

Chapter 11

Prioritizing tributary care for comprehensive river pollution management and sustainable urban development: A case study of Nandini

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Introduction

Water is a precious liquid and very essential for every life form present on earth. (Ahmed Shabbir Khan, 2021) In addition to fulfilling the basic domestic purposes, man has been using water amply for irrigation to cultivate food and many other purposes. In this modern-day world too, all industries are near the river for easy availability of water. This, in turn, results in water pollution. (Arnab Majumdar, 2024)

Amongst the various sources of water, rivers have played a vital role in the existence of humanity. From over thousand years, all the ancient civilizations arose and thrived near the river. In the urban context One of the most significant areas in cities all over the world is the waterfront area. The position of cities on the banks of rivers has always played an important role in their development. (Branislava, 2020). Nevertheless, they have been badly abused under the pretext of development. Rivers are the major carriers of municipal and industrial wastewater and run-off from agricultural land and are one of the most susceptible to pollutants.

In a study of 258 of the world's rivers, over a quarter of these were found to have concentrations of active pharmaceutical ingredients that exceeded safe limits. The most contaminated sites were found in Sub-Saharan Africa, South Asia and South America, in areas associated with poor wastewater and waste management infrastructure, and with pharmaceutical manufacturing industries. (Wilkinson, 2022)

Godavari river

In India every river is considered to be sacred and is an extension and manifestations of divine gods. (Singh, 2017) Rivers are considered as the living heritage of the country, shaping its landscape, history, and traditions. Many cultural practices and rituals in India are closely tied to rivers, with people worshipping them as goddesses and performing ceremonies to honour their sacredness. The cultural diversity and richness of India are reflected in the various customs and traditions associated with rivers across different regions of the country. The reminiscence of water heritage and river heritage is found to be preserved in different parts of India. (Gayen, 2020)

As is the Ganga in North, Godavari is the second longest river flowing in southern central part of India and called Dakshin Ganga. Along with mythological significance, it is also the major source of drinking water to the states it flows from. Godavari river rises in the Sahyadri mountain range near Trimbakeshwar, about 80 km from the shore of Arabian sea, at an elevation of 1067m in the Nashik district of Maharashtra. The river travels a distance of about 1465 km flowing through six states of Central India like Maharashtra, Andhra Pradesh Madhya Pradesh, Chattisgarh, Orisa Karnataka etc. and extends for over 9.5% of the total geographical area of India. (NMC, 2022)

Godavari in Nashik

The Godavari River is considered very sacred by Hindus which hosts numerous temples along its banks in the Nashik district where it originates. Notably, the Trimbakeshwar Temple, one of the twelve Jyotirlingas dedicated to Lord Shiva, is located approximately 29 kilometres from Nashik. Every twelve years, the Sinhastha Kumbh Mela

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(religious gathering of mega scale) is conducted along the banks of the Godavari River in Nashik, establishing the region as a significant pilgrimage site for thousands of years.

However, as a result of various anthropogenic factors the transformation of the Godavari from a pristine free-flowing river to a sewer has occurred. (MPCB, 2022-23) In Nashik, Godavari lost all the crucial elements of being a river, as described by Dr. Rameswamy R. Iyer (during India Rivers Week 2014) like Aviralita or uninterrupted flow, flow variation, and Nirmalata or absence of pollution, and hence it ceases to be a river. (Dahake, 06, 2018).

Nandini alias Nasardi tributary of Godavari

Nandini is a minor tributary of the Godavari River, considered insignificant due to its considerably shorter length compared to the smallest significant tributary of the Godavari, the Pravara. The Pravara extends for 208 kilometres and has a catchment area of 6537 square kilometres. (MPCB, 2015). The Nandini originates in the Anjineri hills (just 8 kilometres from the source of the Godavari) and flows approximately 38 kilometres before merging with the Godavari near the Takali area.

Currently, The Nandini River, has become a turbulent ecological system due to a significant decline in water quality. The issue of pollution in the Nandini (Nasardi) has garnered substantial media attention. Citizens are alleging that the municipal corporation is responsible for the current degraded state of the river.

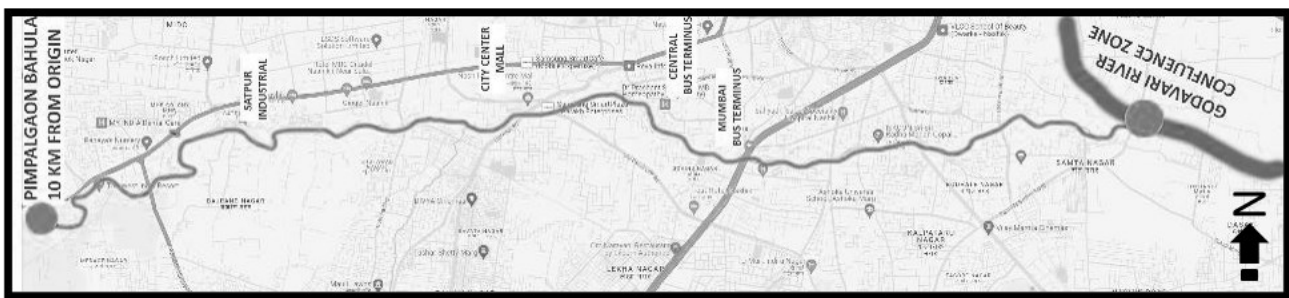


Figure 1. Nandini river map from Origin to Confluence

Importance of study

The importance of studying the Nandini tributary of the Godavari River lies in the fact that while extensive research has been conducted on the main river Godavari and its water quality, the tributaries have not received adequate attention. The Godavari River holds immense cultural importance and serves as a repository of both tangible and intangible heritage for the states it traverses. The health of Godavari is intricately linked to the well-being of its larger and smaller tributaries. Despite media discussions highlighting pollution in the Nandini tributary, a detailed empirical study and analysis are essential to uncover the underlying issues. This study aims to delve into the causes of degradation in the Nandini tributary and explore the impacts it has on the overall health of the Godavari River. By focusing on this specific tributary, a more comprehensive understanding of the environmental challenges facing the region can be achieved, leading to informed urban conservation and sustainable management strategies.

Aim of study

To conduct an analysis of the historical and ecological background of the Nandini tributary, evaluate its current unfavorable conditions such as pollution, exploitation, and habitat degradation, assess their effects on local biodiversity, identify the risks to the Godavari River system, and propose sustainable urban conservation strategies.

Scope and Limitations

The conclusions drawn from this study are derived from empirical data collected through field observations and interviews, supplemented by references from secondary sources. It is important to note that this study did not involve direct testing of water quality or geological surveys of underwater channels. Rather, the findings are based on a comprehensive analysis of existing data and expert insights, providing valuable insights into the ecological status of the Nandini River and its implications for the broader ecosystem of the Godavari River.

Material and Methods

The research methodology involved a two-fold approach. Firstly, secondary data was gathered through an extensive literature review of various sources, including scholarly books, research articles, and governmental documents, to understand existing information on the subject.

Simultaneously, primary data collection was conducted using an empirical approach to ascertain the precise causes, severity, and impacts of the issues at hand. Experts and locals staying along the banks of the Nandini river were interviewed. The Nandini River, spanning from the origin to its confluence, was divided into five distinct zones

for detailed field visit and data collection. Observations were meticulously recorded for each zone, capturing pertinent environmental parameters and characteristics.

The analysis and interpretation of both primary data and literature review served as the foundation for subsequent discussions and conclusions in the research study.

Formally, the research is structured into the following sections and subsections:

- a) Literature review for gaining a comprehensive understanding of the broader context.
- b) Literature review for examining evidence related to Nandini
- c) Primary data collected from field observations categorized into five zones
- d) Findings derived from both the literature reviews and primary data
- e) Discussions on various emerging subtopics from the study
- f) Conclusion

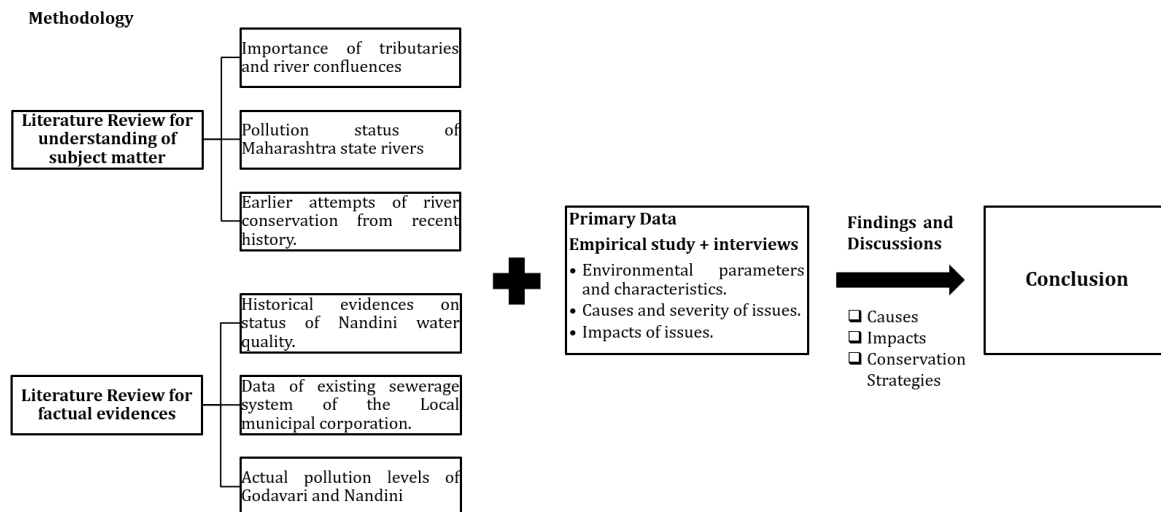


Figure 2. Schematic Diagram showing Methodology

Literature Review

Multiple research papers and scholarly articles were systematically assessed to obtain an understanding of the subject matter, the significance of the study, and the factual scenario regarding pollution in Indian rivers. Out of these, the three most pertinent are outlined below:

- I. One paper discusses the importance of tributary confluences (Rice S. a., 2008) suggesting that tributaries and confluence zones provide unique habitats and support important ecological functions. The paper further stresses upon the paucity in sufficiently detailed and extensive empirical data of tributaries and argues that these and other information gaps hinder our ability to develop sustainable management strategies that accommodate tributary value. Citing the examples of various rivers like Missouri, Meuse, etc, the paper explains the importance of Confluence zones for the in-stream and floodplain ecology of large rivers.
- II. Another paper examines how Indian rivers are treated as open pits for waste disposal without adequate treatment, resulting in toxic elemental contents (Dey, March 2024). The paper highlights alarming reports from India's Central Pollution Control Board (CPCB), which identifies 351 of the most contaminated river sections, with Maharashtra state having the highest number, 53 contaminated rivers.
- III. A recent paper by Dahake discusses the efforts of the Peshwas (Maratha rulers of the 18th century) to address water pollution in the Godavari River and their initiatives to mitigate it (Dahake, 2018). On April 29, 1758, they issued an order to maintain the purity and sanctity of the Godavari River. The order mandated that no one should dispose of any domestic waste or garbage into the river. It emphasized that the Godavari must be kept clean, and anyone found violating this directive would be subject to punishment or a fine.
- IV. Additional research material was referred to gather historical evidence supporting the claims of experts, to identify the agents responsible for pollution, and to ascertain the actual pollution levels in the Godavari and Nandini rivers
- V. The British gazetteer for the Bombay Presidency, (Maharashtra T. G., 2006) dating back 150 years, provides insight into the Nandini (Nasardi) River and its picturesque surroundings. It clearly mentions that the Godavari water supply was impure, as it was contaminated by bathing, washing clothes, religious offerings,

burnt bones, town sweepings, and house sullage, and therefore should not be used for drinking purposes. The gazetteer reveals that in 1865, Dr. Leith, and in 1881, Mr. Hewlett proposed a scheme to bring water from the Nandini (Nasardi) River, recognizing it as a purer water source compared to the Godavari. Unfortunately, due to financial constraints, the implementation of this scheme was deemed unfeasible.

- VI. Another paper (Navasakthi, 2023) studied the water quality of the Godavari River by extracting data from the Central Pollution Control Board, India's openly available portal. The study utilized data spanning five years, from 2015 to 2019. Water quality parameters for the Godavari River were analysed using ANOVA and correlation. The study concluded that there was a significant deterioration in river water quality over time.
- VII. A comprehensive report drafted by the Nashik Municipal Corporation on the water supply and drainage system of Nashik (NMC, 2022) mentions the following:
- Page 2-21: Part of the sewerage system designed for Nashik city terminates at discharge points into STPs and part directly into the Godavari, Nandini and Waldevi without treatment as the targeted completion dates for the required STPs were not met.
 - Page 2-35: Due to the geology of Nashik city, there are numerous natural drains (nallas) sloping towards the Godavari and Nandini (Nasardi) river basins. These nallas which originally carried rainwater and sub-soil water, but are now indiscriminately used for disposing of liquid and sometimes solid wastes
 - Page 2-38: There are a total of 3,000 industries housed in the Satpur and Ambad MIDC areas. Effluent from the Ambad MIDC area is discharged into the Nasardi River.
- VIII. In another research, Nandini (Nasardi) River water quality was assessed through sample collection and analysis of samples were done as per APHA, 2001 and IS each water sample were analyzed for various physico chemical parameters. (Kathe Shubham 1, Mar 2019). Water of Nandini river was found to be polluted.
- IX. In the last paper studied, samples of Godavari River water were tested for dissolved oxygen at various points. (Wagh & V, 2016) Among these points, (A8) and (A9) were taken before and after the confluence with the Nandini River, respectively. Dissolved oxygen levels suddenly dropped at point (A9), indicating increased pollution after the confluence and clearly suggesting that the water of the Nandini River was polluted.

Primary Data from field visits and interviews.

Primary data was collected from actual field visits, discussions and detailed observations were recorded. The entire length of the Nandini River was divided into five zones, starting from its origin to its confluence. The zones varied in length depending on the surrounding rural and urban development in their vicinity.

1) Zone 1 – Origin of River: Countryside

Up to a distance of 10-12 kms from the origin, in its initial areas, there is rich vegetation along the shoreline combined with the meandering curves of the stream. The water is clearer, supporting a habitat for microbes, stream insects, and other food sources for fish and other aquatic life. Riparian vegetation, including herbaceous plants, shrubs, and trees, can be found on sediment deposits, banks, and along river margins.

The observed trees include large natives like Neem (*Azadirachta indica*), Peepal (*Ficus religiosa*), Coconut (*Cocos nucifera*), Palm (*Arecaceae*), and Rockweed.

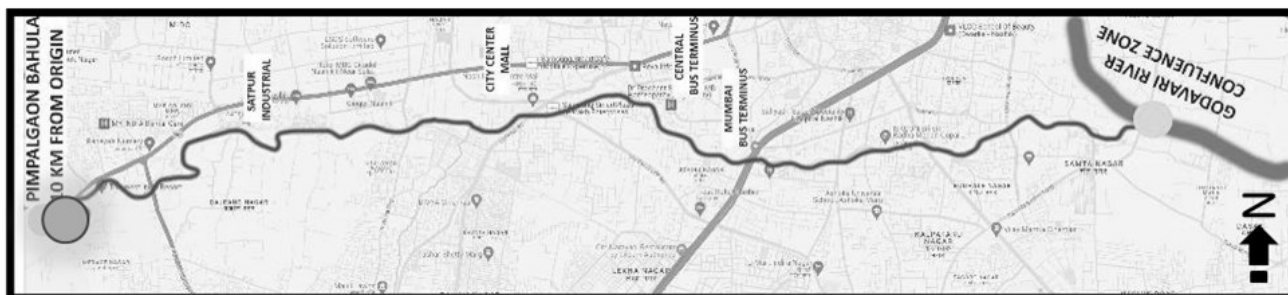


Figure 3. Nandini river map showing location at 10 kms from Origin



Figure 4. Images showing pollution free water and rich riparian vegetation at Zone 1

II) Zone 2 – Industrial Area

The river then passes through two major industrial areas in Nashik, namely Satpur and Ambad (developed in 1964-65 and 1977 respectively) (Karbhari, 2011), with roughly 3,500 industries located in the vicinity. A stark degradation in the vegetation can be observed in these areas. At many places, industrial wastewater is directly discharged into the riverbanks. Pipes or channels used for discharge from industrial facilities disperse effluents directly into the river without pre-treatment. This is the main source of pollution in the river.

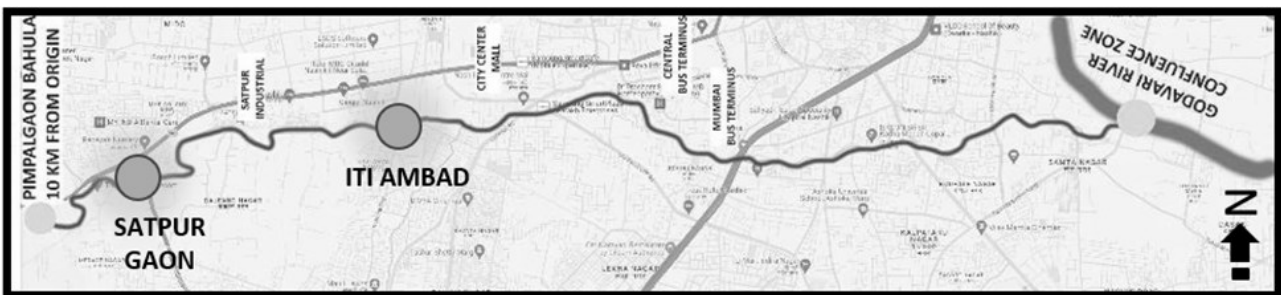


Figure 5. Nandini river map showing stretch of industrial area



Figure 6. Point discharge of Industrial wastewater into Nandini (left). Beginning of pollution and change in vegetation (right)

III) Zone 3 – Residential and Commercial

In the following mixed-use zone, drainage sewage pits are observed along the river's periphery. Road drainage patterns lead directly into the river, and many drainage pipes are broken or choked with slush and plastic garbage. The river flow is further burdened by discharges from residential sewer systems. Natural silt is excavated from the riverbanks, increasing the river's depth. The natural flow of the river is disrupted by encroachment and excavation. The flood zone is delineated by two lines: the Blue Line and the Red Line. Various constructions exist within both the red and blue line areas.

The built environment along the riverbed encompasses urban structures, including both legal and illegal constructions, alongside some slum areas. Many of these structures are located within the flood zone. Domestic waste is directly disposed of into the river.

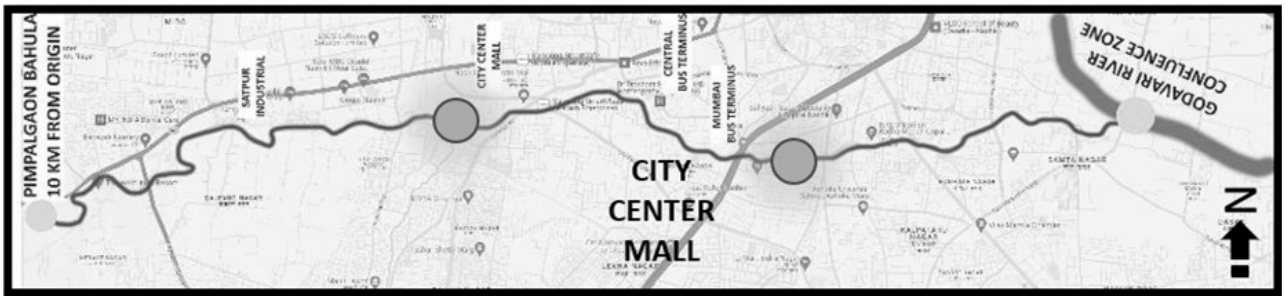


Figure 7. Nandini river map showing stretch of Residential and Commercial area

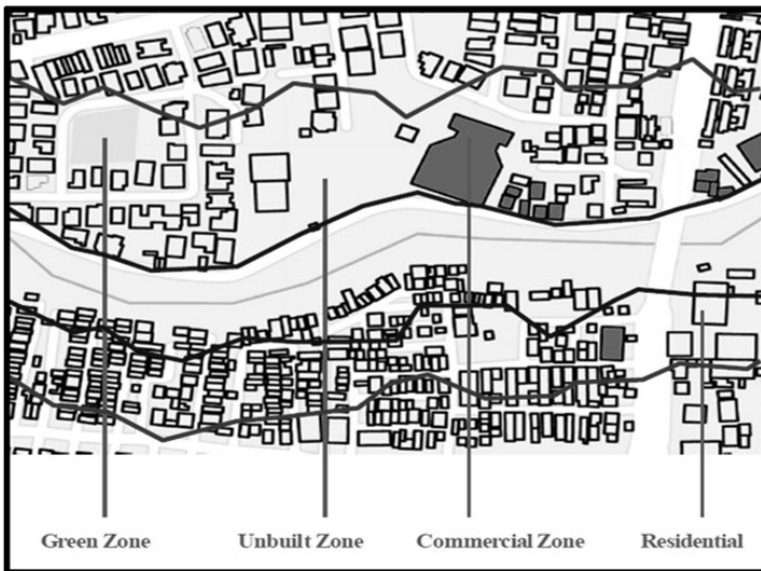


Figure 8. Map showing demarcation of red and blue lines Source: nmc.gov.in (left). Building Constructions being done within red and blue lines (right)

IV) Zone 4: Bharat Nagar Slum Area

Informal settlements (slums) are present along certain areas of the river banks. There is a significant road network adjacent to the river. Human activity in these areas has increased. Solid waste from slums is directly dumped into the river banks. Residents of the slum settlements use the river water for washing clothes, utensils, and vehicles, contributing to water pollution. Additionally, post-religious ritual debris is dumped into the river, further contaminating it. Soiled water from overflowing drains, sewers and commercial processes causes stagnant water resulting in hazardous and infectious surrounding.



Figure 9. Nandini river map showing stretch of slum area

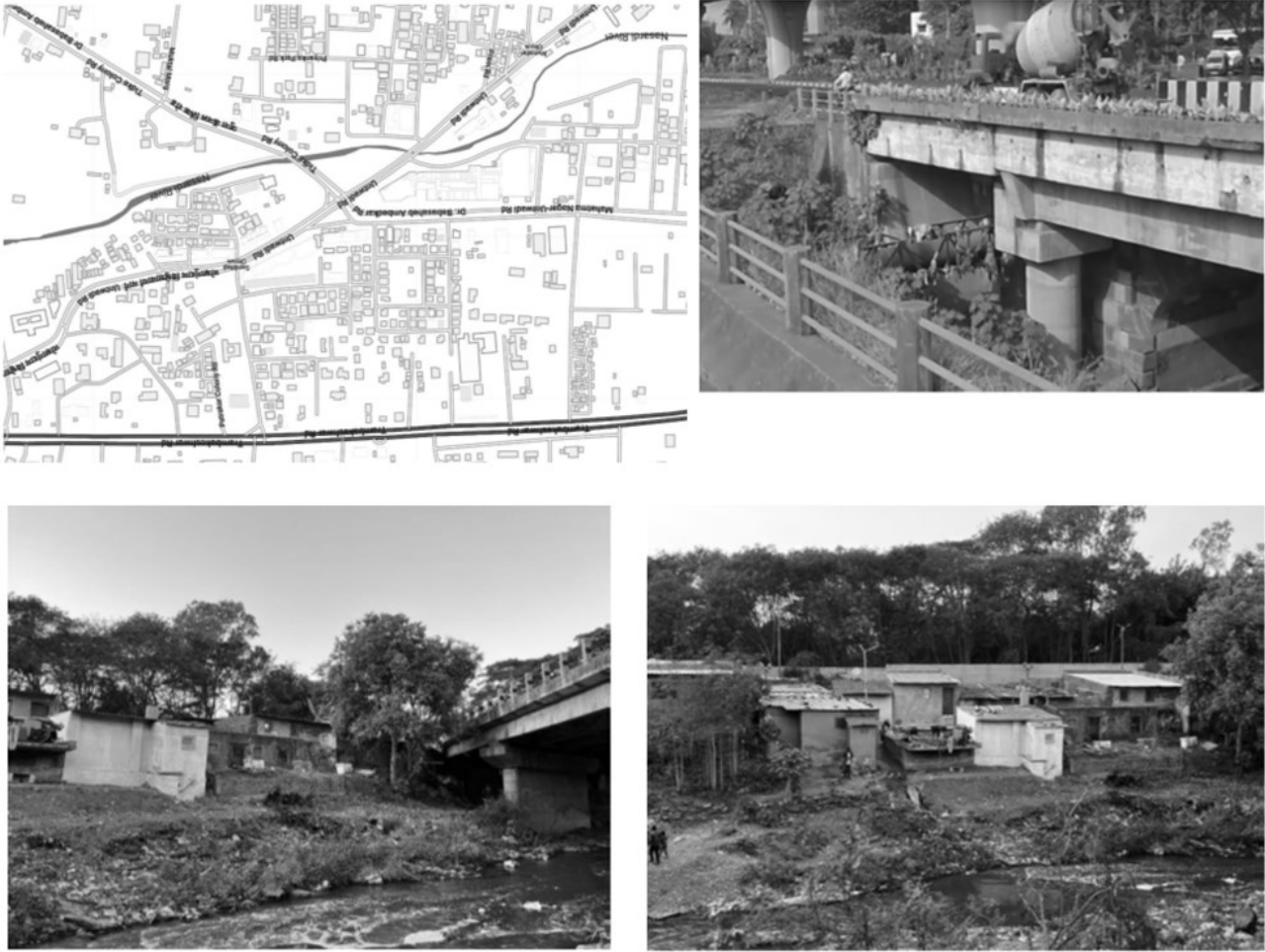


Figure 10. Map showing road network (top left) image (top right) slums abutting the river, directly discharge solid waste into it. (bottom)

V) Zone 5 – Confluence with Godavari

The Merger of the two rivers is shadowed by the Ramdas Swami Marg Bridge Constructed above it, perpendicular to the direction of the flow of Godavari. This has led to solid waste accumulation. Foam formation is seen. Along one of the edges of the river, concrete steps (ghats) are constructed in Cement Concrete for easy access of the river to the people. Algae formation is visible on one side of the river where such construction has occurred. Additionally, a large area of the water surface is covered by hyacinths.



Figure 11. Nandini river map showing confluence zone



Figure 12. Confluence zone showing concretization, algae, hyacinth formation (left) water getting clogged due perpendicular bridge. (right)

Findings

The findings from the literature review can be summarized as under

- I. Concerns regarding the pollution of the Godavari River have been documented since the 18th century. Despite these early efforts, by the Peshwas the long-term effectiveness of such measures remains unclear, highlighting the need for sustained and systematic interventions.
- II. On the other hand, records from a century ago indicate that the water of the Nandini River remained pristine and uncontaminated.
- III. The Nashik Municipal Corporation (NMC) report (2022) outlines several strategies to address river pollution, however, due to missed completion deadlines for the required STPs, part of the untreated sewage is directly discharged into the Nandini River.
- IV. Due to the geology of Nashik, and development of industries, polluted water from streams (nallahs) is conveyed and discharged into the Nandini River.
- V. Levels of pollution of Godavari water increased after the confluence of Nandini.

The findings from the field study can be summarized as under

- I. A significant difference in the ecology is evident in the initial section of the Nandini River and its confluence zone.
- II. The rapid growth of industries in the Satpur and Ambad areas is contributing to the pollution of the Nandini water.
- III. Neglect of the flood zone of the Nandini is apparent, with extensive uncontrolled construction activities taking place nearby, leading to a large-scale human impact on the river. This results in the generation of significant amounts of solid waste, leading to soil and water pollution.
- IV. Human activities such as waste dumping, clothes washing, and discarding items along the riverbanks are contaminating the water, leading to a decline in the soil fertility of the Nandini River.

- V. Contaminated water from overflowing drains, sewers, and industrial processes creates stagnant water, resulting in hazardous and infectious environments, which then flow into the Godavari River.

Discussions

Overall discussions generated from findings are enlisted under following subheads

- I. **Historical Concerns and Effectiveness of Interventions:** Dahake highlighted 18th century concerns raised over pollution resulting from age old religious rituals, leading to efforts to restore its sanctity and cultural importance. The contrast with the pristine condition of the Nandini River a century ago highlights the significant environmental changes and challenges that Indian rivers have experienced over the centuries. This emphasizes the need for continuous and sustainable efforts to tackle river pollution.
- II. **Modern-day Challenges and Pollution in Maharashtra:** Dey discusses contemporary challenges confronting Indian rivers, with the Maharashtra Pollution Control Board (MPCB) identifying 53 polluted rivers in Maharashtra alone. The significant number of polluted rivers underscores the dearth of stringent regulatory measures, effective pollution control strategies, and public awareness campaigns to mitigate pollution levels and safeguard river ecosystems. As per Laura, public participation is the key of the democratic process. This makes government institutions accountable to the society, in addition public participation is of utmost importance which enables government to incorporate non-professional knowledge into decision-making, improves public policy support and improves planning outcomes. (Jankauskaite-Jureviciene, 2021). There is a substantial need to increase public awareness.
- III. **Strategies and Implementation Challenges in Nashik:** The Nashik Municipal Corporation (NMC) report outlines various strategies to combat river pollution. However, acknowledges challenges, such as missed deadlines for constructing sewage treatment plants (STPs), leading to the direct discharge of untreated sewage into the Nandini River. This situation highlights the gap between policy intentions and implementation realities, emphasizing the importance of effective governance, accountability, and community involvement in achieving sustainable river management goals.
- IV. **Imperfect Planning System:** Alterations in the red and blue lines of the river have led to a deviation in the river's natural course. Both legal and illegal encroachments along the river banks have contributed to an unstable and unbalanced state of the river. This underscores the necessity for a reassessment of bye laws when permitting constructions within the river's flood zone.
- V. **Human Footprint from Urban Settlements and Slums:** The existence of urban settlements and slums along the Nandini River results in a substantial human impact on its ecosystem. Activities like waste dumping, clothes washing, and improper disposal practices along the riverbanks lead to water contamination, which in turn degrades soil fertility. This indicates a noticeable lack of awareness among individuals and highlights the necessity for public awareness programs. Soiled water from overflowing drains, sewers, and commercial activities creates stagnant water conditions along the Nandini River, resulting in hazardous and infectious surroundings. Stagnant water not only poses health risks to local communities but also fosters conditions conducive to the proliferation of disease vectors and pollutants.
- VI. **Overall, Numerous issues have affected the water quality of the Nandini river. Issues are worsened because river management and protection have not kept up with the rising demands of rapid urbanization.**
Water Pollution: Rapid industrialization and urbanization have resulted in a rise in the outflow of home and industrial sewage. Residential and industrial sewage is deposited directly into rivers, causing eutrophication and deteriorating water quality.
Channel Hardening: Human influence in urban building has intensified in recent years, altering the river's natural structure. Concretization of river basins, unregulated riverfront development, and the construction of impermeable surfaces such as hard pavement has disrupted the relationship between terrestrial and aquatic ecosystems, resulting in riparian zone deterioration.
River Ecosystem Destruction: Near the origin overhanging vegetation provides habitat that supports microbes, stream insects, and other food sources for fish and other aquatic life. Considerable degradation is observed in the vegetation pattern from Nandini's origin to its confluence with Godavari that is directly relatable to the level of human intervention and is destroying the aquatic life.
Foam Formation: Foam layer has formed due to Industrial effluent and chemical content discharged in the Nandini River. The presence of sewer content in the water has generated eutrophication and hyacinth on surface water resulting in oxygen depletion killing aquatic life and breeding mosquitoes

The challenges associated with river pollution are multifaceted and evolve from factors such as policy formulation, rule enforcement, public education, and monitoring efforts.



Figure 13. Various issues like sewers running along river banks (top left), broken sewers (top right), foam formation (bottom left) and solid waste thrown in Nandini (bottom right)

Conclusion

The research findings highlight the concerning degradation of the Nandini River's water quality due to various human activities. The lack of adequate infrastructure and support facilities, coupled with poor administration and insufficient public awareness, have exacerbated the situation. Nandini's contaminated water readily flows into Godavari, spreading all of its negative effects and worsening the issue. Not only does it have a wide-ranging influence on the biodiversity of its surrounds, but it also poses a severe health risk to the city's population.

It is essential to adopt innovative approaches that integrate cultural heritage preservation with sustainable urban development. This can be achieved by implementing robust policies, improving governance through the involvement of experts, and raising public awareness about the importance of environmental conservation.

By taking proactive measures and engaging stakeholders at various levels, it is possible to address the pollution issues affecting the Nandini River. This approach not only helps in safeguarding the environment but also ensures the well-being of the community that relies on the river for various purposes. By combining efforts to preserve cultural heritage with sustainable urban development practices, it is possible to create a more environmentally conscious and resilient society.

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Conflict of Interests

The author declares no conflict of interest.

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