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Archaeo-Botanical Analysis in Odisha: A Review of the Botanical Evidence from Golbai Sasan and Suabarei

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ABSTRACT

Archaeo-botanical work from the coastal lowlands of Odisha has begun to fill a long-standing geographic gap in South Asian palaeobotany. Excavations and flotation/phytolith sampling at Neolithic–Chalcolithic mound sites provide direct evidence of crop choices, cultivation strategies and crop processing activities. This review synthesizes archaeobotanical research from coastal Odisha, focusing on two influential Neolithic–Chalcolithic mounded settlements: Golbai Sasan (Khurda/near Chilika) and Suabarei (Puri district). Systematic flotation, macrobotanical identification, phytolith analysis and direct AMS radiocarbon dating have produced robust plant assemblages that document rice (Oryza sativa) as the principal staple in these coastal occupations, accompanied by a consistent complement of pulses (horse gram, mung/green gram, urd/pigeon pea) and low-frequency small millets and wild grasses. Suabarei is notable for a directly dated rice grain (calibrated to 3370–3210 cal BP), which provides an explicit chronological anchor for rice use in the Odisha coastal plain; Golbai Sasan provides a stratified sequence with rice spikelet bases and phytolith assemblages that indicate domesticated rice cultivation over multiple occupational phases. The combined evidence from these sites indicates mixed, resilient cropping systems adapted to estuarine and wetland ecologies rather than exclusive high-input irrigated paddy systems. Integration with faunal, ceramic and geomorphological data

highlights flexible coastal economies that combined cultivation with fishing and foraging. The review evaluates methodological strengths and biases (taphonomy, sampling intensity) and identifies research priorities: expanded flotation across more sites, systematic single-seed AMS dating, geoarchaeological work to resolve cultivation ecologies (wet paddy vs. rainfed), and integration of aDNA/isotopic methods. These priorities will refine models of rice adoption and agricultural intensification along the Bay of Bengal littoral.

1. Introduction

Reconstructing ancient plant use is essential for understanding trajectories of subsistence, economy, landscape management and social change. In South Asia, archaeobotanical methods principally flotation to recover charred macroremains and microscopic analyses of phytoliths and starches have transformed debates about the antiquity and ecology of staple crops, especially rice (Oryza spp.), millets and pulses (Fuller, 2011; Fuller, 2020). Coastal Odisha occupies a critical geographic position on the eastern Indian littoral: riverine plains, estuarine wetlands and lagoons provided diverse ecological niches around which early communities could combine cultivation, fishing and gathering (Harvey et al., 2006). Two mounded settlements Golbai Sasan and Suabarei have yielded high-quality archaeobotanical datasets, making them pivotal points for assessing early cereal cultivation, crop mixtures and human–environment interaction in the Bay of Bengal corridor. This review synthesizes the published macrobotanical and microremain evidence from these sites and integrates the findings with regional archaeobotanical syntheses to draw implications for crop adoption, cultivation ecologies and future research priorities. (See Fuller, 2011; Harvey et al., 2006; Kingwell-Banham et al., 2018 for methodological and regional background).

2. Regional setting and archaeological background

Odisha's coastal plain is shaped by the deltas of several rivers (Mahanadi, Brahmani, Baitarani, Subarnarekha) and a chain of estuarine lagoons (including Chilika), producing a mosaic of tidal flats, seasonally inundated lowlands and elevated ridges suitable for early settlement and cultivation. Archaeologically, the region is characterised by numerous mounded settlements often called "tels" or mounds with Neolithic to Iron Age material culture sequences (Harvey et al., 2006). Many such mounds represent long-lived habitations with stratified deposits that preserve hearths, pits and midden deposits

responsive to flotation sampling (Harvey et al., 2006). Golbai Sasan is among the best-excavated of these mounds and has long been central in discussions of early agriculture in eastern India; Suabarei is a comparably important mounded site in Puri district whose recent archaeobotanical sampling produced a directly dated rice grain (Murphy et al., 2019). Both sites lie within lowland coastal ecologies in which wetland rice cultivation would have been viable, but local geomorphology and hydrology could have encouraged multiple cultivation strategies (e.g. seasonal wet paddy, inundated niches, rainfed plots).

3. Methods in Archaeo-botanical research: standards and practices

Contemporary archaeobotanical practice in South Asia combines recovery by flotation, morphological identification of charred macrobotanical remains (seeds, grains, rachis bases), and microscopic approaches (phytolith and starch grain analysis) to mitigate biases caused by differential preservation (Jones & Rowley-Conwy, 2007; Piperno, 2006). Flotation separates light organic remains (charred seeds and charcoal) from sediments and is the primary method for retrieving macrobotanical evidence; sample volume, stratigraphic context and sampling distribution strongly affect recovery sensitivity and taxonomic representation (Pearsall, 2000). Phytolith analysis is especially valuable in wetland settings where rice phytoliths and grass silica bodies record the presence of Poaceae even when charred grains are rare (Ball et al., 2016). Standard practice also recommends direct AMS dating of single charred grains or spikelet bases where possible to anchor specific crop remains chronologically (Higham et al., 2016). Golbai Sasan and Suabarei studies both employed systematic flotation combined with phytolith work and, for Suabarei, direct dating of a charred rice grain — providing robust datasets for interpretation.

4. Golbai Sasan: site overview and excavation history

Golbai Sasan (often spelled “Golbai” or “Golabai Sasan”) is a major coastal mound traditionally associated with Neolithic–Chalcolithic occupations in Odisha and has been the subject of several systematic excavations and archaeobotanical analysis (Harvey et al., 2006; Kingwell-Banham et al., 2018). Excavations have revealed deep stratigraphic sequences containing habitation deposits, hearths and artisanal debris, enabling targeted sampling for flotation and microremain analyses. The site has been interpreted as a settled, primarily sedentary community with a mixed economy (crops, fishing, exploitation of wetland resources) and long occupational duration spanning the later Holocene. Kingwell-Banham and colleagues published detailed macrobotanical and phytolith results that form the principal dataset on plant use at Golbai Sasan (Kingwell-Banham et al., 2018).

4.1 Chronology and stratigraphic context at Golbai Sasan

Radiocarbon series reported for Golbai indicate Neolithic–Chalcolithic activity across multiple stratigraphic horizons; several dates have been modelled to provide an occupational framework across the mid-to-late Holocene (Kingwell-Banham et al., 2018). The archaeobotanical samples derive from contexts such as hearths, floor deposits and midden layers — contexts that typically preserve agricultural processing and consumption residues (Kingwell-Banham et al., 2018). These stratigraphic data are crucial for interpreting the tempo of crop adoption and change through time.

5. Golbai Sasan: archaeobotanical results

Kingwell-Banham et al. (2018) report a diverse assemblage of charred macrobotanical remains and phytolith spectra from Golbai Sasan. Key findings include:

- **Dominance of rice (Oryza sativa)**: Charred rice grains and domesticated-type spikelet bases are common in multiple contexts, and phytolith assemblages show abundant grass silica bodies consistent with rice cultivation. The morphology of spikelet bases indicates domesticated traits rather than purely wild harvest.

- **Pulses and legumes**: Horse gram (Macrotyloma uniflorum), mung/green gram (Vigna radiata), and other legumes occur in many samples, demonstrating their role in the crop package. Legumes have agricultural significance beyond nutrition because they can improve soil fertility in rotation systems.

- **Minor millets and wild grasses**: Setaria, Echinochloa and other small-grain grasses appear at lower frequencies; in some contexts these likely represent small millets or gathered wild grasses that supplemented the diet.

- **Fruits and woody taxa**: Fragments interpreted as citrus (mesocarp/peel) and a spectrum of charcoal taxa point to the use of tree resources and possibly local arboriculture or exploitation of wild fruit trees.

Taken together, the Golbai assemblage suggests a mixed subsistence economy in which cultivated rice was central but not exclusive; pulses and small grains supported dietary diversity and resilience. The combined macrobotanical-phytolith approach strengthens interpretations because phytoliths document grasses even when charring biases limit seed recovery.

6. Suabarei: site overview and archaeobotanical sampling

Suabarei is a mounded settlement located in the Puri district of coastal Odisha; archaeobotanical sampling was reported by Murphy and colleagues (2019) as part of recent efforts to document Neolithic–Chalcolithic plant use in the eastern coastal plain. Flotation recovered charred grain and seed remains and phytolith sampling supplemented macrobotanical data; importantly, one charred rice grain was submitted for AMS dating, yielding a calibrated age of roughly 3370–3210 cal BP (Murphy et al., 2019). The Suabarei dataset thus provides an explicitly dated occurrence of rice in coastal Odisha and a crop spectrum similar to Golbai Sasan (rice dominant, with pulses and some small millets).

7. Suabarei: archaeobotanical results and significance

Murphy et al. (2019) report the following principal findings from Suabarei:

- **Directly-dated rice**: A single charred rice grain produced a calibrated AMS date of ca. 3370–3210 cal BP, offering direct chronological evidence for rice consumption at the site in the late 4th millennium BP. This new date is significant for regional chronologies of rice adoption.
- **Crop package**: The assemblage includes rice (Oryza sativa cf. subsp. indica), horse gram (Macrotyloma uniflorum), mung bean (Vigna radiata) and possible occurrences of browntop millet (Brachiaria ramosa) and other small millets. The prevalence of pulses indicates they were important complements to rice in the diet and perhaps in agronomic practice.
- **Wild plants and wetland exploitation**: Some remains attributable to wild rice (Oryza rufipogon) and other wetland taxa suggest combined exploitation of wild/managed wetland resources alongside cultivation. This spectrum underscores the blurred line between foraging and farming in transitional economies.

The Suabarei evidence corroborates the interpretation that coastal Odisha communities in the later Holocene practiced mixed agriculture with rice as a central staple, and it crucially anchors such activity to a calibrated date in the late 4th millennium BP (Murphy et al., 2019).

8. Comparative synthesis: Golbai Sasan and Suabarei

When considered together, the Golbai Sasan and Suabarei datasets illustrate several consistent patterns as well as site-level differences:

1. **Rice as a core staple**: Both sites show clear evidence of cultivated rice (macrobotanical grains, domesticated spikelet bases and phytoliths), indicating rice was part of the staple crop package in coastal Odisha from at least the mid-to-late Holocene (Kingwell-Banham et al., 2018; Murphy et al., 2019).

2. **Mixed cropping and dietary buffering**: Pulses (horse gram, mung bean) and occasional small millets at both sites indicate mixed cropping strategies that increase dietary breadth and reduce risk from crop failure. This multi-crop strategy is consistent with other lowland South Asian farming systems where legumes complement cereal staples.

3. **Site-specific differences**: Golbai Sasan's richer charcoal spectrum and reported citrus fragments may reflect stronger engagement with arboriculture, tree-crop use or different local ecological settings compared with Suabarei. Differences may also reflect sampling intensity and preservation. Such variation highlights the need to expand sampling across more mounds to document regional variability.

4. **Chronological anchoring**: Suabarei's directly dated rice grain (c. 3370–3210 cal BP) provides a robust anchor for rice use, while the Golbai Sasan sequence — with multiple radiocarbon dates and stratigraphic modelling — demonstrates continuity of agriculture through broader timescales. Together, these datasets support early rice cultivation in the Bay of Bengal coastal corridor and document crop continuity and variability across sites (Murphy et al., 2019; Kingwell-Banham et al., 2018).

9. Broader implications: rice domestication, dispersal and cultivation ecologies

The Odisha evidence contributes to several longstanding debates in archaeobotany and agricultural history:

9.1 Antiquity and dispersal of rice in South Asia

Archaeobotanical syntheses emphasise multiple fronts and ecologies in the spread of rice across Asia (Fuller, 2011; Fuller, 2020). The Suabarei date and Golbai Sasan sequence confirm that coastal eastern India was an early locus of rice consumption and cultivation, consistent with models that propose varied regional timings and pathways for rice adoption across South Asia (Fuller, 2011; Kingwell-Banham,

2015). The data do not require a single diffusionist model but support mosaic adoption in appropriate ecological niches.

9.2 Wet paddy vs. rainfed cultivation

A persistent challenge is distinguishing wet-paddy irrigation from rainfed or seasonally inundated cultivation using archaeobotanical evidence alone (Richards, 2003). Morphological traits of domesticated rice spikelet bases and phytolith assemblages confirm cultivation, but identifying water management requires integrated geoarchaeological proxies such as palaeosol indicators, sedimentary facies diagnostic of paddy wetting/drying cycles, and weed-flora analysis (Fuller et al., 2014). In Odisha, the coastal geomorphology suggests that inhabitants could have exploited natural wetland niches for low-input water-reliant rice cultivation before the emergence of intensive irrigated paddy systems. Continued geoarchaeological sampling is essential to resolve cultivation modes at Golbai and Suabarei.

9.3 Crop packages and resilience

The combined presence of rice, legumes and small millets indicates labour and ecological partitioning: rice for high caloric returns in wet niches; legumes for protein and soil management; and small millets for cultivation on drier or marginal plots. This diversified package would have enhanced subsistence resilience in variable coastal environments (Fuller, 2011; Harvey et al., 2006).

12. Gaps in knowledge and research priorities for Odisha

Despite the progress represented by Golbai Sasan and Suabarei, several priorities remain:

- Wider geographic sampling should be prioritised by expanding flotation and phytolith programmes to a greater number of mounded settlements, intertidal marshes, and hinterland sites in order to better characterise spatial variability in crop use across Odisha.
- Targeted single-seed AMS dating is required, with increased direct dating of charred grains and spikelet bases to build high-resolution chronologies for crop introduction and agricultural intensification; the successful single-grain date from Suabarei provides a model that should be replicated across multiple sites.
- Integrated geo-archaeological campaigns, including soil micromorphology, palaeosol analysis, and sedimentary facies studies, are necessary to detect evidence of paddy irrigation, raised beds,

or other water-control infrastructure; when combined with weed-flora and weed-phytolith analyses, these methods would provide crucial insights into cultivation regimes.

- Interdisciplinary datasets need to be developed by linking archaeobotanical findings with zooarchaeology, material culture, palaeoclimate records, and ancient DNA, in order to reconstruct socio-ecological systems in a more comprehensive manner.
- Capacity building is essential, particularly through strengthening regional laboratory facilities for flotation, phytolith, and starch analyses, as well as fostering collaborations with established archaeobotanical centres to ensure the continuity and advancement of research in eastern India.

13. Conclusion

Archaeobotanical research at Golbai Sasan and Suabarei has significantly advanced knowledge of prehistoric plant use in coastal Odisha. Both sites demonstrate that rice was a central cultivated staple in the coastal plain's Neolithic–Chalcolithic economies, accompanied by pulses and a suite of small millets and wild plants that contributed to dietary breadth and resilience (Kingwell-Banham et al., 2018; Murphy et al., 2019). Suabarei's directly dated rice grain (c. 3370–3210 cal BP) provides an important chronological anchor; Golbai Sasan's multi-layered dataset demonstrates continuity and diversity of plant use in a major settlement. To refine our understanding of cultivation ecologies — particularly the question of whether early rice cultivation in Odisha was managed as wet-paddy or rainfed systems — future research must prioritise integrated geoarchaeological studies, broadened sampling across sites, and targeted single-seed dating. Interdisciplinary approaches that combine archaeobotany with faunal, sedimentary and molecular proxies will deliver the fuller socio-ecological picture needed to situate Odisha within regional and global histories of early farming.

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