IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

# Integration of Indigenous Knowledge System (IKS) with Geographical Analysis, Cartographical Mapping in the essence of Modern Geospatial Technology in India

**Dr. Bhaskar Das**

Cartographer, Department of Geography

Visva-Bharati (A Central University of Govt. of India

**Abstract:**

The integration of Indigenous Knowledge Systems (IKS) with geographical analysis and cartographical mapping in the context of modern geospatial technologies presents a transformative framework for sustainable and culturally rooted spatial planning in India. The fusion of IKS with geospatial technologies is not just a methodological advancement but a decolonial and epistemic shift in spatial sciences. The indigenous knowledge of ancient spatial planning layout from Indus Valley Civilization, cosmological belief from the text like *Vedas*, *Puranas*, and *Upanishads*, cartographic impression in the *Surya Siddhanta* or temple layouts in Vastu Shastra enrich modern geographical practices with geospatial interpretation in different states India. The author tried to explain how digitizing traditional practices and belief into cartographic representation, incorporating oral histories, and georeferencing of culturally significant sites collaborating modern geospatial environment with GNSS applications creates participatory planning models in different corner in India successfully reviewing multiple references and IKS examples.

**Keywords:** Indigenous Knowledge Systems, Inclusive, Geospatial Technology, Urban Layout, Cartography, Paradigm of Geoinformatics

## 1. INTRODUCTION

Indian Knowledge Systems (IKS) encompass the frame of traditional, indigenous, and often orally transmitted knowledge developed over centuries within Indian civilization which offers a rich and diverse legacy of astronomy, geography, hydrology, agriculture, ecology, architecture and blending of cartographic knowledge with geospatial understanding since ancient era to modern ages.

The interpretation and deep understanding of cartographic mapping was known in Indian civilization more than 2500 years having idea of spatial shape, scale, length, area and angle during the archeological excavations period of Indus Valley Civilization (Mackay, 1938). Ancient Indian texts such as the *Vedas*, *Puranas*, and *Upanishads* (Radhakrishnan, S. 1957) were highly enriched with nature, ecology with different cycles of environment. This inheritance continued in the mathematical, astronomical works and spatial knowledge of eminent Indian scholars viz. Aryabhatta, Barahamihira, Bhāskara and Bhaskaracharya during 5$^{th}$ -12$^{th}$ century (Amma, 1979) where detailed observations made on regional weather pattern and its nature, river systems and associated agricultural practices, and ecological zones that align with modern geographical concepts.

The Indian Knowledge System (IKS; Dasgupta, S. 2016)) deeply enriched with traditional and indigenous urban spatial knowledge and architectural pattern of Indus Valley Civilization in northern India and temple structure based architecture models in south India. Indian cartography and geo-spatial knowledge is deep-rooted in the ancient and medieval history of India with traditional insightful understanding of space, location, direction, and extraterrestrial phenomena (Acharya, P.K.1934). Though colonial interventions disrupted indigenous systems, the revival of IKS presents a unique opportunity to integrate traditional geographical knowledge with modern geospatial technologies with the advent of Remote Sensing and Geographic Information Systems (IIRS,ISRO,2023).

## 2. NEED OF INDIAN KNOWLEDGE SYSTEM (IKS) IN GEOGRAPHICAL, CARTOGRAPHICAL AND GEOSPATIAL STUDIES

- Integrating of traditional practice and beliefs under IKS with geography, cartography and geospatial technology will develop insightful path of *holistic, inclusive, and indigenous understanding (*Agrawal, A. 1995) of the environment, spatial phenomena, human-nature relationships and sustainable spatial planning.
- A balanced synthesis of traditional knowledge, belief and practice with modern technology can lead to contemporary to modern cartographic practices are scientifically robust and also socially and culturally meaningful.
- Aesthetic representation and interpretation from ancient maps in the *Surya Siddhanta* or temple layouts in *Vastu Shastra* (Pingree, D. 1973) under Cartography and GIS environment reveals indigenous approaches towards landscape based architect planning and orientation.
- Comprehensive analysis of recent weather and climate change, rapid urbanization and associated sprawling and ecological degradation in India, the fusion of IKS with geospatial technologies could provide innovative solutions rooted in centuries of lived experience.

## 3. AIMS AND OBJECTIVES

Therefore, keeping in mind the needs of integrating and explanation of traditional belief, practices since ancient times could be a strong fusion with modern cartography and geospatial technology which enable preserving India's indigenous heritage, enrich scientific inquiry and practices, and enable more sustainable, inclusive, resource management based geospatial planning. Therefore, the followings are the key objectives:

A. To study the ancient Indian Cartography and its evolution and development
B. Integration IKS with Geography, Cartography and Modern Geospatial Technologies
C. Encompassing IKS into new paradigm of Geoinformatics and GNSS system

## 4. ANCIENT INDIAN CARTOGRAPHY AND ITS EVOLUTION AND DEVELOPMENT

### 4.1 Indus Valley Civilization (3300–1300 BCE)

The primitive but advanced urban and town architectural planning with earliest evidences of geospatial understanding is well defined in Indus Valley Civilization in India highlighting presence of a grid-iron pattern with well-defined streets and drainage systems (Possehl, 2002) reflecting centralized governance and advanced civil engineering. The uniformity of house design and patterns, having well defined city planning may have had ritual or symbolic dimensions, hinting at a deeper socio-cultural framework underlying the urban layout (Kenoyer, S.1998). The functional classification of city, adaptive urban design across different environmental settings (e.g., floodplains vs. arid zones) highlights the flexible cohesive nature (Wright, P.2010) of Indus Valley Civilization planning. The tripartite division of the city i.e. the citadel, middle town, and lower town was surrounded by massive walls with gates, the water management system at Dholavira, including interconnected reservoirs and channels (Bisht, R.S. 2000), diplayed an advanced understanding of hydro-engineering. The regional variation in town layout**,** broader Indus cultural zone (Mughal, et al, 1997), has shown how urban design evolved across the Indus sphere.

### 4.2 Vedic and Post-Vedic Periods Indigenous Knowledge System in India

In the Vedic literature, particularly the Rig-Veda and Atharva-veda, geographical references to rivers (Saraswati, Sindhu), mountains (Himalayas), and regions (Aryavarta) during Vedic seers (Altekar, A.S. 1958) had a clear awareness of natural landscapes, seasons, and directions (*dik*), which shaped their worldview. 'Dik' (direction) was central to Vedic rituals and spatial arrangements of the Earth's surface landscape and its associated cardinal directions implicit understanding of geodesy (Balasubramaniam, R. 2012). In view of cosmological and geographical references in the *Rig-Veda*, Vedic people had a sophisticated understanding of *celestial cartography***,** allegorical mappings of the heavens, with symbolic representations of cardinal directions, constellations, and seasonal cycles (Kak, S.1994). These cosmic maps influenced how the early Indo-Aryans conceptualized terrestrial space, linking sky observations to geographic orientation with spatial science.

The concept of *Janapadas* (territorial units) and later *Mahajanapadas* reflected geopolitical mapping of space and proto-cartographic references in texts like the *Mahabharata* and *Ramayana* (Ray, HP.2011), which describe vast networks of cities, trade routes, rivers, and sacred geography. Early Indian maps as schematic diagrams rooted in Vedic cosmological beliefs includes *mandalas*, *vastu-purusha mandalas* (Dani, AH. 1960), and temple layouts which encode spatial understanding derived from Vedic texts and insights of symbolic and metaphysical cartography.

Vedic geography was enriched with regional natural features, cardinal directions, climatic zones, and riverine settlement patterns aligned with human-environment interaction and ritual-centric (Mishra, V.S. 1972). Later mythological texts like the Mahabharata, Ramayana, and Puranas discussed terrestrial and cosmic geography with its descriptions of the seven continents (Sapta Dvipa) and seven oceans (Sapta Samudra) (Tagare, G. V.1978), illustrates symbolic cartography that linked geography with mythology and cosmology.

### 4.3 Jyotisha and Astronomical Mapping in India

The science of Jyotisha, encompassing astronomy and astrology, was described in ancient Indian cartographic practices. Astronomical observations were used to determine calendars, timekeeping, and navigation. explored the textual and mathematical foundations of Jyotisha, emphasizing its dual role in calendar-making and astronomical geography from the *Vedanga Jyotisha* (circa 1400 BCE) (Pingree, D,1981) highlighting its significance in determining seasons, solstices, equinoxes, and nakshatras (lunar mansions). These astronomical tools were essential for agricultural planning and mapping time-space coordinates, linking celestial and terrestrial geographies. Ancient Indian calendared systems, deeply embedded in Jyotisha, were shaped by regional geography and observational precision (Iyengar, R. N.2007). Textual evidence of calculating of celestial events using location-specific inputs like latitude and longitude *were* found in *Surya Siddhanta* and *Aryabhatiya* long before modern cartography. This regional calibration of astronomical constants reflects a geo-astronomical awareness and implies that Jyotisha was not just time-based but also space-sensitive, contributing directly to proto-cartographic effort The epicyclic models and eclipse maps of nakshatras and planetary motions (Sarma, K.V. 1994) across the sky dome were instrumental in temple alignment, urban planning, and rituals. Geometric and trigonometric mapping techniques of planets and stars in the sky**,** with implications for both calendar systems and spatial orientation (Abhyankar, K. D. 2001) exhibited a profound understanding of celestial mechanics, indirect evidence of celestial cartography and the conceptual foundations for ancient geographyemphasized *Meru* (cosmic mountain), *Jambudvipa*, and *seven continents* were part of cosmological mapping traditions in India (Balachandra Rao, S. 2000) and symbolic representations evolved into more precise astronomical calculations involving coordinates and spatial grids, laying a conceptual foundation for early Indian cartographic systems**.**

### 4.4 Vastu Shastra and Spatial Architecture Design

Vastu Shastra, the traditional Indian science of architecture, involves the design and orientation of spaces based on directional alignments and cosmic principles reflects modern Indian architectural pattern.

The ancient Vāstu texts**,** especially the *Manasara*, (core classical architectural treatises) revealing the geometric, spatial, and cosmological principles used in ancient temple and settlement planning with a built spaces and cosmic forces (*Panchabhutas*), reflecting the Indian belief in space as sacred (Acharya, P.K. 1934). The use of mandalas, sacred geometry, and orientation rituals in ancient constructions and how traditional spatial practices from Vedic times influenced temple architecture, domestic spaces, and city layouts (Vatsyayan, K.1997). The Vastu Purusha Mandala, a square grid used in spatial planning, exemplifies a symbolic cartographic model. The Vāstu-informed architecture since ancient times now been adapted in modern architectural practices, highlighting building orientation, airflow and ventilation, modern environmental friendly design concepts**,** such as bioclimatic architecture, water recycling, water utilization and solar system installation in urban India (Sharma,A.2021) to revive indigenous knowledge systems for sustainable urban development. Cities like Jaipur, designed by Maharaja Jai Singh II, were laid out using Vastu principles integrating traditional knowledge with practical fort design.

## 5. INTEGRATION IKS WITH GEOGRAPHY, CARTOGRAPHY AND MODERN GEOSPATIAL TECHNOLOGIES

### 5.1 Historical Roots of Geospatial Knowledge in India

India has a rich tradition of spatial thinking since its ancients time where the texts like the *Surya Siddhanta*, *Brihat Samhita*, and the *Panchasiddhantika* (Ranganathan ,2006) reflects understanding of planetary motion, spatial coordinates, and cosmographical events. Ancient Indian geospatial knowledge, although symbolic and cosmological, was fundamentally rooted in empirical observation and practical application framed conceptual base for later cartographic practices and geospatial thinking. Evolution of spatial knowledge from the Vedic to post-Siddhantic periods, depicted the indigenous development of mapping, land measurement, and celestial observation. . India's ancient geographic and spatial understanding, as embedded in Vedic texts, Jyotisha (astronomy), Vāstu Śāstra, and classical cartographic traditions, offers culturally contextualized, eco-centric, and sustainable knowledge systems relevant even today. Tools such as gnomons (shanku), the use of meridians, and nakshatra-based sky mapping (Ranganathan, 2006) considered as early forms of coordinate systems and spatial referencing. For instance, the *Rigveda* and *Puranic* texts provided symbolic but spatially informed descriptions of landforms, rivers, and regions such as *Sapta Sindhu* and *Jambudvipa*, reflecting an early attempt at territorial classification. Similarly, *Sulbasutras* (800–500 BCE), which guided altar constructions, used precise geometric and directional knowledge (Joseph, 2000) considered as an early form of geodesy and cartographic planning. Ancient to medieval temple architecture and urban planning was made using modular grids, water channel mapping, and advanced surveying systems showing a continuity of indigenous surveying techniques, early geodesy, topographical surveying and engineering precision which are bases of geospatial technology (Balasubramaniam, R. 2012). Furthermore, cultural mapping initiatives today are increasingly using GIS to digitize traditional knowledge systems in terms of sacred groves, pilgrimage routes, traditional water bodies, and oral navigation maps (Varma, et al, 2020).

### 5.2 Indigenous Knowledge on Geodesy with Modern Navigation System

Kautilya's Arthashastra, written in the 4th century BCE, references the use of maps for military and administrative purposes where terms like "Patta" (map or plan) (Mishra, V.S. 1972) indicate a tradition of spatial documentation.

In *Surya Siddhanta* and *Vedanga Jyotisha*, where ancient Indian astronomers calculated surprising accuracy of coordinates, latitudes, and time zones which were essential for early geodesy (Iyengar, R.N. 2004) especially for determining geographic positions relative to celestial bodies and this indigenous geodetic logic forms a conceptual precursor to modern satellite-based navigation systems. Indigenous surveying, orientation, and topographic alignment methods were followed for buildings of temple complexes and water structures (Rajan, K. 2011) in ancient south-Indian societies. Remote sensing and GIS technologies now rediscovering and verify these traditional spatial alignments, illustrating a valuable ancient landscape knowledge and modern spatial analytics incorporating local geodesic insights into digital navigation and heritage mapping systems. Tribal and rural communities in different pockets in India traditionally use natural landmarks, solar cues, and oral mapping **(**Srivastava, P. et al 2018) for localized navigation systems. These ethno-geospatial insights help in improving route mapping, participatory land-use planning and disaster risk assessment**,** especially in regions where GPS signal reliability is poor or socio-cultural relevance is needed. Contemporary cartographic mapping of ancient travel and trade routes and sea voyages route through astronomical positioning is perfect blend of object orientation and practical route planning for modern geospatial mapping and navigation system (Varma, R. et al 2020). Mariners from South India used celestial navigation techniques to travel across the Indian Ocean, connecting India with Southeast Asia, the Middle East, and East Africa.

## 6. INDIGENOUS KNOWLEDGE SYSTEM INTO NEW PARADIGM OF GEOINFORMATICS AND GNSS SYSTEM

IKS could be a promising resources for enriching the new geospatial paradigm in India by bridging ancient traditional practices and need based symbolized cartographic map, text, drawing or sketch impression with advanced geoinformatics and satellite based navigation system in India. Vāstu-based building planning have been observed in all over India major cities and town's temples, historical and architectural buildings, residential buildings following guideline of *Vāstu Purusha Mandala* leading site suitability analysis, and heritage landscape mapping under GIS environment.

This integration promotes a major comprehensive and resilient geospatial future, where technology harmonizes with India's tradition.

### 6.1 IKS based holistic approaches towards Geoinformatics in India

Modern geospatial technologies includes Remote Sensing (RS), Geographical Information System (GIS), Global Navigation Satellite System (GNSS) and WebGIS platforms (Chambers, R., et al. 2006) like ISRO's Bhuvan which offer high-resolution satellite based spatial analysis, thematic and real-time mapping for the optimum resource management, planning and data-driven decision-making. Integrating IKS with these technologies enables a more holistic spatial analysis of ecological, cultural, and historical layers which enhances participatory mapping and climate-resilient planning in tribal and rural regions in India (Srivastava & Ramachandran, 2018). Geoinformatics in India has remarkably researched and developed through different space mission by the Indian Space Research Organisation (ISRO), satellite image processing by the National Remote Sensing Centre (NRSC), and academic programs in IITs, NITs, and universities. The integration of cartographical inputs with geospatial technologies now significantly applied in agriculture, water resource management, urban planning, disaster management, and infrastructure development.

### 6.2 GNSS and India's Navigation Ecosystem

India's GNSS ecosystem (Kaplan, E. D. et al,2017). is led by the Indian Regional Navigation Satellite System (IRNSS;ISRO), also called NavIC (Navigation with Indian Constellation). NavIC aims to provide accurate position and timing data across the Indian subcontinent and up to 1,500 km beyond. GNSS is considered to be backbone to India's spatial infrastructure having increasing applications in navigation, agriculture, climatic hazards and disaster response, and military use and so on. Integrating IKS with GNSS provides highly positioning accuracy through bridging gaps in rural accessibility, indigenous navigation, and community mapping.

### 6.3 Convergence of IKS and Geoinformatics

**6.3.1. Local Environmental Intelligence:** The people residing interior of forest or hills region and the tribal communities traditionally navigated using natural markers, oral maps, star positions, and river systems (Rajan, 2011). These non-digital practices demonstrate a deep geospatial logic that can complement GNSS in regions lacking digital penetration

**6.3.2 Cultural Cartography:** Traditional Indian cartography included cosmographic diagrams and sacred spatial models such as the *Vastu Purusha Mandala* (Acharya, 1934). These models, while symbolic, obey spatial logic and can be integrated through digital cartographic technique and GIS platforms to support heritage conservation with planning and management.

**6.3.3 Participatory Mapping:** Empowering local communities to integrate their indigenous knowledge with GNSS-based tools promotes more inclusive spatial databases through vreating of mobile GIS apps (Varma & Rao, 2020) can be customized to record traditional routes, water bodies, and sacred sites.

**6.3.4 Early warning and weather forecast:** The fusion with traditional knowledge, ethos and belief on weather before any kind of climatic hazards, events or disaster can enhance satellite-based observation could have forecast early warning to people to the place of occurrence. For instance, tribal communities have long predicted floods or droughts through ecological indicators, which could be merged with remote sensing data for risk assessment (Srivastava & Ramachandran, 2018).

### 6.4 Participatory GIS (PGIS)

PGIS allows communities to input their own spatial knowledge into digital maps. PGIS empowers marginalized communities, especially in rural and tribal regions (Kumar, S., & Corbridge, S. 2002) to articulate spatial knowledge and assert rights. Tools like GPS, satellite imagery, and community mapping facilitate bottom-up planning. In India, this method has been effectively used in tribal areas for:

- Traditional agriculture practices with Land use planning
- Ecological interpretation and Biodiversity mapping
- Water resource management specially in draught prone areas

Community participation enhances the accuracy and local relevance through PGIS maps (Chambers et al. (2006, Rambaldi et al. 2009) for monitoring and transparency several government programs.

### 6.5 Ethno-Cartography

Ethno-cartography includes traditional ways of spatial representation that may not follow modern cartographic norms but are rich in contextual and cultural data (Sen,G. 2006). The ancient times river pilgrimage routes, mythological landscapes, or tribal boundary markers could be transforming under geospatial compatible environment using spatial storytelling and oral maps leading to preparation of ethno-cartographic digital map for planning and implementation. Such maps serve as instruments of identity, resistance, and heritage preservation. In India, ethno-cartographic studies highlight tribal spatial practices and sacred landscapes (Chaudhuri, 2007). These maps are vital tools in participatory GIS, land rights advocacy (Wood and Fels, 2008), and cultural preservation, blending modern geospatial technologies with Indigenous Knowledge Systems.

### 6.6 IKS and Modern Geodetic Understanding

The integration of Indigenous Knowledge Systems (IKS) with modern geodetic understanding reveals deep-rooted spatial knowledge in traditional practices. IKS includes celestial navigation, landmark-based measurement, and oral cartography, which align with principles of geodesy such as coordinate systems and reference points (Semali & Kincheloe, 1999). Structures such as the Sun Temple of Konark or Jantar Mantar observatories reflect astronomical-geodetic design. These cultural artifacts illustrate early attempts to measure angles, distances, and alignments using fixed celestial points (Balasubramaniam,R, 2012). Integrating GNSS with IKS enhances accuracy in rural cadastral mapping and resource planning under GIS environment and also overlay historical alignments, supporting archaeological geoinformatics and cultural route mapping with higher accuracy.

## 7. CASE STUDIES AND APPLICATIONS OF INGENIOUS KNOWLEDGE SYSTEM WITH GEOSPATIAL TECHNOLOGY IN INDIA

Fusion of IKS practices with geospatial technology contributes significant impact in several places in India which are as follows:

- The Zabo (also called Ruza) system is a traditional integrated farming-water-management practice by the Chakhesang Nagas in Phek, Nagaland (Singh et al. 2018).
- Bamboo drip irrigation in Meghalaya's Khasi–Jaintia hills transports spring water via gravity-fed bamboo channels, delivering 18–20 L/min upstream and reducing to 20–80 drops per plant to irrigate spices and vegetables—low-cost, eco-friendly, and enhancing water use efficiency by ~25–30 % (Sharma et al. 2021).
- Traditional water harvesting structures like *johads*, *baolis*, and *tanksin Rajasthan* Gujarat, Madhya Pradesh have been spatially documented using GIS and RS. Studies (e.g., by the Centre for Science and Environment, Govt of India) have integrated these systems with satellite imagery to revive water catchments and watershed management (Hussain,et al, 2014).
- Sacred Grove Mapping and Ecological Buffering in and around Western Ghats and Northeast India part for conservation of biodiversity hotspots through community-designated *sacred groves* which supports biodiversity mapping, land cover change detection, and community-based GIS (Bhagwat, S.A. 2012).
- Agricultural Land Zonation Using Panchang and Nakshatras in Pan-India (esp. Karnataka, Maharashtra) where farmers traditionally used lunar calendars and *nakshatra* systems to decide sowing, harvesting, and irrigation zones which can be linked to climate zonation, agro-ecological mapping, and crop calendar GIS applications (Gadgil, S. et al ,2000).
- Indigenous Navigation Using Stars and Landscape Markers in Coastal Odisha, Tamil Nadu, and tribal regions where people used star paths, wind patterns, and natural features instead of compasses or maps which is useful for ethno-cartography, cultural navigation layers and GNSS applications in low-connectivity areas.
- Construction of Check dam and renovation of gully head bund in Purulia District, West Bengal where in-depth geospatial maps have been prepared and other terrain based artificial water recharge structure suggested based on the indigenous knowledge of local people (Das, B, 2022).
- Traditional Monsoon Prediction Techniques in Tamil Nadu, Rajasthan, Coastal Karnataka where observation of bird behavior, cloud shapes, wind direction, and animal movements for predicting rain denotes people forecasting capabilities of weather and climatic parameter which can be mapped under GIS environment (Tripati, S, 2017).
- Indigenous Boundary Mapping by among Gond, Baiga, Santhal Communities (Chaudhuri, S. 2007) in Central India where people used to make mental map of land boundaries using trees, rocks, and oral memory rather than formal cadastral surveys considered as an aids in participatory GIS, forest land rights mapping, and customary tenure systems.
- Geomancy and Site Selection in Temple Architecture in Tamil Nadu, Odisha, Karnataka where indigenous knowledge been used of astronomical calculations and geomantic rules to choose sites applied in geodetic surveying, digital elevation modeling (DEM), and temple GIS layers (Shilpa, S et al 2024).
- Indigenous Soil and Terrain Classification in Telangana, Chhattisgarh, Bihar where local farmers use color, texture, and smell to classify soil for different crop types leading to prepare geospatial soil maps, land capability analysis, and agriculture map (Satyavathi et al, 2006).

## 8. RECOMMENDATIONS FOR FUTURE RESEARCH

8.1 Development of IKS-GIS frame: Creating of IKS-GIS frame allows for encoding indigenous concepts into GIS systems.

8.2 Narrative GIS: Use of community based storytelling and oral histories to accompany maps for context-rich spatial understanding.

8.3 Citizen Science Platforms: Enabling local communities to contribute spatial data using mobile GIS tools.

8.4 Culturally Sensitive Cartographic Design: Creating maps that reflect local symbology, languages, and meanings.

8.5 Open Access IKS Databases: Digital repositories that store validated indigenous spatial knowledge with community consent.

## CONCLUSION

Integrating Indian Knowledge Systems (IKS) with Geography and Geospatial Technology is essential for enriching contemporary research, infrastructural development with eco-ethnographical preservation. Fusion of traditional and indigenous practices over centuries, belief with ecological knowledge, agricultural practices, water management, and land use techniques with modern geospatial technology now practiced and implemented in different states of India. Incorporating IKS in geography and geospatial curricula promotes interdisciplinary learning**,** innovation, and deep knowledge for cultural diversity. Their integration leads to holistic solutions for environmental management, resource planning, and rural development, especially in India's diverse landscapes.

## References:


- Abhyankar, K. D. (2001). A Critical Evaluation of the Indian Planetary Theories. Indian Journal of History of Science, 36(3), 201–220.
- Acharya, P.K. (1934). Architecture of Manasara: Translated from Original Sanskrit,vol.4, https://archive.org/details/in.ernet.dli.2015.108320
- Agrawal, A. (1995). Dismantling the Divide Between Indigenous and Scientific Knowledge. Development and Change, 26(2), 413–439.
- Altekar, A. S. (1958). Education in Ancient India (2nd ed.). Varanasi: Nand Kishore & Bros.
- Amma, TAS 1979, Geometry in Ancient and Medieval India, Motilal Banarsidass Publishers Private Limited, Delhi.
- Balachandra Rao, S. (2000). Indian Astronomy: An Introduction. Bangalore: Indian Institute of Astronomical and Sanskrit Research.
- Balasubramaniam, R. (2012). "Engineering and Geodesy in Ancient and Medieval India." Current Science, 103(6).
- Bhagwat, S. A. (2012). Sacred groves and biodiversity conservation: A case study from the Western Ghats, India. In G. Pungetti, G. Oviedo, & D. Hooke (Eds.), Sacred species and sites: Advances in biocultural conservation (pp. 322–334)
- Bisht, R. S. (2000). Urban Planning at Dholavira: A Harappan City in the Rann of Kutch. In B. B. Lal & S. P. Gupta (Eds.), Indus Civilization: Sites in India (pp. 113–145). New Delhi: Indian Council of Historical Research & Books India.
- Chaudhuri, S. (2007). Tribal mapping in India: A case study of ethno-cartography. The International Journal of Cultural Property, 14(3), 299–317
- Chambers, R., Simmons, C., & Wuyts, M. (2006). Participatory GIS: Guide for Good Practice. International Institute for Environment and Development (IIED).
- Dani, Ahmad Hasan. (1960). Indian Pictorial Maps: A Study in Cartographic Art. Imago Mundi, 15(1), 37–44
- Das, Bhaskar (2022),A Geographical assessment of water resource pattern with emphasis upon surface water balance and flow equation in Purulia District, West Bengal, Journal of Emerging Technologies and Innovative Research, Vol,9 (8),pp.c304-c311

- Dasgupta, S. (2016). Indian Knowledge Systems: Foundations and Perspectives. Springer.
- Gadgil, S., & Rao, P. R. S. (2000). Farming strategies for a variable climate – A challenge. Current Science, 78(10), 1209–1210
- Hussain, J., Husain, I., & Arif, M. (2014). Water resources management: traditional technology and communities as part of the solution. In Proceedings of the International Association of Hydrological Sciences (Vol. 364, pp. 236–242).
- ICIMOD report (2020). Enhancing water use efficiency and applicability of traditional bamboo drip irrigation system. International Centre for Integrated Mountain Development. ( https://www.icimod.org/adaptation-solutions-portal/)
- Indian Institute of Remote Sensing. (2023). Overview of Remote Sensing & GIS Applications. Indian Space Research Organisation (ISRO), Department of Space, Government of India.
- Iyengar, R. N. (2007). Indian Calendric Astronomy: Its Geographical Context. Indian Journal of History of Science, 42(1), 15–32.
- Iyengar, R.N. (2004). "Indian Calendric Astronomy and Its Geodetic Framework" in Indian Journal of History of Science, Vol. 39(4)
- Joseph, G.G. (2000). The Crest of the Peacock: Non-European Roots of Mathematics. Princeton University Press.
- Kak, Subhash. (1994). The Astronomical Code of the Rigveda. Indian Journal of History of Science, 29(4), 395–416.
- Kaplan, E. D., & Hegarty, C. J. (Eds.). (2017). Understanding GPS/GNSS: Principles and Applications (3rd ed.)
- Kenoyer, Jonathan Mark. (1998). Ancient Cities of the Indus Valley Civilization. Oxford University Press and American Institute of Pakistan Studies. ISBN: 9780195779405.
- Kumar, S., & Corbridge, S. (2002). Programmed to Fail? Development Projects and the Politics of Participation. Journal of Development Studies, 39(2), 73–103.
- Mackay, EJH 1938, Further excavations at Mahaenjo-Daro: Being an official account of archaeological excavations at Mahenjo-daro carried out by the Government of India between the years 1927 and 1931, vol.1, Government of India Press, New Delhi.
- Mishra, V. S. (1972). Geographical Concepts in the Vedic Literature. Annals of the Bhandarkar Oriental Research Institute, 53(1/4), 131–141
- Mughal, Mohammad Rafique. (1997). Ancient Cholistan – Archaeology and Architecture. In F. Raymond Allchin & Bridget Allchin (Eds.), South Asian Archaeology 1995 (pp. 133–141). Oxford & IBH Publishing Co., New Delhi.
- Nitesh Tripathi, Bhattarya, S (2004)Integrating Indigenous Knowledge and GIS for Participatory Natural Resource Management: State-of-the-Practice,The Electronic Journal of Information Systems in Developing Countries 17(3):1-13
- Pingree, D. (1973). The Mesopotamian Origin of Early Indian Mathematical Astronomy. Journal for the History of Astronomy, 4(1), 1-12.
- Possehl, Gregory L. (2002). The Indus Civilization: A Contemporary Perspective. Rowman Altamira. ISBN: 978-0-7591-0190-4.
- Radhakrishnan, S., & Moore, C. A. (Eds.). (1957). A Sourcebook in Indian Philosophy. Princeton University Press.
- Rajan, K. (2011). "Situating Indigenous Knowledge in Archaeological Landscapes: A Case from South India" in Man and Environment, Vol. 36(2)
- Ray, Himanshu Prabha. (2011). The Archaeology of Seafaring in Ancient South Asia. Cambridge University Press. ISBN: 9780521011099.
- Tagare, G. V. (Trans.). (1978). The Vishnu Purana (Vol. 1). Delhi: Motilal Banarsidass.

- Pingree, David. (1981). Jyotiḥśāstra: Astral and Mathematical Literature. Wiesbaden: Otto Harrassowitz,http://www.worldcat.org/oclc/464378306
- Ranganathan, S.R. (2006). "Historical Development of Geospatial Concepts in Ancient India." Indian Journal of History of Science, 41(1).
- Sarma, K. V. (1994). Astronomy in India. In H. Selin (Ed.), Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures (pp. 24–32). Dordrecht: Kluwer Academic Publishers.
- Satyavathi, P. L. A., & Reddy, M. S. (2006). Characterization and classification of shallow, medium deep and deep red and black soils of northern Telangana zone in Andhra Pradesh. Journal of Tropical Agriculture, 41, 23–29.
- Semali, L., & Kincheloe, J.L. (1999). What is Indigenous Knowledge? Voices from the Academy. New York: Falmer Press.
- Sen, G. (2006). Indigenous Cartography and the Sanskrit Cosmographs. India International Centre Quarterly, 33(3/4), 112–123.
- Singh, R., Avasthe, R. K., Babu, S., Sharma, P., Vrushali, V., & Qureshi, M. A. A. (2018). Performance of sunflower (Helianthus annuus L.) hybrids under organic management conditions in mid hills of Sikkim. Indian Journal of Hill Farming, 31(2), 243–247.
- Sompur, S. S., & Udachan, V. (2024, September 28). Iconography and symbolism in Indian temple architecture. International Journal of Engineering Research & Technology (IJERT), 13(09)
- Srivastava, P. & Ramachandran, R. (2018). "Integrating Indigenous Knowledge in Modern Geospatial Technologies for Land and Navigation Management" in Journal of Geomatics, Vol. 12(1)
- Tripati, S. (2017). Seafaring archaeology of the East Coast of India and Southeast Asia during the Early Historical Period. Ancient Asia, 8, Article 7, pp. 1–22.
- Varma, R. & Rao, M. (2020). "Geo-Cultural Navigation: Revisiting Ancient Indian Knowledge Systems." Current Science, 119(6).
- Vatsyayan, Kapila (1997). "Traditional Indian Architecture: Cosmology, Space and Architecture" in India International Centre Quarterly, Vol. 24(2/3)
- Wood, D., & Fels, J. (2008). The Natures of Maps: Cartographic Constructions of the Natural World. University of Chicago Press