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ENVIRONMENTAL IMPACTS AND MITIGATIVE MEASURES ON RURAL EMBANKMENT PROJECT OF MULA-MUTHA RIVER IN PUNE, MAHARASHTRA.

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***Abstract* :**The Mula-Mutha River flows in western Maharashtra. It begins in the Western Ghats and runs eastward until it meets the Mula River near Pune. River water is utilized for drinking, bathing, industrial purposes, and agriculture. The rising urban and industrial activities have an impact on the water quality of this river, which runs virtually through the Pune city. Minimizing effects on our environment is the primary goal of the sustainable construction. India's Prime Minister Narendra Modi set the groundwork for Pune's River Rejuvenation Project, declaring the start of the ambitious project that aims to redesign and restructuring a 44 kilometer widen of the Mula, Mutha, and Mula-Mutha rivers with an objective to clean and beautify the river within the city's boundary. The project is scheduled to be completed in 11 phases over a 10-year period. Total length of Mula Mutha river is 44 kilometers, Project area covered 10.4 kilometers of Mutha river, 22.2 kilometers of Mula river, and 11.8 kilometers of the Mula-Mutha river. The study is about sustainable construction taking over the construction field in India. This study will provide the importance of green construction to sustain in future market. Though it is the sustainable construction, it shows the impact on environment caused by the construction. The mitigative measures are taken during and after construction. The area has an abundance of flora and fauna. Serious destroying actions have been noted in this study. Residents have less knowledge about the value of ecosystems and wildlife. Present pollutants; which include the main contributory factor, uncontrolled polluted water discharged openly into the Mula-Mutha stream, which at first affects fish, birds, or human well-being.

Key words: Mula-Mutha River, Green construction, Wildlife, Value of ecosystem

INTRODUCTION

The rapid rises of industrialization, urbanization, and globalization have a significant impact on the rivers that run through Pune. The river is a benefit to the city and plays a significant role in economic growth. The Mula-Mutha River flows in western Maharashtra. It begins in the Western Ghats and runs eastward until it meets the Mula River near Pune. River water is utilized for drinking, bathing, industrial purposes, and agriculture. The rising urban and industrial activities have an impact on the water quality of this river, which runs virtually through the city. The rivers have become hazardous and highly polluted as a result of direct sewage discharge, industrial effluents, intensive farming, and overuse of fertilizers in an agricultural production, and other anthropogenic activities, posing a significant threat to the public and water body creatures that live and feed in its vicinity. The horizontal gradient and geology of the river bank cause annual flooding during the monsoon season.

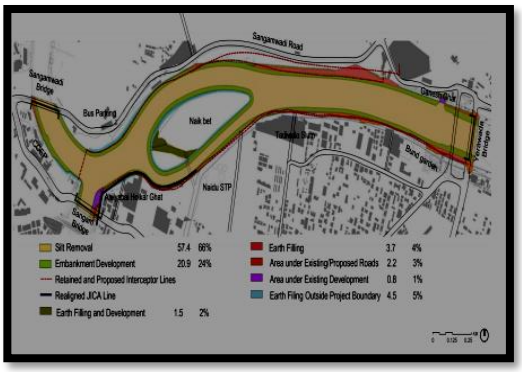
India's Prime Minister Narendra Modi set the groundwork for Pune's River Rejuvenation Project, declaring the start of the ambitious project that aims to redesign and restructuring a 44 kilometer widen of the Mula, Mutha, and Mula-Mutha rivers with an objective to clean and beautify the river within the city's boundary. The project is scheduled to be completed in 11 phases over a 10-year period. Total length of Mula Mutha river is 44 kilometers, Project area covered 10.4 kilometers of Mutha river, 22.2 kilometers of Mula river, and 11.8 kilometers of the Mula-mutha river (Kurtkoti, 2022). Every construction project or sustainable construction practices covers four following key types of construction: Residential construction, commercial construction, industrial construction, infrastructure construction. Construction produces a major amount of waste involving 40 percent water pollution, 50 percent of climate change, and 23 percent of air pollution.

Sustainable Construction is defined as utilizing renewable and recyclable materials in construction projects and reducing production of waste and consumption of energy. Minimizing effects on our environment is the primary goal of the sustainable construction. Not only the process of the construction but also the output should have minimum impact on environment then only it will be successfully known as sustainable construction. It includes solar panels, energy efficient roof hatches on the rooftop, minimizing the fossil fuel uses in energy consumption, etc. (Jackson, C. 2021). Several species which are less known like invertebrates, algae, fungi, bacteria would have been extinct. Human tendency is to consider only large mammal as wildlife and give attention on conserving them and focus on endangered species, however the less visible species might be more important for nature. EIA in past did not paid attention on biodiversity impacts and paid attention only on ecological impacts faced due to construction. They have remained focused only in forest habitat and endangered species and have been ignored the urban biodiversity and environment. But now the Convention on Biological Diversity (CBD) is the platform that provides a strong stage for analyzing impact assessment on biodiversity. This will help humans to pay attention on positive aspects of biodiversity, to deal with issues related to fragmentation, and many more (Tata, R. 2019).

STUDY AREA

Pune is located at latitude 18° 31′ 48″ North and longitude 73° 50′ 24″ East. It is 560 meters (1837 feet) above sea level on average. The city has grown from its embryonic form of Kasba Peth to a massive city of 244 square kilometers, with enormous potential to become one of India's top cities. The city is located at a junction of the Mula and Mutha rivers which later joins the Bhima River, and then to the Krishna, which finally unifies in Bay of Bengal. The location of the project includes bridge, roads, temples, and ghats, as well as drainage pipes and manholes; it is open and floodable terrain along the river. The land use study was completed up to 4 kilometers on both sides of the 44-kilometer river section. The B. G. Shirke Const. Tech. Pvt. Ltd. is carrying out the construction in this area. The project selected for the area is River Embankment of Mula-Mutha River between Bund Garden and Sangamwadi route.

Map:



MATERIALS AND METHODS

The area was thoroughly inspected and following materials and methods were used to study the zone:

MATERIALS:

Camera: Canon 1200D with 55mm -250mm Lense captured 1489 total photographs of existing river building, vegetation, and fauna.

Data Register: During study register is used to collect data like: Floral Data, Bird frequency rate as well as collecting existing pollution data.

Survey sheet: Sheet is used to collect data of engineers or labours related to environment, and sustainable construction according to questionnaire survey format.

Binocular: Binocular is used for identifying far objects like pollution sites and faunal species and mostly used for high canopy trees.

METHODS:

Sign survey: Sign Survey is performed for capturing nocturnal species activities.

Total 21 footprints and pugmarks are documented, identified footprints and pugmarks include: Jungle cat, Indian Grey mongoose most of them cannot be identified or are confusing like Leopard, Hyena due to construction activities, vehicle movement, anthropogenic factors.

Data collection:

The zones were carefully examined. The data was documented; photographs and videos are used for documentation.

Questionnaire Survey: This Questionnaire survey was conducted during the Mula-Mutha River rejuvenation project, which consisted of 142 working staff, including 15 plus engineers, and rest was the workers. Due to lack of interest and communication issues 35 ± workers are not able to give response; hence, data with respect to these 35 individuals is not mentioned. After performing a questionnaire survey to labour and engineers for my research, several types of outcomes emerged. The results of this survey are listed in question order, and the answers to the questions are listed below based on what workers and engineers said?

STATISTICAL ANALYSIS:

Histogram: In this study Histogram is applied to analysis the responses the question asked to public.

One Sample Run Test: It is a non-parametric method to evaluate the level of randomness used in the selection of the sample items. Also, a useful technique for determining if the sample observations have been selected at random, which is based on the order in which the sample observations are collected. The following is the formula for the one sample run test equation:

The values of μ_v and σ_v are computed as follows: The number of runs 'V' is a statistic with a special sampling distribution. The mean μ_v of V - statistics is given by $\mu_v, where$

$$Mean\ of\ V-Statistic: \quad \mu_v = \frac{2n1n2}{n1+n2} + 1,$$

Where n1 = the number of first response;
n2 = the number of second response.

Variance of V-statistic is α_{v^2}, where

$$Variance\ iof\ V-Statistic: \quad \alpha_{v^2} = \left[\frac{2n1n2(2n1n2-n1-n2)}{(n1+n2)2(n1+n2-1)}\right].$$

The standard error S.E. (V) of the V-statistic is given by α_v.

The sampling distribution of V-statistic can be closely approximated by the normal distribution. If either n1 or n2 is at least equal to 8 in that case,

Test Statistic: $Z = V - \frac{V-\text{statistic}}{\text{S.E.}(V)}$ or $Z = \frac{V-\mu_v}{\alpha_{v^2}}$

RESULT:

The study area selected was Bund Garden to Sangamwadi Bridge which is 4km long each side, here is an island situated in a middle portion of both river stretches named 'Naik Bet', one of the project area's best-preserved island and floral hotspots. Ganesh temple is located near the Bund Garden Bridge, on the left bank of the Mula-Mutha. It also known as Visarjan Ghat; this location has become a major river access point. The Mula Mutha river has natural banks from Bund Garden bridge to Sangamwadi Bridge. With healthy riparian vegetation present along both banks, the length of the river channel considerably expands. Naik island divides the flow in this region. There is a high canopy forest on this island. River construction work is

currently underway between both banks, including Naik Island, from the Bund Garden Bridge to the Sangamwadi Bridge. There are two forms of construction: Rural Embankment and Urban Embankment. 16 Stone masonry, Gabions, RCC (Reinforced cement Concrete), Earth fill, and Strom Water Drainage are all the part of the river construction. JCB, LNT, Damper Truck, Tractor, And JCB Drill Machine are among the machines employed in this construction.

The river Mula and Mutha meet at the Sangam. The combination of two separate flows affects the separate flows affects the normal stream flow pattern and produced new habitats. Here, the river channel is relatively wider and deeper. Near Naik Island, a fast-moving, white, foggy river that is likely polluted may be seen. The habitat here is mixed habitat comprising Open Grassland patches, Riparian Vegetation, and the Naik Island, with dense forest, is an important aspect of this zone.

The vegetation on Naik Island is rich and lush. Being in the middle of the stream, the area receives new deposits of fertile soil every year, so vegetation is thick and rich. The island's perimeter is densely forested with Syzygium, Phoenix, and Pongamia trees, with tress of Mango, Coconut, and Santalum also displaying lush growth. The area in the darker parts is used for fruit orchards and the cultivation of crops such as sugar cane and other vegetables. (V.D. Vartak, 1958). Because of the low water level, it was possible to reach the island. The vegetation was noticed from the left bank as well. Riparian vegetation is abundant and covers the high canopy forest near the Mula-Mutha junction, on the right bank at the back side of Ghat. Trees such as Pongamia and Syzygium, along with lianas such as Argyreia nervosa (Samudrashok), contribute to the formation of a dense canopy cover. Because this area is not used by people, open areas along the pathway turn into protected zones, supporting strong vegetation development such as: Abutilon, Ricinus, Ficus, as well as grasses and herbs such as: Alysicarpus, Indigofera, Crotalaria, and so on. There are various host and nectar plants for butterflies in this zone.

FAUNAL SPECIES SPOTTED DURING THE STUDY WERE AS FOLLOWS-

Avifaunal species: Asian Koel *Eudynamys scolopaceus* Black kite *Milvus migrans* Crested Serpented Eagle *Spilornis cheela* Rock dove *Columba livia* Laughing Dove *Spilopelia senegalensis* Ashy Prinia *Prinia socialis* Red vented bulbul *Pycnonotus cafer* Red whiskered bulbul *Pycnonotus jocosus* Indian grey hornbill *Ocyceros birostris* Indian Robin *Saxicoloides fulicatus* Oriental magpie-robin *Copsychus saularis* Purple Sunbird *Cinnyris asiaticus* Bhramani Starling *Sturniapagodarum* Common Myna *Acridotheres tristi* Grey francolin *Ortygornis pondicerianus* House Sparrow *Passer domesticus* Black drongo *Dicrurus macrocercus* Greater Coucal *Centropus sinensis* Red weteld Lapwing *Vanellus indicus* Cenarious tit *Parus cinereus* House crow *Corvus splendens* Little Swift *Apus affinis* Tickell's blue flycatcher *Cyornis tickelliae* White broad Fantail *Rhipiduraaureola* Rose-ringed parakeet *Psittacula krameria* White broad wagtail *Motacilla maderaspatensis* White wagtail *Motacilla alba* Indian Silverbill *Euodice malabarica* Baya weaver *Ploceus* philippinus

Aquatic avifaunal species: Little Cormorant *Microcarbo niger* Great Cormorant *Phalacrocorax carbo* Indian Spot billed duck *Anas poecilorhyncha* Ruddy shell duck *Tadorna ferruginea* Yellow Bittren *Ixobrychus sinensis* White-throated kingfisher *Halcyon smyrnensis* Pied Kingfisher *Ceryle rudis* . Great egreat *Ardea alba* . Glossy ibis *Plegadis falcinellus* Red naped ibis *Pseudibis papillosa* Black-headed ibis *Threskiornis melanocephalus* Moorhen *Gallinula chloropus* . Eurasian coot *Fulica atra* Painted stork *Mycteria leucocephala* Little Gerbe *Tachybaptus ruficollis* Lesser whistling duck *Dendrocygnajavanica* Purple heron *Ardea purpurea*

Mammalian and Reptilian species: Indian palm squirrel (*Funambulus palmarum*), Indian Grey Mongoose (*Herpestes eswardsii*) Jungle cat (*Felis chaus*). Oriental Rat Snake (*Ptyas mucosa*), Spectacled cobra (*Naja naja*), Russell's Viper (*Daboia russelii*), Checkered keelback (*Fowlea piscato*).

Fig. A. Avifaunal diversity: Black kite *(Milvus migrans),* Indian Silverbill (*Euodice malabarica),* Red whiskered bulbul (*Pycnonotus jocosus),*Indian grey hornbill (*Ocyceros birostris*) Greater Coucal (*Centropus sinensis)*Tickell's blue flycatcher (*Cyornis tickelliae);* B Aquatic Avifunal diversity: Yellow Bittren (*Ixobrychus sinensis*), Red naped ibis (*Pseudibis papillosa*), Indian Spot billed duck (*Anas poecilorhyncha*), White-throated kingfisher (*Halcyon smyrnensis*), Purple heron (*Ardea purpurea),* Little Cormorant (*Microcarbo niger);* C Mammals; Indian Grey Mongoose (*Herpestes edwardsii*), Jungle cat (*Felis chaus*), Leopard (Panthera pardus), Striped hyena (*Hyaena hyaena);*D Reptiles: Oriental Rat Snake (*Ptyas mucosa)*Spectacle Cobra (*Naja naja)*Russell's Viper (*Daboia russelii).*

ISSUES AT MULA-MUTHA RIVER:

There are parking spots along the river near Sangam. Grazing, washing clothes, vehicle washing in the river bank; Releasing of trash in tributaries and water courses; Defecation in open surroundings; Ongoing River Construction activities on both river banks; Raw dirt is poured into the river water; Nalas contaminate the environment; Adjustment in the river width and gradient of slope allows for adjustment in cross-section during design; Activities such as boating, shows people's affinity with the river; Culturally significant heritage sites and spaces in neighbouring areas; Numerous highways and arterial roads cross the river. At the moment, except during the monsoons, the water flowing in Pune's rivers is completely untreated sewage. Methane bubbles can be seen in the water while walking along the riverbanks. The primary aim of this river rejuvenation project is to ensure that the water is completely sewage-treated. According to studies, dirty rivers emit more greenhouse gases, potentially boosting their global warming potential by up to ten times. The Mula-mutha river was named the state's second-most contaminated or polluted river by the Maharashtra Pollution Control Board in 2018.

The project clearly deals with only a few aspects of Pune's rivers, namely flow, floods, land in floodplains, and river water quality. In Pune for the furnishing service of brackish force by Mula-Mutha, there is a social reality of five heads being erected on them to store their water, and for the additional service of waste assimilating; there is a social reality of several discharges untreated wastewater into the river.

Project's Sustainable Work shows different fixing issues, such as frequent floods, untreated sewage discharge, solid waste and debris dumping, and the poor state of the river bed and banks. The project's goal for flood control is to remove impediments in the river's flow and to add engineering interventions to the river's cross section to channelize the banks. Main aspects are River cleaning and make it pollution free, reduce flooding risk, produce a nonstop public realm along with the swash river, retain water, take part heritage constructions, present actions, parks and gardens, and improve city's access to the riverfront. In the case of the studied stretch of river Mula-Mutha, biodiversity is an important, but vulnerable. The following types of hotspots were noticed:

A. Environmental Hotspots: River plains, Stony Edges, Grassy regions, Tributary streams openings, faunal hotspots and Riparian habitats

B. Cultural Hotspots: Ghats, Worship Places, Monuments, and Structures of heritage.

MITIGATIVE STRATEGIES:

The solid waste produced will be separated at the point of production into biodegradable and non-biodegradable waste, and then separated waste is to be delivered to the PMC facility, treated sewage water will be utilized for landscape gardening and

replacement into Mula-Mutha river. Water sprinkling will be done for dust suppression Road side. Plantation will be done for gaseous emission. Riverside development during construction work and growth of green cover is been performed. Appropriate slope will be maintained at both the river sides.

PLANTATION STRATEGIES:

Tall grasses will be planting on river bank, plant category capable for survive in high flood water. Grasses will be planting on the pitching, plant category capable for survive in water flow speed. Shrub will be planting on the pitching. Tress will be planting on the pitching; trees plantation should have penetrative root system that effective for deep level plantation. Tree line along the upper and lower walkway, trees plantation should be evergreen with some flowering plant species. These will attract different types of birds, and make a favourable habitat for faunal species.

POST CONSTRUCTION DESCRIPTION:

The photographs represent a sustainable river embankment where ecological balance, community engagement, and aesthetic appeal coexist harmoniously. Through these images, the viewer is invited to witness a remarkable example of sustainability in action, where the preservation of natural resources, enhancement of biodiversity, and the provision of economic opportunities converge seamlessly. The photographs beautifully capture how the sustainable embankment serves as a meeting point for the community. In this example, the embankment has been transformed into a recreational space, featuring walkways, cycling paths, and seating areas. These amenities encourage people to appreciate nature, fostering a sense of stewardship and connection to the environment. The photographs describe a resplendent representation of a sustainable river embankment, where ecological balance, community engagement, and aesthetic appeal converge seamlessly. From the preservation of natural resources through the flourishing vegetation to the integration of recreational amenities that foster community engagement, this example serves as an inspiring model for sustainable development.

Fig : Sustainable river embankment

STATISTICAL ANALYSIS:

Table: Response table sorted according to the subareas of study area.

Locations	**A**		**B**		**C**		**D**		**E**	
Questions	**YES**	**NO**	**YES**	**NO**	**YES**	**NO**	**YES**	**NO**	**YES**	**NO**
Q1.	12	3	11	4	9	6	8	7	10	5
Q2.	16	4	15	5	12	8	11	9	14	6
Q3.	19	8	18	9	15	12	15	12	17	10
Q4.	13	5	12	6	11	7	10	8	11	7
Q5.	21	6	20	7	18	9	17	10	15	12

Total	**81**	**26**	**76**	**31**	**65**	**42**	**61**	**46**	**67**	**40**

H0 = Null Hypothesis response are random, **H1** = Response is not random

Location A; n1=81, n2=26 **Location B;** n1= 76, n2= 31 **Location C;** n1= 65, n2 = 42

Location D; n1 = 61, n2 = 46 **Location E;** n1 = 67, n2= 40

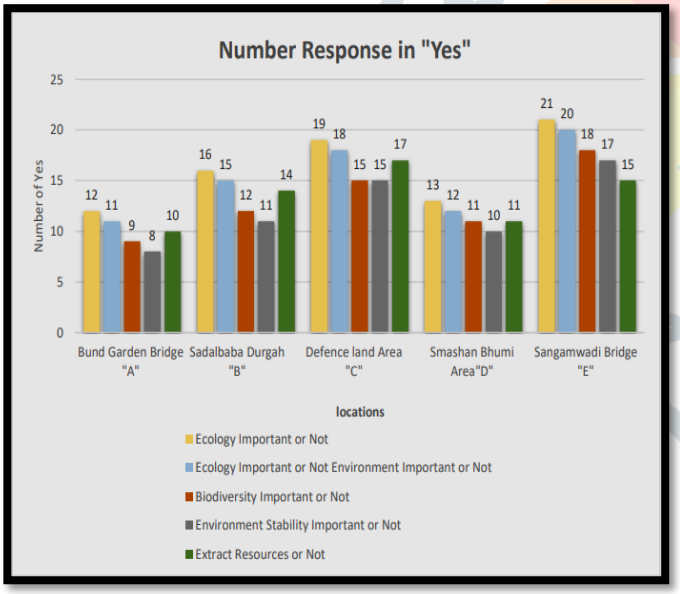
Where, **n1** = Yes, **n2** = No, ***V***= 107

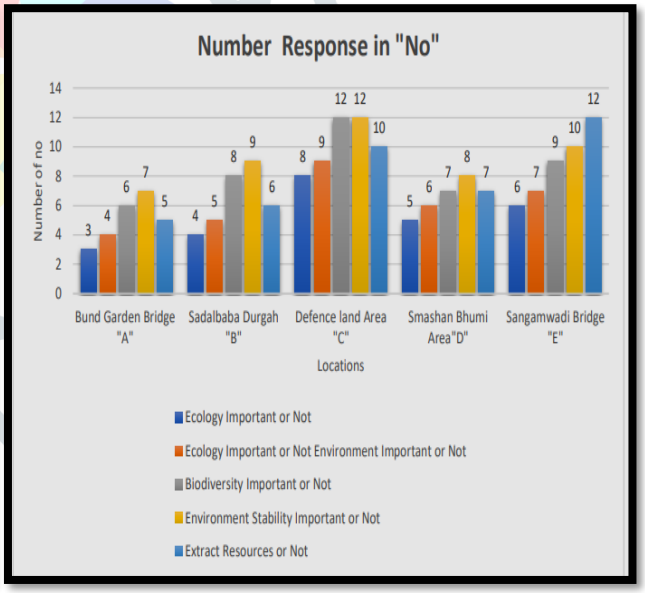
Table: Result of statistical analysis.

Location	n1=Yes	n2=NO	$\mu_v = \frac{2n1n2}{n1+n2} + 1$	$\alpha_{v^2} = [\frac{2n1n2(2n1n2-n1-n2)}{(n1+n2)2(n1+n2-1)}]$	$Z = \frac{V-\mu_v}{\alpha_{v^2}}$
A	81	26	40.36	3.774	**17.657**
B	76	31	45.03	4.228	**14.657**
C	65	42	52.02	4.907	**11.204**
D	61	46	53.44	5.045	**10.616**
E	67	40	51.09	4.816	**11.609**

Assuming that the calculated value is greater than the table value of 1.96 and that the level of significance is 0.05, the results demonstrate that the responses are not random

and that all null hypotheses are rejected.





CONCLUSION

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basis. Several times people will drink along the river, then dispose of the bottle along the river, which is why glass pieces are lying along the river, for stop these things and prohibit can be done in this area so that the river can be kept in good condition. On the river's left bank, there are numerous slum areas where people's residential trash is completely disposed of into the river. A proper relocation can be done and provided area for living, as well as awareness about clean living standards.

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