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Land Reclamation for Rejuvenation of Mula-Mutha River

Jui Kishor Sathe[1], Vivek Rajesh Kasat[2], Rupali Vinod Ghodichor[3], Mrs. Sarika Patil[4] (Guide)
Bachelor of Engineering, Civil Engineering, Sinhgad College of Engineering, Savitribai PHULE Pune University, Vadgaon (Bk.), Pune-411041

Abstract: ***Rivers play a major role in shaping the development of cities, as many major ones across the world have originated by the banks of rivers. Such river systems have not only been used for irrigation, drainage and supply of potable water but they also possess a close relationship with the social fabric. The Mula-Mutha riverfront in Pune is multi-functional with bulk of its premises being residential, commercial and institutional buildings along with some heritage structures. The rapid urbanization of the city has adversely affected the river with various forms of pollution, becoming a major issue for the city authority. This phenomenon has lead to the detachment of the city from the river. In view of this demographical change, it becomes essential for any city authority to restore such a valuable resource to its lost glory, thereby enhancing its appropriate role in transforming the vacant riverfront to a place of planned development.***
The aim of the project is to provide suggestive measure for the rejuvenation. The aspect studied in the particular report is that of land reclamation. This project consist of various case studies regarding rejuvenation projects carried out for different rivers. Introduction will be consisting of all the basic aspects of the project followed by Literature review and methodology of particular topic. The suggestive measures are provided at the end of the project report.
Keywords: urban rivers, water front, water quality, mixed-use, land reclamation, rejuvenation, riverfront zone

I. INTRODUCTION

A. *Introduction*

Pune, located in the State of Maharashtra lies on the western margin of the Deccan plateau, on the leeward side of the Sahyadri mountain range. It lies at the convergence of two rivers Mula and Mutha. The Mula and Mutha Rivers originate in the Sahyadri ranges and traverse across Pune city, and form Mula-Mutha River which eventually joins the Bhima River. The total length of the three rivers Mula, Mutha and Mula-Mutha traversing through Pune Municipal Corporation area is approximately 44 km. The river length covered in this project along the land is as follows:

1) *Mula River:* Mumbai-Pune Bypass to Sangam Bridge (22.2 Km).
2) *Mutha River:* Mumbai-Pune Bypass to Mula-Mutha Sangam (10.4 Km).
3) *Mula-Mutha River:* Mula-Mutha Sangam to Kharadi (11.8 Km).

The growing urban activities have left these water bodies in vulnerable state. Due to lack of planning the rivers presently face growing levels of pollutants and rapid degradation, creating unhygienic conditions. Therefore, the city has turned its back to these rivers. These highly neglected rivers have raised concerns amongst the authorities and the citizens of Pune.

B. *Regional Context*

The growth of city relates directly to the activities and events that occurred along its rivers. The timeline also shows that improvement of infrastructure facilities along the river, for example, making provision for water and sewage disposal (development of aqueducts, construction of underground sewerage system) and bridges have played a significant role in the expansion of the city, evident through its growth pattern.

Pune is the second most populous city of the state of Maharashtra with a population of 31.15 lakhs and an area of 243.84 sq. km (2011). Pune city is well-connected to the important metropolitans - Mumbai, Hyderabad, Bangalore, etc. by air, rail and road. Major National and State Highways passing through the city, connect it with all major cities of Maharashtra such as Nashik, Ahmednagar, Solapur, and Kolhapur ensuring cultural, economic and religious dependency.

C. Issues Faced By The River

1) Dry river bed.
2) Inaccessible banks.
3) Illegal reclamation by unknown persons, poses threat to the free flow of water and the danger of flooding during monsoon.
4) Dumping of debris on riverbeds to increase land level.
5) Land used by luxury buses to pick-up and drop off passengers.
6) Proposed public transportation like Metro and BRTS routes in close proximity to river.
7) Highways and arterial roads cross the river at many locations.
8) Choked by development
9) Polluted by outfalls
10) Polluted by nallas
11) Acts as a barrier that divides Pune
12) Neglected and underutilized

D. Potentials In The River's Existing Condition

1) Variation in river width and slope gradient provides the opportunity to have variations in Cross- Section during design.
2) Numerous access points (steps, ramps).
3) Controlled discharge of water into the rivers by upstream dams prevents sudden floods except in extreme situation.
4) River bed has a rocky terrain as a result of which there is less amount of water loss through seepage.
5) Variation in the extent of development and existing land use in the adjacent land.
6) Religious activities, and recreational activities like boating, etc. still practiced, thus reflecting the association of people with the river.
7) Heritage structures and spaces of cultural significance in adjacent areas
8) Existing gardens are seen along the river length.
9) Frequent bridges on Mutha ensure good connectivity across the banks.

E. Aim Of The Project

To study land reclamation for rejuvenation of Mula-mutha river.

F. Objective

1) To study issues faced by Mula – Mutha.
2) To study land reclamation of the Mula – Mutha river bed and river bank for various purposes.
3) To study possible and environment friendly land reclamation for rejuvenation.
4) To give Suggestions for proposed project of rejuvenation.

G. Purpose Of Project

The environmental study undertaken is aimed at identifying existing environmental conditions, predicting environmental impacts associated with the proposed Mula, Mutha & Mula-Mutha River Rejuvenation to suggest mitigation measures to mitigate the adverse environmental impacts. The different activities that are likely to take place were analyzed and proposed mitigation measures were assessed for their adequacy. Further mitigation measures shall be proposed if necessary. The study will also establish the likely effect on the environment, human beings, local communities, and on the adjoining/neighboring areas as a consequence of the relevant phases of proposed project, methods, and measures contemplated for minimizing environmental damage and carrying out site restoration activities.

II. LITERATURE REVIEW

A. Gurdeep Singh, D.K. Sinha

This case study attempts to present sincere efforts being carried out in environmental restoration by NEC authorities. Background of mining, geology, climate and ecology in the region and also Impacts of opencast mining operations have been described in this paper. Slope stability and aspects of control of soil wash off are also dealt with particularly civil engineering and mechanical measures such as terracing. Bamboo barricading in the slopes, stone-barriers at the toe of dumps. Revetment and retaining walls. Check-dams in the channels and valleys and gully-plugging etc.

Vegetation restoration through plantation of various selected species Including turfing/transplantation etc. are also presented. Silt quality aspects of In-situ soils dealt with. Vegetation results obtained have been quite successful with survival of diverse species at the rate of over 90%. The aspects of restoration of natural ecosystem restoration in this region of subtropical climate have also been described.

B. Chandanshive Navnath Eknath

The paper highlights pollution status and impact on fish diversity in Mula-Mutha River and damps on it**.** Seventy two species was reported in 1942 in this river. However, it has been observed that fish diversity is gradually decreasing since last thirty years unprecedently, mainly due to manifold human activity. Fish diversity in midway of river is becoming rare and only four species have been reported form polluted stretch of river. The physico-chemical aspects of water pollution of Mula-Mutha Rivers was analysed seasonally with respect to following parameters from July-2004 to May-2005. i. Water temperature, ii. pH, iii. Dissolved solids, iv. Dissolved oxygen, v. Free carbon dioxide, vi. Acidity, vii. Alkalinity, viii. Chloride content, ix. Nitrates, x. Phosphates, xi. Biological oxygen demand, xii) Chemical oxygen demand.

C. Dipali Babubhai Paneria, Vishwa D. Mehta, Bhasker Vijaykumar Bhatt

The abused river can be brought back to the city by utilizing the resources of the river itself and convert the abandoned land of riverbed and nuisances at the centre of the city into people's attraction, tourist attraction, creation of infrastructural and recreational facilities and transform the city more livable in terms of environmental improvement and inclusive development.

D. Rana Amirtahmasebi, Mariana Orloff, Sameh Wahba, Andrew Altman

In this book, a total of 8 cities have been taken into consideration that have faced major challenges of land loosening and weakening. How does a transformational urban regeneration process—either for the city as a whole or for a specific land parcel starts is mentioned. Regenerating Urban Land draws on the experience of eight case studies from around the world. The case studies outline various policy and financial instruments to attract private sector investment in urban regeneration of underutilized and unutilized areas and the requisite infrastructure improvements. In particular, each case study details the project cycle, from the scoping phase and determination of the initial amount of public sector investment, to implementation and subsequent leveraged private-sector funds. This manual analyzes rates of return on the investments and long-term financial sustainability. Regenerating Urban Land guides local governments to systematically identify the sequence of steps and tasks needed to develop a regeneration policy framework, with the participation of the private sector. The manual also formulates specific policies and instruments for expanding private sector participation; structuring effective administrative and legal frameworks; utilizing land readjustment/assembly methods; determining duration of contracts, adequate phasing, and timeline; and balancing the distribution of risk and sustainability measures.

E. Chirayu Bhatt, Isabel Brain

Regenerating Urban Land draws on the experience of eight case studies from around the world. The case studies outline various policy and financial instruments to attract private sector investment in urban regeneration of underutilized and unutilized areas and the requisite infrastructure improvements. In particular, the case study of Sabarmati Redevelopment in Ahmedabad details the project cycle, from the scoping phase and determination of the initial amount of public sector investment, to implementation and subsequent leveraged private-sector funds. The book and its case studies guide local governments to systematically identify the sequence of steps and tasks needed to develop a regeneration policy framework, with the participation of the private sector.

The Sabarmati Riverfront development in Ahmedabad, India, is a self-financed project, backed by funds from the future sale of a portion of reclaimed land. The project was initiated in 1997 with the formation of a special purpose vehicle (SPV), the Sabarmati Riverfront Development Corporation Limited (SRFDCL), to undertake the development of the riverfront and to return developed land and public amenities to Ahmedabad Municipal Corporation (AMC) in order to recover the project costs.

III. METHODOLOGY

A. Scope

1) An intensive reconnaissance and preliminary collection of environmental information to plan field study.

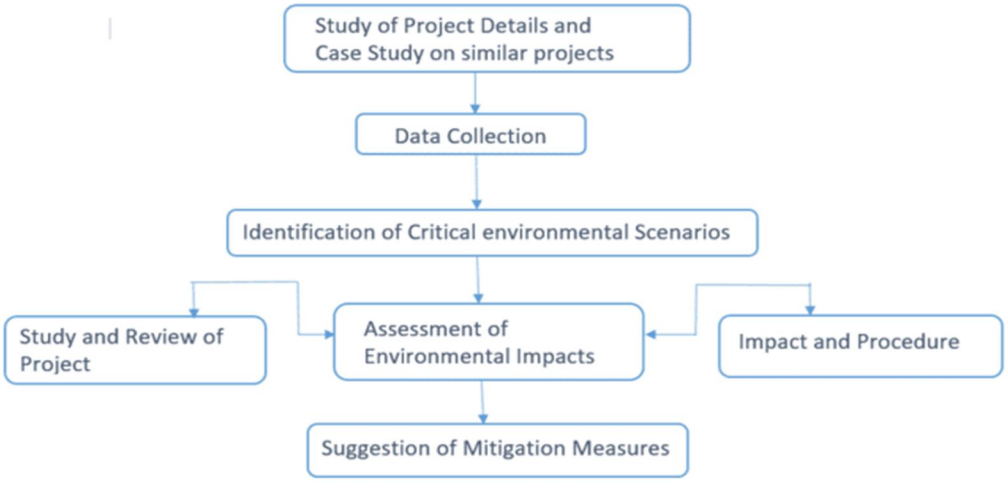
2) Field studies to collect preliminary information, particularly on the quality of the physical environment. Experienced scientists and engineers will collect the data.

3) Baseline data generation and characterization of air, water, soil, noise and vegetation in the 10 kilometer radius area (impact zone) over a period of 3 months.

4) Preparation of Environmental Monitoring Program. Preparation of Environmental Management plan suggesting suitable methods for mitigating and controlling the pollution levels. Environmental monitoring plan is suggested for monitoring the pollution loads at various facilities in the premises and to ensure compliance with the statutory requirement.

5) Complete geotechnical investigation was undertaken to obtain the required subsurface information to study and to indicate the nature and behavior of soil/rock under the application of load of proposed structures under Pune River Rejuvenation Project.

B. Flowchart



IV. CASE STUDIES

A. Sabarmati Riverfront Development Project

1) Problems faced by Sabarmati River

a) Release of sewage
b) Open defecation
c) Discharge of industrial waste
d) Illegal construction on the river bed
e) Reduction in flood carrying capacity

2) Objective of the Project

a) Environmental improvement
b) Rehabilitation of slums, gujari bazar and dhobis
c) Creating vibrant neighborhood

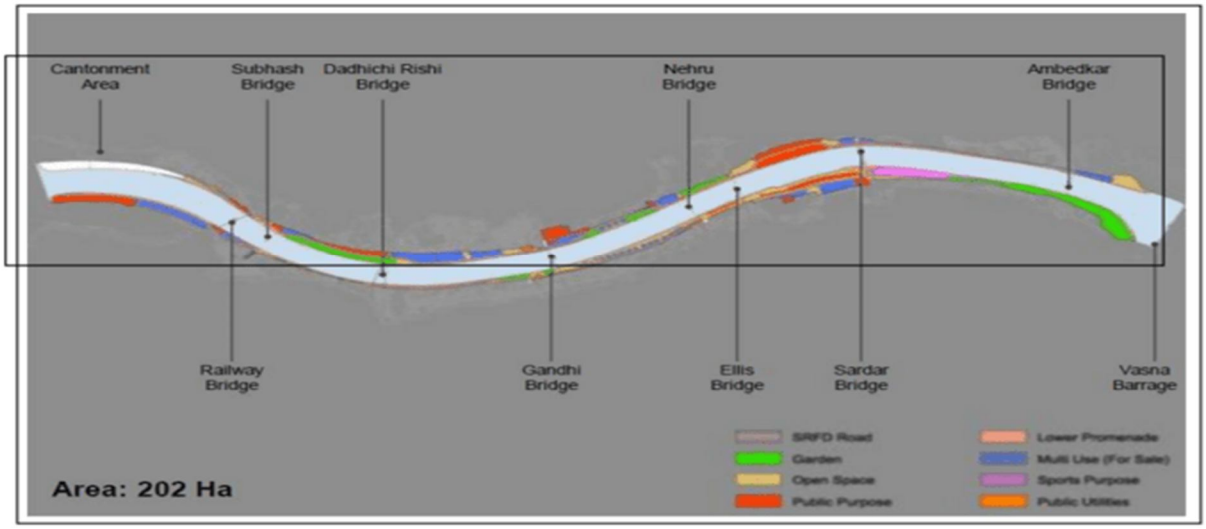
KPMG (Klynveld Peat Marwick Goerdeler), one of world's top advisory firms has included Sabarmati Riverfront Development Project in '100 most Innovative Projects' in the field of urban regeneration (2012) that make cities livable as well as sustainable. Ahmedabad Municipal Corporation (AMC) received HUDCO National Award 2012 for innovative infrastructure development for the riverfront project. The project consists both banks of the Sabarmati for a 10.5 km stretch, creating approximately 202 hectares of reclaimed land. There is a water management system for minimizing flooding and clean up the river with new sewage treatment infrastructure. The Sabarmati River Front Development Corporation Limited (SRFDCL) is established in 1997 for the development of the riverfront in the city. (1) SRFDCL reached out to a number of NGOs and citizen groups for planning and implementation. The process of implementation was done by build, maintain, operate and transfer. SRFDCL appointed Independent Third Parties to supervise the private sector contractors who were selected on fixed time and rate. The fund for the project is set out by different sources that are equity capital, loan fund and proceeds from land sales.

3) Riverfront Land Use

The proposed development is of mix land use that includes commercial, recreational and residential developments within the both side of river bank from Gandhi Bridge to Sardar Bridge.

Sr. No.	Sanctioned Land Use	Area Sq. m.	Area Ha.	%
1	Road	4,44,378	44	22
2.	Garden	2,74,585	27	14
3.	Open space	3,71,198	37	18
4.	Public purpose	2,88,875	29	14
5.	Lower Promenade	2,66,462	27	13
6.	Multi use for sale	2,94,083	29	14
7.	Sports	72,503	7	4
8.	Residual (Utilities, Residential, Commercial, General, Education)	15,787	2	1
	Total	20,27,871	202.8	

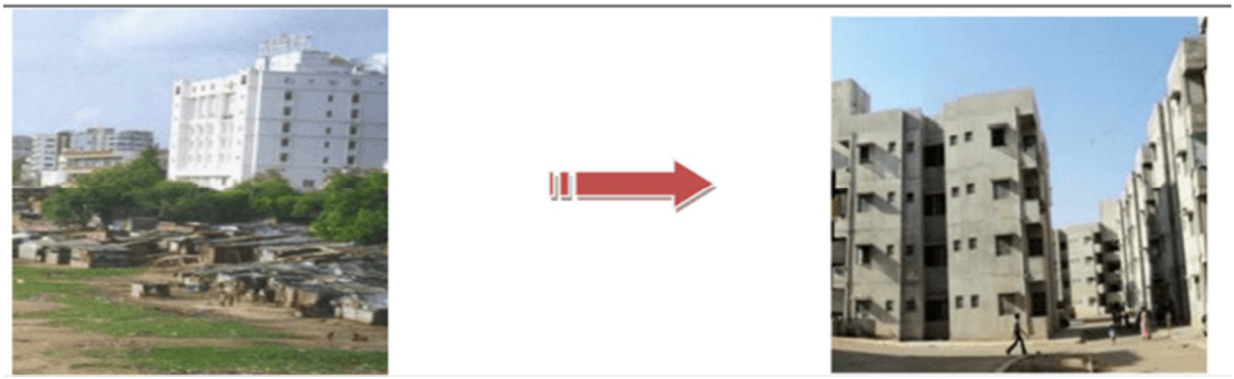
Fig. Land Use Map



4) Development in Different Sector

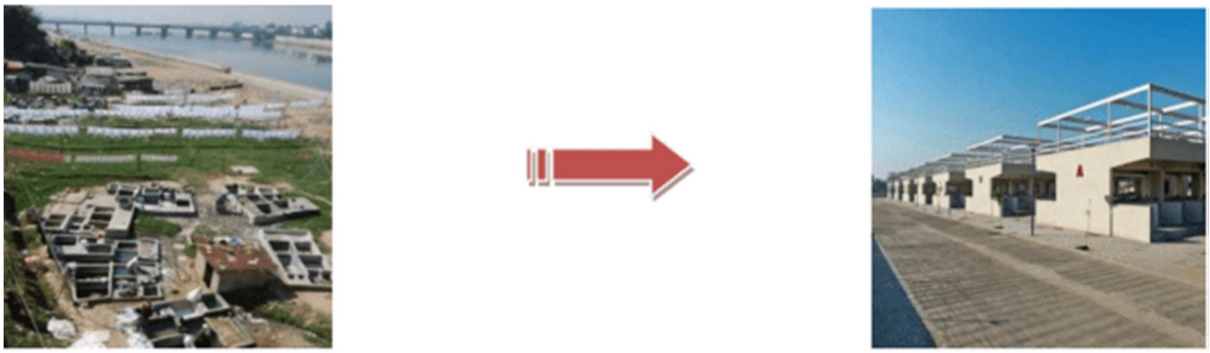
The major component of the project concludes embankment and reclamation works, construction of road and installation of infrastructures such as water, sewer network, storm water drainage, etc., resettlement and rehabilitation work, construction of promenades and garden and maintenance of public spaces.

a) Rehabilitation of Slum Dwellers: There were around 12000 hutments on both side of river bank that cover nearly 20% of the critical project area. More than 10000 families are allotted with houses for resettlement, and 9078 odd families have already been shifted. Each house is of 26.77 sq m carpet area. Commonly the relocation of a slum is provided on the outskirt of the city, but in this case, it is located near to the prime location of the city.

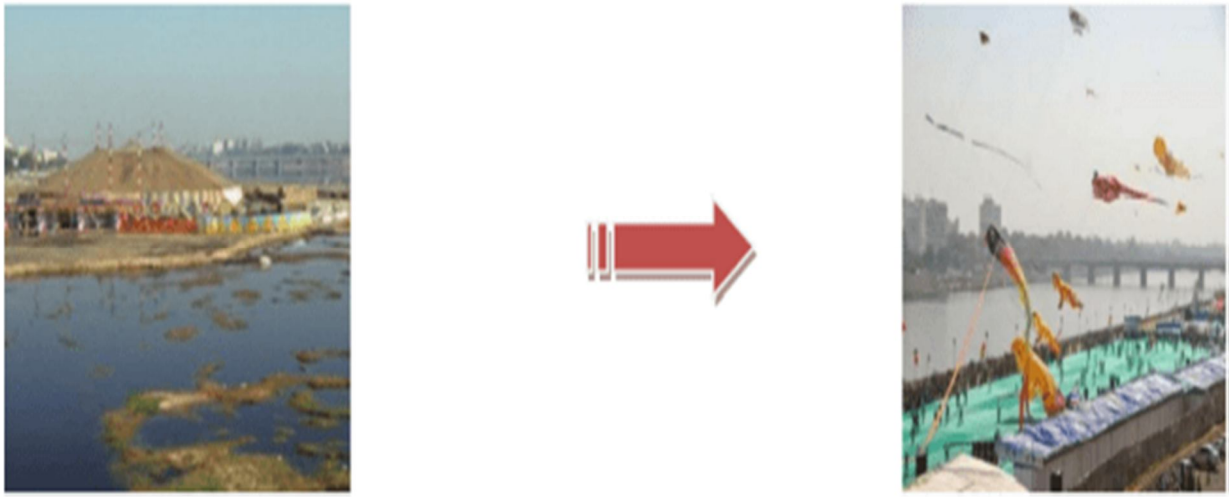


b) *Gujari Bazar - Sunday Market:* It is an age-old Sunday market, where 40% of traders were women and half of them describe themselves as Dalits. It was unhygienic and also there is a risk of flood in monsoon. Now, it is spread over 70.00 sq.mt area, and 1600 vendors can do their business on 788 pucca platforms and 783 laris.

c) *Dhobi Ghat:* Around 172 Dhobis were using both the bank of the river for washing activities. On the eastern bank of the river near Vasna Barrage is constructed as dhobi ghat spread over approx. 9400 sq.mt area has utility area of about 600 sq.mt. There are seven blocks in modern Dhobi Ghat, and each block has 24 units with well-developed water supply and drainage system with a water meter for inlet watering.



d) *Event Area:* Earlier the dry river bed was used to host events like circus and cricket etc. However, a mega city like Ahmedabad requires a proper event management ground facilities. So that an area of 60.00 aq.mt, spread between Sardar Bridge and Ellis Bridge on the west bank has been designed for hosting events such as the Kite Festival, the Marathon, the Cyclothon and Garib Kalyan Mela are organized.



e) *Urban Forestry:* Between Vasna Barrage and Ambedkar Bridge, the unique afforestation project is situated over 1 lakh sq.mt area. The natural forestry is being developed with different plant species from Gujarat, including certain very rare species



f) *Sewage System:* To intercept the sewer running into the river and divert it to the treatment plants, the interceptor sewer system was constructed. Earlier the sewage from 36 drainage points directly falls into the river that makes the water dirty, mosquito ridden and unhealthy environment. Now, there is an extreme change in the environment around the river because all sewage goes to a pumping station for transformation it to river quality.



g) *Promenade:* A key feature of this project is a two-level, continuous walk on both sides of river bank built just above the water level for pedestrian and cyclists. So there will be no private ownership of river bank, and the whole stretch is open for every citizen.



5) *Project Benefits and Impacts*

a) Surface water can be retained in the river all year around.
b) The ground strata are recharged with storage of 12.5 million cubic meter river water.
c) More than 250 MLD sewage is diverted from the river and pollution is eliminated.
d) The river is protected from the scour and stopped the erosion of the river banks with Diaphragm walls.
e) 202 ha. land is available by retaining wall on both sides for further development for the city and flood protection.
f) The embankments provided with wide walkways, green space with tree plantation and many other facilities.
g) Rehabilitation of resettlement of 10000 slum dwellers in great pukka houses.
h) Traditional users of a river like washer men and unorganized vendors are now provided with organized facilities.
i) Easy access to the river water through Ghats, Stairs/ Ramps.

Before – After : D/s of Subhash Bridge

Before – After : Gandhi Bridge West D/s

B. Namami Gange Programme

'Namami Gange Programme', is an Integrated Conservation Mission, approved as 'Flagship Programme' by the Union Government in June 2014 with budget outlay of Rs.20,000 Crore to accomplish the twin objectives of effective abatement of pollution, conservation and rejuvenation of National River Ganga.

The mission also has projects to clean the ghats, rid the river of biological contaminants and improve rural sanitation and afforestation.

1) Main pillars of the Namami Gange Programme are

a) Sewerage Treatment Infrastructure
b) River-Front Development
c) River-Surface Cleaning
d) Bio-Diversity
e) Afforestation
f) Public Awareness
g) Industrial Effluent Monitoring
h) Ganga Gram

2) Reasons Behind the Pollution of Ganga

a) The sewage generated is quite huge as compared to the treatment capacity.
b) The rapid increase in population, the exponential growth of industrialization and urbanization.
c) Unauthorized industrial operations.
d) Religious activity performance at the ghats.
e) Large quantities of fertilizers, when washed through the irrigation, rain or drainage to the river.

3) Key Achievements of the Programme

a) Creating Sewerage Treatment Capacity - 63 sewerage management projects under implementation in the States of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal.12 new sewerage management Projects Launched in these states. Work is under construction for creating Sewerage capacity of 1187.33 (MLD).Hybrid Annuity PPP Model based two projects has been initiated for Jagjeetpur, Haridwar and Ramanna, Varanasi.

b) Creating River-Front Development - 28 River-Front Development projects and 33 Entry level Projects for construction, modernization and renovation of 182 Ghats and 118 crematoria has been initiated.

c) River Surface Cleaning - River Surface cleaning for collection of floating solid waste from the surface of the Ghats and River and its disposal are afoot and pushed into service at 11 locations.

d) Bio-Diversity Conservation - One of NMCG's long-term visions for Ganga rejuvenation is to restore viable populations of all endemic and endangered biodiversity of the river, so that they occupy their full historical range and fulfil their role in maintaining the integrity of the Ganga river ecosystems. To address this, Wildlife Institute of India (WII), Dehradun, Central Inland Fisheries Research Institute (CIFRI), Kolkata & Uttar Pradesh State Forest Department has been awarded projects to develop science - based aquatic species restoration plan for Ganga River by involving multiple stakeholders along with conservation & restoration of aquatic biodiversity.

e) Afforestation - One of the major components of Ganga rejuvenation is 'forestry interventions' to enhance the productivity and diversity of the forests in head water areas and all along the river and its tributaries. Accordingly, Forest Research Institute (FRI), Dehradun prepared a Detailed Project Report (DPR) for afforestation in an area of 1,34,106 hectares in the Ganga river bank states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal at an estimated cost of Rs. 2293.73 Crores. The FRI DPR provides for taking up works under four major heads viz. Natural landscape, Agriculture landscape, Urban landscape and Conservation interventions.

f) Industrial Effluent Monitoring - The number of Grossly Polluting Industries (GPIs) in April, 2019 are 1072. Regulation and enforcement through regular and surprise inspections of GPIs is carried out for compliance verification against stipulated environmental norms. The GPIs are also inspected on annual basis for compliance verification of the pollution norms and process modification, wherever required through third party technical institutes. First round of inspection of GPIs by the third-party technical institutes has been carried out in 2017. Second round of inspection of GPIs has been completed in 2018. Out of 961 GPIs inspected in 2018, 636 are complying, 110 are non-complying and 215 are self-closed. Action has been taken against 110 non-complying GPIs and are issued closure directions under Section 5 of the E(P) Act. Online Continuous Effluent Monitoring Stations (OCEMS) connectivity established to CPCB server in 885 out of 1072 GPIs.

g) Ganga Gram - Ministry of Drinking Water and Sanitation (MoDWS) identified 1674 Gram Panchayats situated on the bank of River Ganga in 5 State (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal). Rs. 578 Crores has been released to Ministry of Drinking Water and Sanitation (MoDWS) for construction of toilets in 1674 Gram Panchayats of 5 Ganga Basin States. Out of the targeted 15, 27,105 units, MoDWS has completed construction of 8, 53,397 toilets.

C. Pune Riverfront Development Project (PRDP) Proposal

The project incorporates a unique and context specific comprehensive proposal, providing a large public realm. It aims to develop and rejuvenate the rivers and to improve environmental conditions to create social up-liftment and redefine the identity of Pune.
The riverfront is proposed to be developed as a green and recreational space that can transform the existing neglected waterfront into a centre for social, cultural and recreational activities in the city. It will create a vibrant and a completely public riverfront which will provide many opportunities for leisure and recreation.

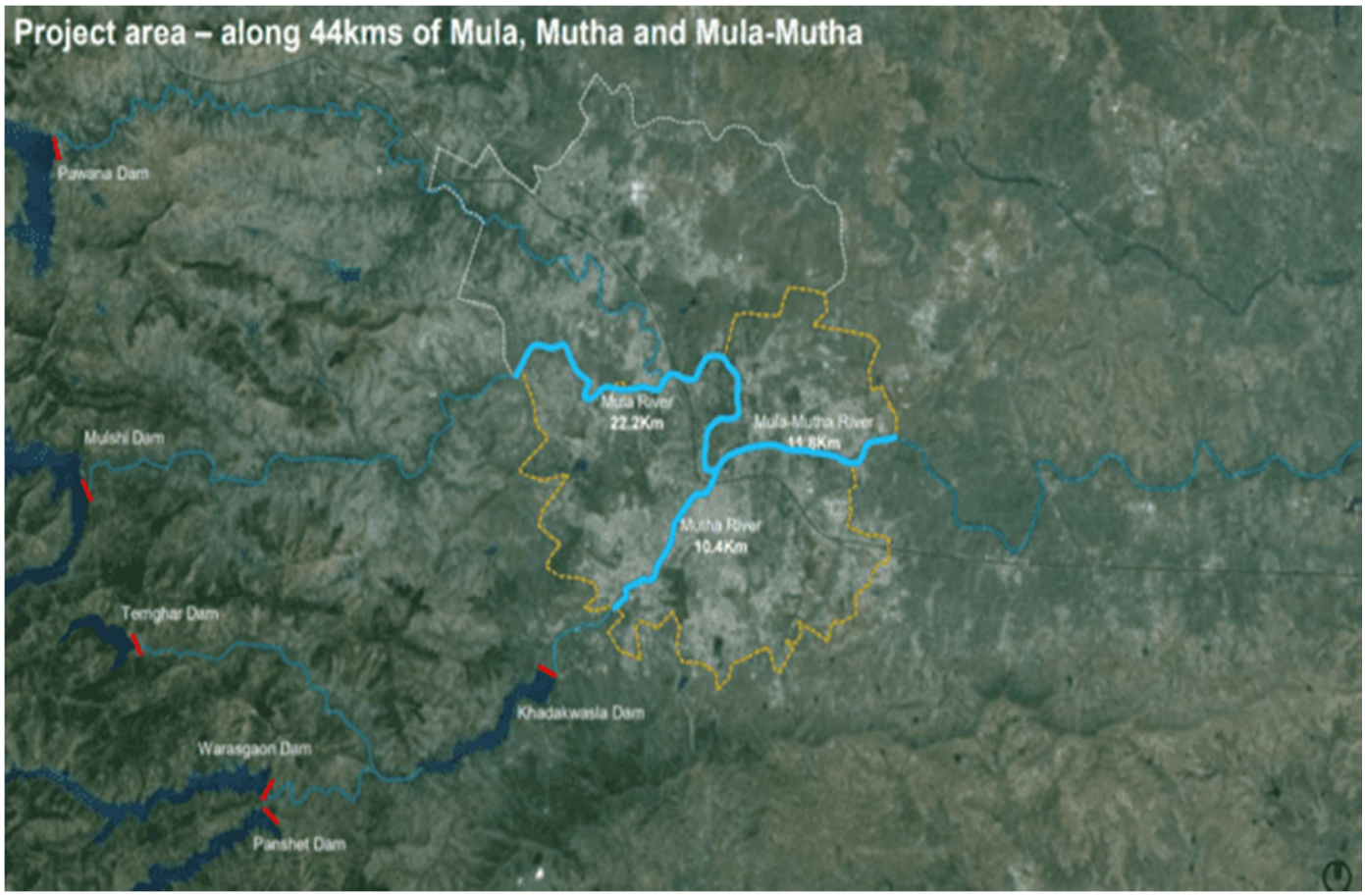
The Objectives of the project are:

- To clean the river and make it pollution less
- Reduce risk of flooding
- Retain water
- Improve city's access to the riverfront
- Integrate heritage structures, current activities, parks and gardens

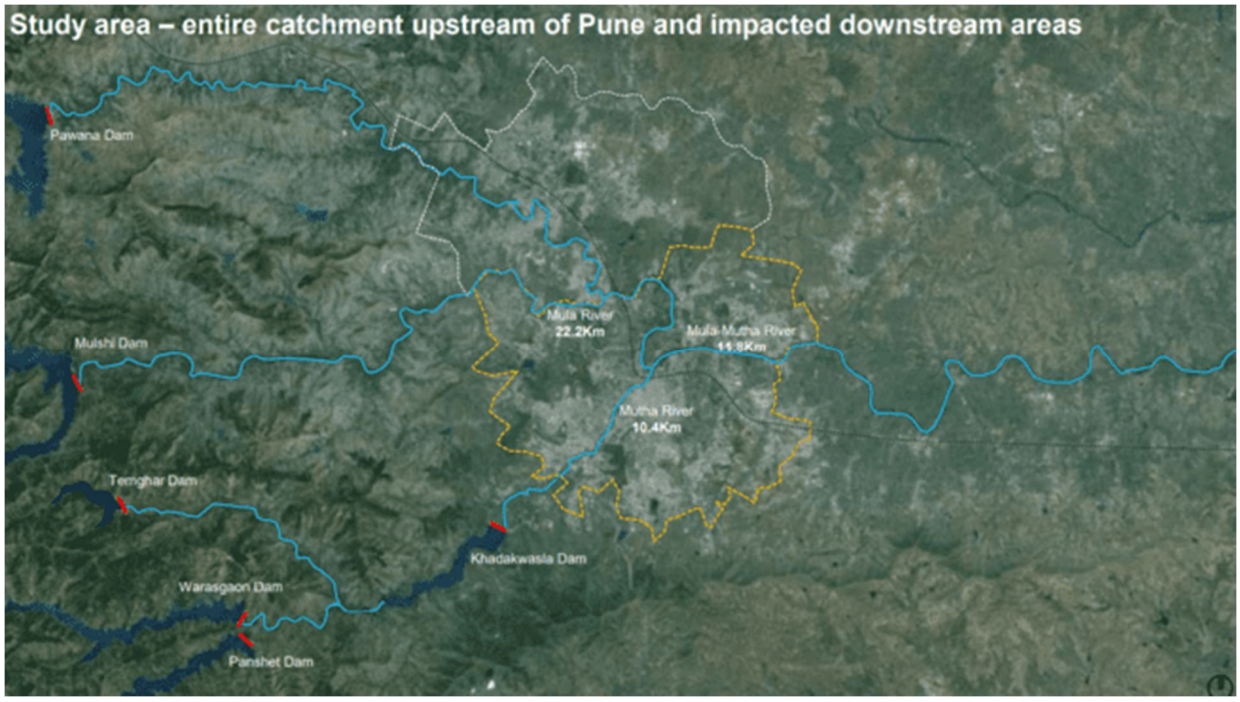
1) Project Location

The project lies within Pune Municipal Corporation (PMC), Pune Chinchwad Municipal Corporation and Kirkee Cantonment Board boundary.
The total proposed area is 820 Hectares including river & river banks. Pune is located at 18°32' N & 73°51' E. It has an average elevation of 560 meters (1837 ft).
The proposed project is divided into four stretches for its analysis and study.

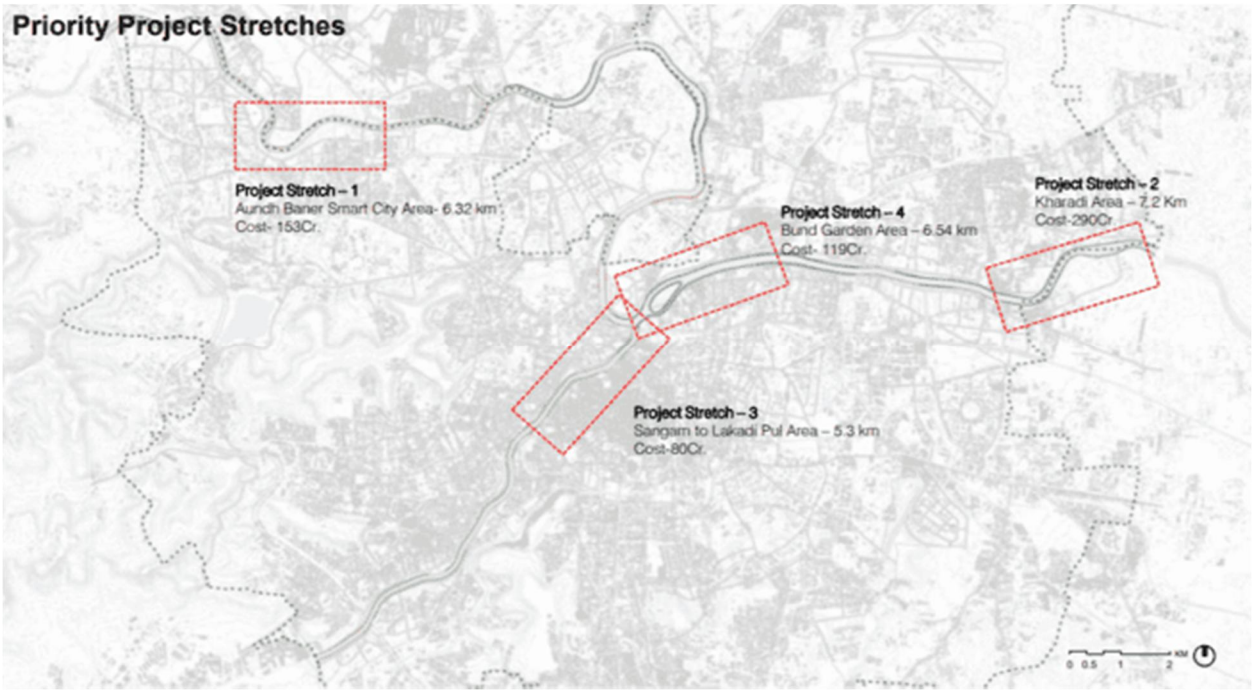
2) Project Area



3) Study Area



4) Project Stretches



5) Proposed Steps for the Project Implementation

a) Provision of Complete Sewerage Network and Improvising Interceptor Sewer.

The existing STPs in Pune fall short in their treatment of the large amount of sewage generated. Non-functioning STPs contribute directly to the pollution in the river by dumping untreated water into the river. Under the JICA and NRCD schemes, 6 new STPs have been proposed along the river, in addition to capacity augmentation of 5 STPs.

b) Reduce HFL.

Obstructions to the flow of water (as identified in the Final Hydrology and Hydraulics Report approved by CWPRS, Pune)-

- Water Retention structures- weirs, check dams
- Low-level bridges
- Structures like Visarjan tanks
- Infrastructure elements like manholes, pipelines, etc.
- Rocky protrusions
- Silt and construction debris
- Low-lying roads within the river bed

All of these obstructions can be tackled by reducing the HFL.

c) Embankments according to area (Rural, Urban, Intensely developed)

River embankments are constructed to prevent the riverbank from collapsing during floods, prevent erosion, and prevent flood water from entering the surrounding area. The primary function of these embankments is to protect the city from flooding.

Based on the various parameters such as the surrounding level of development and availability of river land, the embankment typologies are defined. On a broader level, there are 3 types of developments scenarios in existing surrounding areas such as Intensely Developed, Moderately Developed and Sparsely Developed Areas.

d) Improvising the longitudinal section of the rivers
e) Roads to be removed and alternative roads to be strengthened
f) Bridge provisions
g) Integrating existing gardens with the riverfront project

6) Problems with PRDP Proposal

a) The project shows a lack of understanding of the bio-physical reality of the river.
b) The project does not pay any attention to the river's ecology.
c) By narrowing the river, the water levels will rise. During monsoons, this will put back-pressure on the streams that flow into the river and may cause flooding. The project does not address this issue.
d) Unreasonable and unscientific assumptions about the social reality of the river.
e) The sewage generation is 'estimated' and not 'measured'. It thus completely excludes the sewage generated from growing groundwater consumption.

V. CONCLUSION

A. Suggestive Measures

1) The overlap of privately-owned land and land within inundation boundaries should be removed without the use of acquisition and without lowering the flood-carrying capacity of Mula – Mutha.
2) Debris can be utilized within the project area for levelling purposes.
3) Provision of impervious cover to restore the base flows.
4) Construction of Embankments and provision of parking lots for buses and private vehicles to be done.
5) Creation of Public realm.
6) Study to be conducted by authorities like CWPRS.
7) Optimal land use planning for the riverfront areas and implementing the most suitable activities for the delicate balance of the river environment.

B. Conclusion

1) Land reclamation and river rejuvenation is relatively a new topic, and by the study of which we can contribute towards the development and rebirth of the river.
2) As we have discussed 'Sabarmati riverfront' and 'Namami Gange', are the largest river rejuvenation projects which have played a major role in the development of society.
3) By considering the above two projects, we can contribute towards the river rejuvenation and development of the Mula – Mutha river.

4) As per our suggestions discussed on the previous slide, we can conclude that rejuvenation of the Mula – Mutha river can be done through Land reclamation, which will help in the development of society as a whole.

VI. ACKNOWLEDGEMENT

We find great pleasure in expressing my deep and sincere sense of gratitude towards all, who have made it possible for us to complete this report with success. We would also like to express our deep and sincere gratitude to our project guide, Mrs. S. B. Patil, Department of Civil Engineering, for her dynamic and valuable guidance and keen interest in our project work. We are grateful to her, for her constant encouragement and inspiration in the fulfillment of this project work.
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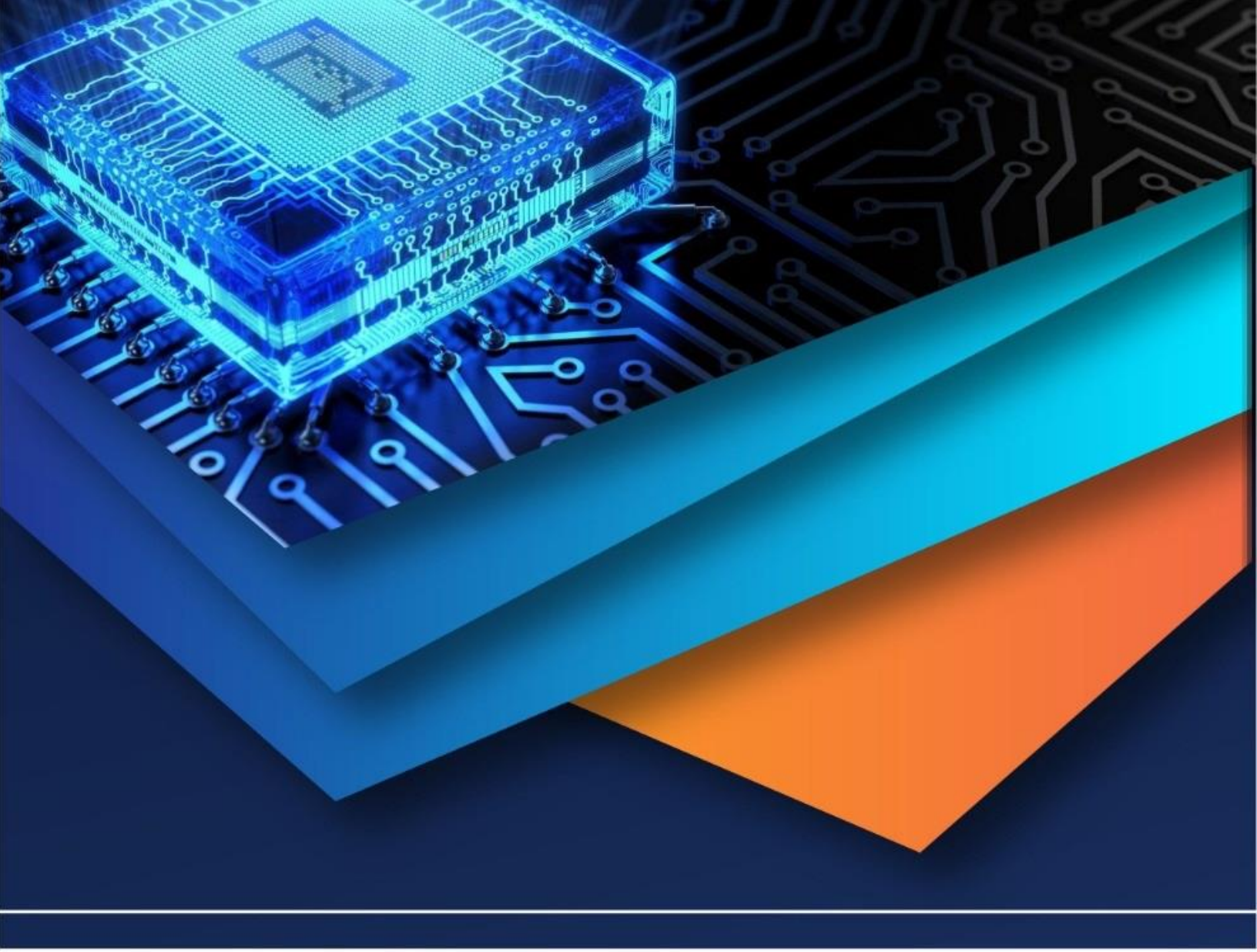

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