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Hydraulic heritage of eastern India: A study of the water-bodies of Raibania fort, Odisha

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Abstract
Raibania Fort, located in the Balasore district of northern Odisha, is a medieval fortification of strategic and cultural importance, dating to the 13th century CE during the reign of the Eastern Ganga ruler Narasimhadeva I. While its military architecture has been documented in archaeological and historical studies, the fort's sophisticated water management system-including moats, rain-fed tanks, sacred ponds, and natural wetlands remains understudied. This paper examines the design, function, and socio-cultural significance of these waterbodies, drawing upon archaeological reports, oral traditions, GIS-based mapping, and on-site ecological observations. The study situates Raibania's hydraulic heritage within the broader context of medieval Eastern Indian fortifications, highlighting the integration of indigenous engineering, ritual practices, and environmental adaptation. Current challenges to conservation are discussed alongside heritage management strategies, underscoring the relevance of traditional water systems for sustainable resource management today.

Keywords: Medieval Odisha, Raibania fort, hydraulic heritage, water management, sacred ponds, heritage conservation

1. Introductions

Fortified settlements in pre-modern India were not merely military strongholds but integrated socio-ecological systems designed to ensure security, sustenance, and resilience. Water management was a critical component of these systems, enabling forts to withstand sieges, support daily needs, and sustain agricultural activity (Gupta 2007) [3]. The Raibania Fort complex, built in the 13th century CE during the reign of Narasimhadeva I, stands as one of the largest medieval forts in Eastern India (Mishra 2004) [5]. Located near the Subarnarekha River and within a marshy landscape, the site utilised an elaborate network of water bodies both natural and constructed for defensive, domestic, and ritual purposes.

Despite its significance, Raibania's hydraulic system has received minimal scholarly attention compared to its architectural and military history. This paper addresses this gap by analysing the types, technologies, and cultural meanings of the fort's water bodies, while also assessing their current state and conservation prospects.

2. Literature Review

The study of hydraulic heritage in India has often focused on urban waterworks (e.g., stepwells, temple tanks) and large irrigation systems, with limited attention to fort-based water systems (Dutta 2014; Ray and Sen 1961) [2, 9]. In Eastern India, the integration of moats, ponds, and marshlands into fort design is documented at sites like Barabati Fort (Cuttack) and Garh Nokha (West Bengal), but these are rarely analysed in an environmental-historical framework (Panda 2016) [7].

In Odisha, scholarship on temple tanks (Behera 2012) [1] and ritual waterbodies (Mahapatra 1998) [4] provides useful cultural parallels, while ecological assessments of ancient tanks in northern Odisha (Rout and Nayak 2019) [10] offer methodological models. The Raibania Fort has been surveyed archaeologically (Odisha State Archaeology 2021) [6], yet its hydraulic features are often mentioned only as part of defensive architecture. This study contributes by combining heritage archaeology with hydrological and socio-cultural perspectives, situating Raibania within both regional hydraulic traditions and medieval fortification studies.

3. Historical Background of Raibania Fort

Raibania Fort, situated in the Balasore district of northern Odisha, occupies a significant place in the political and military history of Eastern India. Established as a strategic frontier outpost during the reign of the Eastern Ganga dynasty, it functioned as a defensive bulwark against repeated incursions from the Bengal region, particularly during the 13th - 15th centuries CE (Panda, 2016) [7]. The fort's primary role was to safeguard the northern borders of the Ganga kingdom and protect vital inland trade routes linking Odisha with the Gangetic delta.

Historical records, including the Ekasari Rajavamshavali, corroborated by epigraphic sources such as copper plate grants and temple inscriptions, describe Raibania not as a single enclosure but as a sprawling complex of multiple fortified units or garh. These were constructed using a combination of earthen embankments and laterite stone ramparts, complemented by bastions at key intervals to enhance defence capabilities (Mishra, 2004) [5]. The fortification system was further reinforced by an elaborate network of moats, natural wetlands, and riverine channels. These aquatic features not only formed formidable barriers to enemy movement but also acted as integrated water management systems, ensuring a sustainable water supply for both military and civilian purposes during sieges.

Archaeological surveys indicate that the fort's siting was meticulously chosen to exploit the natural terrain. Located on a slightly elevated tract, it commanded views over the surrounding floodplains and wetlands, enabling early detection of enemy advances. The proximity to fertile alluvial lands also provided agricultural resources, contributing to the fort's self-sufficiency. Furthermore, Raibania's position facilitated control over local riverine trade, thereby combining military, administrative, and economic functions within a single fortified landscape.

In addition to its military significance, the fort and its surrounding settlements became a hub of cultural interaction. The movement of troops, artisans, and traders contributed to the diffusion of architectural techniques, craft traditions, and religious practices between Odisha and neighbouring Bengal. This dynamic exchange is evident in the blend of Odishan and Bengali architectural motifs in surviving structures and in the diverse ceramic assemblages recovered from the site.

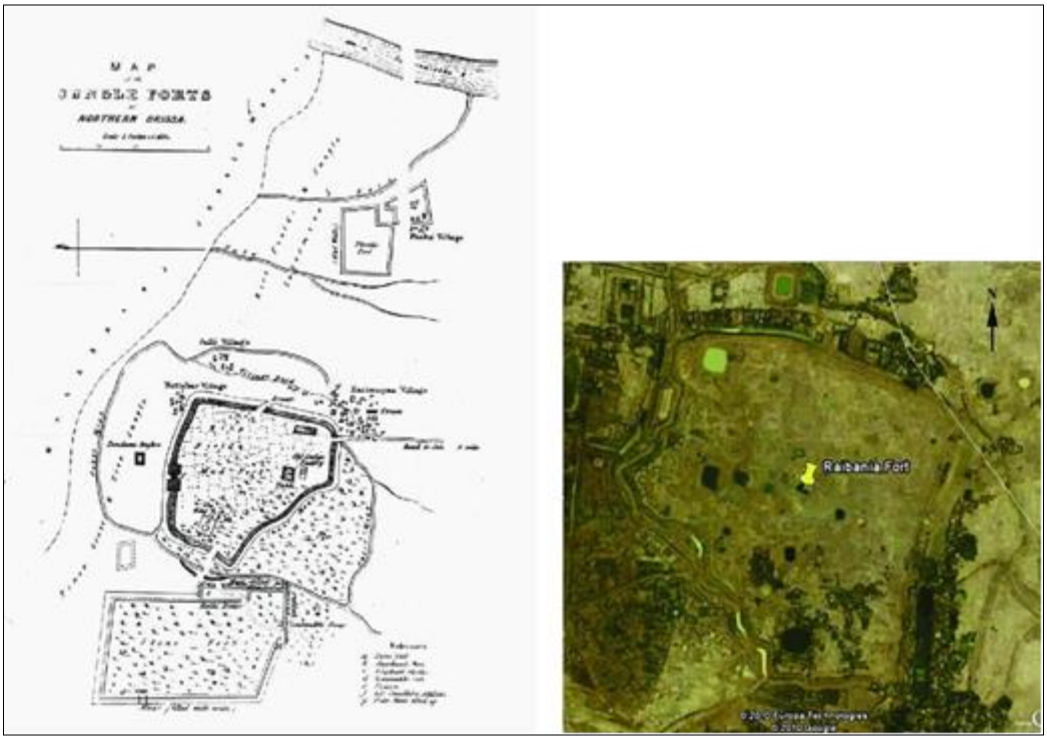


Photo courtesy: Map by Beams (Beams 1872) B) Satellite Map of the Raibania Fort

The decline of Raibania Fort is attributed to shifting political power in the late medieval period, with the rise of the Bengal Sultanate and later the Mughals, who altered the military geography of the region. Despite the loss of its strategic primacy, the remains of Raibania Fort continue to bear testimony to the Eastern Ganga dynasty's sophisticated military engineering and frontier policy.

4. Types of Water bodies in the fort complex

The fortified enclosure contains a considerable number of tanks of varying dimensions, which appear to have been constructed to secure a reliable water supply for both the garrisoned soldiers and their animals, who likely resided in camps situated in close proximity to these reservoirs. In a survey undertaken in 1964 and later published in 1986, H. C. Das documented twenty-six such tanks, providing a detailed list that includes Nandika, Deula, Bhunya, Sirsa, Hirarani, Kaushalya, Bazarghanta, Biria, China, Mangaraja, Dhinkipara, Gandaguda, Matha Kaumari, Pandasaro, Mahisi, Gadakhai (also referred to as Kaliadahana), Dhanuphata, Tendagadia, Silapata, Pallababeharagadia, Balipaka Pokhari, Dhanagada, Chinakunda, Netakunda, and Jalayantra Pokhari.

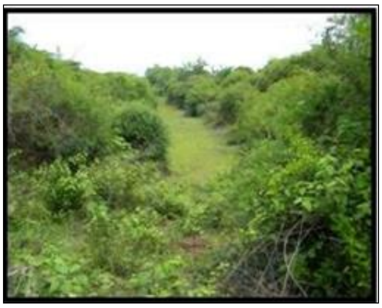
The nomenclature of these tanks offers valuable insights into their historical context. Several appear to have been commissioned under the direction of military generals, while others seem to commemorate queens and princesses, thereby reflecting the socio-political hierarchy of the period. Moreover, a number of these reservoirs are associated with local traditions and folklore. Of particular interest is the

Jalayantra Pokhari, located in the north-western sector of the fortified precinct, just beyond the main fortification wall. Oral tradition attributes to it a concealed subterranean chamber, reputedly used to store weapons during times of conflict, thereby underscoring the strategic and military significance of such water structures.

4.1 Moats and Defensive Ditches

The defensive system of Raibania Fort incorporated an extensive network of moats (pankhas), strategically positioned around the outer perimeter to impede enemy approach. These moats, in several sectors, exceeded 20-30 metres in width and were maintained at a consistent depth through a combination of diverted channels from nearby seasonal streams and catchments that collected monsoonal runoff (Gupta 2007) [3]. Archaeo-hydrological surveys suggest a dual-purpose design: while their primary function was to hinder siege engines and mounted cavalry, the moats also acted as controlled flood basins, preventing waterlogging of the fort interior during heavy rains. The presence of sluice gates, inferred from stone remnants at embankment gaps, indicates a sophisticated water management system, allowing defenders to regulate water levels seasonally.

a) Moat



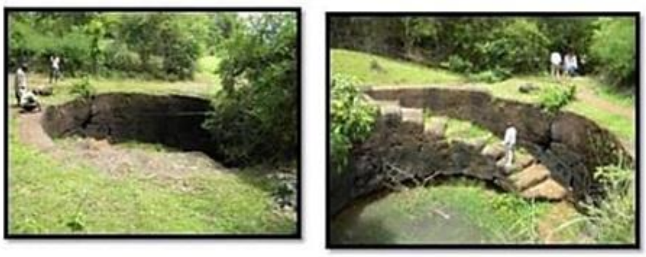
b) Second Moat

4.2 Rainwater Harvesting Tanks: The fort complex contained several bandhas (artificial water tanks), many of which were situated adjacent to residential or administrative zones. These tanks, some measuring over 100 metres in length, were constructed with laterite or sandstone lining to reduce seepage and facilitate easy maintenance (Rout and Nayak 2019) [10]. Their strategic distribution ensured that water was available year-round, even during extended sieges. Micro-topographic mapping indicates that these tanks collected runoff from elevated areas of the fort, functioning as early forms of rainwater harvesting systems. The combination of gravity-fed channels and settling basins reflects an understanding of sediment control, which would have prolonged the usability of these reservoirs.

4.3 Ritual Ponds

In addition to utilitarian water features, Raibania also contained sacred water bodies, locally referred to as katas. Positioned near temple complexes, these ponds were used for ritual bathing (snana), purification rites, and ceremonial immersions during festivals (Mahapatra 1998) [4]. Some ponds, according to oral traditions, were believed to be akshaya (never-drying), a belief that enhanced their spiritual significance. Archaeological traces of stone steps (ghats) and platforms suggest that these ponds were integral to the socio-religious life of the garrison and surrounding settlements. The placement of these water bodies also hints at the syncretic blending of martial and ritual landscapes within the fort precinct.

A) KAUSHALYA POKHARI B) JALAJANTRA POKHARI



TOP VIEW VIEW INSIDE THE WELL

Fig 3: Joda Halia Kuan

4.4 Natural Marshes and Wetlands
The southern and south-eastern periphery of the Raibania complex was flanked by expansive marshlands, likely seasonally inundated due to the overflow of nearby rivers and monsoon-fed channels (Odisha State Archaeology 2021) [6]. These wetlands not only served as natural ecological buffers, limiting direct approach from hostile forces, but also provided an abundant supply of fish, edible aquatic plants, and reeds for craft production. Historical and ethnographic evidence indicates that local communities integrated these marshes into the subsistence economy of the fort, supplementing stored grains with fresh protein sources. The wetlands may also have functioned as wildlife corridors, creating an additional natural deterrent against enemy encampments in these zones.

5. Methodology
This study employed a mixed-methods approach to capture the multifaceted historical, cultural, and ecological significance of the waterbodies associated with Raibania Fort. The combination of qualitative and quantitative methods ensured both empirical precision and cultural depth.

5.1 Archival Research
Primary and secondary historical sources were reviewed, including medieval Odisha chronicles, British-era survey reports, inscriptions, and previous archaeological assessments (Mishra, 2004; Odisha State Archaeology, 2021) [5]. Archival research helped establish a chronological framework for the fort's hydrological infrastructure and revealed references to lost or modified water features. Special attention was given to rare manuscripts held in local libraries and private collections, which often preserve vernacular place-names linked to water systems.

5.2 Field Surveys
Systematic on-site surveys were conducted to document the spatial layout and condition of surviving waterbodies. These surveys used handheld Global Positioning System (GPS) devices to obtain precise coordinates for each tank, moat, and marsh. The survey also included visual inspection of masonry linings, sluice structures, and associated embankments, allowing for preliminary structural classification (laterite-lined, sandstone masonry, or earthen embankments). Field notes recorded hydrological connectivity and signs of modern alteration, such as agricultural encroachment or siltation.

5.3 Oral histories and ethnographic data
Semi-structured interviews were conducted with local elders, temple priests, and long-term residents to collect oral traditions, folk narratives, and place-name etymologies associated with specific waterbodies (Mahapatra, 1998) [4]. These accounts often revealed intangible cultural values, such as beliefs about sacred ponds that never dry, or moats that 'sing' during monsoon winds. This ethnographic layer added a socio-cultural dimension often absent from purely archaeological studies.

5.4 Ecological Observations
Current flora and fauna associated with each waterbody were recorded through direct observation and opportunistic photography. Seasonal variations in biodiversity were noted, particularly the presence of migratory waterfowl, native aquatic plants, and fish species. The ecological data were analysed to assess the continuing environmental role of these waterbodies in the region's hydrological network and their potential as cultural-ecological heritage zones.

6. Technological and Ecological Features
The water systems of the fort complex were engineered with a nuanced understanding of both structural stability and long-term sustainability. Sloped embankments were a consistent feature, designed not only to prevent sudden collapse under the weight of retained water but also to distribute hydrostatic pressure evenly along the perimeter. In many cases, these embankments were reinforced with compacted earth cores, overlaid with stone revetments, to resist scouring during heavy inflows.

Clay linings, often sourced from nearby deposits of fine alluvial soil, were applied to the base and sides of reservoirs to create a semi-impermeable layer. This significantly minimized seepage losses, ensuring that stored water could be retained well into the dry season. In areas with porous subsoils, a multi-layered system was used first, a compacted clay layer, followed by a bed of gravel and sand to filter and slow percolation, striking a balance between storage retention and groundwater recharge.

Vegetative buffers, consisting of bamboo, vetiver grass, and other moisture-tolerant species, were strategically planted along banks. These plantings served dual purposes: their root systems anchored the soil, preventing erosion, while their canopy helped reduce direct evaporation by moderating microclimatic conditions along the water's edge.

To manage the intense and often unpredictable inflows of the monsoon season, the system incorporated spillways and overflow channels, often stone-lined, to safely divert excess water away from embankments and habitations. Some overflow channels were connected to secondary holding ponds or agricultural fields, effectively transforming floodwaters into a controlled irrigation resource.

The juxtaposition of percolation-friendly ponds with tightly sealed clay-lined reservoirs indicates a sophisticated hydrological strategy. Percolation-enhancing ponds allowed for gradual groundwater recharge, benefiting wells and maintaining moisture in surrounding agricultural soils. Conversely, the sealed reservoirs prioritized long-term surface water storage, ensuring a dependable supply for drinking, ritual purposes, and emergency defense needs. As Dutta (2014) [2] observes, this integrated system reveals not only advanced technical knowledge of seasonal hydrology but also a deep environmental adaptability balancing water security with ecological resilience.

7. Socio-Cultural Significance
Beyond their utilitarian function in sustaining the fort's population and garrison, the waterbodies of Raibania were deeply embedded in the site's socio-cultural and religious life. These tanks, ponds, and marshes often served as focal points for seasonal festivals, ritual observances, and communal gatherings.

One prominent example is the celebration of Makara Sankranti, a winter solstice festival marking the sun's northward movement (uttarāyaṇa). On this occasion, sacred ponds within and around the fort became sites for ritual bathing (snāna), offerings, and community feasts. Such practices were believed to purify the body, accrue spiritual merit, and ensure agricultural prosperity in the coming year. Oral traditions suggest that some of these ponds were considered tīrthas (pilgrimage spots), thereby elevating their spiritual importance far beyond ordinary water storage.

Place-names associated with several tanks reflect their integration into local memory and royal patronage. For instance, certain reservoirs bore the names of Eastern Ganga rulers, suggesting either their direct commissioning or later dedication in their honor. Others were linked to local deities such as Mangala, Durga, or Shaivite manifestations, indicating a blend of royal and folk religious traditions. In some cases, mytho-historical narratives connected these waterbodies to legendary events such as the miraculous appearance of water during a siege or the performance of yajñas on their banks which reinforced their status as symbols of divine favor and fort resilience.

The cultural role of these water features also extended to social cohesion. Collective maintenance activities desilting, repairing embankments, planting protective vegetation were often carried out during prescribed times of the year, turning them into occasions for communal labor (śramadāna) and strengthening ties among different occupational and caste groups within the fort's domain. Such practices reveal that waterbodies were not passive landscape elements but active arenas where political authority, religious devotion, and community identity intersected.

8. Current Condition and Conservation Issues

Many of Raibania's historic tanks are now in varying states of degradation, with several suffering from extensive siltation that has significantly reduced their storage capacity and altered their original contours. Silt deposition, largely accelerated by upstream soil erosion due to deforestation and unregulated farming practices, has diminished the hydraulic efficiency of these waterbodies (Patnaik and Sahu, 2020) [8]. Encroachment poses another critical threat, as portions of tank beds and embankments have been repurposed for agriculture, settlement expansion, and infrastructure development, disrupting both their physical integrity and ecological functions.

The combined pressures of agricultural intensification, population growth, and administrative neglect have weakened the maintenance traditions that once sustained the fort's hydraulic network. Seasonal desilting and embankment repairs once integral to the community's collective water stewardship are now rare or absent, leading to further deterioration. In certain areas, irrigation borewells have replaced surface water management, resulting in lowered community reliance on, and therefore care for, the traditional tanks.

Nevertheless, despite this decline, a number of waterbodies still function as seasonal wetlands, providing critical habitats for aquatic plants, fish, and migratory birds. These surviving systems also continue to regulate microclimatic conditions and groundwater recharge, thereby retaining a degree of their original hydrological function. Such remnants highlight the resilience of certain components of the hydraulic network and offer potential anchor points for heritage-based ecological restoration initiatives.

9. Policy and Conservation Framework

Aligning conservation efforts with heritage policies

Such as the National Policy on Conservation of Ancient Monuments, Archaeological Sites and Remains offers a framework for integrated management of Raibania's waterbodies. This policy emphasizes not only structural preservation but also the maintenance of associated cultural landscapes, making it well-suited for safeguarding the fort's historical hydraulic systems. By bringing waterbody restoration under the same legal and administrative umbrella as monument conservation, authorities can ensure that both tangible and intangible heritage values are protected in tandem.

Community participation should be central to this process. In Odisha, several successful heritage tank restorations such as those in Puri district and around Bhubaneswar's old temples demonstrate the value of involving local stakeholders in planning, monitoring, and maintenance. These initiatives often integrate palli sabha (village council) oversight, voluntary desilting drives, and the revival of traditional festivals tied to waterbodies, which not only restore functionality but also renew community pride (Patnaik and Sahu 2020) [8].

Linking heritage tourism with restoration provides an additional economic incentive for preservation. Well-maintained water systems can be presented as part of an immersive heritage experience, combining guided tours of the fort with interpretive signage, storytelling of associated myths, and seasonal festivals staged at restored tanks. Such initiatives can generate employment for local guides, artisans, and service providers while funding ongoing maintenance. Furthermore, conservation strategies could adopt adaptive reuse approaches, where rehabilitated tanks serve both heritage purposes and modern needs such as rainwater harvesting, aquaculture, or eco-tourism without compromising historical authenticity. Partnerships with NGOs, academic institutions, and heritage tourism boards could ensure technical guidance, sustained funding, and broad public engagement.

10. Conclusion

The Raibania Fort waterbodies exemplify a sophisticated medieval hydraulic engineering system in eastern India, reflecting a confluence of military utility, ecological adaptation, and ritual symbolism. Strategically, the reservoirs and tanks served as essential components of the fort's defensive infrastructure, ensuring reliable water supply during sieges and facilitating moat replenishment. Ecologically, their design demonstrated a nuanced understanding of seasonal hydrology, soil-water interactions, and biodiversity support, with evidence of percolation-enhancing features, clay linings to minimise seepage, and vegetative embankments to stabilise soil and reduce evaporation losses (Dutta 2014) [2]. Culturally, the waterbodies were embedded in local ritual practice, functioning as sacred spaces linked to festivals and royal patronage (Behera 2012) [1].

Preservation of these hydraulic features extends beyond heritage value, offering actionable insights for contemporary water governance in monsoon-dependent regions. Their integrated approach balancing water storage, flood control, and ecological services aligns closely with modern sustainable water management principles, such as conjunctive use of surface and groundwater, community stewardship, and climate-resilient design. Thus, systematic documentation and conservation of Raibania's water systems not only deepen historical understanding but also provide a replicable model for addressing current water security challenges (Patnaik and Sahu 2020) [8].

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