Rejuvenation Of The Historical Water System Of The Champaner-pavagadh World Heritage Site

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Abstract **- India's history of advanced water management dates back to the Indus Valley Civilization and continues with sites like Champaner-Pavagadh in Gujarat. Known for its sophisticated medieval water systems, Champaner-Pavagadh is a UNESCO World Heritage site. The Pavagadh hills, called the "hill of a hundred pools," feature tanks for rainwater collection, while Champaner, dubbed the "city of a thousand wells," showcases a network of wells and stepwells. These systems were expanded under Sultan Mahmud Begada in the 15th century, demonstrating architectural and engineering prowess. However, recent neglect, pollution, and modern development have led to the decline of these systems, threatening the region's cultural heritage. This thesis aims to identify the causes of this degradation and propose solutions to restore Champaner-Pavagadh's water management systems. By combining historical research with modern engineering and sustainable practices, the project seeks to preserve these ancient marvels for future generations and reintroduce traditional water management techniques for contemporary use.**

Keywords – water management, Champaner-Pavagadh, water infrastructure, government negligence, pollution, pilgrimage site, catchment areas, degradation, rejuvenation, historical research, sustainable practices, cultural heritage

I. BACKGROUND AND INTRODUCTION

A. *Current World :* The modern world faces a paradox in water management: some regions suffer from floods, while others endure severe droughts. This imbalance, worsened by climate change, urbanization, and mismanagement, highlights the need for innovative water solutions. Historically, civilizations like the Indus Valley displayed a deep understanding of water systems, creating efficient networks of wells, reservoirs, and channels to ensure sustainability. A prime example is the Champaner-Pavagadh region in Gujarat, India, known for its sophisticated water management. The "hill of a hundred pools" and "city of a thousand wells" featured intricate systems like the Ganga, Yamuna, and Saraswati Kunds, which were both practical and spiritually significant. Helical stepwells, or 'vavs,' demonstrated advanced engineering and aesthetic beauty. Champaner, founded in the eighth century and expanded under Sultan Mahmud Begada in the 15th century, thrived with a sustainable water supply until the mid-20th century. However, modern development, neglect, and pollution have led to the decline of these systems, threatening the region's cultural heritage. Urgent intervention is needed to restore these ancient waterworks and preserve their legacy.. [1]

Figure 1: *Current world scenario*
Source: *newindianexpress.com , UnitedRepublicofTanzania.com*

B. *Water Wise Civilization:* A water-wise civilization effectively manages and conserves water resources with a focus on sustainability, efficiency, and equity. This society integrates strategies and technologies to ensure responsible water use. Key features include modern water treatment plants for safe wastewater reuse, advanced irrigation systems to minimize agricultural water use, and robust stormwater management systems to reduce flooding risks. Innovative technologies like smart meters provide real-time water usage data to detect leaks and optimize distribution, while

desalination plants and rainwater harvesting expand water resources. A strong legal framework supports water conservation and quality protection, with regulations setting standards for industrial discharge, agricultural runoff, and wastewater treatment. Water pricing reflects the true value of water, promoting efficient use while remaining affordable for all. Government agencies enforce these regulations, ensuring compliance and sustainability. Public education and community engagement are vital, with schools, community programs, and media campaigns raising awareness about water conservation. Involving local communities in water management decisions empowers individuals to protect their resources through conservation programs and citizen science initiatives. [2]

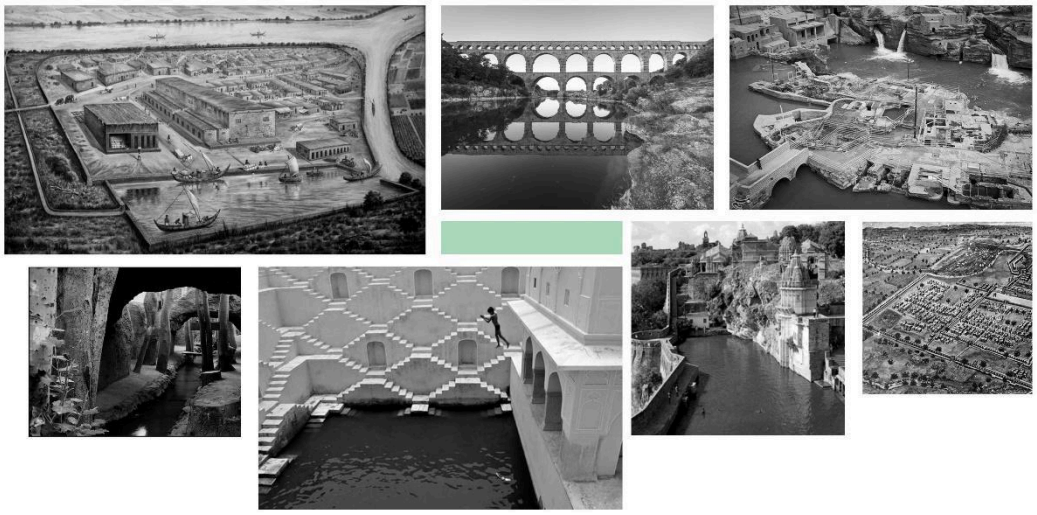

Figure 2: *Waterwise civilizations*
Source: https://www.wikipedia.org/

C. *Breif About Project:* The "Mapping and Rejuvenation of Champaner & Pavagadh's Watershed" project aims to map and restore the region's historic water systems. It involves detailed historical mapping through archival records, cartographic representations, and oral histories to uncover past water management practices. The project also assesses the current state of the watershed using field surveys, GIS, and aerial imagery. An extensive literature review and expert consultations with academicians, environmentalists, and conservation architects provide a theoretical foundation and practical insights into watershed management. The project actively engages local stakeholders, including residents and businesses, to gather input and shape a rejuvenation strategy that includes sustainable water management practices and community engagement initiatives. A monitoring mechanism involving local representatives and experts will ensure long-term success through regular assessments and strategy refinements. This dynamic approach guarantees the project's relevance and effectiveness over time. The project serves as a model for integrating historical preservation with modern environmental stewardship, promoting a sustainable future for the Champaner & Pavagadh watershed.

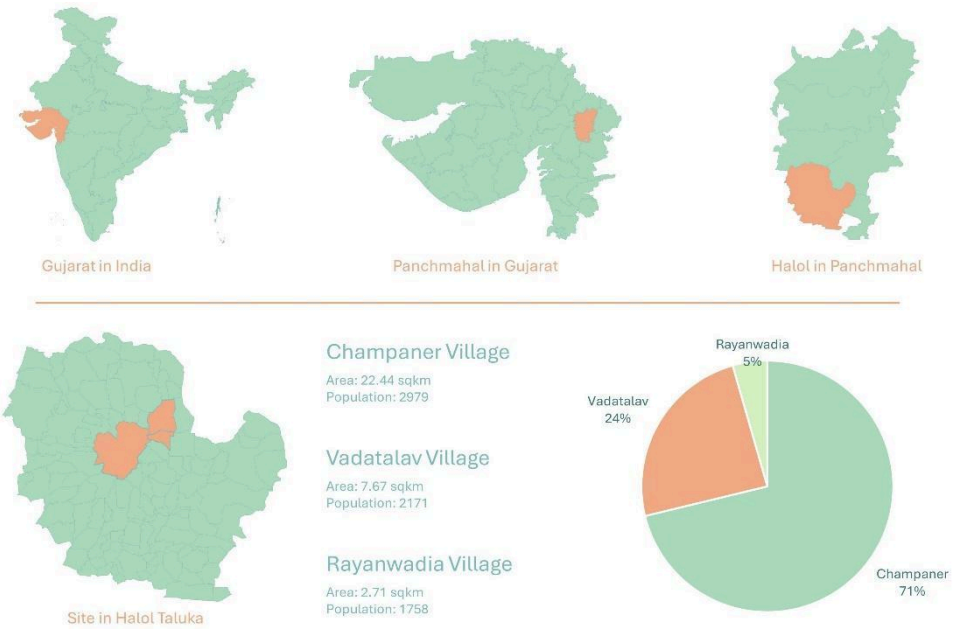

Figure 3: Site location maps
Source: Author

D. *Need of Project:*

1. Ecological and Climate Change Considerations

Restoring the watershed's water systems is essential for long-term water security. Enhanced water storage and conservation practices will help mitigate the impacts of droughts and other climate-related challenges. The project aims to secure a reliable water supply for future generations by promoting sustainable water management, thereby enhancing the region's resilience to climate variability. Reviving water bodies within the watershed will create crucial habitats for local wildlife, supporting a diverse range of species and contributing to a healthier ecosystem. These efforts will improve the natural environment, promoting ecological balance and resilience.

2. Social and Spiritual Awareness

The project seeks to rekindle a connection with the site's historical ingenuity and respect for traditional water management practices. By emphasizing the cultural significance of these ancient systems, the project fosters a sense of pride and responsibility for heritage preservation within the local community. This renewed cultural connection can inspire contemporary water conservation efforts and sustainable practices. Many historical water structures, such as stepwells, hold significant religious and spiritual importance. Restoring these structures can enhance the spiritual experience for pilgrims and visitors, providing a meaningful connection to the region's cultural and religious heritage. Revitalizing these sacred sites highlights the intertwined nature of water management and spiritual practices.

3. Physical Heritage and Cultural Knowledge

Mapping and restoration efforts will document and preserve the historical water system's physical structures. This safeguarding of architectural and engineering heritage is crucial for maintaining the integrity of the region's historical landscape. By preserving these structures, the project ensures that future generations can appreciate and learn from the ingenuity of past societies. Studying the historical water management techniques used in the Champaner & Pavagadh watershed provides valuable insights into how past societies addressed their water needs. This knowledge can inform contemporary water management strategies, offering lessons in sustainability and resilience that are particularly relevant in modern environmental challenges. The project aims to preserve the past and apply its wisdom to future water conservation efforts.

E. Vision, Aim& Objective

The Champaner-Pavagadh Water System Rejuvenation Project envisions restoring the Champaner-Pavagadh World Heritage Site as a model of sustainable water management. This revitalized system aims to demonstrate humanity's ability to coexist harmoniously with nature, ensuring a stable water future for the region and serving as an inspirational model for areas globally facing water scarcity or flooding challenges.

The primary aim of the project is to achieve a comprehensive rejuvenation of the historical water system at Champaner-Pavagadh. This involves creating a detailed map of the entire historical water system, including tanks, wells, stepwells, and canals, and focusing restoration efforts on repairing damaged structures, clearing debris, and ensuring the system's overall functionality. Additionally, the project emphasizes developing and implementing sustainable water management practices, such as rainwater harvesting, water conservation techniques, and promoting responsible water usage within the region.

The objectives of the project are multifaceted. Comprehensive Mapping involves conducting a thorough historical and archaeological survey to identify and map all components of the historical water system. This includes using archival records, historical maps, and oral traditions to reconstruct the system's layout and functionality, as well as employing modern technologies like GIS and aerial imagery to create a detailed and accurate map. Restoration and Rehabilitation prioritize restoring key waterworks, including tanks, wells, stepwells, and canals, by developing a phased restoration plan that considers historical significance, structural integrity, and community needs. Whenever possible, traditional and sustainable construction techniques will be used to preserve the site's historical character. The project also focuses on Sustainable Water Management, which involves implementing water conservation techniques within the Champaner-Pavagadh region, such as rainwater harvesting and drip irrigation. A comprehensive plan for managing water flow and preventing future flooding events will be developed, alongside educating local communities about the importance of water conservation and responsible water usage.

Finally, Knowledge Sharing and Replication aims to document the project's methodology, challenges, and successes to create a replicable model for water system rejuvenation. The project's findings and best practices will be shared with other regions facing water scarcity or flooding issues. Workshops and training programs will be organized to equip other communities with the knowledge and skills necessary to implement similar projects.

II. METHODOLOGY & ANALYSIS

A. Methodology Overview: The Champaner-Pavagadh Water System Rejuvenation Project begins with Phase 1: Mapping, focusing on the historical and current state of the watershed. The historical outline involves a detailed analysis of the Champaner-Pavagadh watershed by examining archival records, historical maps, and oral histories to reconstruct the original layout and functionality of the water system. Historians and archaeologists collaborate to gather comprehensive data on the historical significance and engineering techniques used in the construction of the water systems. The current situation is assessed through field surveys and modern technologies such as GIS and aerial imagery to identify existing water bodies, their conditions, and any degradation or alterations from the original structures. The mapping of existing issues includes identifying structural damage, siltation, pollution, and overexploitation of water resources, and analyzing the impact of these issues on the water system's functionality and the broader ecosystem.

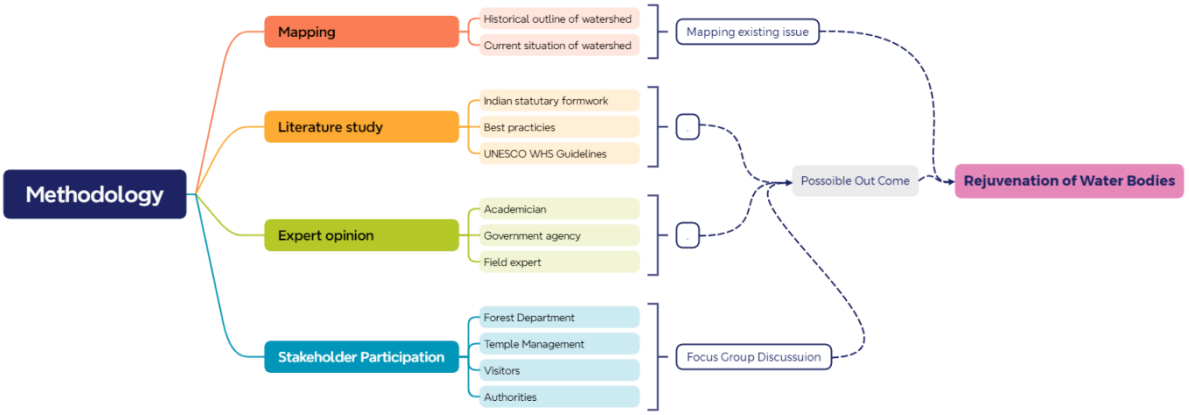

Figure 1: *Methodology*
Source: *Author*

In Phase 2: Study of Regulatory and Best Practices Frameworks, the project reviews relevant Indian laws, regulations, and policies related to water conservation, heritage preservation, and environmental protection, including acts like the Environment Protection Act and Water (Prevention and Control of Pollution) Act. An extensive literature review is conducted on academic papers, case studies, and historical documents related to watershed management and water conservation to provide insights into successful methodologies and practices globally. Best practices in water system restoration and sustainable water management are identified to serve as benchmarks for the restoration efforts at Champaner-Pavagadh. Additionally, adherence to UNESCO World Heritage Site (WHS) guidelines ensures that the restoration maintains the site's cultural and historical integrity.

Phase 3: Stakeholder Engagement and Expert Consultation involves gathering suggestions from a wide range of stakeholders, including academicians specializing in history, archaeology, environmental science, and water management, as well as local and national government bodies responsible for water resources, heritage conservation, and environmental protection. Field experts such as hydrologists, ecologists, and engineers with experience in watershed management provide expert opinions. Collaboration with the Forest Department addresses issues related to forest conservation and biodiversity within the watershed, while stakeholder participation engages residents, businesses, and community groups to ensure their needs and perspectives are considered. Temple management is also involved in integrating the restoration with religious practices and pilgrim needs. Visitors' feedback is collected to understand their experiences and expectations. Focus group discussions with various stakeholders facilitate detailed and interactive dialogues to identify key issues, potential solutions, and areas for collaboration.

Phase 4: Rejuvenation of Water Bodies prioritizes the restoration and rehabilitation of key waterworks such as tanks, wells, stepwells, and canals based on the mapping and stakeholder inputs. A phased restoration plan is developed, considering historical significance, structural integrity, and community needs, outlining specific restoration activities,

timelines, and resource requirements. Traditional construction techniques and sustainable practices are employed to preserve the historical character of the water systems. Implementation of sustainable water management includes water conservation techniques like rainwater harvesting and drip irrigation within the region, along with strategies for managing water flow and preventing future flooding events, such as creating buffer zones, improving drainage systems, and restoring natural waterways. The local community is educated about water conservation and responsible usage through workshops, campaigns, and educational programs. A monitoring and evaluation mechanism is established involving local representatives, experts, and stakeholders to oversee the progress of the restoration efforts. Regular assessments and feedback sessions are conducted to evaluate the effectiveness of the restoration and make necessary adjustments

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B. Spatial Analysis: As part of the Champaner-Pavagadh Water System Rejuvenation Project, a comprehensive spatial analysis was performed using Geographic Information Systems (GIS) to collect and evaluate critical data about the area. This analysis focused on several key components: elevation, terrain, slope, land use, and administrative boundaries. By examining elevation data, we were able to identify the topographical variations across the region, which are crucial for understanding water flow patterns and potential storage locations. Terrain analysis provided insights into the physical features of the landscape, helping to pinpoint areas prone to erosion or flooding and those suitable for restoration efforts.

Slope analysis further refined our understanding of the watershed by indicating the gradient of the land. This is vital for designing effective water conservation structures, such as check dams and contour trenches, which rely on accurate slope information to function correctly. The land use data revealed how the area is currently utilized, including agricultural fields, forested regions, urban settlements, and other land cover types. Understanding these patterns is essential for integrating sustainable water management practices that align with existing land use while promoting ecological balance.

Administrative boundaries were also mapped to delineate jurisdictional areas, ensuring that restoration and management plans respect local governance structures and facilitate coordination between different administrative units. This spatial analysis not only provided a comprehensive overview of the current state of the watershed but also served as a foundational tool for planning and implementing targeted restoration interventions. The insights gained from GIS data enable a strategic approach to rejuvenating the Champaner-Pavagadh water system, ensuring that efforts are both effective and sustainable.

Figure 4: Administrative Map of Halol

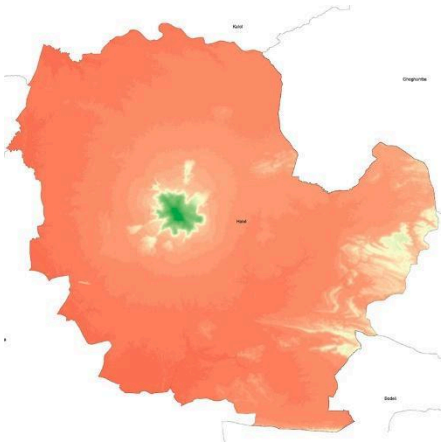

Figure 5: Elevation Map of Halol

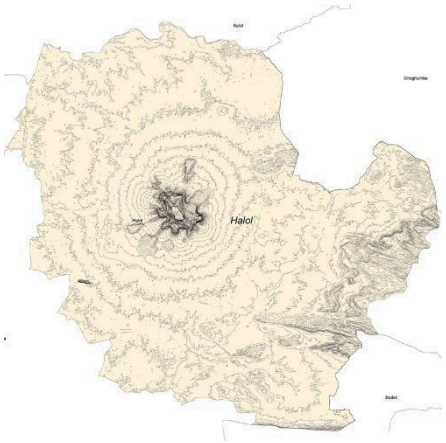

Figure 6: Contour Map of Halol

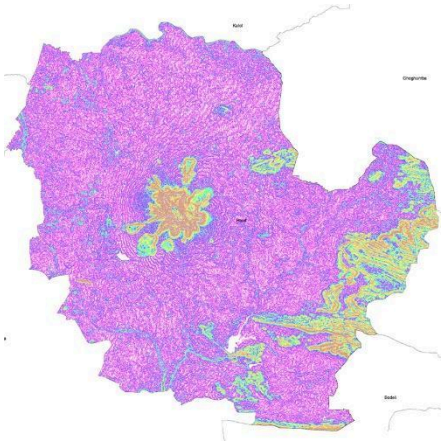

Figure 7: Slope Analysis Map of Halol

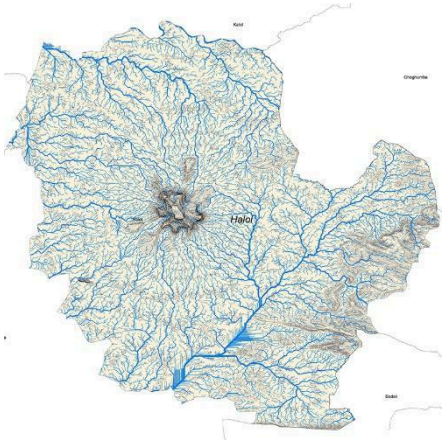

Figure 8: Contour Map of Halol

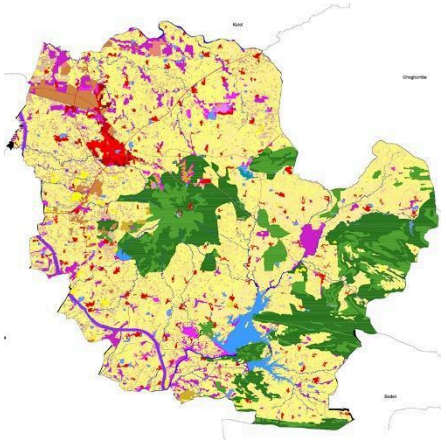

Figure 9: Slope Analysis Map of Halol

C. *literature Analysis*: The document “Water Intelligent City” by Sonal Mithal provides an in-depth look at the sophisticated rainwater harvesting system that once sustained the ancient city of Champaner-Pavagadh in Gujarat, India. This system, a remarkable example of early sustainable water management, consisted of a well-planned network of catchment basins, conveyance systems, and storage facilities. The city's water harvesting system included strategically placed catchment basins, known as talaos, designed to capture rainwater runoff effectively. Among these, the Wada Talao was the largest and most significant, chosen for its location due to the silty soil's water retention properties and its elevated position for efficient distribution. Other important catchment areas, such as the Kasbin Talao and those on the Atak, Machi, and Mauliya Plateaus, expanded the system's capacity.

Once collected, the rainwater was channeled through an elaborate network of canals and subterranean channels. Stone canals, like those running along the city's fortifications, and subterranean channels, such as the one serving the Kasbin Talao, facilitated long-distance water transportation. The water was then stored in various tanks and wells throughout the city. Notable tanks included the Wada Talao, Kasbin Talao, and others, which provided water for domestic use, irrigation, and recreation. Additionally, numerous wells, particularly in the Jahanpanah area, supported daily water needs.The water system was intricately integrated into the city's design, enhancing both functionality and aesthetics. Pleasure pavilions and gardens, like the Zar-e-Zamin and Baba Ghulam Ali Manzil, utilized water channels to cool the air and regulate temperatures, demonstrating a holistic approach to urban planning. However, the system's sophistication did not prevent its decline. After the 16th century, a shift in population and knowledge discontinuity led to its deterioration. The city's subsequent decline and abandonment worsened the neglect and damage. Despite these challenges, there is significant potential to revive this historical water harvesting system. By studying its design and functionality, valuable insights can be gained for modern water management strategies. The principles of sustainable water management and the possibility of restoring and integrating existing infrastructure offer lessons for arid regions. Documenting and preserving this knowledge can empower future generations, making it essential to explore areas such as detailed system mapping, hydrological analysis, and archaeological investigations. Engaging local communities and sharing knowledge will be crucial in reviving and adapting these techniques for contemporary water challenges.

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E. *Data Interpretation*: This project goes beyond simple restoration, serving as a key to unlocking insights for sustainable water management. By integrating historical and contemporary data, it aims to inform both the Champaner-Pavagadh revival and broader global water issues. The project utilizes a multifaceted approach to data collection and interpretation. Historical records, such as maps and administrative documents from the period when the water system was functional, offer clues about the original design and management practices. These insights help researchers understand water flow patterns and historical usage, guiding restoration priorities. Oral histories from local residents provide additional context, revealing traditional water management practices and changes over time. This information is crucial for ensuring that the restored system meets current community needs and retains its cultural significance. Spatial data, including high-resolution satellite imagery and elevation information, enables detailed mapping and condition assessment of the water system. Geographic Information Systems (GIS) help identify areas needing restoration and assess flood risks, aiding in the development of effective management strategies. The expected outcomes of the project include a comprehensive map of the historical water system, a prioritized restoration plan, and a sustainable water management strategy. Beyond Champaner-Pavagadh, the project’s findings offer valuable lessons on traditional water management techniques and serve as a model for similar efforts worldwide. Its emphasis on sustainable practices like rainwater harvesting provides a blueprint for addressing water security challenges in various contexts.

F. *Conclusion:* The Champaner-Pavagadh Water System Rejuvenation Project relies heavily on data interpretation to create interconnected maps that direct restoration efforts and ensure long-term sustainability. A land use and cover map will categorize the watershed into forests, agricultural fields, built-up areas, and water bodies. Analyzing both historical and current land use data will reveal changes affecting the water system, such as increased agricultural land indicating higher water demand or runoff. This analysis will inform strategies to address these issues and maintain efficient system operation. A watershed delineation map will identify the catchment area that supplies water to the system and highlight sources of pollution like industrial waste or agricultural runoff. This information will support targeted conservation efforts and pinpoint areas suitable for water harvesting, thereby enhancing water security. Slope analysis will determine terrain steepness, helping to identify areas prone to erosion or flash floods, which will guide restoration efforts in these high-risk zones through measures like slope stabilization or channel modifications.

Mapping water catchments will locate areas where rainwater collects and infiltrates, which is vital for replenishing water resources. Protecting these catchment areas may involve promoting vegetation or setting up rainwater harvesting systems. Finally, a map of the connections between water bodies will optimize water flow throughout the system. Together, these maps will provide a comprehensive understanding of the watershed, guiding the project toward successful and sustainable management while honoring the rich legacy of Champaner-Pavagadh.

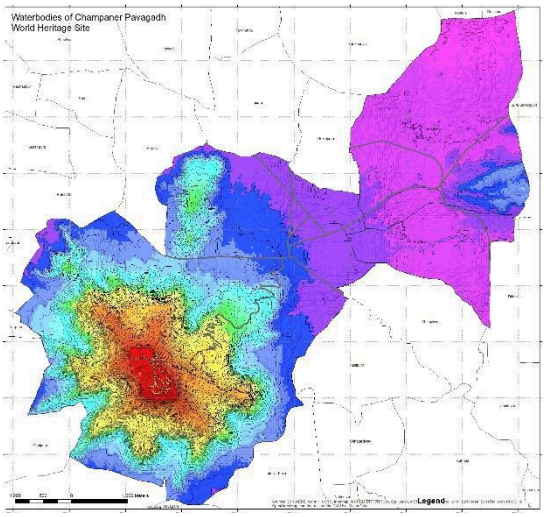

Figure 10: Elevation Map of Site

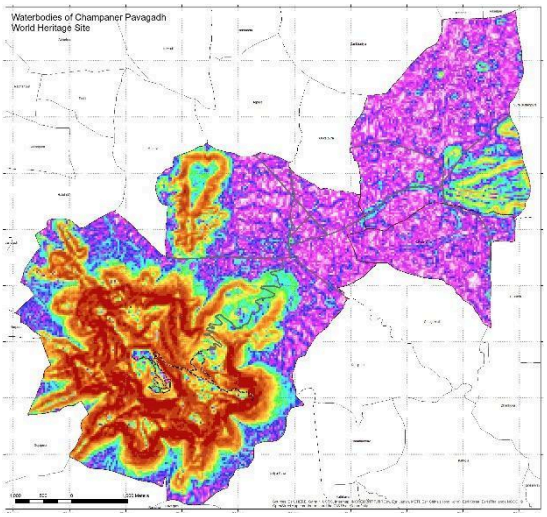

Figure 11: Slope Analysis Map of Site

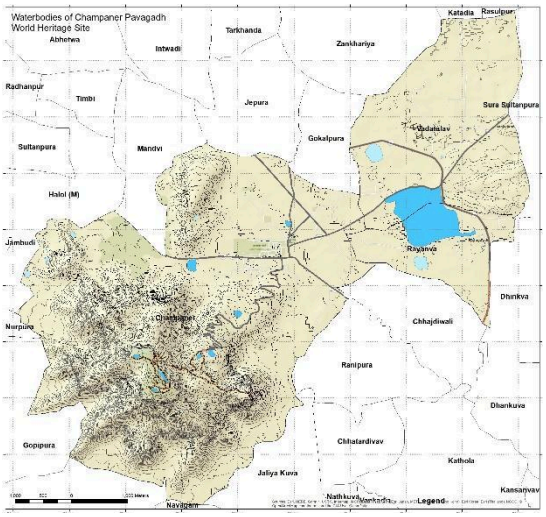

Figure 12: Village Map of Site

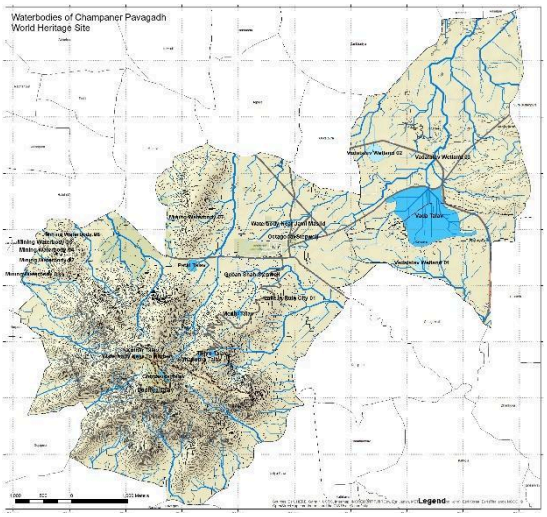

Figure 13: Watershed Analysis Map of Site

III. ISSUE IDENTIFICATION

A. *Locations Identification with issues*: Within the Champaner-Pavagadh World Heritage Site, several locations face various water-related challenges. Among the natural lakes, Teliyu Talav is likely experiencing water quality degradation and declining water levels. While the document doesn't detail the extent of these issues, it notes the presence of a historical water system around the lake, hinting at potential problems with encroachment or pollution that could affect these structures. Dudhiya Talav and Vada Talav face similar challenges, with issues related to water quality and quantity. Although the report lacks specific details, restoration efforts may be necessary to enhance their health and functionality within the water system. Patal Talav is in a critical state, as the document notes it completely dries up during December and January. This suggests a severe decline in water levels, possibly due to reduced rainfall or poor water management in the surrounding areas. Restoration efforts focused on improving water retention and recharge are essential for this location.

The Geban Shah Vav (Stepwell) is an important historical structure within the water system but is noted to be in a deteriorating condition, indicating structural damage and potential safety hazards. Restoration and maintenance are likely needed to preserve this heritage structure and ensure its continued functionality in water collection and storage. The document references the Champaner Fort area within the project scope but doesn't specify particular water-related issues. However, given the fort's historical importance and the potential presence of water structures within its complex, issues like water quality degradation, encroachment, or deterioration of water infrastructure may arise. Further investigation is necessary to identify specific problems at this location.

Similar to the Champaner Fort area, the document doesn't specify water-related issues for Pavagadh Hill. However, considering its location within the heritage site and the potential presence of historical water channels or reservoirs, similar challenges as those faced by the fort area may be encountered. Further assessment is needed to identify and

address any water management concerns on Pavagadh Hill. The Vismitri River is identified as the source of water for the historical water system, yet the document highlights a critical issue: the river is drying up. This poses a significant threat to the entire water network, as the river's water is essential for replenishing lakes, stepwells, and groundwater resources. Restoration efforts to revive the Vismitri River are likely a crucial component of the overall project strategy.

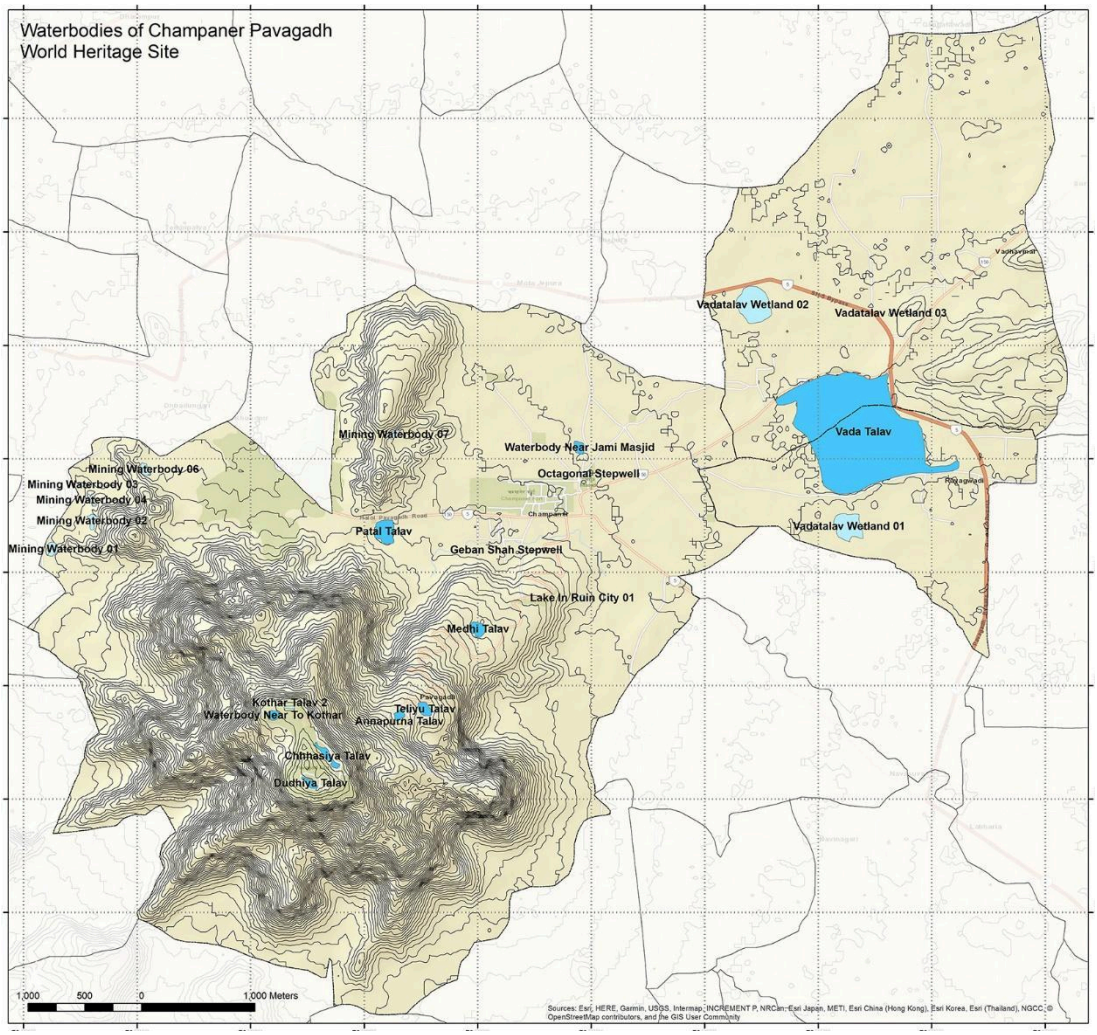

Figure 14: Watershed Analysis Map of Site

B. *Identified Issues*: The project identifies several critical issues plaguing the historical water system of the Champaner-Pavagadh World Heritage Site. These issues threaten the very existence of this once-thriving water management network, endangering the cultural heritage and ecological balance of the region. One of the primary concerns is water quality degradation, with the document highlighting poor water quality across the system. This includes lakes such as Teliyu Talav, Dudhiya Talav, Vada Talav, and Patal Talav, as well as stepwells like Geban Shah Vav. The report mentions problems like bad odor and the presence of waste materials, making the water unfit for consumption or even recreational purposes.

Encroachment and uncontrolled activities pose another significant threat to the water bodies. The document identifies encroachment as a major concern, disrupting the natural flow of water and reducing the system's overall storage capacity. Additionally, human activities around these water bodies are potentially leading to pollution and damage to the surrounding infrastructure. The improper disposal of waste around the water bodies is yet another critical issue, polluting the water sources and creating unsanitary conditions. The report suggests a lack of proper management and maintenance practices, leading to the deterioration of the water system’s overall health. A significant decrease in water levels across the water bodies is also highlighted, particularly during the summer months. Patal Talav, for instance, is mentioned to dry up completely by December-January, attributed to reduced rainfall and unsustainable water management practices in the region. The historical water system suffers from aging and deteriorating infrastructure, with the report mentioning the poor condition of Geban Shah Vav as an example. The deterioration of these structures can lead to safety hazards and hinder their ability to capture and store rainwater. Limited groundwater development within the Panchmahal district, where Champaner-Pavagadh is located, is another issue. While there is potential for increased groundwater usage, the report suggests a lack of proper management strategies to ensure its sustainability. Additionally, groundwater pollution is identified as a concern, with both geogenic and anthropogenic sources affecting

the resources in the area. Geogenic pollution refers to naturally occurring contaminants in the rock formations, while anthropogenic pollution arises from human activities like industrial waste disposal. This pollution can further decrease the usability of groundwater resources.

Figure 15: Dudhiya Talav

(Natural Lake) , Area: 6140 sqmtr , Perimeter: 364 meter

Issues Found: Bad water quality, Encroachment ,Waste disposal ,Bad Smell , Poor Aesthetic ,Human Activities

Figure 16: Chhasiya Talav

(Natural Lake) , Area: 11,070 sqmtr , Perimeter: 690 meter

Issues Found: Bad water quality, Encroachment, Low Water level, Waste disposal, Bad Smell, Poor Aesthetic, Human Activities

Figure 17: Vada Talav

(Natural Lake), Area: 8,37,833 sqmtr, Perimeter: 4580 meter

Issues Found: Bad water quality, Unmonitored, Bad Smell, Poor Aesthetic, Human Activities

Figure 18: Patal Talav
(Natural Lake), *Area:* 27,289 *sqmtr, Perimeter*: 662 meter
Issues Found: Low Water Level, Unmonitored, Poor Aesthetic, Human Activities, Deteriorating Condition

Figure 19: Geban Shah Stepwell
(Stepwell), *Area:* - xxxx *sqmtr, Perimeter*: - xxx
Issues Found: Deteriorating Condition, Unmonitored, Waste disposal, Poor Aesthetic, Hazardous Condition

Figure 20: Teliyu Talav
(Natural Lake), *Area:* 10,010 *sqmtr, Perimeter*: xxx meter
Issues Found: Bad water quality, Encroachment, Waste disposal ,Bad Smell , Poor Aesthetic ,Human Activities

Figure 21: Medhi Talav
(Natural Lake), *Area:* 12819 *sqmtr, Perimeter*: xxx meter
Issues Found: Bad water quality, : Deteriorating Condition, Lack of Monitoring ,Human Activities

Figure 22: Waterbody Near Jami Masjid
(Natural Lake), *Area:* 7392 *sqmtr, Perimeter*: xxx meter
Issues Found: Bad water quality, Encroachment, Low Water level, Waste disposal, Human Activities

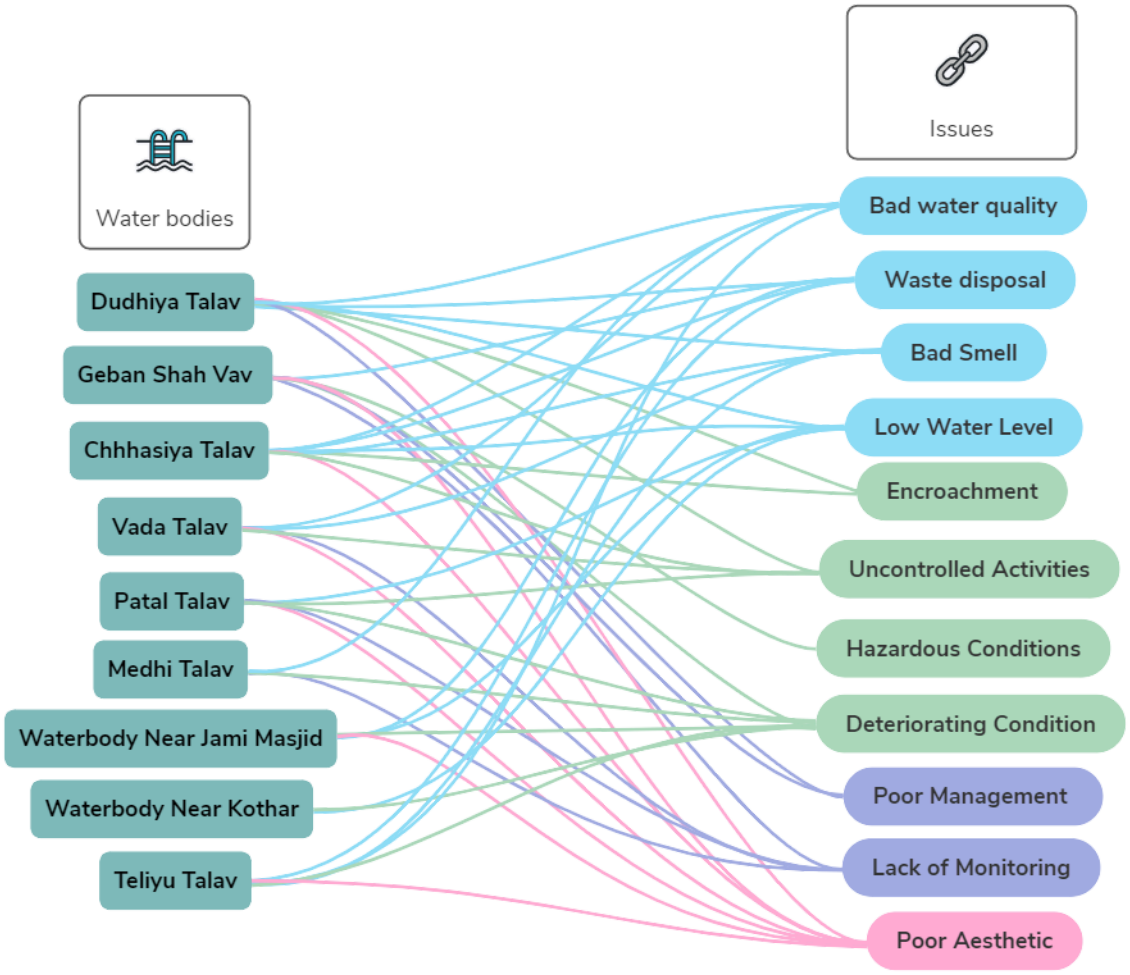

Figure 23: Identified Issues ff Water Bodies

C. *Site Survey: Summary and Analysis of Tourist Survey Data*

Tourist Profiles: The survey reveals a diverse age group among tourists, with an average age of 45.52 years, ranging from 18 to 80. This suggests that the destination appeals to a wide demographic. In terms of gender, although the data is incomplete, it indicates at least 22% representation for one gender, implying some variation. Further analysis is required to get a clearer picture of the gender distribution. Nationally, the survey highlights a significant disparity, with some nationalities representing as little as 2% and others up to 75% of respondents. This variation could be due to factors such as geographical proximity, cultural connections, or targeted marketing efforts.

Travel Patterns: The data shows a spread across visit frequencies, with an average of 16% of respondents falling into each category, indicating a mix of first-time visitors and repeat tourists. The significant number of repeat visitors

(potentially exceeding 16%) suggests satisfaction with previous experiences or ongoing attractions that keep them coming back. The survey reveals diverse travel motivations, with religious purposes accounting for a portion of visits, alongside leisure and work-related trips. This highlights the destination's ability to cater to various interests. Travel preferences also vary, with an average of 26.67% of respondents choosing each mode (private, public, or non-motorized transport), likely influenced by factors like cost, convenience, and personal environmental values. The length of stay varies widely, averaging 11 days, which has implications for local accommodation and service industries, requiring them to cater to both short-term and long-term visitors.

Tourist Experiences: The survey identifies key concerns impacting tourist satisfaction, with cleanliness and public infrastructure emerging as the most prevalent issues, reported by up to 32% of respondents. Addressing these concerns is crucial for enhancing the overall tourist experience.

Key Observations and Recommendations: The data offers a comprehensive overview of tourist profiles and experiences, highlighting the destination's appeal to a diverse clientele. Addressing major issues like cleanliness and public infrastructure should be a top priority for stakeholders seeking to improve tourist satisfaction. A more balanced nationality distribution could be achieved through targeted marketing campaigns aimed at underrepresented demographics. Diversifying travel options by improving public and non-motorized transport infrastructure can cater to a wider range of preferences. Accommodation planning should consider the varying lengths of stay to cater to both short-term and long-term visitors.

Data Gaps and Further Analysis: To gain complete insights, a more detailed breakdown of the gender distribution is necessary. Addressing missing data in the "Days of Stay" category would provide a more accurate picture of tourist behavior patterns. An in-depth analysis of why certain nationalities dominates the visitor statistics could inform targeted marketing strategies, potentially leading to a more geographically diverse tourist base. By addressing these recommendations and conducting further analysis, stakeholders can utilize this valuable data to enhance the tourist experience and ensure the destination remains attractive to a broad spectrum of visitors.

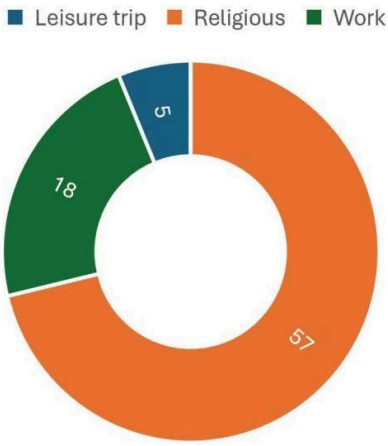

Figure 24: Purpose of Trip

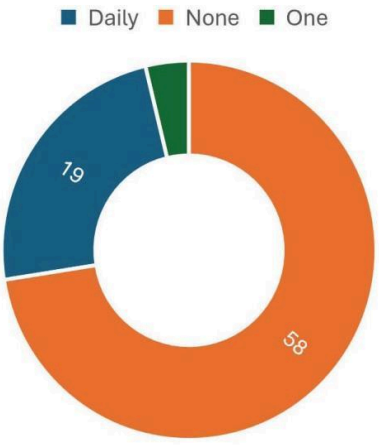

Figure 25: Days of Stay

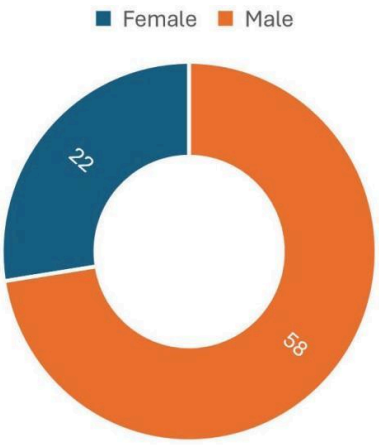

Figure 26: Gender Count

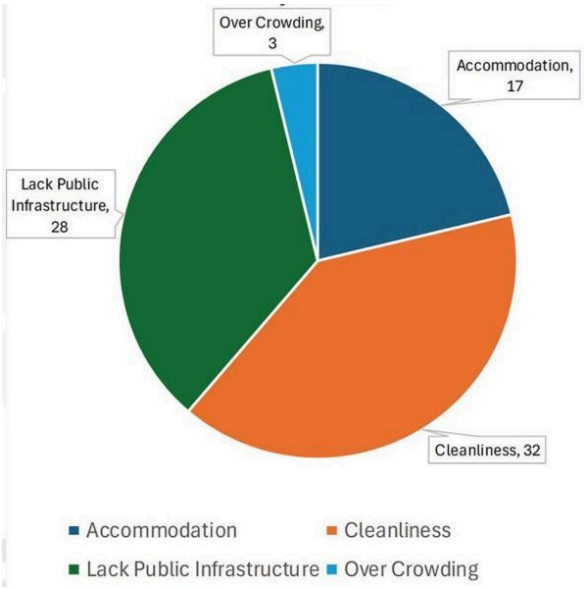

Figure 27: Major Issues

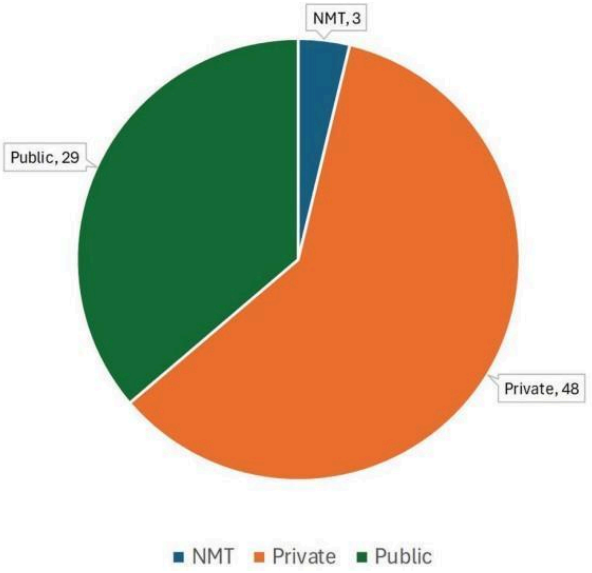

Figure 28: Mode of Transport

IV.MASTER PLAN & STRATAGIES

A. *Components of Master Plan*: The components of a master plan for a city or region are crucial in guiding development and ensuring that growth is sustainable, culturally respectful, and beneficial to the community. A key component is Land Use Planning, which includes the establishment of a Heritage Zone. This involves preserving areas of historical, architectural, and cultural significance to maintain the character and integrity of historical sites, prevent incompatible developments, and ensure renovations and new constructions respect the historical context. These areas often attract tourists, which can bolster the local economy, but they require stringent regulations to protect their unique qualities. A Buffer Zone acts as a transitional area between different land uses, providing a protective barrier around sensitive sites such as heritage zones, natural reserves, or residential areas. This zone helps mitigate potential conflicts between varying land uses, like industrial activities and residential neighborhoods, and ensures that the impact on sensitive areas is minimized. Another crucial element is the Sustainable Development Zone, which focuses on encouraging development that meets current needs without compromising the ability of future generations to meet their own. This typically includes eco-friendly buildings, renewable energy sources, efficient water and waste management systems, and green spaces, aiming to create self-sufficient communities with a low environmental footprint. Furthermore, Green Corridors are linear green spaces connecting parks, natural reserves, and urban green spaces, facilitating wildlife movement and providing recreational areas for residents. These corridors improve urban biodiversity, enhance the city's aesthetic appeal, and offer ecological benefits such as air purification and temperature regulation.

Transport Planning is another vital component. Pedestrian and Cycling Priority focuses on creating safe, accessible, and extensive networks of sidewalks, bike lanes, and pedestrian paths. This reduces traffic congestion, lowers pollution levels, and promotes healthier lifestyles by encouraging walking and cycling as primary modes of transport. Developing Electric Vehicle Infrastructure is crucial for reducing reliance on fossil fuels and cutting greenhouse gas emissions, involving installing EV charging stations, incentivizing EV purchases, and integrating EV-friendly policies into urban planning. Public Transportation Integration is essential for reducing traffic congestion, lowering emissions, and providing equitable access to mobility. Integrating various modes of public transport—such as buses, trams, and trains—ensures a seamless and convenient transit experience for users. Additionally, in cities with significant water bodies, incorporating Water Transportation can offer an alternative travel mode, reduce road congestion, and enhance tourism appeal. Water taxis, ferries, and boats can connect different city parts efficiently.

Infrastructure Planning covers essential services and utilities. Water Management Infrastructure involves systems for potable water supply, stormwater management, and wastewater treatment. Effective water management ensures a reliable water supply, prevents flooding, and protects water quality. Waste Management Infrastructure is essential for maintaining public health and environmental cleanliness, involving waste collection, recycling facilities, composting units, and landfills designed to minimize environmental impact. Investing in Renewable Energy Infrastructure such as solar, wind, and geothermal power reduces dependence on fossil fuels and mitigates climate change. This includes the installation of solar panels, wind turbines, and energy storage systems. Moreover, robust Digital Infrastructure supports the development of smart cities, encompassing high-speed internet, data centers, and technologies for digital governance, enhancing efficiency and connectivity.

Economic Development is also a core component. Sustainable Tourism promotes tourism that is eco-friendly, culturally sensitive, and economically beneficial, ensuring that tourism development does not harm local environments or communities. Sustainable tourism initiatives often include eco-tours, cultural festivals, and heritage conservation efforts. Supporting Cultural Activities enriches community life and preserves local traditions through funding for arts and cultural festivals, museums, performance spaces, and cultural education programs. Sustainable Agriculture encourages sustainable practices to ensure food security and reduce environmental impact, promoting organic farming, reducing pesticide use, conserving water, and supporting local food systems. Climate Change Adaptation involves implementing strategies to adapt to climate change impacts for long-term resilience, including building flood defenses, improving building standards to withstand extreme weather, and developing emergency response plans.

Environmental Sustainability includes Biodiversity Conservation, which protects and restores natural habitats to preserve biodiversity through creating protected areas, restoring degraded ecosystems, and implementing conservation programs for endangered species. Pollution Control measures reduce emissions from industries, manage waste effectively, and monitor air and water quality, implementing stringent pollution regulations to protect public health and the environment. Promoting Sustainable Building Practices ensures that new constructions are energy-efficient, environmentally friendly, and healthy for occupants, using sustainable materials, enhancing energy efficiency, and incorporating green roofs and walls. Climate change adaptation is reiterated to highlight the importance of developing infrastructure and policies that help communities withstand climate change impacts, creating green spaces that act as carbon sinks, improving stormwater management, and enhancing urban resilience.

Urban Design and Public Spaces focus on creating inclusive and engaging environments. Public Plazas and Gathering Spaces foster community interaction and enhance urban areas' livability, serving as venues for public events, socializing, and recreational activities. Installing Interpretive Signage and Information Centers helps educate residents and visitors about local history, culture, and natural features, enhancing the visitor experience and promoting cultural heritage. Landscaping with Native Plants supports local biodiversity, reduces water usage, and requires less maintenance, as native plants are adapted to the local climate and soil, making them more resilient and beneficial for local wildlife. Ensuring Accessibility in urban design means creating inclusive spaces accommodating people of all abilities, designing wheelchair-accessible paths, providing adequate signage, and ensuring public facilities are accessible.

Community Engagement and Participation are essential for ensuring that development reflects the community's needs and desires. Engaging the community through Workshops and Meetings fosters a sense of ownership and collaboration. Offering Skill Development Programs empowers residents by providing education and training opportunities in various areas, such as digital literacy, green technologies, and traditional crafts. Creating Volunteer Opportunities encourages community involvement and fosters a spirit of civic responsibility, with volunteers participating in environmental conservation, cultural events, and community projects. Community Benefits Programs ensure that development projects contribute positively to the local community, including affordable housing initiatives, local hiring practices, and community health services.

B. *Strategies and Framework*: The ClimateSmart Cities Assessment Framework (CSCAF), initiated by the Ministry of Housing and Urban Affairs (MoHUA), Government of India, serves as a catalyst for sustainable urban development in India. As the country grapples with the dual challenges of climate change and rapid urbanization, Indian cities face increased energy consumption, pollution, and vulnerability to extreme weather events. The CSCAF provides a strategic framework to guide these cities toward a more sustainable future.

Objectives and Functionality: The CSCAF is a comprehensive assessment tool that enables Indian cities to evaluate their performance on climate-related issues across five key categories: Urban Planning, Green Cover & Biodiversity, Energy and Green Buildings, Mobility and Air Quality, Water Management, and Waste Management. The first category focuses on strategies for incorporating urban green spaces, conserving biodiversity, and employing climate-resilient urban planning practices. The second category assesses a city's progress in promoting energy efficiency in its built environment and adopting green building practices. The third category examines efforts to reduce traffic congestion, promote sustainable transportation modes like cycling and public transport, and improve air quality through pollution control measures. The fourth category evaluates water resource management practices, including conservation initiatives, rainwater harvesting techniques, and wastewater treatment infrastructure. Finally, the fifth category examines waste management practices, such as waste reduction at the source, recycling programs, and safe disposal methods for various waste streams.

Beyond its assessment function, the CSCAF serves as a roadmap for cities to navigate the complexities of climate change mitigation and adaptation. The framework offers guiding principles and best practices, such as promoting energy-efficient building codes, investing in public transportation infrastructure, developing green spaces and urban forests, and implementing sustainable water management practices. The CSCAF fosters healthy competition and knowledge sharing among Indian cities, allowing them to benchmark their performance against each other and drive continuous improvement. Exemplary cities can serve as models for others, promoting a collective national effort

toward climate-resilient urban development. Furthermore, cities demonstrating strong performance on the framework can attract green investments, showcasing their commitment to sustainability and making them attractive destinations for investors seeking environmentally conscious projects. This can lead to increased funding for renewable energy initiatives, sustainable infrastructure development, and green technologies within these cities.The CSCAF is a dynamic framework that evolves to address current needs and emerging challenges. Currently in its third iteration (CSCAF 3.0), the framework recognizes the crucial role of urban planning and green infrastructure in combating climate change, assigning the highest weightage (25% each) to the "Urban Planning, Green Cover and Biodiversity" and "Energy and Green Buildings" categories.

Area Treatment focuses on the catchment area and surroundings of water bodies through afforestation, installing silt traps to manage stormwater drainage, beautifying waterfronts, and providing bunds and fencing for protection. Planting wetlands can enhance natural filtration of water entering lakes.

Quality Improvement aims to prevent the discharge of untreated effluents, conduct regular water quality monitoring, and provide designated immersion tanks for religious or cultural festivities. Restrictions and Awareness involve public participation through prohibitive notices, recreational activities, and awareness programs, emphasizing the importance of eco-sensitive zones around water bodies.

Figure 29: *: Indicators of ClimateSmart Cities Assessment Framework 3.0*
Source: ClimateSmart Cities (niua.in)

Rejuvenation & Conservation of Water Bodies & Open Areas: This aspect of the framework emphasizes strategies for rejuvenating water bodies, preventing pollution, and treating catchment areas to ensure unobstructed water flow. **In-situ Conservation involves techniques like bioremediation, which utilizes naturally occurring microorganisms to

break down toxic pollutants in water, and bio-manipulation, which controls eutrophication by managing herbivorous fish populations. Sedimentation basins, green bridges, and rainwater harvesting are other methods used to maintain the ecological balance of water bodies.

A coordinated approach is necessary for effective implementation, involving a committee of representatives from various stakeholders, including government departments, civil society organizations, academic institutions, and community members. This ensures better planning and collaboration among the Gram Panchayat, Temple Trust, Shop Holders, Forest Department, Municipality of Halol, Government of Gujarat, Field Experts, and Social Workers.Project Execution and Monitoring involves regular evaluations comparing actual outcomes with strategic plans, maintaining communication with community members and local NGOs, and providing comprehensive reports on actions, priorities, and progress indicators.

Financing Mechanisms include sustainable methods like municipal bonds, operations and management (O&M) budgets, value capture financing (VCF), public-private partnerships (PPP), and loans from financial institutions for infrastructure projects. Monitoring and Maintenance Mechanisms are crucial for evaluating progress over time. Regular feedback to stakeholders, community engagement, and private management of rejuvenated parks or water bodies ensure long-term sustainability.

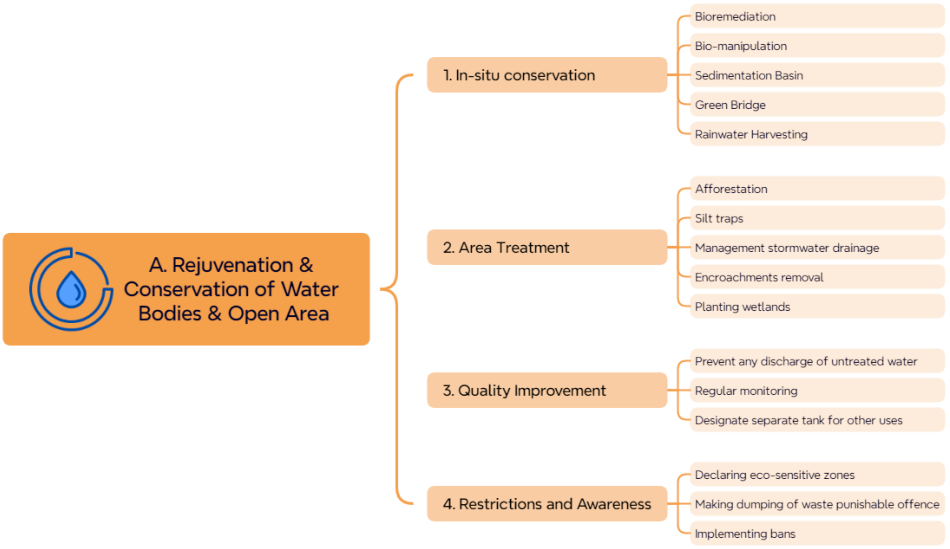

Figure 30: *: Indicators of ClimateSmart Cities Assessment Framework 3.0*

By implementing these comprehensive strategies, the rejuvenation and conservation of water bodies and open areas can be achieved sustainably, ensuring ecological balance and community well-being.Water Resources Management: This strategy involves establishing a dedicated team within the water utility department to handle key tasks such as conducting Water Resource Assessments (WRA) to evaluate the current water situation in the city, preparing Water Resource Management Plans outlining sustainable water use strategies, and implementing these strategies to improve water management practices.

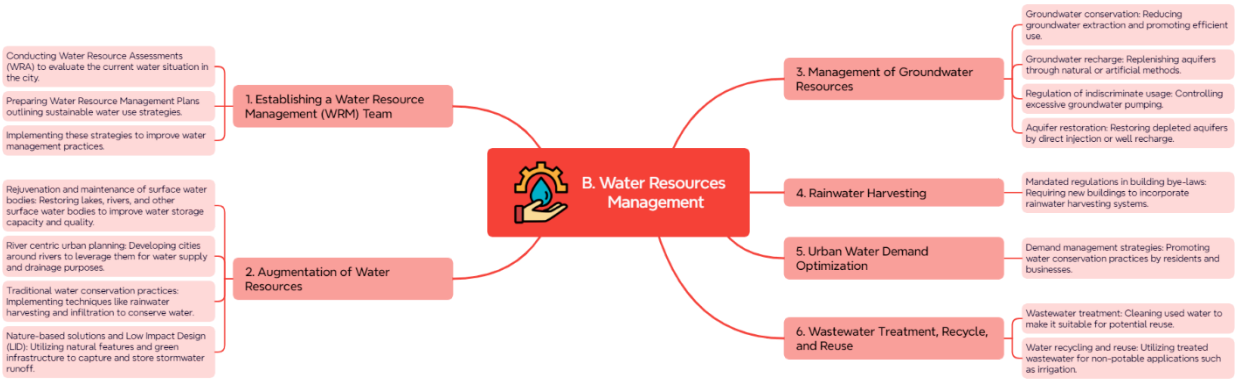

Figure 30: *: Indicators of ClimateSmart Cities Assessment Framework 3.0*

Augmentation of Water Resources focuses on increasing the availability of water resources through methods like rejuvenating and maintaining surface water bodies, restoring lakes, rivers, and other surface water bodies, river-centric urban planning, traditional water conservation practices like rainwater harvesting and infiltration, and using nature-based solutions and Low Impact Design (LID) to capture and store stormwater runoff.

Figure 31: Acts and Guidelines

Figure 32: Indicators

Management of Groundwater Resources aims to protect and restore groundwater resources through conservation, recharge, regulation of indiscriminate usage, and aquifer restoration. Rainwater Harvesting encourages collecting and storing rainwater for later use, with mandated regulations in building bye-laws requiring new buildings to incorporate rainwater harvesting systems. Urban Water Demand Optimization focuses on minimizing water consumption through demand management strategies promoting conservation practices by residents and businesses. Wastewater Treatment, Recycle, and Reuse maximizes water utilization by treating used water for potential reuse, utilizing treated wastewater for non-potable applications such as irrigation.

C. *Nature Based Solution*: Based on the information about the Champaner and Pavagadh watershed project, several nature-based solutions could be implemented to address challenges related to limited groundwater development, pollution, and sustainability. To tackle the issue of limited groundwater development, rainwater harvesting systems can be employed to capture runoff from rooftops and other surfaces, storing it for irrigation or domestic use and thus reducing the pressure on groundwater resources. Additionally, restoring degraded wetlands within the watershed can

naturally filter and replenish groundwater, improving its quality and availability. Streambank stabilization using native vegetation can also prevent erosion and sedimentation, enhancing water quality and infiltration.

To combat both geogenic and anthropogenic pollution, constructed wetlands can be established to treat wastewater and agricultural runoff before it enters natural waterways. These wetlands utilize natural processes to remove pollutants from the water effectively. Filter strips consisting of native vegetation planted along streams and rivers can trap and filter pollutants before they enter the water. Additionally, bioremediation techniques, which use plants or microorganisms, can be explored to break down or remove contaminants from the soil and water.

For sustainability, encouraging farmers to adopt agroforestry practices by integrating trees and shrubs into their agricultural practices can improve soil health, reduce erosion, and provide habitats for beneficial insects. Establishing riparian buffers with native vegetation along streams and rivers can protect water quality, provide habitats for wildlife, and reduce flooding risks. Furthermore, promoting sustainable land management practices, such as conservation tillage and cover cropping, can improve soil health, reduce erosion, and conserve water. These strategies collectively contribute to a more sustainable and resilient watershed ecosystem.