

Manifestations of Cultural and Vernacular Built Heritage Around Canals: Insights from the Ganga Canal Route in India

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Abstract

Water canals have played a vital role in shaping urban and rural landscapes throughout history, fostering economic growth, and improving the quality of life of its inhabitants. Built by Sir Proby T Cautley, The Ganga Canal in India, is one such engineering marvel dating back to 1854. The canal originating from Haridwar is a key part of India's colonial history that has led to significant rural and urban transformations in the Gangetic plains. The system has a main canal of about 438 km and about 6438 km long distribution channels. It was designed to bring water to dry areas in western Uttar Pradesh, turning them into productive farmland. Over time, the canal has grown from a colonial engineering project into an important tool for managing water systems and supporting regional growth, highlighting its lasting importance and recognition today. This study examines the cultural and vernacular built heritage development along this Ganga Canal Route in time. The study area spans from its origin at Haridwar up to the Roorkee railway bridge.

This study uses archival research, photographic documentation, interviews with locals and stakeholders from living sites, and secondary literature to examine the canal's impact on the built vernacular heritage and its significance over time.

In conclusion, the research identifies and discusses tangible and intangible aspects contributing to a deeper understanding of Canal 'Routes' through its Vernacular 'Roots'. Its historical significance, both in engineering and cultural impact, continues to shape the region's development. By integrating conservation efforts with modern advancements, the canal offers opportunities for sustainable tourism and heritage preservation.

Keywords: Built heritage, Canal, Cultural heritage, Intangible heritage, Vernacular.

Introduction

Canals have shaped civilizations and facilitated global trade for centuries, connecting regions and promoting economic growth. From ancient Egypt to modern engineering feats like the Suez and Panama Canal, these waterworks have transformed transportation and commerce. Canals have not only served as trade routes but also shaped identity and cultural heritage. The Erie Canal in the United States, opened in 1825, spurred westward expansion and economic growth while becoming a popular symbol in American folklore and songs (E.Shaw, 1966). However, in India, canal studies have traditionally focused on their use for irrigation, often overlooking their broader architectural, cultural, and heritage-related impacts. Additionally, the narratives that do exist about the influence of canals are sparse and lack systematic documentation.

There is little research available on historic canals in Asian and specifically Indian geographies that discusses and deliberates from architecture, vernacular built heritage, and human settlements perspective. This gap highlights the need for a more comprehensive study that investigates at how canals, such as the Ganga Canal, shape the surrounding landscape both in tangible and intangible ways. This study explores how the Ganga Canal influences the architectural landscape and cultural identity of the region, while also contributing to a new architectural value to the city. Understanding the canal's role beyond irrigation could reveal its impact on the local environment, industrial growth, urban development, and placemaking.

Water canals have historically been a crucial lifeline for both rural and urban regions, playing a pivotal role not only in agricultural productivity but also in economic development, and shaping cultural identities. One such canal, the Ganga Canal, stands as an engineering masterpiece that has significantly transformed the landscape of the Gangetic plains. Designed by Sir Proby T Cautley in the 19th century, the Ganga Canal was initially conceived to bring water to the arid lands of western Uttar Pradesh, turning them into fertile farmlands (Cautley, 1860). Over time, this colonial infrastructure project evolved into a multifaceted entity, influencing regional development and leaving a profound impact on the cultural and built heritage of the regions it traverses.

This study examines the Ganga Canal's cultural and historical significance, focusing specifically on its journey through the state of Uttarakhand, from Haridwar to Roorkee. By employing archival research, photographic documentation, and interviews with local stakeholders, the study delves into how this irrigation canal has shaped the vernacular built heritage in the region. This research aims to explore the enduring legacy of the Ganga Canal in Uttarakhand, and the ways these canal routes have manifested cultural identities and the built vernacular heritage of the Uttarakhand region in time. For this purpose, the following objectives are outlined:

- To trace different layers of cultural and vernacular built heritage developed around the Ganga Canal route.
- To photo document the present-day cultural and built heritage around the Ganga Canal route.
- To analyze the Ganga Canal's contribution to regional development and growth.

Theoretical Framework

Throughout history, scholars worldwide have offered various definitions for Cultural Heritage and Vernacular Architecture. Rapoport (1969) proposes that vernacular architecture is influenced by cultural norms, climate, available resources, and social practices, serving as a direct representation of the values and way of life of a community (Rapoport, 1969). UNESCO, on the other hand, characterizes cultural built heritage as "monuments, groups of buildings, and sites with historical, aesthetic, archaeological, scientific, ethnological, or anthropological value." This comprehensive definition highlights the physical structures that hold cultural significance, often emphasizing buildings and locations that embody a specific historical or cultural identity. Researchers such as Howard Davis and Julian Smith have expanded the scope of our understanding of cultural and vernacular-built heritage. Davis (2006) connects the concepts by explaining how vernacular architecture reflects the cultural values of a community. He argues that vernacular structures are not only cultural artifacts but also reveal significant information about the society that created them through their designs, purpose, and symbolic meanings (Davis, 2006).

Similarly, Smith (2007) broadens the scope of this discussion. He contends that cultural and vernacular built heritage encompasses more than just individual structures. It includes entire landscapes that mirror the cultural practices, beliefs, and social organizations of the communities responsible for their creation (Smith, 2007). Rose (2015) says, over the last two decades, the perspective on cultural heritage has undergone significant changes. It has expanded beyond just monuments and museum collections to include a multifaceted framework of significance, values, connections, and associated ideas. Because of these changes, cultural heritage has transitioned from being understood as property or an object, to being assessed as a process, progressing through several intermediary and frequently simultaneous interpretations such as place, product, project, and performance (Viejo-Rose, 2015).

Indeed, canals serve as both practical infrastructure and markers of cultural identity, and scholars have recognized this dual role by developing various important theories to explain the cultural and physical history surrounding them. Nora (1989) suggests, certain locations like canals act as archives for shared memories. Particularly in old cities, canals take on the significance of Sites of Memory, signifying a common history and identity. For instance, the canals of Venice and Amsterdam serve as both transit routes and cultural icons, representing a long history of human contact with water (Nora, 1989). Canals provide orientation, acting as recognizable features that help people navigate urban spaces while simultaneously fostering a sense of continuity and historical significance as discussed by Lynch (1960). Clarifying this, Rossi (1982) suggests that canals act as enduring urban artifacts that shape the collective memory and identity of a city.

Anthropologists investigate canals as liminal spaces (Kaaristo, et al., 2023). According to them, these are transitional areas where various social practices and cultural traditions intersect. Historically, canals have served as crossroads for people, ideas, and goods. Especially those linked to established trade routes often become culturally significant. Their constructed legacy reflects a variety of influences, and the surrounding industries, architecture, and urban forms serve as symbols of exchange and hybridization of cultures.

In summary, the evolving understanding of cultural heritage and vernacular architecture underscores the profound influence of both tangible and intangible elements in shaping our built environment. Canals, as dynamic infrastructure, exemplify this interplay by embodying historical significance, cultural identity, and social interactions, thus enriching our comprehension of their role in urban and cultural landscapes.

Review of Literature

Several studies related to canals focus on aspects such as hydrology, irrigation and agricultural practices, environmental impacts, and landscape studies. However, Cosgrove (1990) argues that canals are more than utilitarian infrastructure; they are embedded cultural landscapes shaped by socio-economic, religious, and ecological dynamics (Cosgrove & Petts, 1990). In the global context, a few studies examine the historic and cultural significance of water canals. For example, Grześkow and Iga (2020) study the construction history, technological advancements, and revitalization efforts of Old Canal in Bydgoszcz, Poland. Huan Xu (2018) discusses potential threats to the Grand Canal, China, a UNESCO World Heritage Site, while Fei Qiao and Chih-Ming Shih (2020) investigate traditional vernacular dwellings along the Li Canal section of the Grand Canal. Furthermore, concepts like Canal-Oriented Development (COD) are studied by Stephen Buckman (2016) focusing on urban development. Each of these cases is discussed briefly in the following section.

European cities represent centuries-old networks of social and cultural interactions. Here a particular model of group life and culture has been shaped by the history and legacy of successive generations. Grześkow (2020) says that the culture-forming regeneration of urban space is the modern significance of the Old Canal region for downtown Bydgoszcz, Poland and its influence on the evolution of the cultural landscape of the city. The study focuses on the construction history of the canal, technological advancements, and revitalization efforts. Furthermore, it emphasizes the role of the canal in promoting tourism and inland navigation, underscoring its historical importance to the city. The area also witnesses various cultural, sports, and leisure initiatives led by local associations. These initiatives not only aim to revitalize the area but also to reconstruct social traditions associated with the canal, highlighting its importance to the local community (Grześkow, 2020).

The Grand Canal stands as a significant cultural heritage site, reflecting the ancient wisdom of Chinese civilization. The Yangzhou section is part of this heritage, which was inscribed on the UNESCO World Heritage List in 2014. Huan Xu (2018) examines the potential threats to the canal. Using Remote Sensing (RS) and Geographic Information System (GIS) applications, Xu analyzes landscape patterns and land classifications. The surrounding urban areas are found to be facing severe degradation due to rapid development. The study highlights, ongoing construction and changes in land use disrupt the historical landscape and demand immediate preservation efforts (Xu, 2018). Shih's (2020) research involves field investigations and a comparative analysis of 397 typical vernacular dwellings. The study examines the layout, structural styles, and construction methods of these dwellings. Vernacular dwellings are characterized by their use of gray bricks and gray-tiled roofs, reflecting a combination of the robustness of northern architectural styles and the delicate elegance characteristic of Jiangnan architecture. This distinctive architectural style results from cultural interpenetration between northern and southern regions. The study attributes local climatic conditions and regional customs as key factors influencing the unique styles of the dwellings along the canal (Fei Qiao, 2020).

Canals emerge as significant sites for waterfront development, particularly in urban areas that do not have direct access to rivers or harbors. They offer opportunities to create vibrant, water-driven, place-based districts that support leisure, recreation, and economic growth while encouraging environmental stewardship. Buckman (2016) conducts research focused on the concept of Canal-Oriented Development (COD). COD adapts to diverse community needs and canal types. It allows for multiple development sites of different scales, which can create hubs of activity tailored to the specific characteristics of the community and its transportation network (Buckman, 2016). The idea is derived from Transit Oriented Development (TOD). The study employs ethnographic observation methods to analyze three case studies: Bricktown, Mandalay Canal, and the Waterfront. This method allows for an in-depth understanding of how these developments engage with their communities and the effectiveness of their design. Findings show successful canal-oriented developments must integrate the canal into the broader urban fabric. For instance, the Mandalay Canal case study highlights neglecting access, linkages, and community engagement results in low vibrancy and poor integration. In contrast, successful developments demonstrate the importance of holistic design that considers various urban design aspects. The literature therefore asserts that a canal must function as a central element of a comprehensive urban design strategy, not an afterthought, if space is to thrive and benefit its community (Buckman, 2016).

In the context of the Ganga Canal, existing research is primarily focused on environmental and agricultural aspects. These include assessments of water quality (Matta, 2014), analyses of physio-chemical characteristics (Kamboj, et al., 2018), studies on the impact of the canal on thermal comfort on the city of Roorkee (Rahul, et al., 2020), and numerical modelling of pollutant dispersion (Bahita, et al., 2024). Other research has focused on chemical composition of mortars from the ganga canal system (Dave & Malhotra, 1992), crop productivity constraints (Tripathi, 2011), impact of land use change on groundwater (Mishra, et al., 2013), modeling of water hyacinth growth (Kumar, et al., 2021) and similar scientific concerns. However, these studies largely overlook the cultural aspects, and the built vernacular heritage associated with the canal. Canals hold not only functional importance but also significant historical, cultural, and social value.

At present, the body of research reflects a significant gap in the cultural, architectural, and socio-economic study of the Ganga Canal. Unlike the global examples that offer holistic approaches to study canal heritage, the Ganga Canal lacks documentation and analysis of its cultural and vernacular built environment, such as ghats, temples, institutes, settlements etc. Intangible cultural heritage, such as rituals, seasonal festivals, occupational practices, oral traditions, etc also remains underrepresented in academic discourse. Likewise, there is limited engagement with the perceptions and roles of local communities in conserving and revitalizing these landscapes. Furthermore, cities are yet to adapt frameworks like Canal-Oriented Development (COD) to suit the unique cultural and spatial conditions of Indian canal towns. There is also little research on integrating ecological and heritage-based strategies to promote sustainable urban and rural development along canals.

In summary, while environmental and technical studies of the Ganga Canal are well established, there remains a significant gap in understanding its cultural and vernacular built heritage. The canal, beyond serving as an irrigation and hydrological infrastructure, embodies layered histories, traditional knowledge systems, and architectural practices that are integral to the identity of the regions it traverses. However, these dimensions remain largely undocumented and underexplored in current academic discourse. This study helps reposition the Ganga Canal not merely as a utilitarian system but as a dynamic cultural corridor. Such a perspective opens pathways for community-led revitalization, sustainable tourism, and heritage conservation, offering valuable insights for canal-edge development across India and beyond.

Research Methodology

The study is based on a qualitative research approach, with case study as the prime method of investigation. The Ganga Canal route from Haridwar to Roorkee is investigated in the study. This study employs a multifaceted research methodology combining archival research, photographic documentation, interviews, and secondary literature analysis to comprehensively examine the canal's impact on built vernacular heritage and its evolving significance over time.

1. Archival Research: Extensive archival research forms the foundation of this study, providing historical context and insights into the canal's construction, development, and the surrounding vernacular architecture. This includes review of old maps, government records, construction documents, historical writings and photography housed in local and national archives. The “Report on Ganga Canal Works, Proby. T. Cautley, Volume 1, 2 and 3” forms the base of the archival research for the study. The reports are retrieved from M.G Central Library, IIT Roorkee archive section. Other archival reports and photographs are sourced from the web. A number of photographs are sourced from the collection “The Ganga Canal; Illustrated by Photographs, T. G. Glover, 1867” and “Report on Ganga Canal Works, Proby. T. Cautley, Volume 1, 2 and 3”. An old photograph is received by one of the stakeholders at the living sites near Bheemgoda Headworks. The archival materials help trace the development of the canal and its relationship with the built environment.

2. Photographic Documentation: A systematic photographic documentation of the canal and its adjoining structures is carried out by the authors from August - October 2024 to visually capture the current state of the tangible and intangible heritage. The authors traveled back and forth between Roorkee to Haridwar along the canal route, to photo document. Photographs are taken to documents, architectural details, materials, and the overall condition of these structures spanning from Bheemgoda Headworks, Haridwar to Railway Bridge, Roorkee. This visual record serves both as a tool for analysis and as a means of comparison with historical photographs obtained during archival research.

3. Interviews with Locals and Stakeholders: A total of six non-structured interviews are conducted around the canal with local stakeholders and the community. These interviews gathered personal narratives on how the canal has influenced architectural styles and building practices over time. The interviews were conducted among a range of stakeholders, during the field visit from August - October 2024, between Roorkee to Haridwar along the canal route. The stakeholder includes employ at Dharoni works, residents of Dhanori and Bheemgoda, shopkeeper, the gwala community (milkmen), and caretakers of Dam Bungalow at Haridwar. These interviews were strategically selected to ensure a comprehensive understanding of the socio-cultural dynamics and the impact of architectural heritage on local communities. The authors employed a combination of convenience sampling and snowball sampling methods. Authors initially employed convenience sampling to engage readily accessible participants, such as local residents, shopkeepers, and workers encountered during field visits. Which was followed by snowball sampling, wherein initial interviewees referred the researchers to other relevant individuals within the community. The approach helped to identify and engage with a diverse range of interviewees and community members associated with the canal route.

4. Document Survey: A comprehensive review of existing literature related to vernacular architecture, water infrastructure, and historical development around the canal globally is undertaken. This includes journal articles and conference papers that provide theoretical frameworks and literature studies relevant to the research area. These studies provide a foundational context for understanding the intersections of cultural landscapes, traditional knowledge systems, and infrastructural development of Canal Routes across the globe.

The data collected from archival research, photographic documentation, interviews, and document survey are synthesized to identify patterns, trends, and their impact on tangible and intangible heritage in the study area of the Ganga Canal Route. Qualitative analysis is used to interpret the interviews and historical narratives, while visual analysis methods are applied to photographic documentation to assess the different layers of built heritage over time, classified into three time periods that are Pre-Colonial, Colonial and Post Colonial works. The findings were then produced in several maps showing the evolution in time of various built and cultural heritage along the canal route. The maps include eight categories of built heritage and various events mapped along the canal route. Further synthesizing all the research findings to conclude how the canal has shaped its heritage and its significance in contemporary times. The study reflects on the implications of these findings for future conservation efforts and policymaking in the region.

The Case Study Area and the Context of Ganga Canal

Introduction

The Indian state of Uttarakhand is situated in the Northwest of the nation. The Tibetan Autonomous Region of China borders it to the Northeast, Nepal to the Southeast, the state of Uttar Pradesh to the South and Southwest, and the state of Himachal Pradesh to the Southwest. The 27th state of India, Uttaranchal, was created on November 9, 2000, when Uttar Pradesh was divided into two states. The state's name, Uttarakhand, was adopted in January 2007 to reflect the area's tradition and the name of the "Northern region". The region is further divided into 13 districts. The Ganga Canal originates from Haridwar, Uttarakhand, and goes up to Kanpur, Uttar Pradesh (Mathur, 2024).

Famine and crop failure in Upper India between 1887 and 1838 caused catastrophic occurrences that are still remembered today. It was questioned if the irrigation canal would have saved the government money and spared the populace's suffering. It was suggested by Governor-General Lord Auckland that the government grant a few thousand rupees to investigate the Ganga Khadir and ascertain the viability of canal work from Haridwar to Kanpur. The inquiry began in December 1839 by Proby T. Cautley. In September 1841, the court highlighted the financial advantages and significance of the canal irrigation project and on the 25th of February 1842, orders were issued by the Agra Government for the commencement of the work. On the 16th of April, the grounds were broken in the neighborhood of Kankhal by the commencement of the excavation of the channel. For Indians, the Ganga is not just a river but a life-giver that has nourished successive civilizations alongside holding a profound religious significance. The canal work system consists of a main canal of 272 miles and about 4,000 miles long distribution channels (Fig. 1). The canal is administratively divided into the Upper Ganges Canal which runs from Haridwar to Aligarh and includes several branches, and the Lower Ganges Canal, which constitutes several branches below Aligarh (Cautley, 1860).



Fig. 1: Part of map of United Provinces highlighting the canal work from Haridwar to Kanpur.

Source: Imperial Gazetteer of India Atlas, 1908

As discussed earlier, the research scope is limited to the study of the canal between Haridwar to Roorkee. Considered an engineering marvel of its time, the canal is truly one to this day, completing almost 180 years of standing still. Over 180 years the canal facilitated agricultural development, supported urban trade and industrial growth, and influenced local heritage, including religious and colonial aspects. At present, the canal still retains the grandeur with which it was originally constructed. A small section, from Jatwara Bridge, Haridwar to Solani Park, Roorkee is redone, and a new canal and aqueduct are built just along the one built in 1840. The new construction is reported to have been completed in 2001, as recalled by one of the local stakeholders at Dhanori.

The landscape encompassing various layers of built and cultural heritage, from Haridwar to Roorkee, undergoes a series of changes and interconnection as one moves from the former to the latter. Prominent sites of observation are identified through archival texts, and the author's observations are recorded at these same locations, which are marked on the map below (Fig.2). Haridwar is predominantly characterized by Hindu religious influences, visible through the numerous temples and old havelis that may have served as religious sites, particularly extending to Kankhal. The holy Ganga River holds immense significance for Hindus, shaping the spiritual landscape of Haridwar and enhancing the prominence of the canal route. Moving further along the canal towards Roorkee, the landscape reflects a blend of colonial and religious heritage. The development of the canal by the British introduced various colonial structures, which are still evident along the old routes, connecting settlements and reflecting the area's historical significance. The canal route navigates through areas like Ranipur, Pathri, and Dhanori, which historically facilitated various trade activities, including those associated with the annual “Kanwar Yatra” during the “Sawan” month, a Hindu religious pilgrimage. A notable religious point along this route is Piran Kaliyar, a prominent Muslim Sufi Saint shrine dating back to the 13th century. The shrine is a focal point for people-centric development and reflects the area's rich Sufi heritage. Traditional modes of transportation, such as horse carriages, were historically common between Roorkee and Piran Kaliyar, underscoring the connectivity and significance of this route. In Roorkee, the canal route is marked by colonial heritage, including old churches, a cemetery, workshops etc. Roorkee also stands out as an educational hub, primarily due to the presence of the Indian Institute of Technology Roorkee (formerly known as the Thomson College of Civil Engineering and the University of Roorkee), further diversifying the landscape with institutional influences. Additionally, Roorkee's strategic location has fostered the development of an army center, contributing to the region's multifaceted heritage. Overall, the Ganga Canal route from Haridwar to Roorkee showcases a multilayered landscape of colonial, religious, and institutional heritage, reflecting the area's historical evolution and cultural diversity.

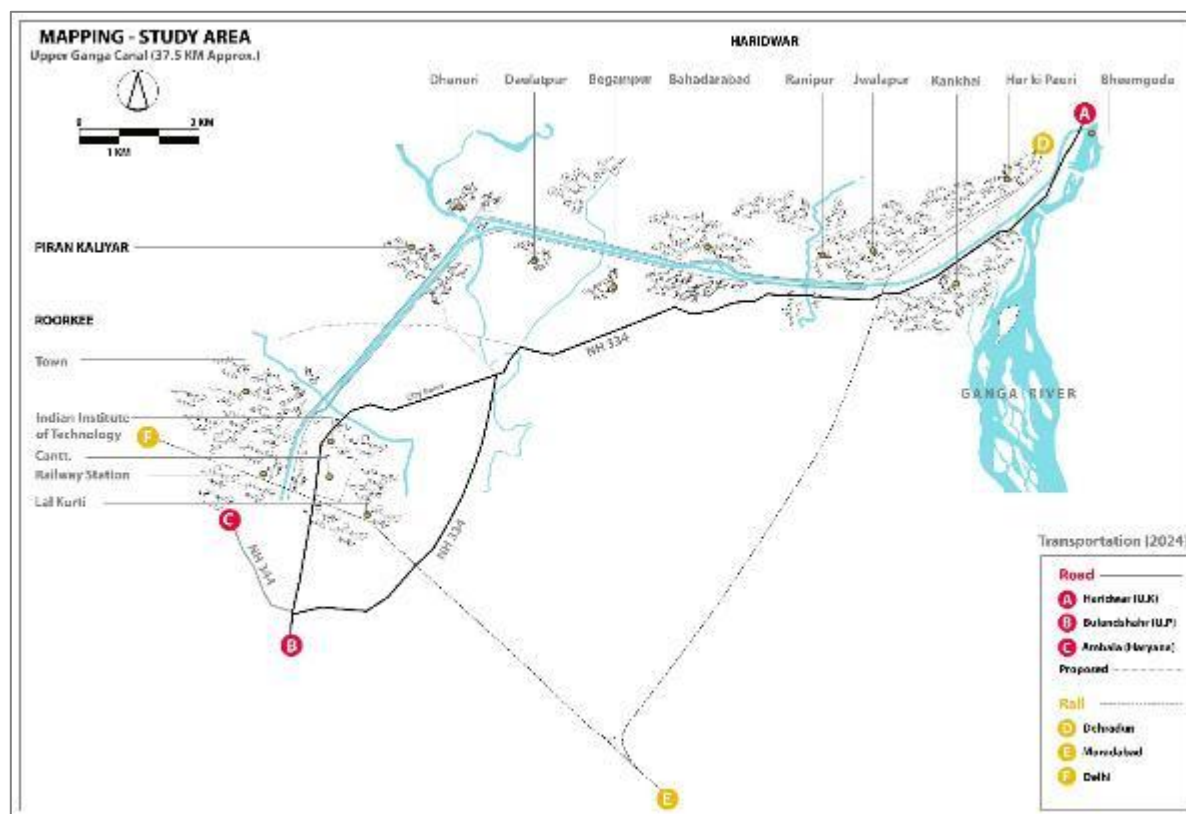







Fig. 2: The study area from Haridwar to Roorkee.

Source: Authors, 2024





The study area from Haridwar to Roorkee can be identified by seven major zones or areas as mentioned in the records of Report on the Ganges Canal Works (Volume I, II, III) (Cautley Proby T, 1860) and Saharanpur-District Gazetteers of the United Provinces of Agra And Oudh (Nevill, H. R, 1909) namely Haridwar, Mayapur, Kankhal, Ranipur, Bahadarabad, Dhanori, Piran Kaliyar and Roorkee (Fig.2). Observations are made by the authors at all the above identified zones.

Findings



Haridwar, often known as the “gateway to gods”, is one of the most revered pilgrimages in the country. Nested in the foothills of the Himalayas, the city houses a number of temples, ghats, and ashrams. Hindus believe that bathing in the Ganga's waters is sacred and cleansing. The city attracts a lot of tourists due to its location and religious significance. Nonetheless, the city also has a rich colonial past housing, check posts, bungalows, and workshops constructed for aid in the Ganga Canal work. The Ganga canal originates from the head works of Haridwar, today known as Bheemgoda Barrage (N29° 58' 15.303", E78° 11' 1.53"). However, upon the site visit it was observed that it is not the barrage but a small opening near Sarvanand Ghat, Haridwar where the canal starts (Fig.3). The construction of the dam near the canal's mouth, according to the Hindu priests of Haridwar, would imprison the Ganga's sacred waters. Cautley, therefore gave them his word that he would leave a gap in the dam through which unrestricted water flow would occur. The headworks have a memorial installed marking the great engineering marvel with sectional details and the discharge levels, however lost from the public eye (Fig.5,6,7).

Fig. No	Photographs	Description	Source
Fig. 3		Photograph of the headwork of the Ganges Canal in Haridwar.	Samuel Bourne, 1860 (Archival Research)
Fig. 4		An old image of boats used to check the waterworks showed by a local resident at Haridwar during an interview.	Local Resident, 2024 (Stakeholder Interview)
Fig. 5		The point of origin of the Ganges Canal.	Authors, 2024 (Photographic Documentation)
Fig. 6		A stone memorial near the opening	Authors, 2024 (Photographic Documentation)
Fig. 7		Sectional details of construction and discharge at different times, mentioned on the side of memorial.	Authors, 2024 (Photographic Documentation)

The location contains several dwellings (Fig.8) and workshop (Fig.9) purportedly constructed in 1929 to accommodate the employees responsible for maintaining the canal, as recounted by a resident of the colony. The current living quarters are said to have once been stables for horses. The Uttar Pradesh Irrigation and Water Resources Department currently oversees the colony. The resident, reminiscing, presented a vintage photograph and recounted how, in earlier times, boats were employed to traverse the river and reach the barrage for maintenance purposes (Fig.4). Subsequently, it was also discovered that the old crossing bridge had a malfunctioning railway line that is said to be utilized to transport materials to the workshops (Fig.10). Another nearby bungalow, called “Lal Kothi” (Fig.11) is also identified. A local resident at Bheemgoda points it out when asked about other colonial structures in the area. The specific ownership of the same bungalow is not explicitly mentioned, but it could be inferred that it served as a residence for an officer. Nevertheless, the construction dates back to the year 1929, aligning with the residential and workshop settlement, suggesting a strong interrelationship.

Fig. No	Photographs	Description	Source
Fig. 8		The residential colony at Haridwar, near the starting point of canal.	Authors,2024 (Photographic Documentation)
Fig. 9		The workshops at Haridwar as informed by stakeholders around site. There lies an old boat remains, probably used to navigate earlier.	Authors,2024 (Photographic Documentation)
Fig. 10		View of the bridge and dysfunctional railway line, Haridwar.	Authors,2024 (Photographic Documentation)
Fig. 11		View of Lal Kothi, Haridwar.	Authors,2024 (Photographic Documentation)



Moving ahead of the settlement site, one crosses several ghats, which highlight one of the most important aspects of the city. As discussed earlier, the city is famous among Hindus, for bathing in the holy waters of the Ganga. This practice has evidently been long-standing, also illustrated in a photograph found in the Report on the Ganges Canal Works (Volume II) (Cautley, 1860) (Fig.12). Further the photograph clicked at one of the very famous ghat called “Har Ki Pauri”, one can see the drastic development that has happened around the ghat in recent times (Fig.13). A shopkeeper at Har Ki Pauri mentioned that it is rare to find the area without devotees. The site experiences significant crowds during festivals, religious occasions, and holiday seasons.

Fig. No	Photographs	Description	Source
Fig. 12		Archival picture of pilgrims taking a bath at a ghat in Haridwar.	Proby T Cautley, 1860 (Archival Research)
Fig. 13		Present day pilgrims at Har Ki Pauri, Haridwar	Authors,2024 (Photographic Documentation)

“At Mayapur too, just below Ganosh-ghat, are the head works of the Ganges canal, and on the opposite side of the bridge over the regulator are the canal offices and the inspection bungalow, the latter being in a beautiful situation looking northwards up the river, with a magnificent view of the town, the gorge and the hills beyond”




Nevill, 1909:265.

The archival photographs of the same “Dam Bungalow” (Fig 14) were found, and the bungalow remains standing to this day. The building underwent renovation during the COVID-19 pandemic and is currently serving as a government guest house as informed by the caretaker interview present on site (Fig.15).

Fig. No	Photographs	Description	Source
Fig. 14		Photograph of the bungalow from Ganesh ghat, Mayapur	Charles Leslie, 1900 (Archival Research)
Fig. 15		Photograph of the present condition of the bungalow from Ganesh ghat, Mayapur.	Authors,2024 (Photographic Documentation)

Further encountered is another historically significant town, Kankhal, which is also a major religious site. The historical importance of Kankhal predates that of Haridwar. However, as Haridwar rose to prominence as a hub for trade and pilgrimage in the late 19th century, Kankhal's significance gradually diminished. The town's main temple, “Daksheswara” (Fig. 16), is situated at its Southern edge. According to traditional Hindu scriptures, this site marks the location where “Sati”, the daughter of “Raja Daksha” and spouse of “Mahadev”, self-immolated in flames. The “Sati Kund” is also linked to this event. The town extends across a vast expanse, featuring a stone-paved market street with brick-built shops and substantial residences flanked on either side (Fig.17). Kankhal was a scenic locale,

abundant with trees, religious structures, and dwellings adorned with exquisite frescoes. The town took pride in its numerous gardens, enclosed by high walls and accessible through ornate entrances. Kankhal was also home to multiple “Akharas” (Nevill, 1909). Kankhal has evolved into a hub of regional activity and contemporary urban uses (Fig.18), while continuing to retain its place within the religious and tourism circuit of Haridwar.

Fig. No	Photographs	Description	Source
Fig. 16		Daksheswara temple, Kankhal.	Authors,2024 (Photographic Documentation)
Fig. 17		Oil painting of Kankhal.	Sita Ram,1814-15 (Archival Research)
Fig. 18		Present photograph of streets and marketplace in Kankhal.	Authors,2024 (Photographic Documentation)

As per the Saharanpur District Gazetteers of United Provinces of Agra and Oudh 1909, Jwalapur housed several Sanskrit pathshalas along with an American mission school. Upon investigation, the Gurukul Kangri University was located in Jwalapur was found (Fig.19-20). The institution was established in 1902 by Swami Shraddhanand. The university comprises numerous buildings, the construction dates of which could not be determined; however, several noteworthy architectural features were observed. These features are distinct from other colonial structures encountered, indicating a possible earlier origin. However, the schools mentioned in the Gazetteers could not be located during the investigation.



Fig. No	Photographs	Description	Source
Fig. 19		Photograph of the entry gate to the Gurukul Kangri University, Jwalapur	Authors,2024 (Photographic Documentation)

Fig. 20		Photograph of one of the prominent structures in the Gurukul Kangri University, Jawalapur.	Authors,2024 (Photographic Documentation)
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Beyond Kankhal, the canal crosses Jawalapur and proceeds to the riverbeds of three waterways: Ranipur, Pathri, and Rutmoo, in that order. To ensure uninterrupted water flow, it was necessary to devise appropriate crossing methods that considered each river's basin and flow characteristics. Consequently, two super passages were suggested for crossing the Rutmoo and Pathri rivers (Fig.21-22). These structures still stand (Fig.23-24), though the water flow of rivers appears altered over time, likely due to climate change and natural shifts in the landscape.

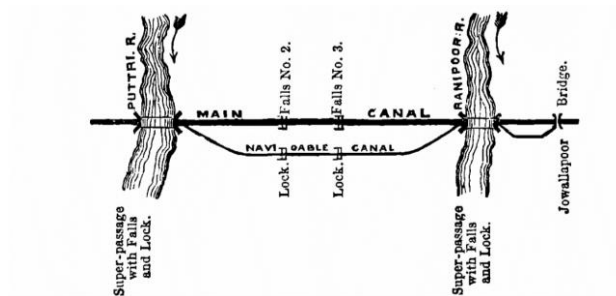




Fig. 21: Canal drawings for the two super passages.

Source: Proby T. Cautley, 1860





Fig. 22 :Canal section for super passages.

Source: Proby T. Cautley, 1860

Fig. No	Photographs	Description	Source
Fig. 23		Canal passing below Pathri River in Ranipur.	Authors,2024 (Photographic Documentation)
Fig. 24		View of the Rutmoo river, and the canal passes below it in Begampur.	Authors,2024 (Photographic Documentation)

The colonial powerhouse (Fig.25), dating back to 1930, is situated in Bahadarabad between these two super passages. In addition, a field research station was established in 1946 in collaboration with the Roorkee Irrigation Research Institute. Another powerhouse, known as the Pathri Powerhouse (Fig. 26), was subsequently constructed in the nearby vicinity.

Fig. No	Photographs	Description	Source
Fig. 25		Bahadarabad powerhouse that was built in 1930, Bahadarabad.	Authors,2024 (Photographic Documentation)
Fig. 26		Pathri powerhouse commissioned in the year 1955.	Authors,2024 (Photographic Documentation)

Dhanori is recognized as yet another significant milestone in the evolution of colonialism. A colonial colony and offices for regulatory work were established in the vicinity with the advent of the Dhanori works (Fig.27). One of the present employs found at the site informed of the colonial connection of the structures found around. He also showed the remains of a boat (Fig.29) that was formerly used to navigate along the canal were found in the workshop. Upon further inquiry, he directs attention to another structures located across the canal. On either side of the canal, the landscape contains remnants of colonial buildings. The remnants of the structure on the right bank downstream are currently a part of the local police station (Fig.30). According to a resident of the area, one of the residential buildings is remembered as “Taj Babu ki Kothi” (Fig.31). The residential colony and workshops on the left are now a part of the irrigation department (Fig.28).






Fig. No	Photographs	Description	Source
Fig. 27		Archival photograph of Dhanori works.	T.G. Glover,1867 (Archival Research)
Fig. 28		The workshop shed, Dhanori.	Authors,2024 (Photographic Documentation)

Fig. 29		Remains of an old boat, most probably used for the water works at Dharoni.	Authors,2024 (Photographic Documentation)
Fig. 30		The police station, Dhanori.	Authors,2024 (Photographic Documentation)
Fig. 31		The remains of what is recalled as "Taj Babu ki Kothi" by a local, Dhanori	Authors,2024 (Photographic Documentation)

The enormous dome in Piran Kaliyar that encloses the grave of the Sufi saint Alauddin Ali Ahmed Sabir is the most noticeable aspect of Piran Kaliyar Sharif (Fig.35-36) dating back to 13th century. Owing to the ideals of the Sufi Saints, it is a place where one could encounter a multifaith, hybrid culture and diverse visitors. Over the years it has developed into a major religious tourism spot among the Muslim community. Colonial bridges (Fig.33-34), historic gates, regional food, and vernacular transportation (Fig.35) are found along the route. Additionally, it is noted that India's first railway line was laid between Piran Kaliyar and Roorkee to transport construction materials during the building of the Solani Aqueduct, marking an early example of rail infrastructure used to support canal engineering works. Evidence of this early railway line is also documented in the drawings and illustrations (Fig.32) included in Proby T. Cautley's 1860 publication on the construction of the Ganga Canal, providing historical validation of its role in facilitating the project.

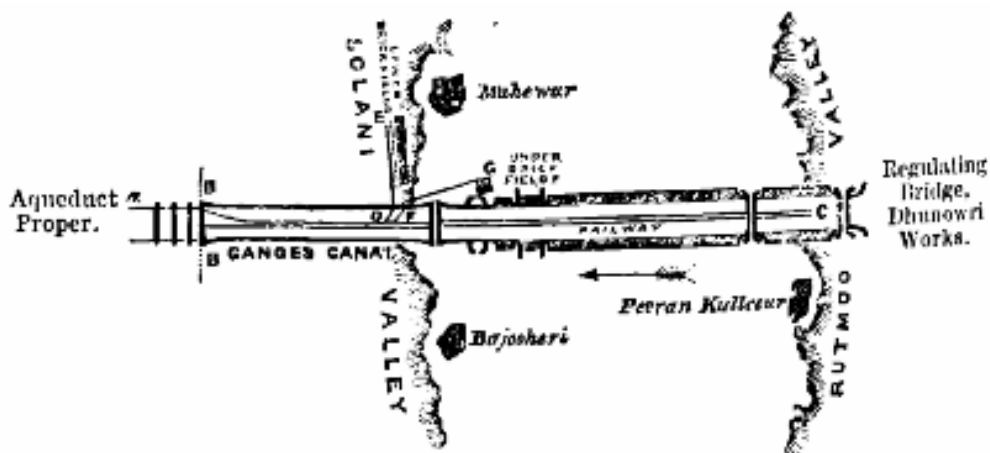






Fig. 32: Canal drawing between Kaliyar and Roorkee
Source: Proby T. Cautley, 1860

Fig. No	Photographs	Description	Source
Fig. 33		Archival photograph of the Canal and Piran Kaliyar bridge, looking towards Haridwar.	Proby T. Cautley, 1860 (Archival Research)
Fig. 34		Present day photograph of the Canal and Piran Kaliyar bridge, looking towards Haridwar.	Authors,2024 (Photographic Documentation)
Fig. 35		The entry view of the Piran Kaliyar shrine.	Authors,2024 (Photographic Documentation)
Fig. 36		View of the Piran Kaliyar shrine.	Authors,2024 (Photographic Documentation)

As one approaches Roorkee from Piran Kaliyar, two magnificent lions await, positioned on either side of the canal. In Roorkee's city core, there are two more (Fig.33). It is stated that these lions are marked to indicate the water's high flow and slope. Another lion exists, which is said to be the first lion, constructed as a model for replication (Fig.35). Away from the spotlight, this lion sits amid a dense neighborhood called "Sher Kothi," close to Saint Andrew's Church (Cautley, 1860). It is believed that these lions served as the model for the lions at London Trafalgar Square (Fig.36).






Fig. No	Photographs	Description	Source
Fig. 37		Illustrated record of the canal looking upstream, Roorkee.	Proby T. Cautley, 1860 (Archival Research)

Fig. 38		Present day photograph of the lion and the canal, Roorkee.	Authors,2024 (Photographic Documentation)
Fig. 39		Present day photograph first lion built as a prototype, Roorkee.	Authors,2024 (Photographic Documentation)
Fig. 40		Illustrated record of the first lion built as a prototype, Roorkee.	Proby T. Cautley, 1860 (Archival Research)
Fig. 41		Sir Edwin Landseer's Lions at the base of Nelson's Column, Trafalgar Square, London	Jacqueline Banerjee (Accessed: 15 September 2024)

The city of Roorkee contains several churches that were constructed during the colonial period, representing a significant religious dimension of the growth surrounding the canal. These include Saint Andrews Church, Sacred Heart Church (1889) (Fig.42-43), Anglican Methodist Church (1890) (Fig.44), and Saint John Church (1857) (Fig.45). One and the only ASI-protected monuments in the town, the British Cemetery (Fig.46) is another structure that was a part of this colonial ecclesiastical growth.






Fig. No	Photographs	Description	Source
Fig. 42		Illustrated record of the Saint John Church, IIT Roorkee.	Proby T. Cautley, 1860 (Archival Research)

Fig. 43		Present day photograph of Saint John Church, IIT Roorkee	Authors,2024 (Photographic Documentation)
Fig. 44		Present day photograph of Anglican Church, Roorkee	Authors,2024 (Photographic Documentation)
Fig. 45		Present day photograph of Sacred Heart Church, Roorkee	Authors,2024 (Photographic Documentation)
Fig. 46		Present day photograph of Saint Andrews Church, Roorkee	Authors,2024 (Photographic Documentation)

Solani Aqueduct is one of the most prominent engineering marvels and monuments of industrial archeology related to canal construction (Fig 48-49). A water-carrying channel 25m above the Solani River's bed. The Colonial-era aqueduct is a 980-foot-long aqueduct consisting of 15, 50-foot-high arches that are separated by 10-foot-wide piers. The structure was built using approximately 85 million bricks, which were locally made, developing a new type of brick in kiln called the "Roorkee kiln" (Cautley, 1860). To facilitate the smooth construction of canal work and the aqueduct, there was an emerging need for engineers. As a result, the famous Thomson College of Engineering was established in the year 1847, which later became the Indian Institute of Technology, Roorkee (Fig.50). As supporting infrastructure, the Ganga Canal workshop (Fig.51-52) and Iron Foundry to supply articles for the canal works were established in the year 1843. A lesser-known fact is that the first-ever railway line in India was set up between Piran Kaliyar and Roorkee in 1851 for the transportation of soil. This was two years before the first passenger train ran from Bombay to Thane in 1853. The historical drawings suggest that the line was laid in the canal bed itself thus the remains are no longer found (Fig.47). The locomotive named "Mary Lind" was imported from Britain, and a replica of the engine is currently displayed at the Roorkee Railway Station (Fig.53). Roorkee also became home to the Bengal Sappers and Miners in 1853 (Fig.54) (Cautley, 1860).

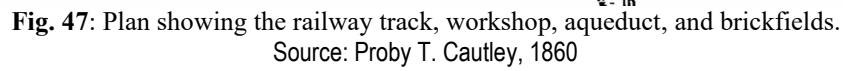




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Fig. 52		Present day photograph of the workshop taken from across the Canal, Roorkee.	Authors,2024 (Photographic Documentation)
Fig. 53		Replica of the locomotive, outside Roorkee railway station.	Authors,2023 (Photographic Documentation)
Fig. 54		Entry to Roorkee Cantonment area.	Authors,2024 (Photographic Documentation)
Fig. 55		Institutes along the canal in Roorkee.	Authors,2024 (Photographic Documentation)

Intangible Heritage

Apart from its vernacular built heritage, the landscape along the canal route from Haridwar to Roorkee is enriched with diverse cultural events and activities that contribute to its intangible heritage. These activities foster a sense of vibrancy and promote social cohesion among local communities. The nature and intensity of these practices vary along the stretch, influenced by regional contexts and the sacred identity of the river Ganga. Owing to the religious significance of the river Ganga, numerous ritualistic and festival-based activities are observed along the canal. Ghats along the route serve as important sites for sacred bathing, especially during religious occasions. During the month of “Sawan” (July-August), a large influx of devotees participates in the “Kanwar Yatra” (Fig.56). Devotees carrying pots filled with Ganga Jal suspended on decorated poles. The canal route becomes a significant pilgrimage corridor during this time, with temporary facilities and resting points established to accommodate the devotees. It also acts as a pilgrimage corridor during the “Urs” (anniversary of a saint) held at Piran Kaliyar shrine. A significant number of devotees traverse the canal route to the shrine, during which the pathway is often adorned with religious decorations, banners, and temporary installations. In addition, several Hindu festivals involve idol immersion ceremonies (Fig.57), which are performed at designated ghats along the canal.

Beyond these special occasions, the ghats remain active public spaces where informal, everyday interactions take place. Children playing in the water, families gathering to relax, and individuals enjoying the ambience with their feet immersed in the canal is a common sight (Fig.58,60,62). The canal at times contributes to economic activities like fishing (Fig.59). The water of canal is also used in the upkeep of castles, as informed by a member of the gwala community. While the canal edge also supports various small-scale economic activities (Fig.61), making it a socially and

economically dynamic space. The multifunctional character of these public spaces contributes to a layered urban experience, where sacred practices coexist with leisure and livelihood.

Fig. No	Photographs	Description	Source
Fig. 56		Kavar Yatra, July 2024, Roorkee	Authors,2024 (Photographic Documentation)
Fig. 57		Idol immersion on the last day of Navratri being done at the ghat in Roorkee	Authors,2024 (Photographic Documentation)
Fig. 58		People sitting along the ghat in Roorkee	Authors,2024 (Photographic Documentation)
Fig. 59		Fishing activity in the canal, Roorkee.	Authors,2024 (Photographic Documentation)
Fig. 60		Kids enjoying along the ghats of the canal near Jawalapur.	Authors,2024 (Photographic Documentation)
Fig. 61		Economic activities along the edge of the canal near Pathri Powerhouse	Authors,2024 (Photographic Documentation)
Fig. 62		Celebration of Ganesh Chaturthi around the canal road.	Authors,2024 (Photographic Documentation)

Findings

The findings are analyzed and synthesized to produce maps of the tangible and intangible heritage in time, with respect to Pre-Colonial (Fig.64), Colonial (Fig.65), and Post-Colonial (Fig.66) time in India. The tangible heritage is categorized into eight typologies namely Waterworks Engineering (W), Religious (R), Army (A), Industrial (Y), Railways (T), Socio-Economic (S), Residence (H), and Educational Institute (E) upon their characteristics and use and then marked in the map as per timeline. The intangible aspects are also marked along the canal route map (Fig.67). The table below discusses each category with the associated timeline.

Table 1: Categorization of Built Heritage around the Canal from Haridwar to Roorkee.

Source: Authors,2024

LOCATION	Identified Built Heritage	Water Works Engineering (W)	Religious (R)	Army (A)	Industrial (Y)	Railways (T)	Socio Economic (S)	Residence (H)	Educational Institute (E)
Haridwar	Bheemgoda Headwork	W1							
	Workshop Bheemgoda				Y1				
	Govt. Residences Bheemgoda							H1	
	Old Railway Bridge					T1			
	Laal Kotli							H2	
	Railway Tunnel					T2			
	Har ki Pauri		R1						
	Old Market Har ki Pauri						S1		
	Havelis Haridwar							H3	
	Ganesh Ghat Mayapur		R2						
	Dam Banglow							H4	
	Kankhal Town		R3						
	Gurukul Jwalapur								E1
	Jatwara Bridge	W2							
	Ranipur Passage	W3							
	Settlement							H5	
	Pathri Power House				Y2				
	Bahdarabad Power House				Y3				
	Small Canal	W4							
	Field Research Station (Irrigation Research Institute)								E2
	Pathri Super Passage	W5							
Piran Kaliyar	Settlement							H6	
	Dhanori Workshop				Y4				
	Dhanori Government Inter College								E3
	Kaliyar Sharif		R4						
Roorkee	Kaliyar Bridge	W6							
	Haridwar University								F4
	Lion Statue	W7							
	Solani Aqueduct	W8							
	Roorkee Workshop				Y5				
	Saint Andrew's Church & Lion		R5						
	College of Civil Engineering (IIT Roorkee)								E5
	Roorkee Cantonment			A1					
	Lion Statue	W9							
	Methodist Church		R6						
	Sacred Heart Church		R7						
	Old Cemetery		R8						
	Irrigation Research Institute								
	Roorkee State Water Informatics Centre Roorkee								E6
	Boat Club House			A2					E7
	Railway Station Roorkee					T3			

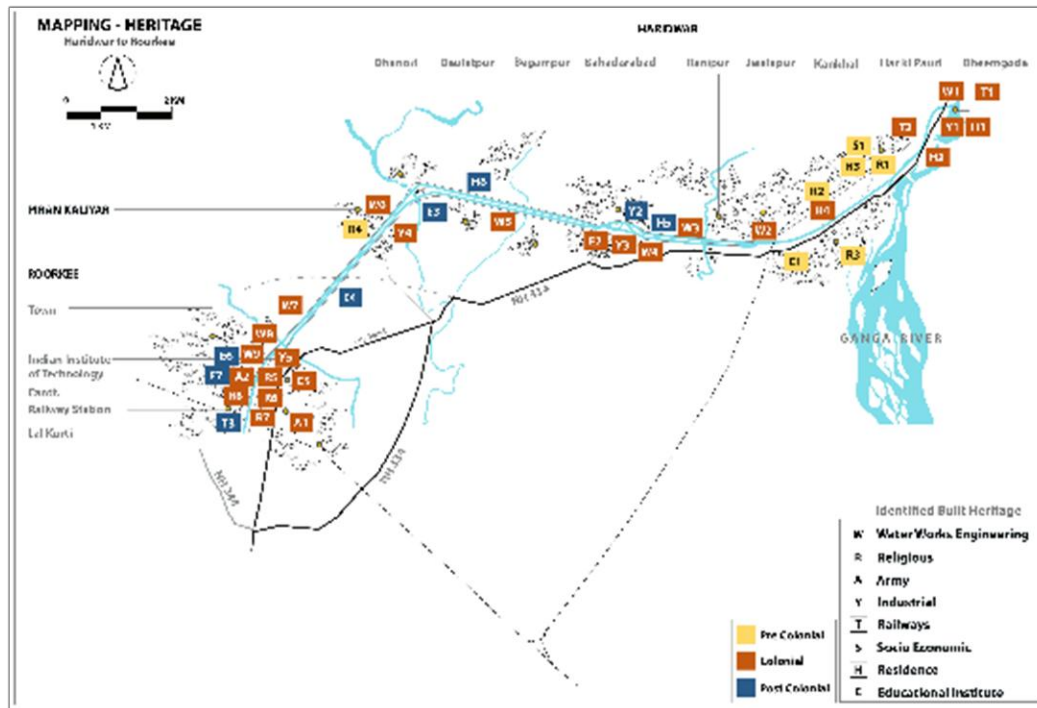


Fig. 63: Built Heritage at Different Locations, from Haridwar to Roorkee.
Source: Authors, 2024

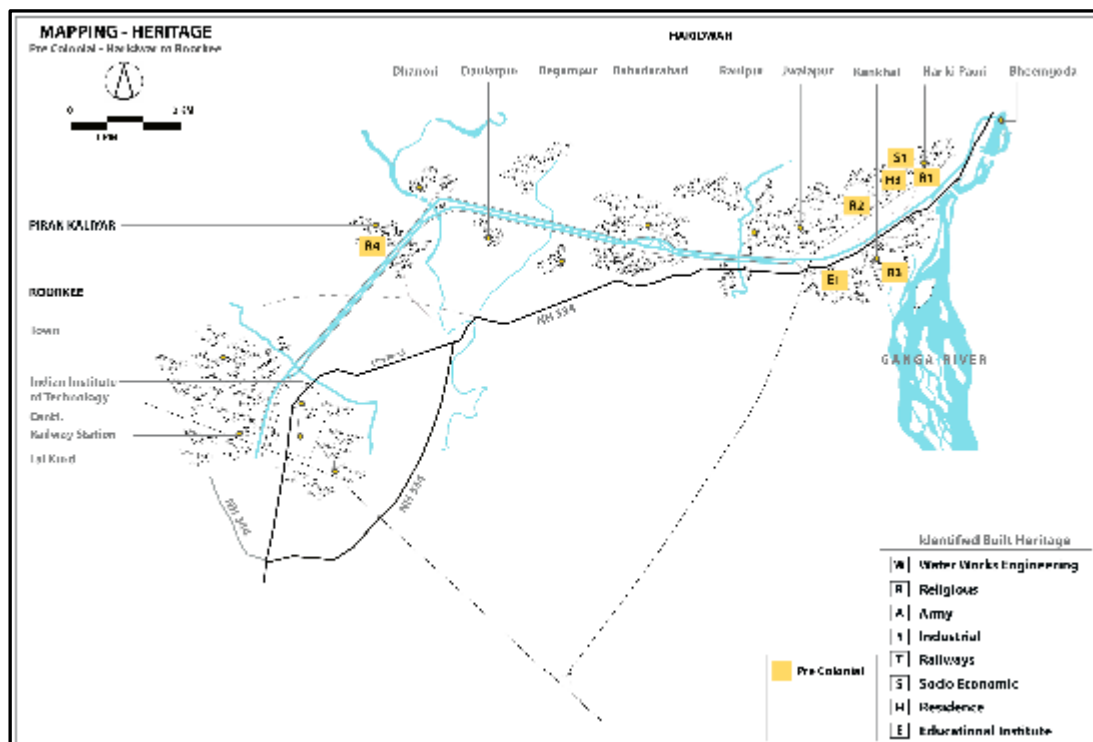


Fig. 64: Pre-Colonial Built Heritage at Different Locations, from Haridwar to Roorkee
Source: Authors, 2024

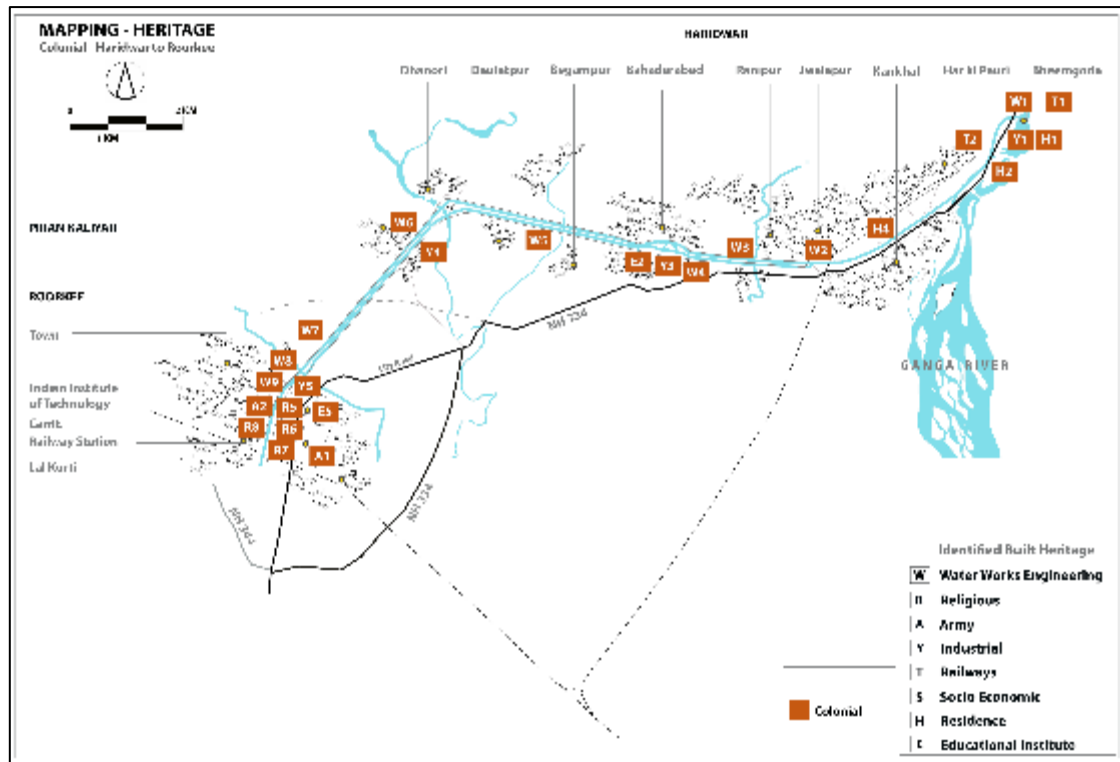


Fig. 65: Colonial Built Heritage at Different Locations, from Haridwar to Roorkee
Source: Authors, 2024

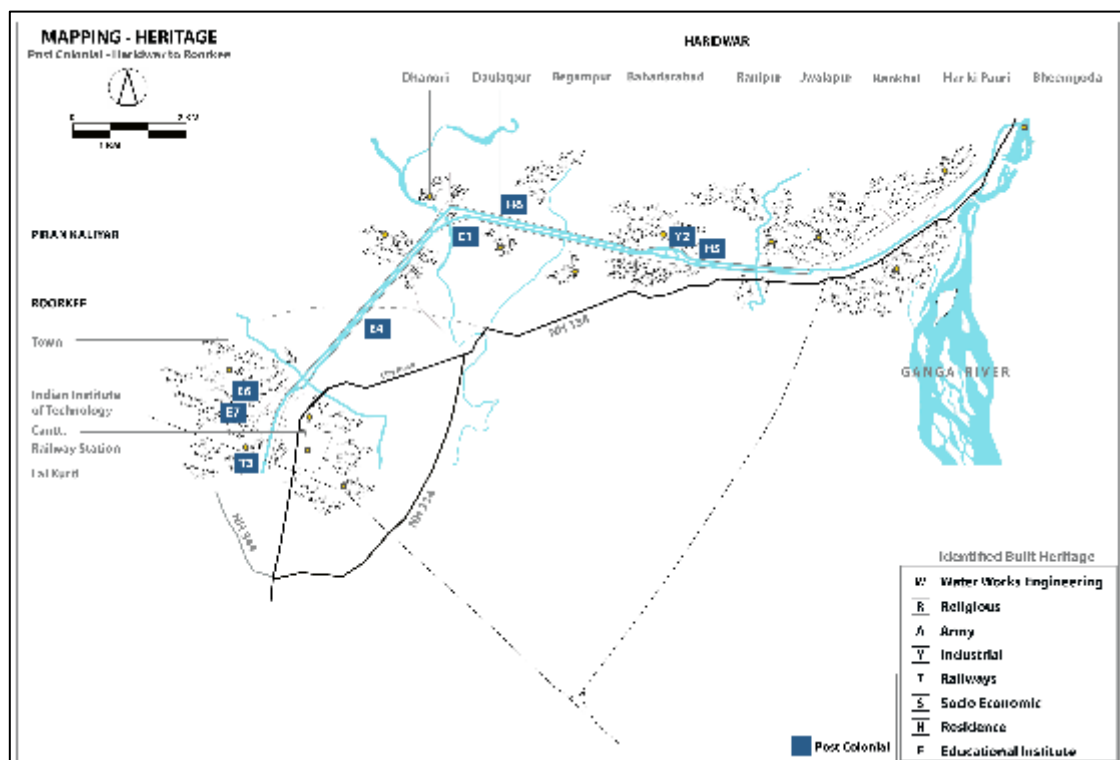


Fig. 66: Post Colonial Built Heritage at Different Locations, from Haridwar to Roorkee
Source: Authors, 2024

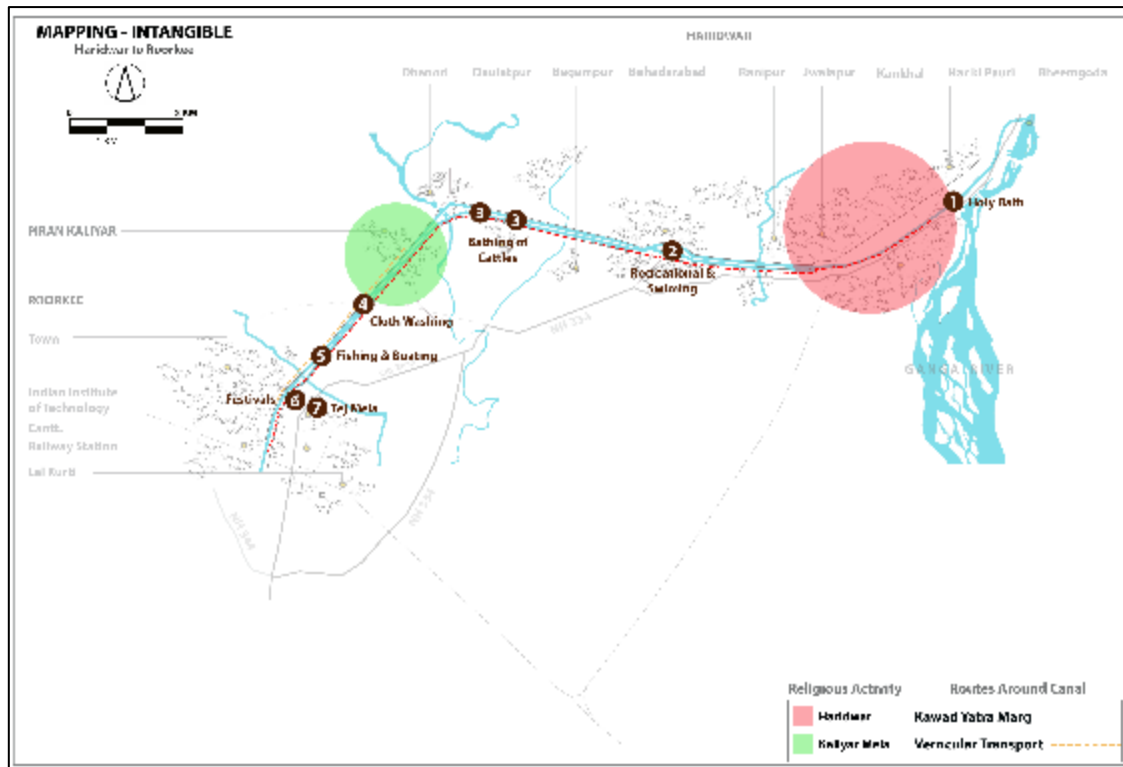


Fig. 67: Intangible Heritage at Different Locations, from Haridwar to Roorkee.
Source: Authors, 2024

Discussion

The manifestations of cultural and vernacular built heritage along canal landscapes are expressed through both tangible and intangible elements that reflect the historical, social, and spiritual connections of communities with water. Based on the results and findings of the study, the manifestations of cultural and vernacular built heritage along the Ganga Canal route can be meaningfully analyzed under six key themes: pattern and movement, connectivity, cultural exchange, building marvels, intangible identity, and economic development.

- Pattern and Movement of Canal Route:** The Ganga Canal creates a unique landscape as it traverses Haridwar's religious and colonial spaces. Starting from Haridwar, the canal flows towards Roorkee, juxtaposed against the sacred ghats and temples of the Ganga. The colonial-era water engineering on the southern side shapes modern infrastructure, while traditional religious structures continue to thrive alongside it. The canal undergoes a notable shift near Dhanori, where colonial-era structures and a dam illustrate the influence of British civil engineering on the landscape. The route subtly bends and meanders to accommodate the natural topography and existing waterways, with aqueducts allowing rivers to flow beneath the canal. The spatial arrangement of ghats, shrines, and settlements along the canal reflects historical patterns of human movement, pilgrimage, and seasonal rhythms. The Ganga Canal thus reflects both natural and engineered patterns, blending history with function.
- Connectivity of the Canal Route Across Locations:** The Ganga Canal links several key regions, establishing not only hydrological connections but also infrastructural ties between colonial and religious sites. It runs parallel to the Ganga, creating a contrast between spiritual and colonial development in Haridwar. Bahadarabad, home to an electricity generation plant, demonstrates the intersection of industrial progress with the canal route. Historical super passages, such as those near Ranipur and Begampur, where rivers cross the canal through aqueducts and super passages, highlight the engineering feats that enhance connectivity while preserving natural water flows. This canal also parallels the new national highway connecting Haridwar to Delhi, emphasizing its ongoing importance in shaping the geography and infrastructure of the region.

- **Ranges of Cultural Exchange:** As a site of religious observances, the canal facilitates a rich exchange of traditions, languages, and practices. The canal's path serves as a conduit for cultural blending, particularly in places like Haridwar and Piran Kaliyar. Where the sacred river Ganga and tomb of the Sufi saint Alauddin Ali Ahmed Sabir attracts pilgrims from across India. The presence of both colonial and vernacular architectural elements, such as the Buland Darwaza and colonial bridges, symbolizes the fusion of diverse cultural influences. The diverse religious practices along the canal's route, ranging from Hindu temples in Haridwar to the Islamic influence in Piran Kaliyar, underscore the interconnection of beliefs fostered by the canal's presence. The coexistence of these different religious structures exemplifies a dynamic cultural exchange, a byproduct of historical trade and spiritual journeys along the canal's course.
- **Evolutionary Projects and Infrastructure Marvels:** The Ganga Canal stands as an enduring marvel of colonial engineering, exemplifying British expertise in water management and civil infrastructure. Roorkee, home to the Indian Institute of Technology (IIT) Roorkee, is a direct outcome of the canal's construction, establishing it as a significant hub for engineering and technological advancements. The super-passages, dams, and aqueducts scattered along the canal were remarkable achievements for their time, illustrating a mastery of integrating human-made structures into the natural environment. The colonial legacy continues to shape the region through these projects, transforming it into a center for education, industry, and cultural exchange. The town of Dhanori, with its colonial government buildings, dams, and livable environment, exemplifies the socio-cultural and infrastructural impact of the canal project.
- **Intangible Identity of the Canal Route:** The Ganga Canal is not just a physical structure of water management and engineering; it also holds a significant intangible cultural identity, deeply rooted in the cultural and religious practices of the people living along its route. Two prominent festivals highlight its spiritual importance: the Kavar Yatra during the Hindu month of Sawan, and the Piran Kaliyar Mela during the Islamic month of Rabi' al-Awwal. These festivals transform the canal route into a vibrant, living space where water from the canal is revered as holy, reflecting the shared yet distinct spiritual significance for both Hindu and Muslim communities. The concept of "one water with different colors" aptly describes how a single waterway serves diverse religious purposes, illustrating the interplay of faiths along the canal. Beyond these major religious events, other celebrations such as Janmashtami, Eid, and Independence Day see the canal as a focal point for gatherings and festivities. These events further reinforce the canal's role as a shared space for communal activities, bridging divides between different social and religious groups. In terms of transportation, the canal route retains traditional modes of mobility alongside modern ones. Horses and local buses are commonly used, demonstrating a blend of traditional and contemporary transport systems. The steps along the canal function as informal seating areas, facilitating social interaction. Spaces like Solani Park and various locations along the canal have evolved into social gathering spots where people meet, relax, and engage in various social activities.
- **Economic Development:** Economically, the canal plays a pivotal role in supporting livelihoods. Fishing along its banks is a common practice, and specific areas serve as dhobi ghats where cloth washing takes place. Additionally, recreational activities such as boating and water-based training exercises highlight that the canal is not merely a utilitarian structure, but also a space for leisure and sport. Religious tourism, especially during festivals, boosts local economies through informal trade, food stalls, and transport services. This blend of cultural and economic activity underscores the canal's role not only as an infrastructural asset but as a living socio-economic landscape.

In summary, the Ganga Canal represents a unique intangible cultural identity that transcends its physical presence. It fosters a rich tapestry of religious, social, and economic activities, establishing itself as a living entity and functioning as a cultural and spiritual artery for the communities along its banks.

Conclusion

Before the construction of the Ganga Canal, the landscape of the region was predominantly religious in Haridwar and characterized by a mud-built village in Roorkee. With the development of the Ganga Canal, the landscape began transforming in the mid-1800s, with the establishment of workshops and institutes, and has continued to evolve to the present day. What was initially a functional hydraulic project gradually evolved into a catalyst for socio-cultural development, educational advancement, and the emergence of a vernacular-built heritage embedded within everyday life. This study addresses its core objectives by identifying the layers of cultural and vernacular built heritage along the Ganga Canal route. Through archival review and spatial analysis, the study identifies how sacred, colonial, and vernacular elements have coexisted and evolved over time. Further, photo documentation captures the present-day cultural and architectural landscape. Finally, the study concludes how the Ganga Canal significantly influenced and shaped the region and its surroundings through “vernacular-built heritage, cultural landscapes, and intangible values”. The study findings demonstrate that the canal became a unifying corridor where religious practices, colonial infrastructure, and community life intersect. This transformation can be traced across several key domains; the following section elaborates on each aspect in detail.

- **Educational:** The Ganga Canal system, incorporating natural watercourses later integrated with engineered structures, profoundly impacted regional development from the 19th century under British rule. It facilitated the establishment of a commercial hub and led to the founding of Asia’s first civil engineering college and India’s first engineering college in 1847, now known as the “Indian Institute of Technology Roorkee”. “The Central Building Research Institute (1950)” was also established for research and development purposes. These developments transformed the Ganga Canal route into a major educational hub for architecture and civil engineering. Other prominent research institutes, including the “National Institute of Hydrology (1978)”, the “Irrigation Research Institute (1954)”, the ‘State Water Informatics Centre, Roorkee’, and the “Irrigation Design Organisation (1978)” — focused on the design of multipurpose hydroelectric projects in the Ganga and Yamuna valleys in the Himalayas, further underscore the canal’s significance.
- **Defence:** The canal facilitated commerce and trade growth, supported by one of India’s oldest cantonments, established as the “Bengal Engineers Group” in 1853 by the British. The cantonment is situated adjacent to the Indian Institute of Technology. A significant remnant of this history is the old aircraft hangar, now functioning as the institute’s convocation hall. The hangar is said to have been used for repairing aircraft during World War II. This site, while functional today, retains its original architectural character, showcasing how military infrastructure has been absorbed into the educational landscape.
- **Industrial & Engineering Marvels:** Beyond irrigation, the canal served as a catalyst for broader infrastructural development, including the “Government Workshop (1843)”, established for the fabrication of hydro-mechanical equipment for canal construction. Key engineering accomplishments, such as the “Dhanori Level Crossing, Pathri Super Passage, Ranipur Syphon, and India’s first aqueduct, the Solani Aqueduct”, underscore the region’s engineering heritage. The “Pathri Powerhouse and Hydraulic Research Station, Bahadarabad”, further contributes to the canal’s significance. Roorkee’s symbolic lion statues, incorporated into the IIT Roorkee logo, were constructed to serve as slope warnings for the canal. Five such statues were made in Roorkee, with the prototype located near “St. Andrew’s Church”.
- **Railway Development:** The canal’s construction in Roorkee led to the use of India’s first freight trains. The service began on December 22, 1851, between Roorkee and Piran Kaliyar, with an 8-km-long track. The track was laid during the construction of the Solani Aqueduct.
- **Cultural Activities:** The Ganga Canal transformed the landscape it traversed, enhancing its religious significance for both Hindu and Muslim communities. Haridwar and Kankhal remain centers of Hindu rituals, closely tied to the sacred waters of the Ganga River, while Piran Kaliyar, a settlement dating back to the 13th century, is a revered site for Muslims due to its association with a Sufi saint. Sir Proby Cautley, the canal’s chief engineer, thoughtfully

integrated these cultural and religious elements into its design and route. The region's British influence also introduced Christian elements, leaving remnants such as one of India's oldest British cemeteries (a protected monument by the Archaeological Survey of India) and several old churches in Roorkee dating back to the 19th century. From Haridwar to Roorkee, the canal features numerous ghats that host festivals and rituals. Boating training activities are conducted by the Indian Institute of Technology through its boat club. On national and religious festivals, local authorities organize artistic light and music performances near the canal, creating a vibrant atmosphere and boosting the local economy. Additionally, the ghats are frequently used by visitors for socializing and recreational purposes.

- **Navigation:** The canal also serves as a key navigational link between Haridwar and Roorkee, integrating with national highways and railway tracks. The canal's route continues to shape the social and economic landscapes of Haridwar and Roorkee. The proposed Eight-Lane Upper Ganga Canal Expressway aims to connect Uttarakhand with Bulandshahr (Uttar Pradesh), providing a direct route to New Delhi and Western Uttar Pradesh and reducing travel time. The canal route is also integral to the "Kawad Yatra" pilgrimage during the month of Sawan, further reinforcing its cultural importance.

The research is context-specific and is limited to a single case study, which constrains its generalizability. The findings are not intended to represent all the canal landscapes but to provide insights into one historically significant and culturally active corridor. The strength of this study lies in its multidimensional approach, which integrates spatial analysis, field-based observation, and cultural interpretation. It successfully bridges the gap between heritage studies and infrastructural history, offering a lens through which canals can be studied as cultural entities.

This study demonstrates that the Ganga Canal, originally conceived in the 19th century as a hydraulic engineering project, has evolved into a dynamic heritage corridor. More than a century and a half after the Ganga Canal's construction, the surrounding landscape continues to evolve to address emerging needs. The canal's route embodies layering of cultural, technological, and social meanings. The convergence of heritage nodes and the persistence of intangible practices such as festivals, pilgrimages, daily rituals, establish the canal as a site of cultural plurality. As a lasting example of the intersection between engineering and culture, the Ganga Canal continues to shape the region's landscape, presenting opportunities for tourism, religious pilgrimage, and heritage conservation. Unlike global precedents such as the Grand Canal of China or Venice's mercantile canals, the Ganga Canal uniquely functions as both a pilgrimage spine and an engineering corridor. However, it remains under-recognized in formal heritage policy. Our study also underlines the urgency of integrated conservation strategies to safeguard the layered cultural landscape from neglect, unplanned development, and tourism pressures. Technological advancements, such as remote sensing and geographic information systems (GIS), can help map canal routes and associated landscapes. There is potential for development authorities to integrate these layers of physical heritage, cultural landscapes, and intangible values. The concept of canal-oriented development illustrates how a single infrastructural project can intertwine with cultural heritage and historical layers. Through these efforts, the Ganga Canal route has the potential to foster a future that harmonizes development with cultural and historical preservation.

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Author Contributions: All authors have read and agreed to the published version of the manuscript. **Ethical Considerations:** All participants were adults and engaged voluntarily. Verbal informed consent was obtained prior to interviews, with clear explanation of the study's objectives. No identifying information has been disclosed, and pseudonyms were used in reporting. The study involved non-vulnerable populations and non-invasive methods; therefore, formal Institutional Review Board (IRB) clearance was not required as per institutional policy.

Informed Consent Statement: Not applicable.

Data Availability: The data can be provided upon a formal request to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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