“RE-IMAGINING GODAVARI RIVER AS AN ECONOMIC ASSET AND SUSTAINABLE DEVELOPMENT OF NASHIK THROUGH ECOSYSTEM SERVICES”

A THESIS

Submitted by

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DECLARATION

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text."

Place: NIT Calicut

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Signature:

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Arya Rajesh Kumbhre

ABSTRACT

"The healthy rivers underpin economies" with this seed idea, the project is envisioned to integrate a conservatory approach for water-related ecosystem services in a holistic manner of urban development, capitalising on their synergies to achieve long-term water security and resilience, whilst creating fiscal capacity expansion and sustainable urban environments. The initiative builds on the historic character of a river as a lifeline for human survival, which is particularly evident in the selected site of the "Godavari River Influenced Zone" in Nashik, Maharashtra. The river flows 19 km through the heart of the city, carrying multiple benefits and acting as a catalyst for growth. Despite supporting the city's agricultural, industrial, and cultural growth, the river encounters degradation from unregulated development and human dependence on water resources. Thus, the project aims to adapt the river-sensitivity approach in planning to generate revenue and manage watershed services. The objectives include identifying different ecosystem services provided by the Godavari River, analysing the urban morphology of the river precinct, mapping human dependencies, and proposing land-use zoning policies that balance sustainability and resilience. The tools, like Remote Sensing and GIS applications, followed by ground truthing, will be used to analyse land use and water consumption patterns. The study emphasises generating a river-related economy through river assets by incorporating innovative planning mechanisms and policy-oriented interventions. The outcomes are expected to address land-use challenges, regulate tourist footfall and prioritise conservation of ecological and cultural values. The project's long-term vision is to establish Nashik as an ideal city utilising water services, which can also contribute to both economic growth and the achievement of specific Sustainable Development Goals (SDGS). The project can offer a broader perspective on the historically established role of the river as a pioneer for the development of cities.

Keywords: Ecosystem Services, Godavari River, Land Use, Nashik, River Sensitivity, Resilience, Sustainability

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List of Abbreviations

AMRUT	The Atal Mission for Rejuvenation and Urban Transformation
CIFOR	Center for International Forestry Research
DCR	Development Control Regulations
DEFRA	Department of Environment Forest and Rural Affairs
DP	Development Plan
ES	Ecosystem Services
GIS	Geographic Information System
HFL	High Flood Level
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IUCN	The International Union for Conservation of Nature
MCA	Multi-Criteria Assessment
MoHUA	Ministry of Housing and Urban Affairs
MEA	Millennium Ecosystem Assessment
MLD	Mega liters per Day
MPCB	Maharashtra Pollution Control Board
MSL	Mean Sea Level
NbS	Nature-based Solutions
NEERI	National Environmental Engineering Research Institute
NIUA	National Institute of Urban Affairs
NMC	Nashik Municipal Corporation
OECD	Organization for Economic Co-operation and Development
PES	Payment for Ecosystem Services
PWD	Public Works Department
SDG	Sustainable Development Goals
SLR	Systematic Literature Review
SPV	Special Purpose Vehicle

TCPO	The Town and Country Planning Organisation
TEEB	The Economics of Ecosystems and Biodiversity
UNEP	United Nations Environment Program

CHAPTER 1: INTRODUCTION

1. INTRODUCTION

1.1.Background and Context

Rivers are said to be the lifeline for living beings, as all types of development directly or indirectly relate to them. Since ancient times, rivers have served as the foundation of the economic engine for the survival of humans. Early civilisations like the Indus Valley on the Indus River, Egypt on the Nile River, and Mesopotamia between the Euphrates and Tigris are examples of planning innovations that were established for trade, agriculture, and safe livelihood.

Rivers are essential to the urban metabolism of cities, which refers to the complex flow of resources that supports urban existence. They function as essential water supply sources, facilitate drainage and stormwater management, serve as channels for waste management, and significantly enhance a city's cultural identity and economic interactions, historically acting as trade routes and settlement foundations. In modern urban planning, rivers are widely acknowledged as ecological corridors that enhance biodiversity by connecting fragmented habitats and enabling species migration. They constitute the foundation of blue-green infrastructure, a planning approach that integrates water systems with plants to mitigate urban flooding, purify water, diminish heat islands, and improve public spaces. Renowned landscape architect Ian McHarg, in Design with Nature (1969)(Yang & Li, 2016), highlighted the design need in line with biological systems, a theme currently reflected in contemporary frameworks such as Nature-based Solutions (NbS) and Sponge City models in China. These frameworks promote collaboration between cities and natural hydrological processes, employing strategies such as permeable surfaces, regenerated wetlands, and riverbank buffers to establish climate-resilient and sustainable urban landscapes. Rivers should be seen as urban assets to be respected, restored, and integrated, not as burdens to be managed. Many urban design projects have been considered as a solution to the urban river issues, e.g., Thames revitalisation (UK), Sabarmati riverfront (Ahmedabad in India), or Cheonggyecheon stream restoration Project (South Korea). (Shinde et al., 2024)

The river’s value is often overlooked in urban economics because of the absence of formal acknowledgement and assessment of the various environmental services it offers. But this absence causes a disjunction between natural capital and financial capital, wherein rivers are perceived as passive backdrops rather than active contributions to urban productivity and resilience. By neglecting to integrate these services into economic frameworks, cities jeopardise ecological stability and miss potential revenue sources that may be derived from mechanisms such as Payment for Ecosystem Services (PES), ecotourism, or investments in green infrastructure. Identifying, delineating, and appreciating these concealed contributions is therefore an essential measure for developing river-sensitive urban areas that harmonise ecological well-being with economic advancement.

The selected site for the project, the Godavari River, is an identity of Nashik, one of the oldest cities situated along the riverbanks. With the relevance of the Ramayana, the Mahabharata, and numerous heritage and natural sites, the city is not only known as the spiritual capital of Maharashtra but also contributes to the Indian economy, attaining a district GDP of more than 33 billion, including agricultural, automobile, and industrial sectors. The multi-layered land use around the river stretch is a beneficial aspect for the growth of the city. However, it also increases the human dependency on rivers, contributing to the drivers of ecosystem degradation. The water ecosystem present in Nashik provides a range of benefits (services) that are not formally valued due to its free availability.

The research seeks to balance the river's ecological health with its economic functions. The mapping of human dependence on water services will help build interconnections between the city and the river, which urban planning solutions will solve. The identification of critical zones along the 19 km stretch of the river involves mapping areas of high ecosystem degradation against areas with preserved natural assets, as well as estimating the economic value of these services to emphasize their importance for Nashik's economy and urban fabric. (Reid & Mooney, 2016a)

Figure 1: Godavari River, Nashik

1.2.River Ecosystem Services and Key Issues in Urban River Management

Among all the urban water assets, rivers play an important role in providing a wide range of ecosystem services that support livelihood, biodiversity, and development. The rivers provide many tangible and intangible benefits, but these services are not formally valued. During the post-industrialisation phase, economists and environmentalists were finding difficulties in assessing environmental health. Quantification methods and concepts have been proposed to maintain accountability of the natural assets. Further, the benefits we humans draw from the environment are termed "ecosystem services" to establish the value of the environment. Further, the Millennium Ecosystem Assessment (MEA) categorized these ecosystem services into four major types, i.e., provisioning services (drinking water, agricultural usage of river water), regulating services (microclimate regulation, flood control), cultural services (pilgrimage tourism along ghats, recreation), and supporting services (soil formation, nutrient cycling). (Chopra et al., 2022; Reid & Mooney, 2016a)

Rivers have been a focal point for settlement growth due to the accessibility of water, transport, recreation, etc. Also, from the ancient period, rivers have been praised as deities and referred to as a sacred component. Later, with technological advancement, traditional factors started diminishing, and industrialisation occurred. (Shinde et al., 2024) With this historical shift, the river, once a sacred source of living, transformed into a force serving human wants.

On one hand, humans still celebrate rivers, especially in areas where daily spiritual practices and festivals are being performed. However, this also results in degradation by dumping waste, over-extraction of water, and bathing/washing activities in the river. There remains a general lack of awareness among humans about the potential benefits they get from the river. Therefore, to foster sensitivity towards this issue, planning must incorporate river consideration for optimal utilization.

Urban rivers face increasing pressure to supply services due to technological advancement and the needs of an increasing population. These services include industrial water supply, waste disposal, bathing, and washing in the river, which in turn causes heavy degradation.

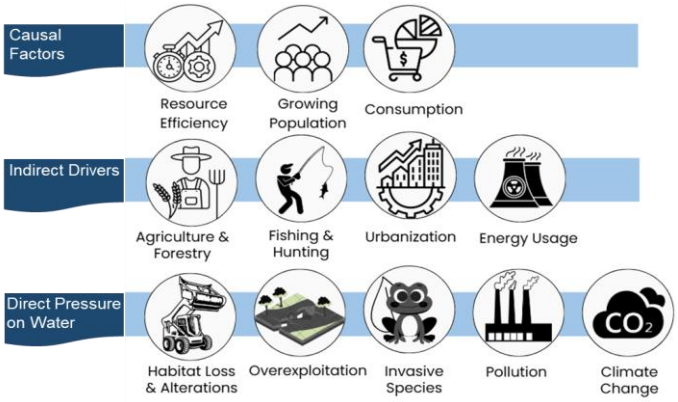


Figure 2 River Ecosystem Services and Human Induced Pressure (Source: Author)

1.3.Selection of Themes for the Project

Following a comprehensive review of the literature and contextual study, two themes influenced by challenges and opportunities related to the planning of river-based cities or regions were selected for this thesis project.

River Sensitivity: The theme addresses the current situation and potential of the river to provide ecosystem services. It measures the resilience, disturbance level, and usage of the river water. The terminology is taken from the NIUA's report, "Making River-Sensitive Master Plans." The sensitivity considers the impacts of anthropogenic activities, natural events, and disaster patterns on river health. (*River_Sensitive_Urban_Planning_NMCG_1737536820*, n.d.)

Sustainability: In 1987, the **United Nations Brundtland Commission** defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their needs." The project is envisioned to propose solutions, including sustainability principles. The project also caters to the direct achievement of the UN's Sustainable Development Goals (SDGs) – Goal 11 Sustainable Cities and Communities, Goal 14 Life Below Water, and Goal 15 Life on Land. (Sorooshian, 2024)

1.4.Existing Research

As part of the literature review for this thesis, existing global studies have been reviewed to understand the relationship between ecosystem services and rivers. We used the systematic literature review method, selecting the material from the Scopus database. Keywords used: ecosystem services, rivers, ecosystem services mapping, and land use zoning. The process included title screening, abstracts and keywords, and a full-text review. Preference was given to peer-reviewed journal articles published between 2010 to 2024. The following is a brief study of the final 15 selected research papers.

The study's purpose is to analyse river-related ES and how the services are identified and mapped. It also helps to assess how spatial and social data can support the area's development.

Sr.No.	Author(s)	Year	Title of Study	Study Area	Objectives	Methodology Used	Key Findings	Relevance to Current Study	Limitations of the Study
1	Tomasz Grzyb	2024	Mapping cultural ecosystem services of the urban riverscapes: the case of the Vistula River in Warsaw, Poland	Warsaw, Poland	To assess recreational benefits associated with urban riverscapes and identify drivers of these experiences through spatial analysis	PPGIS (Public Participation GIS) survey	Cultural Services were highly valued, especially a sense of natural heritage, aesthetic value, and physical condition. Spatial clustering of benefits was observed in central areas. Emotional attachment was stronger among long-term and frequent visitors.	Helps the project to analyse sensitivity through how people use water and river adjacent spaces.	Sample selection of middle-aged female respondents (via Facebook), limiting representativeness. Limited intergenerational analysis. Seasonal preferences have not been deeply analysed.
2	Smith et al.	2020	Urban Riverfront Development & Ecosystem Services	Chicago, USA	To analyse the impact of land use changes on river ES	GIS analysis, stakeholder interviews	Found significant loss in provisioning services post-urban expansion	Provides a framework for assessing urban impact on river ecology	The study is limited only to provisioning, cultural and services and land use changes

3	Mesfin Sahle, Osamu Saito, Christine Fürst, Kumelache w Yeshitela	2019	Quantifying and mapping of water-related ecosystem services for enhancing the security of the food-water-energy nexus in a tropical data–sparse catchment	Wabe River Catchment, Ethiopia	To quantify and map water provisioning and erosion-regulating ecosystem services in a data-sparse catchment to improve the food-water-energy nexus security.	Use of InVEST method and sediment delivery models, use of land use/land cover data, climate and hydrologic parameters for analysis, and household-level water demand surveys; GIS-based spatial analysis	Ecosystem services mapping helps identify spatial mismatches between supply and demand.	Justifies a spatial approach to assessing water-related ecosystem services and their interlinkages with development needs. Relevant for informing land-use zoning and ecological planning in river-adjacent urban areas, especially in regions with data limitations.	The study focused mainly on physical provisioning and regulating services, with limited attention to socio-cultural dimensions. Further, temporal variability beyond the seasonal scale was not deeply analysed.
4	Sayantani M. Basak, Md Sarwar Hossain, Joanna Tusznio, Małgorzata Grodzińska-Jurczak	2021	Social benefits of river restoration from an ecosystem services perspective: A systematic review	Global (Systematic Literature Review)	To identify progress, gaps, and future directions in river restoration research, specifically focusing on social benefits within the ecosystem	Systematic review of 125 studies (1998–2019) using Web of Science and Scopus, metadata categorisation (focus, ES types, scale, method), word cloud analysis, chord diagram,	River restoration research focuses on ecological and economic aspects, with social benefits. The study focuses mainly on provisioning, regulating, and providing	Provides a broad conceptual and methodological foundation for linking ecosystem services with social benefits in river-related planning.	Limited inclusion of local and regional social data. Social benefits are measured only through economic valuation. Validation through community perception is done.

					services (ES) context.	qualitative and quantitative synthesis	cultural services.		
5	Natalia Alvarado-Arias, Vinicio Moya-Almeida, Francisco Cabrera-Torres, Andrea Medina-Enríquez	2023	Evaluation and mapping of the positive and negative social values for the urban river ecosystem	Loja, Ecuador	To map and assess the spatial distribution of non-monetary social values (positive and negative) associated with urban rivers and their ecosystem services (ES).	Public Participation GIS (PPGIS) via Survey; spatial analysis using SolVES and Maxent tools; environmental variables like distance to green areas, slope, and elevation were analysed to determine the spatial distribution of ES values.	Mapping revealed the co-existence of ecosystem services and disservices in urban river landscapes.	A practical and participatory mapping method to incorporate **community perceptions of river ecosystems** into planning. Helps identify **zones of conflict and opportunity**, which supports the current study's goal of zoning for urban resilience and ecosystem sensitivity.	Requires advanced GIS tools and expertise (e.g., SolVES, Maxent) not easily accessible in all contexts. Relies on self-reported perceptions, which may not represent all demographics, limited analysis of long-term change or integration with economic/ecological datasets.

6	Danielle K. Petsch, Vivian M. Cionek, Sidinei M. Thomaz, Natalia C. L. dos Santos	2023	Ecosystem services provided by river-floodplain ecosystems	Global	To review and update the ecosystem services (ES) provided by river-floodplain ecosystems (RFEs) and their regulation by flood pulses	Literature review using a non-systematic survey of existing studies; categorised ES using the MEA framework.	Flood pulses are crucial for maintaining ecosystem functions. Categorisation of services into different types that are suggested by MEA.	The study justifies the ecological roles of river systems, useful in zoning that protects floodplains and prioritises ecosystem processes.	Focuses on global and theoretical insights, doesn't include valuation data or stakeholder perspectives
7	Lilei Zhou, Dongjie Guan, Xiaoyong Huang, Xingzhong Yuan, Mengjie Zhang	2020	Evaluation of the Cultural Ecosystem Services of Wetland Park	Chongqing, China	To identify and map the cultural services of two wetland parks and understand public perceptions for better park planning	SolVES model, survey-based preference analysis, transfer value comparison across two parks	Biodiversity perception, aesthetic, historical, and recreational values were highest.	Reinforces the value of participatory mapping and Solves modelling for understanding public use and perception, supporting zoning based on non-material services	The study focuses only on CES in small parks, lacks broader integration with ecological data, and cultural values are assessed subjectively and not longitudinally

8	Sander van der Ploeg, Dolf de Groot, Yafei Wang	2010	The TEEB Valuation Database: Overview of Structure, Data, and Results	Global	To compile a searchable monetary valuation database of ecosystem services across major biomes to support decision-making	Meta-analysis of 1310 case studies using standardised valuation formats, categorised by ecosystem type and ES	Global dataset for ES valuation across provisioning, regulating and cultural services. Designed for policy use and planning	Supports the economic rationale for including ES in land-use planning and helps understand valuation trends across services	Focuses only on monetary valuation, lacks integration with socio-cultural or ecological processes.
9	Gabriela dos Santos Simões, Fabiana A. Fiore, Lívia C. Silva	2022	Mapping of Ecosystem Services Provided by the Paraíba do Sul River Alluvial Plains APA	São José dos Campos, Brazil	To identify and map key ecosystem services provided by a protected area integrated into an urban environment using stakeholder input	Participatory mapping, land use analysis, Rapid Participatory Diagnosis (RPD) method adapted from TEEB	Identified priority ES: freshwater supply, nutrient cycling, photosynthesis, local climate regulation. Reinforced role of APA in supporting urban sustainability	Demonstrates how ES mapping in urbanised river zones can inform zoning and policy, relevant for integrating stakeholder perceptions in ecological planning.	Limited generalizability; localised data with qualitative focus; lacks detailed spatial modelling; long-term ecological monitoring not incorporated.
10	Burkhard et al.	2012	Mapping ecosystem service supply, demand and budgets	Schleswig-Holstein, Germany	To spatially assess and visualise ES supply, demand, and budget	GIS-based modelling, matrix approach linking LULC types to ES values	Spatial mismatches exist between ES supply and demand, multifunctional landscapes improve ES balance	Concludes that spatial analysis of ES supply-demand gaps can inform zoning decisions	Limited to one region and uses expert-based scoring, which may not fully reflect public perceptions

11	Raymond et al.	2009	Mapping community values for natural capital and ecosystem services	South Australia	To map social values for ES and integrate them with ecological data	Public participation GIS (PPGIS), interviews and spatial overlays	Cultural values like recreation and aesthetic appreciation were spatially distinct.	Highlights the importance of community perception in planning ES; highly relevant for participatory land-use planning	Focus on non-monetary values
12	Haase et al.	2014	Indicators for measuring urban ecosystem services: A review	Global	To identify indicators suitable for assessing ES in urban environments	Literature review, framework analysis	Developed indicators for provisioning, regulating, and cultural ES in cities, focusing on spatial data integration	Provides a framework for assessing urban ES, aligning with land-use zoning needs in urban river contexts	Lacks first-hand testing of indicators
13	Rall et al.	2017	Using green infrastructur e to improve urban climate and ecosystem services	Multiple European cities	To evaluate how green infrastructure supports ES and urban climate resilience	Case studies, ES assessment framework, spatial planning tools	Green Infrastructure contributes to climate regulation, biodiversity, flood management, and recreation.	Supports ES and Green Infrastructure in special-purpose zoning for urban rivers	Results are context-specific-implementation depends on local governance capacity.
14	Crossman et al.	2013	A blueprint for mapping and modelling ecosystem services	Australia	To develop a national strategy for ES modelling and mapping	Modelling framework combining land-use data, ecosystem function, and	Presents a systematic approach to ES mapping	Valuable for structuring ES planning across large urban-rural areas like river basins	Challenges in applying uniformly across regions

						stakeholder input			
15	Wu, J., Huang, L., Deng, L., & Hao, Y.	2020	Assessment of ecosystem services provided by urban rivers using the DPSIR framework: A case study in Beijing, China	Beijing, China	To analyse the state and pressures on ecosystem services (ES) in urban river systems and provide strategic planning input	DPSIR (Drivers–Pressures–State–Impact–Response) framework; integrated assessment combining policy, ecological, and socioeconomic indicators	Land-use change and pollution are the main concerns. Provisioning services were declining, and regulating and cultural services were highly valued by residents.	Supports strategic zoning that addresses both environmental and social dimensions	Limited to one urban case, relies on secondary data and expert judgment.

Table 1: Existing Studies

(Alvarado-Arias et al., 2023; Basak et al., 2021, 2021; Chopra et al., 2022; Lu et al., 2019; Pabjanek & Szumacher, n.d.; Pandolfi, n.d.-b)

1.5.Research Gap

The synthesised existing literature review on the valuation and mapping of water-related ecosystem services shows significant gaps remain in their implementation within land use planning and policy-making, particularly concerning urban rivers in India.

Instruments like GIS and InVEST have been utilised to delineate ecosystem service flows (e.g., research in Ethiopia, the USA, and Ecuador), but these models are predominantly restricted to regional or basin-wide scales, with insufficient application at the urban area level where zoning and land management choices occur. Land Use Land Cover (LULC) analysis for comprehending spatial patterns of ecosystem functionality has been inadequately employed in correlating ecological worth with tangible land-use alterations and human activities. (Chopra et al., 2022; Mukhopadhyay et al., 2025, 2025; Pandolfi, n.d.-a)

The cultural ecosystem services gaps, although some research (e.g., Warsaw, Chongqing) recognises recreational, spiritual, and heritage capacities, these services have rarely been converted into actionable planning instruments or conservation-focused site designations.(Pabjanek & Szumacher, n.d.) Their intangible and non-monetary characteristics make them susceptible to exclusion from formal valuation and policy integration, although their key significance is in influencing local identity, tourism potential, and community well-being.

Methodologically, most research depends on secondary datasets, expert evaluations, or public opinion surveys, lacking a foundation in multi-layered empirical analysis or cross-verification with economic and demographic data. There is inadequate coordination between ecological valuation methods and socio-spatial frameworks in urban planning, resulting in inconsistent findings that do not immediately contribute to actionable planning outputs.

A geographic and thematic bias is noticeable. Despite floodplain management, agricultural watersheds, and protected areas have been thoroughly researched globally, urban rivers in India, especially those of cultural, religious, and economic importance, like the Godavari in Nashik, are insufficiently examined. These rivers showcase planning challenges characterised by diverse land ownership, informal settlements, religious intrusions, tourism demands, and disconnected institutional governance, which current models fail to handle.

1.6.Research Questions

- How do areas of high ecosystem service value correspond with current urban land use patterns?
- Which spatial discrepancies might impact the accuracy or interpretation of the results?

1.7.Aim

To facilitate river-sensitive urban planning of the Godavari River zone in Nashik, emphasising **Special Purpose Planning** (economic generation) through water-related ecosystem services while ensuring the preservation of the river's ecological integrity.

1.8.Objectives

- To identify ecosystem services provided by the Godavari River in Nashik.
  (Objectives Breakdown – for tapping river potential as a natural and economic resource.)

- To analyse the urban morphology around the Godavari River, concentrating on land-use patterns, their relationship to the river's ecological health, and mapping human dependencies on any one prominent type of river-based service.
  (Objective Breakdown –
    - To identify the critical areas based on potential and degrading ecosystem services and water quality degradation patterns.
    - Prioritisation of key zones based on service usage. (Area Delineation)
- To propose land-use zoning policies around the Godavari River in Nashik and recommend solutions that support economic prosperity and sustainability to enhance urban resilience while safeguarding critical ecological zones through a special-purpose plan.
  (Objective Breakdown –
    - River-Centric Planning
    - Specific, Measurable, Attainable, Relevant, and Time-bound (SMART) Recommendations.
    - long-term water security and resilience.)

1.9.Scope of the Project

This thesis deals with spatial planning within an identified river-influenced zone within the Nashik Municipal Corporation's (NMC) boundaries. Since this effort is a special purpose plan, the study is purposefully limited and does not try to extend results to an entire river length or city. If the solutions result positively in the future, the study can be applied to other patches of the river zone as needed and under the conditions. The study spans only six months academically. Thus, thorough spatial ideas and assessments are prepared for a smaller, important portion of the riverfront instead of an entire corridor. This method enables targeted evaluation of land use/land cover changes, ecosystem service mapping, and locally based planning ideas that may be scaled or extended further.

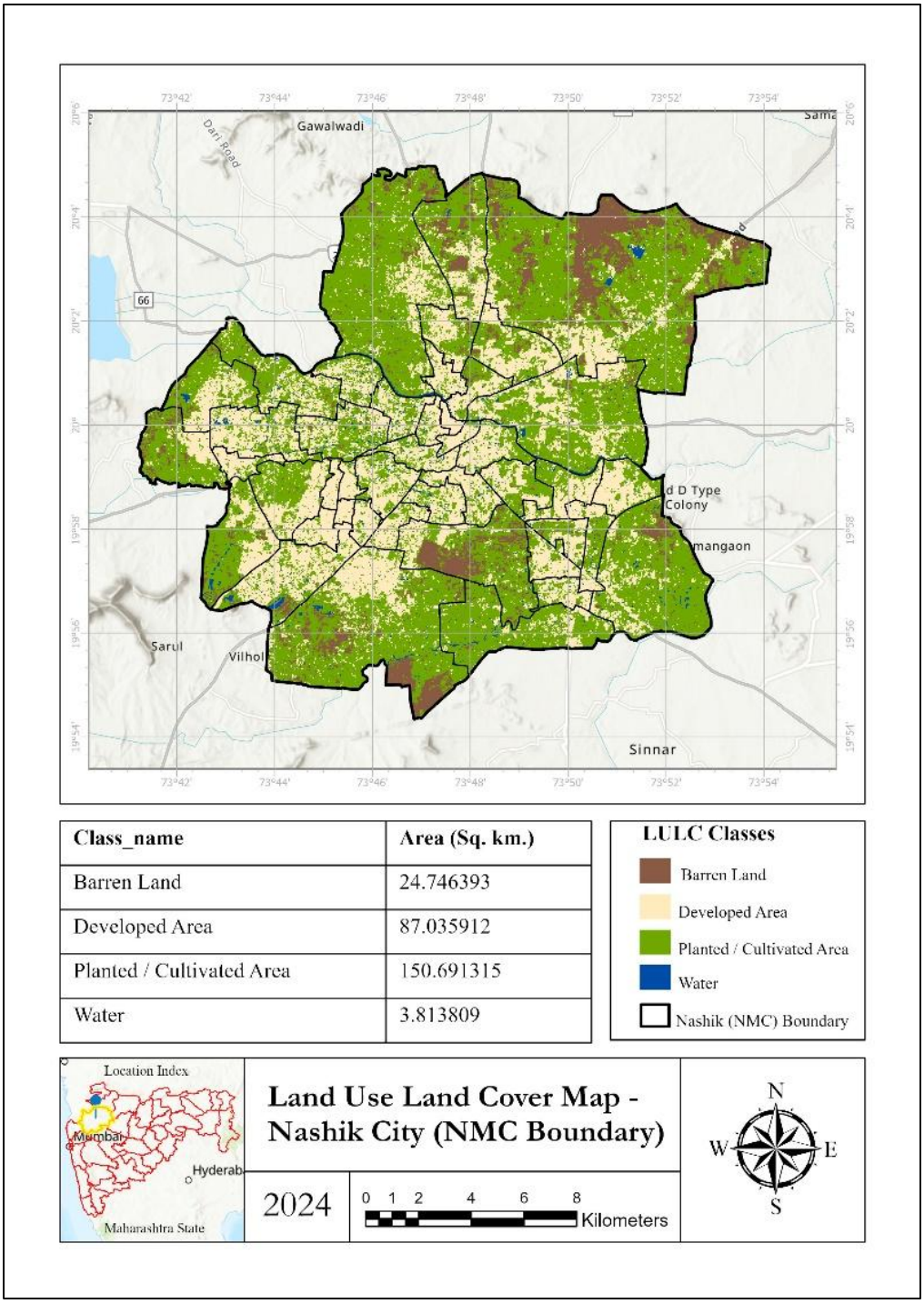
1.10. Limitations

- The restricted access to quantitative data and the lack of detailed ecosystem service valuation metrics for the study area limit the study. Hence, the methodology has been formulated using a stakeholder's survey, an expert survey and a citizen perception survey, followed by the expert's validation and site survey. Due to less

accountability in service valuation, the study is limited to the data received from the surveys and does not use any standard methods defined in MEA and TEEB.

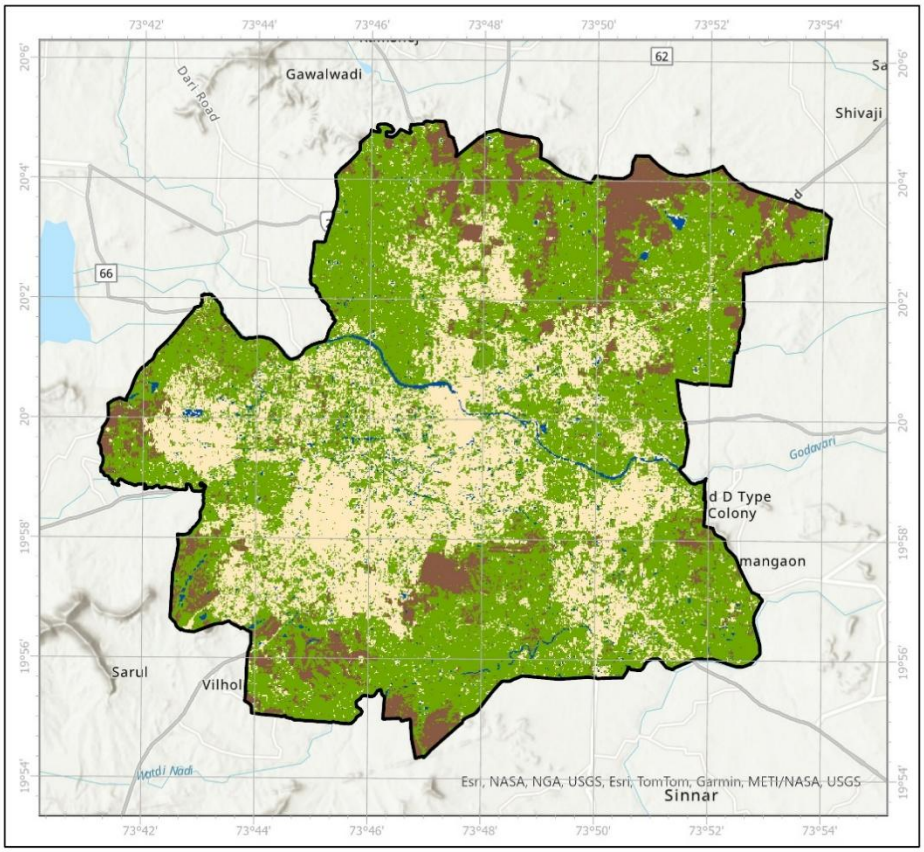
- Due to technical complexity and time constraints, the study does not include hydrological exercises or environmental impact modeling. The interventions that have been suggested are founded on qualitative and spatial analysis rather than predictive environmental modeling.

1.11. Need for the Study



Class_name	Area (Sq. km.)
Barren Land	24.746393
Developed Area	87.035912
Planted / Cultivated Area	150.691315
Water	3.813809

Figure 3 Land Cover Map 2024 (Source: Author)



Class_name	Area (sq. km.)
Barren Land	30.633667
Developed Area	80.85379
Planted / Cultivated	150.238998
Water	4.569365

LULC Classes

- Barren Land
- Developed Area
- Planted / Cultivated Area
- Water
- Nashik (NMC) Boundary

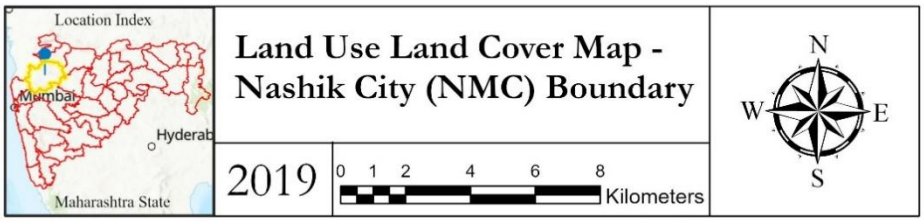
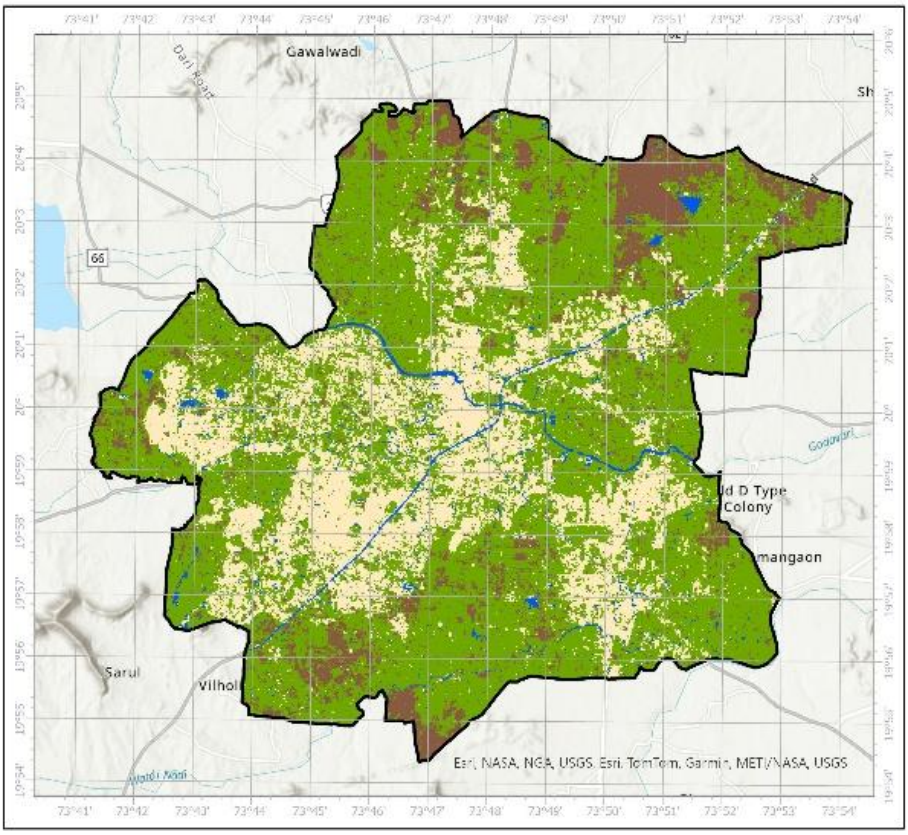


Figure 4 Land Cover Map 2019 (Source:Author)



Class_name	Area (Sq. km.)
Barren Land	31.366716
Developed Area	65.420746
Planted / Cultivated Area	163.954407
Water	5.560909

LULC Classes

- Barren Land
- Developed Area
- Planted / Cultivated Area
- Water
- Nashik (NMC) Boundary

Land Cover Map - Nashik City (NMC) Boundary

2014

0 1 2 4 6 8 Kilometers

N W E S

Figure 5 Land Cover Map 2014 (Source: Author)

The Godavari River in Nashik is facing an increasing level of environmental stress due to unregulated urbanisation, inadequate service infrastructure, and the loss of ecologically sensitive zones. The spatio-temporal Land Cover analysis conducted for 2014, 2019, and 2024 reveals an extensive growth of developed areas, with a 38% increase in urbanised land from 63.62 sq. km in 2014 to 87.63 sq. km in 2024. Urban expansion in vacant or agricultural land could be justified by a slight rise in agricultural/green areas and a decline in barren land by over 20%. The ecological functions and risks of flooding, pollution, and the loss of cultural-recreational spaces are further threatened by these land cover shifts, which tend to occur around the river-influenced zones. The need for selected small-area special purpose planning that can restore, manage, and protect the Godavari corridor while balancing urban demands and ecological sensitivity can be seen by this evident evidence of transformation in space.

According to the official NMC records, the urban built-up area increased from 5.21 sq. km. in 1981 to 137.51 sq. km. in 2020. The rise has resulted in a significant decrease in open spaces and natural habitats, with wastelands decreasing from 47.55% to 17.61% of the overall area covered during the same period. (*GodavariRiver_ComprehensiveStudyReport*, n.d.)

According to the MPCB Official Reports of the Water Quality Index (WQI) showed a significant decrease from 133.44 (good quality) upstream to 35.01 (poor quality) in urban areas. The Nashik Municipal Corporation identified 43 sites where domestic sewage is directly discharged into the river via stormwater drains. The existing sewage treatment plants (STPs) in Nashik are inadequate and lack quality. The NMC supervises nine outdated sewage treatment plants (STPs) with a total capacity of 342 million litres per day (MLD), which do not comply with environmental regulations, resulting in elevated Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) concentrations in the effluent. A new sewage management project costing Rs 1,632 crore has been planned to establish four major sewage treatment plants (STPs) with a combined capacity of 400 million litres per day (MLD). (India, 2025)

1.12. Research Methodology

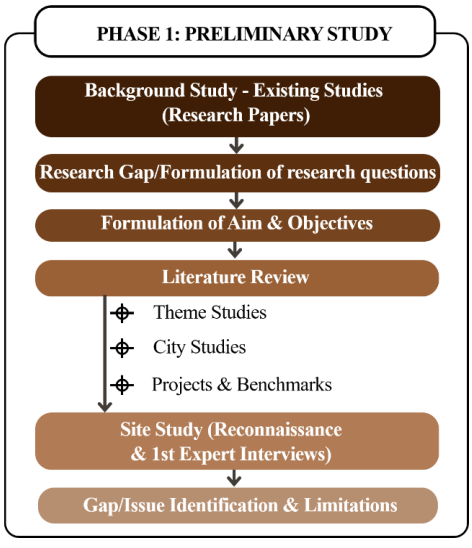


Figure 6: Phase 1 Methodology (Source: Author)

The methodology has been divided into four phases. Phase 1 covers a preliminary study that lays the foundation for the research. The process starts with a comprehensive survey of the existing literature, including research papers, theme analyses, key urban case/city studies, and project benchmarks. This supports the identification of research gaps and the formulation of research questions, aims, and objectives. A comprehensive literature review is undertaken to assess current levels of knowledge. This phase comprises reconnaissance surveys and preliminary expert interviews to establish the study in local contexts, resulting in the identification of concerns, gaps, and constraints.

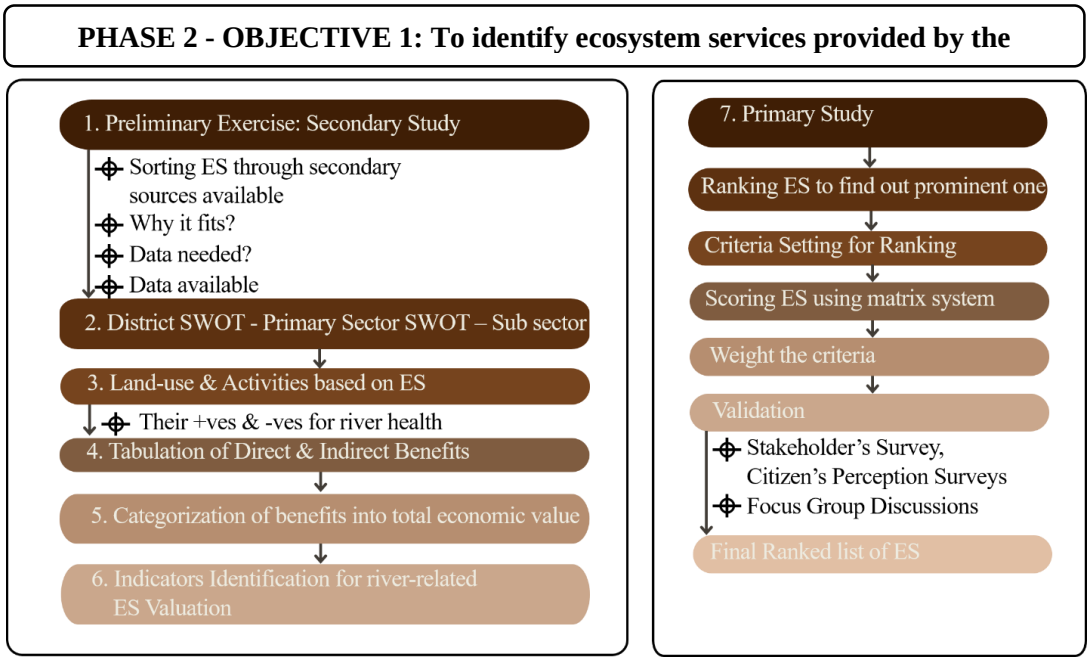


Figure 7: Phase 2 Methodology (Sourc:Author)

Phase 2 aims to achieve Objective 1: to identify the ecosystem services (ES) offered by the Godavari River. This phase is categorised into secondary and primary studies. The secondary study starts with initial exercises of categorising environmental services based on existing literature, analysing their significance, and assessing data availability. A district-level SWOT analysis evaluates the main sectors and their sub-sectors, maps land use and activities related to ecosystem services, and assesses their positive and negative impacts on river health. The direct and indirect advantages of these services have been structured and classified of economic value given in MEA. Indicators are also identified to assist in the pricing of river-related ecosystem services. The principal study involves stakeholder participation, wherein ecosystem services are prioritised through a matrix-based scoring system. Criteria are established, and weights are assigned to facilitate systematic assessment. Validation is conducted via stakeholder interviews, public perception surveys, and focus group discussions, resulting in a final ranked list of ecosystem services informed by community viewpoints and their perception about river health.

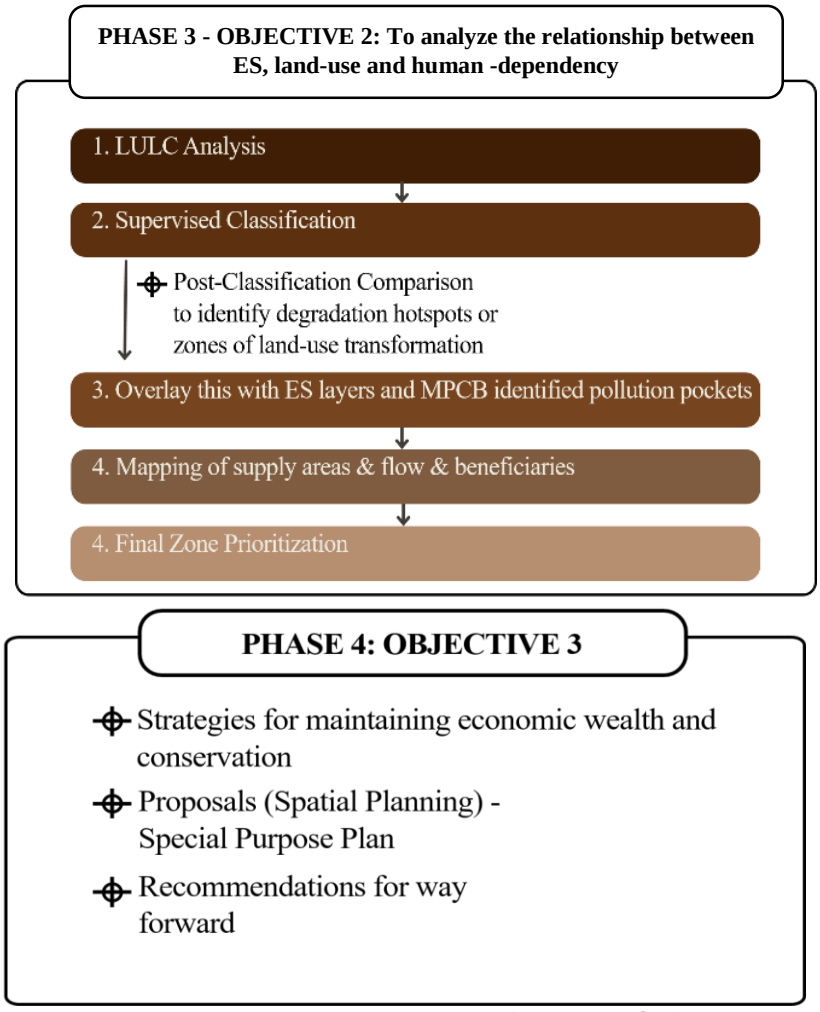


Figure 8: Phase 3 & 4 Methodology (Source: Author)

Phase 3 ties to Objective 2 of the project, which aims to examine the correlation between ecosystem services (ES), land use, and human dependency. This phase begins with a Land Use Land Cover (LULC) analysis utilising remote sensing and GIS technologies. Supervised classification methods are utilised to produce land use and land cover (LULC) maps over various temporal intervals, facilitating post-classification analyses to identify areas of land-use change and pinpoint degradation hotspots. The spatial changes are then overlaid with previously recognised ecosystem service layers and pollution data from the Maharashtra Pollution Control Board (MPCB) to evaluate spatial correlations and overall impacts. This is succeeded by delineating the flow of ecosystem services from supply regions to beneficiaries, illustrating human dependency and pressure on ecosystem functions. The results are consolidated to execute the final prioritisation of zones for intervention planning. Phase 4 aligns with Objective 3 and focuses on formulating strategies and actionable recommendations derived from previous analyses. This involves developing strategies to preserve economic value alongside conservation efforts, drafting spatial planning ideas as a Special Purpose Plan for selected river zones, and offering active recommendations.

CHAPTER 2: LITERATURE REVIEW

2. LITERATURE REVIEW

2.1.Introduction

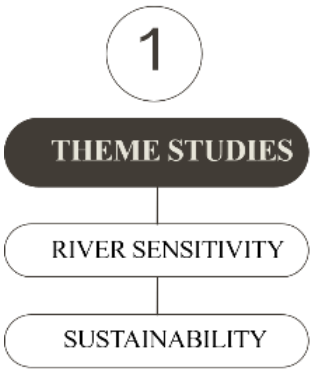


Figure 9 Categorized Literature Review (Source: Author)

The literature review aims towards ecosystem services, land use–land cover (LULC) changes, human dependency on the environment, and spatial planning strategies within riverine settings. The scope covers global ideas, national frameworks, and local case studies about river ecosystems, emphasising approaches for evaluating ecosystem service values and their integration into urban development. The research papers, official policy framework documents, and government reports related to the study's objectives are considered. The literature was reviewed across three levels: (i) conceptual and theoretical frameworks (e.g., Millennium Ecosystem Assessment), (ii) data collection on river ecosystems and urban riverfront development, and (iii) practical case studies and tools. This systematic strategy helps in identifying research shortcomings and assessing methodological importance.

2.2.Summary of past literature reviewed

The comprehensive literature review was conducted as part of the author's unpublished academic work (dissertation) as a preliminary study for the thesis. This literature review analyses the theoretical and practical foundations of Payment for Ecosystem Services (PES), specifically highlighting watershed ecosystem services. This review aimed to identify global best practices, assess implementation mechanisms, analyze success factors and limitations, and ultimately establish a conceptual framework for applying PES in urban riverfront planning in India, specifically regarding the Godavari River in Nashik. The existing research in the PES subject shows significant commonality in essential themes, such as stakeholder engagement, valuation methodologies, cultural ecosystem services, watershed integrity, and spatial planning. Throughout these investigations, SLR has surfaced as a prominent approach for extracting structured knowledge and identifying conceptual deficiencies, methodological advantages, and policy connections. (C. Agarwal, 2007)

2.2.1. Scope of the Literature Review

The literature review aims to cover a diverse range of subjects relevant to PES, including

1. The standard definitions and theoretical frameworks of PES are delineated by UNEP, OECD, IUCN, World Bank, and Sven Wunder (environmental economist—most cited definition of PES).
2. The justification for Payment for Ecosystem Services (PES) is a market-oriented conservation mechanism.
3. Categories of ecosystem services (MEA framework): providing, regulating, sustaining, and cultural.
4. Mechanisms, settings, and phases relevant to the design and execution of PES schemes.
5. Legal, institutional, economic, and communal dimensions of PES.
6. A comprehensive assessment of ten case studies, covering both international (Costa Rica, Mexico, China, Kenya, France, USA, Philippines) and Indian (Sukhomajri and Himachal Pradesh) examples.

2.2.2. Selection Criteria of the Cases/ Methodology

The existing research papers referred on the PES subject to formulate this methodology, shows significant commonality of keywords and context of watershed services or water-related services including stakeholder participation, valuation approaches, cultural ecosystem services, watershed health, and spatial planning. In most of the research papers SLR is the most common approach for extracting structured data and identifying conceptual deficiencies, methodological advantages, and policy connections. For example:

Savyantri M. Basak et al. (2022) conducted a SLR on 125 research concerning ecosystem services to assess the extent, methodology, and sectoral priority of ES integration across various countries. Their assessment highlighted that the majority of studies concentrate on provisioning and regulating services, and no consideration given to cultural and supporting services, a crucial observation that guided the cultural mapping in this research. (Basak et al., 2021)

Alvarado-Arias et al. (2022) used SLR to assess PES in the urban river ecosystems of Quito, Ecuador. Their approach offered a systematic framework for evaluating spatial interventions and stakeholder mechanisms, informing the multi-scalar spatial assessment of this study. (Alvarado-Arias et al., 2023)

Sander van der Ploeg et al. (2020) conducted SLR for the TEEB valuing Database to identify trends in ES valuing methodologies. Their focus on monetary vs non-monetary instruments showed the necessity of integrating economic, perceptual, and geographical techniques in data-deficient contexts such as Nashik.

Crossman et al. (2013) used a literature mapping framework to develop a blueprint for ES modeling, the necessity for the integration of LULC-based spatial data with participatory mapping methods, informing the application of LULC-GIS in this study.

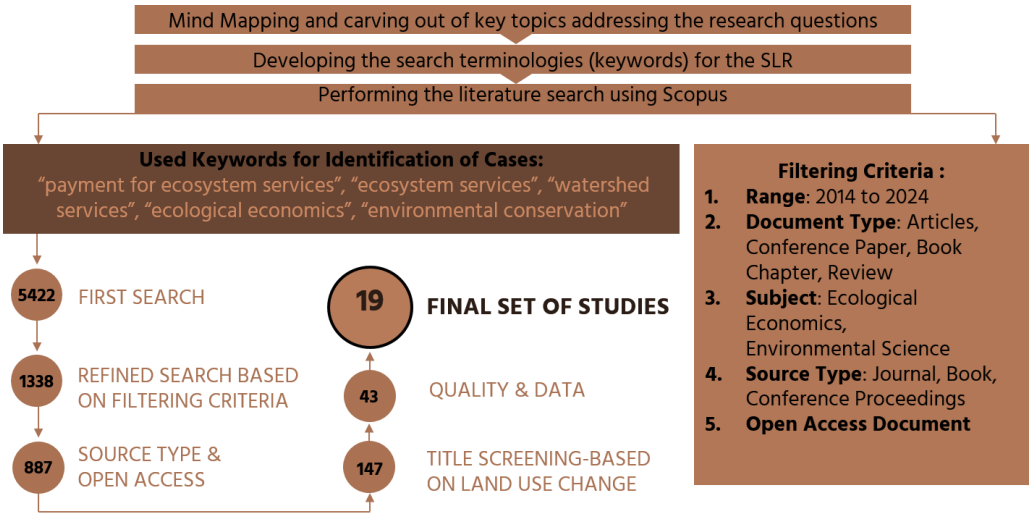


Figure 10: SLR Methodology for a past study conducted (Source: Author)

In this study, a systematic (SLR) approach was initiated to select and analyse case studies (material) focused on the relationship between land use change, human activity, and watershed services degradation. The literature search was performed using the Scopus search database. Since PES is performed on a unique basis depending upon geological conditions and the farmer's landowner's willingness to pay, different parameters supporting the period range for the study are not taken into consideration but extracted based on keywords, title, abstract and quality of data. The literature review not only contains conference papers but also articles, journals, reports, book chapters etc. The subject area selected was "Environmental Science", and "Environmental Economics"; Source title selected as "Environmental Services", and "Ecological Economics"; Final publication stage and open access material.

Followed by the development of search terminologies for SLR the initial dataset of 5422 documents were found, which later got refined through time period i.e. 2014 to 2024, received 1338 literature documents. Selection was again filtered by putting limitation to type of the document i.e. articles, book chapters, conference paper by which 887 documents were obtained. 147 research papers, gathered using targeted keywords – Payment for Ecosystem Services, Watershed Services and Case Studies; was progressively refined by specific relevance criteria: first, focusing on watershed-related cases which extracted getting 87 materials, and then narrowing to studies on land use change impacts. By title screening of the material 19 cases were collected. This led to a final selection of 10 cases, chosen for data quality and relevance for which thorough reading was purposefully done. The documents collected for the case studies are all open access. A literature review informed the development of a parameter list guiding analysis, which was conducted using a synthesis matrix to comparatively examine and summarize the cases. This methodology ensures a focused, high-quality dataset supporting robust conclusions about land use impacts on watershed services. The synthesis matrix for the comparative assessment of cases is performed with the help of MS Office Excel. The extension of the sheet is attached to an appendix at the end of the report.

10 case studies are selected namely –

1) Payment for Ecosystem Services (PES) Programs in Costa Rica
2) Payments for Hydrological Environmental Services (PSAH) programs in Mexico, Payments for Biodiversity and Carbon Capture Services Programs (PSAB)
3) Payment for Environmental Services pilot project in Lake Naivasha basin, Kenya, Africa (Equitable Payment for Watershed Services)
4) Upper Tana-Nairobi Water Fund
5) China's PES - Sloping Land Conversion Program
6) New York City Watershed Program
7) Philippines' Bakun Watershed Management Program, RUPES: Payments for Watershed Functions
8) Protecting Environmental Services in Vittel, Contrex, Hepar France (Agrivair Project)
9) Himachal Pradesh Reforestation Project – Improving Livelihoods and Watersheds
10) Sukhomajri Participatory Integrated Watershed Management Program (Community watershed management)

2.2.3. Analysis of the selected cases

These 10 cases were studied based on different parameters that are given in the synthesis matrix to achieve the objective certain parameters are taken into consideration for analysis such as Primary Drivers for Watershed Degradation, Key Ecosystem Services Affected, Area Selection Criteria, Type of PES Program/Financing, Payment Mechanisms, PES Activities/ Implementation tools, Post-Implementation Impacts of the program etc. With the help of Gantt Charts/Matrix, different parameters on which the case study is assessed with sub-divisions. The subdivisions of each parameter are achieved through different cases. (For example: 3 cases state that deforestation is an issue of watershed degradation, as soil runoff is causing water quality issues, the sub-division Intensive Farming Method is experienced by a set of cases as a primary driver of watershed degradation as pesticides, fertilisers and chemicals runoff in the waterbody.) Similarly, subdivisions (consolidated from 10 cases) are taken of every parameter for analysis.

Primary Drivers of Watershed Degradation

Case Studies	1A. Primary Drivers of Watershed Degradation									
	Deforestation	Forest Loss	Agricultural Expansion	Agricultural Runoff	Intensive Farming Method	Soil Erosion	Overgrazing	Unsustainable Land-use Pattern	Population Pressure (Resource Overuse)	Urban-Suburban Development
Case 1- Costa Rica	■	■	■					■		■
Case 2- Mexico		■				■				
Case 3- Naivasha, Kenya, Africa				■	■		■	■		
Case 4- Nairobi, Kenya, Africa	■	■	■				■	■		
Case 5- China	■					■	■	■		
Case 6- NYC				■	■	■				■
Case 7- Philippines' Bakun	■		■			■		■	■	
Case 8- Vittel, France (Agrivair)			■		■			■		
Case 9- Himachal Pradesh		■			■	■		■	■	
Case 10- Sukhomajri, Haryana	■				■	■	■			

Figure 11 Matrix showing Primary Drivers of Watershed Degradation

The analysis of 10 cases states that the Unsustainable Land Use Pattern is the major driver of watershed degradation. The cases like Costa Rica (1), Mexico (2), China (5), Philippines (7) show poor land management practices, also the deforestation rate is much higher which is causing sedimentation in rivers in turn impacting the quality and quantity of water. Also, altered hydrological patterns and rainfall degradation have been noticed. In the matrix, deforestation, overgrazing, and forest loss (due to forest fire, and climate change) are distinguished as sub-divisions whereas, unsustainable land states the maximum number of such activities. Hence, among all the cases we can see it as a primary driver of the watershed degradation in (maximum) 7 case studies.

Agricultural activities such as expansion and runoff were the major drivers in cases like Vittel-France and fields near the Nairobi watershed. (Costedoat et al., 2015)This analysis also shows, how raising pressure on resources due to the increasing population can degrade the quantity of water. This pressure may lead to the destruction of other water-based services and can create difficulty in the survival of dependents. Hence, it also gives an idea of resource management and conservation through the efficient use of resources by consumers. (Osewe et al., 2023)

Key Ecosystem Services Affected

Case Studies	1B. Key Ecosystem Services Affected								
	Water Quality	Water Quantity	Water Regulation	Carbon Sequestration	Biodiversity Loss	Forest Management	Horticulture	Soil Preservation	Recreation/ Scenic Beauty
Case 1- Costa Rica	■		■	■	■				■
Case 2- Mexico	■	■	■		■				
Case 3- Naivasha, Kenya, Africa	■		■	■	■		■		
Case 4- Nairobi, Kenya, Africa		■	■	■	■			■	
Case 5- China			■	■	■			■	
Case 6- NYC	■	■							■
Case 7- Philippines' Bakun	■	■	■		■			■	
Case 8- Vittel, France (Agrivair)	■				■				
Case 9- Himachal Pradesh			■	■	■			■	
Case 10- Sukhomajri, Haryana	■	■	■			■		■	

Figure 12 Matrix showing Key Ecosystem Services Affected

The above matrix analysis shows the key ecosystem services majorly affected by the degradation drivers, in many of the cases decadal or gradual water degradation pattern has been seen, and in some cases, unnoticeable degradation such as biodiversity loss has been experienced. Cases like Costa Rica, Mexico, China, and more 4 cases highlight the water quality as well as quantity issues mostly due to deforestation, increased sedimentation, forest loss, altered hydrological cycles, etc.

Forest Ecosystem helps to regulate water-related services such as flood control, water flow, and maintaining groundwater levels. The Himachal Pradesh and Sukhomajri Haryana focused more on forest management and water regulation ecosystem services as experienced negative impacts. (A. Agarwal, n.d.)

Overall, the matrix shows maximum degradation has happened in water quality services, water regulation services, and biodiversity loss.

Type of PES Program/Financing (Funding)

The most common type of financing observed is Government Financed/ Government-led Initiatives, which often involve direct funding, also land acquisition and relative activities become easier being the government a trusted authority from any community perspective. Cases like Costa Rica has received a good amount of funding from FONAFIFO i.e. National Forestry Financing Fund and World Bank. Also, The Ministry of Environment and Energy was involved in the program, making goals achievable before the estimated time. (Chen et al., 2015)

Another financing program is led by the government-private sector collaboration, also known as the public-private partnership (PPP) model. These types of collaborations strengthen the institution's authority and structure of the program. This model is used by the Payment for Environmental Services pilot project in Lake Naivasha basin,

Kenya, Africa, the Philippines' Bakun Watershed Program, and the Sukhomajri Haryana Project. (A. Agarwal, n.d.; De Groot et al., 2012; Osewe et al., 2023)

Case Studies	1C. Type of PES Program/ Financing (Funding)					
	Govt. Financed Mechanism	Private Sector Financed Mechanism	Govt.- Private Sector Financed (PPP Model)	Govt.-NGO Financed Mechanism	Govt.-Locally Financed (Community Participation)	Self help Financed Mechanism
Case 1- Costa Rica						
Case 2- Mexico						
Case 3- Naivasha, Kenya, Africa						
Case 4- Nairobi, Kenya, Africa						
Case 5- China						
Case 6- NYC						
Case 7- Philippines' Bakun						
Case 8- Vittel, France (Agrivair)						
Case 9- Himachal Pradesh						
Case 10- Sukhomajri, Haryana						

Figure 13 Matrix showing the Type of PES Program and Financing of global cases

Area Selection Criteria

Case Studies	Area Selection Criteria														
	Ecosystem Services(1B)	Threat Level(1A)	Vulnerability to Climate Change	Unique Biodiversity	Proximity to Waterbody	Land Tenure	Business Case	Poor Municipalities	Community Involvement	Market Access	Impact of degradation on another area	Poverty	Impact on Livelihood	Tourism/ Recreation	Farmers Willingness
Case 1- Costa Rica															
Case 2- Mexico															
Case 3- Naivasha, Kenya, Africa															
Case 4- Nairobi, Kenya, Africa															
Case 5- China															
Case 6- NYC															
Case 7- Philippines' Bakun															
Case 8- Vittel, France (Agrivair)															
Case 9- Himachal Pradesh															
Case 10- Sukhomajri, Haryana															
	10	8	2	2	6	4	3	3	5	4	6	5	6	3	5
	Ecological Criteria					Institutional Criteria						Socioeconomic Criteria			

Figure 14 Matrix shows Area Selection Criteria

The criteria used for the analysis are segregated into 3 parts i.e. 1) Ecological Criteria following Ecosystem Services, Threat Level, Vulnerability to Climate Change, Presence of Unique Biodiversity and Proximity to waterbody; 2) Institutional Criteria following Land Tenure, Business case as can be seen in Vittel Frances' Case, Poor Municipalities like Sukhomajri Haryana, Community Involvement, Market Access and Impact of degradation on neighbouring or another area; 3) Socioeconomic Criteria following Poverty, Impact on Livelihood, Tourism/ Recreation, Farmers Willingness

to Pay. These all parameters and sub-divisions are taken from the case studies and consolidated in one chart for analysis.

The analysis depicts that ecological criteria is mostly preferable by all the cases wherein primary focus is given to the ecosystem services area is providing and services drawn from the area. The 1B (Table 2) parameters (columns) are ecosystem services whereas, threat level means 1A (Table 1) parameters (columns). The degraded area is selected by the 8 case studies, for conservation through the PES program. Another factor is Proximity to water, to conserve the area near waterbody and to conserve the waterbody from the activities happening around or by assisting community-based programs, which is very essential factor to understand the buyers and sellers of the ecosystem services.

PES/ Payment Mechanisms

Case Studies	PES Mechanisms for sellers (payments)							
	Direct Payments	Subsidies	Tax breaks/ Incentives	In-kind Contributions	Water Tariffs	Corporate Financing	Public Funding	User Fees
Case 1- Costa Rica								
Case 2- Mexico								
Case 3- Naivasha, Kenya, Africa								
Case 4- Nairobi, Kenya, Africa								
Case 5- China								
Case 6- NYC								
Case 7- Philippines' Bakun								
Case 8- Vittel, France (Agrivair)								
Case 9- Himachal Pradesh								
Case 10- Sukhomajri, Haryana								

Figure 15 Matrix showing PES Mechanisms/Payments

From the analysis, it has been noticed that Direct Payment Mechanisms are widely used across cases that involve direct payments from buyers to sellers. Whereas, payments from Public Funding are the essential component of PES Mechanisms. As the PES program is not only based on payments but also contains incentives and subsidies as a mechanism, many of the cases like Mexico, Nairobi, China and India have implemented the program likewise. In some cases, like Mexico, Naivasha, Vittel, France, and Sukhomajri, Haryana, the "Polluter Pays Principle" has been used as a User fee. Incentives from funding agencies are passed downstream to the targeted communities. A portion of the fuel tax is involved in PES funding, and people participating in the program receive a tax break. This has been done for the Costa Rica case. In the case of Sukhomajri, Haryana, the Payment for Environmental Services (PES) component of this watershed management scheme arose from the **need to create**

compensation/ incentives for landless and more marginal farmers to participate in watershed protection activities. (A. Agarwal, n.d.; Kosoy et al., 2007)

PES Activities/ Implementation Tools

As the previous analysis shows Unsustainable Land-use Practices as a major driver of degradation, in this matrix analysis of PES Activities we can see almost all the cases have implemented land-use management as an efficient tool. Also, to measure the effectiveness of the program and work in progress, all the cases give a major focus on Monitoring & Evaluation Tools. PES majorly constitutes government, and private sector but most essential community participation for implementation, training and capacity building have played a major role in the cases. From the 10 cases, 8 cases have implemented this type of tool to bring awareness as well as development of the region. Mechanisms like Carbon Finance and Biodiversity Offsets are used as Conservation Financing Tools. (De Groot et al., 2012; Fripp, n.d.; Grzyb, 2024; Pagiola, n.d.) Community-based Forest Management is another tool implemented by 8 cases being a prominent feature of the program. The matrix given below shows the implementation tools in 10 cases.

Case Studies	PES Activities/Implementation tools							
	Training & Capacity Building	Land use Management	Conservation-Financing Tools	Community-based Forest Mgmt.	Reforestation Program	Agricultural Best Mgmt. Practices	Agroforestry	Monitoring & Evaluation Tools
Case 1- Costa Rica								
Case 2- Mexico								
Case 3- Naivasha, Kenya, Africa								
Case 4- Nairobi, Kenya, Africa								
Case 5- China								
Case 6- NYC								
Case 7- Philippines' Bakun								
Case 8- Vittel, France (Agrivair)								
Case 9- Himachal Pradesh								
Case 10- Sukhomajri, Haryana								

Figure 16 Matrix showing PES Activities/ Implementation Tools

Post-Implementation Impacts Analysis

- Environmental & hydrological Impacts:

The table shown is a comparative analysis of post-implementation environmental and hydrological impacts. This type of analysis helps to draw the effectiveness of the PES program further. The impact is categorized into 3 levels i.e. High, Moderate and Low. The colour legend shown with the chart depicts the level of output for the particular ecosystem given by each of the cases. This analysis has been done with the help of synthesis matrix qualitative tabulated data. (given in the appendix)

Training and capacity building for agroforestry, farming practices, and sustainable land use resulted positively in Soil Health. From all the cases above, a higher impact has been seen in soil health which in turn brings, water quality improvement, water quantity, regulation, and carbon sequestration.

Case Studies	Environmental and Hydrological Impacts							
	Bioddiversity Conservation	Water Quality	Water Quantity	Soil Health	Carbon Sequestration	Forest Cover & Vegetation Change	Wildlife and Habitat Preservation	Streamflow Regulation
Case 1- Costa Rica								
Case 2- Mexico								
Case 3- Naivasha, Kenya, Africa								
Case 4- Nairobi, Kenya, Africa								
Case 5- China								
Case 6- NYC								
Case 7- Philippines' Bakun								
Case 8- Vittel, France (Agrivair)								
Case 9- Himachal Pradesh								
Case 10- Sukhomajri, Haryana								

High
Moderate
Low

Figure 17 Matrix showing Environmental and Hydrological Impacts

- Socio-Economic Impacts

Case Studies	Socio-Economic Impacts					
	Income generation	Employment opportunities	Community participation	Resource equity and access	Improvement in local livelihoods	Infrastructure Development
Case 1- Costa Rica						
Case 2- Mexico						
Case 3- Naivasha, Kenya, Africa						
Case 4- Nairobi, Kenya, Africa						
Case 5- China						
Case 6- NYC						
Case 7- Philippines' Bakun						
Case 8- Vittel, France (Agrivair)						
Case 9- Himachal Pradesh						
Case 10- Sukhomajri, Haryana						

High
Moderate
Low

Figure 18 Matrix showing Socio-Economic Impacts

The sub-divisions show the socio-economic impacts received by the implementation of PES. All the PES Programs are showing a positive impact on the community as participation for conservation initiative is increasing. Almost all the cases are fairly impacting improvement in local livelihoods. By incorporating training and capacity building, local communities have experienced income generation activities installed indirectly through PES. Promotion of Eco-Tourism in Costa Rica is one of the examples for income generation and employment opportunities. The PES is contributing to poverty alleviation in remote areas by improving rural income. (De Groot et al., 2012; Pagiola, n.d.) By increasing awareness and education on conservation, the PES program has benefited water utilities and communities by improving watershed management, reducing water treatment costs and ensuring reliable water access for downstream users. This is especially important for agricultural productivity and urban water supplies.

- Land-Use Change Impacts:

Case Studies	**Land-Use Change Impacts**			
	Changes in agricultural practices	Afforestation and reforestation rates	Shifts in land ownership or usage patterns	Conversion of degraded lands to productive use
Case 1- Costa Rica				
Case 2- Mexico				
Case 3- Naivasha, Kenya, Africa				
Case 4- Nairobi, Kenya, Africa				
Case 5- China				
Case 6- NYC				
Case 7- Philippines' Bakun				
Case 8- Vittel, France (Agrivair)				
Case 9- Himachal Pradesh				
Case 10- Sukhomajri, Haryana				

High
Moderate
Low

Figure 19: Matrix showing Land-Use Change Impacts

The case analysis for Post-Implementation Land-Use Change Impacts, Afforestation and Reforestation shows higher values in almost all the cases, which is a good symptom of soil health improvement. The above 3 analyses show an inter-correlation with each other, meaning environmental conservation practices benefit positive land-use change, which in turn brings socio-economic impacts and development of the participants of the PES program. This impact analysis is solely dependent on

qualitative data tabulated from various official reports, web data, articles and conference papers.

Impact Assessment of PES Activities on Environmental and Hydrological Services

From the previous analysis, we've seen how cases have impacted on land-use, socio-economic factors and environmental-hydrological factors. This analysis covers objective 2 i.e. Impact Assessment of PES Activities on Environmental and Hydrological services. The columns show the Ecosystem services and PES activities selected from the 10 cases in rows. The nos. depict the no. of cases used PES activities for the positive impact of the particular ecosystem services. This analysis method is selected to get an idea of the most effective PES activities for particular ecosystem services.

For Biodiversity Conservation, a maximum of 5 cases have implemented community-based forest management as an effective tool. Some of the successful cases are Naivasha Watershed Kenya, Tana-Nairobi Kenya, Himachal Pradesh Reforestation Program and Sukhomajri Haryana Project. (A. Agarwal, n.d.; Fripp, n.d.; Pagiola, n.d.)

For Water Quality Improvement, 5 cases have used Land-Use Management techniques, and the cases' details are given in the literature matrix.

Similarly, For Forest Cover and Vegetation Change, max 6 cases have thought about the Reforestation Program which, in China's case focuses on sloping forest land conversion into grassland and the Himachal Pradesh Reforestation Program. The land-use Management and Community-based forest management are other tools which are implemented in maximum cases for a positive impact on forest cover.

PES Activities	Environmental and Hydrological Impacts							
	Bioddiversity Conservation	Water Quality	Water Quantity	Soil Health	Carbon Sequestration	Forest Cover & Vegetation Change	Wildlife and Habitat Preservation	Streamflow Regulation
Training & Capacity Building	3	2	2	2	2	3	2	1
Land use Management	4	5	4	4	3	5	3	3
Conservation-Financing Tools	3	3	3	2	3	3	2	2
Community-based Forest Mgmt.	5	3	3	3	4	5	4	2
Reforestation Program	4	3	3	3	5	6	3	3
Agricultural Best Mgmt. Practices	3	4	4	4	3	3	2	3
Agroforestry	4	3	3	3	5	4	4	2
Monitoring & Evaluation Tools	2	3	3	2	2	3	2	2

Figure 20 Matrix showing Impact Assessment of PES Activities on Environmental and Hydrological Services

Impact Assessment of PES Activities and Socio-Economic Services

The analysis shows the activities like community-based forest management and monitoring and evaluation tools show high impacts on community participation. This indicates that these activities effectively engage local communities in decision-making and implementation processes. A maximum of 6 cases have used Training & Capacity Building Activities which give rise to community participation. Activities like training and capacity building, land use management, and conservation financing tools have moderate impacts on income generation and employment opportunities. This suggests

that these activities can contribute to local economic development, but may not be the primary drivers of income and employment.

Community-based forest management, conservation financing tools, and monitoring and evaluation tools show moderate to high impacts on resource equity and access. This suggests that these activities can help to improve the distribution of resources and reduce inequalities.

PES Activities	Socio-Economic Impacts					
	Income generation	Employment opportunities	Community participation	Resource equity and access	Improvement in local livelihoods	Infrastructure Development
Training & Capacity Building	5	5	6	4	5	2
Land use Management	4	3	3	3	4	2
Conservation-Financing Tools	5	4	4	4	4	2
Community-based Forest Mgmt.	3	3	5	5	4	2
Reforestation Program	3	3	4	3	4	2
Agricultural Best Mgmt. Practices	3	3	3	2	3	1
Agroforestry	2	2	3	3	3	1
Monitoring & Evaluation Tools	4	4	5	4	4	3

Figure 21 Matrix showing Impact Assessment of PES Activities and Socio-Economic Services

Impact Assessment of PES Activities and Land-Use Change

In all the cases Agroforestry, reforestation initiatives, and community-based forest management are among the practices that have a significant impact on afforestation and reforestation rates. land use management, conservation financing tools, and community-based forest management show moderate impacts on shifts in land ownership or usage patterns. Out of 10 cases 5 cases have implemented it.

PES Activities	Land-Use Change Impacts			
	Changes in agricultural practices	Afforestation and reforestation rates	Shifts in land ownership or usage patterns	Conversion of degraded lands to productive use
Training & Capacity Building	3	2	1	1
Land use Management	4	5	4	3
Conservation-Financing Tools	3	3	2	2
Community-based Forest Mgmt.	4	5	3	3
Reforestation Program	4	5	3	3
Agricultural Best Mgmt. Practices	5	3	2	2
Agroforestry	4	4	3	2
Monitoring & Evaluation Tools	3	2	2	1

Figure 22 Matrix showing Impact Assessment of PES Activities and Land-Use Change

2.2.4. Results and Discussion

The analysis of several case studies on watershed services showed that unsustainable land-use practices are the primary drivers of watershed degradation. These include extensive deforestation, overgrazing, and unsustainable agriculture methods, all of which disturb natural land cover and result in ecological instability. In other cases, ancillary pressures like unregulated surface runoff and agricultural encroachment into ecologically vulnerable areas contributed to watershed degradation. These activities over time affect the hydrological balance of the watershed, increasing sedimentation and diminishing the land's ability to regulate water flows. As a result, essential ecosystem services, water quantity, water quality, and biodiversity have been severely impacted. The deterioration of these services adversely impacts downstream users, aquatic ecosystems, and regional climate resilience. Most of the PES (Payment for Ecosystem Services) programs examined in the literature have mostly been government-driven, utilizing regulatory instruments and public funding for implementation tactics. In areas where local populations are engaged and responsive, Public-Private Partnership (PPP) (*Payments for Ecosystem Services: A Best Practice Guide*, n.d.) models have demonstrated effectiveness in finance and execution. These PES projects have demonstrated significant post-implementation effects, including increased forest cover, enhanced carbon sequestration, improved soil and streamflow management, and quantifiable benefits in water quality and quantity. Some projects focused on reforestation, afforestation, and agroforestry, resulting in significant changes in land use, including the rehabilitation of degraded regions and the restoration to native vegetation.

PES schemes are showing the ability to improve rural livelihoods by encouraging revenue-generating land-use practices and promoting community control of natural resource management, in addition to ecological restoration. These advantages boost long-term sustainability, as communities adopt stewardship over their respective environments. The research shows that the successful implementation of PES programs is not guaranteed; it necessitates robust institutional frameworks, clearly delineated property rights, ongoing stakeholder involvement, and dependable finance mechanisms. (*PES USAID Guidelines*, n.d.)

2.3.Riverine Studies

Four documents based on the “River Sensitivity” and “Sustainability” selected themes have been studied to understand the river-related challenges, community perceptions, and the planners' accountable responses to them. Experts in consulting picked the documents according to their availability. These documents cover the present situation of rivers in India, propose active solutions for the challenges through frameworks and guidelines, and suggest the use of various media to address sensitivities in river-adjacent regions. These documents look into different planning instruments, community-driven initiatives, regulatory mechanisms, and spatial strategies that could potentially be applied to address the sensitivity and multifunctionality of places near rivers. The conclusions derived from these resources were essential in contextualising the local challenges in Nashik within a wider national framework, ensuring that the offered remedies are both location-specific and compatible with policy. The selected documents under each theme are suggested and discussed with the experts. The purpose of the study is to clarify conceptual understanding and define these terms for the study, and identify potential KPIs for the research.

2.3.1. River Sensitivity

Urban River Management Plan (URMP)

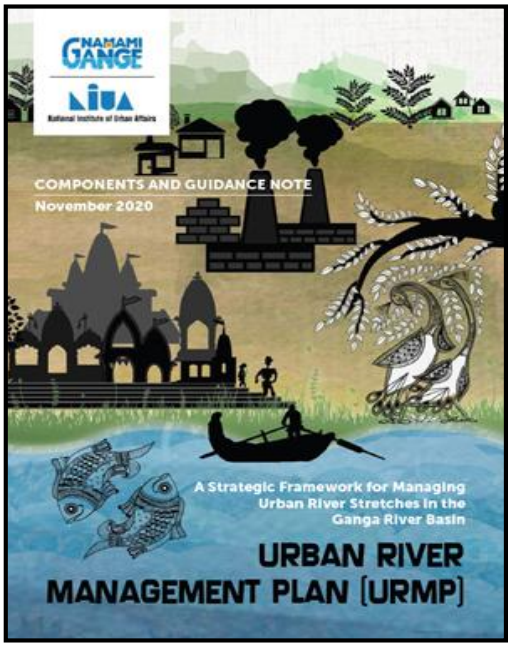


Figure 23 Urban River Management Plan (URMP) by National Institute of Urban Affairs (NIUA),

The Urban River Management Plan (URMP), by the Namami Gange Mission and the NIUA provides a strategic framework for the management of urban river divisions, especially within the Ganga River Basin, but its concepts are also relevant to other urban river systems, such as the Godavari in Nashik. The document is a directive for local governments, planners, and institutions to integrate river-sensitive planning methodologies into urban development frameworks.

The aim of the plan is to implement a strategic planning framework that facilitates comprehensive and sustainable urban river management, to strengthen river resilience by incorporating ecological considerations into governance frameworks, urban infrastructure development, and policy mechanisms at municipal and state levels. The primary objective of the URMP is to provide systematic direction on governance frameworks, spatial planning, land-use control, and conservation methodologies that can restore and preserve urban rivers (*Source: NIUA)* (*48_Urban River Management Plan framework_NIUA_NMCG_MOHUA*, n.d.)

with promoting sustainable urban development. The document specifies 10 broad objectives listed below. The plan proposes a multi-sectoral integration framework, highlighting not only ecological health but also the socio-economic and cultural connections that rivers share with urban residents.

URMP suggests the need for river-centric planning units, riverfront zoning policies, the setting of buffers, the reuse of treated wastewater, and community engagement in river treatment. It promotes the identification of ecologically vulnerable areas, the preservation of natural hydrological processes, and the incorporation of urban rivers into extensive green-blue infrastructure systems. In Nashik, where the Godavari River is under increased stress from tourism, religious activities, and urban encroachment, the URMP's framework offers a consistent and context-specific blueprint for directing spatial actions, ecological zoning, and institutional coordination. (*48_Urban River Management Plan framework_NIUA_NMCG_MOHUA*, n.d.; *GodavariRiver_ComprehensiveStudyReport*, n.d.)

The URMP also highlights the importance of improving institutional capacity via local River Management Committees (RMCs) and stakeholder collaboration approaches that are in line with the methodology of this study, including citizen perception surveys, expert

interviews, and spatial analysis. Based on the study of the concepts of URMP, the research follows to national policy directives while adapting its findings to the distinct socio-ecological characteristics of Nashik's river segment. The main parameters of this document are riverfront development, ecological preservation, governance & policy framework, and water resource management.

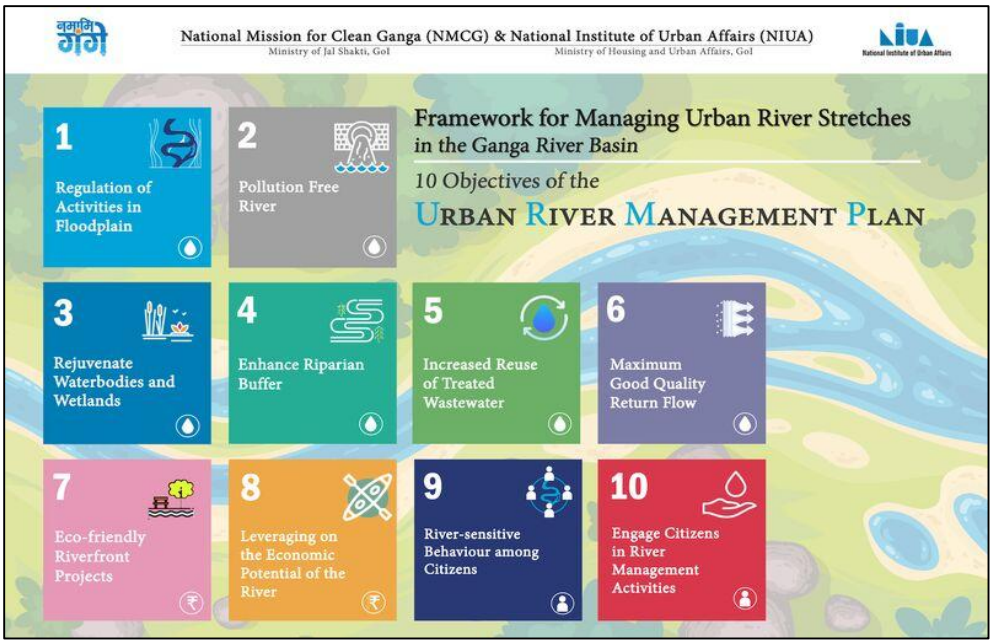


Figure 24 URMP Objectives NIUA and NMCG (Source : NIUA)

Key Takeaways for Nashik: The URMP proposes a multi-stakeholder governance model, integrating local municipalities, river authorities, and citizen participation. Nashik can adopt a similar model to improve river governance. The River-Sensitive Zones concept in URMP can be implemented in Nashik to delineate designated buffer regions where development is controlled, safeguarding biological functions, cultural places, and mitigating encroachment (e.g., Ramkund, Tapovan). Establishment of buffer zones (15–50m) along urban rivers to prevent encroachment, industrial discharge, and construction. URMP also suggests eco-restoration-based riverfront designs with vegetative buffers and permeable pavements. URMP fosters citizen participation via awareness campaigns and stewardship. Nashik's religious festivities attract millions, identifying it as a key site for participatory river conservation via community monitoring, educational activities, and initiatives aimed at behavioural change.

Strategic Guidelines for Making River-Sensitive Master Plans

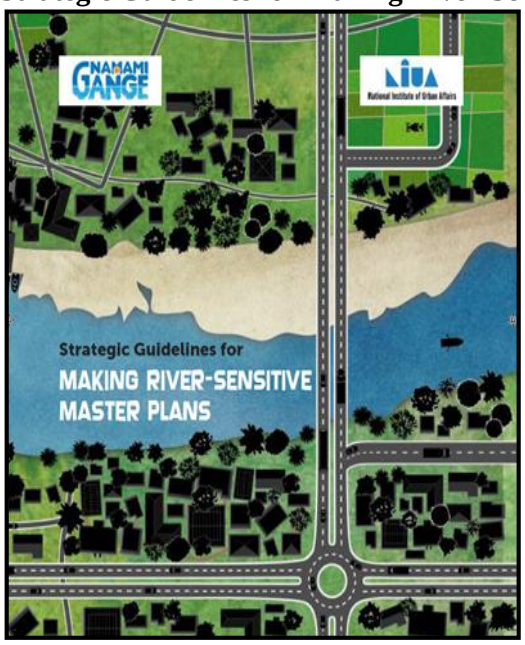


Figure 25 Strategic Guidelines for Making River-Sensitive Master Plans by National Institute of Urban Affairs (NIUA), Namami Gange, 2020

The "Strategic Guidelines for Making River-Sensitive Master Plans" is a key reference for integrating water ecosystems into urban planning frameworks, focusing on the thematic investigation of river sensitivity in urban contexts. This document, created under the direction of the National Mission for Clean Ganga (NMCG) in collaboration with NIUA, outlines a strategic toolkit, guiding urban planners, local officials, and policy-makers in integrating river sensitivity into the framework of urban master plans. The aim is to boost urban resilience and facilitate sustainable urban development by recognising rivers as dynamic natural systems instead of fixed infrastructural limits. This is especially important for Nashik, where the Godavari River serves as both a natural resource and a cultural and economic lifeline inside the city's urban structure. The document is categorised under frameworks, benchmarks, and indices. It highlights key planning domains such as land-use zoning, ecological buffers, open space networks, floodplain (*Source: NIUA)*

management, cultural asset protection, and water-sensitive design that must be aligned with river conservation principles. To strengthen river-sensitive planning principles within urban development practices. To provide a scalable framework for local governments to develop efficient governance systems for river management. The main parameters of the guideline are master planning guidelines, riverfront zoning, environmental impact assessments (EIAs), urban resilience strategies. (*River_Sensitive_Urban_Planning_NMCG_1737536820*, n.d.)

Key Takeaways for Nashik: The master plan for Nashik lacks river-specific zoning layers. The guidelines provide a method to include green buffers, no-development zones, and transitional use areas (such as ghats and public access points) into zoning classifications, so as to address the existing deficiency in spatial management. **River health indicators** must be part of Nashik's Development Plan, incorporating flood vulnerability, biodiversity mapping, and water pollution indices. Cities should designate **"no-build zones" in high flood-risk areas**. Nashik, which experiences seasonal flooding along the Godavari, must adopt this policy. Implementation of **nature-based solutions (NBS)** such as rain gardens, bioswales, and urban wetlands to improve water retention and reduce pollution.

River Centric Urban Planning Guidelines

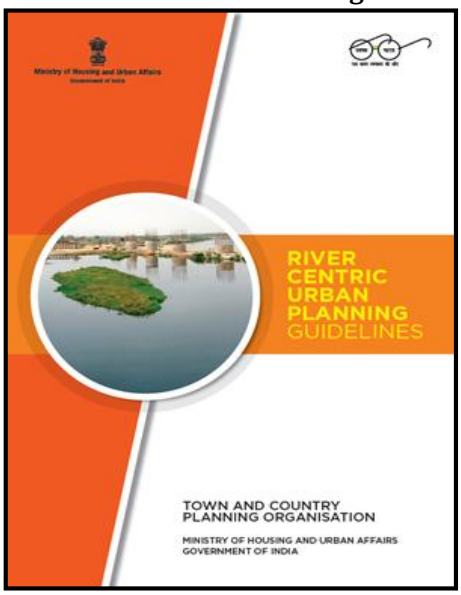


Figure 26 River Centric Urban Planning Guidelines by TCPO, MoHUA

The River Centric Urban Planning Guidelines, published by the Town and Country Planning Organisation TCPO with the Ministry of Housing and Urban Affairs (MoHUA), provides a delineating principles and frameworks for incorporating river ecosystems into formal urban planning processes. The study outlines a strategy for sustainable land-use planning along river corridors in response to the increasing urbanisation risk, pollution, and riverfront encroachment. The main objective is to ensure Indian towns create river-sensitive municipal strategies that conserve waterways and maintain ecological resilience. These guidelines recommend the implementation of ecologically informed zoning restrictions, the establishment of river buffer zones, and the enforcement of no-construction zones in places with high flood risk. These guidelines are especially relevant to Nashik, where the banks of the Godavari River are characterised by both dense residential areas and frequent religious activities. The

(*Source: MoHUA)* (*RCUP Guidelines_MOHUA*, n.d.)

guidelines propose that rivers act as structural components in urban master plans, similar to transportation or housing networks, thus enhancing their role from passive water bodies to active drivers of urban planning. It addresses the need of interdepartmental collaboration, advocating for municipalities to create River Management Units (RMUs) or incorporate river health objectives within Urban Local Bodies (ULBs). It fits with modern planning concepts like Nature-based Solutions (NbS) and Water-Sensitive Urban Design (WSUD), highlighting multifunctional riverfronts that promote recreation, biodiversity, flood management, and spiritual connection. The main parameters for the study are zoning regulations, environmental carrying capacity, water resource planning, and economic potential of riverfronts.

Key Takeaways for Nashik: The three-zone framework (River Buffer, Active Floodplain, and Controlled Urban Interface) must be strictly implemented in Nashik to prevent urban encroachment. **Water-Dependent Land Uses**: The document suggests integrating economic activities like sustainable fisheries and eco-tourism along riverbanks. Nashik can explore **Godavari-based tourism while maintaining ecological balance. Benchmark Cities: Ahmedabad and Varanasi** have implemented riverside conservation corridors, and Nashik can develop a Godavari Conservation Corridor to integrate ecology with economic benefits.

- **River Consideration in The Master Plans of Selected Cities**

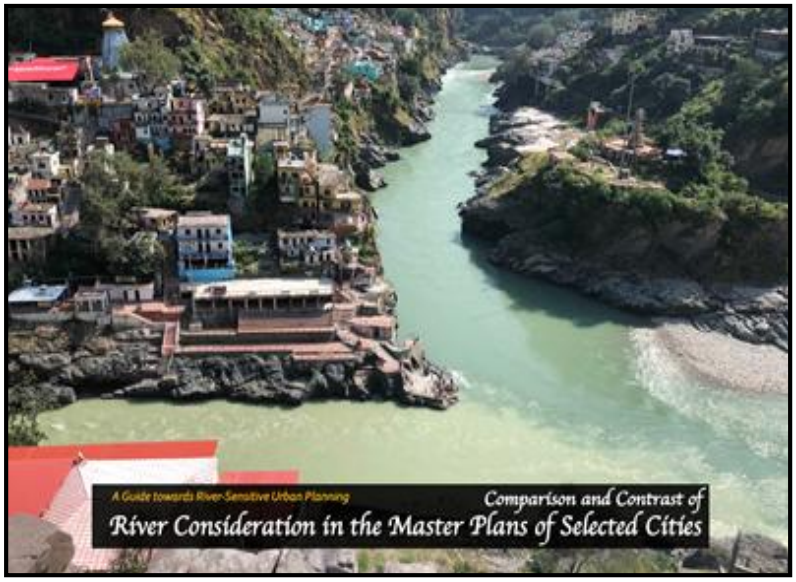


Figure 27 River Consideration in The Master Plans of Selected Cities by NIUA (Source: NIUA)

A guide is a comparative examination of several Indian cities that have rivers into their urban master plans. The main objective of the study is to assess the scope, quality, and methodology of river-sensitive planning techniques and their representation in statutory development documents. This analysis encompasses other towns with notable river interfaces, such as Pune, Ahmedabad, Varanasi, and Delhi, providing essential benchmarks for rapidly urbanizing cities like Nashik that are striving to maintain their river ecosystems. It evaluates the development of river corridors, buffer zones, floodplain management, environmental protections, and recreational activities within master planning frameworks. It shows that despite numerous cities acknowledging rivers as natural and cultural resources, their incorporation into zoning regulations and land-use classifications is sometimes inconsistent or superficial. (*48_Urban River Management Plan framework_NIUA_NMCG_MOHUA*, n.d.) It classifies these initiatives into four primary domains: government integration, spatial planning, environmental management, and socio-cultural intake. It delineates example methods, like Ahmedabad's Sabarmati Riverfront Development and Pune's incorporation of blue-green infrastructure, as well as challenges such as insufficient data, divided institutional responsibilities, and the absence of ecological values in planning. This comparative analysis provides insights into existing policy deficiencies and the potential to integrate river sensitivity into Nashik's Development Plan and Local Area Plans. The study's results show a need for clear guidelines in master plans for riparian buffers, flood zoning, urban wetland preservation, and ecosystem-based land-use allocations. This comparative analysis provides insights into existing policy deficiencies and the potential to integrate river sensitivity into Nashik's Development Plan and Local Area Plans. The study's results show a need for clear guidelines in master plans for riparian buffers, flood zoning, urban wetland preservation, and ecosystem-based land-use allocations. It highlights the importance of connecting rivers such as the Godavari into urban development, viewing them as heritage symbols but

as critical components for urban resilience, ecological integrity, and cultural continuity, by examining the deficiencies and advancements observed in other cities. The Main Parameters of the guide are master plan river components, zoning regulations, sustainable urban drainage systems (suds), floodplain management.

Key Takeaways for Nashik: Gap in Nashik's Current Master Plan: The lack of an explicit river conservation strategy in Nashik's 2031 plan is a key weakness. The city must revise the plan to include floodplain zoning and riparian buffer restoration. Examples of Best Practices: Cities like Surat and Chennai have incorporated sponge city concepts, and Nashik can use similar techniques to improve urban water absorption and reduce runoff pollution. The document highlights controlled public riverbank access while ensuring livelihood opportunities. Using GIS mapping and hydrological modelling for riverfront zoning is recommended—Nashik can integrate remote sensing-based assessments to track urban encroachment. (*48_Urban River Management Plan framework_NIUA_NMCG_MOHUA*, n.d.; *GodavariRiver_ComprehensiveStudyReport*, n.d.; *National Water Policy 2012_0*, n.d.; Shinde et al., 2024)

2.3.2. Sustainability

- **Municipal Performance Index (MoHUA)**

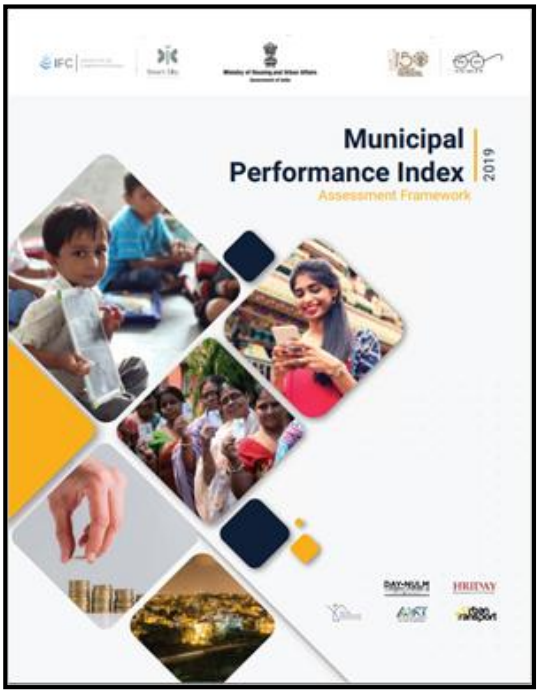


Figure 28 Municipal Performance Index (MPI) (Source: MoHUA)

The **Municipal Performance Index (MPI)** developed by **MoHUA (Ministry of Housing and Urban Affairs)** is a ranking index, a performance-based evaluation framework that enables Indian cities to benchmark and monitor their governance and service delivery systems. The index's primary focus is a comprehensive set of indicators across four principal domains: governance, urban planning, financial management, and fundamental service provision, namely in water supply, sanitation, waste management, and public health. The index aims to establish regular monitoring mechanisms and promote data-informed municipal decision-making, directly aligning with the objectives of sustainable and accountable urban development. It suggests the establishment of Service Level Benchmarks (SLBs), (*MoHUA Municipal Performance Index MPI, 2019*) facilitating municipalities in the adoption of defined performance evaluation standards. The effectiveness of governance structures and the efficiency of urban planning techniques are crucial for facilitating cities' transition to resilience and sustainability. In Nashik, the MPI framework is useful for evaluating the city's institutional preparedness and planning efficacy in managing river-related services and sustainability objectives.

Key Takeaways: It provides a performance benchmarking methodology that can be used to evaluate the impact of zoning modifications on service delivery. It highlights the significance of aligning zoning policies with quantifiable governance and planning indicators. Proposes the potential of ecosystem service delivery as a service-level parameter in river-sensitive urban plans.

- **The China Urban Sustainability Index (McKinsey & Co., Urban China Initiative)**

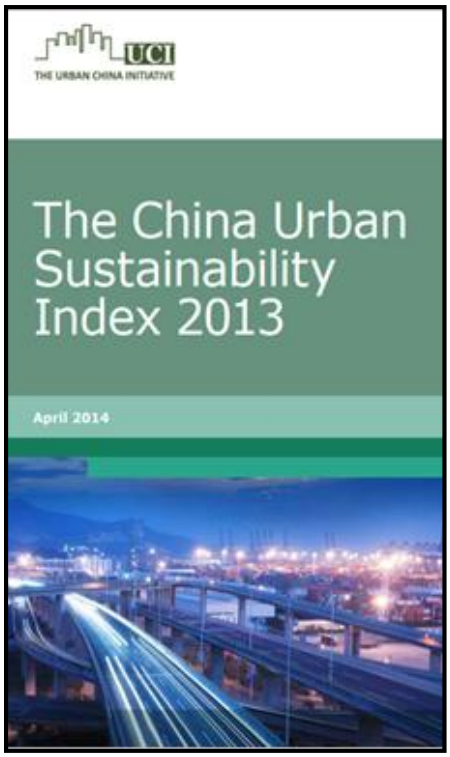


Figure 29 The China Urban Sustainability Index, (Source: McKinsey & Co., Urban China Initiatives)

The China Urban Sustainability Index, created by McKinsey & Company in collaboration with the Urban China Initiative, is a thorough framework for assessing and directing sustainable urbanization in rapidly growing cities. The model, structured as a ranking index, shows a holistic strategy in which economic growth, social inclusion, and environmental preservation are regarded as interrelated features of urban success rather than as separate objectives. The primary objective of the index is to help Chinese cities in addressing the simultaneous challenges of urban growth and industrial intensification, while preserving ecological integrity and social welfare. The index includes sustainability metrics, including the reduction of greenhouse gas emissions, ecological preservation, job creation, and the improvement of social security. It emphasises the value of spatial integration between small and large cities—a framework for transferring industrial burdens and housing demand, therefore mitigating infrastructural and environmental pressures in megacities and promoting inclusive development in adjacent metropolitan areas. (Michael et al., 2014; Sorooshian, 2024) The purpose of the index is to facilitate equitable urban growth by distributing economic advantages between small and large communities; boost employment, social welfare, and resource preservation; assist municipalities in diminishing greenhouse gas (GHG) emissions and reducing environmental strain. The main parameters of the index are environmental sustainability (air, water, GHG emissions), economic equity and employment, urban-rural integration, ecological resource protection.

Key Takeaways: Strengthens the connection between river ecosystem preservation and sustainable urban development. Supports zoning techniques that integrate housing, industry, and ecology, directly relevant to land-use redevelopment in riverside wards. Proposes a zoning that promotes equitable development and minimizes ecological footprints.

Urban Sustainability Framework (USF) – The World Bank, GEF

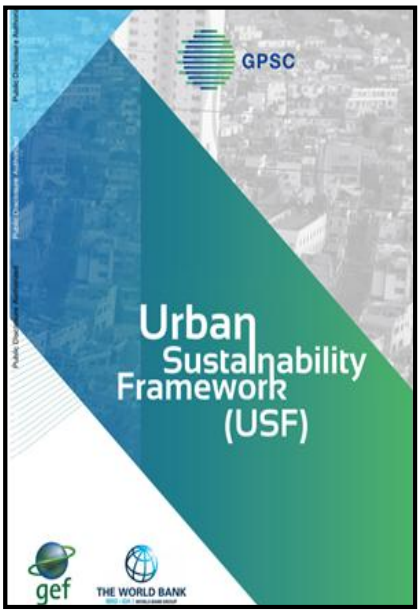


Figure 30 Urban Sustainability Framework (USF) (Source: The World Bank, Global Platform for Sustainable Cities and Global Environment Facility (GEF))

The report dimensions align with the vision plan themes. The framework supports contextual 'data identification and collection". The aim of the framework is to deliver a flexible and thorough sustainability planning framework that communities may adapt according to their specific developmental circumstances. This framework outlines a four-stage process: diagnose, plan, fund, and implement, according to the topics of the vision plan. It promotes planning that is informed by data and tailored to unique contexts. The purpose and objectives of the framework are to facilitate the identification of sustainability problems in urban areas. Direct the incorporation of sustainability into vision plans and spatial planning. And encouraging data collection and contextual analysis for urban transformation. The Main Parameters of the study are environmental quality infrastructure, mobility governance and finance, socioeconomic well-being.

(*123149-Urban-Sustainability-Framework*, n.d.)

Key Takeaways: ItOffers a systematic structure suitable for organizing the Special Purpose Plan (SPP) for the Godavari River zone. It highlights the significance of contextual data acquisition, which connects with the stakeholder matrix and ES scoring methodology. Facilitates the development of responsive zoning regulations based on resilience, equality, and sustainability.

Urban Sustainability Indicators – European Foundation for the Improvement of Living and Working Conditions

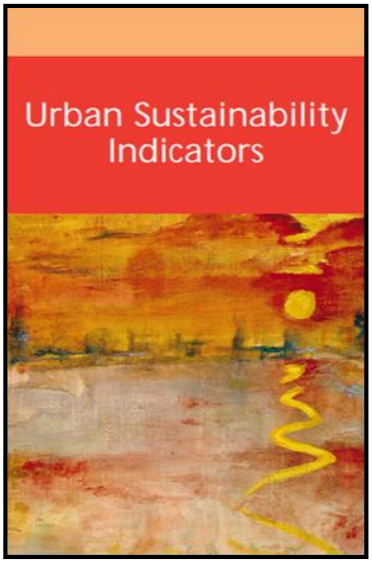


Figure 31: EUROPEAN FOUNDATION for the Improvement of Living and Working Conditions

The document includes set of indicators that provide basic quantifiable indicators for city sustainability assessment and offering flexibility to incorporate city-specific themes. The agenda of the document is to provide a diverse set of quantitative indicators for evaluating sustainability in urban settings. It offers measurable, city-specific sustainability indicators that can be adapted to regional conditions. The indicators can be used to study the base of Godavari River's sustainability performance and ES emergence. The purpose and objectives of the document are to promote comparative assessments and policy improvements, to facilitate urban areas in assessing improvements in sustainability with distinct, flexible indicators. And to support the integration of social, environmental, and economic dimensions into planning. The main parameters of the document are quality of life, land use efficiency, energy and resource consumption. (Guo et al., 2023; Huang et al., 2015)

Key Takeaways: It gives a ready-to-use template for developing performance indicators linked to ecosystem services, especially regulating and cultural services. Promotes zoning impact evaluation with sustainable indicators. It is useful in formulating ward-level monitoring indicators post-zoning implementation

2.4.Conclusion

This thesis's literature review provides a comprehensive overview of ES, Payment for Ecosystem Services (PES), river-sensitive planning, and urban sustainability concerning riverside management. The structure revolves around two principal themes: the global and local implementation of PES, with a particular focus on watershed ecosystem services, and thematic analyses of river sensitivity and sustainability within urban development. The PES literature study analyzes theoretical concepts, governance frameworks, incentive mechanisms, and implementation models developed by international organizations. A Systematic Literature Review (SLR) methodology was employed to identify ten case studies from worldwide and Indian contexts, examining their design, finance, land use effects, and community engagement. This facilitated the identification of optimal methods, challenges, and a contextual set of inferences applicable to Indian urban waterways. This thematic study examines planning principles, policy frameworks, and performance metrics, including the Urban River Management Plan, Strategic Master Plan principles, and sustainability indicators from MoHUA and the World Bank. These publications emphasize essential planning instruments such as floodplain zoning, buffer laws, ecological restoration, nature-based solutions, and data-driven key performance indicators (KPIs). The literature review substantiates the thesis by offering a solid conceptual and methodological framework for incorporating PES and ecosystem service assessment into urban spatial planning, specifically designed for the Godavari River in Nashik. It underlines the viability of context-specific, stakeholder-driven planning methods for river protection, resilience, and sustainable land use. The inferences from this literature study will be used to formulate proposals and achieve the objectives of the research.

CHAPTER 3: STUDY AREA

3. THE STUDY AREA

3.1. Introduction

The River Godavari (also known as Dakshina Ganga) is the second-largest watershed in peninsular India and originates from the Brahmagiri Mountain, Trimbakeshwar, which is approximately 30 km distant from Nashik city. The river stretch plays an important role in Nashik's urban setting, flowing approximately 19 km within the jurisdiction boundaries of the Nashik Municipal Corporation. Starting from the Gangapur reservoir, land use follows agricultural stretches along the river. As the river moves towards the city core, the zoning shifts to residential, institutional and old city heritage zoning, followed by the industrial zone of Maharashtra Industrial Development Corporation (MIDC). The multi-layered land use around the river stretch is a beneficial aspect for the growth of the city. However, it also increases the human dependency on rivers, contributing to the drivers of ecosystem degradation. The water ecosystem present in Nashik provides a range of benefits (services) that are not formally valued due to its free availability. By making these water services visible and quantifiable, the project aims to enhance the city's economy, raise awareness about conservation practices, and re-engineer land-use zoning and sustainable mechanisms. Nashik City contains high development potential, with diverse economic value, as the new proposals of the Delhi-Mumbai Industrial Corridor (DMIC) and six-lane Surat-Chennai expressway are planned to pass through the region. Apart from these, the developing city of Maharashtra is well-known for its "Simhastha Kumbh Mela" festival, which happens once in 12 years. The Hindu religious rituals performed at the ghats of the Godavari hold prominent cultural value of the river while also promoting opportunities for pilgrimage tourism. (*GodavariRiver_ComprehensiveStudyReport*, n.d.)

The ecology of the riparian edge and the natural experience of the river edge have been manipulated by religious events, inviting development projects. Thus, the project is conceptualised to promote sustainable development while ensuring protection from water-related activities from intrusion and encroachment that diminish the natural landscape setting. The dynamics give Nashik a prime case in point for studying the interaction between urban growth and riverine ecosystems. (Dahake, n.d.; Grzyb, 2024) The city is carrying out significant planning initiatives through programs such as the Smart Cities Mission, creating chances to integrate ecological service valuation with spatial planning activities.

3.2.City Profile

3.2.1. Site Context and Boundary

Nashik, a prominent industrial town located at Latitude 19° 0' - 33' N and Longitude 73° 0' - 16' E in Northern Maharashtra, is positioned at an elevation of 565 meters above mean sea level (MSL) approximately 180 kilometers from Mumbai, 210 kilometers from Pune, 165 kilometers from Ahmednagar, and 180 kilometers from Aurangabad. (*5__Ch2_Study_Area___Nov20_2*, n.d.; *30_NASHIK_D_P_COMBINE_MAP_Model*, n.d.; *GodavariRiver_ComprehensiveStudyReport*, n.d.) The overall size is 267 square kilometres, making it the second largest in Maharashtra after Mumbai. It has a population of 1,500,000 and a road length of 850 kilometres. Mumbai Agra National Highway No. 3 (1000 km) and Nashik-Pune National Highway No. 50 (210 km). The primary rivers in the

district include the Godavari, Kashyapi, Darna, Girna, Kadwa, and Nasardi (Nandini). There are two industrial estates: Satpur, encompassing 1600 acres with 750 units, and Ambad, covering 1400 acres with 850 units.

Nashik city serves as the capital of the Khandesh region and the headquarters of the Nashik revenue division, as well as the regional office of the Maharashtra Pollution Control Board (MPCB). Nashik is a significant and renowned historic city in Maharashtra. It is a district headquarters situated on the banks of the Godavari River, at an elevation of 565 meters above mean sea level (MSL). The study area is limited to the administrative boundaries of the Nashik Municipal Corporation (NMC), encompassing roughly 259 square kilometres. These urban boundaries contain a combination of dense residential areas, commercial centres, industrial zones, agricultural peripheries, and notable riverfront areas. The Godavari river corridor under NMC control has been designated as the primary study area because of its varied land uses, significant anthropogenic pressure, and essential function in delivering ecosystem services, including water supply, flood regulation, recreation, and cultural identity. (*GodavariRiver_ComprehensiveStudyReport*, n.d.)

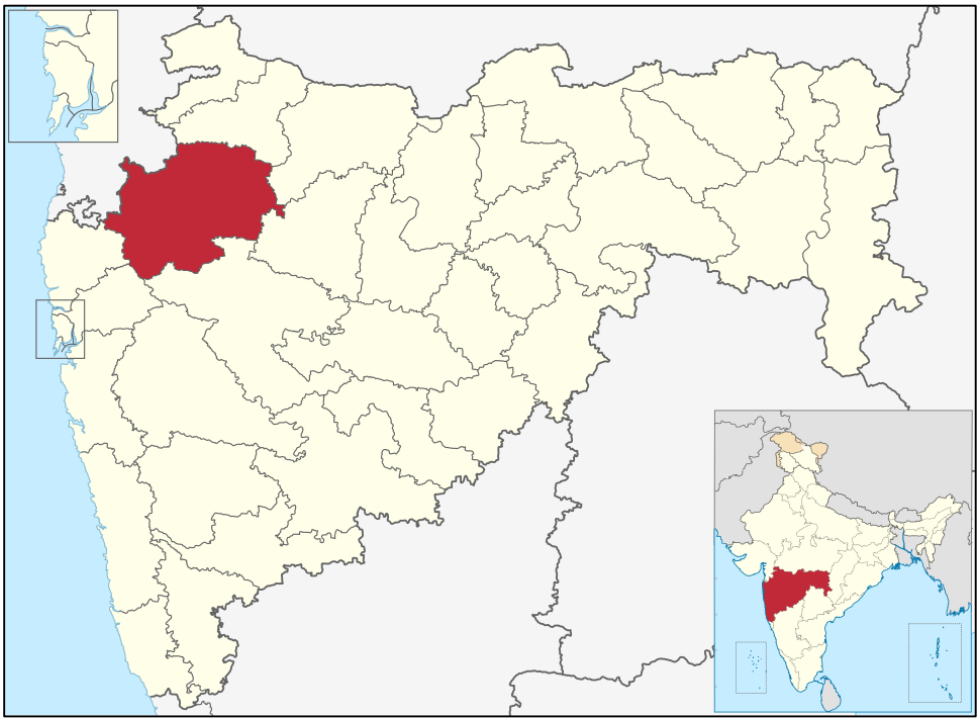


Figure 32: *Location Map of Nashik District in Maharashtra-India (Source: Wikipedia)*

Figure 33: *Nashik District Map (Source: Draft Revised Nashik DP 3026)*

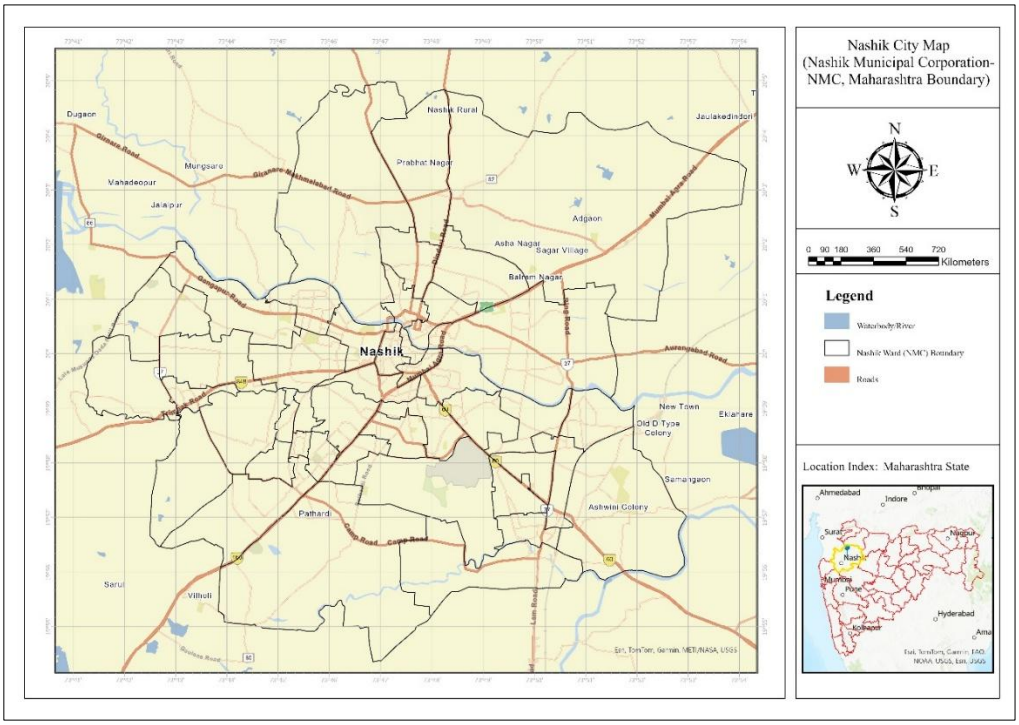


Figure 34: *Nashik City Map (NMC) (Source: Author)*

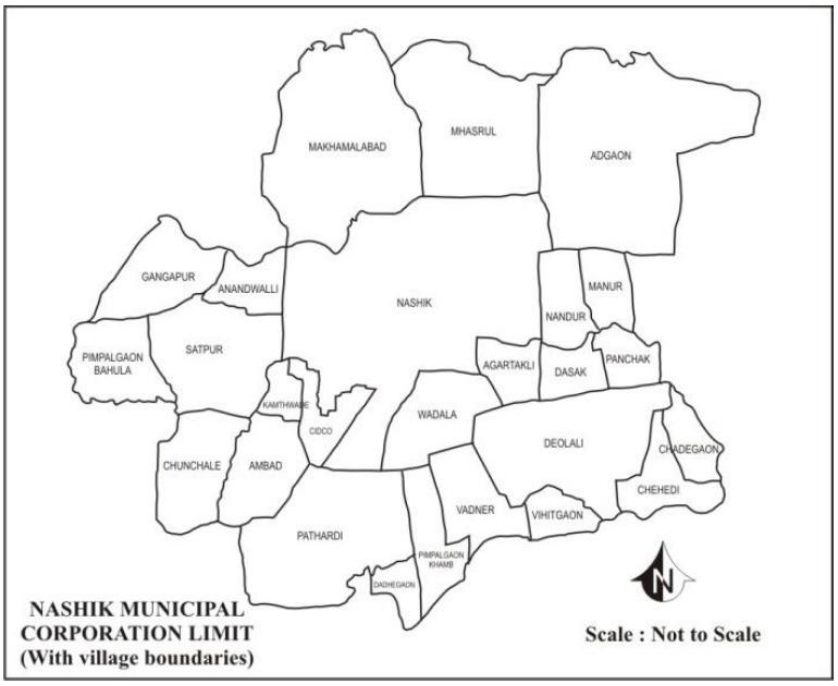


Figure 35: *Nashik Municipal Corporation Limit (Source: Draft Revised DP 2036)*

3.2.2. Evolution of Nashik (Growth & Development Pattern - Master Plan Comparison)

The first Development Plan (1971–1991) focused on basic amenities and infrastructure, and residential zones to support the needs of the residents. Growth was predominantly radial, concentrated around the core city and along major roads, such as the Mumbai-Agra Highway (NH-3). The subsequent DP (1991–2011) indicated a shift toward industrial expansion, as it included the establishment of MIDC zones and higher allocations for commercial and transit facilities. The first official designation of environmental zones was also observed during this period, despite ecological planning being restricted.

Sector	Villages Included	Area (Hect.)
I	Makhamalabad, Mhasrul, Nashik (North).	6663.07
II	Adgaon, Nandur-Dasak, Manur	4146.77
III	Gangapur, Anandwali, Nashik (South) Agartakli.	4440.8
IV	Pimpalgaon Bahula, Satpur, Kamathwada, Ambad, Chunchale	3644.65
V	Pathardi, Wadala, Dadhegaon, Pimpalagaon Khamb(p), Vadner(p).	4162.57
VI	Dasak, Panchak, Chehedi, Chadegaon, Deolali, Vihitgaon(p)	3689.89
	Total Area	26747.75

Table 2: *Sectors in Nashik Development Plan 2036*

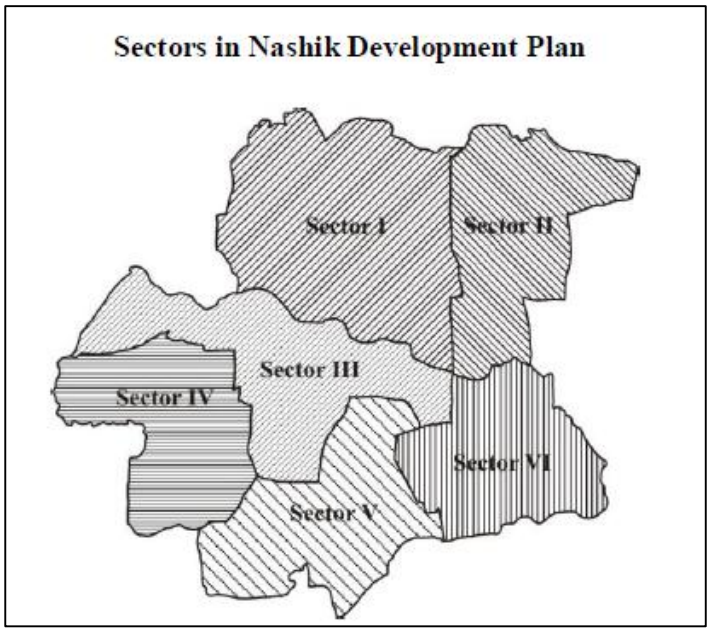


Figure 36: *Sectors in Nashik DP 2036*

A comprehensive urban development strategy to accommodate projected population and economic expansion over the next 20 years is outlined in the Nashik Revised Draft Development Plan (2016–2036). The plan prioritizes sustainable land use, environmental management, enhanced infrastructure provision, and balanced regional development. The widening of the municipal boundary to encompass peri-urban and peripheral areas is one of the key features, as it allows for improved control over informal growth and urban sprawl. The plan advocates for the development of economic clusters, including IT parks, industrial estates, and commercial locations, as well as the integration of transportation corridors and mixed land use zoning, to increase employment. (*Ann__3a__Preliminary_Report__*, n.d.; *Godavari-RAG-Report_27-9-2024*, n.d.) The plan places a significant emphasis on the improvement of infrastructure, which includes the growth of road networks, drainage systems, water supply, and solid refuse management. The DP also designates heritage conservation zones, particularly in the centre of the city and riverfront areas, and provides land for open spaces and recreational areas. The protection of environmentally sensitive zones, particularly those located along the Godavari River and its tributaries, is designated. The mechanisms for implementation are still limited. (*GodavariRiver_ComprehensiveStudyReport*, n.d.)

The DP is by national initiatives such as the Smart Cities Mission and AMRUT, to enhance urban resilience and viability. Nevertheless, the integration of ecosystem services into spatial planning, controls on unplanned development, and encroachments continue to be a challenge.

3.2.3. Historical Background

Two interpretations exist regarding the origin of the name “NASHIK”- the first pertains to the town's location among nine peaks (Navshikhar), while the second references an incident in the Ramayana, wherein Lakshmana is said to have severed the nose (Nashik) of Shurpanakha, the sister of the king Ravana. It is a site of profound heritage and culture, presently evolved into a city with a population of approximately 1.1 million. The banks of the Godavari River are regarded as sacred, where individuals partake in ritualistic bathing in the constructed “Kundas” (ponds). The Godavari River is referred to as “Dakshin Vahini,” and Ramkund is a site of significant religious importance, particularly during the

"Kumbh Mela." (*GodavariRiver_ComprehensiveStudyReport*, n.d.; *Nashik Draft Revised DP 2016-2036*, n.d.)

Archaeological investigations reveal that the region near Nashik has been inhabited since the early Stone Age. Tolls of trap rock typical of that era have been discovered buried in the riverbed at Gangavadi, 16 km northwest of Nashik. Agastya, the great sage, was the earliest Aryan who travelled the Vindhya Mountains and remained along the banks of the Godavari. Agastya was accompanied by other sages. Lord Rama, accompanied by Lakshman and Sita, during their vanvas time, stayed in the Panchavati area in today's Nashik core area. Later on, poets like Walmiki, Kalidas discovered and found in Padmapur, as Nashik was then known, great inspiration. As we approach historical times, we discover that this entire territory was encompassed by Ashoka's formidable empire. Subsequently, during the Satavahana period, the Nashik area became highly prosperous due to its location on the trade route to Broach. The city was designated as Gulshanabad during the Mughal era, in recognition of Nashik's beauty.

The original name of Nashik was reinstated after the Peshwas assumed control in 1751. Raghobadada and Anandibai of the Peshwas resided in Nashik during the latter half of their lives. By 1818, Nashik had developed into a significant town featuring two locations, impressive edifices, and exquisite gardens and vineyards. The Nashik Municipal Corporation has finalised the Dadasaheb Phalke Memorial Park and Buddha Vihar project. The memorial encompasses 29 acres of ground at the base of the Pandava Caves.

3.2.4. Demography

Nashik, one of the most rapidly growing tier-II cities in Maharashtra, had a population of approximately 1.48 million as of the 2011 Census of India. The population of the Nashik Municipal Corporation (NMC) area has been growing gradually as a result of urban migration, industrialisation, and its proximity to Mumbai, Pune and Surat having density of 5,600/sq.km (14,000/ sq mi). The revised Development Plan (2016-2036) projections indicate that the city's population will surpass 2 million by 2036. Nashik has a balanced sex ratio of 932 females per 1,000 males, as well as a relatively high literacy rate of 89.91%. Nashik's hybrid urban-rural economic base shows up in the urban workforce's diversification across industries, including manufacturing, agriculture, wine production, commerce, services, and religious tourism. (*GodavariRiver_ComprehensiveStudyReport*, n.d.; *Nashik Draft Revised DP 2016-2036*, n.d.)

Population Growth			
Year	**Population**	**Decennial Variation**	**Percentage Variation**
1991	733000	0	0
2001	1077236	344236	46.96
2011	1486053	408817	37.95

Table 3: *Population Growth (Source: Draft Revised Nashik DP 2036)*

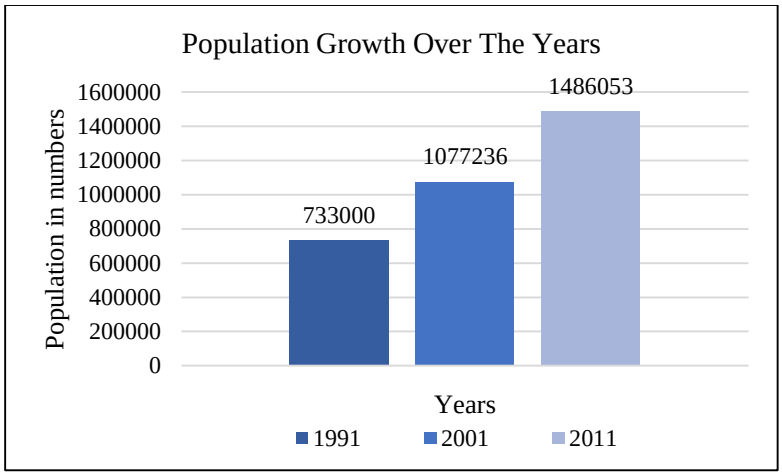


Figure 37: *Population Growth Over The Years in Nashik (Source: Draft Revised Nashik DP 2036)*

Projected Population for Years 2026 & 2036		
Sector	**2026**	**2036**
I	4,24,500	5,89,000
II	59,000	81,900
III	9,67,100	13,42,200
IV	4,29,500	5,96,000
V	1,65,300	2,29,400
VI	4,04,600	5,61,500
Total	**24,50,000**	**34,00,000**

Table 4: *Projected Population for the years 2026 and 2036 (Source: Draft Revised Nashik DP 2036)*

Demographic characteristics (sex and age composition as per the census 2011)						
year	**no. of person**	**Males**	**% of total males**	**Female**	**% of total female**	**No. of females per 1000 males**
1	2	3	4	5	6	7
1991	733000	388000	52.93	345000	47.06	889
2001	1077236	575737	53.44	501499	46.55	871
2011	1486053	782517	52.66	703536	47.34	899

Table 5: *Demographic Characteristics (Source: Draft Revised Nashik DP 2036)*

3.2.5. Geographical Setting

Nashik is situated in the northwestern region of Maharashtra state, India, at an average elevation of 584 meters above sea level, between latitude 19° 55' N and longitude 73° 47' E. The city is situated on the western border of the Deccan Plateau and is encircled by the Sahyadri (Western Ghats) ranges, which have an impact on its topography and climate. Nashik's topography is distinguished by undulating terrain, which is characterised by hillocks, plateaus, and river valleys, resulting in a variety of landforms and ecological zones. The Godavari River, which originates from the nearby Brahmagiri hills in Trimbakeshwar and flows west to east through the city, is the most prominent

hydrological feature. It serves as a natural axis for urban development and cultural life. The significant rivers, Godavari in the south and Girna in the north, move eastward. The Godavari River passes the Nashik and Niphad Tehsils and gets its water from numerous tributaries, among which the Darna and Kadva are significant, featuring canals that irrigate the adjacent land. The significant dams constructed on these rivers are Gangapur, Darna, and Nandur Madhyameshwar. The Girna River, originating in the northwest of the Satmala Range, flows through the Kalwan and Malegaon Tehsils before going into the Jalgaon district. (*5__Ch2_Study_Area___Nov20_2*, n.d.; *Final Report _ NEERI Project Godavari Beautification*, n.d.; *Nashik Draft Revised DP 2016-2036*, n.d.)

3.2.6. Economic Importance

Nashik, which is referred to as the "Wine Capital of India," is home to a flourishing viticulture and agro-processing industry that accounts for over 80% of the nation's wine production. In addition to agriculture, Nashik has a strong industrial base, with some large- and medium-scale industries concentrated in MIDC areas such as Ambad and Satpur. These industries are focused on sectors such as engineering, automobile components, electronics, and pharmaceuticals. It is one of the few tier-II cities that possess a Currency Note Press and an India Security Press, which further enhances its economic and strategic significance. Nashik's status as a logistics and trading hub is further strengthened by its proximity to Mumbai and Pune, as well as its enhanced connectivity via rail and road. Additionally, the informal economy and service sectors, including hospitality, retail, and transportation, are bolstered by religious tourism, particularly during the Kumbh Mela.

Economic Profile of Nashik District

Sr. No.	Indicator	Details	Source Of Data	As On (Date)
1	Gross District Domestic Product (GDP)	136508.Cr	**DSA 2023 Nashik_006**	2022 - 23
2	Growth Rate of GDDP (%)	13.10%	District Social and Economic Review 2023 District - Nashik District Statistics Office, Directorate of Economics and Statistics, Government of Maharashtra, Nashik.	
3	Per Capita Income (in INR)	226221		2022 - 23
4	Credit Available	26202 Cr	Economic Survey of Maharashtra 2022-23	2021-22
5	Primary Sector GDP	26241 Cr	DSA 2023 Nashik_006	2022 - 23
6	Secondary Sector GDP	32978 Cr		2022 - 23
7	Tertiary Sector GDP	77290 Cr		2022 - 23

Table 6 Economic Profile of Nashik District

Existing Status of Industrial Areas in Nashik District:

Name of the area	Area (in hectares)	No. of plots developed	No. of plots allotted	Industrial rate per sq. foot (in Rs.)	Commercial Rate per sq. foot (in Rs.)
Satpur	635.73	975	963	2660/-	7980/-
Ambad	515.5	1246	1185	2660/-	7980/-
Sinnar	510.08	802	647	865/-	1730/-
Dindori	32.72	44	43	195/-	385/-
Vinchur	133.99	94	64	90/-	175/-
Peth	5.46	44	30	40/-	80/-

Table 7: Existing Status of Industrial Areas in Nashik District (Source: The Ministry of Micro, Small and Medium Enterprises, Nashik Profile)

According to the NEERI Godavari Action Plan report, there are two industrial zones: Satpur, covering 1,600 acres with 750 units, and Ambad, covering 1,400 acres with 850 units. Until 2014, this region lacked a common effluent treatment plant (CETP) for the collective treatment of effluent produced by small-scale water-polluting companies. MPCB officials stated that customized treatment schemes are developed by the separate water-polluting industry. The M.I.D.C. has failed to set up an underground drainage system for the collection of industrial and domestic wastewater. In recent years, a project has been undertaken for the construction of a Common Effluent Treatment Plant (CETP) at MIDC with a capacity of 1 MLD, and the land has received approval from the regulatory authorities. No common hazardous waste disposal site has been discovered in the area. Within these industrial zones, a range of significant water-intensive businesses has emerged, such as India Bulls. The Eklahare Thermal Power Plant is situated downstream of Nashik, with its water supply sourced from the Gangapur Dam on the Godavari River, governed by the Irrigation Department. (*5__Ch2_Study_Area___Nov20_2*, n.d.; *Ann__3a__Preliminary_Report__*, n.d.; *Final Report _ NEERI Project Godavari Beautification*, n.d.; *Nashik Draft Revised DP 2016-2036*, n.d.)

The setting up of the Mega Industrial Area at Sinnar, one of the largest in Asia, would lead to significant industrial expansion in the Nashik district. The establishment of a 'Wine Park' by MIDC in Vinchur, Niphad, would enhance the winery sector in the future. Nashik is renowned for its grapes and onions. It is also abundant in various horticultural and vegetable resources. (*Nashik Draft Revised DP 2016-2036*, n.d.; *Nashik Profile_MSME_Industrial Data*, n.d.) Its appropriate and efficient use should be achieved by constructing processing units. Fly ash produced by Thermal Power Stations should be used for brick manufacturing. Efforts should be directed towards using agro-residuals, such as byproducts from sugar mills and groundnut shells, for the production of bio-coal briquettes, handmade paper, and particleboard.

3.3.Project-Specific Details: Nashik

This section focuses on the specific spatial, ecological, and cultural characteristics of Nashik that directly inform and support the objectives of this research. It is necessary to understand the localised context to evaluate land use change and ecosystem services, given the city's dynamic land use transformation, strong riverine identity, and increasing pressure on natural resources. Nashik's urban development has a direct connection to the Godavari River, which not only influences its physical configuration but also plays a critical role in the provision of water, the preservation of biodiversity, the facilitation of cultural practices, and the maintenance of livelihoods. The subsequent subsections look into the city's land-use profile, the ecological and socio-cultural significance of the Godavari, its historical water connections, and the variety of ecosystem services it provides. (*Final Report _ NEERI Project Godavari Beautification*, n.d.; *Godavari-RAG-Report_27-9-2024*, n.d.)

3.3.1. Land-Use

In Nashik, the existing land use pattern as per the Revised Development Plan 2016-2036 is indicative of a polycentric urban structure, with a combination of residential, industrial, commercial, public, and ecological spaces that spread throughout the municipal boundary. The city's spatial organisation is characterized by dense urban cores that are surrounded by emerging peripheral development corridors, particularly along transportation routes and planned townships. (*Nashik Draft Revised DP 2016-2036*, n.d.)

1. The settled urban core and planned townships are surrounded by residential zones, which dominate significant portions of central and southern Nashik.
2. Commercial areas are primarily located near central nodes and along major roadways and highways, including the Mumbai–Agra Road (NH-60) and College Road.
3. In the western and southwestern regions, industrial land use is particularly significant, particularly in the Satpur and Ambad MIDC zones. (*Nashik Profile_MSME_Industrial Data*, n.d.)
4. Public/semi-public and utility spaces are dispersed throughout the city, with concentrations centred on educational institutions, health centres, and government facilities.
5. Recreational and green belt zones appear to be fragmented, with the majority of them being isolated from the fields along the river and hills, as well as peripheral patches.
6. The southern and southeastern peripheries are predominantly occupied by vacant and undeveloped areas, which suggests that these regions have the potential for future development.

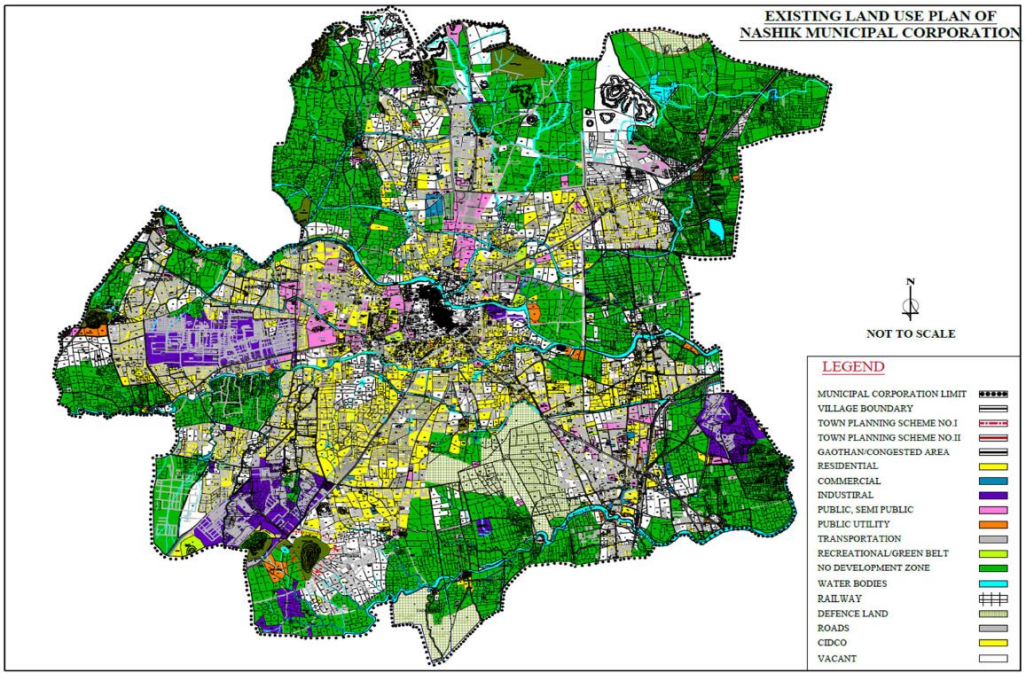


Figure 38: Existing Land Use Map (Source: DP 2016-36)

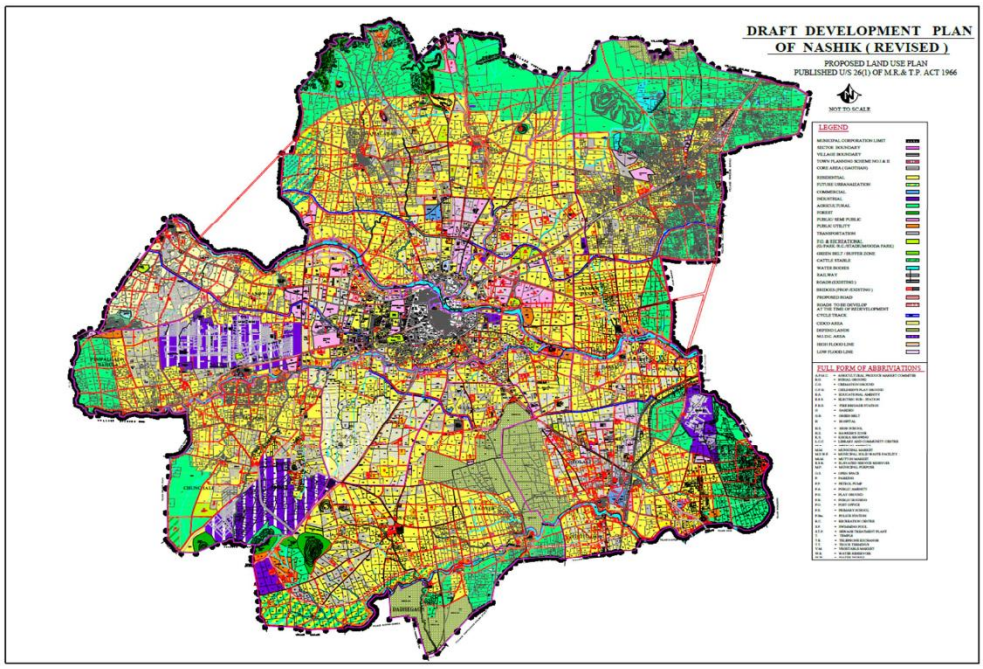


Figure 39 Draft Revised Development Plan of Nashik 2036 (Source: DP 2016-36)

3.3.2. Existing Land Use Details of Nashik:

Existing Land Use				
Sr. No.	**Land Use**	**Area in Hectares**	**% of total Developed Areas**	**% to the Total Area**
1	Residential	5875.36	52.48	21.97
2	Commercial	219.73	1.96	0.82
3	Industrial	1569.98	14.02	5.87
4	Public and Semi-Public	827.41	7.39	3.09
5	Public Utility	168.46	1.5	0.63
6	Transportation	1573.2	14.05	5.88
7	Garden, Playground, and Recreation	126.83	1.13	0.47
8	Military	943.7	8.43	3.53
9	C.I.D.C.O	398	3.56	1.49
	Total Developed Area	**11702.67**	**100**	**43.75**
10	Agricultural	8961.49		33.5
11	Water Bodies	955.13		3.57
12	Vacant Land	4559.33		17.05
13	Forest	569.13		2.13
	Total Undeveloped Area	**15044.33**		**56.25**
	Total Area	**26747.75**		**100**

Table 8: Existing Land Use (Source: CDP for Nashik, 2005) Ch.4)

)

3.3.3. Land Use Surrounding the Godavari River:

The Godavari River, which flows centrally through Nashik, serves as an important ecological and cultural axis. Large portions of the river are surrounded by dense residential and gaothan areas, particularly in central Nashik (Old City and Panchavati). This covers areas that are congested and experience significant human activity, as well as the pressure on riverbanks. Near the river, there is a substantial amount of public/semi-public land use, such as ghats, temples, and civic institutions, which strengthen its status as a cultural-religious landscape. The riparian zone has become divided as a result of the numerous transportation corridors that intersect or run adjacent to the river. Pockets of recreational/green belt and aquatic bodies (denoted in green and blue) are present along the river; they are discontinuous and are regularly encroached upon by development. Though informal and small-scale commercial activity is present along certain riverbanks, industrial land use is generally located at a distance from the river corridor. In certain regions of the river-adjacent area, particularly in environmentally sensitive or flood-prone areas, no Development Zones have been designated; their enforcement appears to be inadequate. (*Final Report _ NEERI Project Godavari Beautification*, n.d.; *Nashik Draft Revised DP 2016-2036*, n.d.)

3.3.4. Key Observations:

The riverfront is challenged with a variety of land uses that are frequently incompatible, such as high-density housing, informal settlements, religious infrastructure, and limited verdant buffers. The Godavari is susceptible to pollution, inundation, and the degradation of ecosystem services due to the absence of a continuous ecological buffer zone. There are opportunities to incorporate green infrastructure and transform underutilised or congested areas into multifunctional spaces that meet urban requirements and restore ecological health.

3.3.5. Importance of the Godavari River in Nashik

The river originates in the Brahmagiri Hills at Trimbakeshwar and runs eastward through Nashik, acting as an important socio-economic and spiritual channel. Its various purposes include religious, residential, agricultural, industrial, and ecological activities that significantly contribute to the city's advancement. The Godavari supports diverse economic endeavours. Residents, especially those in wards adjacent to the river, engage in religious ceremonies, tourism, fishing, laundering, street vending, and minor commercial activities around the ghats. The Kumbh Mela, conducted every 12 years in the Godavari ghats, is among the largest religious gatherings worldwide, generating significant revenue for Nashik through hospitality, transportation, retail, and informal markets. Agricultural areas along the riverbanks employ their water for irrigation, especially for grapes and vegetables, which are essential to Nashik's agroeconomy and support associated industries such as wine production and agro-processing. (*30_NASHIK_D_P_COMBINE_MAP_Model*, n.d.; *Ann__3a__Preliminary_Report__*, n.d.) The Godavari plays a vital role in providing ecosystem services. It serves as a natural drainage channel, absorbing runoff and reducing flood risk during the monsoon season. The river sustains urban biodiversity, including fish species, riparian vegetation, and migrating birds, particularly in more unspoiled areas. It also provides cultural ecosystem services, enabling venues for religious ceremonies, festivals, and daily rituals that are essential to Nashik's identity. Ecologically, the river promotes groundwater recharge, microclimate regulation, and carbon sequestration, particularly in areas where native vegetation and green buffers are preserved. (*Final Report _ NEERI Project Godavari Beautification*, n.d.)

Despite its ecological and economic significance, the river is subjected to increasing pressures from urbanization, encroachments, pollution, and poorly managed land use. The release of untreated sewage, the disposal of solid waste, and alterations to the riverbank have led to the deterioration of water quality and the destruction of natural habitats. The rehabilitation and integration of the Godavari into Nashik's urban setting through an ecosystem-based approach is essential for environmental sustainability and the preservation of the city's socio-economic framework. (Basak et al., 2021)

3.3.6. Historic Water Connections and Water Supply

Nashik evolved as a water-centric settlement, featuring traditional water management systems including kunds (such as Ramkund and Lakshmikut), wells, aqueducts, and tanks that facilitated the management of seasonal rainfall and supported agriculture.

More over fifty per cent of the Godavari river basin (18.6 million hectares) is classified as arable land. A significant volume of river water is extracted for agricultural purposes. A significant dam, known as Gangapur Dam, was constructed downstream of Trimbakeshwar

and finished in 1957. The Gangapur dam, having a catchment area of 357.40 square kilometres and a submergence area of 2231 hectares, supplies drinking water to the inhabitants of Nashik. It also provides water to the industrial zones of Satpur and Ambad, as well as to the thermal power station situated downstream at Eklahare, which generates electricity for the town. Two canals, namely the left bank (62.4 km) and the right bank (30.4 km) from the Gangapur dam, supply water for irrigation. The average supply of drinking water to a citizen is 150 -175 LPCD. Adequate water is supplied in the morning and evening. (*2010-11_Nashik_DSA_Agri Crop Data 5_2*, n.d.; *All Water Data*, n.d.; *Godavari Basin_NRSC_Central Water Commission*, n.d.)

Sr. No.	**Location**	**Capacity (MLD)**
1	Shivaji Nagar	97
2	Bara Banglow / Nashik	83
3	Panchavati	71
4	Gandhi Nagar	26
5	Nashik Road	73
	Total	**348**

Table 9: Location and Capacity of WTP

After filtration of water in these 5 treatment plants, water is supplied to consumers through Elevated Service Reservoirs (ESR). There are a total of 69 (ESR) for the distribution of water in the city. (*Report_Groundwater_Nashik*, n.d.; *Water Provisioning Data_NMC 13032025*, n.d.)

3.4.Conclusion

The settlement structure of Nashik was centered on the Godavari, with residential clusters (Gaothans) and markets developing naturally around water access sites. This traditional strategy aligned with the local terrain and seasonal hydrological patterns. The standard water systems were naturally sustainable and compatible with the region's natural hydrology. Urban development in recent decades has disrupted the spatial and functional connectivity between people and water. (*2010-11_Nashik_DSA_Agri Crop Data 5_2*, n.d.; *Ann__3a__Preliminary_Report__*, n.d.)

CHAPTER 4: ANALYSIS

4. ANALYSIS

4.1. Objective 1

To Identify Ecosystem Services Provided by The Godavari River in Nashik.

Identifying the ecosystem services provided by the Godavari River is a foundational step for this thesis, as it defines a comprehensive understanding of the river's diverse functions in supporting urban and ecological life in Nashik. These services encompass provisioning (e.g., potable water and agricultural resources), regulating (e.g., flood mitigation and microclimate management), sustaining (e.g., biodiversity and soil fertility), and cultural (e.g., religious, recreational, and aesthetic values) services. (Fripp, n.d.; Guo et al., 2023)

4.1.1. Data Collection

Activities	Methodology		
	Methods	Data Source	Expected Data Type
1. Identify & classify ecosystem services	Expert interviews to get industry-wise water allocation data, Secondary Data, Analysis—List Mapping from Secondary Sources	Maharashtra Industrial Development Corporation (MIDC), Nashik	1.Industries registered in MIDC areas that are using river water for production.
		Nashik Municipal Corporation (NMC) - Environment & Water Supply Department	1. Water quality reports, 2. River pollution status, 3. Record of Industries registered for usage of river water.
		Maharashtra Pollution Control Board (MPCB)	1.National Inventory of Water Usage & Discharge Reports, Industries with high water consumption-Industrial 2.Pollution impact, 3.Environmental assessment, River health, pollution trends, and ecosystem impact reports
		Water Resources Department, Maharashtra (Jal Sampada Vibhag)	1.Water abstraction permits given to industries, 2.Industrial water tariff & supply records, 3.Hydrology reports, flood records
		National Environmental Engineering Research Institute (NEERI), Nagpur	1.Research studies on Godavari River pollution & water management
		Indian Institute of Science Education and Research (IISER), Pune	1.Research on river biodiversity and ecosystem services
		Ministry of Environment, Forest, and Climate Change (MoEFCC)	1. Ecosystem service valuation reports 2.Conservation policies & biodiversity studies
2. Economic valuation	Case study analysis, surveys	Economic reports, Stakeholder inputs	1.Municipal Budget Reports (Qualitative, Quantitative)

Table 10 Methodology for Data Collection – Objective 1

The research conducted to fulfil Objective 1 covered both secondary analysis and primary data collection to identify and comprehend the ecosystem services provided by the Godavari River in Nashik.

Secondary Study: A tentative list of ecosystem services was created using existing literature and data sources such as:

1. Research by public and private bodies
2. Published reports and papers
3. Master plan documents of Nashik and related planning guidelines

The aim was to map all provisioning, regulating, supporting, and cultural services linked to the river.

Primary Study:

1. Stakeholder interviews were conducted with: Farmers, industrialists, tourism officials, Representatives from Nashik Municipal Corporation (NMC) and MIDC
2. Citizen Perception Survey was designed to understand public interaction and dependency on river services.
3. Expert opinion was collected through structured questionnaires.

SWOT Analysis

Citizen Perception Survey on Environmental Benefits (ES: Ecosystem Services) Provided by the Godavari River in Nashik was conducted on site and a few through an online medium (Google Forms). The questionnaire covered 3 set of questions i.e. personal information through general questions (Containing distance of residence from river, respondent's familiarity, experience, and connection with river, how often they visit riverfront etc.), river sensitivity among citizens and perception towards development i.e. Awareness & Perception of Environmental and other Benefits(Listing the benefits, rating the benefits, river condition perception, if changed, what reasons are associated with it, etc.), Benefit Assessment – through matrix. A total of 162 sample responses have been collected from the citizens of Nashik. A questionnaire is attached in the appendix. (*2010-11_Nashik_DSA_Agri Crop Data 5_2*, n.d.)

Strengths	Weaknesses	Opportunities	Threats
Presence of Godavari River - a lifeline for drinking water, agriculture, and cultural practices	High pollution levels in the Godavari due to **industrial discharge, untreated sewage, and waste dumping**	**Scope for riverfront development** projects enhancing tourism, recreation, and water conservation	**uneven rainfall patterns** due to climate change impacting river flow and groundwater recharge
Network of local rivers (Darna, Girna, Kadwa) supporting agriculture and biodiversity	**Inefficient water management** — poor rainwater harvesting practices, high wastage	Implementation of Payment for Ecosystem Services (PES) to support watershed conservation and community incentives	**Increasing water scarcity in drought-prone talukas** (like Niphad, Sinnar)
Multiple dams and reservoirs (Gangapur, Darna, Kashyapi) ensuring irrigation and hydroelectricity supply	Inadequate sewage treatment plants (STPs) — **limited capacity leading to river contamination**	**Introduction of integrated water resource management (IWRM) strategies** for better river basin management	**Over-extraction of groundwater** leading to aquifer depletion
Important religious and cultural events (Kumbh Mela) linked to the Godavari, boosting spiritual tourism and local economy	**Lack of real-time data on water quality, flow rates, and groundwater levels**	**Promoting sustainable agriculture through micro-irrigation, drip systems, and watershed farming**	**Rising urbanization** pressure contributing to encroachment of riverbanks
Active fishing practices and river-based livelihoods along the Godavari	Fragmented governance between NMC, MPCB, and MIDC, causing **policy overlaps**	**Development of wetlands for flood control, biodiversity support, and eco-tourism**	**Industrial pollution from MIDC zones** contaminating downstream waterbodies
One of the Largest district in terms of demography,	Lack of agro-processing units	Advancement in Storage facility and Processing units	Uneven distribution of rainfall

Strengths	Weaknesses	Opportunities	Threats
Fertile agriculture land, availability of irrigation	Potential of precision farming not fully utilized	Sericulture production and value addition units being developed	Stressful condition of human resource in agricultural labor
Export of agro-commodities mainly Grapes and Onions	Supply chain for millets and other agro-commodities weakly developed	Development of road networks, namely Samruddhi Mahamarg, Proximity to Delhi – Mumbai Industrial Corridor	High use of chemical pesticides and fertilizers
In the vicinity of metro cities such as Surat, Pune and Mumbai	Potential of Tourism sector not fully utilized, due to lack of infrastructure for tourists	Proposed plan for Nashik – Pune Expressway, Greenfield Expressway project from Surat-Nashik-Ahmednagar-Solapur, Pimprisado to Gonde road six lanes highway, Nashik Road to Dwarka Chowk elevated corridor under Bharatmala project	Emerging Climate Change and environment related issues
Wine Capital (38 Wineries available in the district)		Scope for strengthening Rail connectivity, Proposed Mumbai-Nagpur High-Speed Rail (Bullet Train), Pune-Nashik Semi High-Speed Rail Corridor Project; Greater Nashik Metro	Two blocks in Critical and two blocks in Semi-critical status of groundwater extraction according to Central Groundwater Board

Table 11 SWOT Analysis

4.1.2. Secondary Study Analysis

Various documents received in the first stakeholder meetings and online were thoroughly analyzed, and multiple exercises have been performed with the help of the data. Few documents were collected from the online sources, i.e. official websites, and dashboards. Due to limited studies on a similar subject and insufficient accountability of the services, different exercises have been performed to understand the supply of the services, how services can be identified and valued, and KPIs for the valuation of different types of services. This secondary study output will then be compared with primary data, and the prominent type of services will be announced as a result of the first objective of this project.

The following is the preliminary assessment marked with the help of the literature review done earlier. With an understanding of ES and Nashik city, the possible ecosystem services have been marked with justification and data needed for the analysis. This table will be reassessed post the 1st stakeholder survey and made for accurate answers. (*13__Ch10_Floodplain_Planning__Nov20_Guidelines for Godavari Nashik*, n.d.; *59_Mainstreaming Urban River Report - Compressed*, n.d.; *Van Der Ploeg 2010_The TEEB Valuation Database_overview of Structure, Data and Results*, n.d.)

Preliminary Assessment of the Ecosystem Services – based on the literature review

ECOSYSTEM SERVICE	WHY IT FITS	DATA NEEDED FOR JUSTIFICATION	DATA NEEDED FOR CURRENT SITUATION ANALYSIS	AVAILABLE DATA AND SOURCES
Water Provisioning	The Godavari River is a primary source of water for domestic, agricultural, and industrial use in Nashik.	1. Historical records of water extraction volumes 2. Population growth statistics 3. Agricultural/industrial water demand data	1. Current water extraction rates 2. River flow measurements, water demand projections	
Biodiversity Support	The river supports diverse aquatic and terrestrial species, contributing to ecological balance.	1. Species inventories 2. Habitat maps 3. Biodiversity assessments	1. Current species population surveys 2. Habitat condition reports 3. biodiversity monitoring data	Note: The Nandur Madhmeshwar Bird Sanctuary, located near Nashik, is a Ramsar site known for its rich biodiversity.
Flood Regulation	The river's natural flow regime helps mitigate flood risks, protecting communities & agriculture.	1. Historical flood records 2. Land use maps 3. Hydrological models	1. Current rainfall data, 2. River discharge 3. Measurements 4. Land development plans.	river's hydrology and flood patterns
Recreational Opportunities	The river and its surroundings offer recreational activities, enhancing community well-being and supporting local tourism.	1. Tourism statistics 2. Records of recreational activities 3. Economic impact assessments	1. Current visitor numbers 2. Infrastructure condition reports 3. Community feedback surveys	The Godavari Initiative has launched regional consultations to address ecological challenges and promote sustainable tourism in Nashik.
Cultural and Religious Significance	The Godavari holds cultural and religious importance, hosting festivals and rituals that strengthen community bonds. (For Example: Kumbh Mela, Goda Aarti, Heritage walks in old city, Festival Celebrations along the ghats.)	1. Documentation of cultural events 2. Historical records 3. Anthropological studies	1. Current schedules of religious events, 2. Participation statistics 3. Cultural impact assessments.	

Table 12: Preliminary Assessment of the Ecosystem Services – based on the literature review (Source:Author)

- **Exercise 1 – Direct & Indirect benefits only through floodplains (socio-economic and environmental benefits)**

This exercise was done to systematically identify and analyse both the direct and indirect benefits of floodplains, concentrating on socio-economic and environmental factors, with the help of the Nashik City Development Plan (CDP) 2036 review. Relevant benefits were systematically grouped into organized tables utilizing secondary data from sources such as the Millennium Ecosystem Assessment (2005) and reconnaissance surveys. The socio-economic benefits were evaluated regarding agricultural employment, water supply, fisheries, tourism, and their related indirect effects, including flood regulation and pollution control. Environmental benefits have been identified by functions such as flood reduction, groundwater recharge, and vegetation-driven climate regulation, as well as associated benefits including carbon sequestration and improved water quality. This classification helped a broad understanding of the role of floodplains in enhancing sustainable urban and ecological resilience in the Nashik. (*Nashik Draft Revised DP 2016-2036*, n.d.)

Socio-Economic Benefits

SR. NO.	DIRECT BENEFITS	INDIRECT BENEFITS
1	Agircultural Employment (Fertile floodplain soil supports farming)	Flood Regulation - reducing urban flood risks and economic losses.
2	Water Supply (Groundwater recharge from floodplains- drinking water, irrigation, industrial purpose)	Pollution Control – Natural filtration by wetlands improves water quality, reducing treatment costs.
3	Fisheries (Natural fish breeding in floodplain waters supports local fisheries)	Nashik's Kumbh Mela and temple-based activities boost local economy
4	Tourism and Recreation	Well-maintained floodplain areas increase real estate demand and land value

Table 13 Socio-Economic Benefits

Environmental Benefits

SR. NO.	DIRECT BENEFITS	INDIRECT BENEFITS
1	Flood Mitigation & Water Retention (Floodplains act as natural sponges, absorbing excess rainwater and reducing flood intensity in Nashik.)	Improved Water Quality
2	Groundwater Recharge—Percolation through floodplain soils replenishes groundwater levels, supporting sustainable water supply	Carbon Sequestration – Vegetation along the floodplain captures atmospheric carbon, contributing to climate change mitigation
3	Vegetation along floodplains moderates temperature and humidity, reducing urban heat effects	Riparian forests and wetland plants stabilize riverbanks, reducing soil erosion and sedimentation in the river
4	Natural Filtration & Water Purification—Wetlands and riparian vegetation trap pollutants, sediments, & heavy metals	Afforestation and reforestation in floodplains can help reduce flood risk and provide co-benefits such as air pollution reduction

Table 14 Environmental Benefits

Source: NMC Nashik CDP 2036, Reconnaissance Survey and Adapted from the Millennium Ecosystem Assessment. 2005.

Exercise 2 – Indicators for River-Related Ecosystem Services

In this exercise on indicators for river-related ES, I performed a thorough analysis of provisioning, regulating, supporting and cultural services linked to the river ecosystem, using the MEA (2005) and the NIUA-NMCG River Consideration Guidelines (RCUP). The method involves identifying key ES, including potable and industrial water supply, fisheries, agriculture, and energy generation, and connecting each service to measurable indicators such as water volume delivered, crop yield, fish catch, and hydropower output. Indicators such as sediment load reduction, water quality index (WQI), plant cover, and microclimate measures were evaluated to comprehend the ecological functioning and resilience offered by river systems in relation to regulating services. This systematic classification sought to facilitate evidence-based river management by connecting ES with quantifiable results and their significance for sustainable urban development and conserving resources. (Basak et al., 2021; Huang et al., 2015)

Provisioning ES	Indicators
Drinking Water Supply	Volume of potable water supplied (m^3/day), number of households served
Industrial Water Supply	Volume of water extracted (m^3/year), groundwater recharge rates
Commercial Water Use	Economic contribution of water-based industries
Fisheries	Fish catch per year (tons), productivity per hectare, market price fluctuation
Agriculture & Irrigation	Area of irrigated land (hectares), Crop yield per hectare
Riparian Agriculture Productivity	economic returns from floodplain farming
Raw Materials	Sand/mineral extraction (tons)
Energy Generation	Hydropower production (MW/year), flow regulation capacity

Table 15: Provisioning Ecosystem Services Indicators

Regulating ES	Indicators
Flood Regulation	Water retention capacity (m^3), reduction in flood damages
Erosion & Sediment Control	Sediment load reduction (%), riverbank stability index
Water Purification & Quality	WQI Reduction in pollutants (mg/L of nitrates, phosphates), biological oxygen demand (BOD), dissolved oxygen levels
Riverbank Stabilization & Erosion Control	Vegetation cover along banks (%)
Microclimate Regulation	Temperature regulation (°C reduction in urban areas), humidity variation

Table 16: Regulating Servuices Indicators

Source: Adapted from the Millennium Ecosystem Assessment. 2005, Managing Urban Rivers by NIUA, NMCG River Consideration Guidelines (RCUP)

Exercise 2 – Indicators for River-Related Ecosystem Services

Supporting ES	Indicators
Habitat Availability	Wetland/riparian habitat area (ha), biodiversity index
Nutrient Cycling	soil fertility improvement
Soil formation	Improve habitat quality for plants, increase microphyte primary productivity, provide a sink and source of nutrients
Primary Productivity	Vegetation cover percentage

Table 17 Supporting ES Indicators

Cultural ES	Indicators
Tourism & Recreation	Number of visitors/year, revenue from tourism
Spiritual & Religious Value	Frequency of cultural events (e.g., Kumbh Mela)
Aesthetic & Well-being Benefits	Public perception surveys, green space availability along riverbanks, frequency of community engagement in river conservation
Cultural Heritage	Number of tourists

Table 18 Cultural ES Indicators

Source: Adapted from the Millennium Ecosystem Assessment. 2005, Managing Urban Rivers by NIUA, NMCG River Consideration Guidelines (RCUP) (*48_Urban River Management Plan framework_NIUA_NMCG_MOHUA*, n.d.; *59_Mainstreaming Urban River Report - Compressed*, n.d.; Reid & Mooney, 2016a)

Exercise 3 – Categorisation of Ecosystem Services into Ecosystem Services Values

The exercises cover categorising of ecosystem services into total economic values. The detailed review of the Total Economic Value (TEV) in MEA was carried out to categorise the benefits obtained from the Godavari River in Nashik. I used primary and secondary data sources, including household surveys, stakeholder consultations, market studies, satellite imagery, and government publications, to categorise ecosystem services into five value categories: Direct Use, Indirect Use, Option, Bequest, and Existence. Every service, including drinking water, irrigation, fisheries, and microclimate regulation, was reviewed for its existing and prospective contributions to livelihoods, cultural heritage, ecological sustainability, and future generations. This process directed an in-depth understanding of both tangible and intangible values related to rivers, which promoted integrated and culturally sensitive river management strategies by the MEA. (Reid & Mooney, 2016a; *Van Der Ploeg 2010_The TEEB Valuation Database_overview of Structure, Data and Results*, n.d.)

Total Economic Value				
Use Value		Optional Value	Non-Use Value	
Direct Use Value	Indirect Value		Bequest Value	Existence Value
Resources used directly, services giving direct benefits	Resources used indirectly	Future possible use	Possible use for future generation	Right of existence
Household Survey, Stakeholder Survey	Market Studies, Satellite Imagery, Govt. Publications, NGOs	Household Surveys	Household Surveys	Household Surveys
Drinking water source for Nashik city & nearby regions	Groundwater recharge	Potential future water supply	Preservation of religious & cultural heritage- Ensuring the sacred status of the Godavari for future devotees.	Intrinsic value of the river- Recognizing the river's role beyond human use – as a vital part of the natural world.
Irrigation for agriculture (grapes-vineyards, sugarcane, vegetables, onions, paddy)	Carbon sequestration through riparian vegetation - Vegetation along the floodplain captures atmospheric carbon, contributing to climate change mitigation	Conservation of genetic resources	Biodiversity conservation- Protecting unique riverine flora and fauna for future ecological balance.	Spiritual & cultural identity- The river holds deep spiritual meaning for Nashik's residents.
Fish Farming Sinnar- A town in Nashik District where fish farming is a promising venture. Fisheries- Supports freshwater fish species (e.g., catfish, mahseer) for local consumption & livelihoods.	Microclimate regulation- Water bodies help moderate temperature in Nashik's urban areas.	Eco-friendly urban development- Potential for blue-green infrastructure around the river.	Potential for conservation-based economy-Developing a future economy around sustainable river use.	Symbolic importance: The Godavari's cultural and(Ramayana & Mahabharata) mythological significance is invaluable.

Table 19: Categorisation of ES into Values

Description **Data Sources** **Provisioning Services** **Regulating Services**

Source: Adapted from the Millennium Ecosystem Assessment. 2005.

Exercise 4 – Built V/S Non-Built Activities and Their Connection to River Ecosystem

This exercise is about a comparative analysis of built versus non-built activities along the Godavari River ecosystem to assess their impacts and relationships with the river. Initially, the exercise started by locating the key man-made facilities, including urban settlements, industrial zones, roadways, bridges, riverside developments, and solid waste landfills. These were compared to non-built activities, including traditional religious practices, fishing, wildlife corridors, pilgrimage events, grazing, seasonal agriculture, and informal resource extraction. This classification analyses the impact of both on river health, including water pollution, habitat destruction, sediment load changes, and access to spiritual sites. This comparative analysis addressed the ecological stresses imposed by urbanisation and informal practices. (*13__Ch10_Floodplain_Planning__Nov20_Guidelines for Godavari Nashik*, n.d.; *Godavari Basin_NRSC_Central Water Commission*, n.d.; Grzyb, 2024)

Built Activities (Man-made infrastructure)	Non-Built Activities (Natural or informal uses)	Relationship with River
Urban settlements (e.g. Nashik city core)	Traditional bathing & religious rituals	Encroachment on ghats; increased pollution from domestic sewage
Industrial zones (MIDC areas near river)	Fishing & small-scale farming on riverbanks	Industrial effluents degrade water quality affecting biodiversity
Roads & bridges (Godavari bridge, etc.)	Wildlife movement corridors along ripariaN edges	Infrastructure fragments natural habitats
Riverfront development (beautification, paving)	Pilgrimage activities (Kumbh Mela)	Built form affects flow patterns and spiritual access
Solid waste dumping sites	Grazing lands & seasonal vegetable farming	Dumping contaminates water; informal farming depends on flow patterns
Sand mining (formal extraction)	Informal sand collection, wood & herb gathering	Both affect sediment load, riverbank erosion

Table 20 Built V/S Non-Built Activities and Their Connection to River Ecosystem

Source: An indicator system for assessing the impact of human activities on river structure by Yinjun Zha

4.1.3. Primary Study Analysis

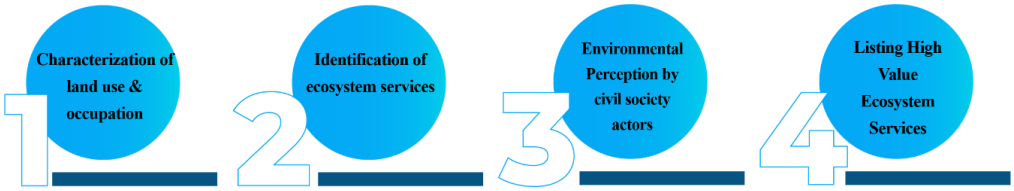


Figure 41: Primary Study Methodology

With the help of primary data, the analysis has been divided into 2 matrix-based studies and GIS-based studies. The first stage is the Classification of land use and land cover classes - Supervised Classification and Reconnaissance Survey and Mapping through Google Imagery. The 2nd stage covers the Identification of ES, with the help of all Services defined by the TEEB (2010) & Exercises conducted on reconnaissance survey, associated with each identified land use. 3rd stage includes a Survey regarding the ecosystem services existing in selected wards- a scoring system - sent to the group of key actors, and a sum of the highest-scoring ES to identify the priority services. (*Van Der Ploeg 2010_The TEEB Valuation Database_overview of Structure, Data and Results*, n.d.)

Matrix-Based Study 1: Multi-Criteria Assessment of Ecosystem Services Along the Godavari

This matrix-based study adopts a multi-criteria assessment (MCA) methodology to systematically evaluate and prioritize the ecosystem services (ES) provided by the Godavari River in the Nashik region. The main goal is to determine the spatial and functional distribution of essential ecosystem services and evaluate their relative importance in promoting environmental health, urban sustainability, and socio-economic development.

- **Key Objectives of the Matrix:**
  a) To measure and evaluate the comparative contributions of diverse landscapes to various ecosystem services.
  b) To prioritize critical zones along the river corridor for conservation, restoration, or sustainable development.

- **The study is divided into 4 parts:**
  a) Criteria Identification
  b) Validation of Criteria through experts
  c) Stakeholders Survey & Citizen Perception Survey
  d) Weight-Based Prioritization

This matrix-based multi-criteria methodology develops a foundational comprehension of ecosystem service dynamics within the Godavari River landscape of Nashik, aligning with the overarching objective of utilizing natural assets for sustainable urban growth and economic resilience.

a) Criteria Identification

The process consists of the selection of suitable indicators that can effectively assess the significance, relevance, and risk status of diverse ecosystem services (ES) provided by the Godavari River in Nashik. The chosen criteria seek to represent the multifaceted significance of ES, covering social, economic, cultural, ecological, and institutional dimensions.

Process of Criteria Selection:

1. Literature Review: A thorough examination of academic journals, governmental papers, and international frameworks (e.g., Millennium Ecosystem Assessment, TEEB – The Economics of Ecosystems and Biodiversity, and IPBES) was performed to find out frequently utilized assessment criteria for ecosystem services. (*13_Methdology for Sample Collection*, n.d.; *36_Study Area*, n.d.; Reid & Mooney, 2016b)
2. Contextualization to Nashik-Godavari River Basin: The preliminary longlist of criteria was customised to the regional context of Nashik, taking into account the urban-river interface, the religious and cultural importance of the Godavari, and the livelihood dependence of residents.

b) Expert Consultation and Validation:

The criteria were tested to guarantee relevance and correctness through five experts-
Interviews and conversations with the expert – local specialists, including urban planners, urban designers, hydrologists, ecologists, and sociologists from the Nashik Municipal Corporation (NMC).

1. Feedback workshops with important stakeholders engaged in riverfront development, water management, and religious tourism.
2. Casual validation during field visits, wherein local stakeholders (e.g., fishers, priests, sellers) were inquired about their interactions with and appreciation for the river's services.

Final List of Criteria:

Criteria	Why It Matters	Rationale
Extent of Use	How many people depend on this ES (e.g. drinking water for 5 lakh people)	Reflects how widely the service is utilised
Frequency of Use	Daily (drinking), seasonal (agriculture), occasional (Kumbh)	Captures how often the service is accessed

Economic Dependence	Employment, livelihood (fisheries, religious tourism, sand mining)	Shows the livelihood or income reliance
Cultural Importance	Historical, spiritual, and traditional relevance (e.g. Godavari Ghat rituals)	Highlights traditional or spiritual values
Environmental Impact	Whether it helps improve or worsen river health	Considers ecological significance
Policy/Institutional Support	Whether it's recognized in policies (DP, River Rejuvenation Plan, AMRUT, NMC riverfront development)	Indicates enforceability and support
Vulnerability / Threat Level	Level of degradation or threats faced by the ES	Accounts for the risk of degradation or loss

Figure 42 Evaluation Criteria

Each criterion was specified with a specific rationale and justification, as illustrated in the matrix. This clarity guarantees accuracy in scoring and improves the scientific precision of the multi-criteria evaluation. (*59_Mainstreaming Urban River Report - Compressed*, n.d.; *River_Sensitive_Urban_Planning_NMCG_1737536820*, n.d.; Alvarado-Arias et al., 2023; Basak et al., 2021; Grzyb, 2024)

c) Stakeholders Survey & Citizen Perception Survey

The surveys were intended to obtain qualitative and quantitative insights about the perceptions, dependencies, and interactions of various groups with the ecosystem services of the Godavari River in Nashik.

Objectives:

1. To understand public awareness about ES.
2. To gain insights regarding livelihood dependency, cultural significance, and perceived dangers to the river.
3. To identify priorities for conservation and development from both institutional and civic perspectives.

Methodology:

Structured questionnaires were created via Google Forms, specifically designed for stakeholders (technical/institutional) and the general public. The questionnaires comprised:

1. Multiple-choice questions,
2. Likert-scale ratings,
3. Open-ended responses.

The form templates are attached in the Appendix of the thesis for reference.

Data Collection:

1. Google Forms were circulated via digital platforms such as WhatsApp groups, emails, local academic networks, and professional connections.
2. On-site surveys were executed in important sites, including Godavari Ghats, riverfront markets, residential areas, and temples to guarantee participation from diverse user groups.

Responses were collected from a diverse mix of stakeholders, including:

1. Urban planners and municipal officials (NMC)
2. Nashik Smart City Officials,
3. MIDC and MPCB Officials
4. Water Resource Department Officials
5. Local NGOs and environmental activists – Nashik Ploggers
6. Business owners, especially near the river, retail shopkeepers, hawkers, etc.
7. Religious leaders and devotees
8. Fishermen, vendors, and informal workers
9. General citizens and students

Sample Size and Coverage: A total of 162 responses have been collected, including 122 from digital formats and 40 from in-person interactions. The sample guaranteed an equitable split of age demographics, professions, and proximity to rivers.

Data Analysis: Survey data was compiled, classified, and examined to identify:

1. Dominant ecosystem services
2. Observed changes in river health throughout time
3. Degrees of awareness and confidence in institutional initiatives
4. Principal issues (e.g., pollution, encroachment, water deficiency)

Outcome: The results from both surveys have been incorporated into the multi-criteria evaluation and recommendations part of the study. They offer a citizen- and stakeholder-driven validation layer which boosts the project's legitimacy and societal value.

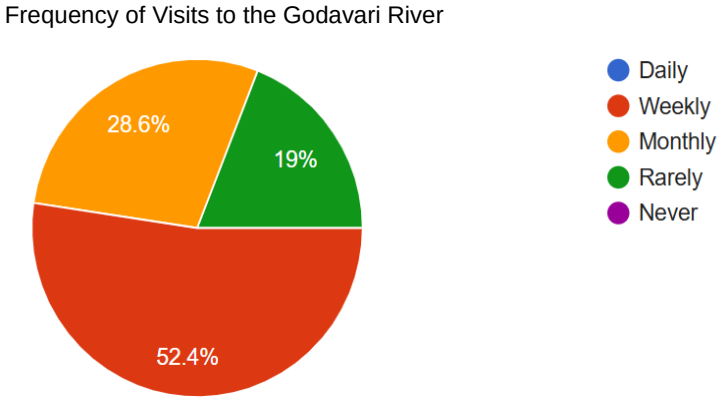


Figure 43 Frequency of visits to the Godavari River

The pie chart showing the responses to the question “How frequently do you visit the Godavari River or adjacent areas?” demonstrates that the Godavari River remains significant in the life of the local population. With 52.4% of respondents visiting regularly, the data indicates that the river and its surrounding area are key to individuals’ routines, likely for activities like as religious practices, social gatherings, or informal economic activities like washing. The 28.6% of monthly visits shows those who may use the river for occasional rituals or seasonal conditions, whereas the 19% who rarely visit likely signify urban residents with less dependence on or access to the river. The lack of everyday visits suggests that, despite the river holding cultural and economic importance, it is not used as a daily resource by the majority. The Godavari River has moderate to high economic and cultural significance in the region, but the level of human interaction varies.

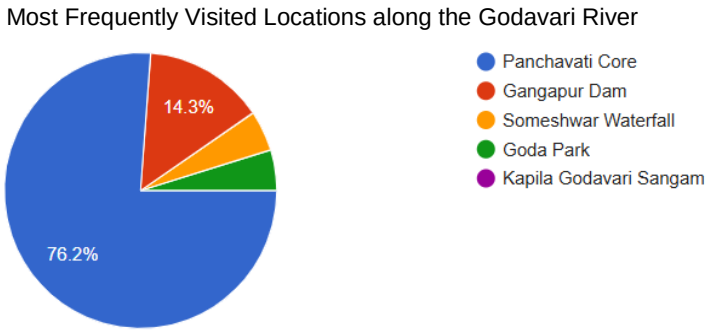


Figure 44 Most Frequently Visited Locations along the Godavari River

The responses show that the Panchavati Core is the most visited section of the Godavari River, with 76.2% of respondents reporting frequent engagement with this area. This denotes its key importance, presumably owing to its religious, cultural, or economic importance. The Gangapur Dam is the second most visited location, attracting 14.3% of visitors for leisure activities in the vineyards around the dam. The Someshwar Waterfall, Goda Park, and Kapila Godavari Sangam show minimal interaction. The distribution pattern shows the close human-river link in the Panchavati zone and indicates a potential disparity in the accessibility or valuation of various river zones.

The bar chart shows that the Godavari River is seen as a vital resource for cultural and spiritual development, with 100% of respondents recognising it as a significant benefit. Agricultural benefits and pilgrimage/religious tourism closely align at 95.2%, highlighting the river’s importance in both economic and spiritual activities. Clean drinking water (85.7%) and natural beauty/scenic views (66.7%) are also highly ranked, highlighting the river’s ecological and aesthetic value. Benefits such as flood regulation (33.3%), pollution control (28.6%), and fisheries (14.3%) are poorly acknowledged, suggesting either a deficiency in awareness of these ecosystem services. None of the respondents chose “None / Not aware,” showing an active public

knowledge of the river's significance across multiple sectors. The results demonstrate a multifaceted valuation of the Godavari, covering both tangible benefits like water and agriculture and intangible aspects like culture and spirituality.

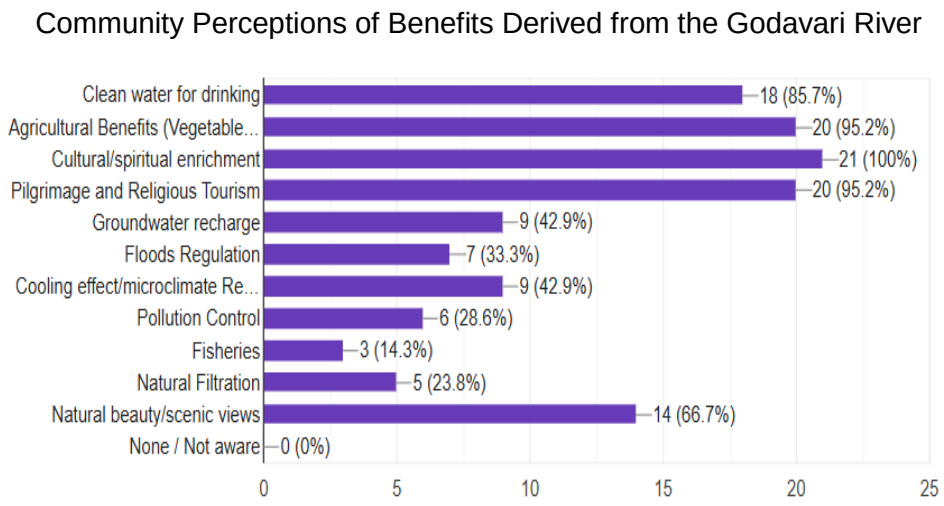


Figure 45 Community Perceptions of Benefits Derived from the Godavari River

With the help of these responses, the weight-based prioritisation has been created for each type of criteria and a detailed classification of each type of ecosystem service. Following is the matrix prepared for representation. The total score in the matrix represents an overall rating of the service, community perception about the particular service and supply of the service by the river in Nashik.

d) Weight-Based Prioritization (MATRIX: 1)

ES Type	Ecosystem Services	Extent of Use	Frequency of Use	Economic Dependence	Cultural Importance	Environmental Impact	Policy/ Institutional Support	Total Score
Provisioning Services	Drinking Water Supply	5	5	4	3	5	5	**27**
	Industrial Water Supply	3	4	4	1	2	4	**18**
	Irrigation for Agriculture	4	4	5	2	3	3	**21**
	Fisheries	2	3	3	2	4	2	**16**
	Sand & Sediment Extraction	3	3	3	1	1	1	**12**
	Timber & Fuelwood	1	2	2	1	3	1	**10**
Regulating Services	Groundwater Recharge	4	5	3	2	5	4	**23**
	Carbon Sequestration	2	4	1	1	4	3	**15**
	Microclimate Regulation	3	3	1	2	4	2	**15**
	Flood Regulation	5	4	2	2	5	5	**23**
	Pollution Control	5	5	2	2	5	5	**24**
	Natural Filtration and Water Purification	4	4	3	2	5	5	**23**
	Soil Erosion Prevention	3	3	2	2	4	3	**17**
Cultural Services	Pilgrimage and Religious Tourism	4	3	4	5	3	5	**24**
	Recreational Activities	3	3	3	3	3	4	**19**
	Heritage	2	2	2	5	3	4	**18**
	Festival and Community Activities	4	3	3	5	2	4	**21**

Figure 46 Matrix Ranking on a scale of 1 (the lowest) to 5 (the highest)

- **Matrix-Based Study 2: To identify which ES contributes the most in each land use zone using a score-based matrix**

Based on the tangible benefits, scores allotted to 5 economic values listed in the Millennium Ecosystem Assessment (MEA), this matrix-based study aims to identify the most significant ecosystem services (ES) within various land use zones by employing a score-based evaluation method. The approach utilizes the five categories of economic value as defined in the **MEA** framework to assess and compare tangible benefits derived from ecosystem services.

Expert Validation: The initial matrix values have been verified through discussions with subject matter experts: Water Management & Environment Specialist at NIUA, Environmental Planner - Worked on Varanasi in a similar context. The Google form used for the validation is attached to the appendix. These experts provided insights on assigning appropriate weightage to different values, helping refine the matrix to ensure contextual accuracy and practical relevance. The finalised values are given below:

1. Direct Use Value - **5**
2. Indirect Use Value - **4**
3. Optional Value - **3**
4. Bequest Value - **3**
5. Existence Value - **4**

Key Informant Interviews (KII): To take into account local and institutional perspectives, Key Informant Interviews (KII) were executed utilizing the following tools:

1. Mentimeter for interactive, real-time feedback.
2. Matrix-based survey forms shared via email and WhatsApp.

Participants included representatives from:

1. **Urban and Infrastructure Bodies:** Town Planners, Smart City SPV officials, NMC (Nashik Municipal Corporation), MIDC (Maharashtra Industrial Development Corporation), PWD
2. **Environmental and Regulatory Authorities**: MPCB (Maharashtra Pollution Control Board), Agriculture Department, Water Resource Department, Irrigation Department
3. **Academic and Research Institutions:** NIUA Experts

The stakeholders shared feedback regarding the importance of each ecosystem service based on their sectoral expertise, refining the ratings and verifying assumptions generated in previous phases. A total of 20 responses were collected and tabulated in a matrix format.

Matrix-Based Analysis Output (MATRIX: 2)

ES Type	Ecosystem Services	Residential Zones	Commercial Zones	Industrial Zones	Recreational Zone	Agricultural Zones	Public/Semi Public Zones
Provisioning Services	Drinking Water Supply	5	5	5	5	5	5
	Industrial Water Supply	3	4	5	3	3	4
	Irrigation for Agriculture	3	3	3	3	5	3
	Fisheries	3	3	3	4	4	3
	Sand & Sediment Extraction	3	3	4	3	3	3
	Timber & Fuelwood	3	3	3	3	4	3
	Total Values	**20**	**21**	**23**	**21**	**24**	**21**
Regulating Services	Groundwater Recharge	4	4	4	5	5	4
	Carbon Sequestration	3	3	3	4	5	4
	Microclimate Regulation	4	3	3	5	5	4
	Flood Regulation	3	3	3	4	5	5
	Pollution Control	3	3	4	4	4	4
	Natural Filtration and Water Purification	4	3	3	5	5	5
	Soil Erosion Prevention	3	3	3	4	5	5
	Total Values	**24**	**22**	**23**	**31**	**34**	**31**
Cultural Services	Pilgrimage and Religious Tourism	3	3	3	3	3	5
	Recreational Activities	4	3	3	5	3	4
	Heritage	3	3	3	3	3	4
	Festival and Community Activities	4	4	3	4	3	5
	Total Values	**14**	**13**	**12**	**15**	**12**	**18**
TOTAL ECONOMIC VALUE		**58**	**56**	**58**	**67**	**70**	**70**

Figure 47 Matrix 2-Based Analysis Output (Source:Author)

4.1.4. Inferences from the Secondary Study

1. **Provisioning services are unavoidable and quantifiable**. The Godavari River is essential for supplying water for domestic (348 MLD), agricultural, and industrial uses. Documents from the NMC, MPCB, and planning standards indicate a significant dependence on the river for water distribution across the city, including MIDC and thermal facilities. This shows a direct economic dependence. (*8_Water Quality*, n.d.; *12_List of Water Polluting Industries in Nashik*, n.d.)
2. **Cultural services have a strong connection in cities identity**. Secondary sources, including the Nashik Development Plan 2036, NIUA documents, and Kumbh Mela Infrastructure Planning, highlight the cultural and religious importance of the river, especially during the Simhastha Kumbh Mela, Goda Aarti, ritual bathing at Ramkund, and the heritage trail of Nashik's Old City. These events attract large crowds and produce tourism-related revenue. (*13__Ch10_Floodplain_Planning__Nov20_Guidelines for Godavari Nashik*, n.d.)
3. Flood Regulation is an Important Ecological Service. Land-use changes Analysis and flood statistics from the MPCB indicate that the river's natural flow contributes to flood mitigation.
4. Supportive biodiversity services exist but are rarely recognised. Documentation from the Nandur Madhyameshwar Bird Sanctuary (Ramsar site) and flora/fauna inventories demonstrate that the river supports a rich biodiversity. Data is dispersed and insufficient in urban planning documents.
5. Indicators and KPIs developed are based on solid frameworks. Riverine ecosystem services were delineated utilising MEA principles and NIUA's planning instruments, using unique indicators for each ES category. This resulted in the formulation of measurable standards for assessing the river's economic worth.

4.1.5. Inferences from the Primary Study

Two matrices have been developed to assess ecosystem services (ES) regarding the Godavari River's impact on Nashik's urban environment:

Matrix 1 concentrated on the identification and evaluation of ecosystem services according to land use classifications, utilizing secondary data and expert validation.

Matrix 2 featured stakeholder-driven prioritizing of identical ecosystem services via score-based evaluation grounded in public perception, sectoral dependence, and neighbourhood knowledge.

1. **Public Perception Strongly Validates Cultural Importance.** Among 162 survey sample respondents, the majority prioritized cultural and religious services as the most significant. Frequent visits to Ghats and engagement in rituals show strong emotional and spiritual relationships.
2. **The dependency on provisioning services is Universally Acknowledged** – Respondents from both core and peri-urban wards showed major dependency on the river for potable water, irrigation, and everyday sanitation activities, validating secondary findings.

3. **Awareness of Environmental Issues Exists but is Limited –**
   Numerous residents noticed degradation in water quality and encroachments, but very few understood their ecological effects, such as habitat destruction or pollution-induced ecosystem degradation.

4. **Economic Utilization Rated Higher Than Ecological Regulation –**
   While Provisioning and cultural services were often acknowledged, regulating services (such as flood control and microclimate benefits) were less appreciated or valued by the overall public.

4.1.6. Comparative Inference:

Strong Similarity on Cultural and Provisioning Services – Both studies independently confirm that cultural-spiritual activities and water provisioning are the two most prominent and economically significant services. This justifies the prioritization of specific ES types in any special-purpose planning. While flood regulation is technically acknowledged in secondary data, primary stakeholders (except experts) often overlook it, highlighting a deficiency in public awareness that can be addressed by education and involvement. Supporting services are known in academic contexts, but are less recognized publicly. While secondary sources highlight biodiversity and nutrient cycling, residents rarely cite these elements unless they are directly associated with tourism or recreation (e.g., birds near ghats).

Land-Use Zone	Dominant Ecosystem Service per Land Use Zone		
Residential Zones	Drinking Water Supply	Natural Filtration and Water Purification	Groundwater Recharge
Commercial Zones	Drinking Water Supply	Festival and Community Activities	Groundwater Recharge
Industrial Zones	Drinking Water Supply	Industrial Water Supply	Groundwater Recharge
Recreational Zone	Pilgrimage and Religious Tourism	Recreational Activities	Festival and Community Activities
Agricultural Zones	Groundwater Recharge	Irrigation for Agriculture	Soil Erosion Prevention
Public/Semi Public Zones	Drinking Water Supply	Festival and Community Activities	Pilgrimage and Religious

Figure 48 Matrix 2 Analysis Output

4.2. Objective 2

To analyse the urban morphology around the Godavari River, concentrating on land-use patterns, their relationship to the river's ecological health, and mapping human dependencies on any one prominent type of river-based service.

4.2.1. Research Intent

This objective focuses on assessing the spatial interactions between urban growth and river health in Nashik's river-adjacent wards, utilizing the Godavari River as the primary ecological axis. It specifically seeks to examine the urban morphology—land use distribution, density, and physical form—adjacent to the river and its changing influence on the riverine ecology. The objective acknowledges that the design and utility of the built environment profoundly affect the state of natural resources, including rivers, particularly via encroachment, pollution, runoff, and habitat fragmentation.

A 500-meter buffer was established around a designated river segment inside four primary municipal wards (Ward Nos. 6, 8, 10 and 12) of the Nashik Municipal Corporation, identified through reconnaissance, stakeholder input, and ecosystem service mapping as areas of high-intensity interaction. A spatio-temporal land cover analysis was performed in this specified area utilizing satellite images from 2014, 2019, and 2024. Supervised classification and post-classification comparison techniques were utilized to evaluate alterations in urban morphology, emphasizing areas of ecological deterioration, heightened impervious surface area, and diminished green space.

The study analyzes the correlation between land use and the ecological integrity of the Godavari River by overlaying land use data with pollutant discharge locations, ecosystem service areas, and MPCB-validated degradation hotspots. Data from the Maharashtra Pollution Control Board (MPCB) and public perception surveys were utilized to associate urban growth trends with deteriorating water quality, depletion of riparian buffers, and diminished service functions.

The study delineates how humans depend on river-based services, particularly focusing on cultural services as a significant ecosystem service. This encompasses religious rites, pilgrimage tourism, and spiritual practices conducted in and around the river ghats. This emphasis was guided by the ecological service grid and stakeholder priority rankings, which indicated that cultural ecosystem services are predominant in the chosen wards. Spatial analysis was facilitated by community questionnaires, field observations, and photographic documentation to evaluate the number, distribution, and socio-cultural importance of river-based interactions.

The results of this purpose are essential for identifying the impact of spatial planning, land use restrictions, and human activities on river ecosystems. This will determine the priority of intervention areas and inform the development of river-sensitive land use zoning policies in subsequent phases of the thesis.

4.2.2. Area Delineation Methodology

To delineate the specific study area for Objective 3, a combination of reconnaissance surveys, primary matrix evaluations, citizen perception surveys (n=162), and spatial land use analysis was used. Wards 6, 8, 10, and 12 in the old city were selected based on their geographical closeness to the Godavari River, diverse land use characteristics, historical and cultural significance, and high levels of provisioning and cultural ecosystem services. Considering the limitations of quantitative secondary data, this methodology adheres to river-sensitive planning principles, wherein local expertise and empirical analysis underpin intervention strategies. (*5__Ch2_Study_Area___Nov20_2*, n.d.; *Env Status Report Nashik*, n.d.; *Nashik Draft Revised DP 2016-2036*, n.d.)

Following the Post Objective 1 study, several challenges occurred that limited the Objective 2 study –

1. Public domains lack specific data regarding the precise volume of water utilised per crop in each taluka.

2. While general irrigation methods and key water sources can be recognised, exact quantitative figures necessitate a comprehensive field study and data collection.

3. Inadequate data and mapping at the micro (ward/village) levels to evaluate the distribution and utilisation patterns of ecosystem services.

4. Stakeholder engagement frequently occurs during limited consultation phases; local expertise regarding ecosystem services is inadequately used in planning processes.

5. Temporal constraints prevented the precise collection and mapping of land use zones.

Step 1: ES Mapping in river adjacent wards – based on Land Cover Analysis

With the help of the Land Cover analysis shown in the section – need of the study (1.11), the 13 river adjacent wards have been analysed and dominant ecosystem services were mapped.

Figure 49 Methodology for Objective 2 - Step 1

For each ward, land cover zones were extracted, and the area corresponding to each land use category (e.g., built-up, green space, waterbody, agricultural) was calculated.

Following this, the concentration index was used to evaluate each ward's spatial dominance and intensity of particular land use categories. By comparing these indices across all wards, the land cover type with the most coverage was determined, identifying the predominant land use pattern for each area.

The spatial data was then merged with the previously established ecosystem service matrix. Each predominant land cover type was correlated with its respective ecosystem services (e.g., urban areas associated with cultural services such as religious activities, green spaces connected to regulating/supporting services). This facilitated the delineation of predominant ecosystem services within each ward, hence allowing for the identification of areas with significant potential and those experiencing substantial degradation along the river corridor. (Akyol et al., 2024; *Godavari-RAG-Report_27-9-2024*, n.d.; Guo et al., 2023)

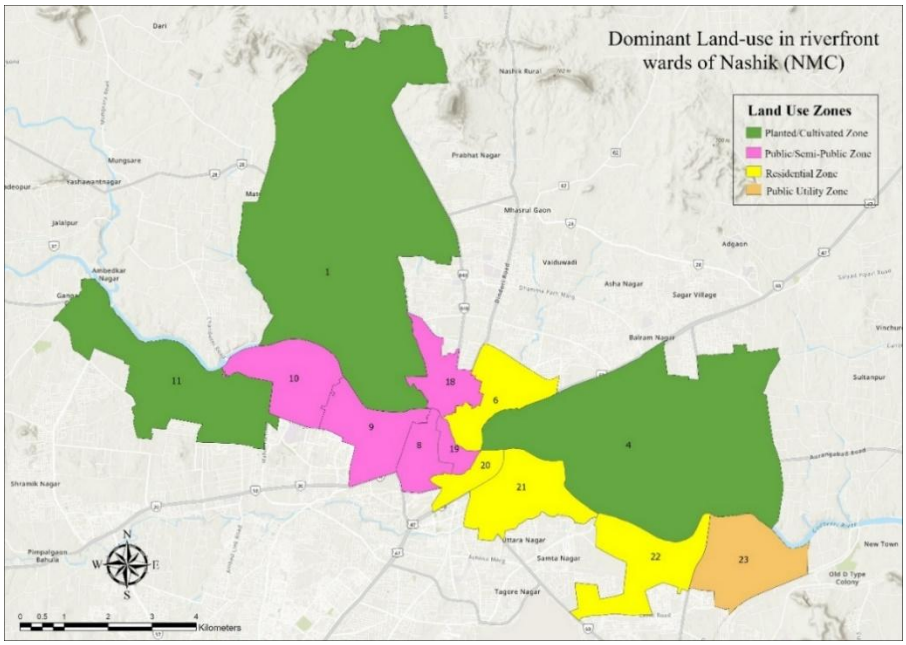


Figure 50: Map showing Objective 2- Step 1 Output (Source: Author)

- **Step 1 Inference –**

1.Planted/Cultivated Zone Dominance: Wards 1, 4, 11

Associated Ecosystem Services:

Provisioning – Irrigation water use, timber/fuelwood.

Regulating – Groundwater recharge, soil erosion control, microclimate regulation, carbon sequestration.

2. **Public/Semi-Public Zone Dominance:** Wards 8, 9, 10, 18, 19

Associated Ecosystem Services:
Cultural – Pilgrimage and religious tourism, recreational spaces, festivals.
Provisioning/Regulating – Possible service access infrastructure, like water distribution and waste processing.

3. **Residential Zone Dominance:** Wards 6, 20, 21, 22

Associated Ecosystem Services:
Regulating – Domestic Water Usage, pollution control, microclimate regulation.
Cultural – Community events, daily religious activities.

4. **Public Utility Zone Dominance:** Ward 23

Associated Ecosystem Services: Regulating: Pollution control, waste assimilation, water purification.

5. The agricultural zones or planted/cultivated zones are ecosystem service hotspots, especially for ecological functions related to water and land quality. It is important to protect these zones from conversion.

6. The Public/ Semi-Public wards support both human wellbeing and ecological health, especially around Nashik's religious and historic nodes. Strategic planning should retain these for a multifunctional urban green space.

Agricultural Zones = Strong in regulating and provisioning services.

Public/Semi-Public Zones = (Dual benefit) cultural identity **+** ecological regulation.

Residential Zones = Demand-heavy, lower contribution, potential for green infrastructure upgrades.

Step 2: Identification of Critical Pollution Zones

To strengthen the environmental aspect of this study, secondary data from the Comprehensive Study of Polluted River Stretches and Action Plan of River Godavari (MPCB, 2015) has been incorporated into the spatial analysis. This document, commissioned by the Maharashtra Pollution Control Board (MPCB) and conducted by Aavanira Biotech Pvt. Ltd., assessed pollution levels along the Godavari River from Nashik to Paithan, with detailed sampling in urban and peri-urban areas.

Among all the river stretches examined, the Ramkund stretch in Panchavati (Ward 9) was identified as the most severely contaminated site within the Nashik Municipal Corporation (NMC) jurisdiction boundary that also has high human interaction. Water quality data indicated high Biochemical Oxygen Demand (BOD) and Total Coliform levels, with BOD values in this segment continuously exceeding the Priority 1 pollution threshold (BOD > 30 mg/L), according to CPCB rules. According to MPCB data, the Water Quality Index decreases from approximately 133.44 upstream to around 35.01 in urban Nashik, indicating a rapid reduction in river health due to concentrated urban activities. This degree of contamination indicates untreated sewage, a significant organic load from ceremonial practices, and persistent human-induced pressure. (*All Water Data*, n.d.; *Godavari Basin_NRSC_Central Water Commission*, n.d.; *Report_Groundwater_Nashik*, n.d.; *Water Provisioning Data_NMC 13032025*, n.d.)

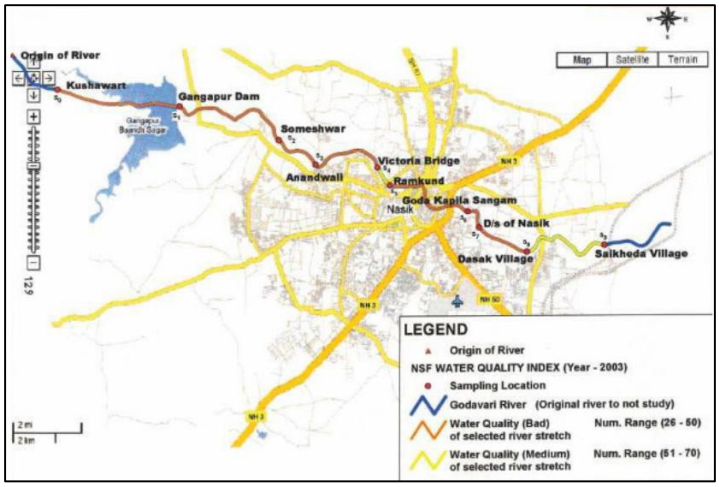


Figure 51 Godavari River Map showing Water Quality level

The degradation observed due to various spatial and anthropogenic factors:

1. High religious'/pilgrimage tourism footfall and ritualistic practices at Ramkund lack adequate waste management.
2. Direct dumping of untreated sewage and greywater into the river at numerous locations. (43 outlets as reported by NMC)
3. Encroachment on natural riparian buffers resulting from urban development and poor ghat constructions.
4. Disposal of solid trash, including offerings, plastics, and food waste, during festivals and religious ceremonies.
5. Insufficient vegetative cover and ecological buffers inside the 500 m zone, leading to surface runoff and pollution accumulation.

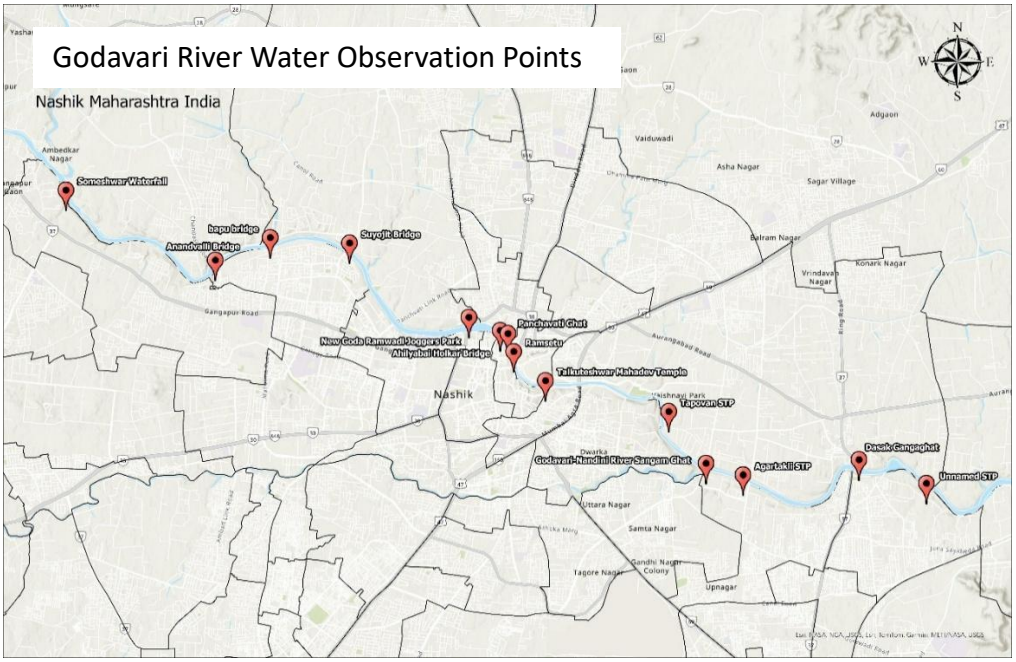


Figure 52 Godavari River Water Observation Points - Ground Truthing

Identified Specific Degraded Zones Within NMC Boundary:

1. **Someshwar to Hanuman Ghat:** Contamination from Chikhli Nalla, carrying industrial effluent from Satpur MIDC and domestic waste from slums at Anandvalli.

2**. Hanuman Ghat to Ramkund:** Evident by religious practices, open defecation, nirmalya visarjan, washing, and unregulated solid waste disposal.

3. **Ramkund to Tapovan:** Significant pedestrian traffic, bathing activities, idol immersion, disposal of vegetable trash from adjacent markets, and inadequate waste segregation at the ghats.

40. **Kapila Godavari Ghat - Tapovan STP Discharge Point:** Observed significant foam formation, signifying elevated concentrations of untreated or inadequately treated effluent entering the river.

5. **Tapovan to Agartakli STP:** These points have higher pollution level due to direct explosions from STPs. The research clearly shows changes in river water colour, the presence of plastic and ceremonial garbage, and the absence of organised waste collection systems at temples in these regions – all of which contribute to ecological degradation.

Step 3: Final Selection of Wards for the Study

The deteriorated areas are located within the four specified wards (6, 8, 10, 12) chosen for the final intervention. Their presence has merit not only from the perspectives of service dependency and cultural importance but also from an ecological urgency perspective. The area comprising Someshwar, Hanuman Ghat, Ramkund, and Tapovan shows a pattern of higher human activity with large river stress, allowing the study of urban morphology and its effects on ecosystem health.

Step 4: Validation

This MPCB report provides strong scientific support for field observations and ecological service mapping, supporting the justification for prioritising these areas in policy and spatial planning efforts. These selections have been verified through MPCB stakeholder meetings and primary survey data. The comparison of this data with the matrix analysis and secondary analysis presented in Objective 1 of section 4.1 corroborates the same findings. These challenges were spatially validated via ground truthing and pollution points layer mapping. The overlay showed that all four selected wards show clear indicators of ecological stress, including floating solid waste, bad odour, decreased aquatic biodiversity, high turbidity, and suspended particles. This research further identifies specific wards for focused study and policy intervention. Areas of high ecosystem service usage, specifically cultural services, are areas of considerable ecological vulnerability. Identifying and addressing these pollution hotspots is essential for environmental conservation and sustainable urban service planning.

4.2.3. Ground Survey – Issues Identified

Post validation, the site was inspected for accuracy in the project work. Ground survey was done in two ways, one done with the help of online secondary sources, stakeholders and local interviews. The following are the issues identified in the selected validated site area.

- **Drying of Ramkund in 2016 – (Past Issue)**

In April 2016, the sacred Ramkund section of the Godavari River in Nashik observed complete drying for the first time in 139 years, according to the Times of India. This unusual event occurred just before the Gudi Padwa festival, disrupting traditional religious practices and preventing thousands of devotees from doing ritual washing. The drying of Ramkund, recorded in the Nashik Gazette in 1877, serves as a significant indicator of the river's deteriorating ecological state. The event highlights the overall effects of declining groundwater levels, unregulated water extraction, urban encroachments, and alterations in land cover—all essential concerns examined in this thesis. Situated in Ward 9, Ramkund functions as a religious centre and a hub for cultural ecosystem services. The drying of the place shows the susceptibility of urban systems dependent on rivers and the urgent need for river-sensitive development methods. This incident proves the rationale for selecting key city wards, particularly those with high human-river interaction, like Ramkund, for a comprehensive analysis of land use impacts and the interdependence of ecosystem services. (Bhor et al., n.d.; *ESM_2022_23_Eng_Book*, n.d.; *Report_under_section_26 DP*, n.d.; □□□, n.d.)

Figure 53: Drying of Ramkund in 2016

- **Overcrowding Crisis at Ramkund**

Figure 54 Ramkund during Festivals

Ramkund, located on the holy Godavari River in Nashik, is a renowned spiritual and cultural destination, attracting thousands of pilgrims and visitors each year. The neighborhood becomes congested during major religious holidays that are deeply rooted in Hindu culture and local cultural norms. Ramkund is a holy bathing ghat where devotees perform ritual bathing, ancestral ceremonies (Shraddha श्राद्ध), and festival offerings. Significant festivals commemorated annually on a grand scale include:

Festival / Ritual	Importance (Why It Is Celebrated?)	Period & Activities at Site	What Degrades the Site?
Makar Sankranti	Marks the sun's entry into Capricorn; symbolises spiritual	**January**: Mass holy dips in the Godavari at Ramkund.	Increased organic waste, soap residues, crowd pressure on ghats, and water contamination.

Festival / Ritual	Importance (Why It Is Celebrated?)	Period & Activities at Site	What Degrades the Site?
	renewal and purification.		
Mahashivratri	Devoted to Lord Shiva; night-long prayers for divine blessings and liberation.	**February/March**: Vigils, temple visits, ritual bathing, large pilgrim gatherings.	Littering near temples and ghats, noise pollution, and overuse of limited public sanitation infrastructure.
Ram Navami	Celebrates the birth of Lord Rama; significant to Ramkund due to his exile-related presence.	**March/April**: Ceremonies, processions, rituals at Ramkund and nearby temples.	Solid waste accumulation, crowding on narrow lanes, and pressure on water and waste management systems.
Gudhi Padwa	Maharashtrian New Year; symbolic of victory and renewal.	**March/April**: Traditional processions, offerings at temples in Panchavati.	Temporary encroachments, noise, improper disposal of ritual materials, and congestion.
Ganesh Visarjan (Chaturthi)	Marks the immersion of Lord Ganesh idols on Anant Chaturdashi	**August/September**: Thousands gather for small idol immersion in Godavari at Ramkund.	Water pollution from Plaster of Paris idols and toxic paints, blocked drainage, and intense crowding at ghats.
Dussehra & Diwali	Celebrates the victory of good over evil (Dussehra) and the return of Lord Rama (Diwali).	**October/November**: Religious performances, lighting of temples and ghats, gatherings.	Fireworks and lamp residue, increased plastic waste, stress on local transport, and public spaces.
Kumbh Mela	Occurs every 12 years, ritual bathing is believed to cleanse sins and bring moksha (liberation).	**Last held in 2015, next in 2027**: Millions take holy dips in the river over several weeks.	Severe overuse of civic amenities, water contamination, erosion of ghats, massive waste generation, noise, and traffic.
Daily Rituals & Ceremonies	Includes shraddha (ancestral rites), bathing, religious offerings, and prayers.	**Year-round, daily**: Offerings in a river, burning of incense and candles, immersion of ashes, etc.	Continuous dumping of organic and ritual waste into a river, soap/shampoo contamination, and erosion of riverbanks.

Table 21 Activity Chart and degradation level

Figure 55 Image showing ritualistic practices on the Godavari Ghat

History of Overcrowding Challenges –

1. Kumbh Mela 2003 and 2015: A huge influx of nearly 7 million pilgrims overburdened the city's civic infrastructure.
2. Ganesh Visarjan Days: Recurring instances of water contamination and riverbank overcrowding resulting from unregulated idol immersion.
3. During annual festive seasons, local authorities have persistently faced challenges related to garbage disposal, sanitary overflow, and traffic congestion.

Why the Area Needs Immediate Attention?

Activity	Type of Degradation
Mass bathing rituals	Increased organic waste, soap/shampoo residues in the river
Idol immersion (Ganesh Chaturthi, other festivals)	Plaster of Paris and toxic paints are polluting the water
Ancestral rituals (shraddha)	Ash, garlands, and ritual materials dumped into the Godavari
Littering by tourists	Accumulation of plastic, food wrappers, and disposable items near ghats
Unregulated street vending	Congestion, waste accumulation, and illegal encroachments
Vehicular congestion in narrow lanes	Air pollution and strain on local mobility infrastructure
Lack of public toilets or their misuse	Open defecation, contamination of water sources
Overbuilt infrastructure	Encroachment on riverbanks and green zones, reducing natural buffer areas

Table 22 Table showing Activities and Degradation Level

Operational Pressures – Severely strained public infrastructure: Sanitation services, drinkable water supplies, and waste containers become nonfunctional during the peak period. Weak crowd management procedures lead to uncontrolled mobility and safety hazards. Traffic congestion on access roads: The narrow streets of Panchavati experience congestion on festival days due to improper traffic control and a rush of vehicles. Spreading effects impact areas nearby. The increasing number of vendors, such as souvenir stores and eateries within sacred areas, damages both the spiritual and environmental integrity of these locations. The site has transformed into a "religious-tourism zone" rather than a "pilgrimage sanctum."

- **Unregulated Urban Development along the Godavari River in Nashik**

According to the Nashik Development Control Regulations (DCR), a designated buffer zone must be protected from the high flood line of rivers, and construction in these areas is governed by strict standards. The permissible Floor Space Index (FSI) in Nashik is dependent upon the development zone and its proximity to environmentally sensitive regions. In waterfront areas, the Floor Space Index (FSI) is often limited between 1.0 and 1.5, dependent upon site conditions and planning approvals. If neglected, these developments continue to degrade the ecological integrity and cultural significance of the river.

Figure 56 Unregulated Urban Development along the Godavari River in Nashik

- **Flooding**

The historical data shows significant floods occurred almost every five years, with major ones in 1939, 1965, 1969, 1976, 1979, 2004, 2005, 2006, 2008, 2016, and 2019. The 1976 flood occurred mainly due to dam releases, with a recorded discharge of 9977 m3/s. Other major floods occurred in 2006, with a discharge of 8857 m3/s at Kopargaon, and in 2016, when Nashik experienced flooding due to intense rainfall. These inundations are often linked with low-pressure systems and heavy rainfall. A primary concern is the growth of construction, such as temples and ghats, within the high flood line (HFL) of the river. According to the Nashik Development Control Regulations (DCR), a defined no-development buffer zone must be protected from the HFL for public safety and ecological balance. In the Panchavati area and the old city centre, this law has been improperly applied, resulting in the construction of unauthorised religious and commercial structures inside flood-prone zones. (Dipali et al., 2019; Netake & Koranne, 2025)

Figure 57 Flooding

Figure 58 Flooding

- **Degradation of Urban Waterbodies due to Poor Governance and Management**

Visible Signs of Degradation – During the visit, extensive vegetative growth was observed on a longer stretch of the Godavari. Algae growth is a major indicator signifies pollution resulting from uncontrolled sewage discharge and runoff from urban and agricultural areas. Lack of buffer zones and riparian vegetation maintenance could be due to illegal construction. Despite its closeness to residential or business areas, the water body seems inaccessible to citizens. This mismanagement affects the waterbody's capacity to deliver essential ecosystem services such as water purification, flood mitigation, microclimatic regulation, and cultural and recreational advantages, leading to both ecological and socio-economic damage for the urban residents. (*Final Report _ NEERI Project Godavari Beautification*, n.d.)

Figure 59 Degradation of Urban Waterbody due to Poor Governance and Management (Source:Author)

- **Post-Festivities Water Pollution**

Before and after major religious festivals like Kumbh, holy bathing, Ram Navami, gudhi Padwa , water bodies often change into dumping grounds for ceremonial offerings and non-biodegradable refuse, significantly impairing water quality. The Central Pollution Control Board (CPCB, 2021) observes that religious activities heavily increase Biological Oxygen Demand (BOD) and faecal coliform levels in river banks near urban areas. Studies, including NEERI (2019), have shown higher levels of pollutants, including nitrates, phosphates, and heavy metals, in Nashik's Godavari River following festivals, attributed to the immersion of idols, synthetic materials, and food waste. As per the NEERI report of Godavari Action Plan 2016, with regulatory frameworks such as the Solid Waste Management Rules, 2016, and the Guidelines for Idol Immersion (CPCB, 2010), enforcement remains inadequate and civic responsibility is usually neglected. (*2_Project Proposals*, n.d.; *30_NASHIK_D_P_COMBINE_MAP_Model*, n.d.; Dipali et al., 2019)

The process of oxygen depletion and the collapse of aquatic ecosystems reduce the river's capacity to provide essential ecosystem services, including self-purification, groundwater recharge, biodiversity habitat, and cultural or religious importance. This contamination directly affects human health, particularly for individuals utilising the water for bathing, drinking, or livelihoods such as fishing and tourism. Also, the floating waste causes contagious and parasitic diseases, including various waterborne diseases. (*Env Status Report Nashik*, n.d.; Petsch et al., 2023)

Figure 60 Image showing waste in the Panchavati Area Post-festivities (Source:Author)

4.2.4. Final Area Delineation

The above-listed methodology (4.2.2) was thoroughly performed, validated and considered for the final area delineation. The Nashik (NMC) ward boundary data was collected through a municipal corporation and used for the digitisation. The delineation is performed using ArcGIS Pro software. The selected 6,8,10,12 four wards were thoroughly analysed and documented during the site visit. Using Google Earth Pro, the river shape file and ward boundary KML/kmz file were created and converted to a layer using the "KML to layer" tool. Using the attribute table (Select by Attributes) as shown in the figure. The wards were selected for the next step using the expression as "Ward_No" IN (6, 8, 10, 12).

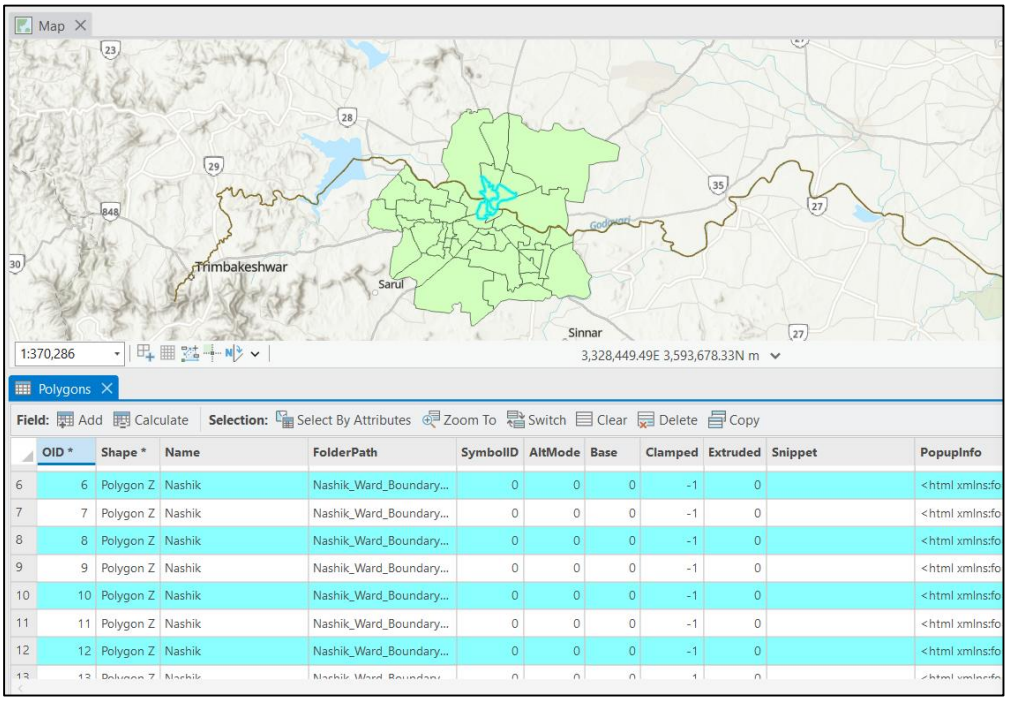


Figure 61: Image showing selected wards for the buffer analysis (Source:Author)

Using the clip tool river line shapefile was clipped to the selected wards. This helps to get the buffer along the river stretch passing through the selected wards. The clipped rive line is then used as an input feature for buffer analysis. To get the buffer, the width was selected on the basis of official guidelines. According to URDPFI, in urban areas 15 to 30-meter minimum is often considered for green belts. The NMCG/ Namami Gange Guidelines suggest buffer zones for afforestation, floodplain restoration and construction control. (*URDPFI Guidelines Vol I*, n.d.) The guidelines recommend a 100-meter to 500-meter buffer along the river, depending on the river width and urban context. The Godavari River flowing through the Nashik NMC area is narrower and has lesser depth compared to the river's another stretch. The river has a maximum width of 580km overall. According to NMC DP reports and the hydrological survey report produced by the water resource department, Nashik, on the selected site, the width is a maximum of 200 meters. (*Nashik Draft Revised DP 2016-2036*, n.d.) While the river has been observed to undergo seasonal changes in depth, the selected site has shallow depth as it is used for the holy bathing and river-related ritualistic practices.

Due to non-permeable surface around the river on the selected part, the flooding and very few summer periods have seen changes in river water depth.

As per the EIA notifications, 200 to 500 m for major rivers, including both sides of the center of the river in urban areas, is suggested for buffer zones around the water bodies in the riverfront projects, land management projects, planning or zoning projects. As per the floodplain planning guidelines of Nashik, published by NMC, prepared by NEERI, suggests a 200-meter width buffer on both the sides of the river center line.

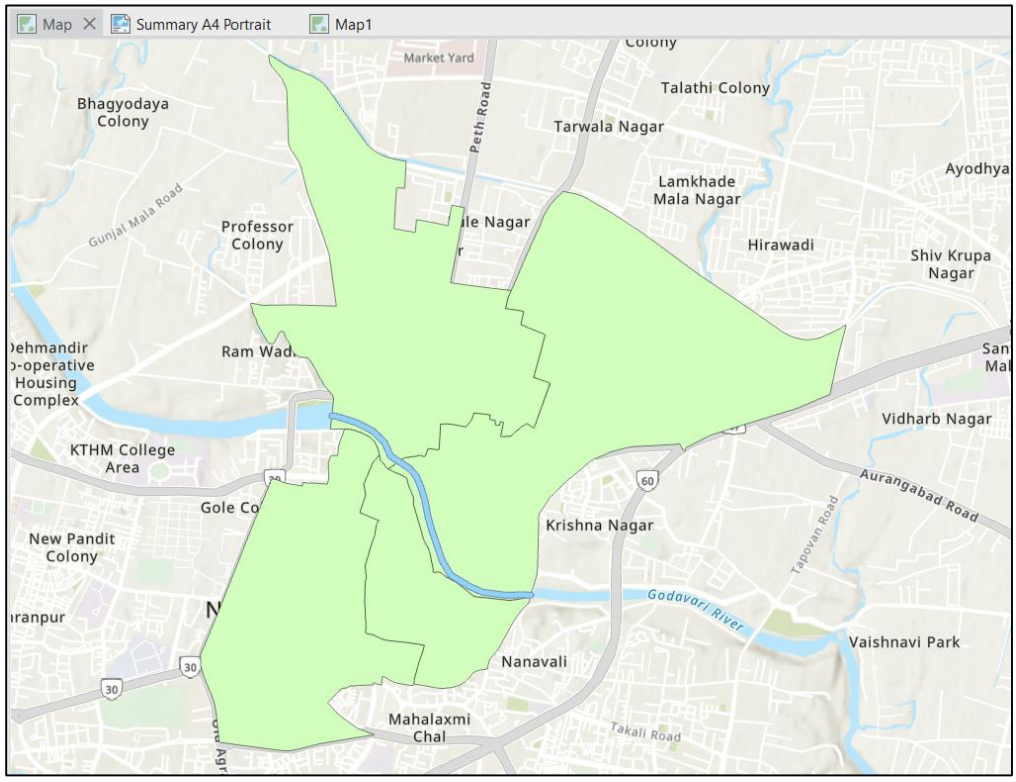


Figure 62: Image showing clipped riverline to selected wards (Source:Auhtor)

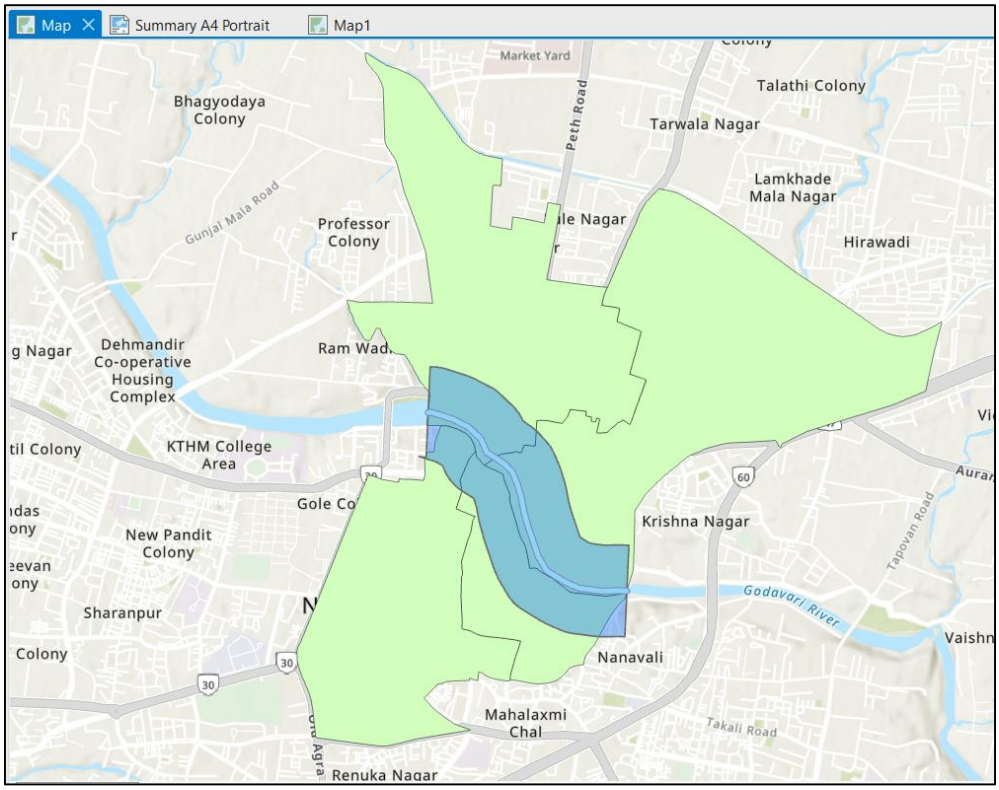


Figure 63: Image showing buffer selected for the intervention (Source:Author)

Considering all the guidelines and official documents listed above, 250 buffer on both the sides of the river centre line was selected for the buffer analysis. A total 500-meter buffer polygon was created with the help of ArcGIS Pro. The buffer was clipped to wards polygon layer again for clarity. As per the methodology, initially mapped polluted points on the Godavari River, detected by MPCB, was overlayed on the buffer map, namely Ahilyabai Holkar Bridge, Panchavati Ghat, Ramsetu and Talkuteshwar Mahadev Temple. In these four polluted points, Panchavati Ghat is the most polluted point observed and informed by the citizens and Nashik-based stakeholders. The selected intervention points were validated by the five experts and 12 stakeholders from NMC, MIDC Nashik, MPCB Nashik, Water Resource Department Nashik, Smart City Mission Nashik SPV, District Planning Office and TCPO. The map (Figure no.64) shows the finalised site area for the final intervention of the project. (*Env Status Report Nashik*, n.d.; *Nashik Draft Revised DP 2016-2036*, n.d.; *River_Sensitive_Urban_Planning_NMCG_1737536820*, n.d.)

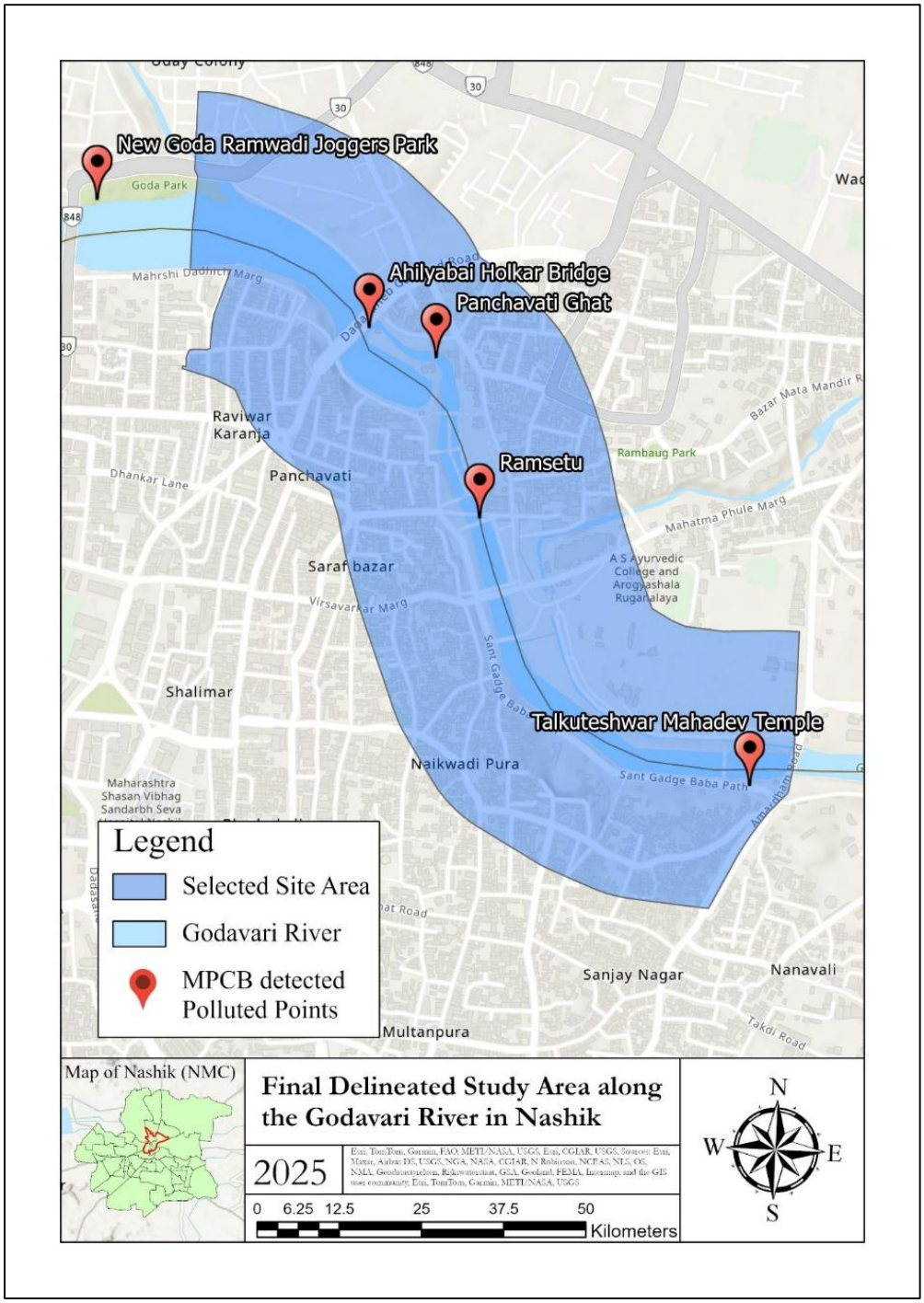


Figure 64: Map showing the final delineated area for the project (Source:Author)

4.2.5. Land Use Analysis

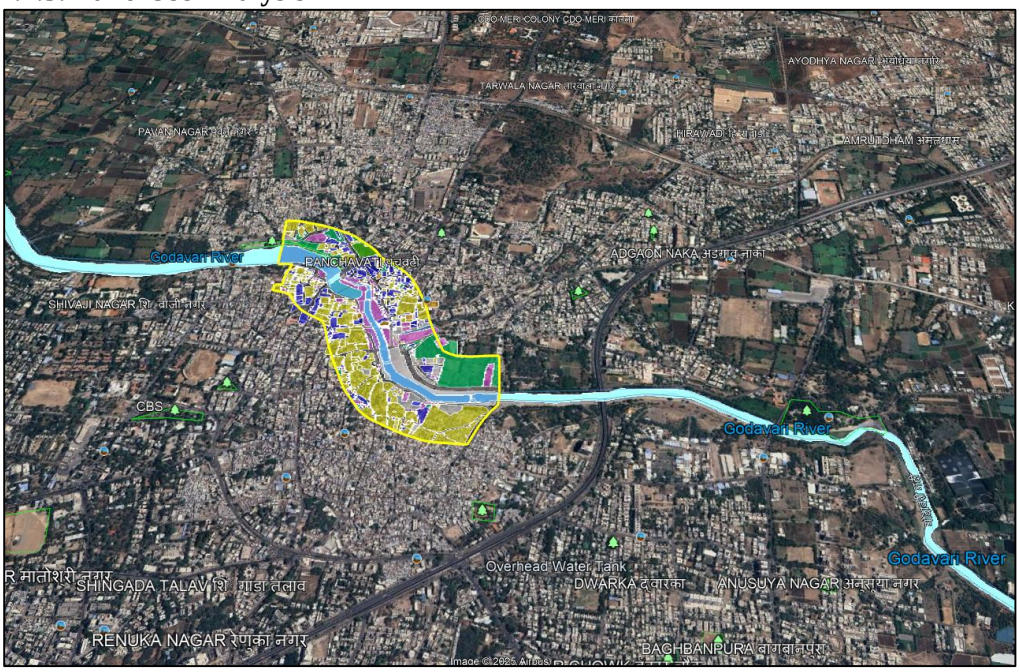


Figure 65: Nashik City View with highlighted project site (Source:Author)

On the selected site, the land use has been digitised using Google Earth Pro, On-site mapping and by referring to existing land use maps. This exercise has been conducted to understand the dominance of land use and the possible ecosystem services in the selected site.

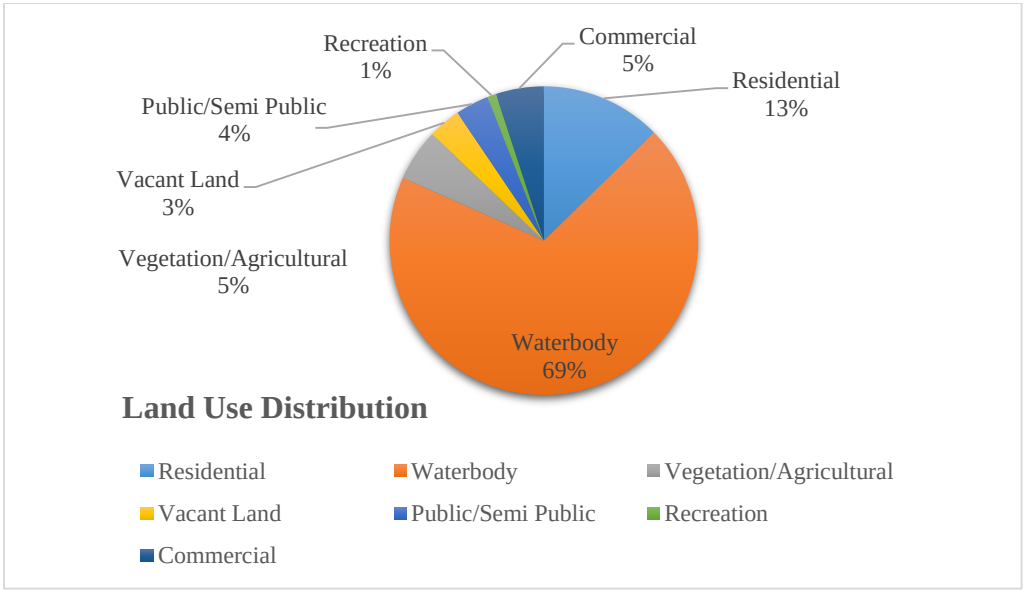


Figure 66: Pie Chart Showing Land Use Distribution (Source:Author)

Table 23: Land Use Distribution on the Selected Site (Source:Author)

Land use	**Area (sqm)**
Residential	234796.28
Waterbody	1281373.43
Vegetation/Agricultural	100672.41
Vacant Land	63718.70
Public/Semi Public	65133.58
Recreation	17202.10
Commercial	93172.87

The land use map no. 67 above depicts the spatial distribution and dominance of different land use categories within the selected riverside study area along the Godavari River in Nashik. The mapping is done using Google Earth Pro digitizing, on-site field surveys, and verification with existing land use maps from the Nashik Municipal Corporation (NMC). The area of interest has been defined using an identified buffer zone along the river stretch passing key metropolitan areas including Panchavati, Ramkund, Tapovan, and Saraf Bazaar. This mapping aimed to examine the spatial organisation of land use patterns and identify their potential contributions to ecosystem services within the urban riverine context.

In ArcGIS Pro, polygons were manually created and classified into seven principal land use categories: Residential, Commercial, Public/Semi-Public, Vegetation/Agricultural, Religious Spaces, Waterbody, and Vacant Land. Each polygon was assigned a land use type and its area was calculated in square meters, utilising the Calculate Geometry tool. The analysis indicates that the predominant land cover is Waterbody, including 1,281,373 sqm, which represents the expanse of the Godavari River. There are Residential zones (234,796 sqm) and Commercial areas (93,172 sqm), highlighting the urban density and economic activity in this section of Nashik. Vegetation and agricultural areas encompass around 100,672 square meters, whereas Public/Semi-Public land uses, comprising institutions, hospitals, and government edifices, constitute 65,134 square meters. Vacant lands cover 63,718 sqm, suggesting either a lack of use or transitional areas, while recreational open spaces (parks, grounds) are limited to 17,202 sqm, highlighting the necessity for better green infrastructure along the riverbank. The map shows unique spatial clustering of various land uses, with residential development concentrated in the southern and central regions, business activity situated along primary road corridors, and vegetation zones mainly located on the southeastern fringe. Religious sites and ghats are primarily situated around the Ramkund and Tapovan areas, indicating the cultural and spiritual importance of the river. The unoccupied and recreational grounds seem scattered and suggesting a deficiency in the continuity of public open spaces.

Inference:

This land use map is important for the thesis as it constitutes the foundational layer for ecosystem service value and spatial planning. Each land use category is associated with various ecosystem services (e.g., provisioning from agricultural areas, regulating from vegetation, and cultural from religious sites), and recognising their spatial impact is crucial for developing spatial strategies. The map shows the gap in land use, specifically the deficiency of recreational areas and the overgrowth of developed regions adjacent to vulnerable riverbanks. These observations will inform the subsequent phase to prioritise conservation areas, eco-sensitive zoning, and the integration of multifunctional land use. This exercise establishes a geographical basis for connecting urban land use with ecological functionality, consistent with the overarching objective of re-envisioning the Godavari River as an economic and ecological resource.

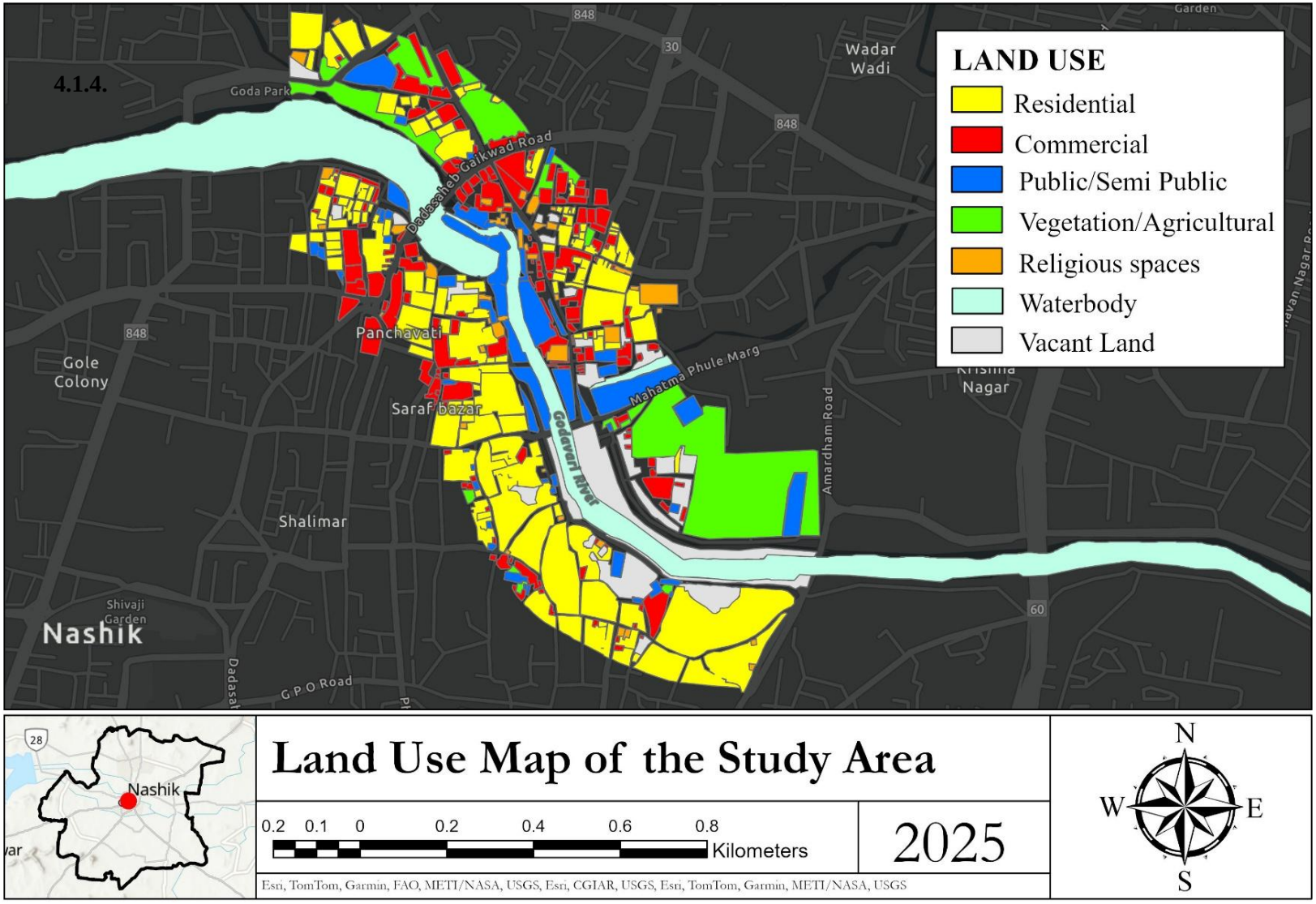


Figure 67: Land Use Map of the Study Area (Source:Author)

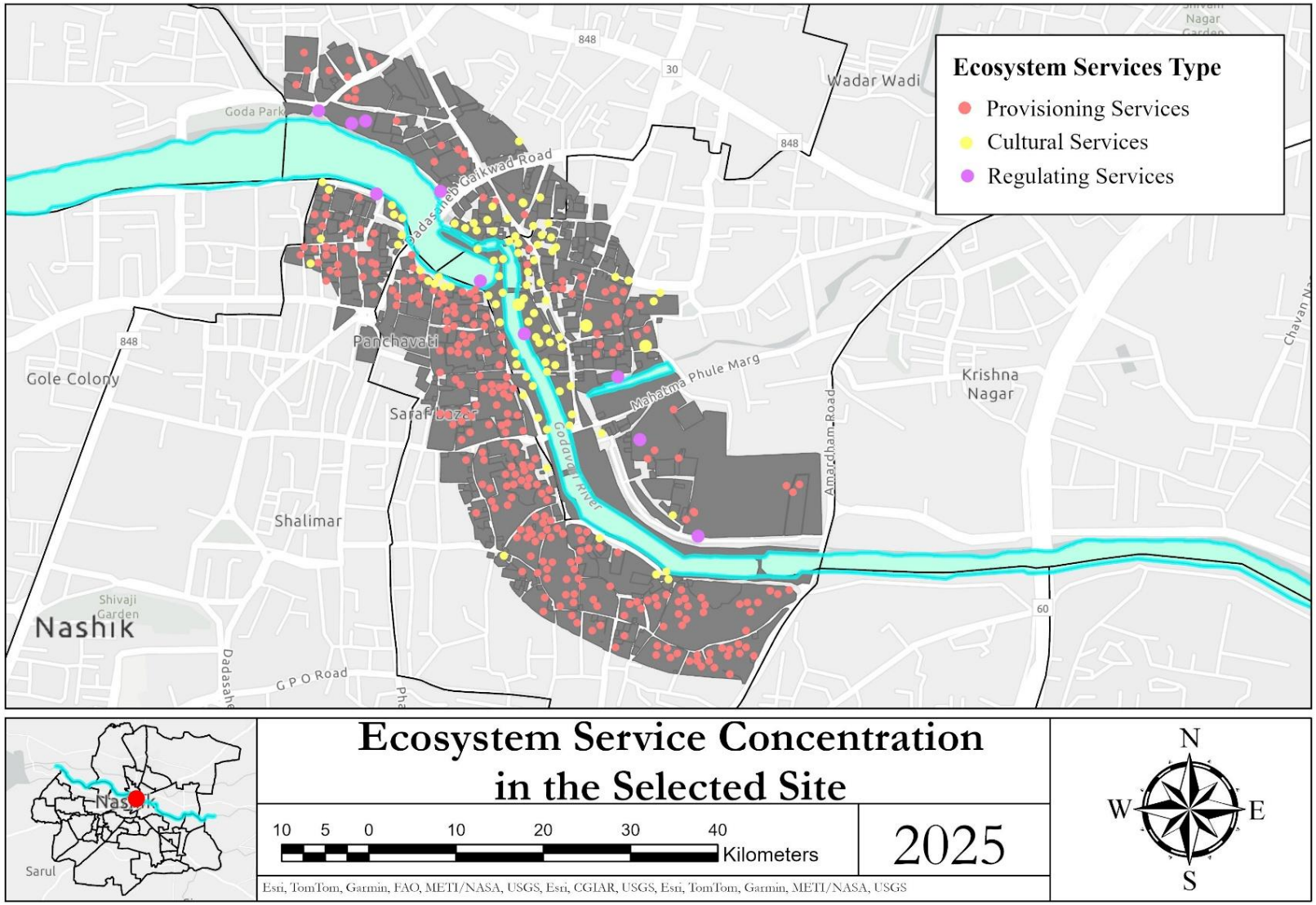


Figure 68: Ecosystem Services Concentration in the Selected Site (Source:Author)

4.2.6. Mapping of Ecosystem Services

This exercise was performed to spatially assess and indicate the concentration of ES at the selected study site along the Godavari in Nashik, with the aim of combining ecological value into spatial planning frameworks. The mapping directly results from a previously developed ecosystem service matrix that quantified the provisioning, regulating, and cultural services received by different land use groups. A systematic GIS-based approach was used in ArcGIS Pro to digitise these services, merging field observations, and attribute analysis.

Three main sources of information are combined to construct the map:
(a) a matrix-based assessment 2;
(b)Stakeholder and citizen perception surveys; and
(c)Ground-truthing via in-person site visits.
According to their service contribution ratings (on a scale from low-1 to high-5), the various land use and functional categories within the site, including ghats, open spaces, waterways, religious sites, and informal settlements, were assigned ecosystem services using the matrix technique. Literature, secondary reports, and expert advice were used to inform these scores. The significance of each service in particular places was further validated by perceptual and usage-based input gathered from citizens and stakeholders using Google Forms.

Methodology:
The initial land use layer was created by mapping built and natural elements via Google Earth Pro by field survey mapping and verified with secondary data sources, including existing land use plans from the Nashik Municipal Corporation (NMC) and Smart City GIS portals. Each land use polygon was classified into a primary land use classification (e.g., Residential, Commercial, Vegetation/Agricultural, Public/Semi-Public, Recreational/Religious) and refined with buffer zoning along the Godavari River corridor. A predetermined ES valuation matrix, created using the Millennium Ecosystem Assessment (MEA) framework, was adopted. This matrix allocated scores (from 1 to 5) to each land use category for three primary ecosystem service types: Provisioning Services (e.g., drinking water, food, industrial water usage), Regulating Services (e.g., air quality, flood mitigation, microclimate regulation), and Cultural Services (e.g., heritage, religious tourism, spiritual significance).

The attribute table of each polygon has been updated with score values in new fields: Provisioning_Services, Regulating_Services, and Cultural_Services. These data illustrated the qualitative-quantitative connection between land use and ecosystem service benefits. Points were created for each polygon using the 'Feature to Point' tool to act as visual indicators of spatial ecosystem service intensity. The points acquired the ES attribute values from their source polygons. For visualisation, each point was represented using Unique Value Symbology, with specific colors designated for each ES type: Red for Provisioning Services, Yellow for Cultural Services, and Purple for Regulating Services. The dimensions and positioning of the dots show ecosystem service concentrations inside each land use section.

Inferences:

The resulting map shows the spatial distribution and amount of ecosystem services inside the selected buffer zone. Red point clusters denote areas where provisioning services prevail, such as densely populated residential or agricultural regions; yellow points are concentrated around religious and heritage sites, highlighting cultural significance; and purple points coincide with natural or semi-natural land uses, representing regulating functions such as cooling, filtration, or carbon sequestration. A spatial relationship between land use density and the concentration of ecosystem services, focusing on areas of multifunctionality along areas that show ecological failure due to the urban proximity.

Importance of the Exercise:

This mapping serves a purpose at this stage of the thesis as it helps to move from land use assessment to spatial strategy development. The map transforms ecosystem service data into spatial indicators, offering justification for zoning suggestions, buffer laws, and ecologically informed land management interventions. It supports Objective 3 of the thesis, which aims to formulate spatial planning recommendations that regard the Godavari River not alone as an ecological component but as an economic and social asset built on ecosystem functionality. The graphical representation connects technical land use analysis with decision-making, facilitating the identification of environmentally significant places, conservation-prioritised zones, and land uses that can be used for multifunctional purposes.

This ES concentration map includes the site area understanding, GIS methodologies, and ecosystem valuation into a uniform spatial representation. The river corridor works beyond limited physical infrastructure; it supports a multidimensional set of ecological and cultural roles that must be conserved and improved in possible development strategy. The study highlights a reproducible approach for integrating ecosystem service considerations into urban development, particularly in river-focused Indian communities such as Nashik.

CHAPTER 5:

PROPOSALS AND RECOMMENDATIONS

5. PROPOSALS AND RECOMMENDATIONS

This chapter synthesizes the principal challenges affecting the Godavari River and its services, derived from both secondary research and primary site assessments. It provides a basis for proposing comprehensive, multi-dimensional actions designed to re-imagine the river as a valuable ecological and cultural resource. The ideas follow to the principles of river sensitivity, sustainability, and smooth-responsible governance.

5.1. Issues Identified

The study explores the interconnected challenges impacting the Godavari River inside the Nashik urban area, mainly in the Panchavati–Ramkund corridor. First, unsustainable land-use practices, including excessive development, encroachment on floodplains, and poorly managed development along the riverbanks, have resulted in diminished groundwater recharge and ecological deterioration. The water pollution from untreated residential sewage, ceremonial waste, and festival debris continuously weakens the river's health and ecological integrity, impacting both aquatic organisms and the human populations reliant on it. The ecosystem services degradation comprising supplying (clean water), regulating (microclimate, water purification), cultural (religious sanctity, heritage, pilgrimage tourism), and supporting (biodiversity) is evident from stakeholder surveys and GIS-based analysis. Overall, insufficient community stewardship and understanding resulted in disconnection and exploitation of river resources, causing ecological strain.

These issues highlight the pressing need for an open and holistic river management framework that surpasses administrative barriers and reestablishes the Godavari as a pivotal ecological backbone of the city. The following sections include proposals that directly address the highlighted challenges, with the objective of facilitating a multi-benefit strategy for river restoration, economic growth, and sustainable urban development.

5.2. Proposals and Recommendations

5.2.1. Proposal 1: Ramkund Real-Time Water Level Monitoring System

Issue Addressing: Drying of Ramkund (4.2.3)

Research Gap: Ramkund, Panchavati, is a sacred place in the core city of Nashik. It has a higher cultural footfall zone overall in the city. The place is used for ancestral rituals-ceremonies, festival celebrations, holy bathing, etc. In 2016, the drying of this ghat was noticed, which occurred first more than a century ago. This proposal has been planned considering future safety and ensuring continuity of cultural ecosystem services on the ghat. The majority of the present water data is either city-level or irregular (pre-festival measurements), lacking continuous monitoring or real-time evaluation. Existing water governance frameworks depend significantly on manual inspections and reactive strategies, which are neither sustainable nor accurate in the face of fluctuating climatic and urban water demand conditions. No publicly available dashboard or early warning system exists that correlates groundwater levels, surface flow, upstream diversions, or localised rainfall to manage the hydrological balance at Ramkund predictively. The lack of a river-level monitoring system at the micro-watershed scale, particularly in valuable heritage areas such as Ramkund, signifies a significant deficiency in technological implementation and proactive governance.

Justification for the Proposal
The Ramkund Real-Time Water Level Monitoring System is proposed to address this gap by installing sensor-based, telemetry-enabled monitoring stations at strategic points within the Ramkund precinct. This system will track water levels, flow variability, and potential early signs of drying or stagnation. CCTV + water level sensors.

Proposed Sensor Locations

Location	Justification
West side entry of Ramkund	Main ritual zone, early indicator of water retreat during summer
South-central wall	Deepest point in tank-ideal for depth trend analysis
North end near overflow channel	Helps detect inflow disruption or backflow
Link channel from upstream feeder	To track consistency and delay in flow recharge

Downstream small weir point	Detects whether outflow is reducing base level

Table 24: Proposed Sensor Locations

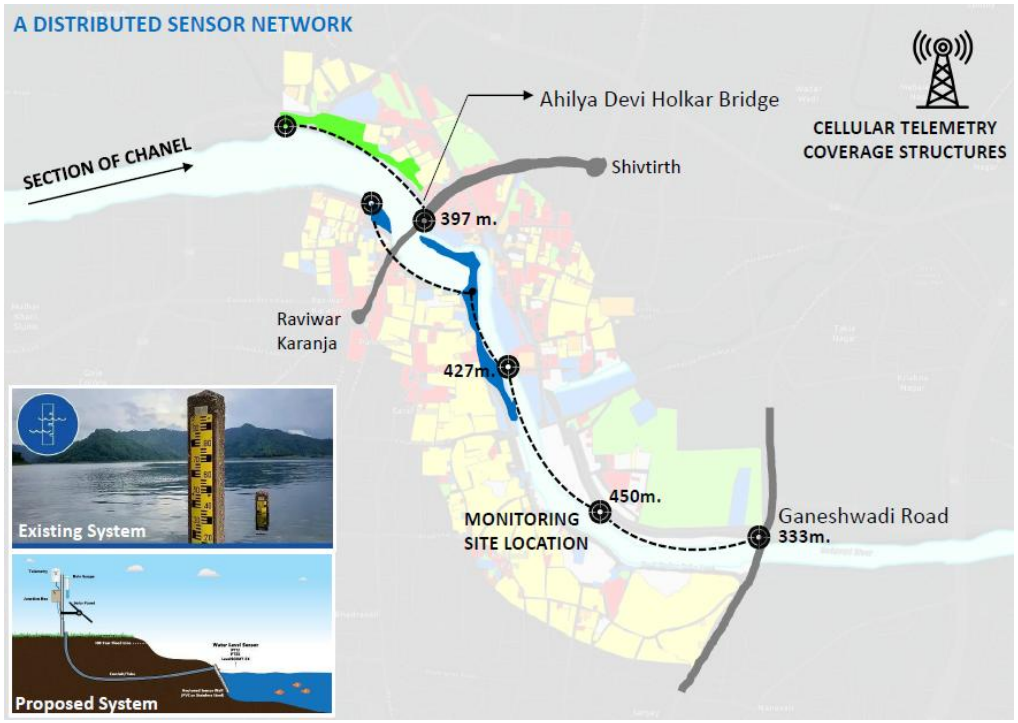


Figure 69: Proposed Distributed Network System

Funding Source: Smart City + AMRUT

Budget: ₹ 15–20 lakhs (approx. for sensors, dashboard, and maintenance)

Benefits to NMC:

1. Early Warning System for Crisis Prevention: Allows NMC to monitor real-time water levels and take timely action to prevent drought events, such as those in 2016.

2. Data-Driven Decision Making: Planning and coordination with upstream irrigation releases using accurate water depth data.

3. Smart City Integration: Nashik's Smart City dashboard with live river data, contributing to intelligent urban water management.

4. Improved Service Delivery: Helps NMC ensure uninterrupted spiritual services, boosting public satisfaction and civic trust.

5. Eco-Policy Compliance: Aligns with mandates under AMRUT, National River Conservation Plan, and NIUA guidelines for urban river monitoring**.**

Benefits to Pilgrims:

1. Protection of Ritual Continuity: Ensures water is available for key religious rituals (snan, pind daan, jalabhishek) even in dry seasons.

2. Preservation of Spiritual Ambience: Prevents emotionally and symbolically distressing scenes of an empty Ramkund.

3. Transparency and Trust: Real-time dashboard and visible sensors give assurance that the spiritual infrastructure is being actively managed.

4. Cultural Heritage Respect: Reinforces the sanctity of Ramkund as a sacred, protected, and cared-for site, maintaining its cultural value.

Timeline:

Phase	Duration	Key Actions
Planning Phase	**1 month**	**Site survey, stakeholder Meetings, vendor hiring**
Sourcing	**1 month**	**Purchase of sensors, IT setup**
Installation	**2 weeks**	**Sensor installation and system testing**
Working	**2 weeks**	**NMC + temple coordination for dashboard use**
Monitoring	**1 week**	**Public dashboard launch**
Ongoing	**Continuous**	**Weekly reporting + seasonal water audits**

Table 25 Timeline for the Intervention

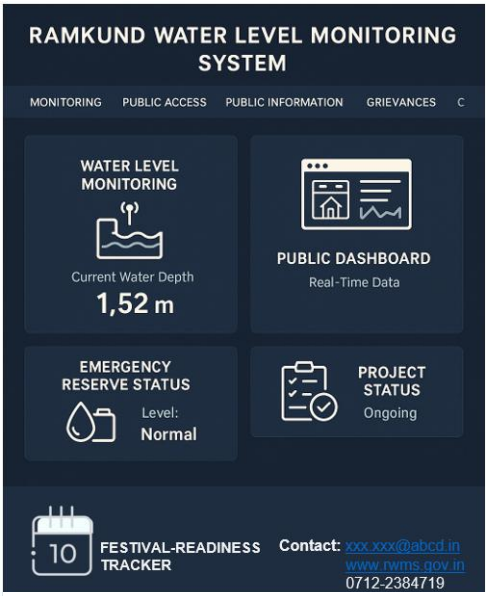


Figure 70: River Health Monitoring Dashboard

Relating to River-Sensitivity and Sustainability

The proposal aligns with the **SDG 6 (Clean Water & Sanitation)** and **SDG 11 (Sustainable Cities & Communities)** by strengthening water security and resilience within urban sacred spaces.

5.2.2. Recommendation 1: Integrated Upstream Flow Regulation Protocol (I-UFRP)

Issue Addressing: Drying of Ramkund (4.2.3)

Research Gap: The present management of the riverbank in Nashik predominantly focuses on downstream urban infrastructure and flood mitigation, while neglecting upstream flow dynamics, biological thresholds, and seasonal flow variability. Integrated frameworks that account for catchment-wide hydrological dynamics, ecological baseflows, and the effects of upstream interventions (such as dams, sand mining, or urban runoff) on downstream ecosystem services and cultural assets are insufficiently developed.

Partnership Through - Memorandum of Understanding (MoU) Formation and Regulatory Framework. A structured, inter-agency coordination protocol to maintain a minimum environmental flow (e-flow) at Ramkund, ensuring year-round hydrological and cultural functionality of the Godavari River stretch in Nashik. MoU Preparation Including:

- Roles, responsibilities, release schedules
- Emergency flow protocols
- Data sharing and real-time coordination mechanism

Relating to River-Sensitivity & Sustainability

- **River Sensitivity:** Recognizes Ramkund's role in Nashik's sacred urban landscape.

- **Sustainability:** Balances urban-industrial use with ecological and cultural continuity. Uses low-carbon, smart infrastructure (sensors, dashboards) for long-term monitoring.

Justification for the Proposal
The proposal fills this crucial gap by setting up a systemic flow regulation mechanism that maintains a balance between urban water demands, religious use patterns, and ecological requirements.

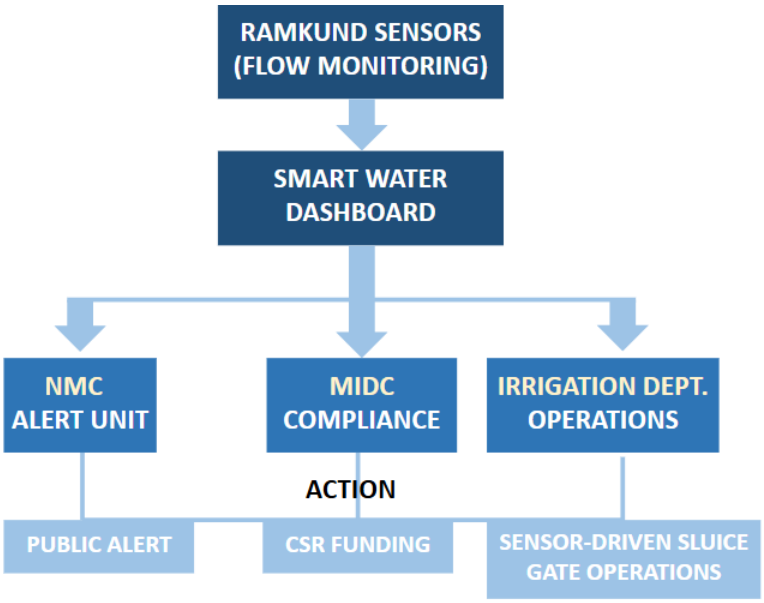


Figure 71 Proposed Monitoring Chart

5.2.3. Recommendation 2: "No-Drying Mandate" in Development Control Regulations (DCRs)

A policy-level amendment to Nashik's DCR that prevents any upstream development (industrial, agricultural, real estate) which interferes with or reduces the base environmental flow (e-flow) into Ramkund and adjacent riverfront ghats. Ammendment of legal clause under Environmentally Sensitive Zones in DCR -
"No land use or infrastructural development shall be permitted that leads to interruption of base environmental flows into Ramkund or associated ghats". Mandate a "Hydrological Impact Assessment" for all new upstream development projects. Applied through Nashik Municipal Corporation, Town Planning Department, and State Government.

Relation with River Sensitivity and Sustainability

- Continuous river flow
- A legal safeguard against encroachment
- Hydrological and Ecological Integrity of the Godavari

5.2.4. Recommendation 3: Mandatory Environmental Clearance Review for Construction Near Upstream Feeder Channels

Any construction near upstream feeder channels or minor tributaries of the Godavari River should submit a mandatory Environmental Impact Assessment (EIA) and special clearance. Focused on upstream zones to secure downstream water flow. Preserves micro-catchments, which are essential for groundwater recharge and maintaining base

flows. Prevents urban choking of natural flow paths, ensuring natural resilience to flooding and drought.

How Can We Implement It?

- Introducing a GIS-based checklist in NMC's building permit system.
- Nodal Authority: NMC's Environmental Cell in coordination with Maharashtra State Environment Impact Assessment Authority (SEIAA) to issue clearances.
- Public Disclosure: Display clearance status on Nashik Smart City dashboard.

5.2.5. Proposal 2 – Spatial Management Strategies for Pilgrim Flow and Activity Zones

Issue Addressing: Overcrowding Crisis at Ramkund (4.2.3)

Research Gap: The proposal addresses the overcrowding situation at Ramkund explained in Section 4.2.3, where high pedestrian traffic during peak pilgrimage periods results in congestion, safety hazards, environmental deterioration, and reduced ritual experiences. Estimates suggest that festival days may draw more than 200,000 to 300,000 attendees, far beyond the accommodation and circulation capacity of the Ramkund area. Integrated spatial planning for the management of large-scale, periodic religious gatherings in riverfront situations is lacking. In India, the majority of riverside development initiatives prioritize aesthetic enhancement or sanitation, neglecting the temporality, cultural practices, and spatial dynamics of pilgrimage.

To delineate and spatially allocate areas within the Ramkund precinct for differentiated user functions (ritual, observation, rest/movement—during festivals and high footfall periods).

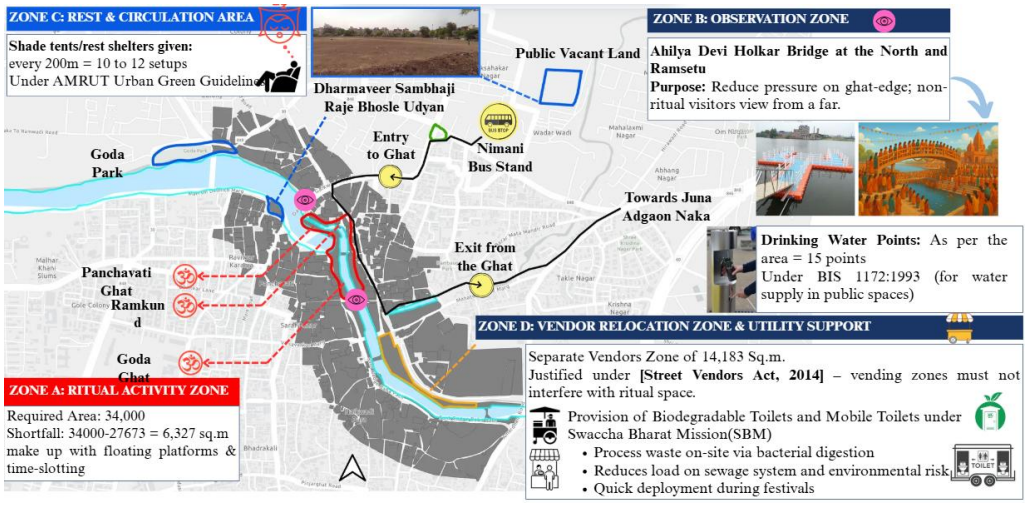


Figure 72: Designated Zones For Each Activity Enhancing Cultural Ecosystem Services

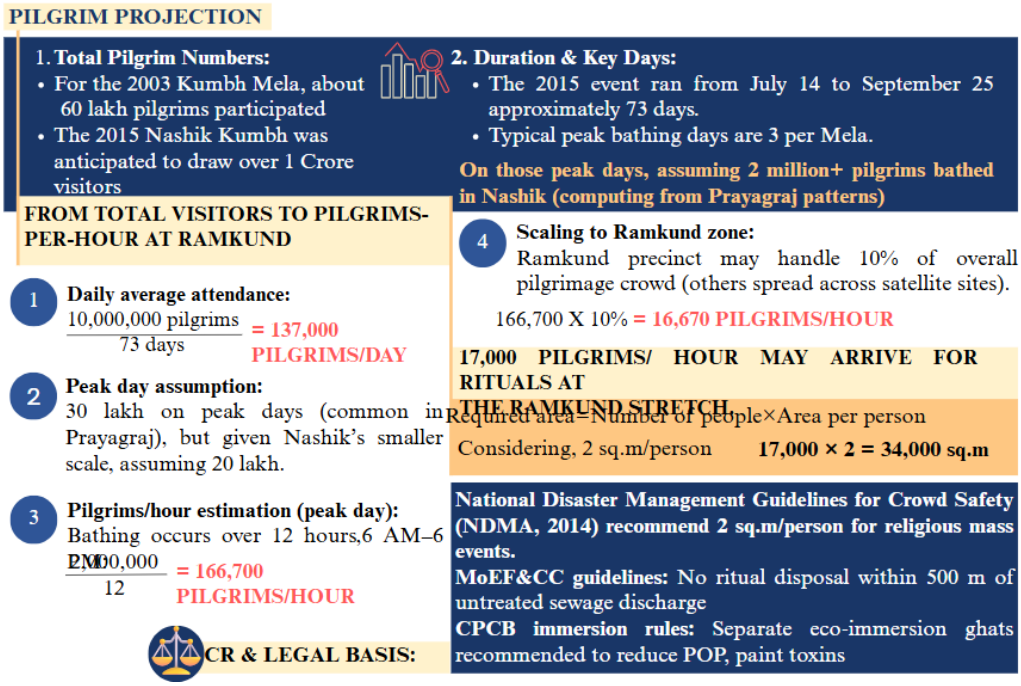


Figure 73: Pilgrim Projection and Area Requirement Calculations

Justification: The plan addresses this need by implementing a zoned spatial framework that encompasses designated ritual platforms, observation zones, circulation buffers, safety exits, and service zones. This approach ensures:

- Enhancing cultural awareness by following to ceremonial demands.
- Public safety using spatial decongestion and crowd flow principles.
- Promoting sustainability through the reduction of stress on riverbanks and the improvement of user experience.

Zone A: Ritual Activity Zone: SIGNAGE

- Ensures Streamlined Crowd Management
- Environmental Protection & Cleanliness
- Improved Visitor Experience

To implement signage and basic zoning infrastructure (entry/exit points, bathing zone markers, utility/waste/toilets) in the Ritual Activity Zone at Ramkund, Panchavati, Nashik. Estimated Total: ₹ 2,16,200/- (Including Design, Planning, Installation, & Contingency) (Can vary slightly depending on material and site-specific civil work). Financing Agency: Pilgrimage Rejuvenation and Spiritual Augmentation Drive (PRASAD) Scheme.

Zone C: Rest & Circulation Area

- **Allocated: 25,664 sq.m.**
- DSRB Udyan = 1664 sq.m.
- Goda Park = 8,000 sq.m.
- Public Vcant Space Behind Nimani Bus Stand = 16,000 sq.m.

Seating Requirement Estimation Peak Crowd: 15,000 pilgrims/hour

Required seating = 10% of 15,000 = 1,500 seats minimum

7 Seats per structure = 215 Structures

Total Cost for 215 Units= 215 × ₹65,000 (avg.) = ₹1.397 Crores

Zone D: Vendor Relocation Zone & Utility Support

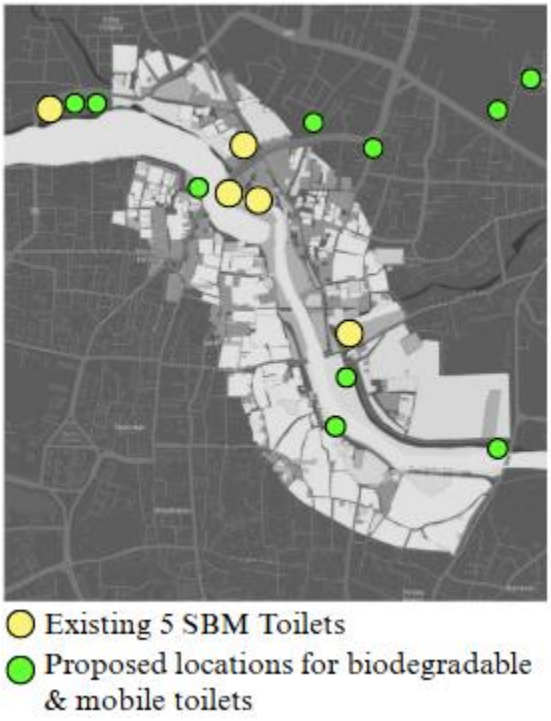


Figure 74: Existing and Proposed Toilet Locations

Bio-toilets comply with SBM 2.0's push for safe faecal waste management with digester systems. **Crowd Assumption:** 15,000 pilgrims/hour in Zone A (peak Kumbh-like events). Gender Split Estimate: 60% male, 40% female (common assumption in pilgrimage events).Men: 9,000 Women: 6,000. Toilet Norms: Swachh Bharat Urban (SBM-U) & MoHUA recommend:1 WC per 100 men and 1 WC per 50 women. For Men: 9,000 / 100 = 90 toilets and for Women: 6,000 / 50 = 120 toilets.

Total Needed= 210 toilet seats (WC).

Budget: (Considering 60% MT & 40% BioT) **Mobile Toilets** mid-range purchase cost (with cleaning service, water tank, and deployment): ₹70,000 per seat × 125 = ₹87,50,000 **Biodegradable Toilets (Bio-digester based units):** Cost per seat (incl. superstructure, twin leach pit/bio-digester, water source): ₹85,000 X 85 = 7,225,000

5.2.6. Proposal 3 – Godavari Pilgrimage Trail Network – Distributed Cultural Footfall

Issue Addressing: Overcrowding Crisis at Ramkund (4.2.3)

Research Gap: The Ramkund area has high pilgrim traffic, particularly around significant religious occasions, resulting in continuous overcrowding, environmental stress, and diminished quality of the ritual experience. Section 4.2.3 indicates that more than 70% of ritual activities and spiritual tourism are cantered in less than 10% of the overall length of the cultural riverside. Simultaneously, many historically and spiritually important locations across Panchavati and the adjacent riverbank are either neglected or not integrated into pilgrimage routes. Urban pilgrimage planning in India often lacks spatial plans for the distribution and connectivity of holy sites. There is a lack of adequate research or implementation of pilgrimage infrastructure that regards the city as a sacred environment rather than segregating sacred areas. Current approaches fail to incorporate pedestrian movement, and the spatial sequencing of rituals. Heritage management initiatives rarely connect invisible spiritual practices with tangible access networks.

Figure 75: Trail Route and Node Mapping

38 Minutes Heritage Spiritual Trail (2.8km)

Start Ramkund (Anchor ritual node)
Stop 1 Kapaleshwar Mandir
Stop 2 Kalaram Mandir (major footfall node)
Stop 3 Sita Gufa
Stop 4 Sri Kala Rama Swamy Temple
Stop 5 Saptashrungi Entry (inner shrines and pedestrian link)
Stop 6 Nashik Panchavati Mandir
Stop 7 Shree Someshwar Mandir (Old City Heritage Walk)
Stop 8 Prachin Shri Goreram Mandir
Final Destination Gandhi Talao

Justification: The trail network mitigates this significant deficiency by:

- Developing a distributed load model that reduces stress on Ramkund.
- Promoting heritage-driven urban revitalization of hidden areas.
- Improving the ritual travel experience via narrative-driven spatial planning.
- Facilitating inclusive pilgrimage through the provision of accessible pathways and shaded connections.

It corresponds with themes of cultural sustainability, spiritual tourism, and river-sensitive urbanism, while calling for decentralized development. The concept has the potential to enhance local livelihoods, foster community stewardship, and enhance urban resilience, serving as a sustainable tool for conservation and community engagement.

5.2.7. Proposal 4 – "Goda Vaani" Geo-Enabled Interactive Trail App

Issue Addressing: Overcrowding Crisis at Ramkund (4.2.3)

Research Gap: Despite the increasing number of heritage and tourist apps, there exists a deficiency of context-specific, geo-spatial digital instruments designed for urban riverscapes characterized by strong cultural and ecological identities. The majority of current pilgrimage applications are generic, static, and lack integration of interactive trail mapping, crowd analytics, or environmental awareness features. Furthermore, no existing platform assists municipal authorities or cultural groups in collecting real-time user data to guide future development.

Justification: The "Goda Vaani" application integrates the digital and physical realms by transforming the Godavari riverfront into an intelligent cultural corridor, improving the experience and administration of river-related activities. It provides support for:

- Decentralization of crowds by diverting people to underutilized websites.
- Cultural continuity via narrative and heritage explanation.
- Enhancing environmental awareness through the integration of river health warnings and reporting mechanisms.

This technology-driven strategy is in keeping with Digital India, the Smart Cities Mission, and urban resilience planning. It also improves data collecting for NMC, facilitating evidence-based decisions regarding infrastructure development, conservation initiatives, and tourist services.

Figure 76: Goda Vaani App

5.2.8. Proposal 5 – Gamified Eco-Pilgrimage App

Issue Addressing: Lack of Community Engagement Initiatives

Research Gap: A major challenge in urban river management is the absence of ongoing community involvement and care. Although pilgrims and tourists use the Godavari River in significant numbers, their engagement is predominantly ritualistic or commercial, exhibiting limited awareness or involvement in the river's ecological health. Authorities' current outreach is restricted to occasional clean-up initiatives or passive signage, which do not foster emotional ownership, behavioural change, or sustained civic engagement. This disinterest affects efforts to preserve river health and maintain cultural-environmental balance. Gamification has become popular in the health, education, and tourism sectors, its implementation in urban river conservation and religious-cultural contexts is nearly non-existent in India. The majority of digital technologies in heritage or pilgrimage planning target navigation or event management rather than behavioural modification or ecological involvement. There is a deficiency of platforms that use gaming techniques to convert knowledge into action, particularly in cases where spiritual incentive may be linked to ecological responsibility.

Figure 77: Gamified Eco-Pilgrimage App

justification:

- Promoting voluntary environmental initiatives in an engaging, transparent way
- Developing a sense of satisfaction and social connection in river stewardship
- Transforming consumers into data contributors and promoters of awareness
- Increasing the cultural-ecological discussion of the river beyond ceremonial applications

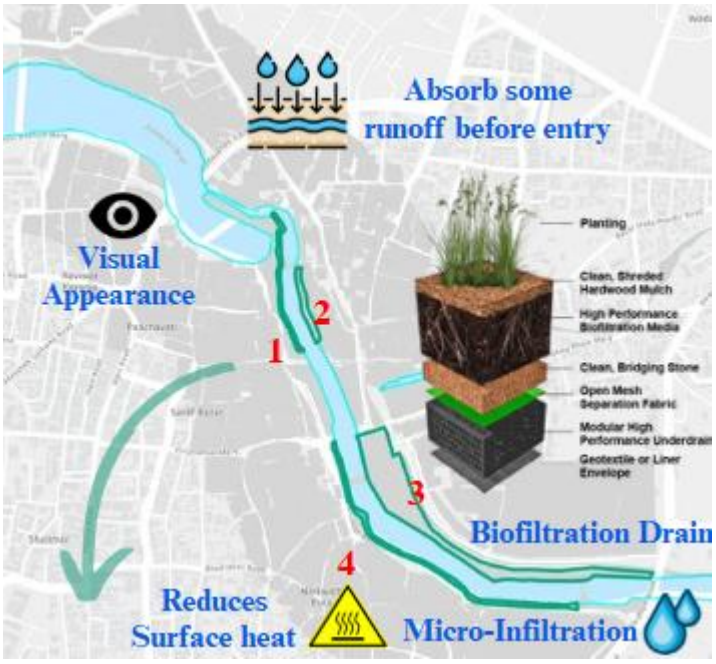
The application facilitates participatory conservation, connects with the objectives of Digital India and Smart Cities, and serves as a significant teaching resource for schools, colleges, and local NGOs. By integrating technology, tradition, and sustainability, it converts each pilgrimage into an agent for environmental consciousness and community-driven influence.

Goda Vaani represents a Smart Heritage solution that digitally enhances pilgrimage experiences and encourages environmentally conscious behavior, in collaboration with the above given mission's river rejuvenation objectives. The application gamifies accountability, maintaining both the integrity and sustainability of the Godavari Riverfront.

5.2.9. Proposal 6 – "Godavari Eco-Ghat Retrofit: A Nature-Based Solution for Riverfront Revival"

Issue Addressing: Deactivated Dead Concrete Edge of the River

Research Gap: The current ghats along the Godavari River, particularly in Nashik's urban centre, are primarily constructed of concrete and impermeable materials, resulting in ecological deterioration, surface runoff contamination, temperature stress, and a decline in biodiversity. These ghats are culturally important and have been designed solely for ritual purposes without incorporating ecological functions, leading to inadequate water-ground interaction, habitat division, and limited climatic resilience. Projection suggest that ongoing hardscaping without ecological modifications will increase heat island impacts, pollutant formation, and flood susceptibility over the next ten years. In India, the majority of riverfront development initiatives prioritize physical infrastructure and aesthetic enhancements, frequently neglecting ecological processes and principles of resilience. Documentation and implementation of hybrid ghats serving both cultural and ecological objectives are limited. Literature on urban design and landscape rarely offers context-specific approaches that implement Nature-based Solutions (NbS) for religious riverfronts in India, particularly in tier-2 cities like Nashik.



Area Allocated:

1 (Triveni Sangam) = 4634 sq.m.
2 (Ramkund) = 3826 sq.m.
3 = 2345 sq.m.
4 = 3320 sq.m.

Figure 78: Locations for Biofiltration Drain

"Green Overlay" = Adding vegetation and modular green systems on top of existing ghats without breaking them
Components include:
Vertical Green Facades: Modular creeper-support systems or pocket planters attached

to the concrete faces
Planter Blocks on Steps/Edges: Lightweight soil containers, coconut coir beds, native vegetation
Green Railings + Shade Plants: Add vegetated railing/handrails using climbers
Turf Mats: Bio-rolls (e.g., jute or coir) laid on upper ghat surfaces

Implementation
Phase 1: Design + Assessment
Load-bearing tests for modular installations on low-footfall ghat segments (e.g., behind temples, unused side steps)
Develop standard planter module sizes (prefab units)

Phase 2: Pilot (150–200m stretch)
Installation of 3–5 types of modular green overlay units
Use species like: Creepers- Madhumalati, Passionflower, Clitoria Shrubs: Parijat, Lemongrass
Grasses/Mats: Vetiver, Dhoob, Coir-based rolls

Phase 3: Scaling & Community Stewardship
Let temple trusts or NGOs adopt segments, add signage ("This sacred ghat also cleans your river")
Awareness campaigns.

Why Is It Needed?
Hard Concrete Ghats = Impermeable & Ecologically Inactive
Traditional ghat construction uses RCC and stone masonry that: Blocks infiltration, Heats up in summer, Does not support vegetation or aquatic interaction, Causes direct runoff into the river during rain events, carrying pollutants
Retrofit Needed to: Enable infiltration + micro-habitat creation
Visually integrate nature into religious and public spaces, Reduce surface temperatures, Begin the transition toward sponge-city principles

Justification: The Godavari Eco-Ghat Retrofit bridges this gap by showing how places designated for ritual usage can simultaneously function as ecological buffers. It fits to international frameworks, including the IUCN Nature-Based Solutions standard, and contributes to:

- Pollution mitigation via natural filtering systems.
- Enhancement of biodiversity through the restoration of riparian habitats.
- Climate adaptation using passive cooling and flood mitigation.
- Preservation of cultural integrity through the maintenance of access to rites and spiritual gatherings.

This plan conveys the "Ecology through Culture" approach, enabling the Godavari River to be simultaneously sacred and sustainable, and offers an outline for scalable retrofits in similar riverscapes throughout India.

5.2.10. Proposal 7 – Ecosystem Services Scorecard: A Monthly Performance Monitoring Matrix for River Benefits

Issue Addressing: Ecosystem Services Conservation Awareness

Research Gap: The river voffers essential ecological services including water supply, cultural and spiritual significance, climate management, and support for livelihoods there is currently no systematic approach to monitor, measure, or assess these benefits across time. Current analysis by municipal or environmental agencies are restricted on pollutant metrics or infrastructural conditions, neglecting the comprehensive range of ecological and socio-cultural advantages offered by the river. This results in a deficiency in evidence-based decision-making and constrains long-term sustainability planning. Ecosystem service frameworks such as the Millennium Ecosystem Assessment (MEA) and IPBES are making progress internationally, their implementation in Indian urban river systems is rare. There is an absence of localized instruments that integrate ecological, cultural, and policy indicators in a practical manner for municipal execution. No existing method combines community perception with scientific measurements on a monthly basis for river governance.

To create a Monthly ES Scorecard Matrix for the NMC to:

- Monitor river potential and performance in supplying ecosystem benefits
- Guide targeted interventions and policy decisions
- Institutionalize river sensitivity and sustainability evaluation

How It Works:

- Monthly data is collected by NMC + partners (MPCB, NGOs, temple trusts)
- ES Matrix is updated as a dashboard or visual scorecard
- Threshold flags highlight services at risk (e.g., if ritual economy drops or aquatic biodiversity index weakens)
- Informs monthly policy actions, funding priorities, or stakeholder consultations.

Justification: The Ecosystem Services Scorecard addresses this essential gap by:

- Converting complex ecological data into implementable performance insights.
- Creating a feedback mechanism between ecological well-being and urban governance.
- Helping local communities, researchers, and municipal authorities to collaboratively monitor and manage river resources.
- Bringing together river performance with sustainability objectives, financing qualifications, and climate resilience initiatives

This method promotes openness, accountability, and adaptive government, and can be tested in Nashik prior to expansion to other urban rivers around India.

SCORECARD Scoring Scale: 1 (Low) – 5 (High)									
Ecosystem Service Type	Service	Source Location	Extent of Use	Frequency of Use	Economic Value (₹/half year)	Cultural Importance	Environmental Health	Community Satisfaction	Vegetation Condition
Provisioning	Drinking Water	Upstream Aquifers (Gangapur)	4	5	₹18 Cr	3	2	4	3
Cultural	Ritual Bathing	Ramkund	5	5	₹6 Cr	5	2	3	2
Regulating	Flood Control	Tapovan Wetland Buffer	3	2	—	1	4	2	3
Supporting	Aquatic Biodiversity	Tapovan to Sadhugram stretch	2	3	—	2	5	2	2
Provisioning	Fish Catch	Downstream Ghats	3	4	₹2.5 Cr	3	3	4	1

Figure 79: Scorecard

5.2.11. Proposal 8 – Strategic Integration of Detention Basins/Ponds for Urban Runoff Management and Ecosystem Restoration (Utilizing Vacant Land through Nature-Based Solutions)

Issue Addressing: Flooding

Research Gap: The rapid urbanisation along the Godavari River in Nashik has resulted in increased surface runoff, flash flooding, erosion, and the discharge of pollutants into the river. Section 4.3.2 indicates that the city lacks a comprehensive strategy for capturing and regulating urban runoff, particularly during the monsoon season. Vacant or underdeveloped public lands adjacent to the river and nallas are either encroached upon or neglected, losing their potential to fulfill ecological or hydrological roles. With the ongoing expansion of impervious surfaces, stormwater runoff may rise by 20–30% by 2035, hence increasing stress on the river ecology. Detention basins have become common in global sustainable urban drainage systems (SUDS), but they remain underutilized in mid-sized Indian cities, particularly in culturally sensitive riverbank areas. Integration of Nature-based Solutions (NbS) in stormwater master plans is limited, and there is a scarcity of research on the conversion of unoccupied land for dual ecological and hydrological purposes. The current urban flood plans rarely integrate runoff management with the restoration of river ecosystems.

To introduce a system of detention ponds at key locations along the selected Godavari riverfront in Nashik, to manage urban runoff, ritual wastewater, and reduce pollution entering the river. **These ponds will act as temporary storage basins that slow down, filter, and naturally treat stormwater before it reaches the Godavari. By leveraging vacant or green patches near the river.** This nature-based solution will help improve water quality, reduce flood risk, and restore urban ecosystem services, aligning with the city's sustainability goals.

Site Selection Criteria: Detention pond locations based on:

- Proximity to Godavari River tributaries or drains
- Low-lying or vacant green areas

- Near areas of frequent waterlogging
- Open spaces within built-up zones (e.g., near parks, cremation ghats, road intersections)
- Government land or land under NMC (easier for implementation)

Estimation and Calculations:

A. Flood Volume Estimation Peak discharge to detain: Assume around 60 m³/second from the worst-case 100-year event. Concurrent catchment volume: Over a 6-hour peak **Volume=60 m3/s×6 hr×3600 s/hr=1,296,000 m3**	**C. Practical Design Adaptation** Instead of one large pond, using a series of detention basins. **This ensures= 12 lakh m³ storage**, Compatibility with the 6-hour peak flow travel time to Nashik
B. Pond Surface Area Computation **To temporarily store 1.3 million m³:** If average pond depth is 3 m, required area: **1,296,000 / 3 = 432,000 sq.m. (43 ha)**	**Considering 10% of for the selected site** 10/100 **x 43 = 4.3 Ha** **Total Allocated Area = 5.518 Ha**

Source Title: Flood Inundation Mapping and Damage Assessment using HEC-RAS and Remote Sensing – A Case Study of Godavari River, Nashik, India
Authors: Anurag Bhowmick, et al.
Published in: The Egyptian Journal of Remote Sensing and Space Science (Elsevier / ScienceDirect)

Figure 80: Estimation and Calculations for Detention Ponds

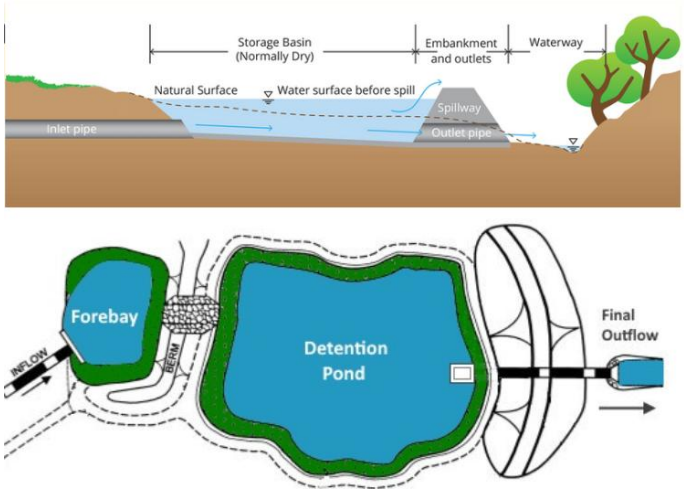


Figure 81: Image showng plan and section for detention pond

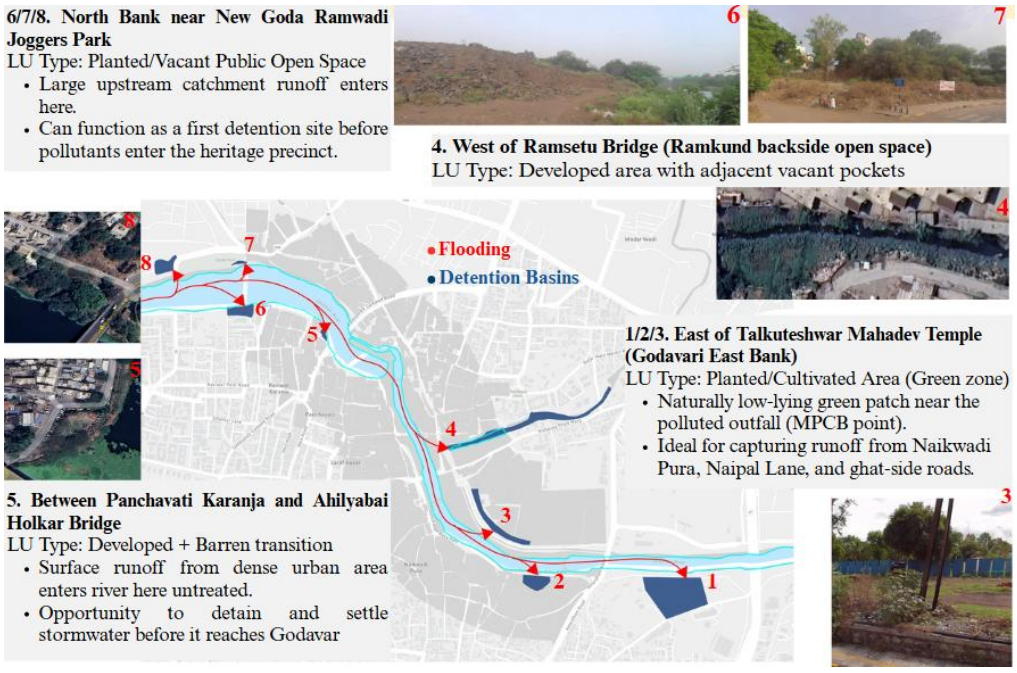


Figure 82: Proposed Locations for Detention Ponds

Justification:

- Providing an economical, high-efficacy Nature-based Solutions strategy for flood reduction
- Improving urban ecological connectedness and resilience
- Preventing untreated runoff from immediately into the Godavari
- Advancing climate adaption, biodiversity, and social co-benefits
- Utilizing publicly-owned, undeveloped property adjacent to flood-prone areas for productive purposes

It supports objectives under the Smart Cities Mission, AMRUT 2.0, and the National Mission on Sustainable Habitat, while promoting Sustainable Development Goals relating to Clean Water (6), Sustainable Cities (11), and Climate Action (13).

Relation with River Sensitivity and Sustainability:

- By temporarily detaining stormwater, the ponds reduce unnatural surges in river volume, protecting natural flow cycles and in-stream habitat.
- Reduces direct high-velocity runoff into the Godavari.
- Can serve as green open spaces, urban cooling zones.

5.2.12. Proposal 9 – Polluter Pays Principle: Involving Polluting Industries in Reforestation Initiatives

Issue Addressing: Industrial clusters in and around Nashik, especially along the peri-urban areas of the Godavari, have resulted in the discharge of untreated sewage, air and soil pollution, and degradation of riparian zones. Despite existing regulatory frameworks, polluters frequently avoid durable ecological accountability, and mitigation strategies are typically confined to compliance-oriented infrastructure (e.g., ETPs), rather than encompassing landscape restoration. This has resulted in the gradual depletion of green buffers, riparian forests, and ecological resilience along impacted river segments. Given the expected rise in pollution levels by 15–20% by 2030 as a result of industrial growth, passive regulation is inadequate.

Research Gap: The Polluter Pays Principle, mentioned in India's Environmental Protection Act and several regulations, suffers from inadequate enforcement and hardly associated with ecological restoration in urban riverfronts. Contemporary corporate social responsibility (CSR) and environmental activities by industries frequently lack connection with their resultant consequences.

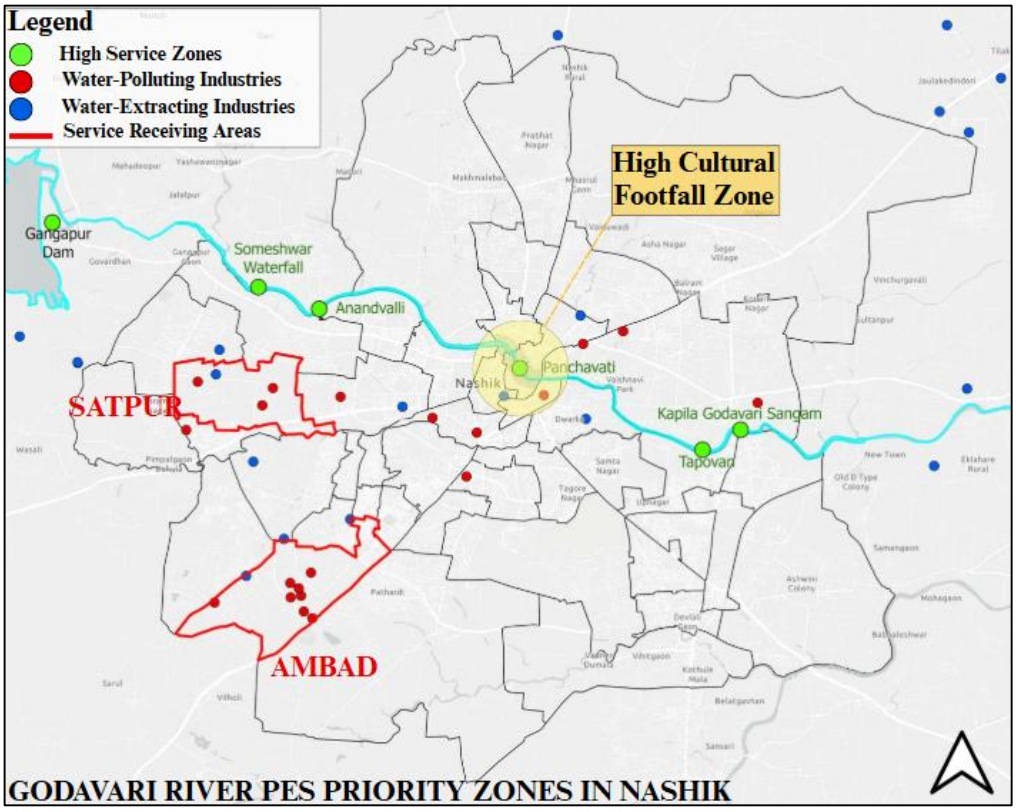


Figure 83: Godavari River PES Priority Zones

Step 1 - Identification of Polluters, Service Receiving Areas, High Potential Service Areas

- Plastic & food-processing units (11 factories received show-cause (Fined) notices in Tapovan/Satpur)
- 22 High chemical & Plastic-Based polluting industries have been found through the Ministry of Micro, Small, and Medium Enterprises (MSME) Industrial data report 2023
- 9 High Water Extracting Industries in NMC & 9 in the outer area have been mapped.
- Considering Reconnaissance Survey - High Service Zones have been mapped.

STEP 2 - Resforestation Mandate in degraded riparian buffer zones via NMC & Forest Department

- Through **a Polluter Pays–based Riparian Reforestation Mandate**, identified polluting and water-intensive industries will contribute funds or in-kind support for the restoration of degraded riparian areas, **facilitated jointly by the Nashik Municipal Corporation and the Forest Department.**
- This model flips the burden from the public bearing the cost of damage to the polluter investing in restoration and formalises this exchange under a Payment for Ecosystem Services (PES) program.

- Reforestation zones are designated within 50–150 meters of the river edge, and degraded canals (Nallas) primarily in degraded stretches near industrial zones.

Under CSR obligations, industries:

- Fund plantation of native riparian trees
- Support soil erosion control and vegetative fencing
- Commit to a 5-year maintenance cycle
- Monitoring is led by NMC/Forest Dept., with geotagged audits and third-party NDVI verification.

Justification:

- Producing immediate environmental advantages like carbon sequestration, soil stabilization, and riverbank preservation.
- Establishing a quantifiable responsibility framework for polluting industries.
- Reducing NMC's debts for ecological restoration while using private-sector resources.
- Linking industry initiatives with ESG frameworks, sustainability ratings, and SDG objectives.

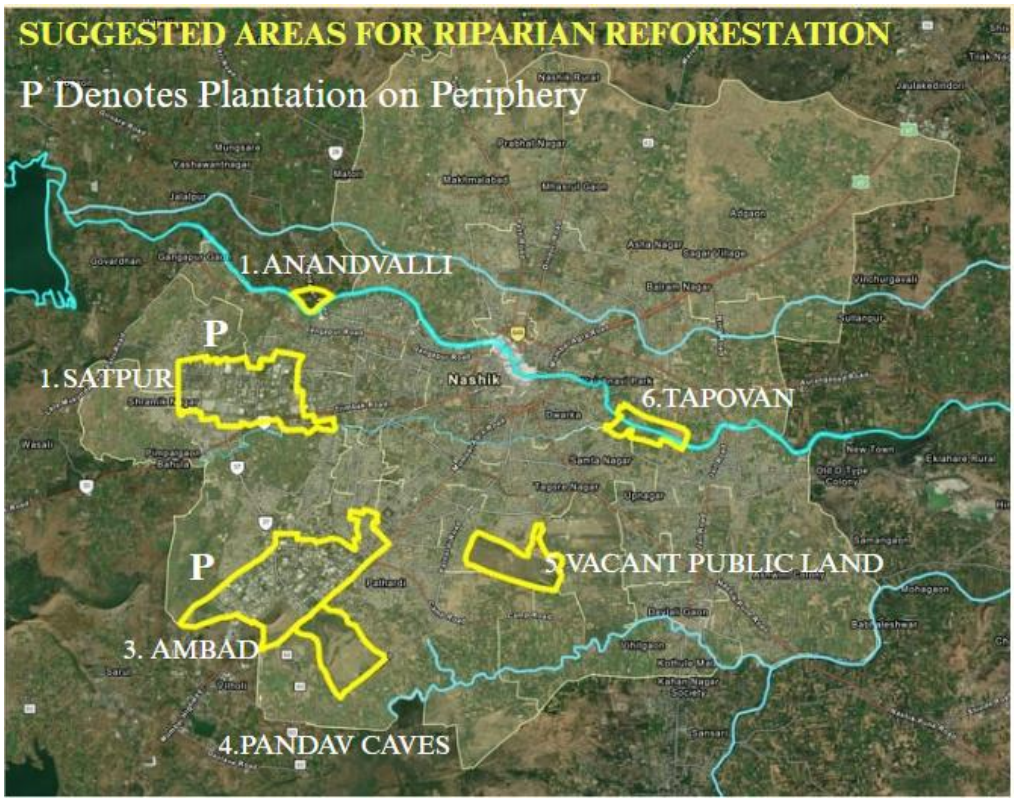


Figure 84: Suggested Areas for Riparian Reforestation

5.2.13. Recommendation 4: Goda Eco-Adoption Program

- In exchange for maintaining, greening, and protecting that river segment, the adopter receives public recognition, branding benefits, CSR reporting validation, and tax-linked incentives.
- The program turns passive corporate responsibility into measurable environmental service delivery, aligning directly with the Polluter Pays Principle and ecosystem restoration goals.

NMC will maintain a public-facing digital dashboard showing:

- Adopted stretches & their status
- Industry contributors
- Impact metrics (e.g., trees planted, waste removed, NDVI score)
- Annual awards for top performers

5.2.14. Recommendation 5: Mandate Green Offset for Environmental Clearance

- This policy mandates any new industry within a defined proximity to the Godavari River (1 km) must commit to "Green Offset" - reforestation commitment for environmental clearance approval (under MPCB norms). integrated into Environment Impact Assessment (EIA)
- MPCB Consent to Operate

The Green Offset would be fulfilled by:

- Direct reforestation of degraded river buffers,
- Stormwater harvesting systems installation,
- Constructed wetlands, or
- Contributing to a Godavari Restoration Fund managed by NMC/Forest Department.

5.2.15. Recommendation 6: Eco-Performance Based Tax Rebates/ Incentives

Industries that treat and reuse at least 50% of their wastewater for cooling, cleaning, or landscaping should be eligible for a partial property tax rebate (e.g., 5–10%). Introduces a system where industries, water users that actively participate in ecosystem restoration, pollution reduction, or sustainable practices receive property tax rebates, fast-track clearances, or ESG recognition.

Why It Works:

- Reduces extraction from the Godavari or municipal supply
- Lowers pollutant discharge into the river system
- Promotes adoption of Zero Liquid Discharge (ZLD) technologies
- Fits under CSR and ESG performance indicators

6. Conclusion

The concept of urban rivers and the issues associated to them are often neglected in the present scenario. The water ecosystem is facing numerous problems associated with water quality, quantity, and regulation which also leads to habitat destruction, water shortage, transformed appearance of the river and so on the city. The urban planning proposal through this project can help today's pressing question of reshaping how the river is viewed and utilized for the future of Nashik. The Panchavati area in the core old city of Nashik have been identified as a higher footfall, service supplier and consuming area. The varied approach of analysis includes all important environmental, social and economical aspects related to the river. The innovative smart proposals framed can ensure river-sensitivity by encouraging community awareness, participation and ease in evaluation and monitoring progress of the city. The research can help manage land-use and prevent unplanned developments along with restoring degraded ecosystems, further River's carrying capacity can be monitored. The policy recommendations given in turn brings tourism satisfaction level increment yet conserving ecosystem. The implementation of concepts such as "Payment for Ecosystem Services" can support local livelihoods, and uplift urban economies while preserving the river's health. The initiative effectively addresses deficiencies in urban river planning by uniting ecological principles with regulatory mechanisms and technology advancements.

The proposals correspond with multiple Sustainable Development Goals, specifically Goals 6 (Clean Water and Saniotation), 11 (Sustainable Cities and Communities), 13 (Climate Action), 15 (Life on Land), and 17 (Partnerships for the Goals) suggest feasible, scalable solutions that may be integrated into initiatives such as Smart Cities Mission, AMRUT 2.0, PRASAD, and Namami Gange. This thesis presents a predictable planning strategy for mid-sized Indian cities, highlighting that river restoration is both an environmental need and a strategic investment for sustainable urban development, despite problems posed by data limits and time limitations. Nashik can serve as an ideal example of intelligent, spiritual, and sustainable river-inclusive development through integrated river-zone planning.

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25) State of Watershed Payments 2018" by Forest Trends. This report provides an overview of watershed payment programs worldwide.
26) UNEP Reports: The United Nations Environment Programme has several reports on the implementation and success of PES programs globally.
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29) PES USAID Guidelines

ONLINE RESOURCES AND WEBSITES:

30) Forest Trends is an organization that tracks and reports on PES schemes and provides a wealth of case studies and data.
31) Ecosystem Marketplace: A comprehensive source for news, data, and analytics on PES and other ecosystem services markets.
32) Katoomba Group: A global network of PES practitioners that offers resources and networking opportunities.

GOVERNMENT AND NGO PROGRAMS:

33) Costa Rica's PES Program: One of the most well-known and successful PES programs, paying landowners for reforestation, sustainable forest management, and biodiversity conservation.
34) United States Conservation Reserve Program (CRP): While not termed as PES, CRP is a similar program that pays farmers to convert environmentally sensitive agricultural land to natural vegetation.
35) Payments for Watershed Services (PWS): Programs in countries like China, Mexico, and Brazil that focus on maintaining or improving water quality through PES.

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8. Appendix

8.1.Survey Questionnaire

Section 1 of 3

Citizen Perception Survey on Environmental Benefits (ES: Ecosystem Services) Provided by the Godavari River in Nashik

Hello,
I am Arya Rajesh Kumbhre, a master's (M.Plan in Urban Planning) student at the National Institute of Technology, Calicut, researching the potential of environmental benefits (ecosystem services) provided by the Godavari River and human dependencies on them.

This survey aims to understand how residents of Nashik perceive, use, and value the benefits provided by the Godavari River. These benefits—known as ecosystem services—include water supply, flood control, cultural significance, recreational spaces, and more. Your responses will help prioritize river-related ecosystem services that are important to the daily life and well-being of Nashik's citizens.

The survey takes about 5 minutes. Responses will be treated confidentially and used only for academic and planning research purposes.

For Queries, contact me at arya_m230654ar@nitc.ac.in

Thank you for your valuable inputs!

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* Indicates required question

1. Name:*

Your Answer

2. Which area or neighborhood of Nashik do you live in?*

Your Answer

3. Approximate distance of your home from the river: *

Less than 500m
500m–1 km
1–2 km
More than 2 km

4. Occupation :*

Your Answer

5. How long have you been living in Nashik?

Your Answer

*

6. How often do you visit the Godavari River or nearby areas? *

Daily
Weekly
Monthly
Rarely
Never

7. How do you or your family use the Godavari River? *

Drinking water
Bathing
Attending Festivals
Walking or recreation
Fishing
I do not use it directly
Vegetables, Grains, Fruits
Other:

8. What does the Godavari River mean to you personally? *

Spiritual significance
Source of livelihood
Natural beauty
Drinking or domestic use
Other:

9. Which part of the Godavari River do you most frequently interact with? *

Panchavati Core
Gangapur Dam
Someshwar Waterfall
Goda Park
Kapila Godavari Sangam
Other:

Awareness & Perception of Environmental and other Benefits

10. What benefits do you feel the Godavari River provides to the people of Nashik? *

Clean water for drinking
Agricultural Benefits (Vegetables, Grains and Fruits)
Cultural/spiritual enrichment
Pilgrimage and Religious Tourism
Groundwater recharge
Floods Regulation
Cooling effect/microclimate Regulation
Pollution Control
Fisheries
Natural Filtration
Natural beauty/scenic views
None / Not aware
Other:

11. From the above, select 3 service benefits that you think are the most important for you or your community:*

Your Answer

12. Have you noticed any change in river condition in recent years? *

Yes, improved
Yes, deteriorated
No change
Don't know

13. If deteriorated, what are the main reasons? *

Pollution/waste dumping
Encroachment
Religious waste
Unregulated construction
Industrial Effluent Discharge
Drying of the river
Lack of public access
Poor water quality
Loss of biodiversity
Reduced flow
Flooding during rains
Nothing
Other:

Benefit Assessment

14. On a scale of 1 to 5, how would you rate the importance of the following benefits of Environment (ES) (1 = Not Important, 5 = Very Important): *

	1	2	3	4	5
Drinking Water Supply	○	○	○	○	○
Groundwater recharge	○	○	○	○	○
Agricultural Benefits (Vegetables, Grains and Fruits)	○	○	○	○	○
Flood regulation	○	○	○	○	○
Cooling Effect/Microclimate regulation	○	○	○	○	○
Cultural/religious enrichment	○	○	○	○	○
Recreation & tourism	○	○	○	○	○
Soil formation & erosion control	○	○	○	○	○
Natural Filtration	○	○	○	○	○
Fisheries	○	○	○	○	○

15. Would you be willing to support or participate in river conservation initiatives? *

Yes
No
Maybe

16. If you would like to share any suggestions for conserving the Godavari River in Nashik, please write here:

Your Answer

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Section 1 of 3

Stakeholder Survey for Validation and Ranking of Ecosystem Services provided by the Godavari River in Nashik

Hello,

I am Arya Rajesh Kumbhre, a master's (M.Plan in Urban Planning) student at the National Institute of Technology, Calicut, researching the potential of ecosystem services provided by the Godavari River and human dependancies on them.

This survey is part of an academic research project aiming to identify, validate, and prioritize the ecosystem services provided by the Godavari River within Nashik's municipal boundary. It seeks expert opinions on the ecological, cultural, economic, and regulatory functions of the river system and how these services can be incorporated into sustainable planning frameworks.

The survey takes about 5 minutes. Responses will be treated confidentially and used only for academic and planning research purposes.

For Queries, Contact me at **arya_m230654ar@nitc.ac.in**

Thank you for your valuable inputs!

* Indicates required question

Email*_____

1. Name:*

Your answer

2. Organization:*

Your answer

3. Field of Expertise:*

Urban Planning
Water Resource Management
Municipal Governance
Other:

4. Experience:*

Less than 5 years
5-10 years
10-20 years
More than 20 years

5. Are you familiar with the Godavari River stretch in Nashik city limits?
Yes
No
Somewhat

6. How prominently do you think the Godavari River provides the following services?

	Not at all	Slightly	Moderately	Highly	Very Highly Prominent
Drinking water supply	○	○	○	○	○
Irrigation for Agriculture	○	○	○	○	○
Industrial Water Supply	○	○	○	○	○
Pilgrimage & Religious Tourism	○	○	○	○	○
Festival Celebrations & Community Activities	○	○	○	○	○
Flood Regulation	○	○	○	○	○
Microclimate Regulation	○	○	○	○	○
Pollution Control	○	○	○	○	○
Fishing/Fisheries	○	○	○	○	○

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Please rate the following ecosystem services (benefits) provided by the Godavari River within Nashik city based on your professional knowledge and experience.

Rate each service from 1 (Very Low) to 5 (Very High)

7. Extent of Use—Rate how extensively each of these ecosystem services is used.

Rate each service from 1 (Very Low) to 5 (Very High)

	1	2	3	4	5
Drinking water supply	○	○	○	○	○
Irrigation for Agriculture	○	○	○	○	○
Industrial water supply	○	○	○	○	○
Fisheries/Fishing	○	○	○	○	○
Sand & Sediment Extraction	○	○	○	○	○
Timber & Fuelwood	○	○	○	○	○
Pilgrimage and Religious Tourism	○	○	○	○	○
Recreational Activities	○	○	○	○	○
Heritage	○	○	○	○	○
Festival and Community Activities	○	○	○	○	○

8. Frequency of Use-

	Daily	Seasonal	Occasional
Drinking Water Supply	○	○	○
Irrigation for Agriculture	○	○	○
Industrial Water Supply	○	○	○
Fisheries	○	○	○
Sand & Sediment Extraction	○	○	○
Timber & Fuelwood	○	○	○
Pilgrimage and Religious Tourism	○	○	○
Recreational Activities	○	○	○
Heritage	○	○	○
Festival and Community Activities	○	○	○

9. Economic Dependence-
Rate each service from 1 (Very Low) to 5 (Very High).

	1	2	3	4	5
Drinking Water Supply	○	○	○	○	○
Irrigation for Agriculture	○	○	○	○	○
Industrial Water Supply	○	○	○	○	○
Fisheries	○	○	○	○	○
Sand & Sediment Extraction	○	○	○	○	○
Timber & Fuelwood	○	○	○	○	○
Pilgrimage and Religious Tourism	○	○	○	○	○
Recreational Activities	○	○	○	○	○
Heritage	○	○	○	○	○
Festival and Community Activities	○	○	○	○	○

10. Environmental Impact - Whether it helps improve or worsen river health
Rate each service from 1 (Very Low) to 5 (Very High).

	1	2	3	4	5
Drinking Water Supply	○	○	○	○	○
Irrigation for Agriculture	○	○	○	○	○
Industrial Water Supply	○	○	○	○	○
Fisheries	○	○	○	○	○
Sand & Sediment Extraction	○	○	○	○	○
Timber & Fuelwood	○	○	○	○	○
Pilgrimage and Religious Tourism	○	○	○	○	○
Recreational Activities	○	○	○	○	○
Heritage	○	○	○	○	○
Festival and Community Activities	○	○	○	○	○

11. Policy/Institutional Support—Whether it's recognized in policies (DP, River Rejuvenation Plan, AMRUT, NMC riverfront development)

	Yes	No
Drinking Water Supply	○	○
Irrigation for Agriculture	○	○
Industrial Water Supply	○	○
Fisheries	○	○
Sand & Sediment Extraction	○	○
Timber & Fuelwood	○	○
Pilgrimage and Religious Tourism	○	○
Recreational Activities	○	○
Heritage	○	○
Festival and Community Activities	○	○

12. Vulnerability - Level of degradation or threats faced by the Environmental Benefits (ES)
Rate each service from 1 (Very Low) to 5 (Very High).

	1	2	3	4	5
Drinking Water Supply	○	○	○	○	○
Irrigation for Agriculture	○	○	○	○	○
Industrial Water Supply	○	○	○	○	○
Fisheries	○	○	○	○	○
Sand & Sediment Extraction	○	○	○	○	○
Timber & Fuelwood	○	○	○	○	○
Pilgrimage and Religious Tourism	○	○	○	○	○
Recreational Activities	○	○	○	○	○
Heritage	○	○	○	○	○
Festival and Community Activities	○	○	○	○	○

13. Whether local populations are aware of the environmental benefits (ES) and perceive them as valuable?

Yes
No
Maybe
Other:

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Stakeholder Survey—Perception Section

14. Based on your professional experience, which environmental benefits (ES) are **most degraded** or **threatened** in Nashik? *

Your Answer

15. Do you think ES-based valuation should be part of the Nashik Master Plan or Riverfront Development Plans? *

Agree
Neutral
Disagree

16. Are there any other ecosystem services you think are missing from the list?

Your Answer

17. Suggestions for better integration of ecosystem services in policy and planning:

Your Answer

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Section 1 of 2

Expert Validation—Ecosystem Services Prioritization

Hello,
I am Arya Rajesh Kumbhre, a master's (M.Plan in Urban Planning) student at the National Institute of Technology, Calicut, researching the potential of ecosystem services provided by the Godavari River and human dependencies on them.

This survey is part of an academic research project aiming to identify, validate, and prioritize the ecosystem services provided by the Godavari River within Nashik's municipal boundary. It seeks expert opinions on the ecological, cultural, economic, and regulatory functions of the river system and how these services can be incorporated into sustainable planning frameworks.

The survey takes about 5 minutes. Responses will be treated confidentially and used only for academic and planning research purposes.

For Queries, Contact me at **arya_m230654ar@nitc.ac.in**

Thank you for your valuable inputs!

* Indicates required question

1. Name:*

Your answer

2. Area of Expertise:*

Your answer

3. Organization:*

Your answer

4. Years of Experience in Riverine Ecosystems/Spatial Planning *

0–5 years
6–10 years
11–20 years
More than 20 years

Criteria Importance Rating

5. Please rate how important you think each of the following criteria is for prioritizing ecosystem services along the Godavari River, on a scale of 1 (Very Low) to 5 (Very High). *

	1	2	3	4	5
Extent of Use	○	○	○	○	○
Frequency of Use	○	○	○	○	○
Economic Dependence	○	○	○	○	○
Cultural Importance	○	○	○	○	○
Environmental Impact	○	○	○	○	○
Policy/Institutional Support	○	○	○	○	○
Magnitude of Benefit	○	○	○	○	○
Spatial Coverage	○	○	○	○	○
Vulnerability / Threat Level	○	○	○	○	○
Resilience Contribution	○	○	○	○	○
Awareness & Local Perception	○	○	○	○	○

6. Validation of Assigned Weights: *

	Agree	Disagree	Suggest Change
Extent of Use (12%)	○	○	○
Frequency of Use (8%)	○	○	○
Economic Dependence (12%)	○	○	○
Cultural Importance (8%)	○	○	○
Environmental Impact (10%)	○	○	○
Policy/Institutional Support (8%)	○	○	○
Magnitude of Benefit (12%)	○	○	○
Spatial Coverage (7%)	○	○	○
Vulnerability / Threat Level (9%)	○	○	○
Resilience Contribution (7%)	○	○	○
Awareness & Local Perception (7%)	○	○	○

For any of the above where you suggested a change, please explain:

Your Answer

7. Based on the degree of tangible benefit to people, please rate the following types of ecosystem values. Use a scale of 1 (very low tangible benefit) to 5 (very high tangible benefit). *

	1	2	3	4	5
Direct Use Value	○	○	○	○	○
Indirect Use Value	○	○	○	○	○
Optional Value	○	○	○	○	○
Bequest Value	○	○	○	○	○
Existence Value	○	○	○	○	○

8. Are there any other criteria you think are missing from the list?

Your Answer

9. Any general feedback or suggestions?

Your Answer

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8.2.Identified List of Polluting Industries

Chemical & Plastic-Based Industries:

1. Advance Biochemicals Ltd. – MIDC, Malegaon – Biochemicals

2. GlaxoSmithKline Pharmaceuticals Ltd. – MIDC, Ambad

3. Gensons Ltd. – Chemical manufacturing – MIDC, Ambad

4. Carbon Everflow Ltd. (Graphite India) – MIDC, Satpur – Graphite Electrodes (High BOD/COD)

5. Garware Polyester Ltd. – MIDC, Ambad – Industrial materials

6. Polygenta Technologies Ltd. – Awankhed – Polyester yarn

7. Sagar Industries & Distilleries Ltd. – Malegaon – Molasses distillery

8. Seagram Distilleries Ltd. – Dindori – Alcoholic beverages

9. Shree Venkateshwara Petrochemicals Pvt. Ltd. – Dindori – Petrochemicals

10. Dirk India Pvt. Ltd. – Industrial byproducts

Industries Likely Extracting Water from Godavari (High Usage)

1. Eklahare Thermal Power Station – Uses river water for cooling

2. Hindustan Coca-Cola Bottling Pvt. Ltd. – MIDC Ambad – Bottled water & beverages

3. Nashik Beverages Pvt. Ltd. – MIDC Ambad & Dindori – Packaged water

4. Government Milk Scheme – Nashik & Dindori – Dairy water usage

5. Hindustan Unilever Ltd. – Malegaon MIDC – Food processing

6. Freshtrop Fruits Ltd. – Jaulke – Fruit washing & packaging

7. Mcdowell & Co. (United Spirits) – Dindori – Alcohol processing

8. Godavari Pulp and Paper Mills Pvt. Ltd. – Dindori – High water use in paper pulping

9. PCI Papers Ltd. – Malegaon – Industrial paper

10. Garware Enterprises Ltd. – Ambad – PVC sheets (cooling/process water)

Industries Located in Proximity to River/Drainage Lines

Satpur MIDC (close to river-connected nullahs)

Ambad MIDC

Sinnar (Malegaon MIDC) – Downstream connections to Godavari

Dindori – Near agricultural canal systems draining into the river basin

8.3.Identified 19 Cases for Brief Study

Sr. No.	Title	Year	Keywords
1	Costa Rica's Payment for Ecosystem Services Programme	2018	Costa Rica; payments for ecosystem services programme; forest; land-use change; willingness to pay; national fund; environmental services; fonafifo; biodiversity
2	How Effective Are Biodiversity Conservation Payments in Mexico?	2015	Mexico; conafor; deforestation; water resource; land-use change; payments; ecosystem services; beneficiaries
3	Estimating the value of ecosystem services in agricultural landscapes amid intensification pressures: The Brazilian case	2022	
4	The institutional challenges of payments for Ecosystem Service Program in China: A Review of the Effectiveness and Implementation of Sloping Land Conversion Program	2015	Grain for green program; land set-aside program; land-use change; effectiveness of implementation; hybrid governance; PES; sustainability
5	The impact of multipurpose dams on the values of nature's contributions to people under a water-energy-food nexus framing	2023	
6	Experiences and lessons learned in payments for ecosystem services (PESPs) in East Africa	2018	Naivasha; ecosystem services; equitable payments; land-use change; communities; watershed; kenya; hydrological services
7	Implications of changes in land use for ecosystem service values of two highly eroded watersheds in Lake Abaya Chamo sub-basin, Ethiopia	2023	
8	Critical Analysis of Payments for Ecosystem Services: Case Studies in Kenya, Uganda and Tanzania	2023	Forest ecosystem services; payments for ecosystem services; conservation efficiency; rural communities; land-use change; livelihood improvement; decision making; sustainable development goals; Kenya; Uganda; Tanzania
9	Payment for Ecosystem Services in Peru: Assessing the socio-ecological dimension of water services in Santa River Basin	2022	Peru; payment for ecosystem services; water services degradation; water-human interactions; social perception; decision-making process
10	Incorporating traditional ecological knowledge into holistic watershed management: Fishery forests in Japan	2023	Hiroshima; Japan; coastal zone; ecological economics; fishery; forest; watershed
11	Payments for Ecosystem Services in Watersheds: Insighths from a comparative study of three cases in Central America	2006	Environmental services; watershed management; rural developents; property rights; Honduras; Costa Rica; Nicaragua
12	Valuing diversification benefits through intercropping in Mediterranean agroecosystems: A choice experiment approach	2020	Spain; agricultural economics; agricultural ecosystem; agroforestry; ecosystem service; experimental study; intercropping; monoculture; rural development; social behavior; valuation; willingness to pay
13	Watershed protection for a world city: The case of New York	2004	watershed management; land use change; payments for ecosystem services; water degradation; ecosystem services; environmental economica
14	Vietnam's Payments for Forest Ecosystem Services scheme's puzzling role in protecting longstanding forests as deforestation rates rise		Viet Nam; deforestation; ecological economics; ecosystem service; environmental economics; forest ecosystem; forestry policy; market conditions; spatiotemporal analysis
15	Equitable sharing of benefits in Sukhomajri, India	2000	Forest ecosystem services, Water conservation, ecosystem services, land use changes, conservation practices
16	Under what conditions do payments for environmental services enable forest conservation in the Amazon? A realist synthesis	2022	Amazonia; conservation status; deforestation; ecosystem service; environmental economics; environmental impact; environmental monitoring; tropical forest
17	Payment for Ecosystem Services forBalancing Conservation andDevelopment in the Rangelands of the Indian Himalayan Region	2014	climate change; Indian Himalayan region; payment for ecosystem services; policy analysis; rangelands
18	From Principles to Numbers: Approaches in Implementing Payments for Environmental Services (PES) in the Phillipines	2018	Payment for Ecosystem Services (PES), tier approach, ecosystem servies, land use change
19	Vittel as a model case in PES discourse: Review and critical perspective	2021	Vittel, Heppar, user-financed payments, ecosystem services, watershed services, land use change, payment for ecosystem services

8.4.Synthesis Matrix of the Literature Study

Study Parameters	1	2	3	4	5
Title	Payment for Ecosystem Services (PES) Programs in Costa Rica	Payments for Hydrological Environmental Services (PSAH) programme in Mexico, Payments for Biodiversity and Carbon Capture Services Programme (PSAB)	Payment for Environmental Services pilot project in Lake Naivasha basin, Kenya, Africa (Equitable Payment for Watershed Services)	Upper Tana-Nairobi Water Fund	China's PES - Sloping Land Conversion Program, "Conversion of Cropland to Forests Program" or "Grain-for-Green"
Author	UNFCCC Costa Rica's Official PES Website, IIED- International Institute of Environment and Development, ESPA- Ecosystem Services for Poverty Alleviation (Ina Porras and Adriana Chacon Cascante)	Convention on Biological Diversity, IIED- International Institute of Environment and Development, ESPA- Ecosystem Services for Poverty Alleviation (Soffia Cortina and Ina Porras) Alix-Garcia et al., 2005; Muñoz-Piña et al., 2008; Aemi et al., 2013	Thomas Chiramba, Silas Mogoi and Isabel Martinez (UNEP), Tim Jones (DJEnvironmental), Dodoo, Jacob Kwamina	The International Water Association	
Purpose/Aim/ Question Posed/ Objectives	1. To reduce deforestation, 2. To promote sustainable land use 3. To generate employment for rural communities, 4. To conserve water resources and forests by using financial mechanisms	1. To ensure watershed protection and aquifer recharge in areas where forestry is commercially unviable. 2. To ensure the continuous provision of hydrological services, such as water regulation, water purification, and soil erosion control. 3. The PSAH program was implemented to address these challenges by providing financial incentives to landowners for maintaining forest cover and sustainable land management practices.	1. To improve the livelihoods of target households upstream in the Malewa River catchment of Lake Naivasha basin and secure green investment downstream. 2. to develop a sustainable financial mechanism that would incentivize local communities 3. to adopt sustainable land management practices	1. Plan to secure water resources 2. Protect the quality of water resources 3. Prepare for extreme events	1. To convert marginal cropland on steep slopes, particularly in the ecologically sensitive regions of western China lands into forests and grasslands to combat soil erosion, conserve water resources, and improve biodiversity. 2. To reduce soil erosion, conserve water resources, improve biodiversity, and alleviate poverty in rural areas.
Location/ Background	Costa Rica (1997)	Mexico (2003)	Kenya, Africa (2006)	The Upper Tana River basin is a vital water source for Nairobi City and surrounding areas in Kenya	China (1999) Primarily implemented in the ecologically sensitive regions of western China, particularly the Loess Plateau and the Three Gorges region. (25 Provinces), Included 32 Million Households
Background	In the 1970s and 1980s, Costa Rica experienced one of the highest rates of deforestation worldwide, driven by agricultural expansion and logging. First implementation program of PES.	Mexico's predominant environmental issues are water scarcity and deforestation. Challenges associated with limited water supplies have been aggravated by (i) subsidies to electricity for pumping water and (ii) the failure to price water according to its scarcity. In order to combat problems of high deforestation and water scarcity, the government of Mexico developed a Programme of Payment for Hydrological Environmental Services of Forest (PSAH). This scheme was developed to make payments to forest owners to conserve forest in order to ensure watershed protection and aquifer recharge in areas where forestry was not commercially viable. The scheme is financed by increasing the already existing federal water fee paid by water consumers and earmarking a percentage to pay for environmental services. This mechanism to link those who benefit from environmental services to those who provide them was rather innovative at the time.	1. Lake Naivasha, a vital ecosystem and a significant economic hub, was facing severe threats from unsustainable agricultural practices, deforestation, and pollution. These factors were impacting water quality, biodiversity, and the livelihoods of the communities dependent on the lake. 2. The EPWS project was designed to address these challenges by incentivizing local communities to adopt sustainable land management practices. The project involved a partnership between the Lake Naivasha Water Resource Users Association (LANAWRUA), representing the downstream users, and the upstream communities.	Ninety five percent of Nairobi's freshwater supply comes from the Tana River, which originates in the highlands above Nairobi. The highlands are home to more than 100,000 small holder farmers who rely on the river for irrigation water. Since the 1970s, due to agricultural activities on the upper reaches of the river, there has been increased abstraction and siltation, which inevitably impacted downstream communities, ecosystems and activities, including reduced water supply to Nairobi, hydropower generation and water quality.	China's Sloping Land Conversion Program, often referred to as the "Grain-for-Green" program, is one of the world's largest ecological restoration projects. It was launched in 1999 with the primary goal of reducing soil erosion, conserving water resources, and mitigating climate change.
Total Area under	1.3 Million Hectares	4.27 Million Hectares	0.034 Million Hectares (Approximately 11,000 hectares in the Upper Turasha and Wanjohi sub-catchments)	Over 330,000 hectares of land in the Upper Tana River basin.	Over 14.67 million hectares of cropland to forests Million Hectares of cropland converted to forests and
Area Selection Criteria (Based on-)	1. Areas with high carbon sequestration potential, such as forests and reforestation sites, 2. Watersheds that supply water to urban areas or agricultural regions. 3. Biodiversity Conservation Area- National Parks and Protected Areas 4. Tourists Destination 5. Preference is given to areas with secure land tenure, such as communal lands and Indigenous territories, 6. Areas with high poverty rates are prioritized to alleviate poverty and promote sustainable livelihoods.	1. Deforestation risk 2. Overexploited aquifers 3. Natural protected areas, 4. Poor municipalities, 5. Vegetation type, prioritising cloud forests and jungles 6. Well-preserved forest (with at least 80 per cent forest cover) Priority areas (maximum area per participant is 4,000 hectares) 7. Critical recharge areas for the over-exploited aquifers of the country (according to National Water Commission/Comision Nacional del Agua (CNA) classification), 8. Area near streams, in regions with problems of water scarcity, poor water quality and high sediment loads and where hydrological natural disasters are more frequent; 9. In areas that supply urban centres of more than 5,000 inhabitants, 10. In priority mountain areas (designated by the Mexican Forestry Commission/Comisión Nacional Forestal (CONAFOR), IF they are also facing water problems).	1. Hydrology Assessment- (River flow and Turbidity Level) 2. Business Case 3. Impact on Livelihood 4. Legal and Institutional Framework 5. Buyers and Sellers Mobilization (Capacity Building) 6. Selection of Target Farms 7. Water Scarce Space	1. Areas with high potential for water conservation and soil erosion control 2. Areas with significant impact on downstream water supply and quality 3. Areas with high levels of poverty and vulnerability to cc	1. Steeply sloping and marginal cropland, 2. Areas with severe soil erosion, 3. Watersheds of major rivers.
Primary Drivers of Watershed Degradation	Deforestation, agriculture expansion, and unsustainable land use practices.	Forest loss and erosion issues impacting water quality in various regions.	Unsustainable land use practices in the upper catchment has led to increasing sediment loading and pollution in river Malewa which affects water quality in the lake downstream. Overgrazing Agricultural runoff	Forest loss and agricultural practices affecting water availability. Deforestation Overgrazing Unsustainable agricultural practices	Soil erosion, deforestation, overgrazing, and unsustainable agricultural practices.
Key Issues	Policies on Extreme Effective Development in Rural Areas were initiated from 1940-1960s. Forest cover had declined to 25% of the national territory,	1. subsidies to electricity for pumping water and 2. The failure to price water according to its scarcity. 3. The deforestation impacted watersheds, reducing the availability and quality of water for downstream users, including urban and rural communities. 4. Many rural communities relied on deforestation and land clearing for agriculture or timber sales to sustain their livelihoods, which further exacerbated environmental degradation. 5. Forest degradation also resulted in habitat loss, threatening numerous species endemic to Mexico. 6. Reduced forest cover contributed to increased greenhouse gas emissions and vulnerability to climate change effects such as droughts and flooding.	1. Water Loss and Lake Shrinkage 2. Water Pollution due to soil erosion, high volumes of fertilisers, pesticides and effluents produced by the Naivasha floricultural industry and linked to the waterbody. 3. Reduced water availability 4. Loss of biodiversity 5. Deforestation leading to deforestation and siltation 6. Illegal and excessive extraction (both surface and groundwater) by farmers 7. Excessive use of agro-chemicals in the upper catchment climate change and reductions in rainfall. 8. Poor Waste Management 9. Weak institutions (lack of law enforcement)	1. Agricultural expansion on the upper reaches of the basin increased soil erosion and sedimentation in the Tana River, disrupting the water supply and causing power outages in Nairobi city and other parts of the country due to the clogging of the Masinga reservoir. 2. Increasingly polluted by sedimentation and the water levels have been reduced due to unsustainable abstraction. This has translated to increased water treatment costs, 3. Increased water rationing in Nairobi, frequent power outages countrywide, and reduced livelihoods for the smallholder farmers along the River. 4. Climate variability, population growth, economic growth and associated rises in food and electricity production are putting ever-greater pressure on the river. 5.	1. Land degradation, 2. Soil erosion, 3. Desertification, 4. Biodiversity loss, 5. Water pollution and water shortages 6. Poverty

Buyers	Hydropower Companies, Urban & Rural Water Consumers, Ecotourism Businesses	Hydropower Companies, Municipalities, Urban & Rural Water Users, Urban water users Agricultural water users Industrial water users Environmental NGOs Government agencies	Flower Companies, Hoteliers, Water Users, Municipalities (Water Service Providers)	1. Small-holder farmers 2. Nairobi City Water & Sewerage Company (NCWSC) 3. Kenya Electricity Generating Company (KenGen) 4. Other downstream water users	Central Chinese Government
Sellers	Local Facilitators, Rural Communities practicing conservation,	Landowners (private, communal, and indigenous) Community-based organizations Forest cooperatives, Areas Vegetation types, prioritizing cloud forests and jungles, Risk of deforestation, Overexploited aquifers, Natural protected areas, and Poor municipalities.	Water Resource Users Associations (WRUAs) - Upstream Small Scale Farmers	Smallholder farmers in the Upper Tana River basin, Public-private partnership	Participant Rural households
Type of PES Program	**Government-Financed Mechanisms**	**Government-Financed Mechanisms & Locally Funded**	**Government & Private Sector Financed Hybrid Model**	**Government and NGOs led**	**Government-financed** ecological restoration program (large-scale, and long-term)
Stakeholders/ Organizations/ Institutions Involved	1. FONAFIFO - National Forestry Financing Fund, 2. Ministry of Environment and Energy, 3. Local Municipalities, 4. Global Environment Facility, 5. World Bank, 6. German Development Bank, 7. Costa Rican Institute of Aqueducts and Sewers	1. National Forestry Commission of Mexico (CONAFOR), SEMARNAT (Secretariat of Environment and Natural Resources) 2. Mexican National Institute of Ecology (INE), 3. The Economic Research and Higher Education Centre (CIDE), 4. The University of California at Berkeley,	1. Lake Naivasha Water Resource Users Association (downstream buyers) 2. Lake Naivasha Growers Group (downstream buyers – the principal participant in the project among the buyers) 3. Upper Turasha-Kinja Water Resource Users Associations (upstream sellers) 4. Wanjohi Water Resource Users Associations (upstream sellers) 5. Ministry of Agriculture 6. Water Resources Management Authority 7. Kenya Forest Services 8. Provincial Administration	1. The Nature Conservancy (TNC) 2. Water Resources Management Authority, 3. Ministry of Agriculture	1. State Forestry Administration 2. Department of Water and Soil Conservation, 3. Ministry of Water Resources (MWR)
Program Financing Agency	1. fuel tax and water charge, 2. Certificates of Conservation of Biodiversity, 3. Carbon Credits, 4. PPP Models 5. Through EcoMarkets - World Bank 6. CAF Forest Subsidy 7. KfW Grant 8. Hydro-CNFL 9. Beverage Company - FI & F	1. Federal Rights Law (Water Law) 2. World Bank Loan 3. Global Environment Facility 4.	1. WWF (WWF-Kenya) 2. CARE-Kenya 3. GEF Project Grant: US$ 1,785,422 4. Co-financing total: US$10,525,689	1. Public and private funding sources 2. Grants from international donors 3. User fees from downstream water users	1. The Grain for Green Project - investment over 63 Billion Dollars
PES Mechanisms (Payment) / Levels	**1. Annual Cash Payments per Hectare** **2. Long Term Contracts**	**1. Annual Cash Payments per Hectare** US$36/ha for cloud forest land and US$27/ha for land with other forest types. (US$28 to US$100/hectare/year), **2. A fixed price two-tiered payment approach (Tiered Payment System) - base rate (US$18/ha) paid for most forest and a higher rate (US$27/ha) paid for cloud forest due to its important role in capturing water from fog in the dry season. (Payment was conditional on performance, i.e. no payment was made if any deforestation took place in contracted areas).** Payment for water regulation (Chiapas), Recognized for its rich biodiversity and Indigenous management of communal lands (ejidos) (Oaxaca), (Yucatán Peninsula)-Includes areas in Quintana Roo, Yucatán, and Campeche, Prioritized for its mangrove ecosystems and wetlands, which are crucial for coastal protection and carbon sequestration, High deforestation risk zones are targeted for conservation payments to maintain water quality and forest cover (Veracruz), Prioritized for protecting water sources and forest conservation (Jalisco), High priority for PES due to the pressure on forests and need for water regulation (Estado de México) **3. Water Tariff** (2.5% from water tax is used for the program) **4. 5 year contracts**	**1. Incentives / Contractural Agreement-** Incentives from private sector downstream to the target communities Upper Turasha-Kinja and Wanjohi Water Resource Users Associations (WRUAs) were provided with an initial financial incentive of USD 10,000, followed by a second payment of USD 10,000. The first incentive rewarded 470 farmers and second reward benefited 504 farmers.	1. Endowment Fund 2. Cash payments for conservation practices 3. Technical assistance and training 4. Access to markets and credit 5. Infrastructure development	1. Direct cash payments, 2. Subsidies for seedlings and fertilizers, 3. Technical assistance, 4. Tax breaks **Benefits for conversion of land into ecological forest - 8 years** **Benefits of conversion into Commercial Forests - 5 years** **Grassland Contracts - 2 years** 5. All income derived from the forests and grasslands planted as part of SLCP is to be exempt from taxation
Implementation Tools/ PES Activities	**1. Rules & Regulations against deforestation: Forest Law 7575- enacted in 1996, established the legal and institutional framework for the PES program.** a) allocating a proportion of fuel tax revenues, later updated with water tax revenues, b) creating the institutions to manage the system c) allowing this institution to charge other beneficiaries of the environmental services to raise additional resources. **Pay-Off Rules-** a) Payments allocated according to land activity b) Properties receiving PES are exempt from property c) Eviction of squatters **Choice Rules-** a) Prohibition to change land use in established forests b) Passive regulation through buffer zone regulations that restrict land use in and around natural springs, along rivers and streams, around lakes, and in recharge zones **taxes** **2. Action-** Based Cash Payments 3. Rules on rent capture - Extract rents from water users (through	1. 5 year contract system 2. Remote Sensing Technology and ICT for monitoring and evaluation 3. User fees and trust fund **4. Direct cash payments to landowners-** Primary forest owners receive 300 pesos per hectare per year (approximately US$27) and cloud forest owners receive 400 pesos per hectare per year (US$36) due to the perceived higher delivery of hydrological services associated with this type of forest (mainly due to their role in capturing water from horizontal rain in the dry season) **5. Monitoring and verification systems to track land use changes and environmental outcomes.** **6. Payment disbursement mechanisms.** 7. The program has increased **training in forest management and activities** devoted to forest management; such skill training is likely to have long-term benefits that extend beyond the program. 8. **The Mexican Forest Fund (FFM)**, is a financial instrument that allows signing contracts with landowners for five years, paying annually. - **The Biodiversity Endowment Fund**, is the financial instrument that allows for long term conservation (50% GEF, 50% CONAFOR). - **The "Local PES Mechanisms through Matching Funds"** is an	**1. Land management changes aimed at improving downstream water quality and quantity** -Rehabilitation and maintenance of riparian zones through adoption of conservation agriculture which is expected to result in continued supply of the agreed ecosystem service. -Establishment of grass strips/terraces to reduce runoff and erosion on steep slopes -Reduced use of fertilizers and pesticides e.g. through integrated crop/pest management, use of new/improved crop varieties -Agroforestry/tree planting – planting native trees and high-yielding fruit trees and cover crops for improved farm productivity, reduced runoff/erosion and increased biodiversity -Training for livelihoods enhancement – training provided to farmers by the Ministry of -Agriculture and Horticultural Crops Development Authority on issues such as: (a) soil and water conservation techniques to boost farm productivity; (b) use of improved fodder storage techniques; and	1. Science based-decision making processes 2. Conservation financing tools 3. Capacity for deployment (implementation of conservation activities) 4. Communication with partners, stakeholders, funders and the general public	Land retirement, afforestation, reforestation, and agroforestry. Mandatory Participation of 86% of households in the program by the government. 70% of the approximately 6.07 million ha of agricultural land with slopes greater than 25 degrees **six key programs -** -Natural Forest -Protection Program, aimed at the state forestry sector, -The Key Shelterbelt Development Program (in north China and the middle and lower reaches of the Yangtze River), -The Program to Combat Desertification near Beijing and Tianjin, -The Wildlife Conservation and Nature Reserve Development Program, -The Fast-Growing High-Yield Plantation Development Program **For Ecological Forests-** 1) an annual in-kind subsidy of grain, 2) a cash subsidy, and 3) free seedlings, provided to the farmer **The grain subsidy** is set at 2250 kg/ha in the Yangtze River Basin, and 1500 kg/ha in the Yellow River Basin **The cash subsidy** is RMB 300/ha of eligible land (US$36/ha) per
Impact on Land use Practices/ Success Factors	1. Program has enables 6.8 million tree plantation 2. Forest Protection - 10,50,135 ha (90% of total area receiving PES) 3. Program has signed almost 16,500 contracts with private landowners, cumulative disbursement of US $ 380 Million. 4. 70000 Ha received payments for reforestation. 5. 30000 Ha received payment for sustainable forest mgmt.	1. Production of food crops, including staple crops, does not decrease on average or show different general trends between beneficiaries and non-beneficiaries, suggesting that the program does not compromise food security.	1. Through PES interventions, upstream landowners manage their land to control soil erosion, 2. Reduce the use of agrochemicals, 3. conservation of riparian land and grass stripping to retain soil envisaged to restore water quality and quantity water flow as an ecosystem service to benefit downstream commercial farmers who mainly depend on Lake Naivasha to sustain their horticulture business. 4. Commercial farmers as beneficiaries and buyers of watershed services therefore compensate upstream stewards for ESs provided. 5. Approx 250 ha of agricultural land under conservation as a result of	1. The Water Fund helps farmers living upstream to employ sustainable farming practices which reduce soil runoff, and improve productivity, whilst conserving	1. Conversion of cropland to forests and grasslands 2. Reduction of Cropland to Forestland over 9 Million Ha from (1999 to 2006) 2. Vegetation cover was accorded great significance in consolidating the reforestation achievements and effectively controlling soil erosion.
Environmental and Hydrological Outcomes	1. Forest cover rose from about 21% in the 1980s to over 50% today, due to reforestation, natural regeneration, and avoided deforestation. 2. Watershed conservation has improved water quality and availability by reducing sedimentation and pollutants from deforested or degraded land. 3. Hydroelectric plants and urban areas benefit from stable water flows for energy generation and human consumption.	1. Both enrolled and unenrolled properties show decreases in normalised difference vegetation index (NDVI) over the period examined. However, the program appears to reduce the temporal change in NDVI by around 62% relative to the counterfactual trend in the control group. This suggests that **the program reduces deforestation or degradation in enrolled properties, although it does not eliminate the overall downward NDVI trend entirely.** 2. Deforestation rates on land included in the scheme are very low (in fact the programme reported no deforestation in participating areas, but as this is unlikely it is thought that monitoring is not as rigorous as would be desired). The scheme is popular and is generally oversubscribed. In 2003, 127,000 ha were accepted for five years and in 2004 another 180,000 ha were enrolled. In 2005 a further 169,000 ha were included.	1.Increased Crop Productivity 2. Tools and materials for implementation of sustainable, biodiversity-friendly agricultural practices (e.g., certified seeds, compost/mulching tools, etc.) 3. Priority forest land management and restoration interventions implemented in the Lake Naivasha upper catchment area for enhanced water and biodiversity protection	1. Reduced soil erosion is projected to increase agricultural yields and to increase water quality further downstream towards Nairobi. 2. Monitoring has identified a decrease by over 15% in sedimentation, with World Health Organization turbidity standards achieved for the first time in July-September 2016. 3. Increased tree cover	1. Monoculture 2. Participation of rural households in a framework of integrated watershed management including afforestation/reforestation activities, small dam construction and terracing of land to reduce water erosion
Socioeconomic Outcomes	1. Contributed to poverty alleviation in remote areas by improving rural income. 2. PES incentivises landowners and farmers to conserve land rather than convert it for agriculture and development. 3. Promotion of Eco-Tourism. 4. the PES program has benefited water utilities and communities by improving watershed management, reducing water treatment costs and ensuring reliable water access for downstream users. This is especially important for agricultural productivity and urban water supplies. 5. Increased Awareness and Education on Conservation	1. Increased income for participating landowners. 2. Reduced poverty and improved livelihoods in rural communities. 3. Strengthened community-based organizations and social capital.	1. Improved Livelihoods- Over 3200 small-scale farmers participating in soil & water conservation, through PES improving agricultural productions, water quality and quantity in terms of reduced soil loss and turbidity. 2. Enhanced Private Sector Engagement in Conservation Work. 3. Enhanced Capacity of municipalities to take part in sustainable natural resource management. 4. Basin-wide communication strategy developed and implemented to support sustainable land management and biodiversity-friendly agricultural practices in LNB 5. Socialization of the LNB Code of Conduct through an awareness raising program 6. Participatory Forest Management Plans for three target Forest Stations (South and North Kinangop and Geta) updated 7. Protection and restoration activities on key degradation areas implemented (in particular passive restoration through demarcation, natural regeneration and where necessary temporary fencing)	1. currently 19,000 farmers engaging in soil and water-saving methods and sediment/pollutant reduction techniques such as rain-water harvesting, drip irrigation, terracing, planting permanent grass buffers along streams, and agroforestry, with a goal of reaching 50,000 by 2020. 2. The UTNWF partners have been providing the farmers with the skills, training and resources needed to conserve water, reduce soil runoff and improve productivity. 3. Within the first three years, the Water Fund has been able to help 8500 coffee farmers earn Rainforest Alliance Certification for conservation measures. Along this timeline, 80 km of riverine vegetation has been restored, and over one million trees have been planted in the watershed, with 65 schools actively engaged in conservation activities locally.	1. Income Change 2. Labour Relocation 3. Poverty Alleviation 4. Sustainability

Study Parameters	6	7	8	9	10
Title	New York City Watershed Program	Philippines' Bakun Watershed Management Program RUPES: Payments for Watershed Functions	Protecting Environmental Services in Vittel, Contrex, Hepar France (Agrivair Project)	Himachal Pradesh Reforestation Project – Improving Livelihoods and Watersheds **(Payment for Ecosystem Services (PES) with a focus on carbon sequestration and watershed services)**	Sukhomajri Participatory Integrated Watershed Management Program (Community watershed management)
Author	The Watershed Protection and Partnership Council (WPPC) https://dos.ny.gov/new-york-city-watershed-program New York City Department of Environmental Protection (NYC DEP) Albert F. Appleton (2002)	World Agroforestry Centre (ICRAF), in collaboration with local community organisations and stakeholders under the RUPES (Rewarding Upland Poor for Environmental Services) initiative.		Government of Himachal Pradesh, Department of Forests	
Purpose/Aim/ Question Posed/ Objectives	1. Protection of New York City's drinking water, and the economic vitality of the Upstate Watershed communities 2. To protect the water quality of the Catskill/Delaware watershed, which supplies drinking water to over 9 million people in New York City and surrounding areas. 3. To avoid the need for water filtration, which is costly and energy-intensive. 4. To maintain the ecosystem health and biodiversity of the watershed.	1. To conserve and sustainably manage the watershed, preventing further degradation. 2. To provide incentives to local communities for adopting practices that support ecosystem health, such as reforestation and sustainable farming. 3. To link upstream communities who manage the land with downstream beneficiaries who rely on the water and ecosystem services.	1. To protect the water resource in the Vittel region and preserve water quality from reducing due to nitrate pollution. 2. To promote sustainable farming pesticides 3. Mitigation of climate change by reducing greenhouse gas emissions through carbon sequestration and other climate-friendly practices. 4. Generating income for local communities, particularly in rural areas.	1. The project aims to reforest degraded land in the watersheds of the Mid-Himalayan region through the plantation of native and local tree species. With these activities, the project aims to improve the productive potential of the degraded land or watershed catchment areas and enhance biomass production and carbon stocks in degraded lands. 2. The forests of the Himachal Pradesh watersheds are an important carbon sink for greenhouse gases. 3. To reforest degraded forest areas in Himachal Pradesh. 4. To improve the livelihoods of local communities, especially women and marginalized groups. 5. To protect and enhance watershed health. 6. Improve the productive potential of the degraded land or watershed catchment by enhancing biomass production and carbon stocks on degraded lands included in the project, 7. sequester Green House Gases (GHG) removals by sinks through reforestation on degraded forest, community and private lands, and 8. contribute revenues from the project to improvement of livelihoods and incomes of rural households residing in the watersheds covered under the project.	1. To reverse land degradation and improve the lives of its residents 2. To address the issue of declining water quality and soil erosion in the Sukhomajri watershed. 3. To improve the livelihoods of local communities through sustainable resource management. 4. To protect the environment and ensure the long-term sustainability of the watershed. 5. Ensuring the legal recognition and enforcement of community rights over natural resources can be challenging, especially in the context of evolving property rights regimes.
Location/ Background	The Catskill/Delaware watershed is located in upstate New York. The program was initiated in the 1990s to address declining water quality and increasing threats to the watershed. Westchester, Putnam, Ulster, and Orange countie	Bakun Watershed, Philippines (Bakun municipality, Benguet Province, northern Philippines), (Predominantly Bago-Kankanaey tribe, dependent on agriculture and forest resources)	Vittel, Contrex, Hepar in northeastern France	Himachal Pradesh, India	Sukhomajri, Haryana, India (1970)
Background	1. By the early 1980s, the shadow of water quality problems had begun to fall on New York's drinking water system. The Croton watershed was rapidly suburbanizing and under assault from non-point source pollutants such as eroded soils, lawn fertilizers, poorly controlled septics, spilled motor fuels and industrial toxics and solvents, and hydrocarbons leached from roads. 2. Local forestry was increasingly characterized by highgrading of premium species, destructive road construction and other non-sustainable land management practices. Land no longer suitable for agriculture or forestry was increasingly being put on the market for vacation home development. 3. By the end of the 1980s, an environmentally destructive pattern of land use was replacing the traditional agricultural and land use patterns that had been compatible with the drinking water needs of the City. 4. American water quality regulations have been notably successful in controlling sewage discharges from individual treatment plants or other urban point sources. 5. The program was initiated in the 1990s to address declining water quality and increasing threats to the watershed.	The Bakun watershed is a vital area that supports agricultural activities, provides water resources, and supplies hydroelectric power. It faces challenges from deforestation, agriculture expansion, and unsustainable land use. One of the most pressing problems was widespread deforestation driven by unsustainable agricultural expansion and illegal logging activities. The forest cover was steadily declining due to slash-and-burn practices and unregulated cutting of trees for timber and fuel.	Vittel is renowned for its mineral water, sourced from a protected area. However, intensive agricultural practices in the region, particularly maize cultivation, were leading to increased nitrate levels in the groundwater, threatening the quality of the mineral water. Natural Mineral Water comes from 2 sources, one of them, called the Triassic Sandstone Aquifer (GTI), is facing a problem of water deficit. The Aquifer is in deficit because users are higher than rainwater inputs. The aquifer water is used for various purposes such as drinking water distribution systems (45%), Industries (45%), of which Nestle uses 25% and cheese factory is using 20%, and other activities such as agriculture and tourism is using 10%.	1. The net sown area of Himachal Pradesh has declined over the past decades, and forests in Himachal Pradesh are in continuous degradation as a result of biomass loss. Since the Government of India's 1980 Forest Conservation Act banned conversion of forestland to non-forest uses, there has been no shift of non-cropland, such as forest, revenue, and common land, to agricultural land. Thus, the degraded forest and community land cannot be converted to agriculture or horticulture, and the most plausible baseline scenario is continued degradation of forest and community land. 2. The HPRP is a subproject of the World Bank's Mid-Himalayan Watershed Development Project (MHWDP). The MHWDP was implemented from 2005–2017. 3. The project is registered for carbon credits by the UN under which the World Bank will buy carbon credits from the new forests/ plantations being developed on degraded areas in 177 gram panchayats covering around 4,000 hectare land falling in 10 districts of the state.	A scheme was launched in 1979 in response to growing water scarcity. Farmers in Sukhomajri were supported by the CSWCRTI and the Ford Foundation to undertake a programme of checking dam construction and watershed management to tackle heavy siltation and low dry seasonal flows (Landell-Mills and Porras, 2002). 1. In the 1970s, Sukhomajri adopted rainwater harvesting to ensure a reliable water supply. This allowed the villagers to grow trees on land that was previously barren. 2. Artificial lake Sukhna lost 65% of its capacity in 20 years. Sediment delivery was estimated at 141 tonnes /ha/year. 3. Out of 4214 ha of total catchment area 25 percent was identified most vulnerable falling in Sukhomajri belt. 4. Agricultural fields of the village were converted into 20meter deep gorge from runoff coming from 4.2 ha.hilly catchment. 5. During1975,CSWCRT lidentified the problem area and treated it with suitable conservation measures. 6. Considered active as of 2008
Total Area under Program	1.3 million acres.	Approximately 29,000 hectares.	Approximately 10,000 hectares (Covering 11 villages)	4003.07 Hectares	Approximately 400 hectares
Area Selection Criteria (Based on-)	Catskill and Delaware watersheds, which are the source of most of the city's drinking water.	1. Watershed significance for water supply and hydroelectric power. 2. Presence of critical ecosystems under threat. 3 High dependency of local communities on watershed services.	1. Proximity to the Vittel water source 2. Potential for significant impact on water quality 3. Farmer willingness to participate	1. High degree of degradation 2. Vulnerability to erosion 3. Importance for water security 4. Potential for biodiversity conservation	1. Areas with significant degradation and erosion 2. Areas with potential for water conservation and soil restoration 3. Areas with high community involvement and support
Primary Drivers of Watershed Degradation	Agricultural runoff (fertilizers, pesticides), Urban and suburban development, Soil Erosion	1. Poverty-driven deforestation 2. Shifting cultivation 3. Deforestation due to expanding agriculture and illegal logging. 4. Soil erosion and land degradation from unsustainable farming practices. 5. Population pressures leading to resource overuse.	Intensive agriculture, particularly maize cultivation Use of chemical fertilizers and pesticides	1. Clearing of forests for agriculture, fuelwood, and timber has led to significant loss of forest cover. 2. Intensive farming methods, including excessive use of fertilizers and pesticides, have degraded soil quality and water resources.	Deforestation Overgrazing Unsustainable agricultural practices Soil erosion
Key Issues	**1. Non-Point Source Pollution-** Erosion of soil, Fertilizer runoff, Septic system failures, Motor fuel and industrial chemical spills, Road runoff **2. Unsustainable Land Management Practices-** Clear-cutting of forests, Destructive road construction, Conversion of agricultural and forest land to residential development **3. Declining Water Quality-** Increased sedimentation, Nutrient pollution, Chemical contamination **4. Urbanization and Development-** Suburbanization of the watershed, Increased impervious surfaces, Altered hydrological patterns	**1. Loss of forest cover and biodiversity-** The loss of forest habitat led to the decline of plant and animal species that depended on the ecosystem. This reduced the overall ecological health and resilience of the watershed. **2. Reduction in water quality and flow-** The degradation of forest cover and land contributed to reduced water retention in the soil, impacting water availability for downstream users. This also led to poor water quality, as eroded soil particles carried pollutants and sediments into the rivers and streams. **3. Erosion affecting agricultural productivity and siltation in downstream areas-** High sediment loads in the rivers due to erosion negatively affected both agricultural activities and hydroelectric power production downstream. Siltation reduced the capacity of water storage facilities and impaired the functioning of hydroelectric power plants.	1. Water Quality Degradation 2. Nitrate pollution of groundwater 3. Decline in water quality 4. Potential impact on the mineral water industry 5. Agricultural Runoff (Pesticides)	1. Significant forest cover loss due to unsustainable practices like fuelwood extraction, timber harvesting, and clearing land for agriculture. 2. Removal of vegetation cover, especially in hilly areas, led to severe soil erosion, impacting agricultural productivity and water quality. 3. Deforestation and soil erosion reduced water retention capacity, leading to water scarcity during dry seasons.	1. Excess runoff and soil loss from both arable and non-arable lands. 2. Severe land degradation resulting in denundation of hills and loss of biodiversity. 3. Burgeoning human and cattle populations leads to heavy dependence on the forest. 4. Erratic distribution of rainfall causing periodic moisture excess and stress. 5. Inscriminate felling of trees and uncontrolled grazing 6. Migration of cattle and human population from villages. 7. Agricultural fields are washed away with heavy flow of water 8. Frequent crop failures, small land holdings (less than 1.0 ha.), low agricultural income forcing villagers to keep large nos. of goats and cattle.
Key Ecosystem Services Affected	Water quantity, Flood control, Water purification (quality), Recreation, Biodiversity	Water regulation (quantity and quality), Erosion control, Biodiversity loss	Water quality Biodiversity	1. Carbon sequestration 2. Water regulation 3. Soil preservation 4. Biodiversity	soil preservation, afforestation, ground water protection and forest management.

Buyers	New York City residents and businesses	Hydroelectric power companies Water utilities Government agencies	Nestle Waters (owner of the Vittel brand)	Carbon market participants (e.g., corporations, governments)	Downstream users of water
Sellers	Landowners in the watershed	Indigenous communities in the Bakun Watershed	Local farmers	Local communities and forest department	Landowners and local communities
Type of PES Program	multi-partner (Regulatory and incentive-based approaches) Private Sector	Watershed-based PES focusing on conservation and sustainable land-use practices. **Government and Private sectors - PPP Model**	**Private Sector**-Led PES with the collaboration of govt and local communities, NGOs (46 stakeholders), **Community Partnership Program** for 20 years.	**Government-Financed Mechanisms**	**Self-help program and Govt-Private Sector Aided (Community-based PES)**
Stakeholders/Organizations/Institutions Involved	1. New York City Department of Environmental Protection (NYC DEP) 2. The Watershed Agricultural Council (WAC) manages the program (PPP)	Downstream beneficiaries such as hydroelectric power companies, municipal water services, and larger agricultural producers.	1. Nestlé Waters 2. Partnership - French National Agronomic Institute (INRA) 3. the national Institute for Agronomic Research, 4. The Rhin Meuse Water Agency	1. Forest Department (Government of Himachal Pradesh) local institutions, Gram Panchayats (GPs) 2. International Bank for Reconstruction and Development as a trustee of the BioCarbon Fund. 3. National Afforestation and Eco-Development Board (NAEB) 4. Compensatory Afforestation Fund Management and Planning Authority (CAMPA)	1. Central Soil & Water Conservation Research & Training Institute. (CSWCRTI) 2. Ford Foundation 3. The Departments of Forests, Agriculture and Soil Conservation, 4. The World Bank aided Integrated Watershed Development Project (IWDP) 5. Water users association, 6. Hill Resource Management Society (HRMS) managed the water allocation.
Program Financing Agency	1. Funded by the New York City Department for Environmental Protection at a cost of USD 1.5 billion 2. NYC Budget	Local upland communities responsible for land management and sustainable practices.	1. Private funds from Nestle Waters 2. Investment of US $24.5 million over seven years to support the transition from intensive to extensive farming practices.	1. International Development Association (IDA) 2. International Bank for Reconstruction and Development (IBRD) is acting as trustee for BioCarbon Fund (BioCF) 3. The green development loan is for US$200 million. (signed between state govt and world bank on july 2012 4. Funding consists of a 90 per cent grant and a 10 per cent loan at interest rate of 0.7 per cent (payable in 30 years). 5. World Bank's Mid-Himalayan Watershed Development Project (MHWDP) 6. Carbon finance mechanisms 7. National Afforestation and Eco-Development Board (NAEB)- Provides funding and technical support for afforestation and eco-development activities. 8. Compensatory Afforestation Fund Management and Planning Authority (CAMPA)- Provides funds for compensatory afforestation to offset forest land diverted for non-forest purposes.	1. Community contributions 2. Government grants 3. Donor funding 4. Water rights: Rs.16 per hour (from which Rs.4 per hour channelled to cover HRMS's administrative expenses). The HRMS also distributes revenue from extraction of bhabbar grass and, in future, timber from common areas, to all villagers. As of 2008, bhabbar grass sales were approximately worth US$3,000 per year. 5. Accumulative dredging costs avoided by sediment reduction saved an approximate US$2,000,000. 6.Other forest product sales provided an additional US$7,000,000 in income.
PES Mechanisms (Payment) / Levels	1. Land acquisition 2. Conservation easements 3. Technical assistance 4. Financial incentives for implementing best management practices **Levels of Implementation-** Watershed-scale, Sub-watershed scale, Individual landowner level	**1. Cash payments** for specific conservation activities (e.g., reforestation, agroforestry) **2. Non-monetary incentives such as training, capacity building, and infrastructure support.** **3. Conditional payments for specific conservation actions.** **4. Financial payments for land management.**	**1. Payments amounted to 200 Euros/ha/ year for a five-year transition period.** (equivalent to 75% of disposable income). This is to ensure a guaranteed income during the transition period and reimburse the debt contracted before entering the program, for the acquisition of farm equipment. The exact amount is negotiated for each farm. **2. Incentives for farmers.** **3. Direct Payment to farmers** **4. Contractual Agreement-** Long-term security through 18 or 30-year contracts. 5. Abolition of debt linked to **land acquisition,** and land acquired by Vittel left in usufruct for up to 30 years. 6. Subsidy of, on average, about 200 euros/ha/year over five years. 4. Up to 150,000 euros per farm to cover the cost of all new farm equipment and building modernization.	**1. Community-based forest management incentives**	**1. Incentives to farmers and local people** **2. Green Tax levied on the income.** **3. NGO intermediary-based transaction & (tradable) water rights/user fees** - to ensure compensation to households that are excluded from reforested areas, Sukhomajri first allocated tradable water rights to every household so all have an interest in maintaining water flows. **4. User Fee -** Irregularity in water flows led to replacement of this system by **a user fee system** whereby the HRMS collects fees for water use and distributes the revenue to all villagers.
Implementation Tools/ PES Activities	**1. Conservation Program and Easement -** Between 1990 and 1993, New York City also designed and implemented the largest **water conservation program** in American history, permanently reducing its per capita water use by close to 20% and, at the cost of roughly $500 million dollars, saving the $3 to $5 billion dollars it would have cost to construct new water supply works on the Hudson River. **2. Public-Private Partnership** A filtration plant large enough to clean the City's water supply would cost between $8-$10 billion in today's dollars, approximately $6 billion to build and another $250 million annually to maintain. **3. Land Acquisition-** NYC DEP purchases land within the watershed to protect it from development and ensure sustainable management practices. **4. Forest Management** **5. Agricultural Best Management Practices (BMPs)** **6. Financial Incentives-** Landowners receive payments for adopting and implementing BMPs that reduce pollution and protect water quality. **7. Rules & Regulations-** NYSDEC Protection of Waters (POW) regulatory program establishes and enforces regulations that are compatible with the preservation, protection and enhancement of the present and potential values of the water resources; protect the public health and welfare; and are reasonably consistent with the state's social and economic development.	1. Community-based forest management & Community agreements on forest protection. 2. Agroforestry 3. Conservation agriculture 4. Soil and water conservation measures 5. Training and workshops on sustainable farming techniques. 6. Forest restoration through reforestation and controlled land use.	**1. Land Management Practice-** Agrivair is a sustainability initiative launched by Nestlé Waters France in 1992. Its primary goal is to protect the water sources of Vittel, Contrex, and Hépar mineral waters by implementing sustainable land management practices in the surrounding areas. 2. Zero Pesticides 3. Enrichment of plant and animal biodiversity 4. 40 km of hedges planted and +20% of birds. 5. Tree Plantation Program 6. Free labor to apply compost in farmers' fields. This is to address the labour bottleneck and ensure optimal amounts are applied to each plot. These amounts are calculated for each plot for each farm every year, and individual farm plans are also developed annually. 6. Free **technical assistance including individual farm plans and introduction to new social and professional networks**. This is particularly important as giving up the intensive agricultural system alienated farmers from traditional farming networks and support organizations.	**1. Afforestation and reforestation** **2. Silviculture** **3. Community-based forest management** **4. Monitoring and evaluation** **It is implemented under four guiding principles-** (i) adopting native and locally preferred tree species for reforestation (including over 50 native species), (ii) involving the local Gram Panchayats (GPs) and small and marginal farmers in reforestation activities that will strengthen the ongoing watershed interventions, (iii) facilitating technical, financial and capacity development support from MHWDP for reforestation activities iv) distributing carbon revenue to the village community (GP and farmers). **5. Restoration forestry model-** In this model, reforestation of degraded forestland is undertaken by planting 1,100 plants/ha of mostly native species. This model of restoration forestry aims to protect the watersheds, conserve biodiversity, and regenerate the native flora, supplemented with planting of native tree species on degraded sloping high altitude lands of selected GPs. Regenerated forests are expected to provide non-timber forest products to local communities and improve their livelihood opportunities. This model has covered 2947.27 ha. **6. Community forestry model-** This model is being undertaken for the reforestation of degraded community lands (common land). The species included in this model are largely native species. The reforestation activity will lead to the protection of watersheds, and improvement in biomass required to meet the local community needs of small timber, fuelwood, fodder for livestock and non-timber forest products. This model covers 225.04 ha and the density of planting in this model is 1,100 trees per hectare. **7. Farm forestry model-** This model covers an area of 29.15 ha and includes reforestation of abandoned or long-term fallow private lands with tree species and aims to provide fruits and fodder to the land owners. The density of planting is 1,100 trees per hectare. Through this model, land owners derive fuelwood, and employment apart from protecting the abandoned land.	The Payment for Environmental Services (PES) component of this watershed management scheme arose from the need **to create compensation/ incentives** for landless and more marginal farmers to participate in watershed protection activities. Since not all of the villagers were benefiting from the improved water resources (which led to better agriculture production and even fish farming in the dams), benefit-sharing arrangements (or PES) were set up to share the water resource more fairly (including non-land owners) and provide incentives for all to take up the protection measures required.
Impact on Land use Practices/ Success Factors	1. Reduced deforestation 2. Improved agricultural practices 3. Increased forest cover 4. Enhanced riparian buffers 5. Reduced nutrient and sediment runoff	1. Increased adoption of sustainable land management practices 2. Improved forest cover 3. Reduced soil erosion 4. Improved water quality	1. Shift towards more sustainable farming practices, such as grassland-based cattle ranching 2. Improved water quality due to reduced nitrate pollution 3. Increased biodiversity in the catchment area 4. Long-term commitment from Nestlé Waters 5. Strong collaboration between the company, farmers, and local authorities. 6. By 2004, 1700 ha of maize had been eliminated, and 92% of the sub-basin was protected.	1. Scaling up vermicomposting and other sustainable agriculture practices increases the organic matter content of the soil, and the enhanced water retention capacity facilitates sustainable and productive agriculture. 2. At mid-term review in November, 2009, the project had already surpassed its end-of-project target of 50 per cent increased agricultural yield, achieving increased paddy (236 percent), maize (163 per cent), wheat (90 per cent), and milk yields (11 percent). Approximately 10,000 farmers had modified their cultivation and marketing approaches, including adopting higher-value crops such as vegetables and spices.1500 farmers were grouped into milk federations connected to milk chilling plants.	1. Shift from Degradative to Regenerative Practices: The project has successfully shifted the focus from unsustainable practices like deforestation and overgrazing to regenerative practices like afforestation, soil conservation, and water harvesting.
Environmental and Hydrological Outcomes	1. Improved water quality 2. Increased water flow 3. Reduced flood risk 4. Enhanced biodiversity 5. Improved habitat for aquatic species	1. Increased water flow 2. Reduced sediment load 3. Improved biodiversity	1. Reduced nitrate levels in groundwater 2. Improved water quality 3. Increased biodiversity 4. Enhanced ecosystem health 5. Reduced charges for water treatment system 6. Less Greenhouse gas emissions (new farm building standards)	1. Through this project, highly vulnerable degraded lands are being restored, including forestland, degraded community land, and degraded and abandoned private lands in the Mid-Himalayan watershed. The productive potential of these degraded lands and watershed catchment areas is improving as a result of the enhancement of biomass production and carbon stocks. In addition, the project activities are promoting biodiversity conservation, soil conservation and environmental protection through planting and protection of native tree species, reduction in soil erosion, and prevention of downstream siltation of water bodies. 2. 41,400 metric tonnes CO2 equivalent per annum	1. The tree density in Sukhomajri increased from 13 per hectare in 1976 to 1272 per hectare in 1992. 2. The concept of social fencing gained wide recognition in the effort to control the grazing of cattle. As a result, forest areas were covered with grass and trees within a period of 10 to 15 years. Grass production more than doubled in the same period (from 3.82 t/ha to 7.72 t/ha) 3. Agricultural productivity increase: Improved watershed protection has generated high returns in the form of improved agricultural productivity due to greater water availability in the check dam and reduced soil erosion. 4. Between 1977 and 1986, agricultural productivity increased by 500 percent for wheat yields, 400 percent for maize, and 30 percent for milk production. From 1979 to 1984, household income went up from about Rs.10,000 to Rs.15,000, with villagers earning about Rs. 3,50,000 from milk sales and another Rs.1,00,000 or so from the collective sale of bhabbar grass. 5. In the 1990s the forest yielded nearly US$3,000 worth of grass annually. However, this led to a steep increase in government charges for the extraction of bhabbar grass from public forests. 6. Reduced siltation and increased tree cover- Siltation in Sukhna Lake fell by 95 percent, saving the city of Chandigarh about US$200,000 annually in dredging and related costs. 7. Vegetation cover on the hillside increased from 13 trees per hectare to 1,292 trees per hectare, raising the value of the forest to an estimated US$20 million capable of generating at least US$700,000 per annum.
Socioeconomic Outcomes	1. Job creation in conservation and agriculture 2. Increased property values 3. Enhanced recreational opportunities 4. Strengthened rural communities	1. Increased income for local communities 2. Improved livelihoods 3. Reduced poverty	Additional income for farmers Improved livelihoods for local communities Strengthened local economy	1. Overall, household incomes had risen 13 %, largely due to project extension services, particularly improved agricultural production technologies and market linkages. 2. Through community involvement, the project is working to improve the livelihoods and incomes of rural households sustainably. Small and marginal farmers are involved in plantation activities on degraded common lands, degraded forestlands, and private degraded lands through the planting of multi-purpose species and implementing sustainable forest management practices. The project is generating employment through silvicultural activities (nursery raising, site preparation, seedling transportation, planting, fencing, and maintenance of plantations) and revenue from the sale of carbon emission reductions, The broader MHWD project includes several activities that promote livestock development, fodder production, infrastructure development, and institutional capacity enhancement.	1. The village experienced a rise in revenue through better crop yields. 2. The village was able to preserve the denuded Shivalik hills from soil erosion. 3. Improved living conditions. 4. As compensation for foregone benefits previously drawn from using the common lands for grazing and non-timber forestry products, farmers were able to profit from the sale of water rights and access to increased fodder from public lands (owned by the forest department).

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National Institute Of Technology, Calicut

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ARYA R KUMBHRE

Urban Planner I Architect

A professional with academic and practical research experience seeks a challenging role in a purpose-driven environment. Skilled in design-oriented and practical solutions that benefit communities, addressing global challenges with innovation.

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Area of Interest

-Urban Environmental Issues,
-Real Estate,
-Urban Planning & Design,
-UP Research & Management
-Water Management

Skills

-GIS Data Analysis and Mapping,
-Extensive Research and Data Visualization,
-Qualitative and Quantitative Analysis,
-Technical Report Writing with Qualitative and Quantitative Analysis,
-High teamwork attributes

ArcGIS | Erdas Imagine | City Engine

AutoCAD | Photoshop | Power BI

MS Excel | MS Word | MS PowerPoint

Other Architectural Softwares:
SketchUp-Vray, Lumion, Revit, Enscape, Illustrator, Indesign, Canva, Miro

Education Qualification

2023-25	**M.Plan**	National Institute of Technology, Calicut (GATE Scholar)	**8.09 CGPA**
2017-22	**B.Arch**	Smt. Manoramabai Mundle College of Architecture, Nagpur	**8.20 CGPA**
2015-17	**Class 12th**	Dr. Ambedkar College, Deekshabhoomi, Nagpur	**76.00 %**
2015-16	**Class 10th**	Somalwar High School, Ramdaspeth, Nagpur	**89.20 %**

Professional Experience and Responsibilities Handled

2024 — **Urban Planning Intern at HCP Design, Planning and Management Pvt. Ltd., Ahmedabad**
Worked on AUDA & GUDA Vision DP Plan & GIFT City Detailed Master Plan for CBD: Critical analysis of quantitative & qualitative data, presentation, critical writing, mapping and research

2022 — **Freelance Architect**
Work Experience of Commercial cum Residential Project, Interior Design Projects

2021 — **Architectural Internship at Ecour Studio Pune**
Working Drawing, Estimation & Costing, Interior Designing, Presentations

2023-25 — **CII-IGBC Student Coordinator at NIT Calicut**

2023-25 — **Social Media and PR Coordinator**
Worked to enhance the institute's online presence through a strategic online public appearance management. Engaged in creating innovative content for the department.

2024-25 — **Teaching Assistant**
Engaged in 1st Year and 3rd Year Design Studio

Academic Projects and Research

2025 | **Urban Planning (M.Plan) Thesis (Sponsored by NIUA &NMCG)**
Reimagining Godavari River through the lens of ecosystem services and sustainable development of Nashik. The project involves identifying ecosystem services, mapping human dependencies, and creating a special-purposee plan as an output.

2024 | **Regional Planning Studio : Planning for Environmental Conservation in impacted area of 5 districts in Kerala (M.Plan-3rd Sem)**
Project involves formulation of directives that facilitate equitable, holistic development in eco-sensitive zones by assessing potential adversaries and proposals for effective conservation and protection measures.

2024 | **Dissertation : A comprehensive review of the concept of "Payment for Ecosystem Services" and its practical applications across various global watershed conservation cases. (M.Plan 3rd Year)**
8 International and 2 National PES System implemented live cases have been analyzed.

2024 | **Research (Mini Project) : Revenue Generation through Asset Management in ULBs (M.Plan-2nd Sem)**
Brief Understanding on revenue sources of ULBs, Value Capture financing and successful examples: Produced detail report and research paper.

2024 | **Preparation of Risk Informed Master Plan for Manali Agglomeration, Himachal Pradesh (M.Plan-2nd Sem)**
Analyzed and Studied the Existing Scenario of the Manali Agglomeration area in terms of Issues / Potential: Featuring Formulation of Strategies and Proposals addressing risk mitigation and disaster management

2023 | **Preparation of Local Area Planning for Urban Periphery considering TOD in Calicut, Kerala (M.Plan-1st Sem)**
Detailed data analysis, Derivation of planning process, Formulation of Planning Process, Site Planning considering TOD aspect of Medical College node in Calicut city.

2023 | **Livelihood Assessment : The livelihood assessment of different wards in Kozhikode Municipality. (M.Plan-1st Sem)**
Project Details: Hypotheses related to various livelihood aspects were considered and studies were conducted to prove those hypotheses.

2022 | **THESIS : The Multi Venue Performing Arts Center for IFFI, Goa (B.arch-10th Sem)**
Designing a Performing arts center and creation of spaces for socio-cultural interaction, leisure and entertainment.

Competitions and Achievements

-Top 9 Finalist in Student Thesis Competition Season 5 organised by NIUA, NMCG

-1st Position in The Vertical Studio-2018 organised by SMMCA

-Poster making competition in International Conference of "PARADOX TO PARADIGM"-2019

-Eco Niwas Samhita ECBC Design Competition-2020

-SA Deshpande competition under IIA Nagpur-2020

References:

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