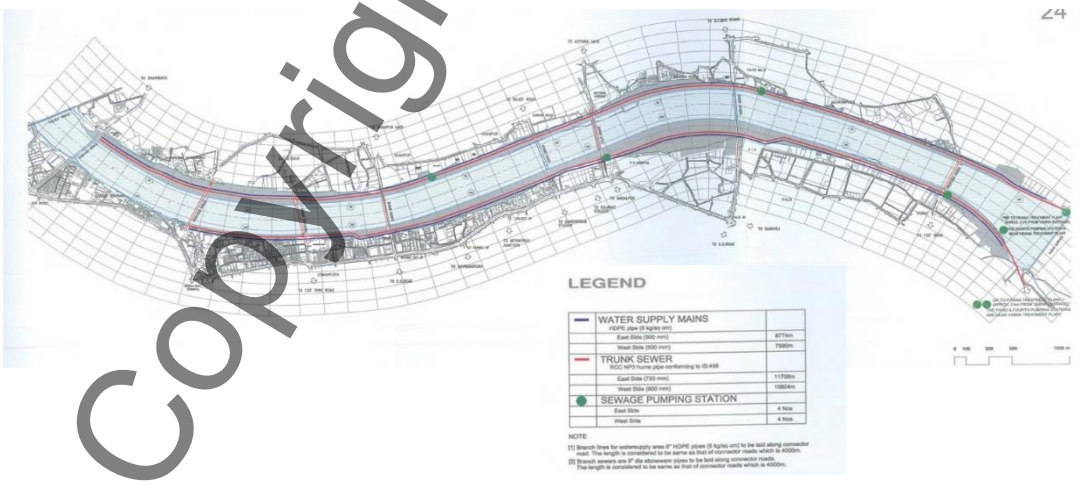


Fig 3.8: Sewerage & Water Supply (Source: SRFD feasibility report)

3) SLUMS ALONG THE RIVER:
5984 households as per 2002 survey which gradually increased to 11736 households by the time of allotment influenced by the scheme,
It was ensured that none would be relocated far from the site while also retain the employment opportunities.

SOLUTION: Rehabilitating the slums
Total 11736 households entitled
Estimated construction cost for each household is Rs 65000-75000.
Estimated cost of laying Infrastructure for each household is Rs 20,000

Fig 3.9: Sewerage & Water Supply Original & located slum locations Blue: original; Red: Located (Source: SRFD feasibility report)

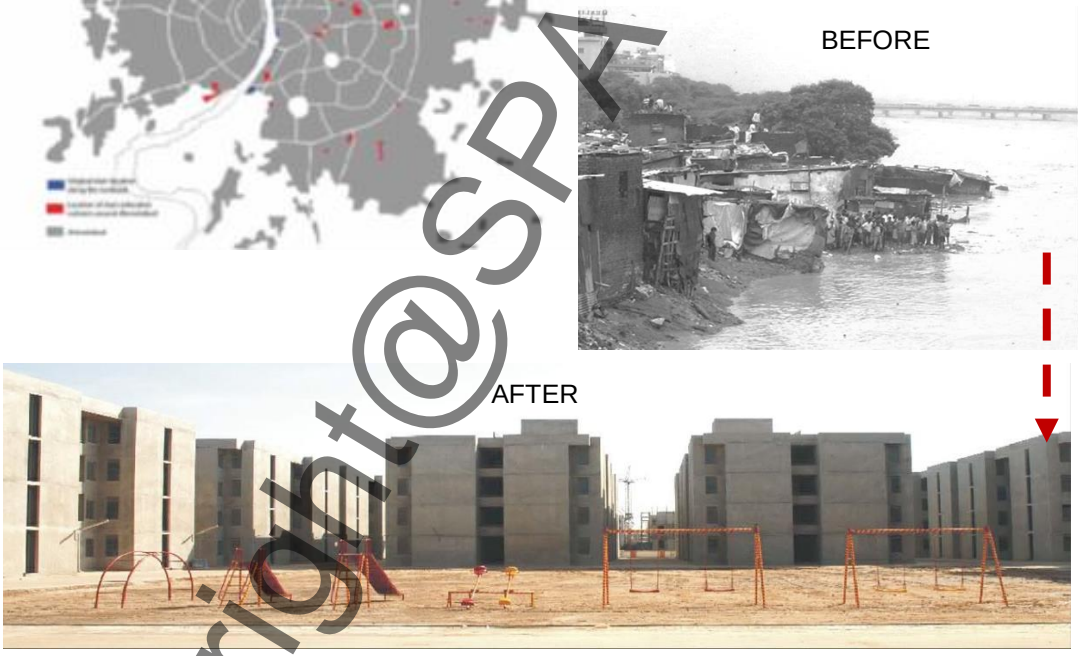
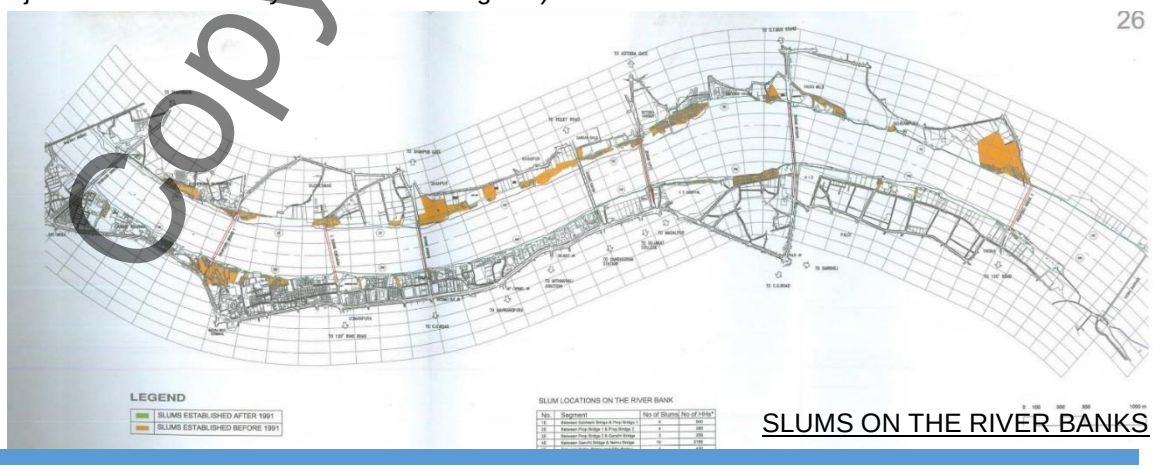


Fig 3.10: Before & after pictures of Slums along the river at Sabarmati River (Source: SRFD Project for Urban Mobility 261114- Mr. Jagdish)



SLUMS ON THE RIVER BANKS

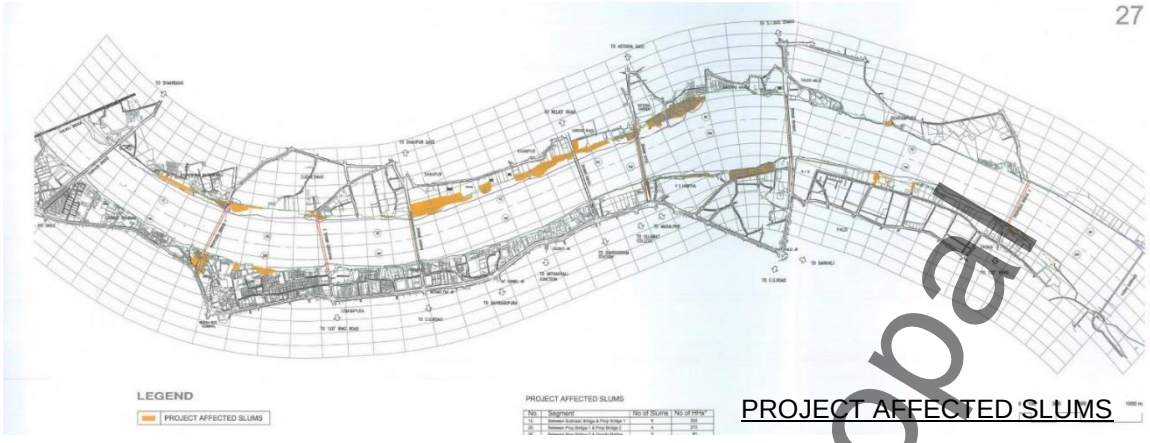
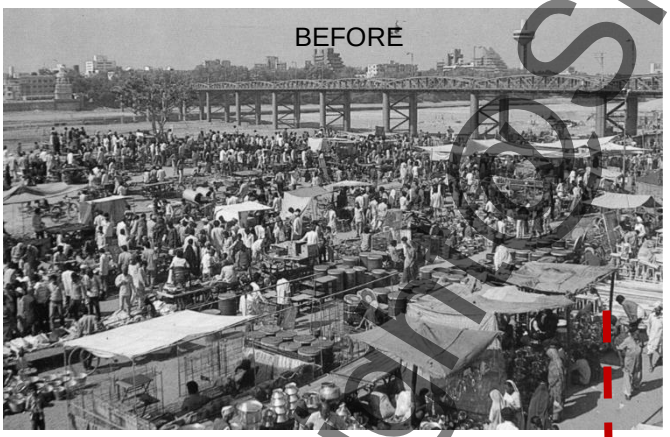


Fig 3.11: Slums & project affected slums along SRFD (Source: SRFD feasibility report)

4) PREVAILING ECONOMIC ACTIVITIES

'Gujri (Sunday market) and 'Phool Bazar: Culturally and economically very significant so relocation would be inappropriate.
Lacked easy accessibility, parking, toilet and other ancillary facilities.
Prone to flooding in monsoons.



PREVAILING ECONOMIC ACTIVITIES

2 markets were removed and accommodated with international level facilities also adding 2 more markets estimating approx. 14,000 direct job employments.
'Dhobi Ghars' (Laundry campus):
- Area: 9380 Sq.Mt
Capacity: 168 allotments for Washing
'Gujari' (Sunday Market)
- Area: 70,000 Sq.Mt; Capacity: 1640 Vendors estimated
- Cost: Rs 29.15 crores
Parking: 8 Bus, 428 Four wheelers, 230 Two wheelers

Fig 3.12: Before & after pictures of Economic activities along the river at Sabarmati River (Source: SRFD feasibility report)

3.1.3. Design strategies used:

- Make the riverfront accessible to the public
- Stop the flow of sewage, keep the river clean and pollution-free
- Reduce risk of erosion and flooding in flood prone neighborhoods
- Create riverfront parks, promenades and Ghats to enjoy the water
- Provide Ahmedabad with new cultural, trade and social amenities
- Provide permanent housing for riverbed slum dwellers

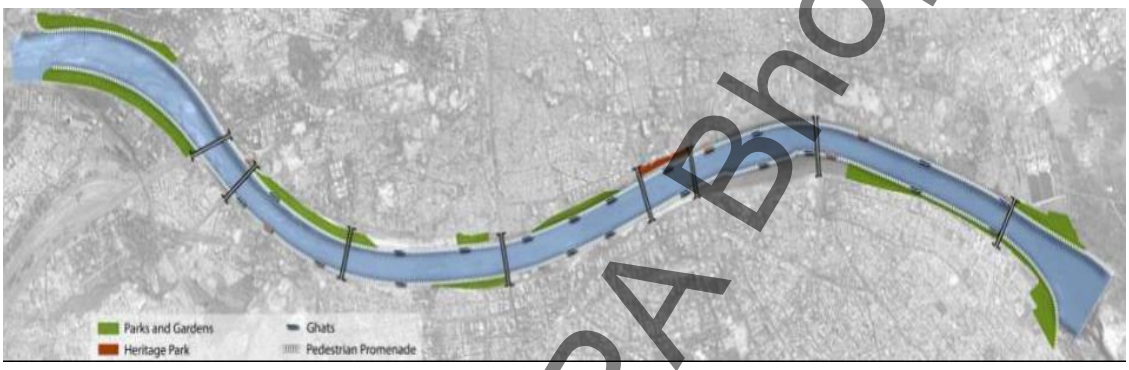


Fig 3.13: Reconnecting To The Forgotten River (Source:www.sabarmatiriverfront.com)

3.1.4. Changes along the river:

Environmental changes:

An asset by making it perennially water filled, at least in the city stretch.

Eliminating the major water polluting agents by diverting as many as 39 sewage outlets that dumped untreated sewer in the river.

The change in the river ecology.

Land reclamation through the narrowing of the river basin

Social changes:

Gifted to the citizens a large, centrally located and much needed civic space to the city chronically starved of open spaces.

Created a new and modern landmark.

Ineffective rehabilitation

Economic changes:

Improvement in economic growth and tourist attraction.

3.1.5. Inferences and Observations:

Opportunity of creating a central civic space to the city.

Project has been seen only with the vision of ‘beautification’ and ‘place making’; but the ‘environmental up gradation is not explored to its potential’.

For any project to be successful, it is very important to connect it with the people. SRFD project is considered successful because it is able to connect people with the river.

Fig 3.14: Reconnecting to the forgotten River to the citizens (Map Source: www.sabarmatiriverfront.com; Picture Source: Author)

3.2. Bishan - Ang Mo Kio Park And Kallang River, Singapore

3.2.1. Project summary

A long-term initiative to transform the country's water bodies beyond their functions of drainage and water supply, into vibrant, new spaces for community bonding and recreation.

Bishan Park is one of Singapore's most popular parks in the heartlands of Singapore. As part of a much-needed park upgrade and plans to improve the capacity of the Kallang channel along the edge of the park, works were carried out simultaneously to transform the utilitarian concrete channel into a naturalised river, creating new spaces for the community to enjoy.

Bishan Park is one of the largest park, constructed in 1988, located in Bishan, Singapore. In year 2006, it has undergone a major redevelopment under the Active, Beautiful, Clean Water Programme. At Bishan Park, a 2.7 km long straight concrete drainage channel has been restored into a sinuous, natural river 3.2 km long, that meanders through the park.

Fig 3.15: Before and after pictures of the park (Source: Singapore Bishan Park.pdf)

3.1.2. Issues & Concerns pertaining to Bishan Park which are similar to NAG River

Bishan Park is a green lung in the heart of city, but was not active till its renovation. People started to come here when they were able to connect to the water body, & have engaging & recreational activities along the river.

3.1.3. How they have resolved the issues

After the park was reopen, the vegetation around the river front was altered significantly, with huge contrast between the water front area and the area opposite the river where the landscape is less altered.

The major factor to this is that the landscape near the river is still new. As time passes, the altered site would be expected to return to how it was in the old park.

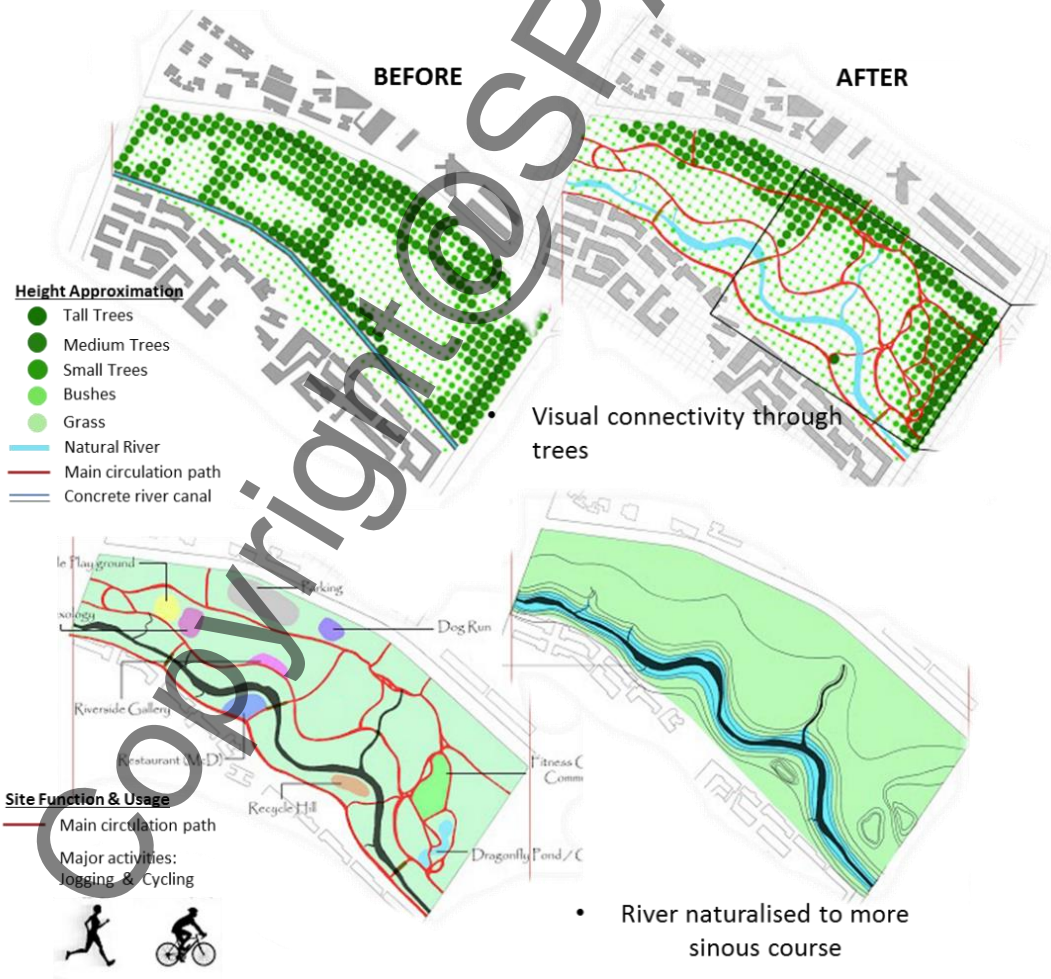


Fig 3.16: Vegetation status & activity generated along the river (Source: Singapore Bishan Park.pdf)

TOPOGRAPHY

During the redevelopment, the site was excavated and the concrete channel was removed. It is being replaced by a natural river also acting as a water catchment area during heavy down pour.

The river bank is stabilised using soil bioengineering techniques. Among the techniques used for the test bed are:

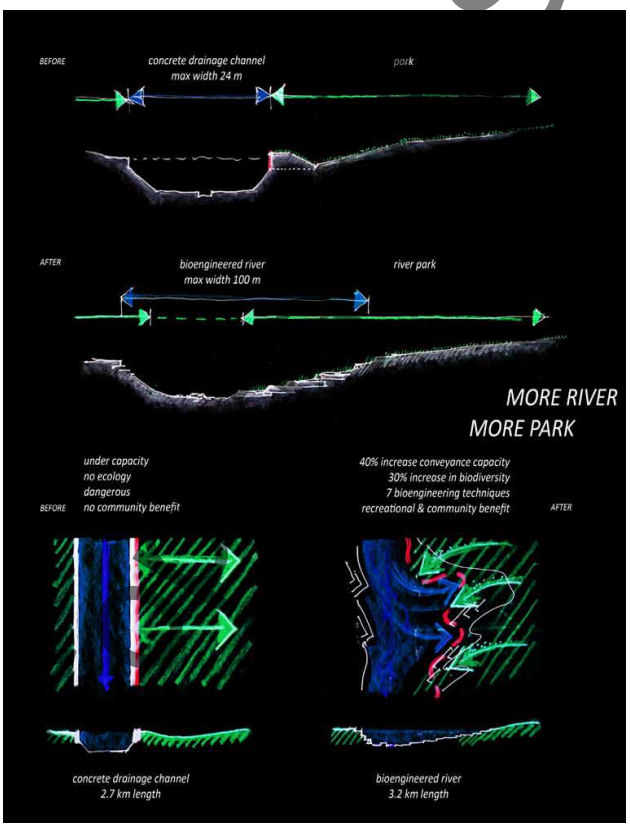
Gabion wall, Log Crib wall, Riprap, Fascines, Wrapped soil lifts, Shrubs Planting, Brush Mattress, Stone wall, Reed roll.

3.1.4. Findings & Inferences

Better Linkages: This welcomes people to come to the park.

Visual connectivity: Small trees along the river edge, safe for different age group people coming to the park

Ecological approach: concreted channel to natural river bed, soil-engineering techniques, biological cleansing of water, re-use of waste material, enriching bio-diversity.



ACCESSIBLE WATERCOURSE

ENHANCING BIODIVERSITY

STABILIZING RIVER EDGES

Fig 3.17: River naturalised from concrete channel by improving the bio diversity (Source: Singapore Bishan Park.pdf)

3.3. Cheonggyecheon Restoration and Reconstruction in Seoul

3.3.1. Project summary

Seoul belongs to the political and cultural centre. Cheonggyecheon flows across the centre of Seoul, in 1397, the capital of Korea moved to Seoul, thereafter Cheonggyecheon has been become the main axis of the city morphology. As the city's centre river, it has become primary sewer for the populace.

During the 1950s and 1960s, because of economic growth and the urban development, Cheonggyecheon was once slated to become a drain, the water of which also deteriorated.

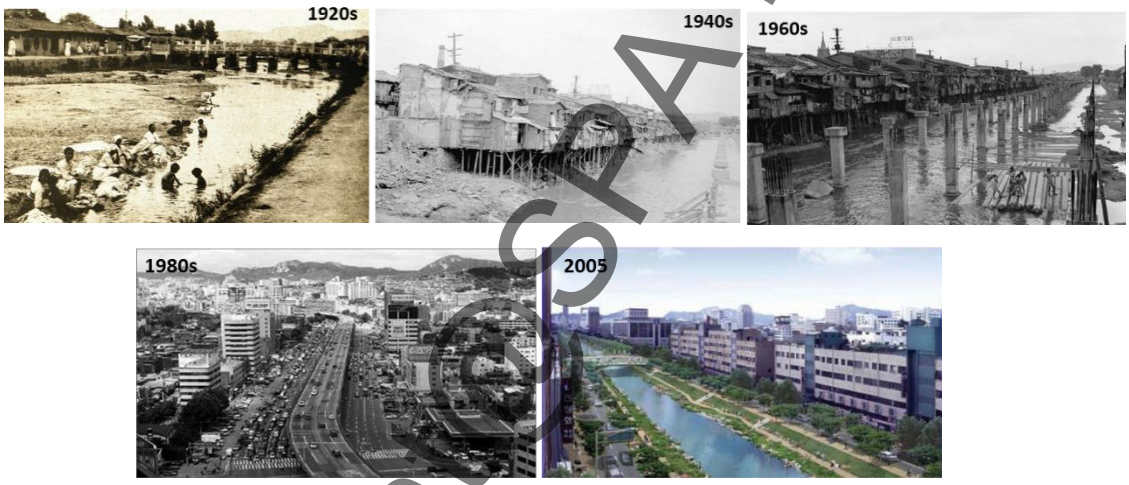


Fig 3.18: Cheonggyecheon River through times (Source: Cheonggyecheon in Seoul.pdf)

From July 2003, the government restored the river with the support of mayor.

Purpose of selecting this case: Cheonggyecheon has a similar case with the Nag as, today even Nag has become a sewer. Even it is flowing through the heart of the Nagpur city, people are unaware of its presence and importance as a resource.

Cheonggyecheon has become the part of locals now after restoration. The river has now given a new identity to the city.

Fig 3.19: View of Cheonggyecheon in Seoul (Source: Cheonggyecheon in Seoul.pdf)

3.1.2. Issues & Concerns pertaining to Cheonggyecheon which are similar to NAG River

- Cheonggyecheon in Seoul flows in the heart of the city, but was not in good condition & had become a sewer. CBD redevelopment stopped where the Cheonggye Expressway started.
- The Cheonggyecheon has great historical significance to Seoul since it ran through the heart of the ancient city, hence its restoration becomes important.

3.1.3. How they have resolved the issues

- Access to Water : Install sidewalks along the lower level of the bank
- Basic design: Secure flood capacity for 200 years frequency rainfall and introduce lower terrace to enhance easy access to water.
- Sewer System: Combined sewer system for rainfall and wastewater. Capacity: 3 times of estimated wastewater.
- CONCEPTS: New green belt with waterfront: West to East.

  Gradual transformation from urban landscape to natural environment.

  Create ecological biotope and environment.

  Thematic places: waterfall and fountains were constructed.

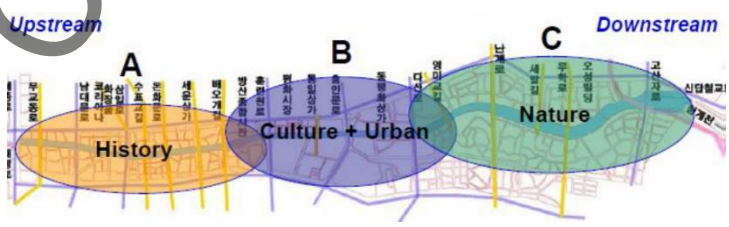


Fig. 20: Showing concept

3.1.4. Findings & Inferences

Activities generated along the river has given new identity to the city. This has even benefitted to the economic growth of the city and attracts tourists.

Significant ecological improvement could be seen after restoration.

Air & water quality has improved. Reduction in air temperature (cooling effect) in surrounding area by an average or 3.6 degree C demonstrated by thermal imagery.

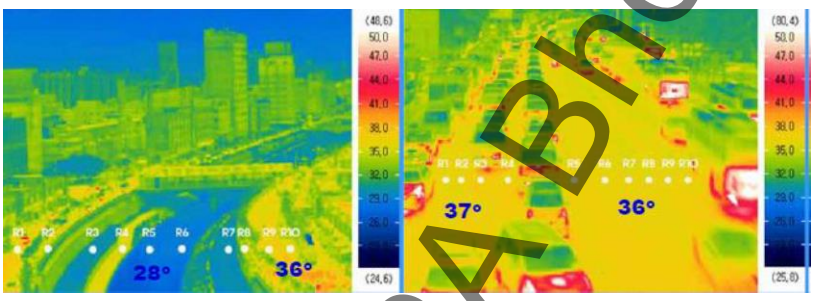


Fig. 21: Represents heat map of the place before & after restoration of the riverfront. (Source: Cheonggyecheon in Seoul.pdf)

4. Site Study & Analysis:

4.1. Physical And Geographical Character Of Nagpur City

Nagpur is a city in the central part of India in Maharashtra State. Nagpur district is located between 21°45' N to 20°30' N and 78°15' E to 79°45' E.

Altitude (from mean sea level) – Avg. elevation of 312.42 meters

Terrain – The city generally have plain terrain with steady gradient slope from west to east with three watersheds parallel to each other. However there are many hilly areas that can be considered as effect of cities location in Satpuda ranges.

Climate – Hot and dry summer (with max temperature recorded is 48°C in May2015) and cold winter (with less than 10°C).

Annual average rainfall – 1161.54 mm

Except for the monsoons, when the humidity is high, the air is generally dry

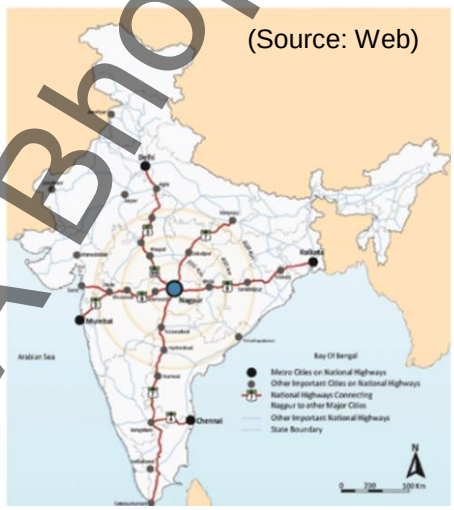


Fig 4.1 Nagpur City's connectivity

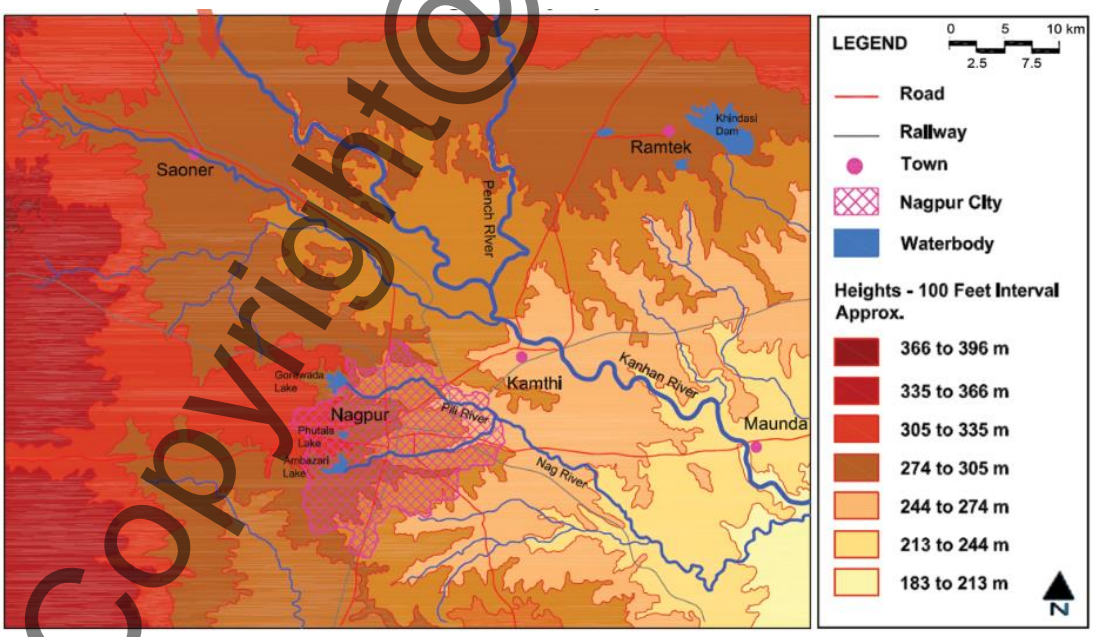


Fig 4.2: Regional setting of Nagpur (Source: NMC Nagpur)

4.2. Chronology of the City:

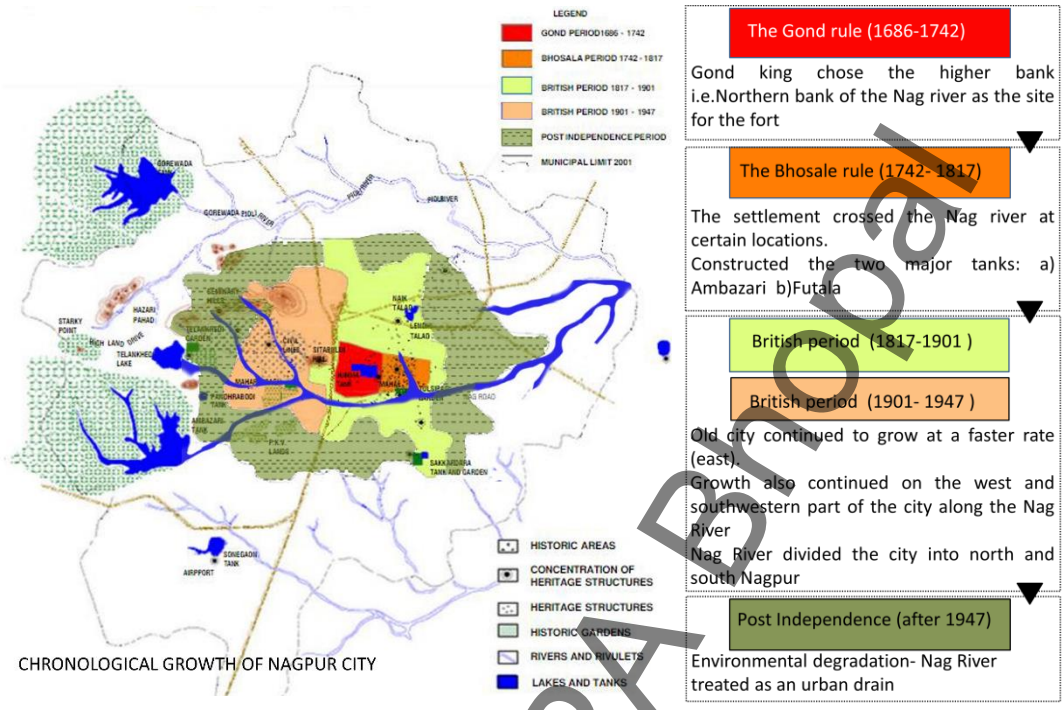


Fig 4.3: Chronological Growth of Nagpur City (Source: NMC Nagpur)

Nagpur city was found by Gond king Bhakth Buland Shah in the early 18th century. He chose Nag River's bank for setting up his kingdom.

Later in mid-18th century Bhosale ruled the city. They were keen in building recreational spaces. Hence, we are able to see lakes in the western part of the city. The two major lakes Ambazari Lake & Futala Lake were constructed during their time.

In early 19th century Bhosales lost to Britishers, and colonial rule began in the city. City saw drastic economic growth. Old city still continued to grow at faster rate. Now the western part of the city started to flourish. This was due to coming up of railway line. Now the city was divided in East-West direction. Nag River divided the city in North- South direction.

Post-independence i.e. after 1947 the environmental degradation started, as the Nag River was treated as an urban drain, and it still is.

4.3. Physiography of the city:

The physiographical studies include study of the physical landform of the place. It focuses on understanding the processes and patterns in the natural environment, as opposed to the cultural or built environment.

It includes an analysis of the following components:

Landform of the region, Slope analysis, Drainage pattern of the river, Geology & geomorphology, Soil etc.

The physiographical studies were carried out using secondary data obtained from Survey of India sheets (Topo sheets), District resource map (First edition 2000), and Satellite images. GIS software was used as a tool for carrying out the slope analysis.

4.3.1. Elevation Map:

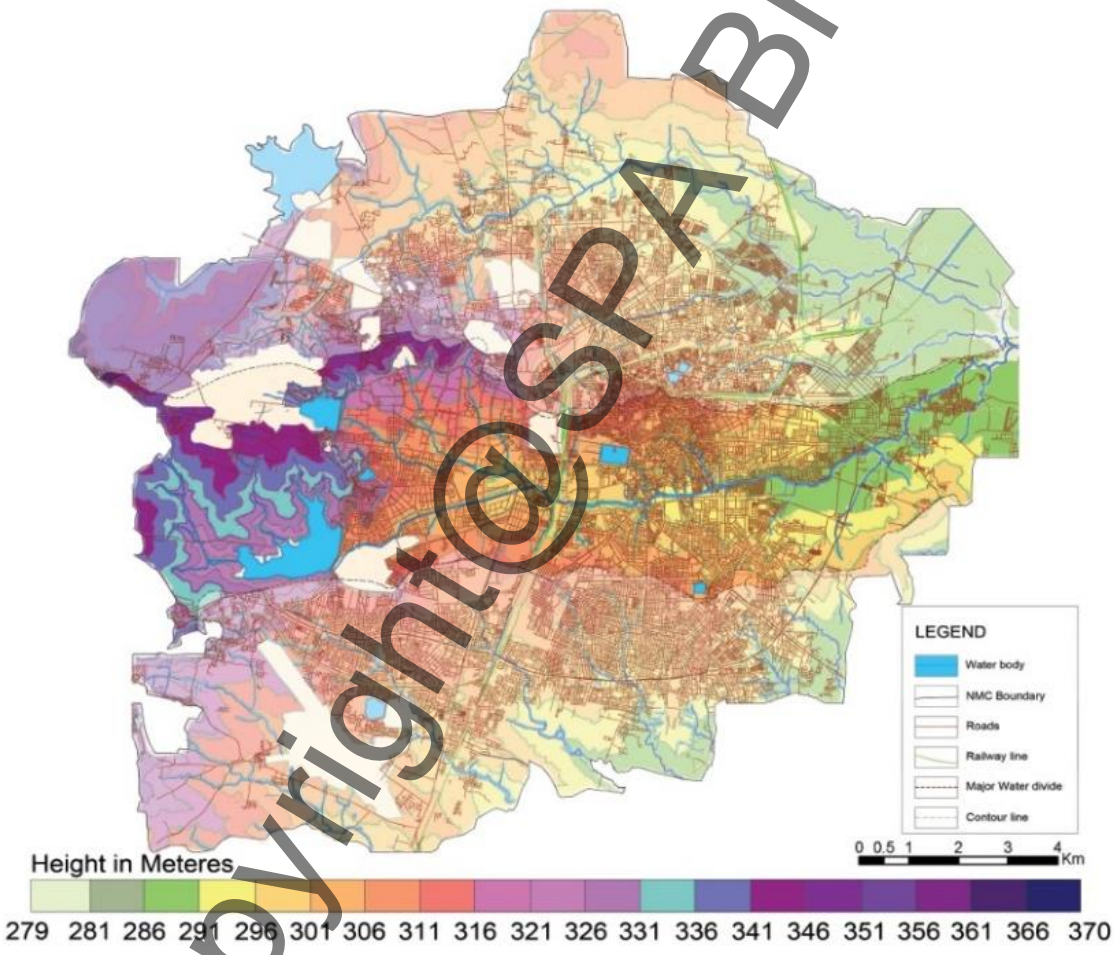


Fig 4.4: Map showing the elevation of the city, Highlighting Nag River's watershed (Source: NMC & author)

The higher ranges are located towards the western side. The general slope of the land is from the west to the east.

Ranging from about 370 meters towards the west to 280 meters to the east side.

The larger water bodies (Ambazari, Phutala etc) are located in this western hilly region. The hills attain to no great altitude (350 M). However they offer good scenic vistas of the surrounding region and can be developed as scenic spots for the city.

Since the topography of the city is sloping from west to east, the Nag does not tend to flood in the western part.

4.3.2. Slope analysis Map:

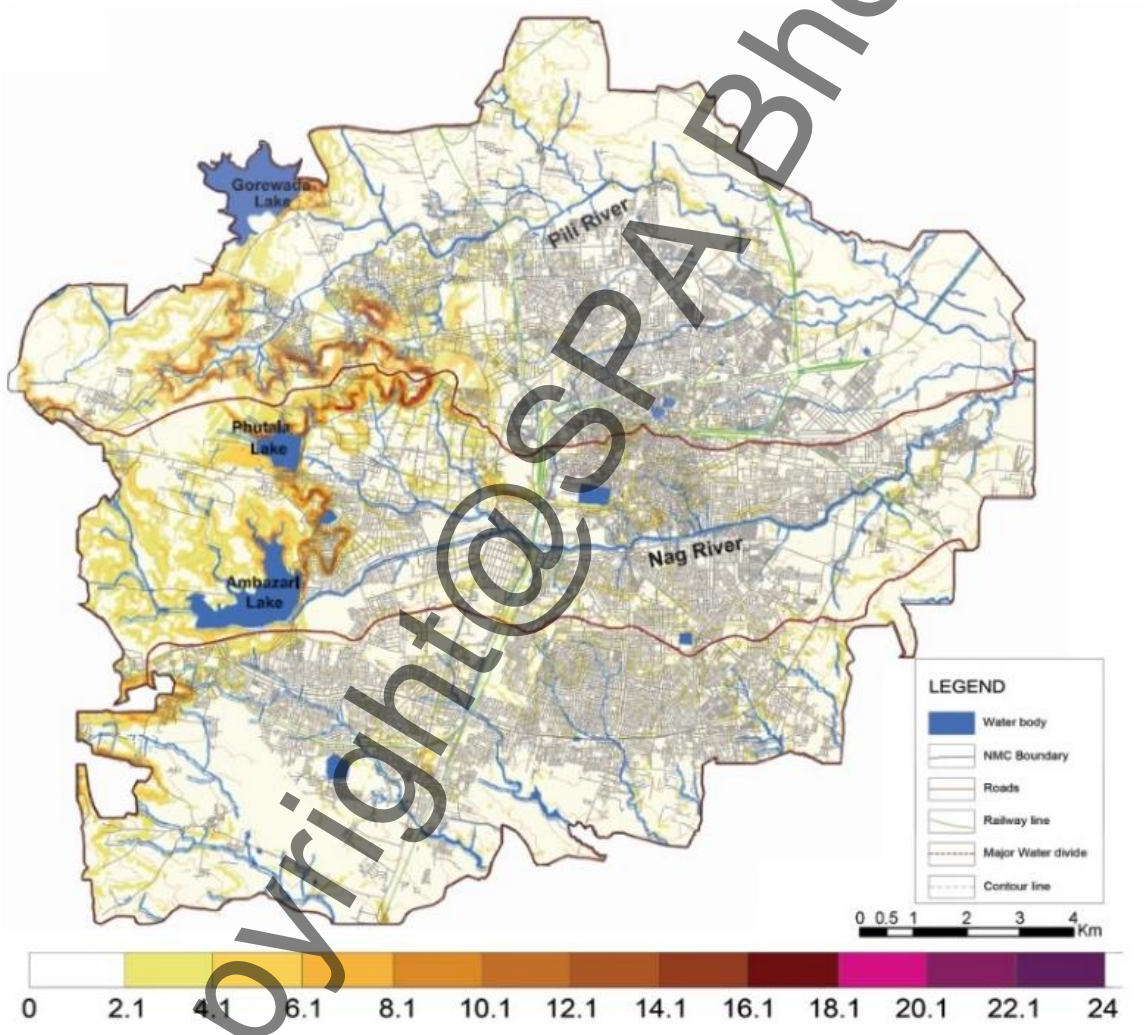


Fig 4.5: Map showing the slope of the city, highlighting Nag River's watershed within Nagpur municipal boundary (Source: NMC & author)

The entire city is gradually sloping, with the slopes ranging between 0 and 25 percent.

The hilly regions to the western side show some characteristic steeper areas. The rest of the city, is gently sloping interspersed with slopes

ranging up to 4 percent.

The slope analysis indicates that due to the low ranges of slope, the landform appears quiet flat in a major part of the city.

This has also contributed to the drainage pattern in the form of shallow and slow moving water courses and rivers in the city.

4.3.3. Watershed & Micro-watershed Map:

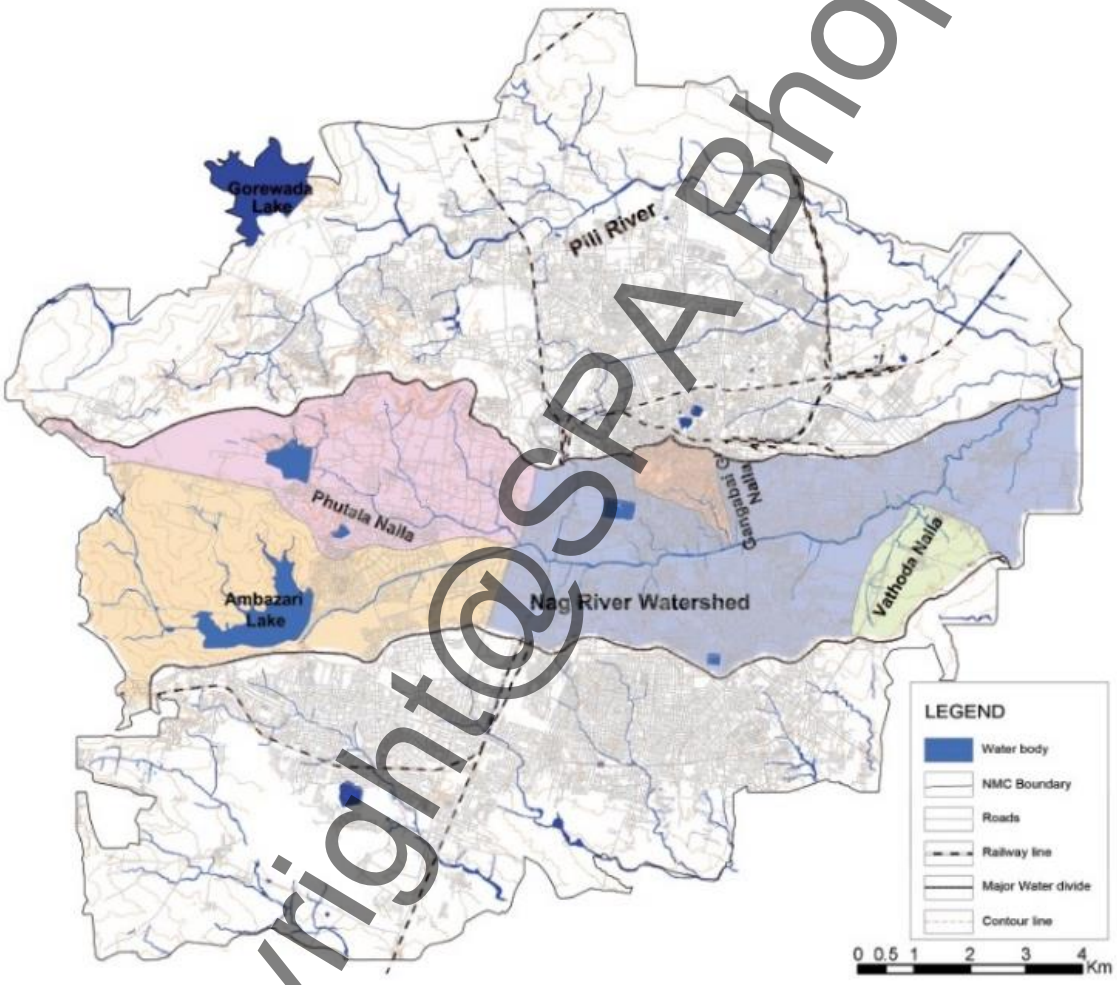


Fig 4.6: Map showing the watershed & micro- watershed of the Nag Rivers catchment, within Nagpur municipal boundary (Source: NMC & author)

The city of Nagpur is categorized into three major watersheds-

The Northern watershed comprising of the PILI river, the central watershed comprising of the historical NAG river and the southern watershed draining into the PORA river.

There is a well-demarcated drainage pattern in the city, sloping down from the west to the east.

Nag river is the 4th order stream, with dendritic pattern.

Catchment area of Nag is 71.37 Sq .Km. (which is about 28% of the city area).

4.3.4. Geology Map:

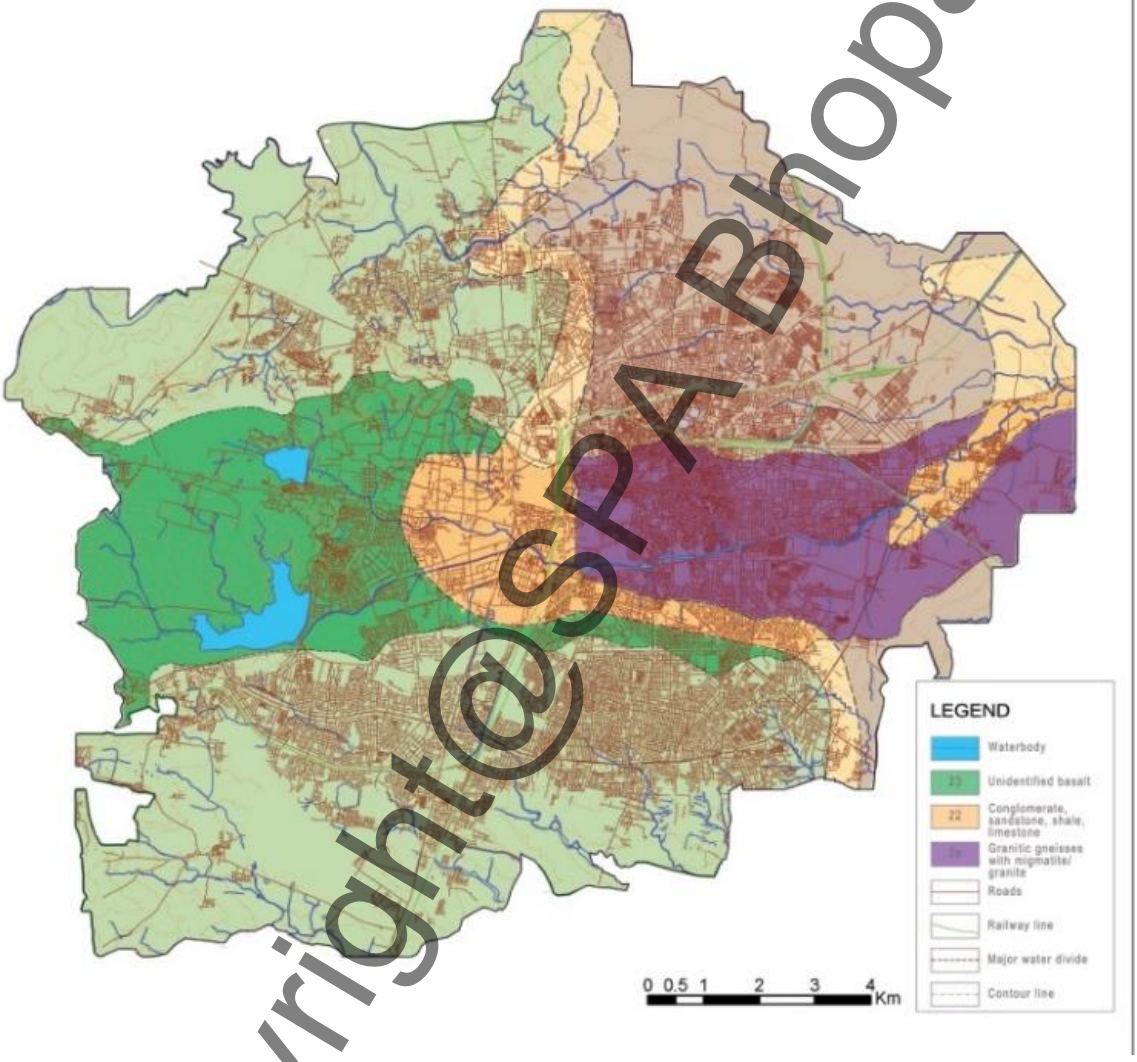


Fig 4.7: Map showing the geological strata of the Nag Rivers watershed, within Nagpur municipal boundary (Source: Resource map of Nagpur District & author)

District can be divided into two main areas, namely - to the west of Nagpur occupied by the Deccan Trap formation and to the east of Nagpur occupied by the metamorphic and crystalline series.

All the 3 rock type are found in the region:

Basalt (igneous rock), Sandstone and limestone (Sedimentary rock) and Gneisses (Granitic Gneisses- metamorphic rock).

4.3.5. Geomorphology Map:

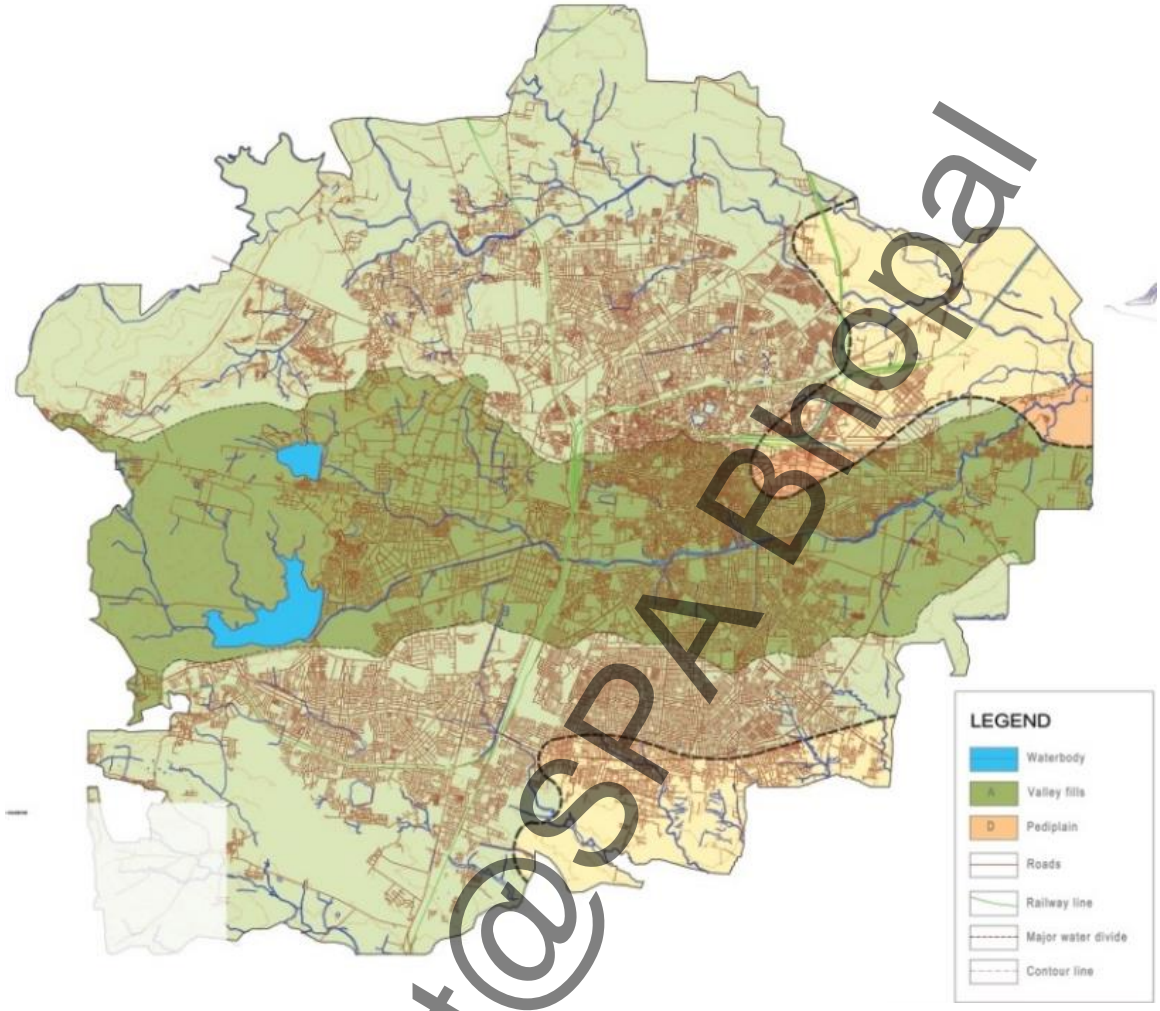


Fig 4.8: Map showing the geomorphology of the Nag Rivers watershed, within Nagpur municipal boundary (Source: Resource map of Nagpur District & author)

To the south east, east and the north east the surface is, for the most part, a plain covered with alluvial deposits of the Kanhan and its tributaries.

It consists of sand, silt & clays.

The area is occupied by denudational hills, dissected pediments and pediplain.

Age	Formation	Lithology
Recent	Alluvium	Consisting of sand, silt and clays
Cretaceo Eocene	Ballistic lava flows	Deccan Trap basaltic lava flows associated with intertrappeans
Permian	Lameta Beds	Calcareous sand stones, sandy lime stones
Carboniferous to lower permian	Gondwana Group	Comprising Kamthi, Barakar and Talchir formation sanstone shales
Plrloterozoic	Sausar Group	Consisting schists, phyllites, granites, quartzites, magmatites, biotite,gneisses, granuluos,marbles, Mn bearing gondites
Plrloterozoic	Sakoli Group	Phyllites, schists, granite, gneisses, quartzites

Table 4.1: The board geological sequence of the area is as under (Source: NMC)

4.3.6. Site Observation & Inferences:

After overlapping of the maps these are the inferences drawn:

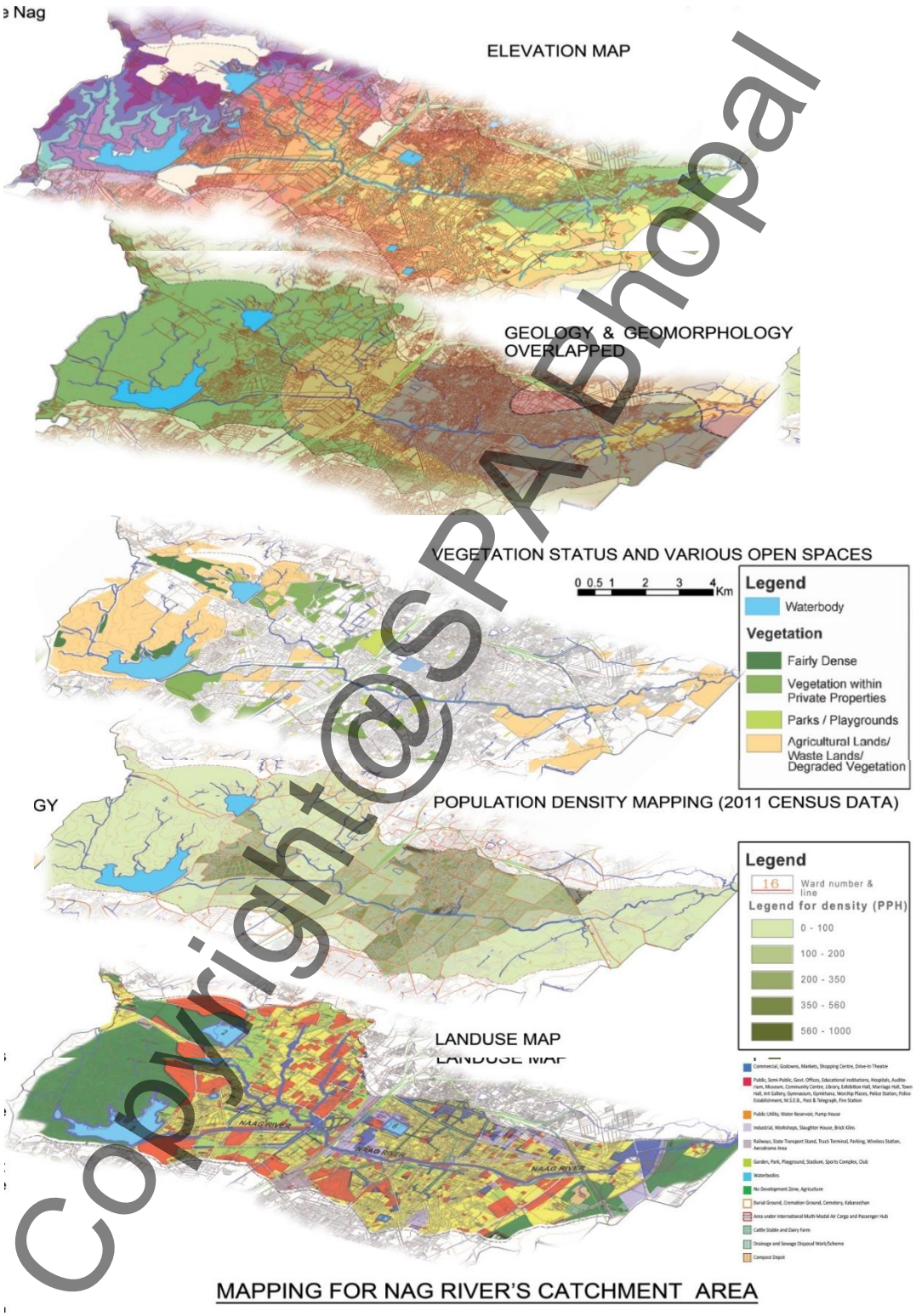


Fig 4.9: Mapping of the Nag Rivers watershed, within Nagpur municipal boundary (Source: Resource map of Nagpur District, Landuse map, Census 2011 ward data, Satellite images, Edited by Author)

The soil is black cotton soil (1-6m depth) and has basalt & sandstone (rocks) as its base. Soil depth varies from 1-6 meters.

Basalt tends to generate fertile, alkaline soils; the black colour of basalt causes the soil to warm quickly. Therefore, good vegetation growth seen in this part.

Upper stream region has Basalt (Igneous rock) strata, that is the reason we could see the 3 lakes (water bodies), in the western part of the city.

Central part consists of Sedimentary rock like sandstone, limestone, and shale: This area has mixed type of soil as sandstone is highly permeable and limestone rich in clay with low permeability. Overall less flooding is seen in this region.

Sedimentary rocks are forming the base strata, which are very good aquifers.

Towards the east the rock is Metamorphic Granitic gneiss:

Gneiss tends to lead to acidic, poorly developed soils

In many places, particularly in low lying, poorly drained areas, the soils are alluvial clays with poor permeability characteristics. The vegetation in this part is also not much and lots of degraded vegetation could be observed (Ref vegetation status map)

Less vegetation & city open spaces could be seen in central and eastern part of the catchment. This may be due to high population density concentration in these areas & also towards the east we have metamorphic rock strata.

Vegetation is in good condition near the water bodies (lakes & rivers) and small rivulets.

The land use along Nag river corridor is mostly Semi-public (Institutions etc.) and Private (mainly residential).

The properties have their back facing the river. Thus, the river is confined by the compound walls of these land ownerships.

4.4. Potential zone study (5 Km):

	Upper Stream			Mid- Stream			Lower Stream			REMARKS
	G	M	F	G	M	F	G	M	F	
Width										Ranges from 12- 30m
Vegetation Status										Deciduous & Semi- deciduous type, patches of evergreen
Edge condition										Not maintained edges, neglected condition
Quality of Water										Good near source, due to heavy sewage entry grossly polluted
Building use										Along the river mainly residenses & institutes
Population Density										Ranging from 0-1000 PPH
Interface										Mostly fair interface
Visual Permeability										Good permeability
Flood Risk										More in low lying areas towards the east
Biodiversity										Nagpur is rich in both flora & fauna
Legibility										Most of the part is covered by backyards of the private properties
Proximity to city level public Spaces										The city level public spaces are easily accessible in the eastern part
Prominent landmarks										Mostly few landmarks & imp heritage structure

Table 4.2: Study of upper, mid, & lower stream on various parameters as good, medium & fair condition

Further study zoom downs to upper stream, as that is the origin point inside the city limits, & its condition is depleting at an alarming rate.

4.4.1. Cognitive mapping- Connectivity, River Edge Condition, Major Nodes

Fig 4.10: Cognitive mapping of the upper stream (Source: Author)

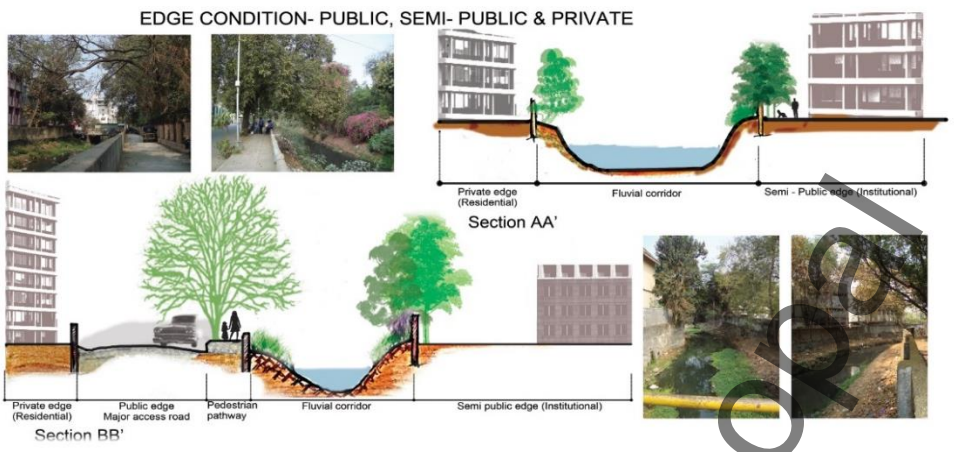


Fig 4.11 Edge condition along the upper stream (Source: Author)

The edge condition near the river corridor is not well maintained. Though it has many green spaces along the edge, but they are not well maintained.

The land use along the river is mostly private, semi- public (Institutional).

4.4.2. Land use mapping along upper stream

Fig 4.12 Land use map along the upper stream (Source: Proposed Master 2040 & Author)

The status of the river is highly influenced by the land uses along it and within its catchment.

It has been observed, due to increase in the developments along the river water quality has deteriorated.

Land use along Nag River is mostly Private (residences) & Semi-public (Institutes).

4.4.3. Density mapping along the upper stream

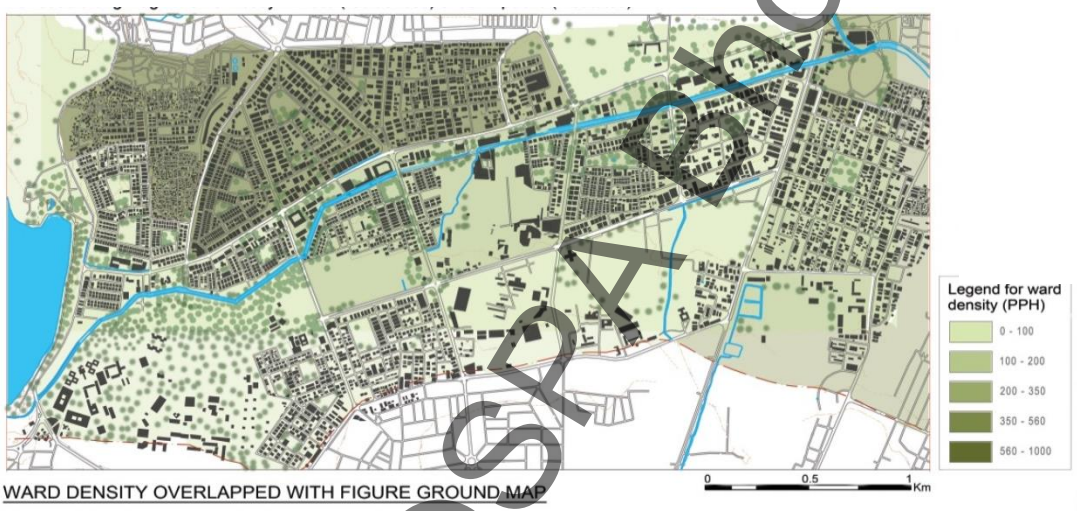


Fig 4.13 Ward Density along the upper stream (Source: Census data 2011 & Author)

The population density along the river increases from west to east, highest in the centre and gradually decreasing towards the fringe.

Population density pattern along Nag River- The density has been highest in the wards forming the city core, ward no.80 sitabuldi is 332 person per hectare & more (as per 2011 census data).

Ward no 48 civil lines, which are well planned by colonial period, have low density.

The wards on the east of the city, forming low lying and flood prone areas are not developed with population density varying from 10 to100 people per hectare.

4.4.4. Vegetation status mapping

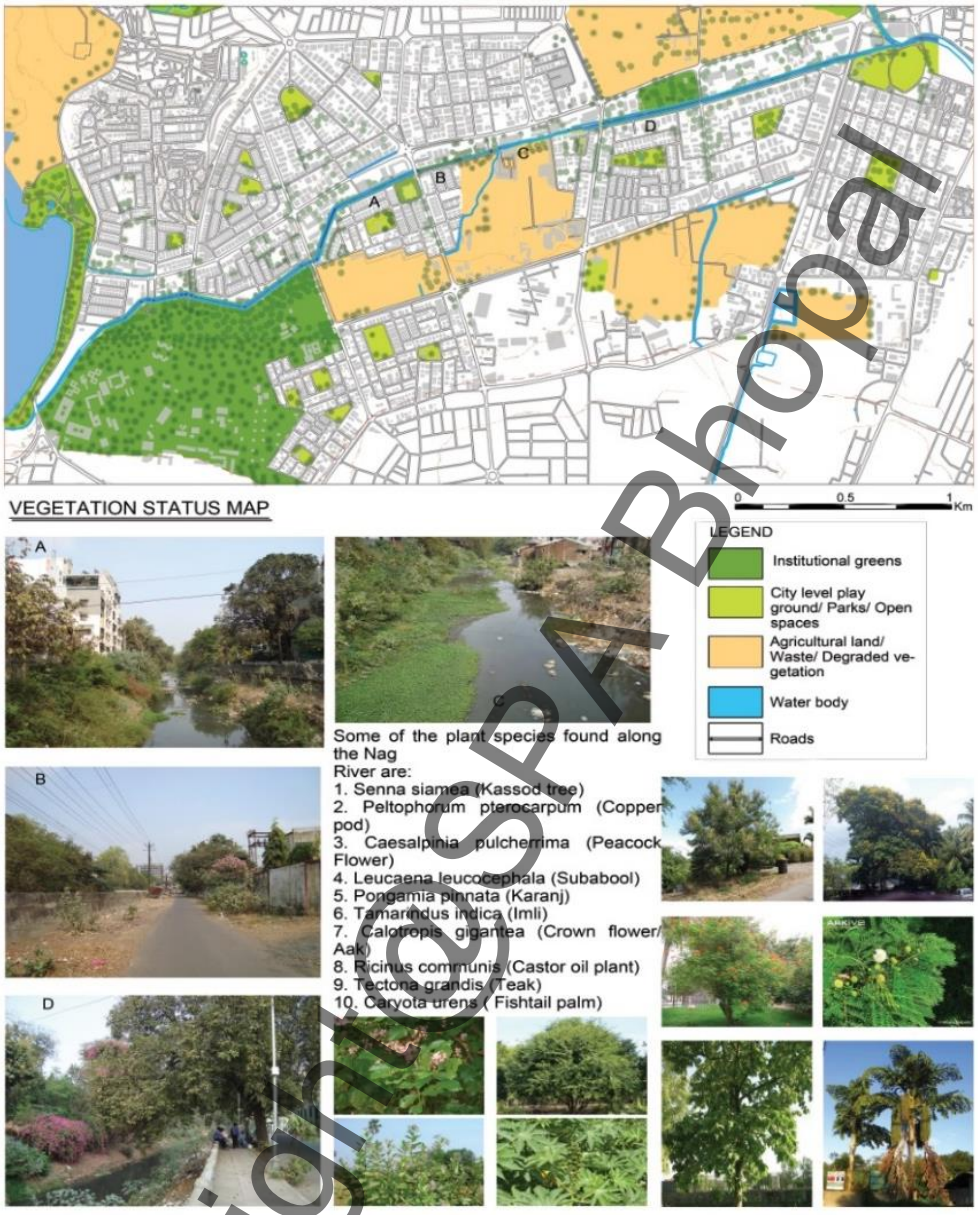


Fig 4.14 Vegetation status along the upper stream (Source: Author's site observations)

The city shows a clear vegetation pattern, with the western hilly regions consisting of forest areas of the deciduous and semi deciduous type with patches of evergreen; while the plains to the east and south having agricultural farm lands.

The planning of Nagpur city had been made in earlier times through history, with a great importance given to the green spaces and the natural systems.

Also institutional belts were introduced within the city limits with large green tracts which have remained protected even till today. Buffers were

left along the rivers and nallas, which became green corridors.

However the newer developments under private bodies are not paying much significance to the green zones.

Biodiversity

The vegetation of the ever expanding, fast developing city of Nagpur is fairly rich and varied.

There are around 850 plant species of the flowering plants and over 160 species of trees.

The diversity is not only limited to the flora; but the city is also a haven for a large number of bird varieties. A phenomenal 240 bird species are found in the municipal limits of Nagpur city.

4.5. Issues at Regional Level

4.5.1. Discharge of Raw Sewage & Garbage

Raw sewage is let to flow into the river by the authority itself, due to inadequate purification system.

Garbage is dumped by the citizens directly from their backyards.

Religious dump is also thrown into the river.

Fig 4.15 Existing condition of sewage & garbage (Source: Author's site observations)

4.5.2. SLUMS & other encroachments near or on fluvial corridor

There are few slums encroaching on the river, thereby polluting the fluvial corridor.Few encroachments by the authority itself (NIT skating ring).

Fig 4.16 Existing Slums & Encroachments (Source: Author's site observations

4.5.3. Maintenance of Flora & Fauna

Fig 4.17 Flora along the river (Source: Author's site observations)

Along the river the flora is quiet rich but not well maintained. Lots of weeds were observed.

4.5.4. Poor edge condition of the river

Today the water edges have either been encroached or are treated as backyard of all buildings in the dense urbanised areas.

Fig 4.18 Poor Edge along the River Nag (Source: Author's site observations)

4.5.5. Less connected to the people

People of are unaware of the river flowing nearby. This is due to poor permeability & visual barriers created which restrict the connectivity with the river.

Fig 4.19 People are not well connected to the River Nag (Source: Author's site observations)

4.5.6. Water quality data by CPCB showing pollution level of Nag River at various locations

Fig 4.20: Water quality at strategic locations along Nag River (Source: CPCB data)

The pollution level of water, at various locations is very high from the normal situation. This is due to raw sewage entering the river directly & without any treatment.

Only Ambazari Lake has good water quality.

5. Guidelines for site level issues:

5.1. Solutions to the Issues at Regional Level

5.1.1. Discharge of Raw Sewage & Garbage

Proposal:

Short term: No sewage from household, institutional buildings etc. would enter the river directly.

Propose DEWATS at neighbourhood level to clean the sewage

To put some screen or net, to keep check on solid suspended waste/ garbage and other materials.

Manual cleaning from time to time by the authority (for garbage)

Bio swales and infiltration basins /buffers for street storm water channels shall be proposed.

Long term: Underground laying of sewage pipes for full stretch of Nag River.

Natural drains to be used only as storm water drains & no domestic, industrial sewage should be allowed to enter.

5.1.2. Slums & Other Encroachments Near Or On Fluvial Corridor

Proposal:

Relocation of slums from the river bed to nearby area.

Remove all the encroachments which hamper the stream flow.

5.1.3. Maintenance of Flora & Fauna:

Proposal:

Short term: Regular cleaning of river bed from weeds, water hyacinth any other invasive species.

Desilting of the bed on regular basis.

Long term: Revegetation along the bank

Root zone filtration for waste water (at few locations) from entering the stream.

Naturalizing the corridor instead of channelization & concretization

Vegetated stretch along the river corridor will reduce silting.

5.1.4. Poor edge condition of the river

Proposal:

Redefine or re-introduce the more natural edge through various techniques which will serve the purpose of the overall rejuvenation of the rivers.

Strengthening & revival of the edge through Biotechnologies.

5.1.5. Less connected to the people

Proposal:

Selection of strategic nodes as activity generators by removing the anthropogenic boundaries.

Interactive spaces and sites for Public discourses- Use educational features, such as storyboards and signboards, to raise awareness of the importance of water: past, present, future.

Site for cultural activities identified along the river edges shall be proposed for such seminars and discourses.

6. Design Solution:

6.1. Design Concept: Erasing the Boundary

This will be achieved by interweaving the natural resource WATER & the natural landscape of the city with existing urban fabric of the city.

Today there are several boundaries that block the valuable areas. The boundaries are created through anthropogenic activities.

Aim would be to reduce the barriers, and build porosity (both tangible and intangible).

This would be done through opening up of open public spaces which are directly connected to the fluvial corridor.

Fig 6.1: Interweaving the built, transitional space & Open public spaces (Source: Web Images)

6.2. Design Strategies & Ideas: At Site Level:

6.2.1. Public connection & strengthening access

Steps

Better linkages: This welcomes people to come to the park.

Visual connectivity: Small trees along the river edge, will connect people visually.

Safe for different age group people, coming to the park.

Fig 6.2: Space of interaction with water (Source: Author)

6.2.2. Landscape buffer for the city

Steps

Vegetated stretch along the river corridor.

Integrating the existing urban fabric of the city with the river.

Using of native species, grasses & shrubs will help in bank stabilization.

6.2.3. Maximizing of green infrastructure.

Steps

Ecological approach: Concreted channel to natural river bed, soil engineering techniques, biological cleansing of water, re-use of waste material, enriching bio-diversity

Recharging of ground water.

Using of pervious surfaces wherever possible.

Revegetating with species which will attract the fauna & enhance biodiversity.

6.2.4. Increasing self-purification capacity of water

Steps

Naturalising the river corridor.

Reducing silt load

Vegetating edges

No raw sewage to enter river, only treated sewage may be allowed.

Maintenance of river edge & riparian zone.

6.3. Design Intervention:

Some solutions for rejuvenation of Nag River Stream:

Connecting the neighbourhood level open spaces & City level open spaces to the fluvial corridor. This will strengthen & give reinforcement to the overall green network along the river as well to the city.

Opening up of City Level Park which is an active space, towards the river. This will engage people with the water. Connecting people to the river will improve its lost identity.

Proposed a wet land park, along the river. This will help in percolation of water, as the location proposed for wetland has sedimentary rock strata. This will help in ground water recharge.

DEWATS to be used for cleansing of sewage generated. DEWATS can be practised both at neighbourhood level as well as individual household level. This treated water can then enter the river, making it perennial during non-monsoon season.

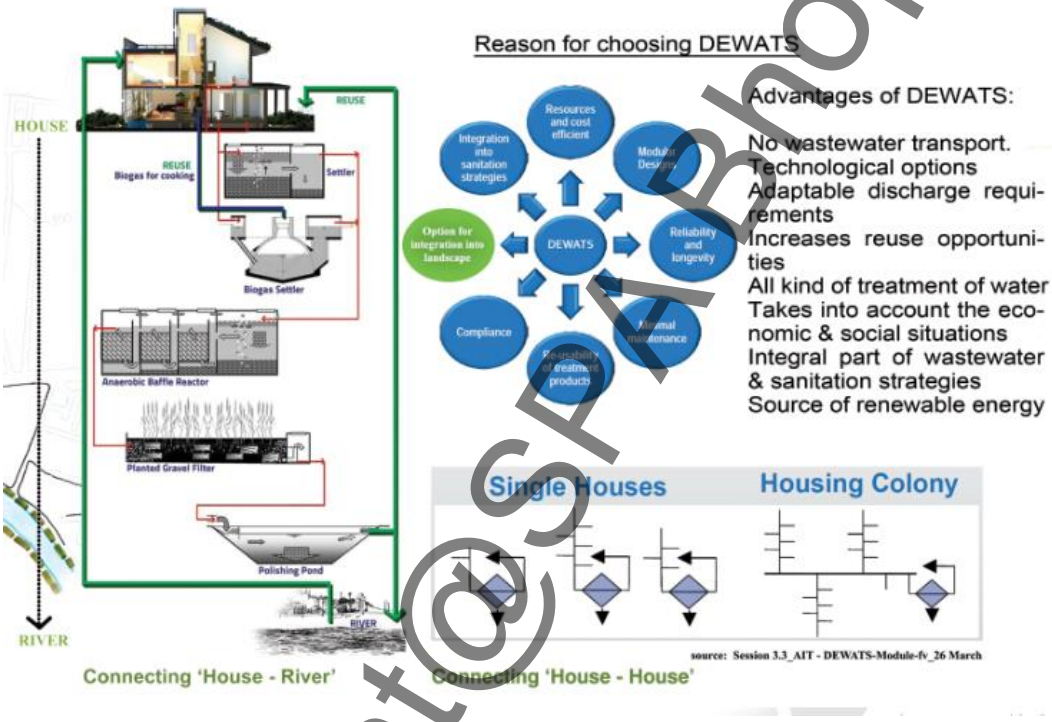


Fig 6.3: DEWATS schematic diagram for cleaning up of sewage generated (Source: Session 3.3_AIT- DEWATS- Module-fv_26 March)

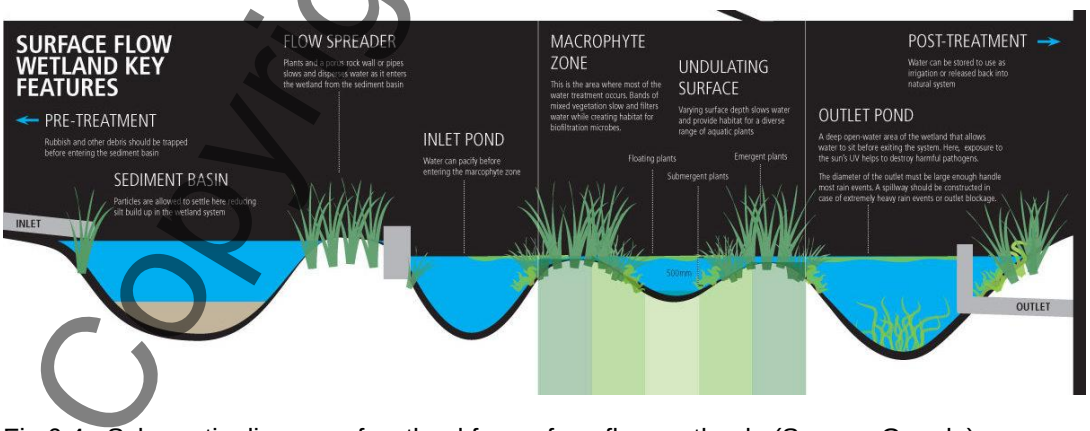


Fig 6.4: Schematic diagram of wetland for surface flow wetlands (Source: Google)

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