



XXII INQUA INDIA 2027

FIELD GUIDE

INMID - 05

QUATERNARY GEOLOGY, FLUVIAL GEOMORPHOLOGY AND
GEOHERITAGE OF GOMTI RIVER, LUCKNOW: A FIELD TRANSECT
THROUGH CHANDRIKA DEVI TEMPLE, THE LONI RIVER AND
DILKUSHA KOTHI OF CENTRAL GANGA PLAIN, INDIA

Manoj M.C., K G Misra and
Niteshkumar Khonde



बीरबल साहनी पुराविज्ञान संस्थान

Birbal Sahni Institute of Palaeosciences

विज्ञान एवं प्रौद्योगिकी विभाग के अंतर्गत स्वायत्त संस्थान, भारत सरकार

An autonomous institute under the Department of Science and Technology, Government of India





Published in 2026 by

XXII INQUA Congress, India
Birbal Sahni Institute of Palaeosciences (BSIP)
53, University Road
Lucknow – 226007, Uttar Pradesh
India

Website: www.inquaindia2027.in
Email: inqua.india@bsip.res.in

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Published under the overall supervision of:

Mahesh. G. Thakkar, Director, Birbal Sahni Institute of Palaeosciences, Lucknow
Binita Phartiyal, Organising Secretary, INQUA India 2027
Pradeep Srivastava, President, INQUA India 2027
Rahul Mohan, Vice-President, INQUA India 2027

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Compilation and editing: Field Trips Committee in collaboration with the INQUA 2027 Secretariat.

Design and Production:

XXII INQUA Congress 2027

Anupam Sharma, BSIP, Lucknow
Akhilesh K Yadava, BSIP, Lucknow
Rakesh Rao, Goa
Creative Team, Expression 360, New Delhi

INQUA INDIA 2027

Field Guide Book

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Quaternary Geology, Fluvial Geomorphology and
Geoheritage of Gomti River, Lucknow: A field
transect through Chandrika Devi Temple, the Loni River
and Dilkusha Kothi of central Ganga Plain, India

Principal Investigator

Dr. Manoj M.C.

Scientist E

BSIP Lucknow

Co-Principal Investigator

Dr. K G Misra

Scientist-E

BSIP Lucknow

Co-Principal Investigator

Dr. Niteshkumar Khonde

Scientist-D

BSIP Lucknow

Email of Contact Person

manoj_mc@bsip.res.in

Mobile No.

+91 8004931255



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Team Leaders



Dr. Manoj M.C.

Scientist E,
BSIP, Lucknow

Dr. Manoj M.C. is a Scientist-E at the Birbal Sahni Institute of Palaeosciences, India, specialising in palaeoclimatology, palaeoceanography, and sedimentary geochemistry. His research employs multiproxy approaches to reconstruct Quaternary environmental and climate variability across the Southern Ocean, Indian Ocean, Bengal Fan, and Indian continental regions. He has participated in several major international oceanographic and polar expeditions, including IODP Expedition 354 and Southern Ocean research cruises. His work addresses monsoon variability, ocean circulation, sediment provenance and cryosphere–climate interactions. He has supervised doctoral and postgraduate researchers and is actively associated with relevant national and international scientific societies.



Dr. K G Misra

Scientist E,
BSIP, Lucknow

Dr. K G Misra is Scientist-E at the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, and Honorary Associate Professor at the Academy of Scientific and Innovative Research (AcSIR). His research focuses on Dendrochronology and Himalayan Ecoclimatology, particularly tree-ring-based hydroclimate reconstructions, glacier–climate interactions, natural hazards, and extreme climatic events. He has led and contributed to several nationally funded research projects supported by DST-SERB and ANRF, New Delhi, and has published extensively in reputed national/international journals. Dr. Misra has supervised PhD and postdoctoral researchers and is actively involved in national and international scientific societies, including AGU, PSI, AOQR, and the Palaeobotanical Society.



Dr. Niteshkumar Khonde

Scientist D,
BSIP, Lucknow

Dr. Khonde is currently working as a Scientist-D at the Birbal Sahni Institute of Palaeosciences (BSIP) in Lucknow. His research fundamentally focuses on marginal marine environments, land-sea interactions, active tectonics, and landscape development. He mostly focuses on Quaternary basins of western India using geomorphological, sedimentological, geochemical studies and isotope tracer approach. Currently, most of his work lies in the coastal environments of western India. He has led multiple extramural research projects supported by the Department of Science and Technology, New Delhi, and participated in several international collaborative research projects. The results from these research engagements were published in several international and national research articles in reputable journals.

Abstract

The Central Ganga Plain, one of the largest Quaternary alluvial landscapes in the world, preserves an exceptional archive of fluvial processes, monsoon variability, neotectonic activity, palaeoenvironmental change, and long-term human occupation. As part of the Indo-Gangetic Foreland Basin, the region has evolved through the complex interplay of Himalayan tectonics, climatic oscillations, sediment supply, and river dynamics throughout the Quaternary, resulting in a diverse assemblage of geomorphic features including river terraces, palaeochannels, floodplain wetlands, oxbow lakes, pedogenically modified alluvial surfaces, and active fluvial systems (Singh, 1996, 2001; Parkash et al., 2000; Srivastava et al., 2003a, b). Despite decades of research on the Ganga Plain, relatively few field excursions have integrated Quaternary geology, fluvial geomorphology, palaeoenvironmental reconstruction, geoheritage, and cultural landscapes within a single transect. This mid-conference field excursion has been designed to introduce participants to the geological evolution of the Gomti River basin through three scientifically complementary localities in and around Lucknow, Uttar Pradesh: (i) Chandrika Devi, a floodplain palaeolake that preserves a high-resolution Holocene sedimentary archive documenting Indian Summer Monsoon variability and environmental change; (ii) Loni Nadi (Loni River), a groundwater-fed tributary of the Gomti River that exemplifies the geomorphic evolution of low-gradient alluvial rivers and provides insights into drainage development, sediment dynamics, and landscape evolution within the Central Ganga Plain; and (iii) Dilkusha Kothi, a prominent geoheritage and historical landscape situated on

the Gomti River terrace, illustrating the close relationship between geomorphology, urban development, cultural heritage, and historical architecture.

The excursion highlights how different geomorphic environments preserve complementary records of Quaternary environmental history. Participants will examine the evolution of floodplain lakes, river terraces, alluvial stratigraphy, active fluvial processes, and geomorphic surfaces, and discuss the influence of Late Quaternary climate change, Holocene monsoon variability, pedogenic processes, and subtle neotectonic adjustments on the evolution of the Gomti River basin. In addition to its geological significance, the excursion emphasizes the importance of geoheritage conservation by demonstrating how geological landscapes have influenced the historical growth of Lucknow and continue to support cultural monuments of national importance. By integrating Quaternary geology, sedimentology, geomorphology, palaeoenvironmental reconstruction, geoarchaeology, geoheritage, and cultural history within a compact and logistically accessible transect, this excursion provides participants with a comprehensive understanding of the dynamic evolution of the Central Ganga Plain and demonstrates the value of multidisciplinary approaches for investigating landscape evolution in one of the world's most significant alluvial basins.

Preamble

The Indo-Gangetic Foreland Basin (IGFB) is one of the world's largest active continental sedimentary basins, extending over approximately 2,500 km from the Indus Basin in Pakistan to the Bengal Basin in eastern India and Bangladesh. The basin originated through flexural subsidence of the Indian lithosphere in response to the ongoing Cenozoic collision between the Indian and Eurasian plates, followed by progressive uplift of the Himalayan orogenic belt. Since the Neogene, enormous quantities of sediments derived from the Higher Himalaya, Lesser Himalaya, Siwalik ranges, and Peninsular India have accumulated within this foreland depression, producing one of the thickest and most extensive Quaternary alluvial successions on Earth (Jordan, 1981; Molnar and Lyon-Caen, 1988; Parkash et al., 2000; Singh, 1996; Srivastava et al., 2003a).

The Quaternary evolution of the Ganga Plain has been governed by the combined influences of Himalayan tectonics, Indian Summer Monsoon (ISM) variability, river dynamics, sediment supply, and pedogenic processes. Repeated glacial-interglacial climatic oscillations altered precipitation

patterns, river discharge, sediment transport, vegetation cover, and weathering intensity, while continued tectonic adjustments within the foreland basin influenced river gradients, channel migration, floodplain aggradation, and terrace development (Singh, 1996, 2001; Srivastava et al., 2003a; Sinha et al., 2005). These interactions have produced a geomorphically diverse landscape comprising river terraces, abandoned channels, floodplain lakes, wetlands, natural levees, alluvial ridges, palaeosols, and calcrete-bearing uplands that collectively preserve a detailed archive of Late Quaternary environmental change.

Situated within the Ghaghara–Ganga interfluvium, Lucknow occupies a strategically important position in the Central Ganga Plain and is drained primarily by the Gomti River, a major groundwater-fed tributary of the Ganga. Unlike the snow-fed Himalayan rivers, the Gomti derives most of its perennial discharge from groundwater seepage supplemented by seasonal monsoon rainfall, resulting in a relatively stable hydrological regime that favours the preservation of floodplain lakes, abandoned meanders, terrace deposits, and other geomorphic features of Quaternary significance (Gupta et al., 2015). Consequently, the Lucknow region has become an important natural laboratory for investigating the interactions between climate, fluvial processes, pedogenesis, and landscape evolution.

Over the past several decades, geological and geomorphological investigations have considerably improved our understanding of the evolution of the Central Ganga Plain. Studies have documented the development of major geomorphic surfaces, the chronology of river incision and floodplain aggradation, the influence of neotectonic movements on drainage evolution, and the preservation of high-resolution palaeoenvironmental records within lakes and wetlands (Singh, 1996, 2001; Srivastava et al., 2003a, b; Gupta et al., 2015). Nevertheless, many aspects of the Quaternary evolution of the Gomti River basin remain insufficiently understood, particularly the responses of groundwater-fed tributaries to Holocene climatic variability, the relationship between floodplain evolution and human settlement, and the integration of geoheritage within Quaternary landscape studies.



This mid-conference field excursion has therefore been designed to provide participants with a multidisciplinary understanding of the Quaternary evolution of the Gomti River basin through three scientifically complementary localities. The excursion begins at Chandrika Devi, where a Holocene floodplain palaeolake preserves a multiproxy archive of monsoon variability, vegetation history, and

environmental change. The second stop at Loni River illustrates the geomorphic evolution of a low gradient tributary system and demonstrates the role of fluvial processes in shaping the interfluvial landscape of the Central Ganga Plain. The excursion concludes at Dilkusha Kothi, an important geoheritage and historical landscape overlooking the Gomti River, where discussions focus on the relationship between geomorphology, cultural heritage, historical land use, and urban development.

Rather than considering these localities as isolated sites, the excursion emphasizes their collective significance as interconnected components of a dynamic Quaternary landscape. By integrating evidence from sedimentology, geomorphology, palaeoenvironmental reconstruction, Quaternary geology, geoheritage, and cultural history, participants will gain a comprehensive understanding of the processes that have shaped the Central Ganga Plain over the Late Quaternary and continue to influence its landscapes today. The excursion further highlights the importance of conserving geological and geomorphological heritage within rapidly urbanizing regions, demonstrating that the scientific, educational, ecological, and cultural values of these landscapes are intrinsically linked.



Research Problem: Global Context and Local Significance of the Transect

Global Perspective

Large alluvial river systems are among the most valuable terrestrial archives for reconstructing Quaternary environmental change because they continuously respond to variations in climate, tectonics, sediment supply, vegetation, and human activities. Rivers integrate signals from their entire drainage basin, preserving evidence of hydrological fluctuations, landscape evolution, and ecological change within their sedimentary successions. Consequently, floodplains, river terraces, abandoned channels, palaeolakes, wetlands, and associated alluvial deposits have become fundamental archives for understanding the interactions between Earth's surface processes and climate over Quaternary timescales (Blum and Törnqvist, 2000; Bridgland and Westaway, 2008).

Across the world, major river basins such as the Mississippi, Nile, Amazon, Danube, Rhine, Yangtze, Yellow River, Mekong, Indus, and Ganga have been extensively investigated to understand how climatic oscillations, tectonic activity, and river dynamics have controlled

landscape evolution. These studies demonstrate that large alluvial plains are not static depositional environments but dynamic systems that undergo repeated episodes of aggradation, incision, avulsion, floodplain construction, channel migration, and pedogenesis in response to changing environmental conditions (Macklin and

Lewin, 2003; Blum and Aslan, 2006). Understanding these responses has become increasingly important because they provide long-term perspectives on river behaviour under changing climatic regimes and offer valuable analogues for predicting future environmental change.

Among these systems, the Indo-Gangetic Foreland Basin occupies a unique position because it receives enormous sediment flux from one of the most rapidly eroding mountain belts on Earth while simultaneously responding to one of the world's strongest monsoon systems. The interaction between Himalayan tectonics and the Indian Summer Monsoon has produced an exceptionally complex Quaternary landscape that preserves evidence of climatic fluctuations, neotectonic movements, sedimentary processes, and human occupation extending over hundreds of thousands of years (Singh, 1996; Parkash et al., 2000; Srivastava et al., 2003a).

Current Challenges in Quaternary Research

Despite decades of multidisciplinary investigations, several important questions concerning the evolution of large alluvial plains remain unresolved. One of the foremost challenges is distinguishing between climatic and tectonic controls on fluvial landscape evolution. River terraces, palaeochannels, floodplain deposits, and lacustrine sediments often record the combined effects of changing precipitation, sediment supply, base-level fluctuations, and crustal deformation, making it difficult to identify the dominant forcing mechanism responsible for observed geomorphic changes (Bridgland and Westaway, 2008).

Another major challenge is understanding how groundwater-fed alluvial rivers respond to climatic variability. Most Quaternary studies have focused on large snow-fed rivers because they preserve extensive sedimentary records and are easier to investigate at regional scales. In contrast, comparatively little attention has been paid to groundwater-fed rivers such as the Gomti, despite their importance for understanding hydrological resilience, floodplain evolution, and environmental responses within low-gradient alluvial settings.

Similarly, although numerous high-resolution palaeoclimate records have been generated from marine sediment cores, Himalayan lakes, speleothems, and glacier archives, comparatively fewer continuous terrestrial records are available from the Central Ganga Plain itself. This represents a significant knowledge gap because environmental changes reconstructed from distant archives cannot always be directly extrapolated to the densely populated alluvial plains where human

societies have flourished for millennia. Continuous sedimentary archives preserved within floodplain lakes, therefore, provide an important opportunity to reconstruct local environmental responses to Holocene monsoon variability.



In recent years, geoheritage has emerged as another important component of Earth science research. Geological landscapes are increasingly recognised not only as scientific archives but also as cultural assets that support biodiversity, tourism, education, and sustainable development. However, geoheritage studies in the Indo-Gangetic Plain remain relatively limited compared with mountainous regions, despite the abundance of geomorphological features and historically significant landscapes preserved within the alluvial plains.

Why the Gomti River Basin?

Although the Ganga and its major Himalayan tributaries have received considerable scientific attention, the Gomti River basin remains comparatively underrepresented in international Quaternary literature. This is noteworthy because the Gomti differs fundamentally from most Himalayan rivers. Originating within the alluvial plains rather than the Himalaya, the river is sustained primarily by groundwater discharge and seasonal monsoon rainfall, making it particularly sensitive to regional hydroclimatic variability rather than glacial meltwater inputs (Gupta et al., 2015).

The geomorphic setting of the Gomti basin has favoured the preservation of a wide range of Quaternary archives, including floodplain lakes, abandoned channels, river terraces, pedogenically modified alluvial deposits, and stable interfluvial surfaces. Together, these landforms preserve complementary records of climatic fluctuations, fluvial processes, and landscape evolution that are ideally suited for multidisciplinary investigations. Furthermore, the basin has supported continuous human occupation from prehistoric times to the present, providing exceptional opportunities to examine long-term interactions between environmental change and cultural development.

Uniqueness of the Field Transect

The present field transect has been specifically designed to integrate three distinct yet complementary components of the Quaternary landscape within a single, logistically accessible excursion. Unlike conventional field trips that focus exclusively on sedimentology or geomorphology, this excursion combines palaeoenvironmental archives, active geomorphic processes, and geoheritage within a unified scientific framework.

The Chandrika Devi locality represents the palaeoenvironmental component of the transect. The Holocene floodplain lake preserves a high-resolution sedimentary archive that records changes in monsoon intensity, vegetation, hydrology, and landscape evolution. It demonstrates how lacustrine deposits can be used to reconstruct environmental changes that are directly relevant to the densely populated alluvial plains of northern India.

The Loni River locality represents the geomorphic component of the transect. The river provides an excellent example of a low-gradient groundwater-fed tributary evolving within a mature alluvial landscape. Observations at this site allow participants to examine channel morphology, point-bar development, floodplain sedimentation, terrace evolution, and the geomorphic response of secondary drainage systems to Quaternary environmental change.

The Dilkusha Kothi locality represents the geoheritage component of the transect. Rather than focusing on sedimentary exposures, this stop illustrates how Quaternary landscapes have influenced human settlement, architectural planning, and historical development. Constructed on a stable terrace overlooking the Gomti River, Dilkusha Kothi exemplifies the intimate relationship between geomorphology and cultural heritage. The locality also provides an opportunity to discuss the broader concepts of geological heritage, landscape conservation, and the sustainable management of urban geoheritage sites.

Collectively, these three localities illustrate the complete continuum from environmental archive to geomorphic process to cultural landscape. Such an integrated approach is rarely available within a single excursion and represents one of the principal strengths of this field transect.

Broader Scientific Significance

Beyond its regional importance, the field transect contributes to several internationally recognised themes in Quaternary science. These include the reconstruction of Holocene monsoon variability, the evolution of low-gradient alluvial rivers, the response of floodplain landscapes to climatic and tectonic forcing, the application of multiproxy palaeoenvironmental techniques, and the integration of geoheritage within Earth science education.

The excursion also demonstrates the importance of interdisciplinary research. Geological observations are linked with geomorphology, palaeoecology, archaeology, cultural history, and heritage conservation to provide a comprehensive understanding of landscape evolution. This multidisciplinary perspective reflects the growing emphasis within the International Union for Quaternary Research (INQUA) on integrating natural and cultural archives to address questions concerning environmental change, human adaptation, and sustainable landscape management.



Regional Geology

Geological Evolution of the Indo-Gangetic Foreland Basin

The Indo-Gangetic Foreland Basin (IGFB) is one of the world's largest active foreland basins, extending from the Indus Basin in Pakistan through northern India to the Bengal Basin in Bangladesh (Fig. 1). The basin developed during the Cenozoic as a consequence of the collision between the Indian and Eurasian plates, which initiated the uplift of the Himalayan orogenic belt and caused flexural subsidence of the northern margin of the Indian Plate (Jordan, 1981; Molnar and Lyon-Caen, 1988). This tectonic loading created a broad foredeep that has been continuously infilled with sediments derived from the rapidly eroding Himalaya and, to a lesser extent, from the Peninsular Indian craton (Parkash et al., 2000).

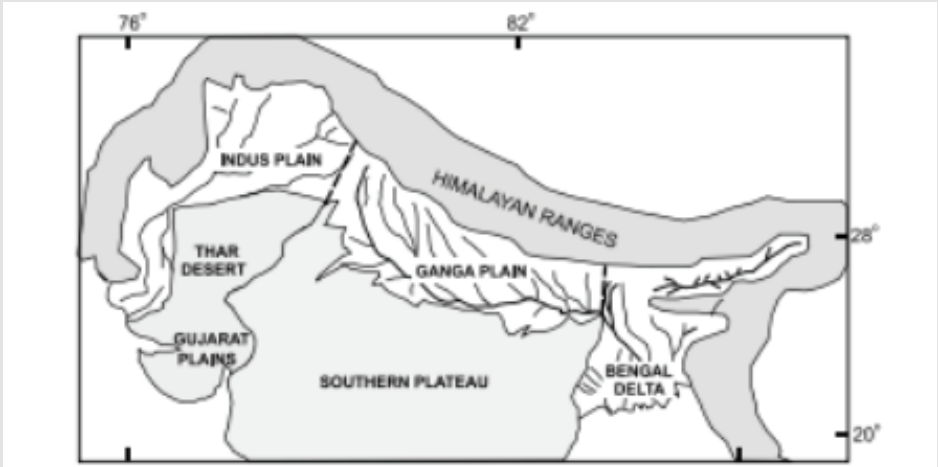


Fig. 1. Indo-Gangetic plain foreland system where Ganga Plain occupies the central position (after Srivastava et al., 2003)

Since the Late Miocene, enormous quantities of siliciclastic sediments have accumulated within the basin, producing an alluvial succession that locally exceeds several kilometres in thickness. Throughout the Quaternary, repeated fluctuations in monsoon intensity, glacial-interglacial climatic cycles, variations in sediment supply, and continued tectonic adjustments collectively governed sedimentation, river migration, floodplain aggradation, and terrace formation (Singh, 1996; Srivastava et al., 2003a). Consequently, the present landscape of the Ganga Plain represents the cumulative outcome of long-term interactions among tectonic, climatic, hydrological, and geomorphic processes.

Geological Setting of the Central Ganga Plain

The Central Ganga Plain occupies the middle segment of the Indo-Gangetic Foreland Basin and extends across much of Uttar Pradesh. It is bounded by the Himalayan foothills to the north and the Bundelkhand-Vindhyan craton to the south. The region is characterised by an extremely low regional gradient (approximately 10–20 cm km⁻¹), extensive floodplains, broad interfluvies, wetlands, and low energy meandering river systems (Singh, 1996, 2001).

The plain is composed almost entirely of unconsolidated Quaternary sediments deposited by the Ganga and its numerous tributaries. These sediments consist predominantly of gravel, sand, silt, and clay, arranged in vertically stacked fluvial sequences that represent repeated episodes of channel migration, overbank flooding, floodplain aggradation, pedogenesis, and local erosion. Because of continuous sediment recycling and lateral migration of river channels, lithostratigraphic continuity is generally poor, making geomorphological relationships particularly important for reconstructing Quaternary landscape evolution (Srivastava et al., 2003a).

The Lucknow region lies within the Ghaghara–Ganga interfluvium, where the landscape is dominated by the Gomti River and its tributaries, including the Loni River, Sai, Kathna, Kalyani, and Reth rivers. The combination of groundwater-fed drainage, low channel gradients, and relatively stable hydrological conditions has favoured the preservation of abandoned channels, floodplain lakes, and terrace deposits that constitute important Quaternary archives (Gupta et al., 2015).

Structural Framework and Neotectonics

Although the Ganga Plain is often regarded as a tectonically quiescent sedimentary basin, numerous geological and geomorphological investigations have demonstrated that it continues to respond to stresses generated by Himalayan convergence. Reactivation of basement faults, differential subsidence, gentle warping of the alluvial surface, and localized uplift have significantly influenced the evolution of drainage and geomorphic development throughout the Late Quaternary (Singh and Rastogi, 1973; Singh et al., 1996; Parkash et al., 2000).

Several major basement faults, including the Lucknow Fault, Kanpur Fault, Moradabad Fault, and Patna Fault, have been recognised beneath the alluvial cover of the Ganga Plain through geophysical investigations (Sastri et al., 1971; Rao, 1973). Although these structures are rarely exposed at the surface, their influence is reflected in drainage alignments, asymmetrical river valleys, displaced terraces, linear channel segments, differential floodplain elevations, and localized river incision.

Within the Lucknow region, the Gomti River exhibits subtle geomorphic anomalies, including distorted meanders, asymmetric valley development, and localized terrace preservation, suggesting that neotectonic adjustments have influenced channel evolution in conjunction with climatic forcing (Singh, 1996; Gupta et al., 2015). However, compared with the major Himalayan rivers, the geomorphic expression of tectonic activity is relatively subdued, making detailed sedimentological and geomorphological investigations essential for identifying neotectonic signatures.

Stratigraphy and Geomorphic Surfaces

The Quaternary succession of the Central Ganga Plain has traditionally been divided into two broad morphostratigraphic units: the Older Alluvium (Bangar) and the Newer Alluvium (Khadar) (Oldham, 1917; Pascoe, 1919; Mukherji, 1963). While this terminology remains widely used, recent geomorphological studies demonstrate that these units encompass multiple depositional episodes and are best interpreted within the framework of geomorphic surfaces rather than as discrete lithostratigraphic formations (Singh, 1996; Srivastava et al., 2003a).

Older Alluvium (Bangar)

The Older Alluvium forms elevated interfluvial surfaces and river terraces standing approximately 10–20 m above the modern floodplain. It is composed predominantly of oxidized fine- to medium-grained sands, silts, and clays with well-developed pedogenic carbonate (kankar) horizons. The surface preserves abundant palaeochannels, shallow

depressions, natural levees, and abandoned drainage systems, indicating prolonged periods of landscape stability and pedogenesis.

Newer Alluvium (Khadar)

The Newer Alluvium occupies the modern floodplain and active river valleys. It consists of unconsolidated sand, silt, clay, and organic-rich floodplain deposits that are continuously reworked by seasonal flooding and channel migration. These sediments represent the youngest phase of alluvial deposition within the basin.

Geomorphic Surfaces

Three principal geomorphic surfaces are recognised within the Lucknow region (Fig. 2):

- **T₂ (Upland Terrace Surface):** Corresponds broadly to the Bangar and represents the oldest preserved alluvial landscape. It is characterised by calcrete horizons, palaeosols, abandoned channels, and stable interfluvies.
- **T₁ (River Valley Terrace):** Represents abandoned floodplain surfaces situated above the modern river but below the upland terrace. This surface commonly preserves meander scars, oxbow lakes, scroll bars, and floodplain deposits.
- **T₀ (Active Floodplain):** Represents the modern river channel and associated floodplain, where sedimentation, erosion, and channel migration continue under present-day hydrological conditions (Singh, 1996; Srivastava et al., 2003a).

These geomorphic surfaces provide the framework for interpreting the three excursion stops, each illustrating a different component of the Quaternary landscape.

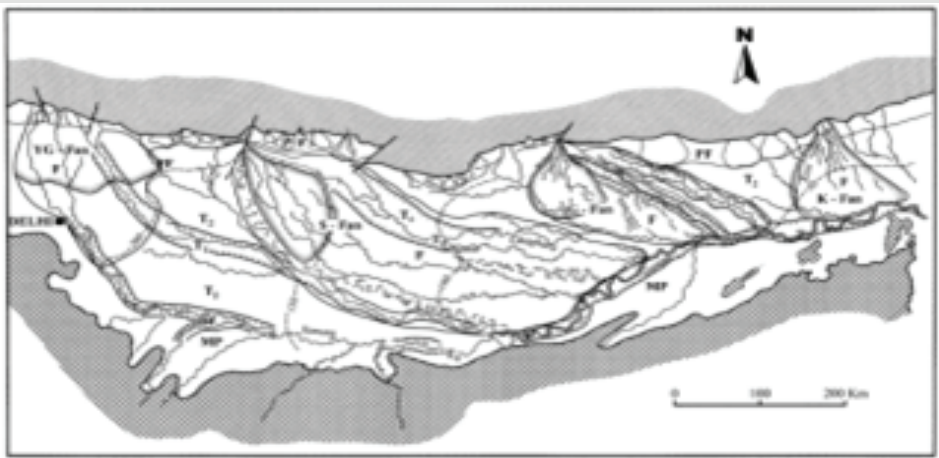


Fig. 2. Regional geomorphic surfaces of the Ganga Plain. T2 - Upland Terrace Surface, MP - Marginal Plain Upland Surface, F - Megafan Surface (YG-fan - Yamuna-Ganga Megafan, S-fan - Sarda Megafan, G-fan - Gandak Megafan, K-fan - Kosi Megafan), T1 - River Valley Terrace Surface, PF - Piedmont Fan Surface, T0 - Active Flood Plain Surface. (after Srivastava et al., 2003)

Quaternary Geology and Palaeoenvironmental Evolution

The Quaternary evolution of the Central Ganga Plain reflects repeated interactions between climatic variability and fluvial processes. During humid phases associated with intensified Indian Summer Monsoon circulation, increased river discharge promoted floodplain aggradation, channel migration, and wetland expansion. Conversely, periods of weakened monsoon activity favoured reduced discharge, floodplain stability, pedogenesis, calcrete formation, and the preservation of terrace surfaces (Srivastava et al., 2003a).

Luminescence dating indicates that many of the major geomorphic surfaces of the Ganga Plain developed through multiple phases of deposition and incision rather than single regional events. Differential erosion, local tectonic movements, and repeated channel migration have produced the complex mosaic of terraces, palaeochannels, and floodplain lakes observed today (Srivastava et al., 2003a, b).

Within the Lucknow region, numerous floodplain lakes and abandoned channels preserve continuous Holocene sedimentary records containing pollen, phytoliths, diatoms, organic matter, stable isotopes, and geochemical proxies. These archives provide valuable information regarding vegetation dynamics, hydrological variability, monsoon intensity, fire history, and anthropogenic activity throughout the Holocene.

Palaeontology

Although the Central Ganga Plain is not renowned for abundant macrofossil assemblages, its Quaternary sediments contain diverse palaeobiological remains that are important for palaeoenvironmental reconstruction. Freshwater molluscs, ostracods, pollen, phytoliths, diatoms, plant macro-remains, charcoal fragments, and microbial remains preserved within lacustrine and floodplain deposits provide critical information regarding past vegetation, hydrology, aquatic ecosystems, and climatic conditions.

Large vertebrate fossils, including remains of elephants, bovids, cervids, rhinoceroses, and other Quaternary mammals, have been reported from various parts of the Ganga Plain, reflecting the rich faunal diversity that occupied the alluvial landscapes during the Pleistocene. Although such fossil occurrences are uncommon around Lucknow, micropalaeontological and palynological records from nearby wetlands and lakes have significantly contributed to understanding Holocene environmental evolution.

Geological Significance of the Gomti River Basin

The Gomti River basin occupies a unique position within the Central Ganga Plain because it represents a groundwater-fed alluvial river system that has evolved independently of direct Himalayan meltwater inputs. Its low-gradient drainage network, abundant wetlands, stable floodplain lakes, and well-preserved geomorphic surfaces provide exceptional opportunities for investigating Quaternary landscape evolution at local and regional scales.

The three localities selected for this excursion illustrate complementary aspects of this evolution. Chandrika Devi documents Holocene environmental change preserved within lacustrine sediments; Loni River demonstrates the geomorphic evolution of a secondary drainage system within the interfluvial landscape; and Dilkusha Kothi highlights the



geoheritage significance of Quaternary landforms by illustrating how stable river terraces have influenced historical settlement, architecture, and cultural development in Lucknow.



Flora, Fauna and Climatic Conditions during the Field

Physiographic and Ecological Setting

The excursion area is situated within the Central Ganga Plain of northern India, a vast alluvial landscape characterized by fertile floodplains, groundwater-fed rivers, floodplain wetlands, agricultural fields, and scattered riparian forests. Owing to the fertile alluvial soils and favourable climatic conditions, much of the natural vegetation has been replaced by agriculture and urban development. Nevertheless, remnants of native riparian vegetation, floodplain grasslands, wetlands, and sacred groves remain preserved along the Gomti River and its tributaries, particularly around Chandrika Devi and the Loni River.

The Gomti River corridor functions as an important ecological corridor supporting diverse terrestrial and aquatic ecosystems. Seasonal flooding, groundwater recharge, and the presence of floodplain wetlands create a variety of habitats that sustain rich biodiversity despite increasing urbanization around Lucknow.

Climate

The Lucknow region experiences a humid subtropical climate (Köppen: Cwa) characterized by three distinct seasons: summer (March–June), southwest monsoon (late June–September), and winter (November–February). The southwest monsoon contributes 80–85% of the annual rainfall, making it the dominant driver of river discharge, floodplain inundation, groundwater recharge, and sediment transport within the Gomti basin. The average annual rainfall ranges between 900 and 1,000 mm, although interannual variability in monsoon intensity can be substantial. Mean daily temperatures exceed 40°C during May and June, whereas winter temperatures commonly range between 8 and 22°C. Relative humidity increases significantly during the monsoon season, often exceeding 80%.

Vegetation

The natural vegetation of the Lucknow region belongs to the Tropical Dry Deciduous Forest type, although extensive agricultural development has considerably modified the original landscape. Present-day vegetation comprises a mosaic of cultivated land, riparian woodland, scrub vegetation, planted avenues, urban parks, and sacred groves. Common tree species encountered during the excursion include: Neem (*Azadirachta indica*), Peepal (*Ficus religiosa*), Banyan (*Ficus benghalensis*), Arjun (*Terminalia arjuna*), Shisham (*Dalbergia sissoo*), Jamun (*Syzygium cumini*), Mango (*Mangifera indica*), Babool (*Vachellia nilotica*), and Eucalyptus (*Eucalyptus* spp.; planted). Riparian vegetation along the Gomti River and Loni





River is dominated by grasses, sedges, reeds, shrubs, and scattered trees adapted to periodic flooding. The Chandrika Devi locality, owing to its religious importance, also preserves patches of mature sacred vegetation that contribute to local biodiversity and microclimatic regulation.

Aquatic Vegetation

Floodplain wetlands and slow-moving reaches of the Gomti River support a variety of aquatic macrophytes. Frequently observed species include: Water hyacinth (*Eichhornia crassipes*) (invasive), Lotus (*Nelumbo nucifera*), Water lily (*Nymphaea* spp.), Hydrilla (*Hydrilla verticillata*), Duckweed (*Lemna* spp.), Typha (*Typha angustifolia*), and Phragmites spp. These aquatic communities play an important role in nutrient cycling, sediment trapping, and providing habitat for aquatic fauna, although invasive species such as water hyacinth locally threaten wetland ecology.

Fauna

The Gomti River basin supports a diverse assemblage of terrestrial and aquatic fauna typical of the Central Ganga Plain.

Mammals

Commonly observed mammals include: Golden Jackal (*Canis aureus*), Indian Grey Mongoose (*Herpestes edwardsii*), Indian Hare (*Lepus nigricollis*), Five-striped Palm Squirrel (*Funambulus pennantii*), Rhesus Macaque (*Macaca mulatta*), Nilgai (*Boselaphus tragocamelus*) (occasionally in peri-urban and agricultural areas)

Birds

The Gomti floodplain and associated wetlands are important habitats for both resident and migratory birds. Representative species include: Indian Pond Heron, Cattle Egret, Little Egret, Grey Heron, White-throated Kingfisher, Pied Kingfisher, Black Drongo, Indian Roller, Red-wattled Lapwing, Common Myna, Rose-ringed Parakeet, Black Kite, Shikra, Purple Swamphen, Indian Cormorant, during winter, several migratory waterfowl may also occur in nearby wetlands.

Reptiles and Amphibians

Common reptiles include: Indian Flapshell Turtle, Garden Lizard, Rat Snake, Checkered Keelback, Common Skink. Common amphibians include: Indian Bullfrog, Skittering Frog, Common Toad

Fish

The Gomti River supports numerous freshwater fishes, including: Rohu (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus mrigala*), Common Carp, Snakeheads (*Channa* spp.), Catfishes (*Mystus*, *Wallago*). These species contribute significantly to local fisheries and the ecological functioning of the river.

Ecological Importance of the Excursion Sites

Each excursion locality represents a distinct ecological setting.

Chandrika Devi supports wetland vegetation and bird habitats while preserving a valuable palaeoenvironmental archive.

Loni River illustrates the ecological role of groundwater-fed tributaries in maintaining riparian biodiversity and hydrological connectivity within the Gomti basin.

Dilkusha Kothi, despite its urban setting, overlooks an important riparian landscape where the Gomti River, floodplain vegetation, and historical gardens collectively form a culturally and ecologically significant landscape. The site provides an opportunity to discuss how urban expansion has altered riverine ecosystems and why conserving green corridors along the Gomti River is essential for maintaining biodiversity and ecosystem services.



Literature Review

The Central Ganga Plain has been the focus of multidisciplinary investigations for more than a century owing to its geological, geomorphological, palaeoenvironmental, archaeological, and cultural significance. Early studies were primarily concerned with mapping the alluvial stratigraphy and geomorphic divisions of the Indo-Gangetic Plain, whereas more recent investigations have employed sedimentology, geochronology, geochemistry, palynology, stable-isotope geochemistry, remote sensing, and GIS to reconstruct the Quaternary environmental evolution. These studies have considerably advanced our understanding of river dynamics, monsoon variability, neotectonic activity, and landscape evolution; however, several important gaps remain, particularly concerning groundwater-fed river systems such as the Gomti River and its tributaries.

Regional Geology and Geomorphology

Systematic investigations of the Ganga Plain began during the Geological Survey of India mapping programmes in the early twentieth century, when the distinction between the Older Alluvium (Bangar) and the Newer Alluvium (Khadar) was first recognised (Oldham, 1917; Pascoe, 1919). Subsequent work by Mukherji (1963) and Singh (1996, 2001) demonstrated that the geomorphology of the Central Ganga Plain reflects repeated phases of river migration, floodplain aggradation, pedogenesis, and terrace development rather than simple lithostratigraphic subdivision.

A major advance in understanding the Quaternary evolution of the Lucknow region came through the work of Srivastava et al. (2003a, 2003b), who combined geomorphological mapping, sedimentological observations, and luminescence chronology to establish the evolution of river terraces, palaeochannels, and floodplain surfaces. Their studies showed that the present landscape developed through multiple depositional and erosional episodes during the Late Pleistocene and Holocene and highlighted the influence of both climatic



variability and neotectonic adjustments on drainage evolution. These investigations remain the principal geological framework for interpreting Quaternary landscape evolution in the Lucknow region.

Quaternary Climate and Palaeoenvironmental Studies

The Quaternary history of the Central Ganga Plain has increasingly been reconstructed using multiproxy approaches involving pollen, phytoliths, diatoms, sedimentology, stable isotopes, organic geochemistry, and geochronology. Such studies have demonstrated that the region experienced significant hydrological and ecological changes in response to variations in the Indian Summer Monsoon throughout the Holocene. Most high-resolution palaeoclimate records from the Indian subcontinent have been derived from marine sediment cores, speleothems, Himalayan lakes, and peatlands. In comparison, relatively few continuous terrestrial records are available from the alluvial plains themselves. This limitation has hindered direct correlation between regional climatic events and local environmental responses within the densely populated Ganga Plain. Recent investigations of floodplain lakes and wetlands in the Lucknow region have begun to address this gap by generating high-resolution sedimentary records that document changes in vegetation, hydrology, fire activity, and anthropogenic influence during the Holocene. These archives demonstrate that floodplain lakes represent valuable repositories of palaeoenvironmental information and complement marine and Himalayan climate records.

Evolution of the Gomti River Basin

Compared with the Ganga and its major Himalayan tributaries, relatively few investigations have focused specifically on the geomorphic evolution of the Gomti River basin. Existing studies have primarily examined drainage morphometry, river migration, floodplain development, groundwater– surface water interactions, and urban environmental issues. Gupta et al. (2015) provided one of the most comprehensive geomorphological assessments of the Loni River basin, demonstrating that drainage characteristics are controlled by lithology, topography, groundwater discharge, and subtle structural influences. Their work highlighted the importance of secondary drainage systems for understanding landscape evolution within the Central Ganga Plain and established the Loni River as an excellent natural laboratory for investigating low-gradient fluvial processes. Despite these advances, chronological control for geomorphic evolution within the Gomti basin remains limited, and the relationships between tributary evolution, floodplain development, and regional climatic variability remain incompletely understood.

Chandrika Devi Palaeolake

The Chandrika Devi palaeolake represents one of the few Holocene lacustrine archives available from the Lucknow region. Previous investigations have demonstrated that the sediment sequence preserves a continuous record of environmental change, including fluctuations in lake level, vegetation dynamics, sediment supply, and human activity. Multiproxy studies incorporating sedimentology, geochemistry, pollen, phytoliths, and chronological analyses indicate that the lake evolved in response to variations in Indian Summer Monsoon intensity and changes in the hydrological behaviour of the adjacent Gomti floodplain. These investigations have shown that floodplain lakes constitute important

archives for reconstructing regional palaeoenvironmental history and provide valuable terrestrial records that complement marine and Himalayan palaeoclimate archives. Nevertheless, further work integrating higher-resolution chronological data, biomarker geochemistry, stable-isotope analyses, and quantitative palaeoecological reconstructions is required to better understand the mechanisms driving Holocene environmental change in the Central Ganga Plain.

Loni River and Interfluvial Landscape Evolution

Research on the Loni River has primarily focused on drainage morphometry, watershed characteristics, sediment transport, and geomorphic evolution. These studies demonstrate that the river retains many characteristic features of low-gradient alluvial drainage systems, including meandering channels, point bars, floodplain deposits, and abandoned channels.

The interfluvial landscape traversed by the Loni River provides valuable evidence for the long-term evolution of secondary drainage systems within the Gomti basin. However, detailed sedimentological investigations, high-resolution chronologies, palaeoflood reconstructions, and geochemical characterisations remain relatively scarce. Consequently, the locality presents significant opportunities for future multidisciplinary research integrating geomorphology, sedimentology, and Quaternary palaeoenvironmental reconstruction.

Geoheritage and Cultural Landscape Studies

In recent decades, geoheritage has emerged as an important component of Earth science, emphasizing the conservation of geological features possessing scientific, educational, aesthetic, historical, and cultural value. While considerable attention has been devoted to mountain geoheritage in the Himalaya and Peninsular India, comparatively little emphasis has been placed on the geoheritage potential of alluvial landscapes.

Dilkusha Kothi provides an excellent example of how geological landscapes underpin cultural heritage. Situated on a stable terrace overlooking the Gomti River, the site demonstrates the influence of geomorphology on historical settlement, landscape planning, and architectural development. Although the monument itself has been extensively documented from historical and archaeological perspectives, its geological and geomorphological context has received comparatively limited attention. Integrating geoheritage principles with the historical significance of Dilkusha Kothi offers an opportunity to broaden public appreciation of the links between landscape evolution and cultural history.

Outstanding Research Issues

Despite substantial progress in understanding the Quaternary evolution of the Central Ganga Plain, several important research questions remain unresolved:

1. **Chronology of geomorphic surfaces:** Improved chronological control is required to establish the timing of terrace formation, floodplain aggradation, and channel migration within the Gomti basin.

2. **Groundwater-fed river dynamics:** The responses of groundwater-fed tributaries such as the Gomti and Loni River to Holocene climatic variability remain poorly constrained compared with Himalayan rivers.
3. **High-resolution palaeoenvironmental reconstruction:** Additional multiproxy studies integrating sedimentology, palynology, geochemistry, biomarkers, and stable isotopes are needed to refine Holocene environmental reconstructions from floodplain lakes.
4. **Climate-tectonic interactions:** The relative influence of monsoon variability and neotectonic adjustments on drainage evolution requires further investigation using integrated geomorphic and chronological approaches.
5. **Geoheritage assessment:** Comprehensive inventories and conservation strategies for Quaternary geoheritage sites within the Central Ganga Plain are largely lacking and should be developed to support scientific research, education, and sustainable geotourism.
6. **Human-environment interactions:** Greater integration of geological, archaeological, and historical datasets is required to understand how Quaternary landscape evolution has influenced patterns of human settlement and cultural development in the Lucknow region.

Relevance of the Present Field Excursion

The present excursion has been designed to address several of the above knowledge gaps by bringing together three complementary sites that collectively illustrate Holocene palaeoenvironmental evolution, fluvial geomorphology, and geoheritage within the Gomti River basin. Chandrika Devi provides a window into Holocene environmental reconstruction, Loni River demonstrates active geomorphic processes and interfluvial evolution, and Dilkusha Kothi highlights the broader societal significance of Quaternary landscapes through their influence on cultural heritage and urban history. By integrating these themes within a single field transect, the excursion offers participants a multidisciplinary perspective on the evolution of the Central Ganga Plain and identifies priorities for future research.



Field Transect

The mid-conference field excursion traverses a representative segment of the Gomti River basin within the Central Ganga Plain of Uttar Pradesh (Fig. 3). The selected transect has been designed to introduce participants to the geological evolution of the Lucknow region through three scientifically complementary field stops that collectively illustrate the interplay between Quaternary environmental change, fluvial geomorphology, and geoheritage.

The excursion extends from the northern outskirts of Lucknow to the central urban sector of the city, covering approximately 126 km by road. Within this relatively short distance, participants will traverse distinct geomorphic settings representing floodplain lakes, groundwater-fed tributary systems, older alluvial terraces, and the modern Gomti River valley. This compact geographical arrangement provides a unique opportunity to examine multiple components of the Quaternary landscape without extensive travel, making the excursion both scientifically comprehensive and logistically efficient.



Fig. 3. The route map of the mid-conference field excursion covers a representative segment of the Gomti River basin within the Central Ganga Plain of Uttar Pradesh (Google map image)



Unlike conventional geological excursions that focus on a single lithological succession or stratigraphic section, this field transect integrates sedimentology, geomorphology, palaeoenvironmental reconstruction, geoheritage, and historical landscape evolution. Each stop has therefore been selected to illustrate a specific component of the Quaternary history of the Gomti River basin while collectively demonstrating the evolution of the Central Ganga Plain during the Late Quaternary.

Excursion Route

The proposed excursion begins from Indira Gandhi Pratisthan, Lucknow, and proceeds northwards to Chandrika Devi, followed by Loni River, before returning to the urban sector of Lucknow to visit Dilkusha Kothi (Fig. 3). The route traverses both rural and urban landscapes, providing participants with an opportunity to observe the gradual transition from relatively undisturbed floodplain environments to densely developed historical landscapes.

The total duration of the excursion is expected to be approximately 7–8 hours, including travel, field observations, discussions, photography, and lunch. Road conditions are generally good; however, short walks over uneven ground and soft alluvial sediments will be required at Chandrika Devi and Loni River. Participants are therefore advised to wear suitable field footwear and clothing appropriate for warm and humid monsoon conditions.

Table 1. Proposed field itinerary

Stop	Locality	Scientific theme	Approx. duration
Start	BSIP, Lucknow	Departure and introduction	15 min
Stop 1	Chandrika Devi	Holocene palaeoenvironment, floodplain lake evolution and monsoon reconstruction	2 h
Stop 2	Loni River	Fluvial geomorphology, drainage evolution and Quaternary landscape development	2 h
Lunch	En route	-	45–60 min
Stop 3	Dilkusha Kothi	Geoheritage, historical landscape and human–environment interaction	45–60 min
End	BSIP/Conference venue	Discussion and return	-

Travel times will depend on prevailing traffic conditions within Lucknow.



Scientific Objectives of Individual Stops

Stop 1 – Chandrika Devi

The first stop focuses on a Holocene floodplain palaeolake developed adjacent to the Gomti River. Participants will examine the geomorphic setting of the lake, discuss its origin and evolution, and review the multiproxy evidence used to reconstruct Holocene environmental and climatic changes. Particular emphasis will be placed on sedimentary facies, chronology, geochemical records, and palaeoecological indicators that document variations in Indian Summer Monsoon intensity and floodplain hydrology.

Stop 2 – Loni River

The second stop introduces participants to the geomorphic evolution of a groundwater-fed tributary within the Gomti River basin. Observations will focus on channel morphology, point-bar development, floodplain stratigraphy, bank sedimentology, drainage organisation, and terrace relationships. Discussions will explore how fluvial processes operating within low-gradient alluvial systems respond to climatic variability, groundwater conditions, and subtle neotectonic influences.

Stop 3 – Dilkusha Kothi

The final stop highlights the geoheritage significance of the Gomti River valley through the historical landscape of Dilkusha Kothi. Rather than examining sedimentary successions, participants will explore how geomorphology influenced the selection of this elevated river terrace for the construction of an important nineteenth-century country house and military estate. Discussions will emphasise the concept of geoheritage, the relationship between geological landscapes and cultural history, and the importance of conserving geological and historical assets within rapidly expanding urban environments.

Integration of the Three Stops

Although each locality represents a different geomorphic setting, the three stops are genetically linked through the evolution of the Gomti River system and collectively illustrate the progression from natural environmental archives to human-modified landscapes.

- Chandrika Devi demonstrates how floodplain lakes preserve high-resolution records of Holocene environmental change and monsoon variability.
- Loni River illustrates the geomorphic processes responsible for shaping low-gradient alluvial drainage systems and the development of interfluvial landscapes.
- Dilkusha Kothi demonstrates how Quaternary geomorphic surfaces have influenced historical settlement, architectural development, and the cultural evolution of Lucknow.

Taken together, these localities provide a comprehensive understanding of the interactions between climate, hydrology, geomorphology, and human occupation within the Central Ganga Plain.

Expected Learning Outcomes During the Transect

By the end of the excursion, participants will be able to:

- Recognize the principal geomorphic elements of the Gomti River basin.
- Interpret the evolution of Holocene floodplain lakes and wetlands.
- Identify sedimentary facies associated with low-gradient alluvial rivers.
- Understand the role of groundwater-fed tributaries in landscape evolution.
- Appreciate the influence of geomorphology on historical settlement and cultural heritage.
- Recognize the importance of geoheritage conservation in urban landscapes.
- Evaluate the application of multidisciplinary approaches in Quaternary research.

Summary of the Field Transect

The proposed transect has been designed to provide a logical progression through the Quaternary evolution of the Lucknow region. Beginning with a natural archive of Holocene environmental change, continuing through an actively evolving fluvial system, and concluding at a historically significant geoheritage site, the excursion demonstrates the interconnected nature of geological processes and human history. The compact geographical setting, diverse geological features, and strong scientific foundation make the Gomti River basin an ideal outdoor laboratory for understanding the evolution of the Central Ganga Plain and its significance within global Quaternary research.



Field Map Showing Local Geology, Road Network and Excursion Stops

The field excursion traverses the central sector of the Gomti River basin within Lucknow District, Uttar Pradesh, and encompasses three representative localities illustrating different aspects of the Quaternary evolution of the Central Ganga Plain (Fig. 10.1). The excursion route begins at the Indira Gandhi Pratisthan and proceeds northward to Chandrika Devi, followed by Loni River, before returning to the southeastern part of Lucknow to visit Dilkusha Kothi. The route provides participants with an opportunity to observe the transition from Holocene floodplain environments to active fluvial landscapes and finally to an important geoheritage site overlooking the Gomti River.



The field map integrates the regional geological setting with the present-day road network, major drainage systems, geomorphic features, and excursion stops. It has been prepared to facilitate field navigation while simultaneously illustrating the geological framework discussed in the preceding sections. The map also highlights the geomorphic relationships among the Gomti River, the Loni River, older alluvial uplands (Bangar), active floodplains (Khadar), and associated Quaternary landforms, which constitute the principal focus of the excursion.

The excursion covers approximately 126 km by road and can be comfortably completed in a full day, including travel, field observations, scientific discussions, and scheduled breaks. The relatively short travel distances between successive stops enable participants to appreciate the geomorphic continuity of the Gomti River basin while minimizing travel time.



Location Descriptions

Chandrika Devi Temple and Palaeolake

Geomorphology

The Chandrika Devi region lies in a shallow, roughly oval depression on the T₁ terrace of the Gomti River, approximately 28 km northwest of central Lucknow, near Kathwara village in the Bakshi Ka Talab area. The terrace stands about 5–10 m above the active floodplain and is not inundated by present-day floods, indicating long-term stability of this surface since channel abandonment. The lake basin represents a former meander or channel segment of the Gomti that was progressively cut off and isolated as the active channel migrated away from this position. The Field Photographs are given in Annexure 1a.

Sedimentology

The lake fill comprises fine-grained, organic-rich clastic sediment recording the transition from an active fluvial channel to a shallow, seasonally variable lacustrine environment. Grain-size data from the published core show a shift from coarser, channel-influenced sediment at the base to progressively finer, more organic-rich facies upward, consistent with declining connectivity to the active river and increasing lacustrine/palustrine conditions through the mid-to-late Holocene.

Chronology

The core chronology is constrained by three AMS radiocarbon dates and two OSL dates, providing a continuous age model spanning approximately the last 6,000 years (5871–75 cal yr BP to present). This makes the site one of the better-dated terrestrial Holocene sequences in the immediate Lucknow region and the primary chronological anchor for the excursion as a whole.

Geochemistry and Proxies

Published multiproxy data from the core include grain size, major- and trace-element ratios, total organic carbon (wt%), stable carbon isotopes ($\delta^{13}\text{C}_{\text{org}}$) and pollen. These proxies together indicate that the lake began forming at approximately 5,000 cal yr BP in association with a weakening of the Indian summer monsoon, with subsequent proxy shifts used to infer vegetation change and hydrological variability through the Late Holocene, including regional dry intervals discussed by co located and comparable studies in the Central Ganga Basin.

Loni River

Geomorphology

The Loni River is a minor tributary that drains the interfluvial terrain within Lucknow district before joining the composite Gomti–Sai drainage network; regional hydrological summaries also record a Loni/Luni stream as a small tributary of the neighbouring Sai River. Locally, the terrain traversed by the Loni is predominantly flat, with a gentle northwest-to-southeast slope that mirrors the regional drainage gradient of the Gomti system. The channel is narrow and low-energy for most of the year, with a markedly higher, sediment-charged discharge during the monsoon. The Field Photographs are given in Annexure 1b.

Sedimentology

The exposed banks and shallow cut sections along the Loni River display fine floodplain sediment — light-coloured alluvium and locally dun-coloured gravels — typical of the Late Pleistocene to Recent alluvial cover of the district. Nodular kankar (pedogenic carbonate) occurs at shallow depth (approximately 0.6–1.5 m, i.e., 2–5 feet) below the surface, marking a period of relative landscape stability and subaerial weathering prior to burial by younger overbank sediment.

Chronology

No dedicated absolute-age chronology has yet been published for the Loni River sediments; the unit is assigned, on lithostratigraphic and geomorphic grounds, to the same Late Pleistocene–Holocene older/younger alluvium framework applied across the district. This stop is highlighted in the literature review as a priority target for future OSL/radiocarbon dating to allow direct correlation with the better-dated Chandrika Devi sequence.

Geochemistry

No site-specific geochemical dataset exists for the Loni Nadi kankar horizons at the time of writing. By analogy with dated calcrete/kankar horizons elsewhere in the Central Ganga Plain, these nodules are expected to preserve a stable-isotope ($\delta^{13}\text{C}$, $\delta^{18}\text{O}$) signal of past vegetation type (C_3 versus C_4) and effective moisture; sampling for such analysis will be demonstrated in the field as a teaching exercise, though results will not be available during the excursion itself.



Dilkusha Kothi

Geomorphology

The Dilkusha area lies on the right (eastern) bank of the Gomti River within the built-up eastern part of Lucknow city. Here, the river has incised a low but locally well-exposed cliff (bluff) into the alluvial surface on which the early nineteenth-century Dilkusha Kothi and its gardens were constructed, offering a natural vertical section through the near-surface Quaternary sediment package immediately below the historic monument. Comparable incised cliff/embankment sections are documented along the neighbouring Sai River valley (e.g., the Chaukhada and Khatihara sections), providing a useful regional facies analogue for description at this stop. The Field Photographs are given in Annexure 1c.

Sedimentology

By analogy with the described Sai River cliff sections, the exposure is expected to show poorly to very poorly sorted, very silty sandy mud facies dominating the floodplain sequence, with one or more mature calcrete (kankar) bands, locally 1–1.4 m thick, developed as laterally extensive but internally massive horizons within the silty mud facies. These calcretes are typically composed of micritic carbonate crystals and may contain fungal borings, reflecting prolonged pedogenic modification of the floodplain surface between episodes of overbank sedimentation. Facies classification in the field will follow standard sand–silt–clay ternary schemes (e.g., after Flemming, 2000).

Chronology

No independent chronology is currently published specifically for the Dilkusha cliff exposure. Given its position within the younger alluvial tract of the active Gomti floodplain and its stratigraphic similarity to dated Late Quaternary cliff sections elsewhere in the Central Ganga Plain, the sequence is provisionally regarded as Late Pleistocene to Holocene in age; targeted OSL sampling during future field seasons would allow this to be tested directly and compared with the Chandrika Devi chronology from the same river system.

Geochemistry

As at the Loni River stops, no site-specific geochemical data are yet available. The calcrete bands offer an opportunity for stable-isotope and trace-element sampling comparable to studies conducted on analogous Sai River sections, thereby allowing the Dilkusha exposure to be placed within the broader regional dataset on Late Quaternary pedogenesis and palaeo-aridity in the Central Ganga Plain.

Geoheritage, Archaeology, Cuisine, and Culture

Geoheritage

None of the three localities on this transect currently holds UNESCO World Heritage status or formal national geoheritage site designation. However, the Gomti terrace sequence and the Chandrika Devi Lake basin are of clear geoheritage value as one of the few directly accessible, well-characterised Holocene lacustrine archives in the Central Ganga Plain, and the Dilkusha cliff exposes a naturally occurring, publicly accessible window into the near-surface Quaternary stratigraphy of the district that is increasingly rare within the rapidly urbanising and channelised city reach of the Gomti. Participants are encouraged to discuss, as part of the field workshop, the case for formally recognizing comparable river-cliff exposures as geoheritage before further riverfront development removes them.

Archaeological and Historical Sites in the Vicinity

- Chandrika Devi Temple: a Hindu shrine, said locally to be some 300 years old, dedicated to a manifestation of the goddess Durga; local tradition links the site to the Ramayana narrative of Chandraketu, son of Lakshmana.
- Dilkusha Kothi (Dilkusha Palace/Garden): built c. 1800–1805 for Nawab Saadat Ali Khan under the design guidance of the British Resident Major Gore Ouseley, drawing architectural inspiration from Seaton Delaval Hall (Northumberland, England); used as a hunting lodge and summer retreat, and the site of significant military engagements during the 1857 Siege of Lucknow, including the death of General Sir Henry Havelock nearby.
- La Martinière College (Constantia) and the Residency of Lucknow, both within a few kilometres of Dilkusha and closely linked historically and topographically to the events of 1857, may be visited as optional add-ons if time permits.
- Hulaskhera archaeological site and Nawabganj (Shahid Chandra Shekhar Azad) Bird Sanctuary, covered on a separate INQUA 2027 field trip in the same district, offer thematically related material on Ganga Plain geoarchaeology for participants attending multiple excursions.





Cuisine and Culture

Lucknow's Awadhi culinary tradition, developed under the patronage of the Nawabs of Awadh, is internationally renowned and directly relevant to the cultural-heritage dimension of the Dilkusha stop. Participants are encouraged to sample local specialties at lunchtime or in the evenings, such as Lucknawi kebabs (galawati and seekh varieties), biryani and pulao, kulcha-nihari, and traditional sweets such as makhan malai (a winter-season speciality well suited to the excursion dates) and various forms of chaat. Lucknow is also known as the 'City of Nawabs' for its refined, syncretic Ganga-Jamuni tehzeeb (composite culture), reflected in the coexistence of Hindu temple traditions (as at Chandrika Devi) with Nawabi Indo-European architecture (as at Dilkusha) within a few kilometres of one another – a juxtaposition that the excursion is specifically designed to highlight.



Local Conveniences

Medical Facilities and Emergency Care

Basic first-aid support and a stocked first-aid kit will be available at all times during the excursion. For more serious medical needs, the following facilities are relevant to the transect:

- Near Chandrika Devi (Bakshi Ka Talab area): primary health centres and other private hospitals are available locally.
- Near Loni River and Dilkusha (within Lucknow city): major hospitals including King George's Medical University (KGMU), Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGI), and several private multi-speciality hospitals in Gomti Nagar are within a 20–30-minute drive.
- Emergency numbers (India): Police – 112; Ambulance – 108; Tourist Helpline – 1363 / 1800-11- 1363.

Assistance for International Participants (Lost or Stolen Passport)

- Report the loss immediately at the nearest police station and obtain a First Information Report (FIR).
- Contact your embassy or consulate (most are based in New Delhi) as soon as possible.
- Visit the Passport Seva Kendra (PSK) in Lucknow for documentation support.
- Keep digital copies of passport, visa, travel insurance, and other identity documents before the excursion, and carry a printed copy separately from the original wherever practical.



Markets and Local Facilities

- Hazratganj and Aminabad markets (central Lucknow, near the Dilkusha stop): general shopping, pharmacies, ATMs, restaurants and souvenirs.
- Local shops and dhabas along the Lucknow–Sitapur Road serve the Chandrika Devi stop for snacks, bottled water and basic supplies.
- Mobile network coverage (Jio, Airtel, BSNL, Vi) is generally reliable across all three stops; coverage may be intermittent in the more forested tract immediately around the Chandrika Devi region.
- Fuel stations, ATMs and pharmacies are readily available along the main Lucknow–Sitapur Road and within the city stretch covered by the Loni River and Dilkusha stops; facilities at Chandrika Devi itself are more limited outside the temple's immediate precinct, so participants should carry adequate water and snacks.



Conclusion

This one-day transect through Chandrika Devi Temple, the Loni River, and the Dilkusha cliff section offers a compact but genuinely representative cross-section of the Late Quaternary depositional systems of the Central Ganga Plain — palaeolake, tributary floodplain, and river-cliff facies — anchored by one of the region's better-dated terrestrial Holocene climate archives at Chandrika Devi. It simultaneously situates that geological record within a landscape of continuous human occupation and heritage, from an actively worshipped temple of considerable antiquity to the ruined Nawabi era Dilkusha Kothi, within a single day's excursion around Lucknow.

For the wider goals of the Mid-INQUA Field Workshop, the transect is intended to stimulate discussion of two linked themes: the sedimentary and geochemical expression of monsoon variability in groundwater-fed alluvial rivers lacking a glacial meltwater signal, and the practical challenge of extending well-dated point records, such as the Chandrika Devi core, into a spatially coherent regional chronology through targeted dating of comparable but currently undated exposures such as those at the Loni River and Dilkusha. Addressing these outstanding issues will strengthen the Central Ganga Plain's contribution to the wider South Asian and global Quaternary monsoon record, while the accompanying heritage and conservation dimension underscores the urgency of documenting such exposures before further urban and riverfront development reduces their accessibility.



Acknowledgements

We gratefully acknowledge the organising committee of the XXII INQUA Congress 2027 and the Mid INQUA Field Workshop programme for the opportunity to design and lead this field transect, and Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, for institutional and logistical support. We thank the management of the Archaeological Survey of India for facilitating access to the temple precinct and the Dilkusha Kothi monument, respectively.

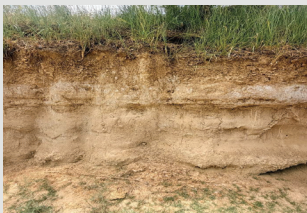


Field Photographs

Chandrika Devi Temple



Loni Nadi (Loni River)



Loni Nadi (Loni River)



Annexure

Field Excursion Guidelines: Do's and Don'ts

To ensure the safety of all participants and to promote responsible scientific field practices, all participants are requested to adhere to the following guidelines throughout the field excursions.

Keep a valid passport (for international participants) or a government-issued photo ID (for Indian participants) with you at all times during the field excursion.

Do's	Don'ts
1. Follow the instructions of the excursion leaders, coordinators, and local authorities at all times. 2. Remain with the group and inform the excursion leader before leaving the designated route. 3. Wear appropriate field attire, including sturdy closed-toe footwear, full-length trousers, a hat or cap, and weather-appropriate clothing. 4. Carry sufficient drinking water, personal medications, sunscreen, insect repellent, and other essential field supplies. 5. Keep a valid photo identification and your excursion registration details with you during travel. 6. Respect local customs, religious sites, cultural heritage, and private property. 7. Follow the Leave No Trace principles by carrying back all waste and helping to keep field sites clean. 8. Use designated trails and approved observation areas to minimise environmental disturbance. 9. Observe geological, ecological, archaeological, and cultural features carefully without causing any damage.	1. Do not collect rocks, fossils, archaeological artefacts, biological specimens, or any other materials without prior authorization. 2. Do not damage, deface, or remove material from geological outcrops, caves, monuments, heritage structures, or other natural features. 3. Do not wander alone or separate from the excursion group without informing the field leaders. 4. Do not climb unstable slopes, cliffs, rock formations, or enter hazardous areas unless specifically instructed or supervised. 5. Do not swim or enter rivers, lakes, lagoons, or coastal waters unless expressly authorized by the excursion leaders. 6. Do not consume alcohol, recreational drugs, or engage in unsafe or irresponsible behaviour during the excursion. 7. Do not operate drones or other restricted equipment without obtaining the necessary permissions. 8. Do not photograph restricted installations, sensitive locations, or local residents without prior permission.

10. Record field observations systematically and collect samples only with prior permission from the excursion leaders and the relevant authorities.

11. Exercise caution near cliffs, riverbanks, caves, unstable slopes, road cuts, and other potentially hazardous terrain.

12. Respect wildlife by maintaining a safe distance from animals, birds, reptiles, insects, and their habitats.

13. Immediately report any illness, injury, emergency, or hazardous situation to the excursion organizers.

14. Be prepared for changing weather conditions and comply with all safety advisories issued by the excursion leaders.

9. Do not create excessive noise or disturb local communities, religious activities, wildlife, or natural habitats.

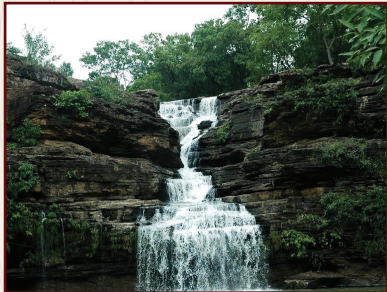
10. Do not leave valuables unattended or rely solely on mobile phone connectivity in remote areas.

11. Do not undertake any activity that may compromise your safety, the safety of fellow participants, or the conservation of the area's geological, ecological, archaeological, or cultural heritage.

Disclaimer

Participation in the field excursions is entirely at the participant's own risk. While the Organising Committee and excursion leaders will make every reasonable effort to ensure participant safety and provide appropriate guidance, they shall not be held responsible for any personal injury, illness, loss of personal belongings, property damage, delays, or unforeseen incidents arising during travel or field activities. Participants are expected to act responsibly, follow all instructions issued by the excursion leaders, and comply with applicable local laws and regulations throughout the excursion.







Scan for
Field Guide Book



Contact Details:

INQUA Secretariat

Birbal Sahni Institute of Palaeosciences (BSIP),
53, University Road, Lucknow-226 007 U.P, India

Email: inqua.india@gmail.com | inqua.india@bsip.res.in

Phone: +916386696896 | +916392507990