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QUATERNARY SCIENCE AS SOCIETAL SERVICES



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FIELD GUIDE

INPOST - 13

MANGROVE RESPONSES TO QUATERNARY CLIMATE AND SEA-LEVEL CHANGE: PALAEOECOLOGICAL INSIGHTS FROM THE SUNDARBANS BIOSPHERE RESERVE, INDIA

Shilpa Pandey and Abhijit Mitra







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Field Guide Book

INPOST-13

Mangrove Responses to Quaternary Climate and Sea-Level Change: Palaeoecological Insights from the Sundarbans Biosphere Reserve, India

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Dr. Shilpa Pandey is a Quaternary palaeoscientist with over two decades of expertise in mangrove palaeoecology, palynology, Holocene environmental change and relative sea-level dynamics. Her research integrates modern pollen–vegetation relationships with fossil pollen and multiproxy records to reconstruct past coastal ecosystem and climate variability. She has conducted extensive research across the Indian Sundarbans and other major coastal systems of India, generating internationally published evidence on mangrove dynamics and palaeoenvironmental change. As Vice-President of the INQUA Coastal and Marine Processes Commission (2023–2027), she brings substantial international scientific leadership and field expertise. Her experience in Sundarbans research, coastal processes, climate change and interdisciplinary palaeosciences provides a strong scientific foundation for leading the INQUA 2027 Post-Congress Field Trip.



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Dr. Abhijit Mitra, is presently serving Techno India University, West Bengal as the Director of Research. He obtained his Ph.D as NET qualified scholar in 1994 after securing Gold Medal in M.Sc from University of Calcutta. Since then, he joined Calcutta Port Trust and WWF (World Wide Fund for Nature), in various capacities to carry out research programmes on environmental science, biodiversity conservation, climate change and carbon sequestration. He has to his credit about 775 scientific publications in various National and International journals, and 66 books of postgraduate standards. Dr. Mitra was invited as a visiting fellow at University of Massachusetts at Dartmouth, USA to deliver a series of lecture on Climate Change. Dr. Mitra also successfully guided 61 Ph.D students. Presently his domain of expertise includes environmental science, mangrove ecology, sustainable aquaculture, alternative livelihood, natural resource management, blue economy, climate change and carbon credit.

Abstract

The Indian Sundarbans Biosphere Reserve, occupying the lower Ganga – Brahmaputra – Meghna Delta, is the world's largest contiguous mangrove forest and a UNESCO World Heritage Site and it sits at the sharpest expression of a problem confronting deltaic coastlines worldwide: can mangrove ecosystems accrete fast enough to track relative sea-level rise, or will they drown beneath it? Answering this requires more than instrumental records. It requires the deep-time perspective preserved in the delta's Quaternary sedimentary archive, where pollen, foraminifera, and dated peat horizons document how mangrove systems have already responded to monsoon variability, sediment dynamics, neotectonic subsidence, and multiple cycles of postglacial sea-level rise and Holocene stabilisation - offering a critical analogue for predicting the future of vulnerable coastal landscapes everywhere.

This four-days field excursion traverses the Sajnekhali–Sudhanyakhali–Dobanki–Jharkhali transect within the Sundarban Tiger Reserve, linking modern geomorphic process directly to the Late Quaternary and Holocene record. Delegates will move through active tidal channels, estuarine deposits, mudflats, peat-forming environments, and dynamic mangrove forest, examining how palynology, sedimentology, geomorphology, geochemistry, radiocarbon chronology, and remote sensing/GIS are integrated to reconstruct past environmental change and evaluate ecosystem resilience. At Sajnekhali, delegates encounter the modern ecological and geomorphic baseline against which the deeper record is measured. At Sudhanyakhali, the reserve's most rigorously dated palynological sequence reveals a striking, unresolved diachroneity in mangrove establishment — one of several open questions this transect is designed to interrogate rather than resolve. At Dobanki, an elevated canopy walkway places delegates directly above paired eroding and accreting creek banks, turning the abstract competition between subsidence and sediment supply into something visible and photographable. At Jharkhali, the transect closes with its sharpest contrast: an embanked, reclaimed coastal margin standing against everything seen upstream a live demonstration of how thoroughly human intervention has already reshaped the delta's natural accretion and salinity regimes, and a direct analogue for the engineered adaptation strategies now being proposed elsewhere in the delta.

Beyond its scientific core, the excursion is an immersive encounter with one of the planet's most biodiverse coastal landscapes, the only mangrove habitat of the Royal Bengal Tiger (Panthera tigris tigris), alongside estuarine crocodiles, spotted deer, Gangetic dolphins, and over 270 recorded bird species — set within a living cultural landscape shaped by the Bonbibi tradition, honey-collecting livelihoods, and centuries of human coexistence with a still-subsiding delta.

Designed around the scientific priorities of INQUA 2027 and framed within its focal theme, Quaternary Science as Societal Services, this excursion bridges Quaternary geology, palaeoecology, coastal geomorphology, biodiversity, and climate science demonstrating an unbroken line from outcrop-scale Holocene evidence to present-day coastal-hazard assessment, blue-carbon conservation, mangrove restoration, and adaptation planning for one of the most densely populated, climate-exposed delta populations on Earth. Delegates

should expect not a finished narrative but an active field laboratory: a landscape where the legacy of the Quaternary continues to shape the future of tropical coasts, and where the questions raised at each stop remain genuinely open for their own expertise to help answer.

Preamble

Mangrove ecosystems occupy the fragile interface between land and sea, and their fate is now recognised as one of the clearest bio-indicators of Quaternary and Anthropocene coastal change. Globally, research on mangrove response to sea-level fluctuation has converged on two urgent, unresolved questions: (i) what determines whether a mangrove system can vertically accrete fast enough to track relative sea-level rise (RSLR), versus drowning or retreating landward; and (ii) how do the deep-time (Late Pleistocene–Holocene) trajectories of mangrove migration, expansion, and collapse recorded in sedimentary and palynological archives inform projections for the coming century. Most of the world's actively studied mangrove-fringed deltas - the Mekong, the Niger, the Amazon and the Ganges–Brahmaputra–Meghna (GBM) sit on subsiding, sediment-starved coastlines where the signal of eustatic sea-level rise is amplified or masked by compaction, neotectonics, and anthropogenic sediment trapping. Disentangling these overlapping drivers from short instrumental or satellite records alone is not possible; it requires palaeoecological proxies: pollen, diatoms, foraminifera, stable isotopes, and dated peat/mangrove-stump horizons anchored in a Quaternary stratigraphic framework that extends the observational window back through multiple sea-level cycles.

The Sundarbans, the world's largest contiguous mangrove forest, sits at the sharpest expression of this global problem. It is shared between India and Bangladesh across the GBM delta, and it is already experiencing one of the highest rates of relative sea-level rise of any populated mangrove coast on Earth. Regional long-term subsidence in the delta averages about 2.7 mm/yr, but modern relative sea level is rising at roughly 8.7 mm/yr once eustatic, isostatic, and subsidence components are combined, and the delta's present configuration reflects eastward tilting, rapid sediment accumulation locally reaching 0.7 cm/yr, and marked land subsidence up to 0.5 cm/yr, compounded by increasing anthropogenic pressure. Reconstructions from submerged kiln sites and buried mangrove stumps show that subsidence has not been steady, but episodic punctuated by discrete events, including an eighteenth-century episode of land-sinking of one to two metres- a finding only recoverable through palaeoecological and geochronological work, not from modern gauges. Model projections built on these geological constraints suggest the Indian Sundarbans could lose between 42 and 80 percent of their current mangrove area by 2100 under continued present-day management, underscoring why the Quaternary record of past mangrove resilience and collapse is not an academic curiosity but a direct analogue for near-future coastal management and climate adaptation policy (Hanebuth et al., 2022).

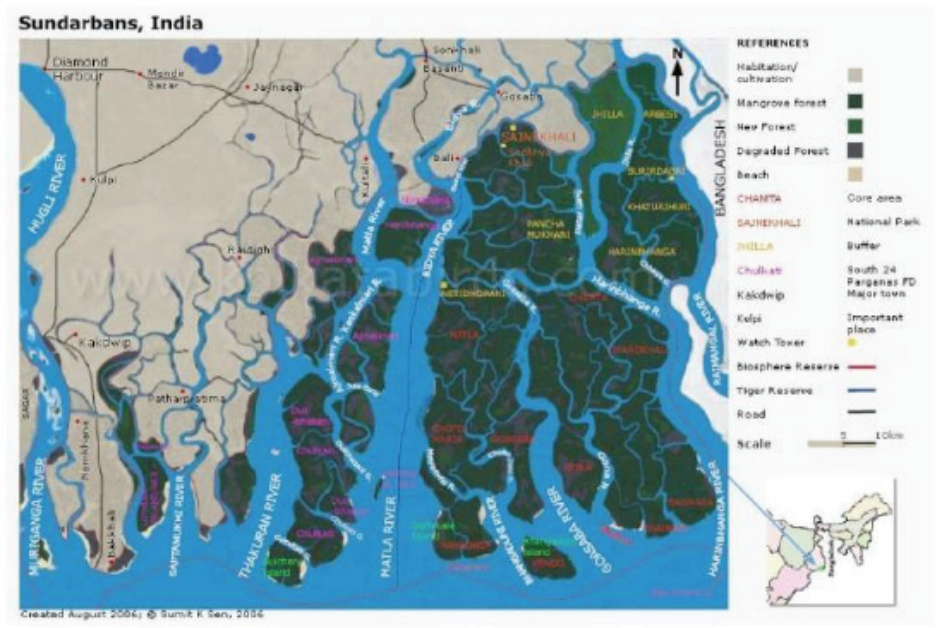


Why the Sundarbans transect is a unique Quaternary field laboratory?

The Sundarbans Biosphere Reserve, situated within the Ganga–Brahmaputra–Meghna delta, hosts one of the world's most extensive and dynamic tropical mangrove ecosystems and stands as an exceptional natural laboratory for Quaternary research. This tide-dominated delta has evolved under the combined influence of monsoon variability, Himalayan sediment flux, neotectonic adjustment, cyclonic disturbance, and Holocene sea-level fluctuation. The continuous accumulation of organic-rich sediment across its estuarine islands has preserved an exceptional palaeoenvironmental archive spanning the late Quaternary and Holocene, offering a rare opportunity to investigate ecosystem resilience, coastal landscape evolution, and environmental thresholds under changing climatic and sea-level regimes.

Few coastal settings anywhere offer what this transect offers within a single traverse. The Sundarbans is a continuous, tidally-active, tectonically-subsiding deltaic mangrove system built on a Holocene sequence that directly overlies the last-glacial-to-postglacial transgressive surface, preserving a near-complete record of mangrove response across metres of postglacial sea-level rise, subsequent Holocene stabilisation, and renewed acceleration through the historical and instrumental period. This vertical and lateral continuity from late Pleistocene alluvium, through the transgressive mangrove peats of the early-to-mid Holocene highstand, to the actively prograding and retreating modern

shoreline is rarely preserved intact elsewhere, since most comparable deltas have been heavily engineered, embanked, or starved of sediment by upstream damming. The Indian Sundarbans, still largely unembanked along its seaward margin, retains a natural sedimentary and biological gradient that makes it an exceptional living laboratory, in which palaeoecological signals pollen assemblages, mangrove-peat stratigraphy, foraminiferal and diatom transfer functions can be cross-checked directly against present-day ecological zonation and ongoing geomorphic change: erosion on some islands, accretion on others, and outright submergence of islands such as Ghoramara, all occurring in real time.



It is this convergence a well - constrained Quaternary chronostratigraphy, an active neotectonic and compactional subsidence regime, and a still - functioning, UNESCO - protected mangrove ecosystem under direct observation that gives the Sundarbans transect a diagnostic power few other Quaternary field sites can match. Within four field days, delegates can walk from outcrop-scale evidence of Holocene sea-level history into a living mangrove system experiencing that same process today.

This makes the Sundarbans an ideal setting through which to demonstrate the Congress's focal theme, Quaternary Science as Societal Services: a landscape where fundamental palaeoenvironmental research directly underwrites coastal-hazard assessment, mangrove conservation planning, and adaptation strategy for one of the most densely populated, climate-exposed delta populations on Earth.

Regional Geology

1. Regional Tectonic Setting

The Sundarbans occupies the distal, seaward apex of the Bengal Basin, the largest and thickest sediment repository on Earth, situated at the collisional junction of the Indian, Eurasian, and Burmese plates. Based on basement configuration, sedimentation pattern, and geodynamic development, three geotectonic provinces are recognised: the Stable Shelf, the Central Foredeep Basin, and the Folded Flank represented by the Chittagong – Tripura Fold Belt. The Sundarbans field area lies within the distal Central Foredeep/Western Sub-basin province, well basinward of the Eocene Hinge Zone, a NE–SW trending flexure that separates the shallow, gently dipping Indian platform to the west from the deep foredeep and eastern fold belt where the hinge zone separates the shallow Indian Platform from the central deep basin and the eastern fold belt. Basin evolution proceeded through five broadly recognised phases, from rift initiation with the break-up of Gondwana, through a passive-margin/foreland-basin transition driven by Himalayan orogenesis in the Tertiary, to a final Quaternary delta-formation event caused by rapid sedimentation from the Ganges - Brahmaputra - Meghna River system. Present-day active deformation is concentrated well to the east and northeast of the field area, along the Indo-Burman fold-thrust belt, where the deformation front has propagated at roughly 100 mm/yr over the past two million years, far exceeding the modern plate convergence rate of about 9 mm/yr, a reminder that even though the Sundarbans itself sits on the stable, aseismic shelf, it is embedded in one of the most tectonically dynamic foreland systems on the planet.

2. Stratigraphy

Beneath the Sundarbans, the exposed and shallow subsurface succession is entirely Quaternary, resting on a much older, deeply buried sedimentary pile. In the foredeep part of the Bengal Basin, a thick pile of sedimentary strata overlies a deeply subsided basement, with the Tertiary section (Eocene limestones, Oligocene–Miocene deltaic and shelf sandstones and shales of the Surma/Tipam-equivalent groups) thickening rapidly basinward beneath the hinge zone. Of direct relevance to the field trip is the terminal Plio-Pleistocene to Holocene package: a lower unit of oxidised, mottled fluvial clay and sand generally correlated with the Older Alluvium/Barind–Madhupur-equivalent surface (regionally capped by a lateritised palaeosol), unconformably overlain by the Holocene deltaic/estuarine sequence that hosts the modern Sundarbans mangrove peats, silty clays, and channel sands. A Pleistocene palaeosol horizon of warm-humid character is commonly found immediately above bedrock, overlain by Holocene fluvio-marine sediments deposited after the Last Glacial Maximum, once post-glacial transgression flooded the basin. This two-tier stratigraphy an incised, weathered late Pleistocene surface buried beneath a Holocene transgressive-to-highstand mangrove/estuarine wedge is the fundamental stratigraphic architecture the field trip will trace across the Sajnekhali – Sudhanyakhali – Dobanki – Netidhopani transect.

3. Structure

Structurally, the Sundarbans lies on the least deformed part of the basin, but it is not tectonically inert. the study area is situated in the southernmost part of the subsiding Bengal

Basin, a tectonically active zone bordered by the Eurasian, Indian, and Indo-Burma plates, and the delta surface itself is subject to differential neotectonic warping. Subsurface facies mapping across the western delta shows that neotectonic displacement, including differential land subsidence of delta-plain sectors, is a major control on the late Quaternary depositional pattern, with dominant structural grain trending NE–SW and a subordinate NW–SE set. This gentle, differential downwarping — rather than brittle faulting — is the structural signature exposed (and inferred from borehole/core data) along the trip: it explains why some islands within the reserve are actively subsiding and eroding while immediately adjacent islands accrete, a pattern the group will observe directly on the water between stops.

4. Palaeontology

Two microfossil/palynological archives underpin the Quaternary reconstruction along this transect: foraminifera and pollen / spores, supplemented increasingly by sedimentary ancient - DNA work.

• **Foraminifera** record the transition from open estuarine/marginal-marine to more open-marine and back to marginal conditions through the Holocene. In cores from the lower Bengal Basin immediately updip of the Sundarbans, a lower brackish-water estuarine phase is succeeded by a more open-marine phase dominated by Bolivina, Globigerina, Nonion, Cibicides, and Pseudorotalia together with Ammonia and Elphidium, before a return to marginal conditions marked by Ammonia, Asterorotalia, and Elphidium approaching the present day. Modern benthic foraminiferal community structure across the Sundarbans mangrove sediments is now also being characterised through sediment eDNA, providing a living baseline against which the fossil assemblages can be calibrated as part of a dataset on benthic foraminiferal community structure derived from sediment eDNA of the Sundarbans mangrove ecosystem.

• **Pollen and spores** from radiocarbon-dated peat horizons in and around the Lower Bengal Basin directly document the mangrove vegetation history that the field trip will see as living forest. Three successive peat layers dated between roughly 7000 and 2650 years BP preserve pollen assemblages dominated by Heritiera, Rhizophora, Sonneratia, Excoecaria, and Phoenix paludosa, indicating a long-lived, broadly stable mangrove swamp community with only minor climatic fluctuation through the mid-to-late Holocene. The uppermost, youngest peat shows an increasing terrestrial and grass component alongside relict mangrove taxa including Typha, Cassia, and Salicornia alongside Heritiera and Excoecaria, with a decline in fern spores signalling a shift toward more terrestrial conditions — a proxy signature of the same land–sea competition still visible today across the reserve's accreting and eroding shorelines.

5. Quaternary Geology and Sea-Level History

The Sundarbans acquired essentially its present configuration only very recently in geological terms. A muddy submarine delta began forming around 7.5 ka BP, and the western delta lobe reached approximately its present extent by about 5 ka BP, once postglacial sea-level rise decelerated and approached its modern position. Since then, the system has been governed by a competition between sediment supply, compactional and neotectonic

subsidence, and relative sea-level rise. Long-term reconstructions from submerged, dated kiln sites and buried mangrove stumps show that the regional long-term subsidence rate averages 2.7 ± 0.3 mm/yr, while modern relative sea level — combining eustasy, isostasy, and subsidence — is rising at roughly 8.7 ± 0.4 mm/yr, a rate so far offset by natural sediment accretion, though this subsidence has proceeded in discrete pulses rather than smoothly, including a documented eighteenth-century subsidence event of one to two metres. Present-day net subsidence across the Indian Sundarbans is independently estimated at around −2.4 mm/year, a rate used in current projections of land loss under 21st-century sea-level rise scenarios. This nested hierarchy of processes Holocene delta-lobe construction, punctuated neotectonic subsidence, and accelerating modern relative sea-level rise is precisely what the palaeoecological (pollen, foraminifera) and geochronological (^{14}C, OSL) proxies at each field stop are designed to unpick.

6. Where This Field Trip Fits

The trip is designed as a single transect through the buffer and core zones of the Sundarban Tiger Reserve, moving from more human-proximal, estuarine-influenced sites to progressively more pristine core-zone forest, allowing delegates to walk the same land–sea, fresh–saline, and subsiding–accreting gradients recorded in the Quaternary stratigraphy:

• **Sajnekhali** (buffer zone, Sajnekhali Wildlife Sanctuary, ~362 km^2) — the entry and orientation stop, with a Mangrove Interpretation Centre offering a turtle and crocodile pond, watch tower, and sweet-water pond; ideal for introducing the modern zonation of mangrove species against which the Holocene pollen record will later be compared.

• **Sudhanyakhali** (buffer zone) — a watch tower facing a sweet-water pond, with a planted Mangrove Park containing the major mangrove species, useful for direct species-level ground-truthing of pollen taxa (Heritiera, Excoecaria, Phoenix paludosa) identified in the dated peat cores.

• **Dobanki** (buffer zone, southern Sajnekhali Sanctuary) — an approximately 400 m canopy walk giving an elevated view through the mangrove canopy, allowing observation of vertical forest structure and accretion/erosion contrasts across adjacent creek banks a direct visual analogue of the subsidence-versus-accretion competition documented in the subsurface record. Taken together, the transect allows delegates to move within a field visit from the basin-scale tectonic and stratigraphic framework, through the microfossil and palynological proxies that reconstruct Holocene mangrove and sea-level history, into a living core-zone mangrove forest that is visibly experiencing the same processes today, directly linking Quaternary geoscience to the Congress's focal theme of science in service of a vulnerable, densely populated delta society.

Flora, Fauna and Climate, weather conditions during field excursion

The Sundarbans is not simply a forest, it is a vegetation gradient that visibly encodes salinity, tidal inundation, and substrate elevation, making it the perfect living counterpart to the pollen stratigraphy. Twenty-six of the world's fifty true mangrove species occur here, and the field transect will cross nearly the full successional sequence in a single traverse.

• Pioneer zone (newly accreted mudbanks): Sonneratia apetala (Keora) colonises first, followed closely by Avicennia officinalis/marina/alba (Baen) and the mangrove palm Nypa fruticans — visible along the actively prograding creek banks near Sudhanyakhali and Dobanki, where sediment is still being added to the shoreline.



• Intermediate/brackish zone: Excoecaria agallocha (Gewa, with its distinctive caustic latex) and Ceriops decandra (Goran) dominate as elevation rises and tidal inundation becomes less frequent — the characteristic understorey seen along the Dobanki canopy walk.

• Climax/mature zone: Heritiera fomes (Sundari — the tree that gives the Sundarbans its name), an endangered, buttress-rooted species requiring the least saline, most infrequently flooded ground, forms closed canopy stands together with Phoenix paludosa and Nypa fruticans — best seen around Sajnekhali and the interior forest near Netidhopani.

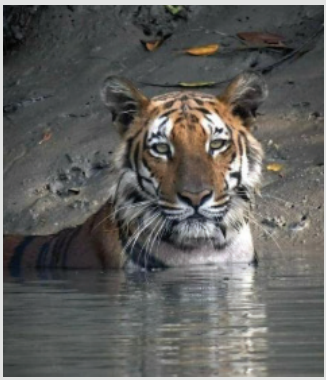
• Understorey and associates: Xylocarpus mekongensis/granatum (Passur), Bruguiera gymnorhiza (Kankra), Aegiceras corniculatum, and Rhizophora mucronata fill the intertidal margins, while elevated, less saline patches near watchtowers support grasses, Salicornia, and scattered freshwater-swamp taxa, a modern analogue for the terrestrial pollen signal seen in the youngest dated peats.

Every one of these zones is a living key to the fossil pollen spectra recovered from the dated peat horizons described earlier (Heritiera, Rhizophora, Sonneratia, Excoecaria, Phoenix paludosa): delegates will be able to stand inside the very ecological zonation that the Holocene palynology records as a buried signal.

Fauna:

The Sundarbans supports over 1,586 recorded faunal species, including 15 mammals, 8 birds, and 17 reptile species listed under Schedule I/II of India's Wildlife Protection Act, and 14 species— an extraordinary concentration of biodiversity for a low-lying, salinity-stressed delta.

• The Royal Bengal Tiger (Panthera tigris tigris) — the flagship species and the world's only tiger population adapted to a saline, tidal mangrove habitat, with strengthened hind limbs for swimming between islands. Sightings are rare but most often reported near Sudhanyakhali and Dobanki, both prime tiger-corridor watchtowers.





• Estuarine/saltwater crocodile (Crocodylus porosus), the world's largest living reptile, is regularly seen basking on mudbanks in winter, alongside an active conservation-breeding programme for the species and the critically endangered northern river terrapin (Batagur baska) centred at Sajnekhali.



• Cetaceans: Gangetic river dolphins (Platanista gangetica) and Irrawaddy dolphins surface in the tidal creeks — a striking reminder that this is a living estuarine system, not a static landscape.

• Other mammals: spotted deer (chital), rhesus macaque, wild boar, fishing cat, jungle cat, leopard cat, small Indian civet, and smooth-coated otter.

• Avifauna: over 270 recorded species, earning the Sundarbans the title "Kingfishers' Paradise" (10 of India's 12 kingfisher species occur here), alongside white-bellied sea eagles, brown-winged kingfishers, mangrove pittas, egrets, storks, and during the winter field season large numbers of migratory waders and waterfowl.

• Reptiles and amphibians: king cobra, Indian python, water monitor lizard, Olive Ridley turtle, and the amphibious mudskippers (Periophthalmus, Boleophthalmus) that colonise the intertidal flats — a vivid, present-day analogue for the marginal-marine microfossil habitats reconstructed from the fossil foraminiferal record.

The tiger's dependence on this narrow, subsiding, salinity-stressed forest is itself a societal indicator: as sea-level rise and salinisation compress the climax Heritiera zone, both the flagship predator and the pollen signal it depends on are tracking the same environmental threshold a direct, visible link between Quaternary science and present-day conservation stakes.

Climate and Weather Conditions During the Field Excursion

Field logistics benefit enormously from the timing: INQUA congress field trips are conventionally scheduled in the winter dry season, and the Sundarbans' winter window (November to February) is unambiguously regarded as the optimal period for both fieldwork and wildlife observation.

• **Temperature:** Cool and pleasant by regional standards, typically ranging from a morning low of ~12–14°C to a daytime high of ~24–27°C — comfortable working conditions for full-day boat-based fieldwork, in sharp contrast to the pre-monsoon heat (35°C) of March–May.

• **Humidity and rainfall:** The dry season carries minimal rainfall and markedly lower humidity than the monsoon months (June–October).

• **Visibility and wildlife activity:** Winter's clear skies and lower vegetation moisture improve sightline visibility along creeks and watchtowers, and coincide with peak crocodile basking behaviour and the arrival of migratory bird flocks maximising the excursion's observational and outreach value alongside its scientific objectives.

• **Tidal regime:** As a tide-dominated delta, all logistics — boat transfers between Sajnekhali, Sudhanyakhali, Dobanki, and access to intertidal exposures are governed by the semi-diurnal tidal cycle rather than time of day alone; itineraries must be built around tide tables, with core outcrop and mudflat stops timed to low tide and channel transits timed to favourable flow.

• **Practical implication for delegates:** the cool, dry, low-rainfall winter window not only maximises comfort and safety on extended boat transects but also delivers the clearest possible expression of the modern ecological zonation described above allowing the field trip to double as both a rigorous Quaternary science excursion and a high-visibility, wildlife-rich showcase of the Congress's societal-relevance theme.

Literature Review

The Indian Sundarbans Biosphere Reserve, located within the lower Ganga – Brahmaputra – Meghna (GBM) Delta, represents one of the world's largest tropical mangrove ecosystems and one of the most significant natural laboratories for investigating Quaternary sea-level change, delta evolution, monsoon variability, and coastal ecosystem resilience. Owing to its strategic position at the interface of fluvial, tidal, and marine processes, the Sundarbans preserve a continuous archive of Holocene environmental change that has attracted multidisciplinary research for more than four decades.

Early investigations established the geological and palynostratigraphic framework of the Bengal Basin and demonstrated that Holocene estuarine sediments preserve well-defined records of marine transgression, regression, and mangrove succession (Sen & Banerjee, 1990; Banerjee, 1991). These pioneering studies showed that fossil pollen, dinoflagellates, foraminifera, and sedimentary facies record the response of coastal ecosystems to relative sea-level fluctuations, salinity changes, and estuarine evolution. Subsequent research integrated radiocarbon chronology, palynology, sedimentology, and stratigraphy to reconstruct Holocene mangrove development and palaeoenvironmental evolution. Numerous sediment-core investigations revealed that mangrove communities dominated by Heritiera, Rhizophora, Sonneratia, Avicennia, Bruguiera, Excoecaria, and Phoenix responded dynamically to changes in monsoon intensity, freshwater discharge, sediment supply, and relative sea level throughout the last ~7000 years (Das, 2014; Kar & Quamar, 2018).

Regional geological studies further demonstrated that the evolution of the Sundarbans is governed by the combined influences of eustatic sea-level change, neotectonic subsidence, Himalayan sediment delivery, tidal hydrodynamics, and channel migration, rather than sea-level change alone (Goodbred & Kuehl, 2000; Allison, 1998; Alam et al., 2003). These studies established the Sundarbans as one of the world's most dynamic deltaic environments and highlighted its sensitivity to future climate change.

Recent investigations have adopted multiproxy approaches, integrating palynology with sedimentology, micropalaeontology, stable isotope geochemistry, elemental geochemistry, remote sensing, GIS, and numerical modelling to reconstruct high-resolution Holocene environmental histories. These studies have strengthened the role of mangrove sediments as valuable archives for understanding monsoon variability, coastal sediment dynamics, blue-carbon sequestration, ecosystem resilience, and adaptation to accelerating sea-level rise (Rogers et al., 2019; Woodroffe et al., 2006).

An important advance has been the development of modern pollen–vegetation calibration datasets for the Indian Sundarbans. Modern pollen rain studies conducted at Sajnekhali established quantitative relationships between contemporary mangrove vegetation and pollen assemblages, providing a robust modern analogue for interpreting fossil pollen records and improving reconstructions of Holocene vegetation dynamics, salinity gradients, and coastal environmental change (Pandey & Minckley, 2019).

Outstanding Research Issues

Despite substantial progress, several fundamental questions remain unresolved:

• The relative contributions of eustatic sea-level rise, tectonic subsidence, and sediment accretion in controlling long-term mangrove stability remain poorly quantified.

• Spatial variability in the timing of Holocene mangrove establishment across the Sundarbans indicates that delta evolution was highly heterogeneous, but the mechanisms driving this diachroneity remain uncertain.

• High-resolution chronologies linking sediment accumulation, peat formation, and mangrove migration are still sparse across many sectors of the delta.

• The response thresholds of mangrove ecosystems to future accelerated sea-level rise, changing sediment supply, and increasing cyclone frequency remain inadequately constrained.

• Greater integration of geological archives with modern ecological observations, blue-carbon assessments, hydrodynamic modelling, and remote sensing is required to improve predictions of future coastal resilience.

Relevance to the INQUA 2027 Field Excursion

The Sajnekhali–Sudhanyakhali–Dobanki–Jharkhali field transect has been specifically designed to examine these outstanding scientific questions in the field. Participants will observe modern analogues of Holocene depositional environments, explore the modern pollen–vegetation calibration site at Sajnekhali (Pandey & Minckley, 2019), examine the well-studied palynological sequences of Sudhanyakhali, investigate active sediment accretion and erosion at Dobanki, and evaluate the influence of human modification and coastal adaptation at Jharkhali. The excursion therefore provides an integrated framework linking Quaternary geological archives with contemporary coastal processes, directly supporting the scientific objectives of INQUA 2027 and the conference theme, "Quaternary Science as Societal Services."

Field Transect

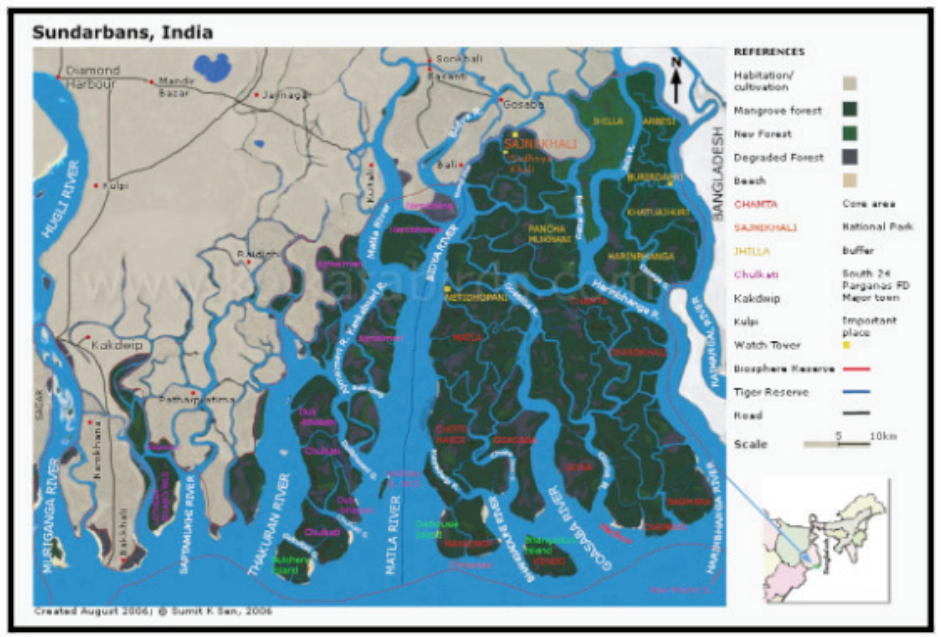
The field transect traverses the Indian Sundarbans Biosphere Reserve, one of the world's largest tide-dominated deltaic systems and an exceptional natural laboratory for Quaternary research. The accompanying field map illustrates the regional geological framework, Holocene depositional units, major road and waterway networks, and the sequence of excursion stops across representative mangrove, tidal, and estuarine environments.

The transect is designed to demonstrate the interactions among Quaternary sea-level change, monsoon variability, sediment dynamics, delta evolution, and mangrove ecosystem responses. Participants will examine modern depositional processes alongside geological archives that preserve evidence of Holocene environmental change, providing direct insights into coastal evolution, ecosystem resilience, and climate adaptation.

In addition to its outstanding geological significance, the Sundarbans is a globally recognized biodiversity hotspot and a UNESCO World Heritage Site, renowned as the only mangrove ecosystem that supports the Royal Bengal Tiger (Panthera tigris tigris). The field excursion offers an exceptional opportunity to observe this unique habitat and its rich biodiversity, including estuarine crocodiles, spotted deer, water monitor lizards, diverse avifauna, and aquatic fauna. With favourable conditions and a measure of good fortune, participants may even have the rare opportunity to sight the iconic Royal Bengal Tiger in its natural mangrove habitat, making this an unforgettable scientific and wilderness experience.

This transect provides a unique opportunity to experience the Indian Sundarbans as a living archive of Quaternary climate and sea-level history, where world-class geological records, exceptional biodiversity, and one of the planet's most iconic apex predators together illustrate the intimate links between Earth's past, present ecosystems and future coastal resilience.

Route Logistics		
From > To	**Mode**	**Approx. Distance/Time**
Kolkata > Godkhali Ferry Ghat	Road	~100 km/~3 hrs
Godkhali > Sajnekhali Island (Stop 1)	Boat (tidal creek)	~1.5 hrs
Sajnekhali Island > Sudhanyakhali Island (Stop 2)	Boat	~45 min
Sajnekhali Island > Dobanki Island (Stop 3)	Boat	~45 min
Sajnekhali Island > Godkhali > Jharkhali (Stop 4)	Boat-Road	~3-3.5 hrs



Location(s) Description

1. Sajnekhali Island

Sajnekhali sits at the confluence of the Gumdi and Matla rivers, within the tide-dominated buffer zone of the reserve. It exhibits classic mangrove-fringed point-bar and levee morphology of an actively meandering tidal channel a low intertidal mudflat grading landward into a stabilised, vegetated supratidal platform (Hossain et al., 2019; World Bank, 2019). The near-surface sequence is fine-grained, organic-rich tidal-flat silty clay interbedded with thin sand laminae from spring-tide and storm-surge events, capped by root-penetrated, bioturbated mangrove peat the fining-upward, tide-reworked signature typical of the abandoned, non-fluvially-sourced western delta lobe (Goodbred and Kuehl, 2000). No dedicated core yet exists for Sajnekhali. Chronological control is inferred by correlation with the nearest dated sequences in the reserve — Chamta and Sudhyanyakhali, at ~5,960 and ~1,520 cal yr BP basal mangrove ages respectively (Hait and Behling, 2019)

leaving Sajnekhali's own establishment age an open question for this field stop. Sajnekhali serves as the modern analogue site for interpreting Quaternary mangrove records. Modern pollen rain investigations conducted by Pandey and Minckley (2019) established quantitative pollen–vegetation relationships across the Sajnekhali Island Wildlife Sanctuary, demonstrating that contemporary pollen assemblages faithfully represent the existing mangrove vegetation and salinity gradients. These modern calibration datasets provide a robust framework for interpreting fossil pollen records, reconstructing Holocene mangrove dynamics, relative sea-level change, and palaeoenvironmental evolution in the Indian Sundarbans.

Regional XRF/XRD studies show K, Rb, Fe, Ti, Zr and Ca function as robust grain-size proxies in this clastic, tide-dominated delta setting, enabling high-resolution, non-destructive core-scan reconstruction of channel-margin versus open-mudflat facies directly applicable to any core collected here. This island hosts the reserve's Mangrove Interpretation Centre, a watchtower, the Bono Bibi temple, a Tiger Reserve station office, and crocodile/turtle breeding grounds — the trip's natural orientation hub (Sundarban Tiger Reserve, official site). As the trip's orientation stop, Sajnekhali anchors the modern ecological and geomorphic baseline against which the more deeply dated sequences downstream will be compared.





2. Sudhanyakhali Island

Sudhanyakhali lies along the Datta River, on a slightly more elevated, less frequently inundated platform than Sajnekhali, reflected in the site's mature climax mangrove stands and lower observed inundation frequency (Hait and Behling, 2019). This is the best-documented site on the transect: Hait and Behling's (2019) cored sequence recovered a lower, less humified mangrove peat unit transitioning upward into a more oxidised, root-mottled surface facies, consistent with progressive platform stabilisation and reduced tidal influence through the late Holocene a pattern broadly consistent with the fining-upward, stabilising deltaic facies trends documented across the western Sundarbans (Goodbred and Kuehl, 2000).

Radiocarbon dating of the Sudhyanyakhali core places the onset of mangrove peat accumulation at approximately 1,520 cal yr BP markedly younger than the ~5,960 cal yr BP basal age recovered at Chamta, some tens of kilometres distant (Hait and Behling, 2019). This ~4,400-year diachroneity in mangrove establishment between two islands of the same reserve echoes the discrete, spatially uneven subsidence and accommodation-space history documented elsewhere in the delta (Hanebuth et al., 2013, 2022; Grall et al., 2018), and is one of the central open problems this field trip is designed to interrogate directly.

Modern pollen-rain calibration at this site shows strong correspondence between surface pollen assemblages and standing vegetation (Hait and Behling, 2019), validating the use of the fossil pollen record here as a faithful proxy for past mangrove zonation. Complementary elemental (XRF) and grain-size data from comparable Sundarbans cores indicate a shift toward finer, more chemically weathered sediment upward, consistent with decreasing channel-margin energy as the platform mature.

Sudhanyakhali's watchtower overlooks a freshwater pond that draws wildlife to drink, and is paired with a planted Mangrove Park featuring labelled specimens of the reserve's principal species a direct, walkable complement to the site's palynological record, letting delegates cross-check fossil pollen taxa (Heritiera, Excoecaria, Phoenix paludosa) against living, identified trees (Sundarban Tiger Reserve, official site). This island provides the transect's most rigorously dated single-site palaeoecological record and is the key locality for direct ground-truthing of pollen taxa against living vegetation (Hait and Behling, 2019).

Geographic Coordinates of the Field Excursion Stops

Field Stop	Latitude (N)	Longitude (E)	Elevation (m asl)	Remarks
Godkhali Jetty	22.272° N	88.769° E	~3	Road–boat embarkation point
Sajnekhali Interpretation Centre & Watch Tower	22.112° N	8.768° E	~2	Modern pollen calibration site; Interpretation Centre; Watch Tower
Sudhanyakhali Watch Tower	22.085° N	88.766° E	~2	Mangrove succession; wildlife observation; Holocene palynological locality
Dobanki Canopy Walk	22.118° N	88.804° E	~2	Mangrove canopy walk; active erosion–accretion; geomorphology
Jharkhali Nature Interpretation Centre	22.013° N	88.729° E	~3	Human-modified delta; mangrove restoration; interpretation centre


SUBHANYAKHALI BEAT
SAJNEKHALI
WILDLIFE SANCTUARY
GOVT. OF W.B., S.T.R.
WELCOME TO SUNDARBAN

3. Dobanki Island

This island is located within the Sundarban Tiger Reserve of the Indian Sundarbans Biosphere Reserve, is one of the most informative sites for understanding the interaction between Quaternary coastal evolution and modern mangrove ecosystem dynamics. Situated in the tide-dominated lower Ganga–Brahmaputra–Meghna Delta, the island provides an outstanding natural laboratory where active geomorphic processes can be directly linked to Holocene geological archives (Allison, 1998; Goodbred & Kuehl, 2000; Woodroffe et al., 2006).

The landscape comprises tidal creeks, intertidal mudflats, mangrove swamps, natural levees, and accreting point bars developed over Holocene estuarine silts, clays, fine sands, and organic-rich peat. Continuous tidal inundation, sediment accretion, and creek-bank erosion illustrate the dynamic balance between sediment supply and relative sea-level rise that has governed delta evolution throughout the Quaternary (Goodbred & Kuehl, 2000; Rogers et al., 2019).

Regional AMS radiocarbon dating indicates that these sediments accumulated primarily during the mid- to late Holocene (~7 ka to present). Organic carbon-rich sediments, together with stable isotopes and elemental geochemistry, preserve valuable records of mangrove productivity, salinity changes, sediment provenance, and palaeoenvironmental evolution, highlighting the Sundarbans as one of the world's important blue-carbon ecosystems (Banerjee et al., 2012; Rogers et al., 2019).

Dobanki supports diverse mangrove communities dominated by Heritiera fomes, Avicennia marina, Avicennia officinalis, Rhizophora mucronata, Sonneratia apetala, Bruguiera gymnorhiza, Ceriops decandra, Excoecaria agallocha, and Phoenix paludosa. The distinct vegetation zonation reflects tidal inundation and salinity gradients and provides an excellent modern analogue for interpreting fossil pollen records and reconstructing Holocene mangrove evolution (Tomlinson, 2016; Pandey & Minckley, 2019). The highlight of Dobanki is its approximately 500 m elevated canopy walkway, one of the longest mangrove canopy walks in India. Constructed above the forest floor, it offers an unparalleled perspective of the mangrove canopy, tidal creeks, and sedimentary landscape while minimizing disturbance to wildlife. The adjacent watch tower provides excellent opportunities to observe spotted deer (Axis axis), estuarine crocodiles (Crocodylus porosus), water monitor lizards (Varanus salvator), rich avifauna, and, with favourable conditions, the Royal Bengal Tiger (Panthera tigris tigris), making Dobanki one of the premier wildlife observation sites in the Sundarbans (Gopal & Chauhan, 2006; UNESCO, 1987).


স্বাগতম
WEL COME
দোবাঙ্কী ক্যাম্প
DOBANKI CAMP
সুন্দরবন ব্যাঘ্র প্রকল্প
Sundarban Tiger Reserve

4. Jharkhali

Jharkhali is a mainland-fringe village in the Basanti block of South 24 Parganas, on the western edge of the Sundarban Tiger Reserve along the Matla–Herobhanga river system. Rapidly developing as the "New Gateway to the Sundarbans," it offers road access that the boat-only Godkhali jetty cannot, serving as the launch point for the western reserve circuit — Dobanki, Netidhopani, Bonnie Camp, Kalash Dweep, and Haliday Island.

Geomorphologically, Jharkhali stands apart from the rest of the transect. It sits at the landward, embanked margin of the delta plain, where reclaimed agricultural land meets the reserve's outer buffer forest across an artificial dike in direct contrast to the natural, unembanked tidal platforms at Sajnekhali, Sudhanyakhali, Dobanki, and Netidhopani. This makes it a living case study of the engineered coastal margin, illustrating exactly how embankment has disrupted natural accretion and salinity regimes since the 18th–19th centuries. The village itself is built on reclaimed, historically diked tidal-flat sediment now under paddy and aquaculture giving delegates a walkable, before-and-after contrast between an engineered coastline and the natural stratigraphic-ecological gradient the rest of the trip explores.

Jharkhali also anchors the trip's orientation infrastructure like a Tiger Rescue and Rehabilitation Centre, a Mangrove Interpretation Centre, deer park, butterfly garden, crocodile and bird enclosures, and a watchtower overlooking the surrounding creeks — a natural complement to Sajnekhali's own interpretation centre as the excursion's opening briefing point.

Field Transect and Itinerary

Duration: 4 Days (04–07 February 2027)

Mode of Travel: Road (Kolkata–Godkhali–Jharkhali) and Chartered Motor Launch/Boat within the Sundarban

Day	Route / Scheduled Halt	Major Scientific Activities	Overnight Stay
Day 1	Kolkata > Godkhali Jetty > Sajnekhali Interpretation Centre	Registration, boat embarkation, introduction to the Sundarbans Biosphere Reserve, modern pollen–vegetation relationships, mangrove ecology, Sajnekhali Watch Tower	Sajnekhali Tourist Lodge / WBTDC Sajnekhali Tourist Lodge or equivalent Forest Department accommodation

Day 2	Sajnekhali > Sudhanyakhali > Dobanki	Holocene palynology, mangrove succession, sedimentology, geomorphology, canopy walk, wildlife observation	Sajnekhali Tourist Lodge or equivalent
Day 3	Sajnekhali > Dobanki > Jharkhali	Tidal geomorphology, estuarine sedimentation, coastal erosion–accretion, anthropogenic modifications, interpretation of Quaternary archives	Jharkhali Nature Camp / WBTDC Jharkhali Tourist Complex or equivalent
Day 4	Jharkhali > Godkhali > Kolkata	Discussion, synthesis, return journey	Excursion concludes

Accommodation

Accommodation will be arranged in government-approved eco-tourism lodges and tourist facilities operated by the West Bengal Tourism Development Corporation (WBTDC) or the West Bengal Forest Department, subject to availability.

Proposed Accommodation Facilities :

• WBTDC Sajnekhali Tourist Lodge, Sajnekhali

• Sundarban Tiger Camp, Dayapur Island (if required)

• Sajnekhali Forest Rest House (subject to Forest Department permission)

• WBTDC Jharkhali Tourist Complex (Jharkhali Nature Camp), Jharkhali

• Equivalent accommodation may be used depending on participant numbers and booking availability.

Embarkation and Disembarkation Points

Route	Distance
Kolkata > Godkhali	~100 km (Road)
Godkhali > Sajnekhali	~22 km (Boat)
Sajnekhali > Sudhanyakhali	~6 km (Boat)
Sudhanyakhali > Dobanki	~12 km (Boat)
Dobanki > Jharkhali	~18 km (Boat)
Jharkhali > Godkhali	~16 km (Road/Boat depending on itinerary)

- **Starting Point:** Kolkata
- **Road Transfer:** Kolkata > Godkhali Jetty (~100 km; approximately 3 hours)
- **Boat Embarkation:** Godkhali Jetty
- **Scientific Transect:** Sajnekhali > Sudhanyakhali > Dobanki > Jharkhali
- **Boat Disembarkation:** Jharkhali/Godkhali
- **Return:** Godkhali > Kolkata

Geoheritage, UNESCO Heritage, Archaeology, and Culture of the Sundarbans Region

UNESCO Heritage Status — The Anchor Designation

the Sundarbans itself carries a nested stack of international recognitions — UNESCO World Heritage Site (1987), UNESCO Man and Biosphere Reserve (2001), and Ramsar Wetland of International Importance (2019) making it one of the few Quaternary field-trip destinations anywhere that is simultaneously a global geoscientific archive and a globally protected cultural-natural landscape. This dual status is the framing device for everything that follows: the region's geoheritage and human heritage are inseparable, both products of the same restless, subsiding, tide-built delta.

A Wider Archaeological Landscape — The Deltaic Heritage Corridor

The Sundarbans sits within a much larger archaeological landscape that UNESCO has formally recognised as significant: the "Archaeological Sites on the Deltaic Landscape of Bangladesh" entry on UNESCO's Tentative World Heritage List explicitly identifies a cluster of sites across the wider Ganges–Brahmaputra delta including, on the Indian side, Tamluk, Chandraketugarh, Mahishadal, Sagar Island, and the Jatar Deul temple dating back to roughly the third–fourth century BCE, with the delta's rivers and water bodies continuously reshaping the landscape over the past 5,000–6,000 years. This framing is directly relevant to an INQUA congress: it positions the entire lower Bengal delta as a single interlinked archive of Quaternary landscape change and early human settlement, of which the Sundarbans is the living, actively-evolving remnant.



• **Chandraketugarh** (~35 km northeast of Kolkata, on the Bidyadhari River) — sometimes called "Bengal's Harappa," a 2,500-year-old fortified settlement with continuous occupation from the pre-Mauryan period through the Sunga, Kushana, Gupta, and Pala periods, yielding exceptional terracotta art, punch-marked silver coins, and identification with the ancient kingdom of Gangaridai, described by Greek and Roman geographers including Ptolemy. Excavations by the University of Calcutta's Asutosh Museum since the 1950s have revealed near-continuous stratigraphic sequences directly comparable in method to the Quaternary coring approach used across the Sundarbans transect.

• **Tamluk (ancient Tamralipti)**, near Haldia — a major ancient port linking the Bengal delta to Java, Sumatra, Malaysia, and Sri Lanka, whose eventual abandonment as the Ganges shifted course is itself a direct human record of the same deltaic channel migration and delta-lobe switching.

• **Sagar Island and Jatar Deul temple** — coastal/deltaic sites at the seaward margin of the delta, offering additional built-heritage sea-level and subsidence indicators comparable in principle to the submerging Netidhopani temple within the reserve itself.

Representative artefacts recovered from the Lower Bengal Delta include:

- Terracotta plaques depicting human and animal figures
- Punch-marked silver coins
- Beads and ornaments
- Pottery and ceramic assemblages
- Seals and sealings
- Early historic sculptures

These artefacts provide direct evidence of long-standing human occupation and demonstrate how settlements evolved alongside the changing Quaternary deltaic landscape.





Living Culture of the Delta

The Sundarbans' human culture is inseparable from its hydrology and its apex predator, and understanding it enriches the scientific narrative of the trip:

• **Bonbibi, the Forest Goddess** — worshipped jointly by Hindu and Muslim communities across the reserve, Bonbibi is invoked by honey-collectors (Mouley), fishermen, and woodcutters before entering the forest, as protector against tiger attack; her shrine at Sajnekhali is a living cultural counterpart to the reserve's ecological and geomorphic hazards.



• **Honey collection** — a centuries-old seasonal livelihood, harvested chemical-free from the dense mangrove forest during the dry season (April–May), representing one of the reserve's key non-timber forest products and a direct human dependency on the same mangrove zonation.

• **"Tiger widows" (Bagh Bidhoba)** — a recognised and studied social phenomenon in Sundarbans villages, reflecting the ongoing human cost of coexistence with the Royal Bengal Tiger, and a poignant reminder of the societal stakes underlying the Congress's "Quaternary Science as Societal Services" theme.

• **Deltaic boat culture** — since no road network penetrates the reserve, an entire material culture of country boats, tidal-timed travel, and river-based settlement has developed around the same tidal regime that governs the field trip's own logistics. The vicinity also contains several sites of historical and archaeological significance. Kolkata, the gateway to the Sundarbans, is renowned for its colonial architecture and cultural heritage, including the Indian Museum, Victoria Memorial, Fort William, and Marble Palace. Along the lower Hooghly River, important heritage landmarks such as Bishnupur, Diamond Harbour, and the Jatar Deul (11th-century brick temple) reflect the rich archaeological history of the Bengal delta and its long-standing maritime and cultural connections. The Sundarbans possess a unique

living cultural heritage, shaped by centuries of coexistence between local communities and the mangrove landscape. Traditional beliefs centred on Bonbibi, the guardian deity of the forest, the Bonbibir Pala folk theatre, Bhatiyali boatmen's songs, and Jhumur folk traditions illustrate the intimate relationship between people and nature and form an integral part of the region's intangible cultural heritage. The regional cuisine reflects the estuarine environment and Bengal's rich culinary traditions. Participants will have the opportunity to experience authentic Bengali cuisine featuring Hilsa (Ilish), Bhetki, Prawn (Chingri), Mud Crab, freshwater fish preparations, locally harvested honey, and traditional sweets such as Rasgulla, Sandesh, and Mishti Doi. The excursion thus combines world-class Quaternary geology, UNESCO-recognized natural heritage, rich biodiversity, cultural traditions, archaeological heritage, and regional gastronomy, providing participants with a truly interdisciplinary experience of the Sundarbans landscape.

Kolkata — The Cultural and Scientific Gateway

For delegates transiting through Kolkata route to the Sundarbans, the city offers a complementary heritage dimension: the Indian Museum (established 1814, the oldest and largest museum in Asia) and the Asutosh Museum of Indian Art at the University of Calcutta hold major collections of Chandraketugarh terracottas and delta-region antiquities, offering a curated preview of the archaeological landscape described above before delegates ever reach the field. Kolkata's own colonial-era built heritage — Victoria Memorial, the Indian Museum building, Howrah Bridge, and the city's tram network situates the congress within a living palimpsest of Bengal's deltaic, colonial, and post-colonial history, bridging the region's deep Quaternary past with its present-day societal and urban present.

Local Conveniences

To ensure a safe and comfortable field experience, the Sajnekhali – Sudhanyakhali – Dobanki – Jharkhali excursion is supported by medical, administrative, communication, banking, and emergency services available at Jharkhali, Godkhali, Gosaba, Basanti, Canning, and Kolkata. As all field localities within the Sundarban Tiger Reserve are accessible only by boat, participants should follow the instructions of the field leaders and forest authorities at all times.

Medical Facilities

Medical facilities within the core mangrove reserve are limited; therefore, emergency evacuation from Sajnekhali, Sudhanyakhali, and Dobanki is by boat to the mainland before onward transfer by road.

Level	Medical Facility	Location	Remarks
Primary Care	Jharkhali Rural Hospital	Jharkhali	First aid, routine medical care, emergency stabilization
	Gosaba Rural Hospital	Gosaba	Government hospital with emergency services
	Basanti Block Primary Health Centre	Basanti	Primary healthcare facility
Secondary Care	Canning Sub-Divisional Hospital	Canning	Referral hospital for the Sundarbans region
Tertiary Care	SSKM Hospital, Apollo Multispecialty Hospital, AMRI Hospitals, Peerless Hospital	Kolkata	Advanced trauma care, intensive care, cardiac and specialist services

Emergency Telephone Numbers

Service	Telephone Numbers
National Emergency Response	112
Ambulance	108
Fire & Rescue	101
Police	100 (or 112)
Disaster Management	1070 (State Emergency Operations Centre)
Coast Guard Emergency	1554
Women Helpline	1091

Passport and Consular Assistance

If a passport or other travel document is lost or stolen during the excursion, participants should take the following steps immediately:

1. Inform the Field Excursion Leaders without delay and file a First Information Report (FIR) at the nearest police station (Basanti, Gosaba, Canning, or Kolkata). An FIR is required for the replacement of a lost or stolen passport.

2. International participants should immediately contact their respective Embassy or Consulate in Kolkata (where available) or New Delhi to obtain an Emergency Passport or Emergency Travel Certificate. The Embassy/Consulate will normally require:

- Copy of the FIR
- Passport-sized photographs
- Identity proof or photocopy of the lost passport
- Completed emergency passport application

3. Indian participants should report the loss through the Passport Seva Portal and apply for passport re-issue through the Regional Passport Office (RPO), Kolkata. Tatkal services may be available depending on eligibility.

4. Foreign nationals who lose their passport together with a valid Indian visa must also obtain an Exit Visa from the Foreigners Regional Registration Office (FRRO), Kolkata before leaving India.

5. Participants are strongly advised to carry both printed and electronic copies of their passport, visa, travel insurance, airline tickets, and conference registration documents separately from the originals.

Service	Telephone Numbers
National Emergency Helpline	112
Police	100 (or 112)
Ambulance	108
Fire	101
Cyber Crime Helpline	1930
Passport Seva Helpline	1800-258-1800 (Toll Free, India)
Passport Seva Portal	https://www.passportindia.gov.in
Ministry of External Affairs – MADAD	https://www.madad.gov.in
FRRO Kolkata	+91-33-2281-5276 (verify before travel)
Regional Passport Office, Kolkata	+91-33-2280-7923 (verify before travel)

Banking and ATM Facilities

Banking and ATM services are available at Canning, Basanti, Gosaba, and Jharkhali, with branches of major nationalized and private-sector banks including the State Bank of India (SBI), Punjab National Bank (PNB), UCO Bank, Bandhan Bank, and Indian Bank. ATM facilities are generally available in these towns; however, cash availability and network connectivity may be limited during peak tourist seasons or adverse weather conditions.

Participants are advised to carry a moderate amount of Indian Rupees (INR) for incidental expenses, as digital payment services and internet connectivity may be intermittent within the remote islands of the Sundarbans.

Useful Banking Contacts

Service	Contact Number / Website
State Bank of India (Customer Care)	1800 1234 / 1800 2100
Punjab National Bank	1800 180 2222 / 1800 103 2222
Indian Bank	1800 425 00000
Bandhan Bank	1800 258 8181
UCO Bank	1800 103 0123
NPCI – UPI Helpdesk	1800 120 1740
Visa Global Assistance	+1-303-967-1096 (International)
Mastercard Global Emergency Services	+1-636-722-7111 (International)

Nearest Banking Centres

Location	Facilities Available
Canning	SBI, PNB, UCO Bank, Indian Bank, multiple ATMs, currency withdrawal
Basanti	SBI, Bandhan Bank, ATMs
Gosaba	SBI branch, ATM, digital payment facilities
Jharkhali	ATM facilities, digital payment accepted at selected hotels and tourism establishments

Communication

Mobile network coverage is generally available at Godkhali, Jharkhali, Gosaba, and Canning, but is intermittent to absent within the core mangrove forest and during boat transit. Participants should inform family/colleagues in advance of possible temporary communication interruptions during the field days.

Markets and Essential Supplies

Local markets at Jharkhali, Godkhali, Gosaba, and Canning provide essential provisions — bottled water, snacks, toiletries, batteries, and rainwear — for last-mile needs before boat departure. Kolkata offers comprehensive shopping for field equipment, outdoor clothing, pharmaceuticals, and travel accessories before or after the excursion, including several markets of particular cultural and commercial note:

Textiles and fabrics

• Gariahat Market — Kolkata's principal saree hub: Bengal cotton (Tant/Taant), Baluchari silk, Dhakai Jamdani, and Kantha-stitch embroidery.

• New Market (Hogg Market) — a colonial-era covered market (est. 1874) for handloom, leather goods, spices, and sweets.

• Burrabazar — Asia's largest wholesale market, for textiles and trade goods at wholesale prices.

• Dakshinapan Shopping Complex — state-government emporiums offering authenticated, fixed-price Bengal handicrafts and handloom.

Crafts and handicrafts

• Kumartuli — the historic potters' quarter, for clay/terracotta idol and figurine work.

• Sholapith crafts, Bankura terracotta horses, Kalighat paintings, and silver filigree (rupa tarkashi) — available through Dakshinapan and Kolkata's craft emporiums and jewellery districts (Bowbazar).

Books

• College Street (Boi Para) — the world's largest second-hand book market, alongside the historic Indian Coffee House.

Sweets and specialty foods

• Sandesh, Rosogolla, Mishti Doi from established houses (e.g., K.C. Das, Balaram Mullick & Radharaman Mullick), and Darjeeling/Assam tea, both easily packable souvenirs of the region.

Emergency Support

The excursion is accompanied throughout by experienced scientific coordinators, trained boat personnel, and authorised Forest Department guides. Emergency communication equipment, first-aid kits, and local emergency contact information are maintained throughout the transect. Participants are requested to follow all safety instructions issued by the organisers and forest authorities at all times.

Conclusion

This field excursion offers INQUA 2027 delegates a rare opportunity: to walk, in a single day, through the full architecture of a delta's response to sea-level change — from the Bengal Basin's tectonic framework, through a near-complete Holocene mangrove record, into a landscape still writing that story today, both where nature shapes it and where engineering has tried to reshape it.

The Sajnekhali–Sudhanyakhali–Dobanki–Jharkhali transect was chosen deliberately, each stop answering a different facet of one question: how does a tide-dominated, subsiding mangrove delta respond to sea-level rise and what changes when that response is engineered against? Sajnekhali anchors the modern ecological and geomorphic baseline. Sudhanyakhali offers the reserve's most rigorously dated palaeoecological record, alongside its own unresolved chronology. Dobanki turns subsidence and accretion into something delegates can stand on, from a canopy walkway suspended above the very process under study. Jharkhali delivers the sharpest lesson of all: an embanked, reclaimed coastal margin standing in direct contrast to everything seen upstream — visible proof of how thoroughly human intervention has already reshaped natural accretion and salinity regimes.

That contrast is the point. Three stops show a delta still behaving as it has for millennia; the fourth shows what happens when that system is diked and converted to paddy and aquaculture. Few transects let a single day double as a natural experiment in the very intervention now being proposed, cautiously and at scale, as climate adaptation across the wider delta.

The transect is deliberately unfinished, like the science behind it. The diachroneity between Chamta and Sudhyanyakhali, the absence of dated cores at Sajnekhali and Dobanki, and the untested link between geomorphic subsidence and biological proxies remain open. Jharkhali adds one more: how much of the Sundarbans' natural resilience survives the shift to an embanked coastline — a question with direct bearing on adaptation strategy elsewhere in the delta.

This is exactly where the transect meets the Congress's theme. The same processes recorded across Sajnekhali, Sudhanyakhali, and Dobanki now threaten the world's largest mangrove forest; Jharkhali shows one community's real-time attempt to hold the line. Reading both the natural record and its engineered counterpart correctly is the evidence base for coastal-hazard planning, mangrove restoration, and adaptation strategy across one of the most densely populated, climate-exposed deltas on Earth.

We hope delegates leave not simply having seen the Sundarbans, but having identified where their own expertise — dating, geochemistry, modelling, palaeoecology, restoration science — could close one of the gaps this guide leaves open. The Sundarbans has already given up much of its Holocene history. What remains to be read, and decided, about its future rests, in part, with the delegates who walk this transect at INQUA 2027.

Acknowledgement

The organisers gratefully acknowledge the Principal Chief Conservator of Forests (Wildlife) & Chief Wildlife Warden, West Bengal, and the West Bengal Forest Department, for granting access and permits to the buffer and core zones covered in this excursion, and for their continued stewardship of the conservation and research infrastructure at Sajnekhali, Sudhanyakhali, Dobanki and Jharkhali.

We thank the Field Director and Deputy Field Director, Sundarban Tiger Reserve, and the Sundarban Biosphere Reserve administration, for facilitating permits and logistical arrangements across the transect, and the Department of Sundarban Affairs, Government of West Bengal, for its continued support of research access in the region.

We are sincerely thankful to the Director, Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, for institutional support, scientific guidance, and encouragement in the planning and execution of this field excursion, and for BSIP's continued leadership in advancing Quaternary and palaeoecological research in India.

We are grateful to the local Forest Range Offices at Sajnekhali and Jharkhali and to the boat crews, licensed local guides, and forest watchers of the Godkhali–Gosaba–Sundarbans circuit, whose navigational skill, tidal knowledge, and wildlife expertise are indispensable to the safe conduct of this excursion, and without whom no part of this transect would be possible.

We acknowledge with appreciation the researchers whose published work underpins this guide particularly the palaeoecological, geochronological and geochemical studies cited throughout Sections 4, 10, and 12 and thank them for building the scientific foundation on which this field excursion stands.

We thank the International Union for Quaternary Research (INQUA) and the Organising Committee of INQUA 2027 for the opportunity to convene this excursion as part of the Congress programme, and for their support in aligning the trip with the Congress's focal theme, Quaternary Science as Societal Services.

Finally, we thank the local communities of the Sundarbans — the honey-collectors, fishermen, boatmen and villagers of Jharkhali, Gosaba, and Basanti whose generations of coexistence with this landscape, and whose generosity in welcoming visiting researchers, make this excursion possible in the truest sense.

Budget Required to Conduct the Proposed Field Trip:

Travel from Lucknow to proposed sites will include all transport modes as below:

Per person costs (INR)				
Travel (INR)		**Food**	**Lodging**	**Field material, permits, field assistants, guide etc.**
Air (to & from)	30,000/-	5,000/- per day (breakfast, lunch and dinner)	4,000/- per day single/double occupancy (AC Room)	2,800/- per person
Air (to & from)	4,000/-			
Air (to & from)	5,000/-			
39,000/-		5,000/-	4,000/-	2,800/-

Grand Total: approx. INR 50,800/- per person **(~460 Euro per person)**

Maximum capacity for this field trip 50 person

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

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.

8. Do not photograph restricted installations, sensitive locations, or local residents without prior permission.

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

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