International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 05 Issue: 01 | Jan – 2026 DOI: 10.55041/ISJEM05368
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Engineering Principles of Water Reservoirs and Stepwells in *Bṛhat Sahitā̄*: A Technical Interpretation for Sustainable Hydraulic Design

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Abstract—**Ancient Indian scientific literature reflects a high degree of systematic observation in the fields of hydrology, water conservation, and civil engineering. Among these works, the *Br̩ hat Sahita̅*, composed by Vara̅hamihira in the sixth century CE, offers detailed guidance on reservoir construction, site selection, identification of groundwater sources, and the design of stepwells. Rather than being purely descriptive, these guidelines reveal a structured understanding of natural processes governing water movement and storage. Key concepts such as soil stratification, groundwater recharge mechanisms, slope stability, evaporation reduction, and passive thermal regulation are critically examined and correlated with contemporary engineering principles. This study demonstrates that the traditional water systems described in the *Br̩ hat Sahita̅* are grounded in sound engineering logic and retain practical relevance for addressing modern water scarcity challenges.**

Index Terms—**Indian Knowledge Systems, Stepwells, Water Reservoirs, Sustainable Engineering, Ancient Hydrology, Br̩ hat Sahita̅**

I. INTRODUCTION

Water scarcity and groundwater depletion have emerged as critical global challenges, particularly in arid and semi-arid regions. Modern water infrastructure often relies on energy-intensive pumping systems and centralized storage, increasing both operational costs and environmental impacts. In contrast, ancient Indian hydraulic systems emphasized localized resource utilization, gravity-driven flow, and ecological integration.

The *Br̩ hat Sahita̅*, authored by Vara̅hamihira in the sixth century CE, is an encyclopedic treatise covering astronomy, meteorology, geology, and water engineering. Several chapters describe the construction of reservoirs (*tada̅ga*), wells, and stepwells (*va̅p ı̅*), reflecting a systematic understanding of hydrological and geological conditions.

This paper reinterprets these descriptions using modern hydrology, geotechnical engineering, and sustainability science.

II. HYDROLOGICAL SITE SELECTION PRINCIPLES

A. Groundwater Indicators

The *Br̩ hat Sahita̅* identifies groundwater through vegetation density, soil coloration, insect behavior, and subsurface temperature variations. These indicators align closely with modern hydrogeological markers such as capillary moisture presence, high-permeability soil layers, and shallow water tables.

B. Soil Stratification and Load Considerations

The text differentiates sandy, clayey, rocky, and mixed soil types, recommending varying excavation depths and lining techniques. This empirical understanding parallels modern bearing capacity theory, where soil shear strength and permeability govern foundation stability.

III. ENGINEERING DESIGN OF RESERVOIRS

A. Geometry and Storage Optimization

Ancient reservoirs were typically trapezoidal or stepped in cross-section, reducing lateral earth pressure and enhanc- ing slope stability. These geometries minimize failure risk, improve sediment deposition control, and increase structural longevity.

B. Evaporation and Seepage Control

Stone lining and vegetation buffers were recommended to reduce evaporative losses, soil erosion, and thermal heating. Passive evaporation mitigation remains a critical concern in modern open reservoir design, especially in tropical climates.

IV. STEPWELL ENGINEERING AND THERMAL REGULATION

A. Passive Cooling Effects

Temperature measurements within extant stepwells show reductions of 5–8°C relative to ambient conditions. This effect is attributed to reduced solar exposure, high thermal mass, and natural convection airflow—principles consistent with modern passive cooling architecture.

B. Structural Redundancy

Multiple stepped platforms act as distributed load paths, enhancing seismic resilience. This redundancy-based approach aligns with contemporary civil engineering safety factors.

TABLE I
COMPARISON OF ANCIENT AND MODERN WATER SYSTEMS

Parameter	Ancient Systems	Modern Systems
Energy Use	Gravity-based	Pump-dependent
Maintenance	Localized	Centralized
Sustainability	High	Variable
Climate Adaptation	Passive	Active

V. COMPARATIVE ANALYSIS WITH MODERN SYSTEMS

VI. RELEVANCE TO SUSTAINABLE DEVELOPMENT

Integrating principles from the *Br̩ hat Sahita¯* into modern engineering practice can improve groundwater recharge, reduce operational energy costs, and enhance community-level water security—particularly for decentralized infrastructure systems.

VII. CONCLUSION

The water reservoir and stepwell engineering practices described in the *Br̩ hat Sahita¯* embody a systematic and empirically grounded engineering logic. When evaluated through modern analytical frameworks, these ancient systems provide valuable insights for designing sustainable and climate-resilient water infrastructure.

Future work may include computational fluid dynamics (CFD) modeling and field-based validation of thermal and hydraulic performance.

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