

Long-term History of Human Adaptations a glance of early stages of our cultural diversity in drylands.



Working document related to HEADS UNESCO
thematic programme on Human Evolution

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Preface

Dr. Nuria Sanz, Director, UNESCO Regional Office for Egypt and Sudan/Liaison Office for the League of Arab States

In 2009, the World Heritage Committee of UNESCO approved the HEADS project, a thematic initiative devoted to Human Evolution: Adaptations, Dispersals and Social Developments, implemented by the World Heritage Centre of UNESCO. This successful programme has celebrated its 15th anniversary. Since its inception, 43 World Heritage Pleistocene-related sites have been inscribed on the World Heritage List, and 46 new “Heads” related sites are included in the Tentative List of 40 countries. The programme’s scientific committee met more than 15 times over the project’s lifespan, and more than 20 international meetings were organised. The HEADS network gathers more than 200 scholars from a myriad of academic disciplines, providing scientific knowledge to support the justification of the Outstanding Universal Value of the candidates’ sites. Significant discussions took place namely focused on the need to incorporate the nature and character of early archaeological records within the implementation of the World Heritage Convention: use of the cultural and natural criteria (namely criteria VIII on the history of life); the definition of integrity for a Pleistocene site; and the importance of considering movable heritage when justifying the values of the early sites.

Over the last 15 years, we have seen how development agendas worldwide are destroying records and revealing new Pleistocene/early Holocene geographies. Long-term preservation of vulnerable sites remains a challenge worldwide, and organic collections are vanishing in museums, labs and research centres. Curators should facilitate research, but current destructive methodologies put at risk the preservation and future use of unique records. The race for issued data in peer review journals is accelerated by competing disciplines to the point that some researchers are advocating for the exercise of a slow(er) science and a more respectful way of producing/informing knowledge. New technologies can (re)interpret records and set ambitious research agendas that were never imagined some years ago.

The Long Term Records of Human Adaptation

Over the last decade, scholars have produced substantive scientific data on:

- Archaeological and palaeoecological evidence of ecologically transformative land use practices by 10,000 BCE, including burning, hunting, species propagation, domestication, cultivation, and others that have left long-term legacies across the terrestrial biosphere.
- Mobility dynamics, site use, and site formation, to reveal human behaviours, adaptive strategies and choices. The World Heritage List of UNESCO includes today a variety of 2 million-year-old deposits, considered as “built anthropogenic environments”: camps, primary and secondary assemblages of fauna and plants processing areas; tool production areas; burning and dumping areas; spatial organisation; niche construction practices; and paleoclimatic and paleoenvironmental records.
- Evidence of adaptations to tropical environments, savannas, deserts and highlands.
- The role of new technologies that have transformed our scientific understanding of the complex relationships between humans and the human–plant and human–animal co-evolutions.

- The use and significance of DNA preserved in sediments. Combined micromorphological and microstratigraphic analysis, together with the retrieval of ancient DNA, allowed genetic information to be associated with the detailed archaeological and ecological record preserved in sediments.
- The long-term dynamics and the detection of specific selective pressures.
- Generative models to interpret the consequences of human-environment interaction.
- Changes in the uses of landscapes and the related long-term implications for the environments that hominins occupied.
- Climate change hazards over the entire timespan of human evolution and human history.
- Traces of climate hazards that pushed mobility or facilitated dispersals, for example, the climatic window of opportunity that eased the migration of humans across southern Siberia and Mongolia ca. 45,000 years ago.
- The critical revaluation on diffusionism, mobility patterns and scales and convergent evolution phenomena. Research offered explicit population-modelling methods in archaeology to reconsider population-driven evolutionary simulations, including paleogenomic and kinship studies that support new scientific hypotheses.
- Lipid biomarker and stable isotope compositions of food residues provide qualitative and quantitative assessments of harvested and processed primary animal-plant consumptions.
- The pivotal role of databanks, their potential, and their methodology to allow scholars to capture dynamic processes and to test theories about the co-evolution (or not) of social complexity.
- The combined application of isotopes, archaeobotanical data and proteomics as a new approach to documenting dietary and health changes across major subsistence transitions.
- Continental-scale connectivity of the late prehistoric/early historic periods.

The work we present here aims to capitalise on the collective reflection undertaken by the HEADS programme, adding two critical dimensions: a focus on adaptation and long-term sequences since the Pleistocene, and the importance of considering the cultural heritage agency in agrobiodiversity since the transition to food production.

The Scientific Committee of the programme met in Cairo in September 2024. It started deliberations on the following steps, namely, focused on Science-policy Interfaces to set up an applied research-conservation agenda that better connects our human, remote, adaptive experience, offering a long-term perspective on cultural responses to climate fluctuations and hazards as a contribution from HEADS to the UN Global Agenda. We emphasised the importance of integrating archaeological records within broader historical and environmental contexts.

Human Adaptations

Participants considered the importance of enrich the inclusion of disciplines such as climatology, sedimentology, paleo-ecology, archaeology, paleo-biology, resource exploitation, and land use in future steps to implement a more scientifically based justification of the World Heritage criteria better, showcasing significant stages of ecological long-term processes in Earth's history (VIII), and strategies to conserve the biocultural diversity along millennia (IV) and (V).

The Scientific Committee agreed on the importance of establishing a map of case studies that provide continuous archaeological records over large areas, revealing patterns of territorial behaviour, species coexistence, technological traditions, and subsistence methods. The investigation into the depositional dynamics of records affected by climatic phenomena is considered a key element of this endeavour. During the meeting, I had the opportunity to present a critical observation regarding the Arab Region. I examined the presence of long-sequence sites and paleolandscapes included in the Tentative List, led by Jebel Faya (UAE), which was recently inscribed on UNESCO's World Heritage List.^{1,2}

	(2,000,000 BP – 3300 BCE)			(3300 BCE – 1200 BCE)			(1200 BCE – 586 BCE)		(present)
Site/Archeological period	Paleolithic (2,000,000 BP – 8300 BCE)	Neolithic (8300 BCE – 4500 BCE)	Chalcolithic (4500 BCE – 3300 BCE)	Early Bronze Age (3300 BCE – 2000 BCE)	Middle Bronze Age (2000 BCE – 1550 BCE)	Late Bronze Age (1550 BCE – 1200 BCE)	Iron Age I (1200 BCE – 1000 BCE)	Iron Age II (1000 BCE – 586 BCE)	Babylonian and Persian periods to Modern period
Al-Faw									
Bestansur									
Bisya & Salut									
Jebel Faya									
Gebel Qatrani Area									
Grotte de Taforalt									
Hatta									
Haua Fteah Cave									
Lagune de Khnifiss									
Nahr el-Kalb									
Oasis of Fayoum									
Oasis de Gabès									
Prehistoric Stone Structures in Saudi Arabia									
Ramsar									
Shush									
Tape Sialk									
Wadi Hower									

This graphic demonstrates the commitment and importance of this Region to our efforts and presents an excellent opportunity to focus on drylands.

Evolving Frameworks for HEADS International Cooperation

The scholars discussed the following issues below:

The updated theoretical perspectives in Archaeology:

- Introduction to new theoretical frameworks such as new materialism, speculative realism, network theories, and longue durée theories.
- Discussion on the changing paradigms in archaeological theory and practice due to innovations in methods, technologies, and the growing availability of big data and their potential to carry out empirically grounded studies, recognise patterns, and test models related to long-term changes in human societies.

1- UNESCO Nomination of the Faya Palaeolandscape <https://whc.unesco.org/en/list/1735/>

2- Chronologies respect the data officially submitted by the Member States.

- Examination of the interdependencies among cultural, social, economic, and environmental factors, using Paul Duignan's outcomes theory.
- Analysis of how systems like antifragility (as per Nassim Nicholas Taleb) and critical transitions (as per Marten Scheffer) apply to understanding archaeological and cultural developments.
- In relation to the transition to productive societies, the ongoing debate on the Neolithic developments using an arrhythmic model, which describes cycles of boom and bust influenced by environmental and social factors (as referred to case studies such as Göbekli Tepe and Çatalhöyük to illustrate the dynamics of social organisation and the impact of climatic changes, both inscribed on the World Heritage List).
- Current discussion on the integration of citizen science into archaeological research, enhancing public engagement and contributions to the field, broadening the interested audiences for archaeological studies and promoting inclusive research methodologies.

In terms of Methodological Innovations and Challenges:

- The complexity of data extraction from archaeological sites, the importance of comprehensive databases for preserving and sharing knowledge, and the new challenges of maintaining and updating archaeological site archives.
- The importance of increasing the role of paleoecology, archaeozoology, paired with geoarchaeology, and archaeobotany in HEADS, since those disciplines are reshaping our understanding of the use and features of the past landscapes and allow for the reconstruction of early agricultural practices.
- The interest in pursuing a detailed study of lithic tools to determine the raw material's provenance and identify the patterns of the use and transit of landscapes.
- The introduction of innovative methods, such as X-ray tomography and microCT scans, to analyse old pottery sherds, demonstrates how these technologies help identify domestication traits in ancient crops preserved in ceramic materials.
- The key role of molecular prehistory is to determine appropriate sampling and preservation methods.
- The meticulous research to reveal fossil footprints alongside evidence of butchered fauna and human activity, suggesting complex interactions between humans and their environment (Melka Kunture, Schöningen site, Sibudu Cave, among others).
- The use of scientific methods such as Ar/Ar dating, ESR, palaeomagnetism, stable isotope analysis, palynology, ichnology, and taphonomic studies.
- The application of advanced scientific techniques, such as isotopic analysis and microwear analysis, to understand the diets and environments of past populations.
- The importance of refined sedimentological methods for understanding the formation and preservation of archaeological layers.

Special emphasis was allocated to the need to follow up on the recommendation of the HEADS publication of the Origins of Food Production and The Origin and Evolution of Food Production and its Impact on Consumption Patterns ² within the HEADS programme, and the need to strengthen the discussion on the global evidence of domestication centres: evidence for centres of plant domestication, highlighting recent findings from the New Guinea highlands and South India, alongside with the emphasis on the importance of creating and maintaining detailed archives and databases and reference collections to support research and education in archaeobotanical globally.

In terms of Preservation:

- Long-term conservation of archaeological records, especially in tropical areas prone to natural phenomena that can damage sites. Scholars underlined the need to compile a collection of good practices for long-term conservation, including the construction of site-specific museums or galleries that respect and integrate local cultural practices.
- The crucial link between site museums and the long-term conservation of records was emphasised, advocating for community involvement in the organisation and curation of these museums.
- Relationships between archaeological sites and museums, and how they can enhance capacity building within local communities to involve them actively in the conservation of archaeological sites.

They stressed the importance of involving local students in archaeological research as apprentice scholars to establish a sustainable engagement. Moreover, they discussed the potential for employing artificial intelligence and geolocation to enhance visitor engagement and understanding of the sites was also discussed.

The final discussion at the meeting centred around redefining and broadening the scope of what was previously known as HEADS, now rebranded as “Cultural Heritage of Human Adaptations - A Science for Policy Agenda.” This shift reflects a strategic pivot to frame the initiative in a global context, with an emphasis on addressing contemporary challenges by integrating cultural heritage and human adaptation into policy-making processes. Discussions focused on setting a direction that not only recognises the legacies of human adaptations but also aligns them with current global green agendas in which the role of cultural heritage is considered and emphasised since COP29. ³

The need for a more diverse multi-disciplinary approach and transdisciplinary research was underscored, incorporating social and cultural anthropology, ethnography, and eco-ethnology, to deepen the understanding of biocultural dynamics until now and the importance of identifying the geographies of the long-term cultural continuities and importance of documenting the current traditional knowledge associated with the permanent, long-lasting human capacity to adapt.

2- UNESCO Publication: The Origins of food production
<https://unesdoc.unesco.org/ark:/48223/pf0000261741.locale=en>

The Origin and evolution of food production and its impact on consumption patterns
<https://unesdoc.unesco.org/ark:/48223/pf0000264379.locale=en>

3- Culture and climate action: from margins to mainstream: a thematic paper <https://unesdoc.unesco.org/ark:/48223/pf0000395681>

Cultural Heritage of Human Adaptations

According to the results of the meeting in 2024, the UNESCO Regional Office for Egypt and Sudan organised an International Conference on the Cultural Heritage of Human Adaptations to support the efforts of the two countries in their current research efforts to represent better represent the early stages of the cultural diversity in their World Heritage Tentative Lists. The conference brought together leading international and national experts to explore key aspects of prehistoric heritage, including rock art, early human occupations, evidence of climate change adaptation, and paleo-landscapes. Scholars examined how past human societies adapted to their evolving environments by providing unique cultural expressions. Special emphasis was placed on the archaeological significance of Egypt and Sudan, particularly regarding Palaeolithic and Neolithic sites, rock art manifestations, and long- sequence cultural sites. By engaging experts from diverse disciplines and covering a broad geographic scope, the three-day event seeks to highlight the Outstanding Universal Value (OUV) of prehistoric and early historic sites, reinforcing the need for their recognition, protection, and integration into the contemporary heritage conservation framework.

Presentations examined recent and current painstaking methodologies applied to long archaeological sequences to understand human choices, emphasising the key role of exceptionally selected sites where long sequences are extraordinarily well preserved, capable of preserving organic materials under optimal conditions. Using key examples from Schöningen, Sibudu, and Hohle Fels, and the way in which detailed reconstructions of human behaviour, technological developments, and ecological adaptations can provide the broader significance of these sites in reconstructing past environments, tracking human adaptation strategies and shaping agencies of human survival and technological progress across different climatic periods.

The meeting presented a case study Faya Paleo landscape in Sharjah, UAE, a unique territory, now inscribed on the World Heritage List and demonstrated the importance of preserving large territorial surfaces to understanding population dynamics and changes in material culture in the Late Pleistocene and the importance of documenting human adaptation over a long timescale, from 210,000 to 6,000 years ago, revealing a long history of cultural choices from the Palaeolithic to the niche construction in the Neolithic times. The inclusion of this site on the World Heritage List opens an urgent discussion on better documenting human behavioural diversity and the related cultural decisions, using the criteria of the 1972 UNESCO Convention.

Palaeolithic landscapes of Nazlet Khater and Abbasiya, areas of Wadi Howar, Kerma culture heritage sites, and the long archaeological and/or historical sequences of Sai Island and Old Dongola in Sudan could be suitable for implementing the same approach. The meeting pledged to conservation efforts and emergency response measures, calling on the international community to support the protection of these unique, irreplaceable, long-term cultural landmarks.

Archaeological research was emphasised as not only foundational for site discovery and evaluation, but also as an integral part of site management. It reflects a site's capacity to generate ongoing knowledge, reinforcing its cultural and scientific relevance over time.

The compiled Long Sequences of Cultural Adaptation cases presented here illustrate the diversity of cultural responses that inform global heritage agendas, which are particularly important for drylands. It was proposed that comparative studies of long adaptations sequences are a crucial baseline for constructing narratives suitable for UNESCO HEADS nominations.

Special attention was given to sites in Nubia and the Western Desert, where human mobility and environmental variability have limited the preservation of long-term sequences at individual sites. In these cases, it was suggested that the concept of “sequence” must adapt to recognise non-sedentary patterns of cultural development and to account for how different parts of the landscape were used contemporaneously or sequentially over time. Specific examples presented included: The First Cataract region and Nabta Playa, where broad-scale paleo-landscapes reveal evidence of ancient adaptations despite the absence of continuous, single-location occupation. Oases—especially in the case of the Western Desert in Egypt are of special interest, where water availability regulated the life of hunter-gatherer societies and their mobility in some of the most extreme natural scenarios of the Earth.

Scholars examined early human migration routes and archaeological evidence related to stone tool industries in northeastern Africa. They explored the role of the Nile as a corridor for human movement. Still, they noted the scarcity of early archaeological evidence in certain regions, such as the Giza Plateau and the Nile-Fayum divide. The Middle Stone Age was better represented, with sites like Sodmein Cave in Egypt and sequences in Sudan providing essential data on human occupation and technological advancements. Discussions emphasised the need for further research, particularly in dating and stratigraphic analysis, to refine our understanding of how early humans dispersed through the northern Nile region.

The meeting did not skimp the recurrent discussion on the additional preservation constraints of open-air archaeological sites, illustrating methodologies in the Kalahari Desert, highlighting the challenges and opportunities of studying past human-environment interactions by documenting lithic distributions and reconstruct past climates through sediment and microfossil analysis and the importance of producing knowledge facing obstacles such as the scarcity of caves and rock shelters, the limited organic preservation, and the difficulty of dating deposits due to the absence of stratified contexts.

Other presentations explored the Pleistocene and Holocene environments and archaeology of the Egyptian deserts, focusing on the potential and threats to cultural heritage. Cases like Wadi Sura, Sodmein Cave, and Wadi Qena demonstrate how climatic shifts influenced human settlement, mobility, and adaptation strategies in the Sahara and surrounding regions. Studies of sea levels, Nile floods, and playa sediments provided insights into environmental fluctuations over the past 150,000 years, while archaeological surveys documented how post-Pleistocene re-occupation patterns reflected seasonal and logistical mobility. Additionally, the research emphasised the significance of rock art sites like the Cave of Beasts and the Cave of Swimmers, and the urgent need for digital documentation to protect and study Egypt’s vast desert archaeology.

The concept and approach of Archaeology of Complexity, understood as a dynamic process of societal change, influenced by climate shifts, landscape transformations, and demographic patterns, was discussed in relation to early Holocene adaptations using theoretical models such as antifragility, tipping points, and bifurcation, which helped explain the resilience, crises, and eventual transformation of Neolithic communities. The Konya Plain in central Turkey served as a key case study, where communities like those at Boncuklu Höyük and Çatalhöyük underwent cycles of growth, stress, and social change.

The presentation highlighted how early farming societies tried to maintain egalitarian structures, and clearly illustrated how these systems became strained over time. Increasing population, the emergence of new technologies (such as pottery and cattle domestication), and pressures from ritual and social systems led to fragmentation and the emergence of new forms of social organisation. The World Heritage site of Çatalhöyük was used to illustrate these dynamics through changes in burial patterns, architecture, and material culture. These types of sites can offer critical insights into resilience, innovation, and the roots of social complexity in human history. Without a doubt, the site research continues, given the example of a robust post-nomination investigation and a commitment to develop equally sophisticated methodologies for documenting and preserving the site.

Important examples of the history of research, such as the case of Merimde Beni Salama, have proven the key role of site documentation for the understanding of early farming communities in Egypt and equally crucial for the broader context of Neolithic adaptations in North Africa, tracing the storyline since the early excavations in the 1920s up to the later investigations in the 1970s and recent interdisciplinary studies. Conservation and heritage protection efforts for these very vulnerable sites were also discussed, emphasising the need for sustainable site management and an accurate survey of the consequences of the extensive irrigation plans in the Nile Delta and adjacent areas.

Gebel Nabta and Gebel Ramlah document the archaeological significance of the Southern Egyptian Sahara. Cycles of wet and dry periods that influenced settlement patterns and cultural development, and are unique spots to explore the transition from hunter-gatherer societies to pastoral communities during the Neolithic, with evidence of ceremonial behaviour, burial practices, and early structured social systems. Scholars discuss the modern threats to these heritage sites, particularly the risk posed by water redistribution from Lake Nasser, which could lead to large-scale flooding that submerges archaeological remains. The call for a renewed conservation initiative, referred to as Nubian Campaign 2.0, underscored the commitment and the urgency of protecting these sites through multilateral coordinated efforts.

Challenges with Site Registration of the Eastern and Western deserts:

- Inventories and documentation methodologies for registering surface evidence in deserts can be updated by using new programs and cataloguing technologies.
- Surveys can assist by providing additional information to support the heritage registration of the archaeological sites by the Supreme Council of Antiquities and (SCA) in Egypt and the National Corporation for Antiquities and Museums (NCAM) in Sudan.
- Leisure travel or touristic expeditions should support efforts to safeguard these unique sites as part of humanity's global heritage.
- Researchers heightened UNESCO's interest in the Nubian campaign in the 60s and articulated new opportunities to revise and ensure proper protection of the documentation and to procure a digital future for the records, which would allow further research of this exceptional cultural riverine landscape.

Presentations showcased the role of plant cultivation and environmental changes in the Fayum region. Findings related to early agricultural practices, particularly the use of wheat and barley, alongside evidence of storage methods such as basket-lined pits and large jars. Research highlighted an array of subsistence practices and tracked the transition from Epipaleolithic gathering of wild grasses to Neolithic farming. The absence of permanent mud-brick or stone structures suggested that early communities relied on mat-based housing and extensive basketry production. Studies also revisited years-old records of past excavations, integrating recent survey techniques, including magnetic and test trenching, to reassess previous interpretations of settlement patterns. The findings contributed to discussions on semi-mobility and early agricultural development in North Africa.

The meeting considered it essential to set up comparative/complementary research on North Africa/NILE and the Arabian Peninsula, since the Palaeolithic archaeological records in both regions have not yet been fully explored. It seems key to deepen the understanding of the archaeological connections between these regions and to better integrate findings from both sides of the Red Sea.

One entire day was dedicated to Rock art sites, studies and prospects. The thematic session introduced Egypt's rock art heritage, focusing on the First Nile Cataract region and its significance in prehistoric and early historic contexts. It highlighted key rock art sites in Upper Egypt, the Western Desert, the Eastern Desert, Sinai, and Lower Nubia, emphasising the importance of Wadi Abu Subeira, Qurta, and Gharb Aswan, which contain some of the oldest known petroglyphs, dating back over 15,000 years. The research explored how rock art reflects early human cosmology, religious practices, and environmental adaptation, with motifs related to animals, boats, hunting, and ruling elites.

The presentation also discussed the role of the Aswan-Kom Ombo Archaeological Project (AKAP) in surveying and documenting these sites, utilising geological analysis, digital documentation, and interactive restoration techniques. A multidisciplinary team, including archaeologists, geologists, and digital specialists, had worked to preserve and analyse these engravings, while outreach activities aimed to raise awareness about the region's cultural heritage. Comparative studies with other North African and Middle Eastern sites further contextualised Egypt's rock art within broader prehistoric artistic traditions. The findings underscored the need for continued documentation, conservation, and recognition of these sites as part of Egypt's cultural heritage.

Rock art manifestations in the Dakhlah Oasis clearly demonstrate how engravings and pictographs provide insights into the lives of early human communities, their beliefs, and their interactions with the environment—situated Dakhlah Oasis within the broader framework of rock art traditions in the Western Desert, comparing stylistic elements and motifs with those found in neighbouring regions like Gebel Uweinat and Gilf Kebir. The research highlighted specific traditions, such as the Bashendi-style engravings from the mid-Holocene.

The presentation also addressed conservation concerns, emphasising epigraphic and rock art sites in Sudan, the fragility of these ancient artworks and the increasing need for protection. Sudanese rock art's richness and diversity serve as an outstanding record of environmental and cultural changes, reflecting shifts in climate, pastoral practices, and the emergence of nomadic traditions. The Atbai Survey Project was introduced as an initiative to map heritage in this region, integrating field surveying, remote sensing, and community engagement to protect archaeological sites and proposing a methodological path for further research.

Particular emphasis was allocated during the discussions to the vulnerability of desert sites due to their remote locations, lack of caretakers, and exposure to vandalism. Rock art presentations highlighted an urgent need for increased awareness, documentation, and stakeholder involvement to ensure the conservation of these valuable heritage sites.

The SRA of Egypt presented the case of Zolma Rockshelter in the Sinai Peninsula. The research focused on rock art and material culture related to the Middle Palaeolithic, Late Palaeolithic, and Pre-Pottery Neolithic. The Zolma Rockshelter contained a variety of images depicting animals, human figures, and abstract shapes, providing insights into early symbolic expression and daily life. Comparisons with other rock art sites in North Africa, such as Qurta and Abu Subeira, suggested connections between early artistic traditions across the region. The study contributed to the understanding of human adaptation and cultural expression in the Sinai Peninsula and undoubtedly deserves further documentation and research.

Community Engagement and Heritage Preservation:

- The group underlined the importance of local communities in the management and safeguarding of archaeological sites was emphasised, especially during times of crisis, such as the post-conflict situation in Sudan.
- It was highlighted that communities can serve as critical sources of information and support during emergencies, contributing to heritage protection efforts when institutional systems are under strain.
- An example was presented from the site of Elkhandaq, where the local community played an active role in heritage preservation by donating personal items related to their own family histories to the local museum. These contributions were made voluntarily and became part of a collective heritage narrative, reflecting a strong sense of ownership and identity.
- The case of Elkhandaq was described as a participatory model of heritage conservation, in which community involvement went beyond passive support to include tangible contributions that enriched and expanded the site's cultural value.
- The use of traditional ovens was interpreted as a form of cultural resilience and an example of how dramatic or challenging circumstances can lead to heritage being reused in ways that benefit the community, while simultaneously reinforcing the cultural continuity of place-based practices.

Archaeobotanical data on climate fluctuations, seasonal rainfall variations, and environmental changes from multiple archaeological sites worldwide were presented, emphasising that domestication was a protracted, multi-site process rather than a single event. Arab Regional and drylands revealed key findings on the role of oasis economies, variations in agricultural strategies across deserts worldwide, and different responses to settlement patterns. The discussion also explores alternative civilisational systems, where land ownership and cash crops shaped Mesopotamian societies, while cattle-based wealth and agropastoralism influenced African regions. Case studies were presented to demonstrate how integrating botanical, climatic, and archaeological data provides comprehensive perspectives on the complex relationship between agriCULTURE and human adaptation.

HEADS and the preservation of Agrobiodiversity

The importance of considering agricultural practices as cultural heritage has been a part of the HEADS programme since 2015. We therefore dedicated a monographic volume to archaeological sites associated with the origins of food production.^{1,2} We completed a global map showing how human societies had embarked on the path of plant and animal domestication on each continent.

The cultural processes of domestication were recorded in soils, seed diversification, the shape of agricultural landscapes, material culture, and the associated technologies for the production, processing, and consumption of food.

The archaeological record provides an account of irrigation, water control and management, crop storage and waste deposits, land-use patterns associated with crop seasonality, and the climatic fluctuations that accompanied the cultural responses of rural communities.

Now that we are embarking on a new stage in the implementation of the HEADS programme in drylands, and in line with our intention to focus on long-term adaptation, the preservation of agrobiodiversity opens a fertile ground for reflection and action. Some places act as reservoirs of knowledge and are so privileged that the accumulation of intergenerational explorations continues to this day. This knowledge needs urgent care, awareness, documentation and protection. The practices associated with the preservation and enhancement of agrobiodiversity could be considered among the most endangered forms of knowledge, and the diversity of landraces, species, and related cultivation practices could be assessed as inexorably heading toward extinction.

Agrobiodiversity refers to the variety and variability of animals, plants and micro-organisms at the genetic, species and ecosystem levels that sustain the ecosystem structures, functions and processes in and around production systems, and that provide food and non-food agricultural products.”³

It includes: (i) the domesticated plants and animals raised in crop, livestock, forest and aquaculture systems, (ii) harvested forest and aquatic species, (iii) the wild relatives of domesticated species, (iv) other wild species harvested for food and other products, and (v) “associated biodiversity”, i.e. organisms found in and around food and agricultural production systems.⁴ Agrobiodiversity is the source of irreplaceable contributions to food security and nutrition, livelihoods, resilience, and sustainable intensification. And all these values are socially generated and are culturally patterned. All these services are evolutionary, and the solutions they provide are not naturally based but heritage-based.

Agrobiodiversity strategies, based on culturally sound and supportive practices, are being designed and implemented within culturally productive landscapes. Those landscapes provide support for climate change adaptation. So far, the UNESCO World Heritage List includes more than 50 outstanding sites that represent key examples of cultural heritage in food production. (Graphic page 17)

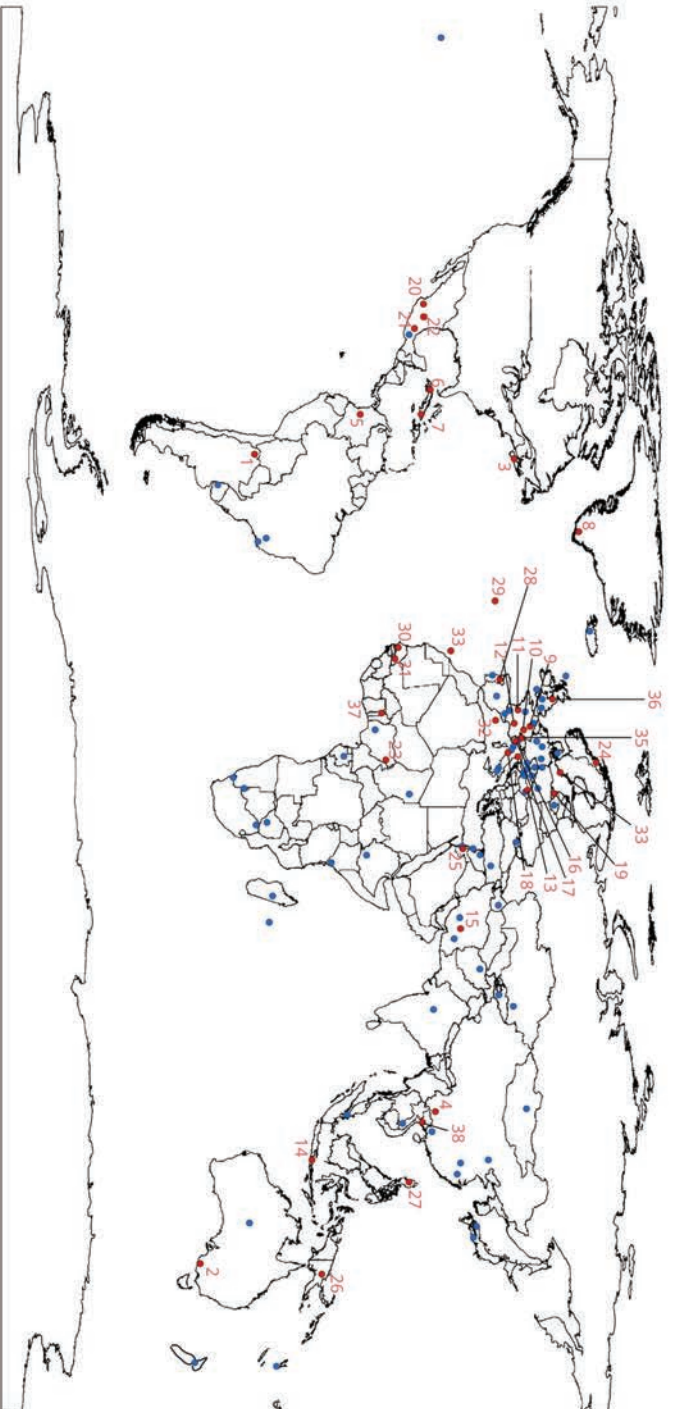
1-<https://unesdoc.unesco.org/ark:/48223/pf0000261741/PDF/261741mul.pdf.multi>

2- <https://unesdoc.unesco.org/ark:/48223/pf0000264379/PDF/264379mul.pdf.multi>

3- The State of the World's Biodiversity for Food and Agriculture. (FAO Commission on Genetic Resources for Food and Agriculture., 2019).

4-Ibid.

Main Cultural Agrolandscapes



1. Quebrada de Humahuaca
2. Budj Bim Cultural Landscape
3. Landscape of Grand Pré
4. Cultural Landscape of Honghe Hani Rice Terraces
5. Coffee Cultural Landscape of Colombia
6. Vinales Valley
7. Archaeological Landscape of the First Coffee Plantations in the South-East of Cuba
8. Kujataa Greenland: Norse and Inuit Farming at the Edge of the Ice Cap
9. Champagne Hillsides, Houses and Cellars
10. The Climate, terroirs of Burgundy
11. Jurisdiction of Saint-Émilion
12. The Causes and the Cévennes, Mediterranean agro-pastoral Cultural Landscape
13. Tokaj Wine Region Historic Cultural Landscape
14. Cultural Landscape of Baili Province: the Subak System as a Manifestation of the Tri Hita Karana Philosophy
15. Cultural Landscape of Maymand
16. Vineyard Landscape of Piedmont: Langhe-Roero and Monferrato
17. Le Colline del Prosecco di Conegliano e Valdobbiadene
18. Val d'Orcia
19. Cironian Spit
20. Agave Landscape and Ancient Industrial Facilities of Tequila
21. Tenucañ-Culcatlan
22. Xochimilco
23. Sukur Cultural Landscape
24. Vegaøyan - The Vega Archipelago
25. Palestine: Land of Olives and Vines - Cultural Landscape of Southern Jerusalem, Battir
26. Kuk Early Agricultural Sites
27. Rice Terraces of the Philippine Cordilleras
28. Alto Douro Wine Region
29. Landscape of the Pico Island Vineyard Culture - Ilha
30. Saloun Delta
31. Bassari Country: Bassari, Fula and Bedik Cultural Landscapes
32. Cultural Landscape of the Serra de Tramuntana
33. Risco Caído and the Sacred Mountains of Gran Canaria Cultural Landscape
34. Agricultural Landscape of Southern Oland
35. Lavaux, Vineyard Terraces
36. The English Lake District
37. Koutamnakou, the Land of the Batemmarba
38. Trang An Landscape Complex

MAP OF AGRICULTURAL LANDSCAPES

Human Adaptations

Agrobiodiversity constitutes the component of biodiversity most closely intertwined with human beings and our social practices. It is “a product of human-environment interactions”⁴ over millennia. Some geographies associated with family farming strategies still reflect traditional agency and ensure the proper transmission of knowledge. Although family farming still accounts for a very high percentage of food production in developing countries, this repository of wisdom is threatened in some cases by national policies and, in others, by markets and companies that aim to multiply the revenues from commercial seeds and pesticides exponentially.

- Today, only 6,000 plant species are used for crop production,
- Only 2,400 species of trees, shrubs, palms and bamboo are managed to provide products and services,
- Only 600 aquatic species are used in aquaculture.⁵

The land-use changes and the reduced numbers of species, breeds, and varieties in our diets are driven by many factors. Varietal and species extinction are linked, in part, to the market’s increasing concentration of production on fewer species and varieties. Varietal, species, and functional diversity are at risk; pollinators are disturbed; soil biodiversity is in decline; and traditional ecological knowledge for managing cultural landscapes’ complexity is being lost. It is essential to understand and measure how traditional knowledge associated with agrobiodiversity conservation has guaranteed the resilience of human capacity over millennia. It is time to start arguing that traditional knowledge decay should be quantified within the mechanisms of Loss and Damage blessed by COPS. In this context, a Scientific Dialogue on the Preservation of Agrobiodiversity as Cultural Heritage was held by the UNESCO Regional Office in Cairo in December 2025, bringing together researchers, practitioners, and community representatives. The dialogue examined the cultural, ecological, and social dimensions of agrobiodiversity preservation, highlighting how traditional agricultural systems, landscapes, and crop diversity embody forms of living heritage that link culture, nature, and identity.

The dialogue was framed as a direct response to the International Decade of Sciences for Sustainable Development (2024–2033), proclaimed by the United Nations General Assembly on 25 August 2023, with UNESCO designated as the lead agency for its implementation. The Decade recognizes the urgent need to bridge scientific disciplines and knowledge systems in order to address the complex challenges of contemporary societies. Its objectives—strengthening scientific literacy, producing actionable knowledge, and advancing the Sustainable Development Goals in alignment with human rights—provided a key conceptual framework for the dialogue. In particular, the Decade’s emphasis on breaking down silos between the natural and social sciences, and on fostering exchange with other knowledge systems, resonated strongly with the recognition of local and traditional knowledge as a critical scientific resource.

Citizen science emerged as a central methodological reference within this framework. The dialogue foregrounded approaches that enable communities to participate actively in the co-production of knowledge about their own biocultural landscapes, aligning with the Decade’s objectives of engaging society in soil and ecosystem research, science communication, and education. By placing traditional agricultural practitioners in dialogue with environmental and social scientists, the initiative exemplified the production of context-specific and actionable knowledge required to support sustainable development pathways, while reinforcing transparency, integrity, and public trust in science.

5- Jones, Sarah K. et. al. Agrobiodiversity Index scores show agrobiodiversity is underutilized in national food systems. *Nature Food* 2, 712-723 (September 2021).

6- Biodiversity for Sustainable Agriculture: FAO’s work on biodiversity for food and agriculture. (Rome, 2018).

The dialogue was also firmly anchored in UNESCO's Environmental and Ecological Sciences frameworks that guide scientific cooperation and sustainability planning. The principles articulated in the Seville Strategy (1995), which called for the integration of social, cultural, and economic dimensions into conservation planning through community-based and scientifically informed approaches, provided an important foundation. More recent global policy frameworks—including the Kunming–Montreal Global Biodiversity Framework, the Paris Agreement, the Post-2020 Global Biodiversity Agenda, and emerging orientations linked to the Brazil COP30 process—further reinforced the relevance of strengthening nature–culture linkages, knowledge exchange, and community participation in biodiversity governance. A particular emphasis was placed on soil health as a foundational component of agrobiodiversity. Building on UNESCO's long-standing engagement with soil sciences, the dialogue reaffirmed that soils are living systems essential to food production, climate regulation, and water filtration, and that they constitute a non-renewable resource under increasing pressure. The launch of the 2025–2034 Decade of Soil Sciences for Sustainable Development by the International Union of Soil Sciences provided additional momentum, underscoring that regenerative and sustainable soil management is indispensable for achieving the Sustainable Development Goals. Traditional practices such as terracing, intercropping, and organic soil enrichment were examined as expressions of ancestral soil stewardship, offering critical insights for contemporary food security and climate resilience strategies.

Agrobiodiversity—understood as the diversity of crops, seeds, and farming systems—was thus approached not only as a scientific concern, but as a repository of memory, creativity, and long-term adaptation. In the Arab region, oasis agriculture, terrace cultivation, and desert farming systems illustrate how communities have co-evolved with challenging environments, producing resilient ecosystems and knowledge systems that sustain both livelihoods and landscapes. Preserving agrobiodiversity therefore emerged as an act of safeguarding biocultural heritage, in which seeds, practices, and agricultural landscapes embody accumulated histories of innovation that connect past experiences with future sustainability. To begin addressing this loss, we wanted to add case studies that have explored how to systematise and document this knowledge, and, to this end, we brought together a large group of researchers in December 2025. The case studies selected offer clear examples of methodologies tested in recent years by different disciplines such as arqueobotany, ethnology, anthropology, linguistics, and genetics. Undoubtedly, this is a very fertile avenue for HEADS to expand and to associate the most remote past of our human practices with the most recent needs of our less diversified productive capacity. Human resilience needs a diverse set of resources to avoid limiting our response capacity. Diversity of options has always been central to human agency. The preservation of the cultural heritage associated with food production guarantees the continuation of the diversification processes.

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**Contributions of the Committee on the
Cultural Heritage of Human Adaptations:
Pleistocene–Early Holocene Archaeology**

The Importance of Preservation at Palaeolithic World Heritage Sites and the “Schöningen Effect”

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Abstract

In the 1990s, the discoveries at Schöningen shifted the course of Palaeolithic archaeology by providing indisputable evidence for systematic hunting of large game on the Northern German Plain during the Middle Pleistocene. Hartmut Thieme’s excavation recovered exceptionally well-preserved lithic, osseous and botanical artefacts and ecofacts that changed how paleoanthropologists view the late Lower Palaeolithic. The key sites preserved in the deposits of the Schöningen Paleolake date to the Reinsdorf Interglacial Complex, which correlates to MIS 9 and dates to ca. 300,000 years ago. These waterlogged sediments exposed by lignite mining yielded uniquely well-preserved archaeological material that provided a new and more complete view of this period, while allowing researchers to reconstruct the interconnected lithic, osseous, and botanical technologies that enabled archaic hominins to occupy the top of the food chain. This paper highlights the history of research in Schöningen. It discusses how the last 18 years of excavation under the current direction have continued to shape our understanding of hominin adaptations to Northern Europe during the Middle Pleistocene. The research at Schöningen serves as a reminder that most sites offer a highly limited view of the Palaeolithic past and that archaeologists tend to underestimate the complexity and richness of early hominin lifeways. The “Schöningen Effect” refers to the vast wealth of new information provided by sites with outstanding preservation of botanical, osseous and lithic materials in undisturbed stratigraphic contexts. The paleolandscape at Schöningen helps to illustrate how much of the Palaeolithic past we have been missing.

Introduction

Prehistorian John Shea is known for saying: “The easiest way to be wrong in paleoanthropology is to underestimate our ancestors’ abilities.” (cited in Balter, 2014, p. 1083). The reason is that Stone Age sites often preserve little more than stone artefacts and sediments. Some sites also preserve faunal remains, while some preserve charred plant remains. Very few Palaeolithic sites, however, protect unburnt botanical material. This helps to explain the unique importance of the Middle Pleistocene landscape archaeology associated with the waterlogged paleolakeshore deposits exposed by lignite mining in Schöningen, a small city on the eastern border of the German state of Lower Saxony. Schöningen’s undisturbed sediments, with in situ finds spanning multiple archaeological horizons and outstanding preservation, provide unique insights into how hominins lived in northern Europe about 300,000 years ago. The many archaeological sites around the paleolake preserve special activity areas rather than living sites, which were located in upland geographic settings outside the waterlogged deposits exposed by coal mining. The systematic study of this unique archaeological context since the 1990s revolutionised how Palaeolithic archaeologists view the lifeways of late Middle Pleistocene hominins and contributed to a paradigm shift that revised incorrect assumptions and interpretations about how late Lower Palaeolithic hominins in northern Europe lived. Subsequently, this shift is responsible for elevating how researchers view archaic hominins across the Old World.

Hartmut Thieme's excavations in the paleolake sediments in Schöningen

Starting in the 1980s, Hartmut Thieme, who had earned his doctoral degree in Cologne with a thesis on the important open-air Middle Palaeolithic site of Rheindahlen in the Lower Rhine Valley, began rescue excavations in the area around the lignite mine in Schöningen for the Heritage Office of the state of Lower Saxony. Thieme's scientific training provided the perfect background for recognising the exceptional archaeological potential of the sediments preserved along the edges of the open-cast coal mine.

The site of Schöningen is located north of the maximum advances of the Elsterian and Saalian glacial phases and south of the maximum Weichselian advance. In connection with the retreat of the Elsterian glacier, meltwater carved a depression that led to the formation of the Schöningen paleolake. Most lines of evidence correlate the main find-bearing horizons with the MIS 9 interglacial cycle, dating to roughly 320,000 to 300,000 years ago. This setting represents a uniquely favourable geological and stratigraphic context that has been the focus of more than thirty years of Palaeolithic research.

In 1994, Thieme's team excavated the first wooden artefact, a spruce wood throwing stick, identified by monitoring the Middle Pleistocene sediments along the edges of the mine. Thieme quickly published this unexpected discovery, but no one imagined the discoveries that would soon follow as systematic excavation proceeded. Thieme negotiated with the mining company to conduct a rescue excavation over an area of ca. 4,000 m² near the throwing stick location. In the fall of 1995, the excavation team discovered some of the most remarkable Palaeolithic finds ever recovered. On November 1, 1995, Thieme invited archaeologists and Quaternary scientists to view these discoveries, which included multiple throwing spears, a thrusting spear, lithic artefacts, dozens of butchered horse skeletons, and reddish sediments that he interpreted as hearths. This deposit, designated Schöningen 13 II-4, has ever since been known to the scientific community as the "Spear Horizon" or the "Horse butchery Site." I had the good fortune to attend this event, which counts among the most spectacular days of my 50 years in archaeology. While travelling to the meeting in Schöningen, I could not imagine that what Hartmut Thieme told me the previous day on the phone could be true. Still, the reality on the ground exceeded my wildest expectations and left me, and the others, nearly speechless.

These discoveries occurred at a time when many Anglophone researchers argued that late archaic hominins and even Neanderthals subsisted primarily by scavenging carcasses rather than hunting. Thieme's research subsequently led to a widespread rejection of the obligate scavenging hypothesis for archaic hominins. It triggered a nearly overnight paradigm shift in which the research community accepted that Middle Pleistocene hominins in Northern Europe regularly hunted large game using multiple weapon systems. These weapons, almost all carved from spruce wood, included throwing spears, thrusting spears and throwing sticks. The discoveries in Schöningen changed how Palaeolithic archaeologists interpret the lifeways of the late Lower Palaeolithic and the Middle Palaeolithic. They also help shift researchers' theoretical approaches to the evolution of Palaeolithic subsistence.

The research at Schöningen led to a shift toward the use of human behavioural ecological theory, which emphasises resource ranking and optimising cost-benefit models, including Optimal Foraging Theory. Human behavioural ecology argues that, with very few exceptions, hunters will exploit large game with large caloric and nutritional yields before hunting small or fast match. Before the discoveries at Schöningen, many researchers viewed the hunting of large and potentially dangerous game as a late development in human evolution and a hallmark of behavioural modernity.

Human Adaptations

Today, many researchers argue that hominins' systematic hunting of large, highly ranked game early in human evolution reflects the expected evolutionary outcome, whereas later increases in population density and a decline in the availability of high-ranked, large game fostered the exploitation of lower-ranked, smaller, and faster game. In this respect, one could argue that Thieme's spectacular results played a central role in the theoretical shift toward popularising human behavioural ecology in the study of hominin subsistence.

Thieme, based on excavation results, attributed other advanced behaviours to the hominins from Schöningen, including the controlled use of fire, a high level of communication skills and planning depth, complex reciprocal relations, and ceremonial practices. His views were summarised and presented to a large audience at a major exhibition of his excavations at Schöningen, which opened in 2007. Subsequent research has tested and revised some of these interpretations.

Research by the Tübingen team in Schöningen

In 2008, the Ministry of Science of Lower Saxony asked me to direct the excavations in Schöningen. I had the good fortune to hire Jordi Serangeli to lead the day-to-day fieldwork that begins in March and continues through December. We initially maintained much of Thieme's excavation team to maintain a high degree of continuity and an optimal transfer of knowledge from the original team to the new excavation team. Since 2008, we have worked closely with the Heritage Office of Lower Saxony and a talented group of 75 international researchers from 30 institutions to achieve the best possible results, with generous funding from the Ministry of Science, augmented by grants from the German Science Foundation and other research agencies. In addition to our professional team of excavators, students from all over the world have joined the excavations, making Schöningen a major centre of research and training in Quaternary sciences and Palaeolithic archaeology.

The first year of our excavation focused on the rescue excavation of a strip of land separating the northern and southern mining fields at Schöningen. This research underlined the great diversity of sites around the paleolake. This phase of fieldwork led to the excavation of many low-density find horizons that represented late archaic hominins' ephemeral use of this lakeside setting for hunting and collecting from the plants growing along the lake's edge. As excavations continued, more evidence emerged of a high number and diversity of tools made from bone and ivory, pointing to the interconnectedness of lithic, botanical, and osseous technologies. Already in 2008, Boudewijn Voormolen's dissertation on the fauna from the Horse Butchery Site had identified numerous bone tools, many of which were used for hammering and knapping flint. The research at Schöningen and the exceptional faunal preservation have changed the discourse on the evolution of osseous technology. Until recently, researchers widely attributed the earliest bone tool assemblages to the Upper Palaeolithic, while considerable debate persisted over the existence of osseous technology in the Lower and Middle Palaeolithic. The work on osseous technology at Schöningen played a key role in shifting the terms of this long and ongoing debate, and today colleagues are working to characterise the diversity of early osseous tool assemblages rather than debating their existence.

The exceptional preservation of plant material at Schöningen opens many new lines of research on subsistence and botanical technology. Gerlinde Bigga's doctoral thesis presented the great abundance of edible botanical resources, as well as medicinal plants that are well preserved in the shore zone of the Schöningen Paleolake.

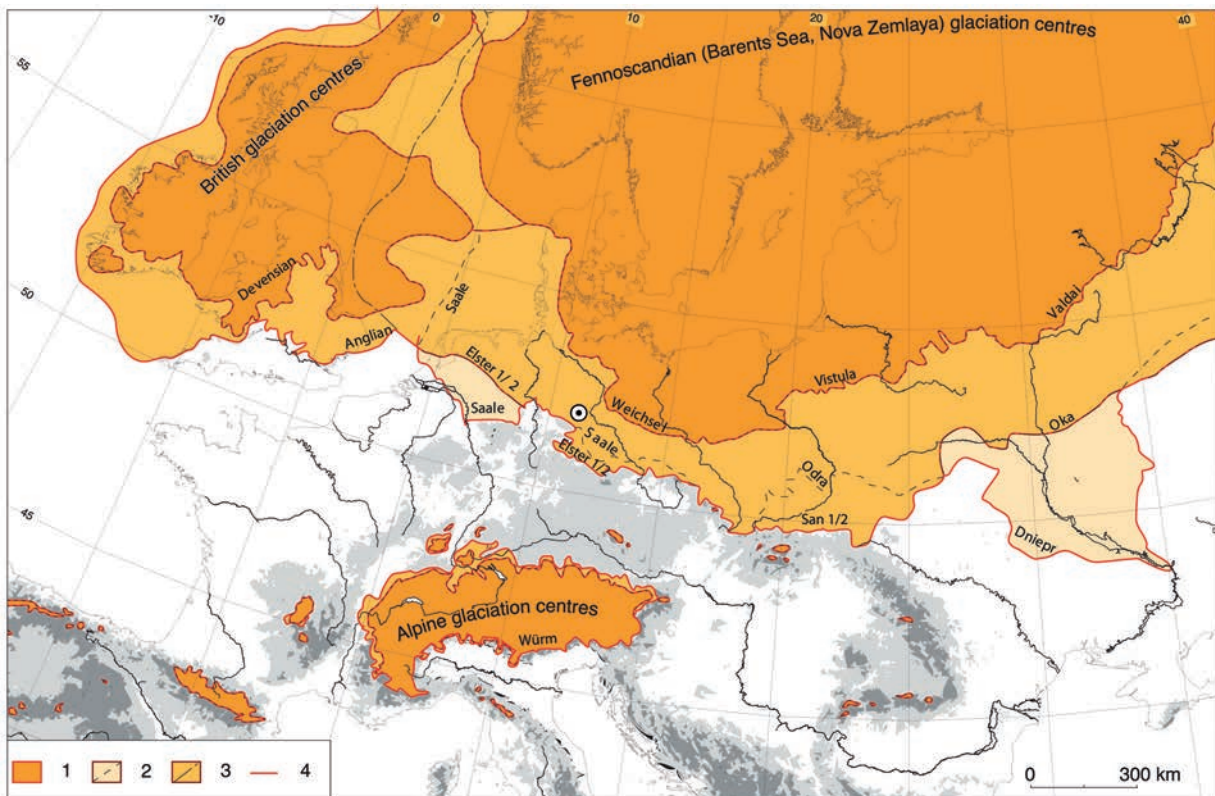


Figure 1. Schöningen. Position of the locality between the maximum southern expansion of the Elsterian and the Saalian and Weichselian continental glaciers. Image: Modified from van Gijssel (2006)

Following the completion of the rescue excavations between the two mining fields, we began focusing on excavations adjacent to the Horse Butchery Site. Here, we identified scattered sites mostly with relatively low find densities. We also tested many of Hartmut Thieme's interpretations, finding evidence supporting some of his ideas and refuting others. Many of these data and conclusions can be found in a special issue of the *Journal of Human Evolution* dedicated to Schöningen, published in 2015.

Research by our team of geoarchaeologists, including Mareike Stahlschmidt and Christopher Miller, failed to find evidence for hearths and controlled use of fire. However, rare burnt wood is suggestive of fires in the area. The reddish sediments reflected natural accumulations of iron oxides rather than sediments rubified by fire. Over time, we concluded that this low-lying setting was consistently waterlogged, making it unsuitable for extended stays. Such marshy sediments would be far from ideal for creating and maintaining fires. Middle Pleistocene hominins appear to have made forays to the lakeshore for hunting and gathering while living mainly on higher ground in the surrounding area. Since we have not identified such residential sites for study, we cannot rule out that they were often destroyed by erosion, in contrast to the lakeshore deposits from MIS 9, which are typically preserved in largely undisturbed condition.

Turning to animal-based subsistence, remains of horses are particularly abundant and bear countless cutmarks and numerous scars and green bone breaks from systematic marrow extraction. Hominins also appear to have killed and butchered a wide variety of game species.

Human Adaptations



Figure 2. Schöningen. Overview of the Rescue excavations at Schöningen in 1995. Source: Heritage Office of Lower Saxony.

Our research using stable oxygen and carbon isotope studies demonstrated that the horses from the Spear Horizon could not have originated from a single cohort of animals killed during a single large hunt, as Thieme argued. The seasonal variation of the isotopic signals from the teeth of juvenile horses showed far more variation than one could find in a single herd. The great variability in dental wear patterns also indicates that the horses from the Spear Horizon were not killed on the same day. The current research indicates that Middle Pleistocene hominins, most likely late *Homo heidelbergensis* or early Neanderthals, frequently hunted individual animals or small numbers of animals in separate events rather than in a single mass kill that led to the occupation of a large aggregation site on the lakeshore.

Such hunting events almost certainly reflect the coordinated actions of hominin groups. Group hunts require effective communication and well-coordinated actions to achieve shared goals. Nonetheless, the current evidence is not consistent with Thieme's interpretation of large aggregation sites with many hearths and wide-reaching reciprocal social-economic relationships and religious beliefs. Despite some of Thieme's interpretations having been shown to need revision, he deserves great credit for discovering the Middle Pleistocene archaeological sites in Schöningen and excavating them with remarkable care under exceptionally challenging circumstances.

The years since 2008 have produced many scientific highlights and other important events. These include the opening of the Paleon Research Museum in Schöningen in 2013. Another key event was establishing a research unit of the Senckenberg Centre for Human Evolution and Paleoenvironment in Schöningen in 2016. The ongoing research at Schöningen highlights the unique importance of landscape archaeology in the Paleolake sediments surrounding the lignite mine, and the Ministry of Science of Lower Saxony's vision to maintain a high level of stable funding for research and outreach for this exceptional series of sites.



Figure 3. Schöningen 13 II-4. View of the stratigraphic position of faunal remains and Spear I, autumn 1995. Photo: Heritage Office of Lower Saxony, Plan: U. Böhner. After Conard et al. 2015a.

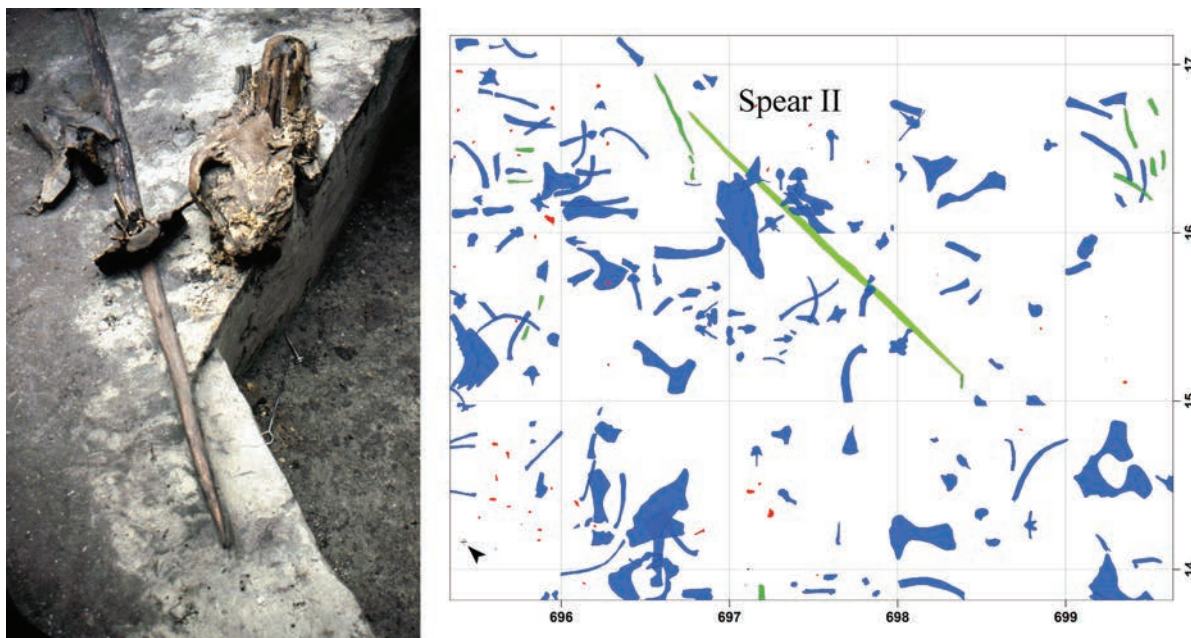


Figure 4. Schöningen 13 II-4. Spear II and horse bones at the interface of the calcareous marl and the peat-like organic horizon. The photo was taken when the new finds were presented on November 1, 1995. Photo: N. J. Conard. Plan: U. Böhner. After Conard et al. 2015a.

Ongoing research at Schöningen

The ongoing excavation and research at Schöningen continue to build on the impressive work of Thieme and other Quaternary researchers, including Dietrich Mania, Brigitte Urban and Thijs van Kolfschoten. While some debate persists over the age of the Reinsdorf Interglacial Complex, the strongest case, based on multiple independent lines of evidence, is for a correlation with MIS 9. The botanical record and faunal biostratigraphy place the series of lakeshore occupations in MIS 9. Recent studies of ancient DNA demonstrate that Schöningen offers exceptional preservation for archaeo- and paleogenetic research, and that molecular dating from Schöningen is consistent with a correlation of MIS 9 with the Reinsdorf Interglacial Complex. One recent study by Arianna Weingarten and colleagues documents the earliest horse DNA from a non-permafrost, open-air setting, and additional research on ancient DNA from Schöningen is nearing completion. The excellent preservation at Schöningen has opened new opportunities for the study of eggshells, insects and innovative methods from molecular archaeology.

Concerning botanical technology at Schöningen, recent fieldwork recovered an additional well-preserved throwing stick carved from spruce wood from the extension of the Spear Horizon. At the same time, Dirk Leder and colleagues from the Heritage Office of Lower Saxony have published a body of 187 diverse wooden artefacts from Thieme's excavation. Although much botanical material from the site has not been studied in detail, Schöningen has already produced the largest and most diverse assemblage of Palaeolithic wooden tools. The exceptional preservation at Schöningen makes the recovery of these finds possible. Perhaps more remarkably, when we excavate new botanical finds, they are typically in excellent condition and are not fragile. Usually, researchers can pick up wooden artefacts and handle them without fear of them breaking. These discoveries of wooden artefacts document how late archaic hominins made and used at least three different wooden weapons for hunting, including throwing spears, thrusting spears and throwing sticks.

These weapons are not composite tools and lack stone tips. While the weapons have been the focus of attention, the assemblage of wooden artefacts includes a range of other tools and byproducts of woodworking, including additional forms whose use we have not yet systematically assessed.

The lithic technology from the many sites at Schöningen shows a clear and consistent signal. The lithic reduction chains never document long, in situ, sequences from cobbles or blocks of Baltic flint that the Elsterian glacier transported to the Schöningen area. The paleo-lakeshore lacks high concentrations of lithic artefacts, consistent with the water-saturated nature of the sites. It seems that most flint-knapping took place at elevated positions away from the lakeshore, but so far we have not yet located such knapping concentrations or residential sites. Repeatedly, we recover isolated tools. Most of these tools are scrapers made on large flakes or thermally shattered, naturally occurring flint. Levallois technology and handaxes are absent from the assemblages. The lack of Levallois technology has generally led archaeologists to attribute the assemblages to a late phase of the Lower Palaeolithic. Other researchers, however, prefer to attribute the sites to the early phases of the Middle Palaeolithic. I am open to either interpretation, given that MIS 9 is often seen as the chronological boundary between the late Lower Palaeolithic and early Middle Palaeolithic.

The many osseous and botanical artefacts from Schöningen are so exceptional that they have few diagnostic counterparts that provide reliable chronological or taxonomic information. Where one draws a line between periods in such cases is arbitrary and probably of little consequence to archaeologists interested primarily in how late archaic hominins in northern Europe lived and organised their social and economic behaviour. Zooarchaeological research has also identified faunal remains of multiple individuals of sabre-tooth cats. One sabre-tooth cat humerus served as a retoucher for knapping flint. Research by Ivo Verheijen has demonstrated that hominins at Schöningen occasionally butchered and likely killed bears along the shores of the paleolake. The cutmarks on the bear bones strongly suggest that the Schöningen hominins skinned the bears. We hypothesise that bearskins provided clothing and bedding, while facilitating survival and comfort during the winters on the Northern European Plane.

Among other discoveries, the current team has recovered a nearly complete skeleton of a ca. fifty-year-old female straight-tusked elephant lying on its side in the lake sediments. The right scapula and the axial skeleton show chew marks from large carnivores. Initially, we assumed that the elephant died without hominin intervention on the lakeshore. As work progressed, excavators recovered three bone retouchers with characteristic scars and small flint chips embedded in their surfaces. We found no lithic artefacts during excavation; however, during waterscreening, we recovered 57 small retouching flakes in direct association with the elephant. Two of the pieces of these small artefacts could be refitted, providing still more evidence that hominins resharpened stone tools at this location. Flavia Venditti, who conducted the studies of use-wear and residues, identified particles of wood embedded in the retouched edge of the tiny flakes.

The tools from which the retouching flakes originated had been used for woodworking. Other small retouching flakes preserved use-wear from butchering. Although we failed to recover a single stone tool associated with the elephant, the contextual data prove that hominins used and resharpened flint scrapers and knives at the spot where the elephant died. Although we cannot determine whether hominins killed the elephant, they appear to have had early access to the animal, and we demonstrate how lithic, osseous and botanical technology are interconnected. We have not yet finished excavating the area around the elephant. Still, with or without the discovery of botanical tools, we can be sure that the hominins who butchered the animal had also recently worked wood, perhaps in the context of gearing up for activities on the lakeshore.



Figure 5. Schöningen 13 II. View of the ongoing excavations in 2014 showing the position of the four preserved sedimentary cycles from the paleolake at Schöningen. Sedimentary cycle 5 was truncated by mining and is not visible in the picture. Photo: J. Serangeli, University of Tübingen. After Conard et al. 2015a.

Another area where research has made considerable progress is with the study of footprints and trackways. Building on earlier observations by Thieme, ongoing research by Flavio Altamura on trackways in many areas of excavation at Schöningen documents the comings, goings and activities of many animals along the marshy lakeshore. The high contrast between the grey marl deposits and the dark, overlying peat-like sediments of the paleo-lakeshore provides nearly ideal conditions for studying trackways.

These sediments preserve clear footprints of horses, rhinoceroses, large and small ungulates, elephants and hominins. This research has identified footprints from three relatively small hominins, possibly reflecting the movements of a group of children or a small adult accompanied by young children.

Perspectives for the future

As a result of the reliable funding, excellent infrastructure and shared vision provided by the Ministry of Science of the state of Lower Saxony, the Paleon Research Museum, the University of Tübingen, the Senckenberg Centre for Human Evolution and Paleoenvironment, the Heritage Office of Lower Saxony and the German Science Foundation, we have every reason to expect outstanding scientific results in the future. Currently, dozens of students and researchers are contributing to the ongoing work at Schöningen in numerous fields of archaeology and Quaternary ecology.

Human Adaptations

The presence of more than two dozen well-preserved find horizons across the paleolandscape around the Middle Pleistocene lake provides good reason for optimism that we will continue to find more sites that fill gaps in our knowledge of the lives of late archaic hominins.

The excellent biomolecular preservation of aDNA in bones and sediments, as well as ongoing proteomics work using ZooMS, may help define new research agendas. In many respects, Schöningen provides the perfect laboratory for testing the limits of archaeological methods in the relatively deep time of the Middle Pleistocene.

One focus of our ongoing work relates to obtaining UNESCO World Heritage Status for Schöningen. More than fifteen years ago, the UNESCO HEADS project identified the Schöningen paleo-lakeshore sites as a particularly strong candidate for World Heritage status. Recently, Schöningen became the top priority among potential World Heritage sites in Germany, and our team is currently preparing the nomination file for World Heritage status. Due to the exceptional preservation and the “Schöningen Effect” research at the locality, much has been done to shape our interpretations of the Palaeolithic past. There is good reason for optimism that UNESCO will inscribe the site based on its outstanding universal value.

Each year, the research team in Schöningen builds on the discoveries of Hartmut Thieme and his team. In close collaboration with our colleagues from the Heritage Office of Lower Saxony and dozens of other institutions, we continue to develop the productive research tradition in Schöningen. The team frequently makes exciting discoveries through excavation and lab work, and there is every reason to think that ongoing research will yield important results that will shape our understanding of hominin lifeways during the Middle Pleistocene. The exceptional preservation at Schöningen and the long-term multidisciplinary commitment to excellence in research will contribute to important debates in human evolution while helping to establish the place of our genus in shaping the world we know today.

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From Grassland hunter-gatherers to grain farmers in Western Asia and Sahelian Africa: Understanding climatic settings, domestication and agricultural origins with regional archaeological sequences

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Domestication processes and agricultural origins were both protracted, regional processes. As these processes took many centuries, or a few millennia, they typically extended across time spans beyond that represented by any individual site and thus can be accessible to study through drawing data across multiple sites within a region. The present contribution will illustrate how agricultural origins can be understood by drawing upon evidence across multiple sites to put together a time series of quantitative data and qualitative observations. The focus here will be on cereal agriculture, setting aside the rather different processes of domestication involved with tuber-based vegetational systems (on those vegetational domestication processes, see Denham et al., 2020; Fuller and Denham, 2021; Fuller et al., 2023). The origins of seed crop domestication and grain-based agriculture can be illustrated with a wealth of evidence from Southwest Asia, i.e. the ancient Near East, but also with an emerging picture from evidence in sub-Saharan Africa, at both the western and eastern ends of the Sahel. The Sahelian and Near Eastern evidence provides both parallel processes but also key contrasts in terms of the nature of human settlement, sedentism versus mobility, as well as contrasting economies in terms of the importance of pastoral modes of production alongside plant food production.

The present paper thus provides a synthesis and comparison of three distinct centres of domestication and agricultural origins in the Sahelian zone of West Africa and in northern Sudan and western Asia. All of these zones share ecological parameters, such as being semi-arid grasslands

The present paper will provide a synthesis that compares the origins of the cereals and cereal farming in Western Asia. While domestication and agriculture are interconnected, they are not the same thing. Thus, we need to consider both of these as distinct transitions, and we will do so across the three regions indicated. Differences in these processes can be suggested to give rise to differing, longer-term civilisational styles that contrast in particular between the Near East and the African savannas. The development of oasis agriculture will be suggested through a process that combines elements of both these sub-Saharan and Near Eastern agricultural traditions and civilisational styles.

Grassland origins of wild cereals

In each of these regions, the dominant ecology is grasslands, ranging from savannas and the Sahel to semi-deserts. In temperate zones, these landscapes transition from open woodlands to steppe regions and, eventually, semi-arid deserts. On a modern climate scale, these grass-dominated areas typically receive between 200 and 700 millimetres of annual rainfall (Fig. 1). The map illustrates the contemporary distribution of wild cereals, which were selected grass species brought into cultivation that evolved into the cereal crops we know today, including wild wheats and barleys, wild pearl millet in western Africa, and wild sorghum. Wild sorghum occurs throughout sub-Saharan Africa (Harlan and Stemler, 1976; Fuller and Stevens, 2018), but it is only the subgroup of this wild sorghum called *race aethiopicum* that is directly involved in initial sorghum domestication, which is found in the eastern Sahel zone west of Lake Chad and north of the Ethiopian highlands (Harlan and De Wet, 1976). Genetic evidence indicates that early domesticated sorghum spread out of this region to other parts of Africa and Asia, although there was also recurrent introgression between regional populations (Burgarella et al., 2021).

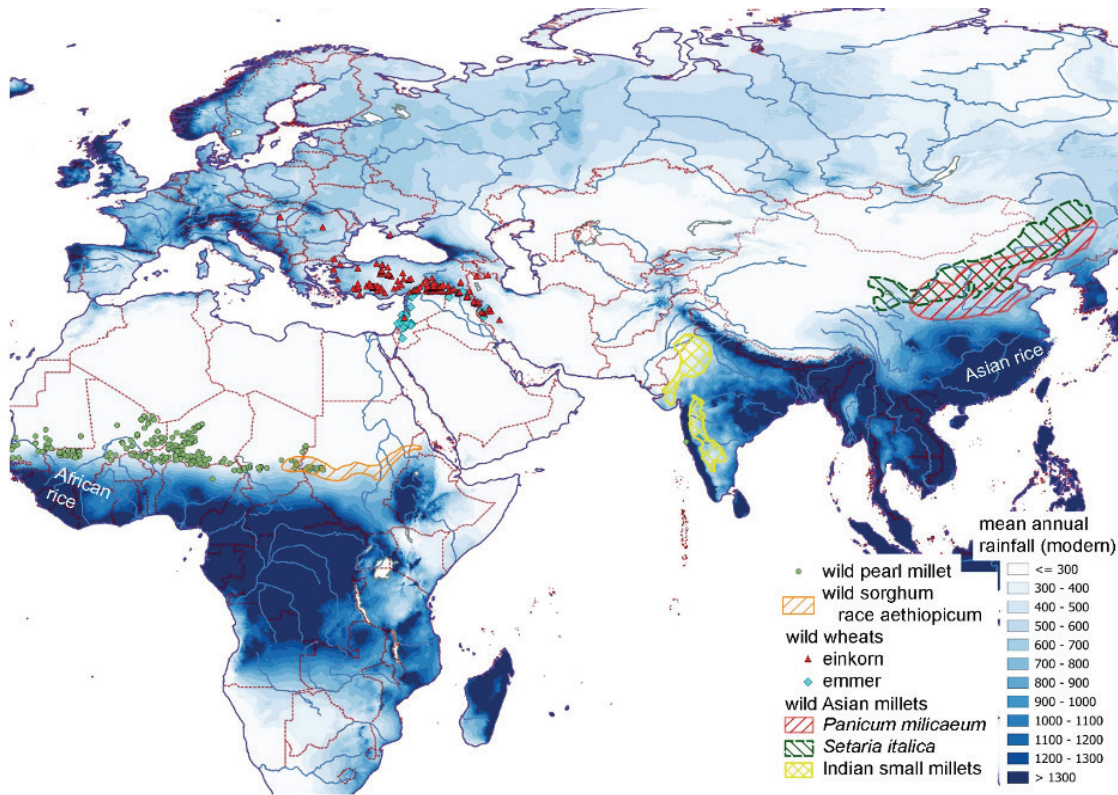


Figure 1. The distribution of wild cereal progenitors in relation to semi-arid climates and desert margins. The base map shows modern rainfall averages in 100mm isohyets (from Hijmans et al 2005), over which are plotted the zones wild cereal population regarded as closest to those brought under cultivation, including wild pearl millet (Fuller et al 2021), wild aethiopicum type sorghum (Fuller and Stevens 2018), wild emmer and einkorn wheats (data from GBIF. org), Chinese wild millets (Zhuang and Fuller 2024), with general regions of Indian millet origins and rices (from wetter zones) also indicated.

Early archaeobotanical evidence for domestication also falls in this general region (Fuller and Stevens, 2018; Barron et al., 2020). Various other wild grasses turned cereals in other regions, such as minor millets of India (e.g. *Brachiaria ramosa*, *Panicum sumatrense*, *Echinochloa frumentacea*) (Fuller, 2011; Fuller and Den Hollander, 2024), Chinese millets (*Panicum miliaceum*, *Setaria italica*) (Zhuang and Fuller, 2024), are also found within grassland zones. Because these grasslands exist at the margins of deserts, they are particularly vulnerable to long-term climate fluctuations. This sensitivity to environmental change makes them an intriguing area of study, raising questions about the role of climatic change and shifting in grassland geography in encouraging cultural adaptations to grassland exploitation that included the cultivation of selected grasses.

A key point to note is the distinct seasonal rainfall patterns observed in these grassland zones, with implications for the availability of foraged plant resources as well as the scheduling of cultivation (Fig. 2). Most regions where domestication occurred experience summer-dominated rainfall, a pattern evident across the Sahel in Africa, as well as in India and northern China. These monsoon zones, where warmer weather and longer daylength overlap with rainfall, making crop maturation periods shorter, often 3 or 4 months. This meant that the summer rainfall grasslands had highly productive rainy and post-rainy seasons that would have been attractive to hunter-gatherers, supporting them seasonally. Cultivation, when it started, often remained seasonal and was not necessarily linked to year-round village sedentism immediately.

In contrast, the Mediterranean region, including Southwest Asia, follows a different pattern. Instead of summer rainfall, it experiences dry summers and a mild, rainy winter—an anomaly compared to the other grassland zones. This means the crops grow through cooler months with shorter days that are less efficient in terms of photosynthesis. During the coolest months, growth may even pause. Maturation of traditional autumn-sown wheat and barley in the eastern Mediterranean may take 8-9 months, with maturation in late Spring. This longer growing season, as well as slower maturing fruits and nuts that became available even later in summer or late summer, meant that varied resources of interest to hunter-gatherers could be available sequentially through much of the year. With such conditions, more limited mobility and sedentism could be expected amongst some hunter-gatherers and among early farmers who tended to be sedentary. There remains, however, much scope for debating the nature of early sedentism and degrees of mobility represented by different archaeological sites (e.g. Boyd, 2006; Asouti and Fuller, 2013; Atakuman, 2014).

This difference in seasonality means there is a challenge to be overcome in moving cereal between these zones. Cereals are often tied to their original seasonality by physiological responses. These include responses to changing day length—short day plants (Willcox, 1992), or shortening day length plants include all of the monsoon adapted millets that flower and set seed after day length is shortening, i.e. towards the end of summer, and long day plants, like wild wheats and barleys that are triggered to flower as days get longer in spring time (Fuller and Allaby, 2009: 273-277; Jones and Lister, 2022). Sometimes there are physiological responses that result from temperature changes, such as vernalisation—a series of cold days, after which warming triggers parts of the floral maturation process in most Mediterranean grasses, including wild wheats and barley.

The native seasonality of wheat and barleys did not suit the rainfall patterns of India or sub-Saharan Africa, but could be well suited to some river systems such as the Nile or Indus. Such rivers swelled and flooded as a result of summer monsoon rains, which left behind wet and fertile silts that could be sown in autumn, allowing such crops to mature on residual moisture as the river level declined. Figure 2 illustrates such seasonality along the Nile, contrasting the ancient seasonality of wheat/barley compared to tropical African cereals like sorghum. Unlike the Nile, the Indus has additional challenges as it may also flood in Spring and Early Summer when the Himalayan snows melt. More often, however, the movement of crops beyond their climatic zones of origin required adjustments, either genetic changes that reprogrammed or de-programmed seasonality triggers for flowering or cultural adjustments (Fuller and Lucas, 2017; Jones and Lister, 2022). For example, genetic changes could allow Near Eastern crops to grow in areas where winters were too cold, but spring-to-summer cropping of species required different variants of flowering time genes. In the case of summer seasonality millets in areas without summer rains, some degree of irrigation is often considered necessary (e.g. Miller et al., 2016), although cultivation may have also been limited to those parts of the landscape that have water that persisted through the summer months. In either case, a key adaptive implication of having summer and winter crops is the potential for increased productivity through two seasons of agriculture. This brings with it the social implication of requiring agricultural labour for more months of the year.

Past climate change and wild cereal distribution: the Sahara

In order to take into account the impact of past climatic changes on grassland hunter-gatherers and the transition to farming, it is necessary to reconstruct shifts in the distribution of vegetation zones and wild progenitors. This is necessarily a complex process, and draws on much research by quaternary scientists through various palaeoclimatic proxy datasets—changing lake levels, sedimentary geochemistry, pollen and other microfossils, data for changing beyond the scope of thorough review here (but see, e.g. Gasse 2000; Lezine et al. 2011; Roberts 2013).

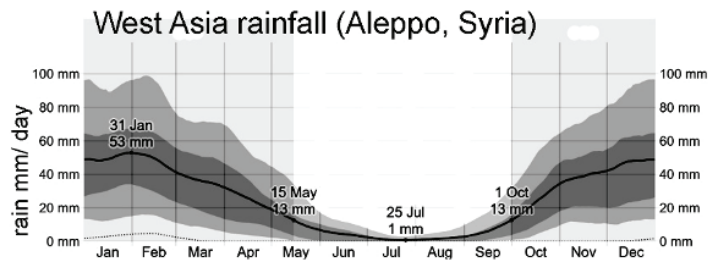
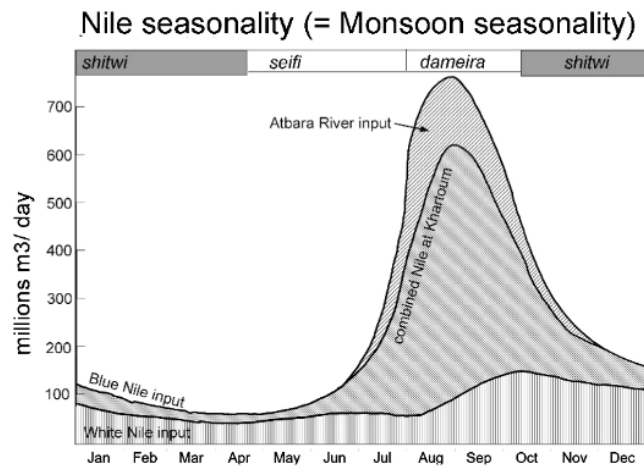
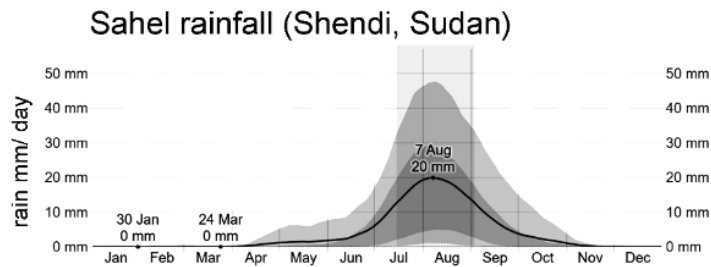
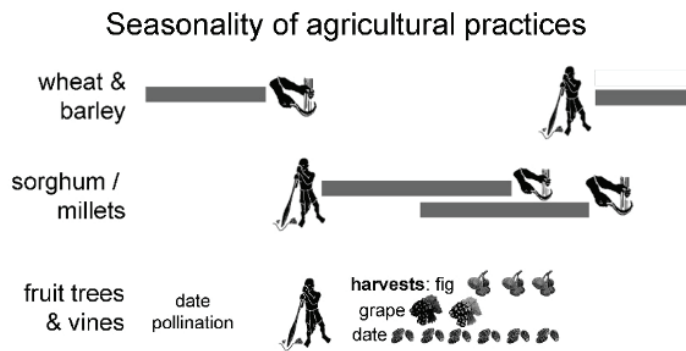


Figure 2. The traditional seasonality of cultivation and rainfall in the African Sahel and West Asia ("Levant"), as well as Nile flood regimes.

Human Adaptations

For example, it is well known that the Sahara expanded in glacial periods, which were colder near the poles and drier towards the equator; on the other hand, interglacials were shorter periods (often ~10,000 years) that were globally warmer and generally wetter. These green Sahara phases were associated with migration into and occupation of the Sahara by hunter-gatherers (Larrasoana et al., 2013; Boivin et al., 2013), which in earlier prehistory facilitated the migrations of humans out of Africa. In the Holocene the Humid Period is associated with the spread of hunter-gatherer fishers through and Sahara, taking advantage of many lakes and water systems that were active under these higher rainfall regimes (Drake et al., 2011; Manning and Timpson, 2014; Manning et al., 2023), and who brought or developed new technological adaptations like harpoons for fishing and ceramics for the processing of plant foods and animal products (Jesse, 2010; Huyescom, 2020; Fuller and Champion, 2024). Later, from around 8000 years ago, livestock and pastoral adaptations spread through the Sahara, but these groups occurred as a patchwork amongst persisting traditions of hunter-gatherer-fishers who continued to take advantage of palaeolakes (Manning et al., 2023).

A key thing to recognise is that a fluctuating climate could make the West Asian “Fertile Crescent” and sub-Saharan African grasslands closer or further apart by expanding the desert. During dry glacial periods, the Sahara and other deserts were larger. This is indicated by now stabilised (vegetated) sand dune fields that had formed in drier periods (Fig. 3). As these overlap with the Sahelian range of wild pearl millet and sorghum, we can infer that the distribution of these wild grasses would have occurred south of this ancient desert margin during the Last Glacial Maximum (~21,000-18,000 BP) (Fig. 3a). By contrast during the Green Sahara periods (including the African Humid period of the Early to Middle Holocene, ~9500 BCE to 3300 BCE (Costa et al., 2014; Manning and Timpson, 2014; De Menocal, 2015), savanna and Sahel vegetation would have occurred much further north, as would the wild sorghum and pearl millet (Fig 3b). This is indeed supported by archaeological evidence as wild pearl millet has been identified from northern Mali, well north of modern wild populations, in the era 5000-4000 BCE (site AZ22: Fuller et al., 2021). Similarly, wild sorghum was exploited by early Holocene hunter-gatherers in northern Mali (Fuller et al., 2021), Southwest Libya (Olmi et al., 2011; Mercuri et al., 2018) and the western desert of Egypt, in Southwest Egypt at Nabta Playa and Gebel Ramlah (Wasylikowa et al., 1997; Litynska-Zajac et al., 2024), as well as in the central Sudan in the middle Holocene (Magid, 1989; Stemler, 1990; Winchell et al., 2018). Taking into account past climate change makes it understandable that wild sorghum, along with other savanna grasses, was widely available to hunter-gatherers in the earlier Holocene. However, as conditions became somewhat drier after 6000 BCE, one adaptation that helped was the adoption of herded livestock, which provided moving larders (Di Lernia, 2021).

Another adaptation that could have helped was to manage sufficient wet micro-environments for edible grasses and even to replant these, i.e. to experiment with cultivation. This indeed appears to have happened several times across the Sahara, including pearl millet cultivation in the west (Mauretania, Mali) and sorghum in the east (Sudan), which are reviewed in more detail below. There were also abandoned trajectories toward domestication, including one recently documented in the central Sahara, the Tardrat Acacus region of southwestern Libya. At the Takrakori rock shelter, occupants in the Early Holocene were ceramic-using hunter-gatherers who included wild sorghum in their harvests (Olmi et al., 2011; Mercuri et al., 2018). Later, after a dry episode (6200-6000 BCE), the site was reoccupied by groups who had adopted livestock (cattle, sheep, goats) and focused their grain consumption on small millet *Panicum* sp. and *Echinochloa* sp. Over time, especially after 4800 BCE, these millet grains undergo morphological changes in grain shape (Mercuri et al., 2018). Such directional changes are consistent with the kind of selection and evolution that takes place during domestication. However, these sites are abandoned around 3800 BC and the morphologically changed forms of these species are not known from later sites or indeed from traditional cultivation; thus, these are lost crops with domesticated forms that went extinct in prehistory.

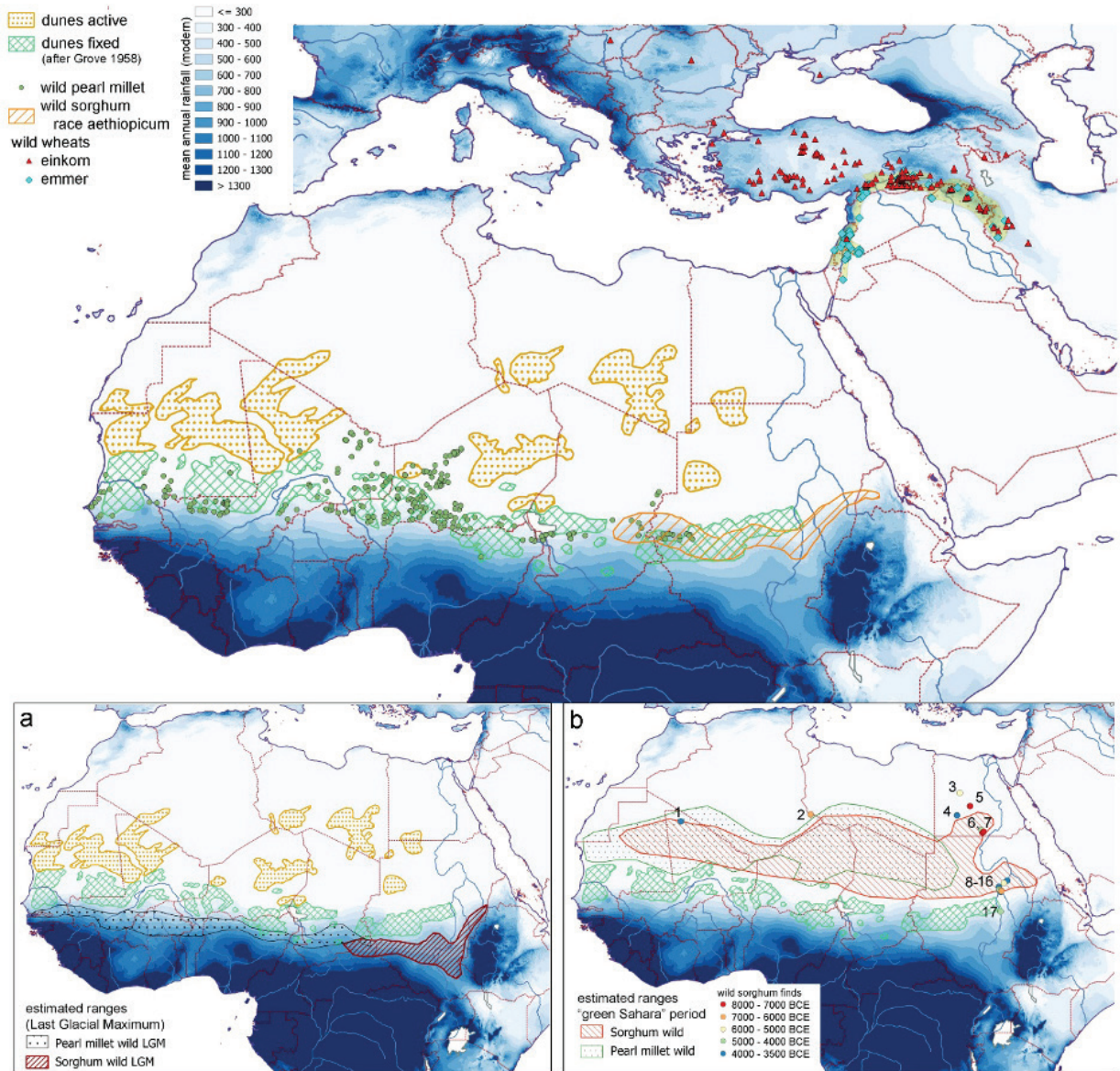


Figure 3. Map of the distribution of wild progenitor populations of selected wild cereals in relation to modern rainfall patterns, also showing area with major mobile (active) dune fields of the modern Sahara and stabilized dune fields of a palaeo-Sahara (after Grove 1958). Insets show reconstructed ranges for wild pearl millet and sorghum under past climatic extremes of (a) drier last glacial maximum (~20,000 BP) and (b) the earlier Holocene Green Sahara period (~9,000 BP), with archaeobotanical finds of wild sorghum indicates: 1. MT25 (Fuller et al. 2021), 2. Takarkori (Olm et al. 2011), 3. Farafr (Barakat and Fahmy 1999), 4. Abu Ballas (Barakat and Fahmy 1999), 5. Dakleh (Thanheiser 2011), 6. Gebel Ramlah/Bargat El-Shab (Litynska-Zajac et al. 2024), 7. Nabta E-75-6 (Wasylikowa et al. 1997); 8. El Kadada (Stemler 1990), 9. Ghaba (Madella et al. 2014), 10. Shaheinab (Magid 1989). 11. El Zakiab (Stemler 1990), 12. Um Direiwa (Stemler 1990), 13. Kadero (Stemler 1990), 14. El Mahalab (Magid 2003), 15. Sheikh el-Amin (Magid 2003), 16. Sheikh Mustafa (Magid 2003), 17. Rabak (Magid 1989)

In this case, the focus seems to have been on smaller-grained grasses that were resilient against herbivore grazing, rather than the taller, larger-grained pearl millet or sorghum. In sum, long-term trends in climatic change can be linked to long, slow processes of cultural adaptation. These include the persistence of hunter-fisher traditions (Manning et al., 2023), as well as the arrival of new pastoral adaptations and various regional experiments in plant cultivation. As we return to below, these long processes of cultural adaptation could include those processes that produced cereal agriculture in Sahelian Africa.

Climate change and the wild cereals of Southwest Asia

Turning to Southwest Asia, it is essential to take into account how climatic shifts affected the distribution of wild wheats and barleys, and then to consider how human groups in those areas may have exploited them. As already noted above, these are part of the grassland habitat that occupies the transition between Mediterranean woodlands and semi-desert steppe, in a zone that averages 400-600mm of annual rainfall (Zohary et al., 2012; Hillman, 2000). The wild wheats (*Triticum* spp.) and barley (*Hordeum vulgare*) occur in the slightly drier, more open parkland steppe with dispersed shrubs, wild almond trees and oaks, while the wild beans of southwest Asia, including lentils (*Lens culinaris*), peas (*Pisum sativum*), chickpeas (*Cicer arietinum*), grasspea (*Lathyrus sativus*), broad bean (*Vicia faba*) and other vetches (*Vicia ervilia* and *Vicia sativa*), occur in the clearings of nearby woodlands. Thus, the wild cereals today, and in general the beans/pulses, are distributed in the arc of foothills in the Near East known as the “Fertile Crescent”. In addition to the wild progenitors, these regions boast numerous wild fruits, such as figs (*Ficus carica*), wild grapes (*Vitis sylvestris*), wild almonds (*Amygdalus communis*), and various wild pistachio relatives with small oily nuts (*Pistacia* spp.). These resources would have been attractive to hunter-gatherer populations.

While during the last glacial maximum (18000 years ago), southwest Asia was a much drier place, after that, as the world warmed up, rainfall increased. This led to the expansion of the moisture-dependent vegetation zones, like the expansion of Mediterranean forests and oak woodlands. In the 1990s, while making sense of the Epipalaeolithic archaeological evidence from the Site of Abu Hureyra in Syria, occupied from 11,150 BCE to 10,450 BCE (and reoccupied later during the Pre-Pottery Neolithic B), the archaeobotanist Gordon Hillman, based on years of botanical fieldwork in the region produced a detailed reconstruction of vegetation zones at the end of the Pleistocene and into the earliest Holocene (Hillman, 1996 and 2000), simplified here as Figure 6. What is striking is that the resource-rich ecosystems (the Mediterranean forest, oak woodlands and cereal zones) all became increasingly widespread between 15000 and 13000 years ago. After 13000 years ago (or 11000E BC calibrated), a dramatic reversal occurred, which is known as the Younger Dryas, an event of glacial cooling and sub-tropical drying that has been documented globally (Roberts, 2013).

Starting in the 1990s, it became popular among some archaeologists to attribute to this climatic reversal a causal role in promoting the beginnings of cultivation (e.g. Hillman et al., 2001; Bar-Yosef, 2011). The Younger Dryas dry period would have included a retreat, with marked vegetation dying off in the previously green woodland and steppe, with increasingly localised and reduced availability of resources like wild cereals. The inference that cultivation might have begun at this time derives from the reasoning that cultivation may have been human intervention to counteract declining wild cereal availability in this period, and has been inferred from the evidence that wild cereals, in particular rye (*Secale strictum/vavilovii*) and einkorn (*Triticum monococcum sensu lato*) continue to occur in high archaeological quantities against the decline in other Mediterranean taxa at Anu Hureyra (Hillman et al. 2001).



Figure 4. The Sahelian environment its agriculture: left, a pearl millet crop (*Pennisetum glaucum*) in the Bayuda Desert Sudan; right, Sahelian semi-desert vegetation in the Butana region, Sudan. [Photos by the author, 1997 and 2018].

That cultivation was necessarily practised, however, remains ambiguous (see Colledge and Conolly, 2010; Willcox et al., 2009), and even if it was practised, it is notable that the most important staple cereals of the Neolithic and later civilisation are missing here, namely barley and emmer wheat (the einkorn present may also be a two-grained variant, a separate taxon from the true one-grained *Triticum monococcum* that was to be important in later periods). Other sites occupied beginning in the Younger Dryas also provide evidence for the consumption of likely pre-domestication cultivation of these cereals, such as Tell Mureybit, Syria (which also has barley) (Van Zeist and Bakker-Heeres, 1986; Willcox and Fornite, 1999). In general, it is later sites, after 9500 BCE, after the Younger Dryas, that provide stronger evidence for Pre-Domestication cultivation (Willcox et al., 2008 and 2009; Asouti and Fuller, 2013). In any case, the key point is that climatic fluctuation here, as was true of the Saharan in the middle Holocene, presents challenges to hunter-gatherers living in these environments. It can be argued that some human communities adapted to these harsher conditions by maintaining certain species of food plants through cultivation, while other groups may have reverted to increased seasonal mobility and moved in pursuit of wild resources.

Finding domestication and agriculture: definitions and expectations

Domestication and the origins of agriculture are both evolutionary processes, and although interconnected, they are different. In a strict biological sense, domestication is the evolution of adaptations (morphological changes) that make a plant suited to the cultivated environments, or an animal adapted to be herded. These changes are underpinned by genetic changes as key genes for these changes become frequent and fixed within the cultivated or human-managed population. Recent work in genomics suggests that many domestication traits were based on rare genetic variants in wild populations that became frequent as a result of domestication, while some other traits were new mutations that arose after domestication. Such genetic characterisation of domestication is quite recent and has focused on only some cereal species, including rice, sorghum and maize (Burgarella et al., 2021; Ge et al., 2023; Alam et al., 2025; Ramos-Madrigal et al., 2016; Kistler et al., 2020), but is presumably similar in other cereals.



Figure 5. The fertile crescent environment: left, oak parkland vegetation in the “hilly flanks”, Iraqi Kurdistan; right, wild barley (*Hordeum spontaneum*), Iraqi Kurdistan [Photos by the author, 2012]

Plant domestication is about changes in the plant. Domestication is a set of changes that evolved as a result of cultivation processes, which took place over hundreds to thousands of plant generations, i.e. 100s to 1000s of years. This process takes place during what we call a domestication episode, which is also often identified by archaeobotanists as a period “pre-domestication cultivation.” In the 1980s and 1990s, it was often inferred that this was a rapid process and short episode, perhaps 20 to 200 years only (e.g. Hillman and Davies, 1990a; 1990b; Harlan, 1995), which was not much different from the error margins on radiocarbon dates at that time. As archaeobotanical data became available to document those, however, it came to be recognised that this episode was much longer and the processes were protracted (Tanno and Willcox, 2006; Fuller, 2007; Allaby et al., 2008; Purugganan and Fuller, 2011; Arranz-Otaegui et al., 2016). As will be seen in the archaeological evidence reviewed below, domestication episodes lasted millennia, often around 2000 years (Fuller et al., 2014).

Agriculture and cultivation, by contrast, are about human practices and cultural evolution. Domestication is underpinned by genetic changes in the plant (or animal), while cultivation is underpinned by changes in traditional ecological knowledge, practices and traditions (e.g. Harris and Fuller, 2014; Fuller and Lucas, 2025). We can draw a distinction between cultivation and agriculture as a difference in scale. All agriculture involves cultivation, but not all cultivation is agriculture. Agriculture is when the scale and importance of cultivation are such that crops dominate the economy and cultural landscape. Between the very earliest small-scale cultivation and fully developed agriculture, there is a range of potential intermediate economic systems mixing various degrees of reliance on crops and gathered foods, just as there were also centuries of changes to the crops themselves as they require more domestication characters and higher frequencies of domestication (Fuller and Lucas, 2025). During the domestication episode, therefore, there are both changes to the crop, as it evolves, and changes to the subsistence systems as crops become more important (Fig. 7).

Botanists have long recognised that a “domestication syndrome” can be defined as a series of features that have evolved in parallel across different crop domestications. The domestication syndrome for cereals and other grain crops, grown from seed and for seed, is well known (Harlan et al., 1973; Hammer, 1984; Fuller, 2007; Jones et al., 2021). These characteristics can be related to different aspects of cultivation in terms of what causes them to evolve. On the one hand, there are traits that offer competitive advantages for the establishment of seedlings in cleared soil conditions of a cultivated field, while on the other hand, there are features that relate to human harvesting: connecting cereal reproduction to dispersal by the farmer.

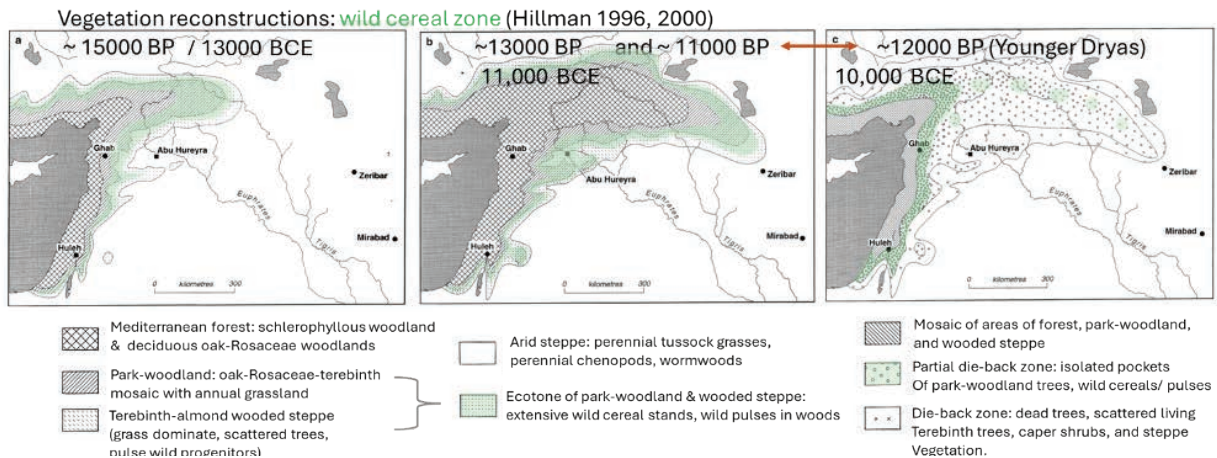


Figure 6. Reconstructed distribution of vegetation zones on the western and northern Fertile Crescent of Southwest Asia before during and after the Younger Dryas dry episode at the end of the Holocene (after Hillman 1996; 2000). Vegetation zones have slightly simplified, and the main wild wheat and barley zones is highlighted in green.

Key changes that relate to soil conditions include a trend towards increasing seed size and loss of germination inhibition. Crops tend to germinate as soon as they are wet and planted, in contrast to wild forms that often germinate after certain conditions have passed, conditions of daylength, temperature, or after the seed coat is physically damaged. More universally, seeds get larger (Hammer, 1984; Fuller, 2007), and seed size is readily documented from archaeobotanical remains (e.g. Fuller et al., 2014). This is even the case with vegetables that are not cultivated for their seeds (Kluyver et al., 2017), and therefore it is not a matter of making the edible portion larger but driven by other processes, most likely competition among seedlings (Allaby et al., 2022a and 2022b). The results of these changes, however, mean that any crop undergoing domestication will gradually increase yields (more calories per seed) over the course of the domestication episode, in addition to many other changes that increase the harvested yield.

A change related to cycles of human harvesting and sowing from stored harvests is the loss of natural seed dispersal, often taken as the sine qua non of domestication (e.g. Zohary, 1969; Harlan et al., 1973; Fuller, 2007). In wild grass, the spikelets fall off the plant as the grains mature, allowing for seed dispersal via wind, gravity, or, in the case of rice, water. An abscission scar forms to cleanly separate and disseminate the mature spikelets of wild cereals. However, with domestication, this abscission is delayed or stopped completely by a series of genetic changes that keep the mature grain attached to the mother plant (Ishikawa et al., 2020). This essentially makes the plant reliant on a harvester (people) to disperse seeds. It means that instead of shedding seeds when they are mature, a plant retains them. Instead, those seeds must be separated by processing (threshing), that is, by the addition of human labour, and then the seeds are dispersed by the farmer. This process may increase the efficiency of harvest, but it comes at the price of locking humans in expending more labour on harvesting, processing and investing in tools and techniques connected to these, i.e. it is an “agricultural labour trap” (Fuller et al., 2010 and 2016). When spikelet bases or the rachis segments of cereal ears survive archaeologically, these can be documented as being either wild-type (shattering) or domesticated-type (non-shattering), allowing the gradual rise of the domesticated type to be documented archaeobotanically. As reviewed below, quantitative data from wheats and barley, pearl and sorghum all document this evolutionary process, but it is also evident that this process is not visible in any single archaeological site but requires pulling together evidence from multiple sites and phases, i.e. long regional sequences.

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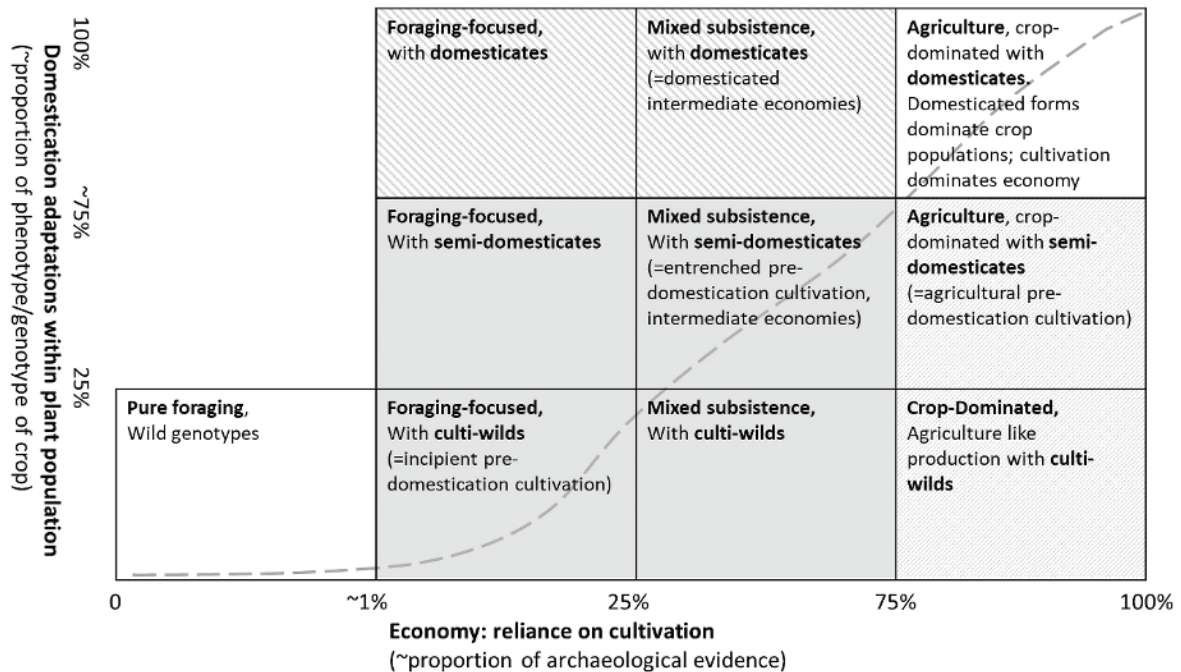


Figure 7. A scheme of intermediate economies and subsistence between full foraging and agriculture based on fully domesticated crops. Evidence for the various mixed combinations has been documented for various sites in Southwest Asia dating between 9500 BCE and 6500 BCE (Fuller and Lucas 2025).

Southwest Asia: cereal domestication in the Fertile Crescent

This region is well known as the natural distribution of several crop wild progenitors, including wheat and barley, pea, lentil, chickpea, bitter vetch, broad bean and flax (Zohary et al., 2012), as well as several important fruit species domesticated later, such as olive, grape and fig (Fuller and Stevens, 2019). In general, these wild progenitors can be found in a restricted set of adjacent vegetation zones from the Mediterranean oak woodlands (e.g. Figure 5), through the open grassland steppe which corresponds to areas of moderate rainfall between the better watered high hills or Mediterranean coast and the more desertic conditions of central Mesopotamia. The wild wheats (*Triticum* spp.) and barley (*Hordeum vulgare*) occur in the slightly drier, more open parkland steppe with dispersed shrubs, wild almond trees and oaks, while the wild pulses of southwest Asia occur in the clearings of nearby. As already reviewed above there were shifts over time in these distributions in response to changing climate (Fig. 6). These wild progenitors do not overlap entirely, nor do their early archaeobotanical occurrences entirely coincide, which has lead in recent years to an archaeological consensus that the fertile crescent had more than one sub-region of parallel origins of cultivation and domestication (Willcox, 2005; Fuller et al., 2011 and 2018; Arranz-Otaegui et al., 2016); although equally it is possible to conceive of this in terms of a more dispersed and interactive process as regional metapopulations of early cultivars were linked through cultural interactions, in other words a landscape perspective on domestication (Allaby et al., 2022a). Archaeological evidence has highlighted evidence for regional networking, starting in the Epipalaeolithic ~15,000 years ago through evidence for trade in ornaments (like Mediterranean sea shells) and geological resources like flint and basalt (Maher et al., 2012; Belfer-Cohen, and Goring-Morris, 2021), and in some regions trade in obsidian (Frahm and Tyron, 2018).

An increasingly prominent part of the archaeological evidence in this period represents grinding equipment, which can be considered a technology for intensifying the exploitation of plant resources through processing. The occurrence of grinding equipment from increasing over the course of the Epipalaeolithic increased efficiency in processing plant seed foods, including cereals, for better digestion of calories. By breaking down seeds into smaller pieces, their surface area increases, and more of them can be absorbed by the digestive system. By grinding them into flour, even more can be absorbed. Two chronological trends in the Levant attest to such an intensification of the use of food resources through their processing (Wright, 1994). The increase in mortars and grinders through the Epipalaeolithic and subsequently the Neolithic, and an increase in querns as opposed to mortars during the Neolithic, imply increasing investment in food processing. This could serve to extract more calories from the same amount of plant foods, which might be connected to increasing population density.

The study of domestication requires pulling together data of the plants or animals people used over long time spans, which requires data from across multiple sites. Here, the focus will be on domestication in cereals (einkorn wheat, emmer wheat and barley). Data on non-shattering and grain size increase together indicate something like 3000-4000 years to shift from nearly fully shattering to non-shattering (Fig. 8). Shattering is nearly ~0% prior to 9000 BCE, with entrenched pre-domestication cultivation (20% to 80% non-shattering) between 9000 and 7000 BCE (Tanno and Willcox, 2012; Fuller et al., 2014 and 2018). The assemblages of >80% and up to ~100% non-shattering occur only after 7500 BCE for barley and 7000 BCE for wheat. There are some outliers, which may be due to imprecision in dating, but they may also indicate more than one local start to the process. Grain size increases during the same period when non-shattering was evolving. Episodes of size increase in pulses may be shorter than in cereals, whereas in cereals this was more protracted than seen for non-shattering (Fuller et al., 2012, 2014 and 2017), starting already before ca. 9000 BCE and finishing around 6000 BCE. Thus, the increase in grain size continued for somewhat longer (up to ca. 6000-5500 BCE) than non-shattering (fixed ca. 7500-7000 BCE). While such trends capture a long-term and large-scale, regional pattern, there is much detailed variability that hints at dynamics taking place at more local scales. For example, highly evolved (large-grained) einkorn co-occurs with small (wild-like) emmer wheat grains at the sites of Ramad (southern Syria) and Er Baba (central Turkey); but large domesticated type barley occurs at both sites. Ramad has ~60% non-shattering barley rachis, so it is also clear that the evolution of the domesticated population was ongoing. At Choga Golan in western Iran, ca. 8200 BCE, barley looks largely wild (3% non-shattering), while emmer wheat is closer to semi-domesticated (56% non-shattering) (original data: Weide et al 2015). Other variations are seen both between regions. Roughly contemporary with Choga Golan is Tell Aswad in southern Syria where both emmer and barley are between 20% and 30% non-shattering, with similarly intermediate levels of grain size increase. In the same era sites on eastern Anatolia such as Çayönü and Gusir Höyük with the largest grain sizes that are known before 8000 BC (see Fig. 8). Even within a region there are contrasts that suggests some communities had taken up domesticated crops while other were still gathering from the wild: Azraq 31 and Wadi Jilat sites in eastern Jordan have wild barley rachis (nearly all shattering) while contemporary sites in southwest Jordan (Wadi Fidan A, El-Hemmeh Late PPNB) or the Damascus Basin (Tell Ramad) are well along the domestication scales (50%-70% non-shattering).

Having documented domestication, there is the related question of economic changes and the emergence of agriculture. Having domesticated cereal morphologies, whether as a minority or majority of cereal remains, does not necessarily tell us whether or not a community was more dependent economically on cultivated cereals or wild resources.

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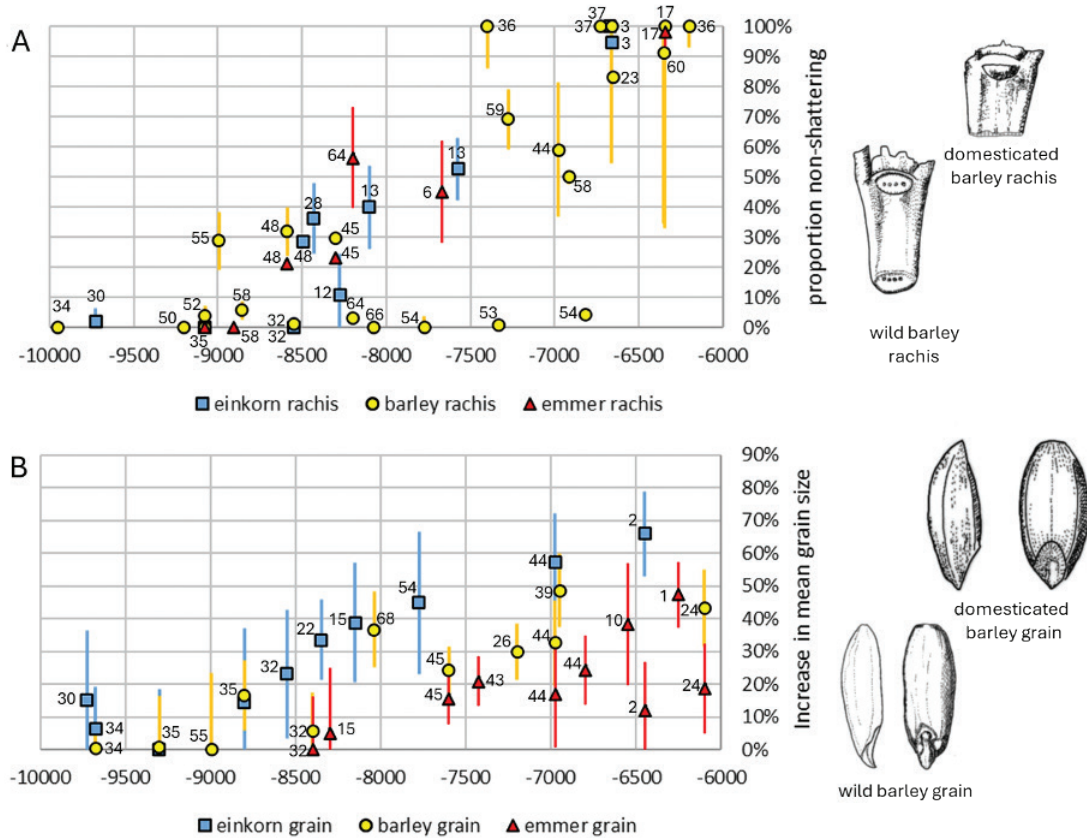


Figure 8. Domestication timelines based on archaeobotanical evidence for barley, einkorn wheat and emmer wheat based on archaeobotanical rachis and grain size data. At right illustrated example of domesticated versus modern rachis and grains of barley (author's drawings). A. Percentage of non-shattering rachis remains in archaeological assemblages plotted against median estimated age BCE; standard deviation error bars are based on using indeterminate remains to estimate maximum and minimum possible proportions. B. Percentage increase in mean grain breadth in grain assemblages plotted against median estimated age BCE; standard deviation is based on variation within assemblage measurements. Sites are numbered following the sites in Figure 9. (Data from Fuller and Lucas 2025).

Instead, we need to look at proportion of crops out all potential food plants (as suggested by the categories in Fig. 7). A large compilation of such data, from all archaeobotanical assemblages with at least 300 identified seeds and at least 10 identified species (Fig. 10), found that on average sites were still largely reliant on wild foods and not early crops upto ca. 7500 BCE, with very few sites reporting more than 50% crops (Fuller and Lucas, 2025).

Even as late as 6500 BC, a majority had less than half their plant remains from crops, whereas at most later sites, crops outnumbered potential wild foods. Thus, the transition to reliance on agriculture was slow and even slower on a regional basis than the evolution of domesticated crop morphologies. Such data suggest that part of the longer-term process of transition to agriculture was a great deal of experimentation with diversity, both in terms of the diversity of wild foods and the diversity of crops. We have only reviewed evidence for wheats and barley, above, while the region and period also saw the domestication of pea, lentil, chickpea, broadbean, bitter vetch and flax- additional plant diversity brought into cultivation.

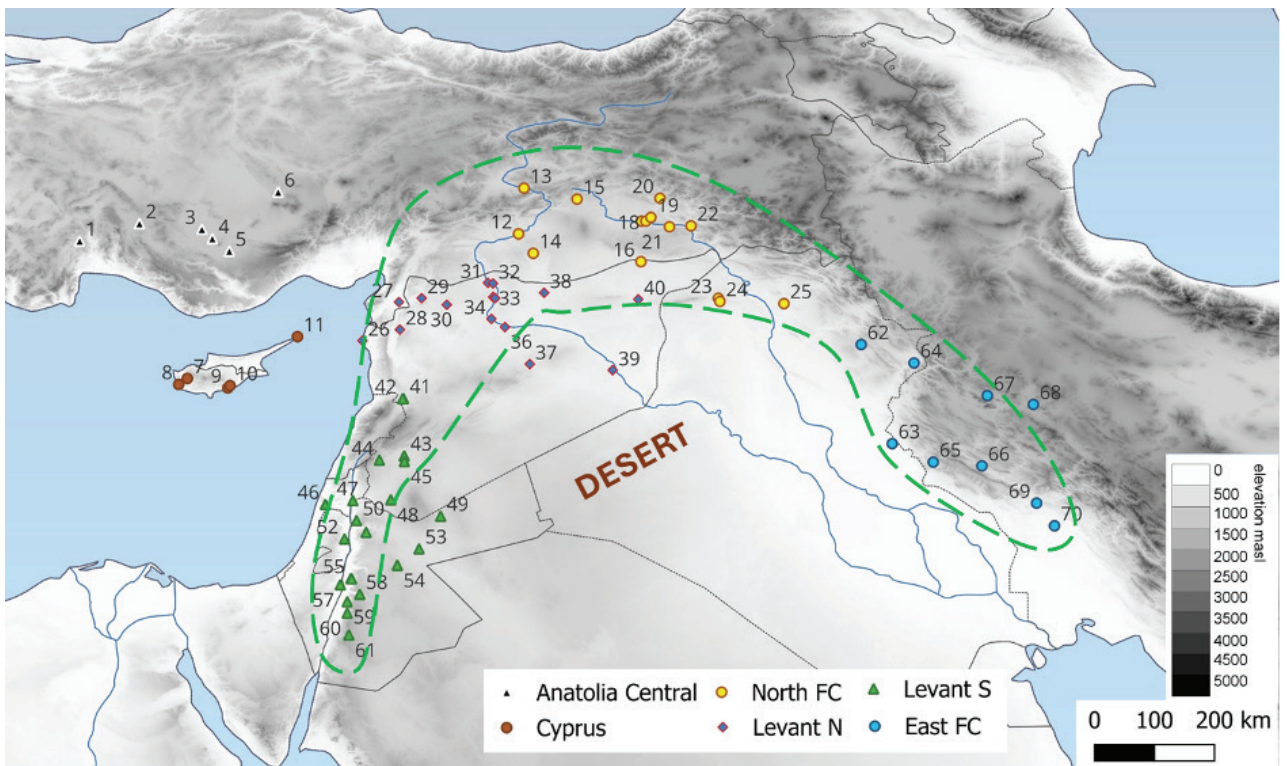


Figure 9. Map of archaeological sites contributing to data on cereal domestication and economic change in the Late Epipalaeolithic and Neolithic of Southwest Asia, dashed green line indicates the conventional “Fertile Crescent” region. Sites numbered Anatolia Central: 1. Höyücek, 2. Erbaba, 3. Çatalhöyük, 4. Pınarbaşı, 5. Can Hassan III, 6. Aşıklı Höyük, 7. Krittou Marottou ‘Ais Yiorkis, 8. Kissonerga Mylouthkia, 9. Kalavassos Tenta, 10. Khirakitia, 11. Cape Andreas-Kastros; 12. Nevalı Çori; 13. Cafer Höyük, 14. Göbekli Tepe, 15. Çayönü, 16. Tell Aqab, 17. Salat Cami Yani, 18. Körtik Tepe, 19. Demirköy, 20. Hallan Çemi Tepesi, 21. Hasankeyf Höyük, 22. Gusir Höyük, 23. Mazgaliyeh, 24. Yarim Tepe, 25. M’lefaat, 26. Tell Ras Shamra, 27. Tell Kurdu, 28. Tell El-Kerkh, 29. Dederiyeh Cave, 30. Tell Qaramel, 31. Tell ‘Abr, 32. Dja’dé, 33. Tell Hallula, 34. Tell Mureybit, 35. Jerf al Ahmar, 36. Tell Abu Hureyra, 37. El Kowm, 38. Tell Sabi Abyad, 39. Tell Bouqras, 40. Umm Qseir, 41. Arjouné, 42. Tell Nebi Mend, 43. Tell Ghoraifé, 44. Tell Ramad, 45. Tell Aswad, 46. Nahal Zehora, 47. Sha’ar Hagolan, 48. Tell Qarassa, 49. Shubayqa, 50. Iraq ed-Dubb, 51. Jebel Abu Thawwb (er-Rumman), 52. Netiv Hagdud, 53. Azraq 31, 54. Wadi Jilat 7 & Wadi Jilat 13, 55. Zahrat Adh-Dhra (ZAD) 2, 56. Dhra’, 57. Nahal Hemar, 58. El-Hemmeh, 59. Wadi Fidan A 60. Wadi Fidan C, 61. Basta, 62. Jarmo, 63. Choga Mami, 64. Tepe Marani, 64. Choga Golan, 66. East Chia Sabz, 67. Sheikh-e Abad, 68. Ganj Dareh, 69. Ali Kosh, 70. Chogha Bonut.

As domestication and reliance on cultivated crops both increased over time, these would have come with advantages in terms of productivity and demands in terms of labour. The domestication process itself created labour traps (Fuller et al. 2010), demanding investments in maintaining soil fertility, watering and weeding crops, as well as harvesting, processing and storing. As more labour was invested in crops, there would have been opportunity costs in terms of time to gather other resources. Cultivation represents a form of intensification as labour is invested in land to increase the caloric yields and storable surplus of that land. Early cultivation in southwest Asia is reconstructed as having been small-scale and intensive, including manuring of soils, at least once herded animals became part of the system (8500-8000 BCE) (Bogaard, 2005; Styring et al., 2017; Fuller and Lucas, 2025). This facilitated growth in population density and sedentism, which is reflected in the increasing size of sites, especially the largest sites, over the course of the Neolithic period, and an increase in site numbers (Kuijt 2000 and 2008; Guerero et al., 2008; Fuller and Stevens, 2017; Birch-Chapman et al., 2017).

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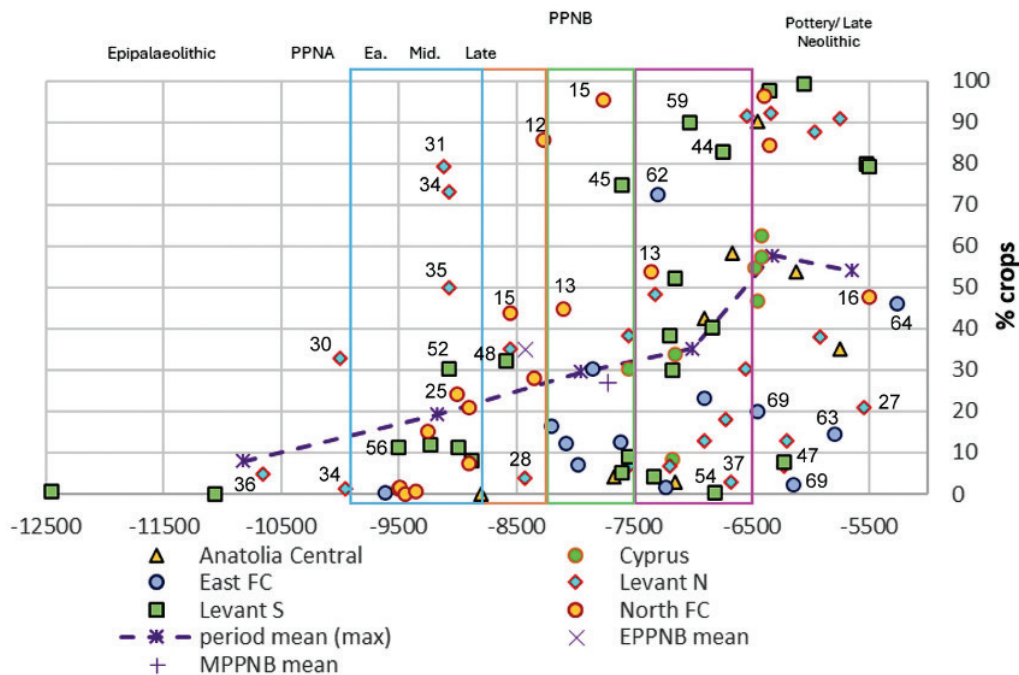


Figure 10. A chart of mixed subsistence economies and the slow rise to dominance based on plotting the percentage of crops (including morphologically wild crops) out of all plant remains against median age (after Fuller and Lucas 2025). The trend line is based on the mean for each period. Selected sites numbered (map numbers from Figure 10) to illustrate sites that fall above or below the macro-regional trend.

In the Pre-Pottery Neolithic, generally considered the earliest phase of widespread pre-domestication cultivation sites, the average site size averages less than 1 ha in size, and up to 3, in the Early and Middle PPNB (8700-7500 BCE), the average site size is ~2.3 ha, with the largest sites up to 8ha by the end of this period. This can be converted into an estimate of average site populations of 60-90 in the earlier period, and 140-220 in the later period. In the next millennium (7500-6500 BCE), the mean site size was ~4.3 ha, with the largest site between 8 and 16 ha (on large sites: Kuijt and Marciniak, 2024). Wheat and barley, once domesticated, were highly productive (4 or 5 times as productive as early sorghum or millet, Fuller et al., 2019), and would have readily supported populations of many hundreds to a thousand or slightly more within the catchment of a single site (Kuijt and Marcianak, 2024). An added new input in subsistence was the utilisation of lifetime products of the newly domesticated sheep and goat, such as milk, which is also argued to have emerged between 8500 BCE and 7500 BCE (Vigne and Helmer, 2007).

In conclusion, there is no horizon that marks a regional “agricultural revolution.” Alongside domestication processes that took several centuries to more than two millennia (between 10,000 BCE and 7000 BCE), there was also a slow and rather piecemeal trajectory of more and more communities becoming more focused on crops, with a growing number of agriculturally focused economies after 7000 BCE, but with some communities continuing to focus on foraging. Alongside the plant story, there was also a growing dependence of some communities on the meat of certain animals, and after the herding of animals and use of their live products, milk for food and dung for agriculture (Vigne and Helmer, 2007).

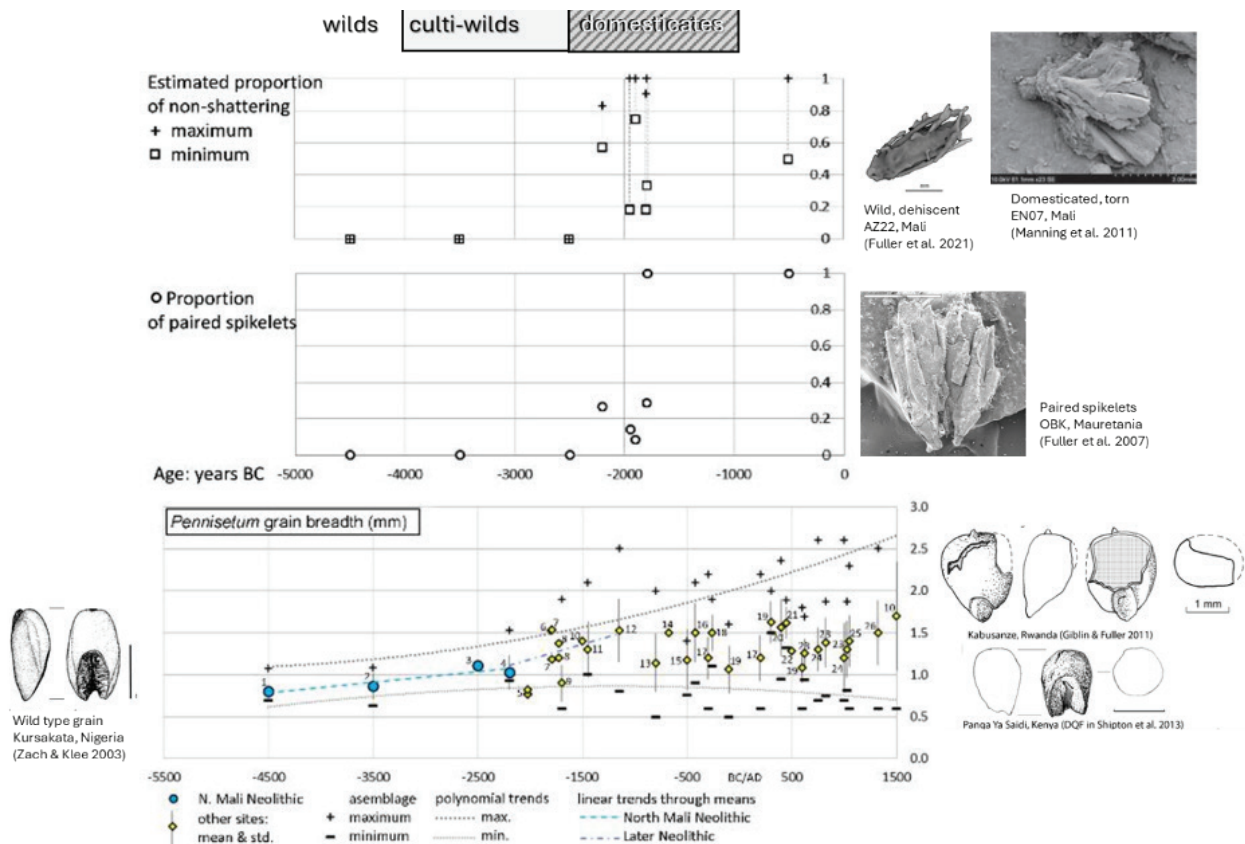


Figure 11. Three charts representing aspects of the evolution of domesticated pearl millet in western Africa, based on proportion of non-shattering involucres (top), paired spikelets (middle) and average grain size (bottom) (after Fuller et al. 2021). Inset are representative example of wild and domesticated type archaeobotanical remains. Sites are numbered as per map below (Fig. 12).

This means that if we want to study these processes, we need more than one site. There's no one site that captures that whole 3,000-4,000 years. There is no single average site or typical sequence but a range of diversity in any region or sub-period of this wider process. We can now turn this way of thinking to some instances of domestication in Africa, where the record remains still more limited.

West Africa: pearl millet farming

Pearl millet (*Pennisetum glaucum* (L.) R. Br., syn. *Cenchrus americanus* (L.) Morrone) was the earliest domesticate of western Sahelian Africa and provides both parallels and contrasts with the example already reviewed. Today, pearl millet is a major cereal throughout the driest regions of Africa and many parts of South Asia. Unlike in Southwest Asia, with its mix of wheats and barleys and legumes, pearl millet was the lone focus of early cultivation and domestication, with no diversity of companion crops. Also, unlike Southwest Asia, in the western Sahel, there is no hint of sedentary societies: villages appear to have evolved later, closer to 2000 BC, and certainly not before 2500 BC (Manning and Fuller, 2014).

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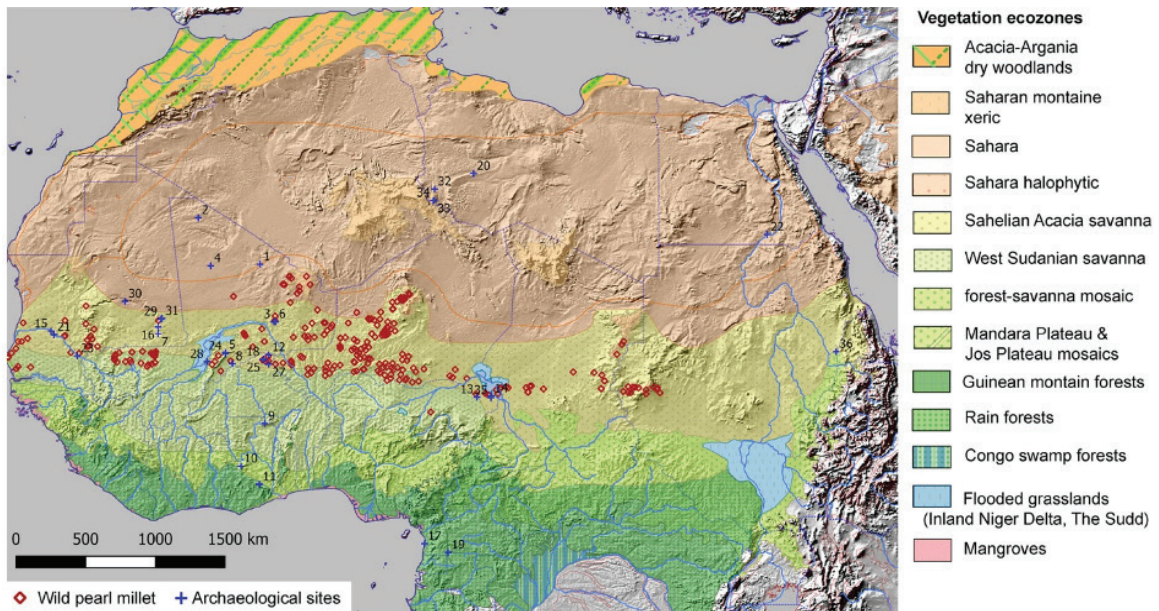


Figure 12. Map of distribution of archaeological pearl millet sites in relation to modern vegetation zones and modern wild pearl millet populations (after Fuller et al. 2021). Sites: 1. AZ22; 2. MT25; 3. Karkarichincat Nord (KN05); 4. MK36; 5. Winde Koroji; 6. Er Negf (EN07); 7. Djiganyai; 8. Ounjougou; 9. Birimi; 10. Boase (B5C); 11. Bosumpra cave; 12. Ti-n-Akof; 13. Gajigana; 14. Kursakata; 15. Walalde; 16. Oued Bou Khzama (OBK); 17. Bwambe-Sommet; 18. Oursi West; 19. Abang Minkoo; 20. Old Jarma; 21. Cubalel; 22. Qasr Ibrim; 23. Arondo; 24. Tongo Maare Diabal; 25. Oursi North; 27. Saouga; 28. Toguere Doupwil; 29. Dhar Oualata; 30. Dhar Tichitt; 31. Oued Chebbi; 32. Ti-N-Torha; 33. Uan Muhuggiag; 34. Uan Tabu; 35. Mege; 36. Kasala (K1)

Instead mobile societies with pastoralism based domesticated livestock -cattle, sheep and goats—had spread across the Sahara by 6000-5000 BC (Linseele, 2010; di Lernia, 2021; Manning et al., 2023). Thus, pre-domestication cultivation of pearl millets appears to have been initiated by groups that had an animal husbandry component of their economy already. Hunting and fishing were also still very important when pre-domestication cultivation began (Jousse, 2004; Manning et al., 2023), but by the time we had domesticated pearl millet, stock-keeping was prominent (Manning and Fuller, 2014). Thus, domesticated animals long preceded domesticated grains in the Sahara and western Sahel. Of importance may be that pearl millet constitutes a poor pasture species (van Oudtshoorn, 1999), and one in which the grains are protected from grazers by a bristly inflorescence. This provides an important contrast from the eastern Sahel, as we return to below, where sorghum domestication appears to have taken place before 3000 BC among societies that had not yet taken up livestock (Winchell et al., 2018).

The wild progenitor of the cultivated pearl millet species has been identified as *Pennisetum violaceum* (Lam.) Rich. [syn. *P. americanum* subsp. *monodii* (Maire) Brunken] (Brunken, 1977; Brunken et al., 1977; D'Andrea & Casey, 2002) and the natural distribution of this species is restricted to the Sahelian zone from Senegal to Chad (Fig. 3), but it is often inferred that domestication occurred in the western part of this range (Tostain, 1998; Burgarella et al., 2018). Today, wild pearl millet is Sahelian, occurring mainly where rainfall is less than 500 mm and ranging north into the Sahara, where rainfall is even <100 mm (although presumably these are localities that see local water accumulation).

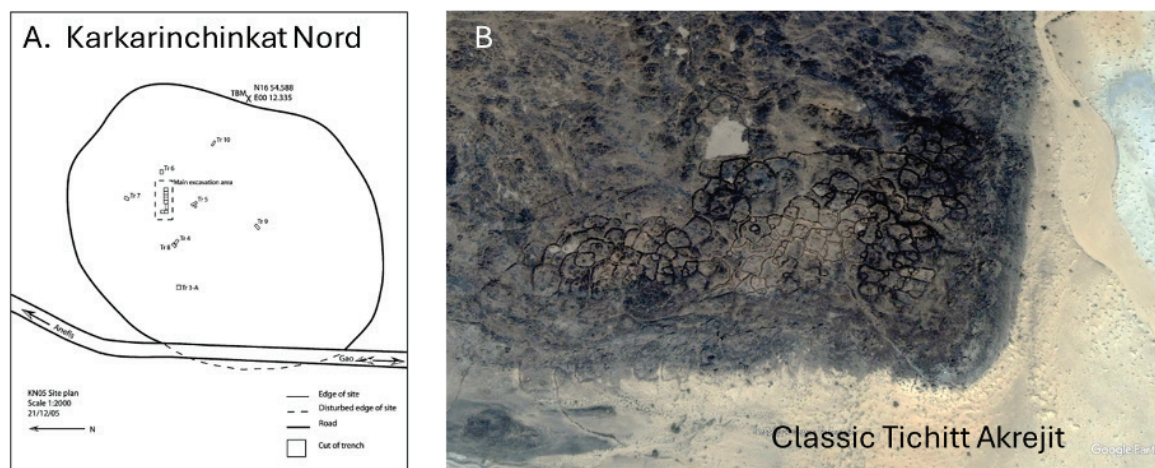


Figure 13. Examples of archaeological sites from the Neolithic western Sahel. A. Plan of the excavated mound at Karkarinchinkat Nord, amli (~2500 BCE) (after Manning et al 2011). B. Satellite view of stone housing complex at Classic Dhar Tichitt site of Akerit, Auretania (~1000 BCE)

As noted above, the period when it was brought into cultivation, perhaps as early as 5000-4000 BC, however, would have been wetter with the Sahel vegetation extending much further north into the Sahara; wild pearl millet was then much more widespread and available to many populations of hunter-gatherer-fishers and pastoralists in the Sahara. The end of the African Humid Period was a process of gradual desiccation, as the expansion of the Sahara from ca. 4300 BCE to 3000 BCE was important in shifting human populations southwards (Manning and Timpson, 2014; De Menocal, 2015). Some groups in the far west of the Sahara took an interest in gathering and then cultivating wild pearl millet, which drew them to those environments that collected sufficient summer rains for a short (~3-month) crop. One such region would have been the Tilemsi valley (a palaeo-river tributary to the Niger) in northeast Mali (Manning et al., 2011; Manning and Fuller, 2014), and another would have been the basins beneath the Tichitt escarpments of southeastern Mauretania (MacDonald et al., 2009; Fuller et al., 2007). Although current evidence is limited, we can place pre-domestication cultivation for pearl millet as taking place somewhere in what is today the desert in northern Mali, but domestication traits became more entrenched in populations as they moved southwards.

Although non-sedentary desert sites rarely preserve conventional archaeobotanical evidence, recent work on chaff-temper added to ceramics in northern Mali has documented wild pearl millet harvesting and processing by ca. 4500 BC, and subsequent morphological change (domestication) taking place between 3000 and 2000 BC (Fuller et al., 2021). Even though the possibility of recent excavations and archaeobotanical sampling has been limited, existing collections of ceramics held in museums have made it possible to use the legacy collection to study pearl millet domestication through chaff temper. Currently there are limited the data but these document the appearance and rise to dominance of non-shattering spikes (indicated by a torn stalk below the spikelet) and paired or grouped spikelets (a trait of domesticated pearl millet that more than doubled productivity) (Fig. 10). Grain size data also indicates a trend of size increase beginning through this period, which accelerated after ca. 2500 BC and continued upto at least 1000 BC (Fig. 10). In addition to the rising mean grain size, the upper range, namely maximum breadth measurements, tends towards larger and larger sizes, whereas the minimum sizes remain about the same. In terms of increasing mean grain size, an increase of ~40% had taken place by 2500-2000 BC, when domestication can be inferred from non-shattering spikelets, with more size increases after this.

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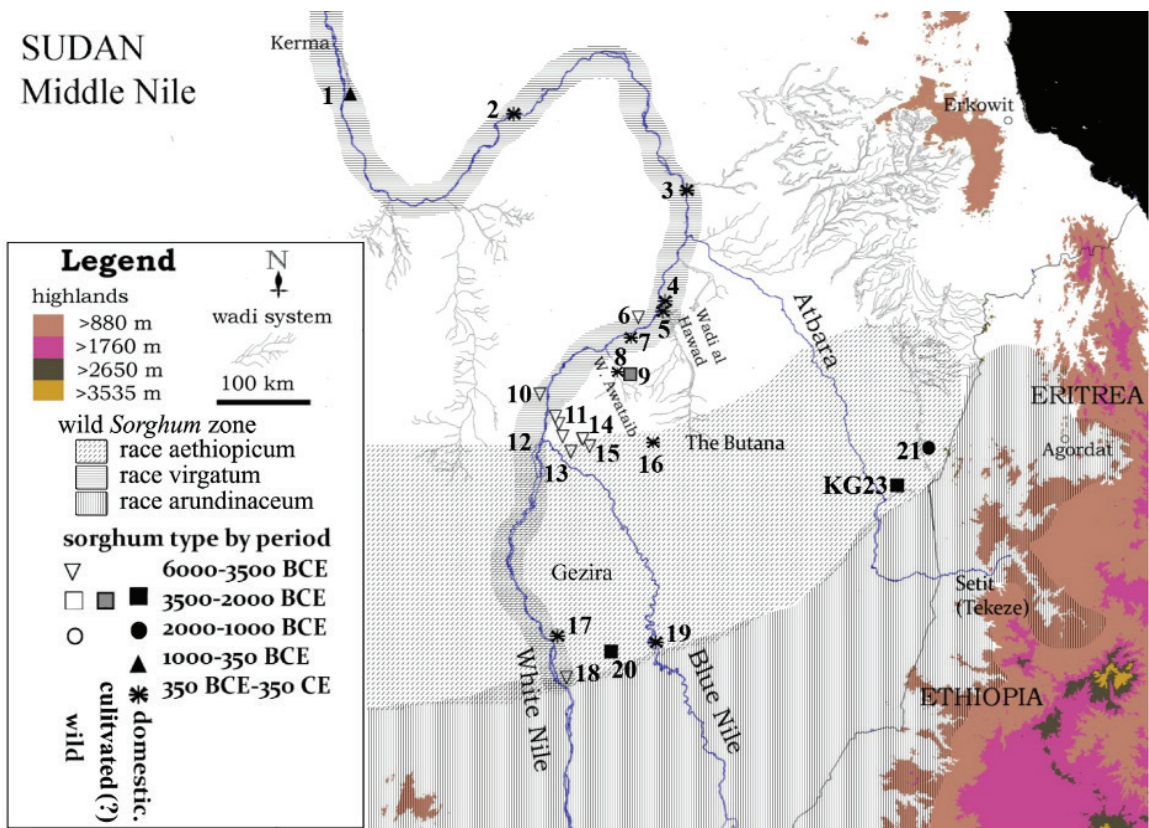


Figure 14. Map with location of Kasm el Girbha 23 [KG23] in relation to other sites with archaeological evidence of sorghum (wild, cultivated, and domesticated); domesticated status indicated for sites with majority non-shattering evidence. Map indicates approximate potential modern extent of wild sorghum races (after Harland and Stemler 1976; Fuller and Stevens 2018). Sites numbered: (1) Kawa; (2) Umm-Muri; (3) Dangeil; (4) Meroe City; (5) Hamadab; (6) El Kadada; (7) Muweis; (8) Naqa (art) (9) Shaqadud; (10) Shaheinab; (11) El Zakiab and Kadero; (12) Umm Direiwa; (13) Sheikh Mustafa; (14) El Mahalab; (15) Sheikh el Amin; (16) Jebel Qeili (art); (17) Jebel Tomat; (18) Rabak; (19) Abu Geili; (20) Jebel Moya; (21) Kasala K1 [Mahal Teglinos]. Updated from Winchell et al 2017; Brass et al 2019; Barron et al. 2020.

In other words, the domestication processes parallel those in other cereals, with a protracted process of non-shattering and an even longer process of grain size increase. Assemblages from which to judge the decline in importance of wild foods are not available, but with the spread of pearl millet, pastoralism and the emergence of more substantial, sedentary sites after 2000 BC, we can suggest that agricultural economies were established by the early second millennium BC.

Early millet cultivators, even as late as domestication (ca. 2000 BC), are unlikely to have been settled year-round. Archaeological sites are mostly ephemeral, with little in the way of preserved architectural features (with the exception of Trichet sites in Mauretania). Buildings were presumably perishable and ephemeral, but it is likely that large sites were occupied through the rainy season for cultivation and fishing, and as water levels receded greatly in the driest seasons, transhumance to wetter areas in the south would have been a requisite for pastoralists (see Smith, 2005). Such transhumance patterns would have benefited by being north of tsetse fly for much of the wetter half of the year and take advantage of greenish Sahara conditions. Sites are recognised mainly by concentrations of ceramic sherds, together with animal bones, lithics and sometimes the presence of burials (human and cattle) (e.g. Finucane et al., 2008; Manning et al., 2011).

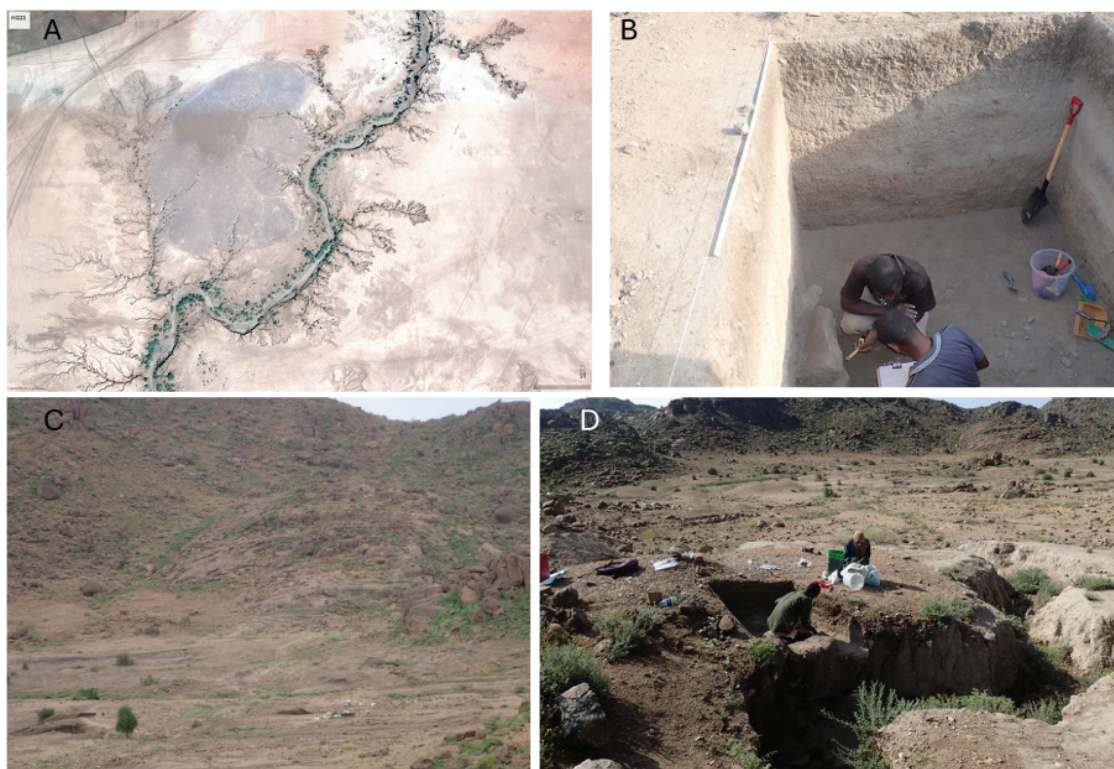


Figure 15. Example of early sites associated with Sorghum cultivation. A. satellite view of the mound at KG23. B-D. Views of excavations at Jebel Moya in 2017 (photos by the author)

Karkarichinkat Nord, which produced some of the earliest domesticated-type pearl millet, can be estimated at ca. 5.7 hectares. Little is known about structures that might have been built at this site, but they were perhaps ephemeral (Figure 13A). While population estimates for early West Africa are largely scarce in the literature, this might represent seasonal gatherings of ~350 people (applying a regression formula from Hassan, 1981), as few as ~190 or even as many as ~780 by taking estimation factors from Dhar Tichitt in Mauretania. Uniquely, in some of the sites of Southeast Mauretania, housing compounds were built in stone. These sites cluster along seasonal water courses and paleolakes below the escarpments that ring the sandy Hodh depression in southeast Mauretania, including Dhar Tichitt, Dhar Walata and Dhar Néma (Munson, 1980; Holl, 1985 and 2009; MacDonald et al., 2009). This is the first period in which substantial architecture is preserved, as house compounds were built in stone. Even though these sites have substantial architecture, palaeolakes in this region had completely dried by 1000 BC, but from ca. 2000 BC, and starting perhaps a few centuries earlier, there was a substantial and growing population in the region which practiced millet cultivation. They are still likely to have practised some transhumance (Holl, 1985). In the Dhar Tichitt, a local polity is considered to have emerged, with large sites and a substantial number of burial tumuli concentrated there. The largest sites are 12 and 15ha, with up to 200 identifiable house compounds (Holl, 1985). Based on assigning a family of 3-5 to each compound, the population arrives at a population between 600 and 1000.

Given these population estimates, we can consider the land use implied by a major contribution from pearl millet. Based on modern traditional data from Africa, the mean yield of pearl millet is 450 kg/ha (Fuller et al., 2019), but lower yields down to ~220 kg/ha are also reported from colonial era India (Heston, 1973).

Given that these estimates are based on domesticated and improved millet, we can expect Neolithic productivity to be at the lower end (~200kg/ha to 300 kg/ha). It is also suggested that the two years of cultivation might be followed by seven years of fallow (Fuller et al., 2019). So to support a population of 350 (Karkarichikat) would require from 185 to 240 ha in cultivation each year (830-1080 ha including fallow lands), whereas for ~800 people (Tichitt 38), would need 420-550 ha (1900-2500 including fallows), which is near limits of what is possible within a local catchment of any site. Setting aside the potential inaccuracies of any such estimates, it does suggest that early pearl millet cultivators were concentrated relative to local productivity at much lower population densities levels than might have been possible in Southwest Asia, where long-term sedentary villages based on more productive wheat and barley, such as Çatalhöyük that lasted for ~1000 years or more (see Marciniak, this volume). This lower carrying capacity of pearl millet can be expected to have added to the factors promoting mobility, human movement and the spread of this crop. Indeed, previous estimates suggest that pearl millet, and indeed sorghum, spread rapidly with African agropastoralist societies, much more rapidly than the rates estimated for the spread of wheat and barley agriculture through Neolithic Europe, for example (Fuller et al., 2019). But this also means that the rapid spread of agriculture through the savanna regions of Africa left behind a more ephemeral record of smaller archaeological sites.

Sorghum originated in Sudan

As already reviewed above, the wild progenitors of sorghum are associated with the Sahel zones, especially east of Lake Chad through a band in Sudan. Under African Humid Period conditions wild sorghum was more widely dispersed further north in Saharan regions (Fig. 3b). Also, as already reviewed, there was quite widespread evidence for the gathering of wild sorghum by Early and Middle Holocene foragers and pastoralist-gatherers, from Southwest Libya to the Egyptian Desert and sites in central Sudan near the Nile (Fig. 13). Archaeobotanical evidence for domesticated sorghum, or populations evolving domestication traits such as non-shattering, appear in sites outside the Nile Valley in the Fourth and Third Millennia BC. The key known sites that contribute to this evidence are Khash mel Girba 23 and Mahal Teglinos (of Kasala K1), both in the southern Atbai region, as well as Jebel Moya in the southern Gezira between the White and Blue Niles.

Domesticated fauna-- sheep, goats, and cattle-- are added to the evidence of the late Butana group, like at the latest occupation of site KG23, but are apparently absent earlier (Peters, 1989). Similarly, at Shaqadud cave, when it is reoccupied by the late Neolithic Butana group occupation at ca. 2900 BC, it has domesticated fauna that were absent in earlier occupations at the site (Peters, 1991). This may indicate that, despite a longer history of pastoral economies along the Nile (represented by Um Deriewa, Kadero, Shaheinab), in the Butana, it was largely hunting economies in which sorghum cultivation emerged. Sadr (1991) and Winchell (2013) have also argued that KG23 and other Butana phase occupations of the 4th millennium BC were more sedentary than the seasonal mobile pastoralism found along the Nile at this time. This could mean that sedentary, or sedentarising, hunters were the innovators of sorghum cultivation, rather than the mobile pastoralist-foragers that were associated with the initial cultivation of pearl millet in the western Sahara.

Jebel Moya excavations in recent years produced archaeobotanical remains through flotation that include fully domesticated sorghum with direct radiocarbon dates on grains between 2500 and 2000 BCE (Brass et al., 2019; Vella Gregory et al., 2023). Jebel Moya is a large complex site of multiple occupation and burial areas located on a granitic plateau. Jebel Moya also has a full complement of livestock—domesticated cattle, sheep and goats, and therefore represents the earliest sites with subsistence based on both sorghum agriculture and pastoralism. Stratigraphically, it is likely that this period began ~3000 BCE, and was preceded by pottery-using hunter-gather occupations that require further investigation.

Similar to pearl millet, the earliest evidence comes from sorghum chaff preserved as inclusions in ceramics. This can be studied by making positive casts of surface impressions (e.g. Winchell et al., 2017; Beldados et al., 2018) or by micro-CT imaging of sherds to see the hollows and organic inclusions within the clay (Barron et al., 2020). The earliest evidence comes from the site of Kasm al Girba 23, a site of the Butana Group dating from ca. 3500-3000 BC located on a wadi tributary of the Atbara. The wadi likely provided more permanent water in the past, allowing for a substantial population to gather, leaving stratified remains over a 12 ha mound (Fig. 15A). This site was excavated in the 1980s, but restudy of pottery collections has provided new archaeobotanical data to be derived from legacy museum collections. Through two different studies, 134 sorghum spikelets or spikelet-based types were identified, of which 72 were torn, non-shattering types, which leads to an estimate of non-shattering domesticated types of 64%. This site was dated by radiocarbon by charcoal in the 1980 as falling between 3800 and 3000 BCE. A somewhat later site at Kasala (K1) produced 60% non-shattering types dating to around 1800-1700 BCE (Beldados et al., 2018). This indicates that some persistence of mixtures of wild sorghum morphotypes in the majority of domesticated populations lasted for some centuries. This could also mean that gathering from the wild population continued alongside the cultivation of evolving domesticated populations. The site of Jebel Moya (Fig. 15B-D) produced abundant charred grains and chaff of sorghum that were examined by this author (Brass et al., 2017; Vella Gregory et al., 2023) and provide a proportion of non-shattering of 71%. In contrast, later Meroitic samples from the end of the First Millennium BC, assessed by this author, are nearly 90% non-shattering. These data provide an initial model of a domestication timeline for sorghum (Figure 16A).

Like with other domestications we have studied, domesticated sorghum also has larger and plumper grains than its wild ancestors. The grains from Jebel Moya are noticeably plump and round, like the shapes of domesticated grains from later periods, like Meroitic Hamadab, 200 BCE-300 CE (Figure 16B). The available metrics from archaeological grains metrics indicate some gradual increase in width (Fig. 16C), and even more markedly a shift in length: width ratio towards rounder grains (Fig. 16D). There is no doubt that the sorghum of the Meroitic period was domesticated, which provided agricultural support for an important civilisation focused on the upper Nile (Edwards, 2004; Fuller, 2014). The morphology of sorghum from Jebel Moya is already similar to that of more than 2000 years earlier, suggesting that domestication was completed around this period (2000 BCE). Once domesticated and integrated with pastoralism, economic conditions were in place to support population growth and social hierarchy, which emerged with the Meroitic state or its precursors from around 900 BCE.

As with the domestication trajectories documented in Southwest Asia and the western Sahel, the domestication of sorghum was protracted, with the beginnings of cultivation likely before 4000 BCE and domestication completed in the period between 2500 BCE and 1500 BCE. The period in which KG23 was occupied corresponded to the very end of the African Humid period, when wild sorghum populations were retreating southwards towards their modern range. The periods of Kasala K1 and Jebel Moya correspond to essentially modern climatic conditions, in which sorghum agriculture could spread as an adaptation to savanna and Sahelian conditions.

Concluding remarks

There are some key conclusions to be drawn from this work about the importance of long regional sequences and data drawn from multiple sites and excavations. No single site has been able to capture evidence for an entire domestication process nor a transition from hunting and gathering to agriculture. Instead, even long-lasting sites pick up only parts of a much slower and less linear process. These were processes of evolution, not just of the crops themselves but of economic systems, social systems and technologies.

These slow, lasting for many dozens of human generations (a few millennia), are not easily understood through traditional historical ways of thinking about civilisations of sites of civilisations. Instead, they need to be understood in archaeological terms through rich comparative analyses of data drawn from across multiple sites over broader regions. Only at a larger scale can we discern processes of human adaptation to changing climates and the ways in which human action reshaped the environment, including the creation of cultivated ecologies and the evolution of new domesticated forms of plants (or animals). Many scholars have commented on how fundamentally the origins of agriculture and social and economic developments made possible, not to forget its massive impact on human demography and human-caused environmental change. However, to better understand this and to preserve the heritage of these transformative epochs in human social and environmental evolution, we need to think in terms of protracted episodes taking place over landscapes and regions, rather than single sites or assemblages. Of course, careful study and preservation of individual sites, layers and assemblages provides the essential building blocks for developing the larger evolutionary picture.

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Early Holocene riverine and deltaic adaptations as Neolithic cultural heritage. The case of the Çaramba river environment, Konya Plain, Türkiye

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Introduction

Relevance of Pleistocene–Early Holocene archaeology in the Near East

The Pleistocene–Holocene transition marks the beginning of the unprecedented transformations in numerous domains of human existence. As it pertains to the divide between two major phases of the Quaternary, it is often presented and understood in a largely dichotomous and normative way when characteristics of both periods are listed and then compared with each other. However, the transition to a new mode of living in the Holocene was very complex, extended over a considerable span of time, and manifested differently across the affected regions. These developments are particularly pronounced in the Near East, both in terms of their scale and complexity, as well as far-reaching consequences going beyond the region itself. The processes in question took place in the period known as the Neolithic and were extended over almost four millennia. In the geological chronology, this period is referred to as the Early Holocene. This initial phase of the Holocene began at approximately 9,700 BC, following the end of the Younger Dryas, and lasted until around 6,000 BC. This period marks the transition from the cold, unstable climatic conditions of the Late Pleistocene to rapid global warming, retreat of continental ice sheets, rising sea levels, and significant reorganisation of vegetation and hydrological systems. These conditions proved highly beneficial for vegetation growth, allowing grasslands, forests, and wetlands to expand into areas previously limited by aridity or glaciation. As plant communities flourished, they provided more reliable food sources and habitats, supporting the growth and diversification of animal populations (Mayewski et al 2004, Walker et al., 2009).

A key aspect of this climatic transition was the increasing predictability of rainfall patterns. Compared to the highly variable and unstable climate of the Late Pleistocene, the early Holocene experienced more regular seasonal precipitation in many parts of the world. This predictability reduced environmental stress on ecosystems and promoted long-term ecological stability. For both flora and fauna, consistent water availability facilitated reproduction, migration, and population growth, contributing to more complex and resilient ecosystems. The combination of warmer temperatures, increased moisture, and ecological stability marked the rise in biodiversity during the Early Holocene. Expanding habitats enabled species to recolonise previously inhospitable regions, while ecological niches became more diverse. This period saw the development of rich and varied ecosystems, ranging from dense forests to productive grasslands, supporting a wide array of plant and animal species (Mayewski et al., 2014, Roberts, 2014).

Despite these generally favourable conditions, the Early Holocene was not climatically uniform. It was characterised by a rapid climate change phenomenon involving a series of abrupt climatic shifts, such as short-lived cooling or drying events. These abrupt changes highlight the sensitivity of Earth's climate system to variations in ocean circulation, atmospheric dynamics, and solar forcing. These are referred to as the Holocene Rapid Climate Change (RCC) events (Weininger et al., 2009). In the period of the gradual warming and stabilisation that characterise much of the Holocene, RCC events represent sudden deviations in temperature, precipitation, or hydrological patterns, often lasting decades to a few centuries. These events had significant ecological and societal impacts, affecting vegetation dynamics, water availability, and human subsistence strategies.

These intervals illustrate that the Holocene climate was punctuated by recurrent, abrupt events, each with ecological and societal consequences. Within the Early Holocene there were three such events: (i) Preboreal Oscillation (ca. 9,400–9,100 BC), which briefly interrupted post-glacial warming, (ii) the 9.3 ka event (ca. 7,300 BC), a short-lived cooling and drying episode likely linked to meltwater pulses affecting North Atlantic circulation and (iii) the most pronounced the 8.2 ka event, characterised by abrupt cooling and increased aridity lasting several centuries and having widespread impacts on hydrology, ecosystems, and early Neolithic communities.

These climatic disruptions have significantly transformed local environments, which themselves had profound implications for human societies, where they coincided with increased sedentism, experimentation with plant and animal management, and the emergence of early Neolithic lifeways that laid the foundations for agriculture and long-term human–environment interactions.

The adoption of the Neolithic lifeways across the Near East was a complex process, which had a form of arrhythmic development, as defined by Jean Guilaine (2001). While there is a considerable correspondence between the pace of human development and the cycles of climatic events, alongside climatically-induced changes of environment, the process is much more complex and yet not fully understood. Rather than viewing developments like agriculture, sedentism, or social developments as occurring at the same pace everywhere, Guilaine emphasises that change unfolds unevenly, discontinuously, and at different rhythms across regions and local communities. According to this view, Neolithic communities responded to environmental, social, and cultural pressures in non-synchronous ways, producing periods of rapid innovation mixed with stagnation and regression, or coexistence of old and new practices, as well as a steady move into a variety of ecumena throughout subsequent millennia of the Early Holocene. At the same time, such arrhythmic developments point to the importance of local conditions, historical contingencies, and human choices, rejecting the idea of a single evolutionary trajectory.

As a result, similar cultural forms might have emerged at different times, persisted unevenly, or developed independently, underscoring the complexity and diversity of prehistoric transformations. This process also involved the development of local practices and activities, the adoption of some elements from the neighbouring regions, and the selection of the most important elements while explicitly rejecting some innovations and technologies. This makes each of the regions of the Near East unique in its own way. The adaptation process is hence heterogeneous, showing flexibility of the Neolithic communities to develop, maintain and sustain the most effective *modus operandi*. Each of such regions can be examined independently, providing different modalities of adaptation.

Central Anatolia, where I have been working uninterruptedly for almost three decades, is particularly relevant to discuss the Early Holocene adaptation of the human communities. My work is focused on the eastern part of this distinct region, known as the Konya Plain, which comprises the Çarşamba River and its delta environment. The relevance of this region stems from two reasons. Firstly, it represents the earliest region of Neolithization beyond the primary core area of the Fertile Crescent. Located at the interface between Southwest Asia and Anatolia, Central Anatolia served as a key zone for the transmission, adaptation, and local development of the Neolithic lifeways. Rather than simply adopting practices from the Fertile Crescent, local communities selectively integrated domesticated plants, animals, and new technologies with existing foraging traditions, which led to the emergence of a distinctive form of the Neolithic. Secondly, the Konya Plain represents the earliest example of a local transition from hunter-gatherer lifeways to farming in the riverine and deltaic environment.

It firmly contrasts with the earliest centres of the Neolithic within the Fertile Crescent, notably the Judean Hills in the southern Levant and the upper Tigris region of northern Mesopotamia, particularly the Şanlıurfa highlands around the Harran Plain. These Fertile Crescent examples developed primarily in upland settings, highlighting differing ecological contexts for the emergence of early farming.

In the paper, I intend to scrutinise the nature, dynamics and outcome of the adaptation of Early Holocene communities in the Carsamba River deltaic landscape, with the focus on the seventh millennium BC, focusing mainly on the large settlement at Çatalhöyük. These will be scrutinised in the dynamically changing broader context of local communities and climatic and environmental changes. These can be captured in two interrelated aspects: (1) sustainability and resilience strategies of local communities and their reconfigurations, and (2) human-environment relations and their transformations. The modalities of these two variables reflect the peculiar nature of the adaptation to the deltaic environment of the Early Holocene groups. Importantly, they anticipate the adaptation strategies to the Nile, Euphrates, and Tigris deltas some two millennia later.

Early Holocene adaptation to the riverine deltaic environment of the Konya Plain as cultural heritage

During the Late Pleistocene, the Konya Plain was characterised by the presence of several large pluvial lakes, which were formed under cooler and wetter climatic conditions. These lakes supported rich wetland ecosystems and provided stable water resources. With the onset of the Holocene, however, climatic conditions shifted toward warmer and more arid regimes, leading to the gradual retreat or, through millennia, ultimate desiccation of these lake systems (Baird et al. 2023).

While the presence of the rich deltaic environment was a trigger for the transformation of local hunter-gathering communities into a unique form of the Neolithic lifeways, the retreat of the Konya Plain lakes towards the end of the Early Holocene had direct and far-reaching impacts on local ecosystems and early Neolithic communities. As surface water bodies shrank significantly, they left behind salt flats and dry lakebeds, transforming once-productive wetland environments into increasingly marginal landscapes. This process reduced the availability of freshwater, fish, and wetland plant resources, placing growing pressure on existing subsistence strategies.

In response to these environmental changes, Early Holocene communities' reaction was to reorganise their settlement and subsistence patterns. Rather than relying on large lake systems, they steadily moved toward locations with more reliable year-round water sources, such as springs, smaller streams, and riverine corridors. These shifts reflect flexible adaptive strategies in the face of hydrological change and played a key role in shaping early Neolithic lifeways in the Konya Plain. A particularly pronounced development took place following the 8.2 BP climate event (Baird et al., 2023; Roffet-Salque et al., 2018).

The Early Holocene adaptation to the riverine deltaic environment of the Konya Plain is an exemplary case of a highly complex and multifaceted process taking place. In order to capture this complexity and reveal the very nature of the process, it is required to adopt a suite of methods and techniques. These need to be effectively integrated, taking their respective heuristic values into consideration. This plea for mobilising cutting-edge and ever-growing technologies well corresponds with UNESCO policy in recognising and discovering Outstanding Universal Value (OUV) of the protected sites and landscape through sustained, systematic research that enhances an understanding of their significance over time. Rather than being stuck to what has been specified and defined, the moment of inscription requires the OUV to be continuously refined and strengthened through archaeological field investigations, respective scientific analysis, and an effective transdisciplinary approach facilitating an integration of these studies. The ongoing research on the Early Holocene occupation of the Konya Plain addresses two important issues.



Figure 1 Map of the Konya Plain in Central Anatolia (after Portilo Ramirez et al. 2020, Fig. 1)

Firstly, it vividly demonstrates both to the UNESCO and scholarly community at large how the region and its forms of occupation and exploitation embody an exceptional testimony to human history, cultural traditions, or human–environment interactions, thereby grounding heritage value in the evidence-based interpretation and long-term knowledge production. Secondly, the OUV of the site of Çatalhöyük from this region, inscribed on the World Heritage List in 2012, needs to be enhanced and expanded beyond this site itself, integrating the region in which it flourished and the unique form of adaptation to the riverine deltaic environment.

Regional Synthesis – The Early Holocene occupation of the Çarşamba riverine and deltaic plain

The Early Holocene communities in Central Anatolia exhibited pronounced local identity, ancestry, and cultural coherence, rooted in the endogenous developmental trajectory of indigenous hunter-gatherer populations. They developed in two geographically distinct regions: (i) the Cappadocia with several well-researched sites, such as Aşıklı Höyük, Balıklı, Köşk Höyük, and Tepecik Çiftlik Höyüğü, and (ii) the Konya Plain with such sites as Pınarbaşı, Boncuklu Höyük, Can Hasan, and in particular Çatalhöyük.

My focus in this paper is on the Konya Plain developments, in particular, the occupation of the geographically very distinct Çarşamba riverine and deltaic plain in its north-eastern part. The Konya Plain is an enclosed basin situated within the high-elevation Central Anatolian Plateau, at approximately 1,000 meters above sea level (Figure 1). Its topography limits external drainage, making local hydrology highly sensitive to climatic fluctuations. Today, the region is one of the driest areas of Anatolia, receiving an average annual rainfall of around 320 mm, reflecting long-term arid to semi-arid conditions. The Çarşamba alluvial fan covers an area of ca. 474 km² and is the largest in the Konya Plain (Hodder, 2011).

Human Adaptations

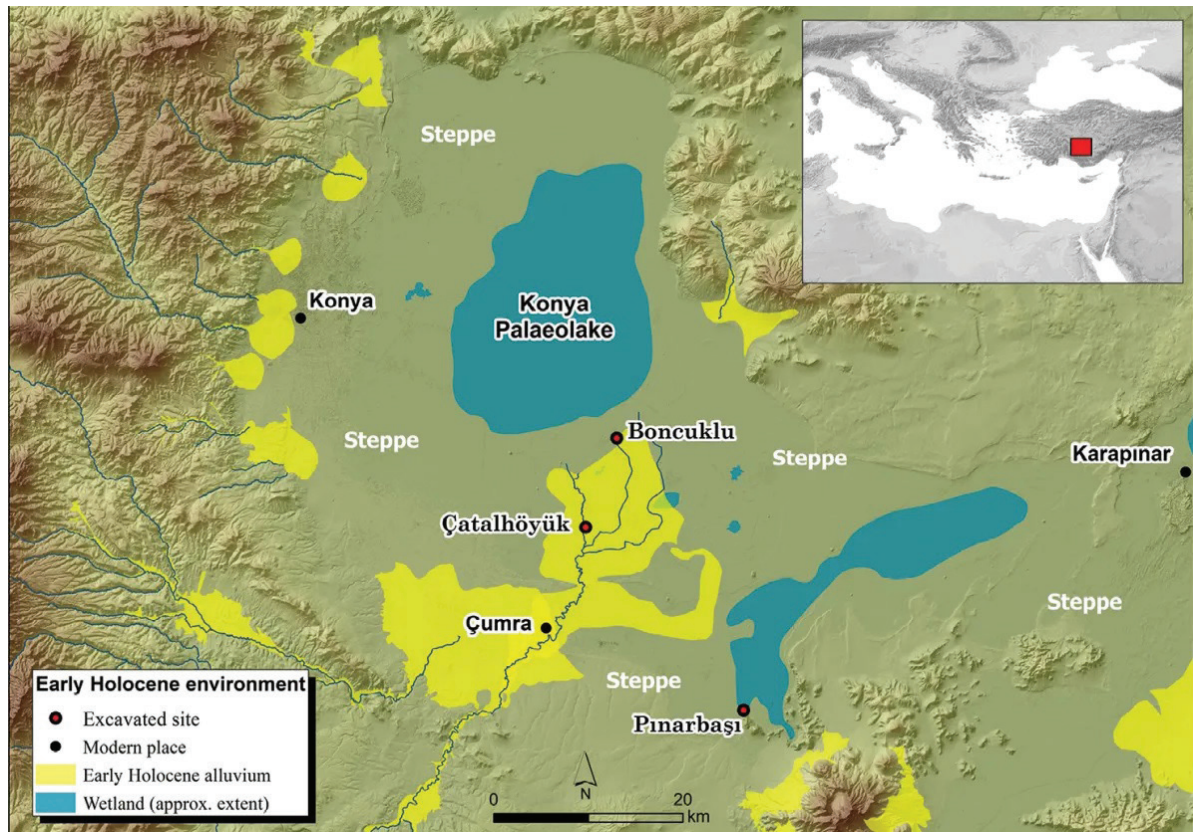


Figure 2 Early Holocene environment in the Konya Plain

The Konya Basin occupies the area of an ancient lake, known as the Konya Paleolake, and represents a classic example of a constrained or closed basin. Unlike open drainage systems, the Konya Basin has no natural outflow to the sea, meaning that any water entering the basin is retained within its boundaries. Water arriving in the basin either accumulates in the low-lying areas, infiltrates the soil, or eventually evaporates back into the atmosphere, creating a sensitive hydrological balance.

The plain is bordered by the Boz Mountains to the north and the Taurus Mountains to the south, which shape both its climatic regime and drainage patterns. Within this basin, the deltas of the Çarşamba and May rivers developed over former lake sediments left by earlier pluvial phases. These deltaic landscapes are surrounded by extensive zones of semi-arid steppe, creating a mosaic of environments that offered both constraints and opportunities for human occupation and adaptation in the Early Holocene.

The Çarşamba delta presents a distinctive environmental and landscape context. It is a low-lying alluvial plain going into the Konya Paleolake, formed by sediment deposition from the Çarşamba River and its tributaries. Over the Early Holocene, the delta experienced substantial alluvial activity, including sediment accumulation, seasonal flooding, and the formation of fertile soils. These processes created a mosaic of environments, ranging from permanently moist floodplains and shallow channels to seasonally dry fields and slightly elevated terraces, providing varied ecological niches for early farming communities. The combination of fertile alluvial soils and reliable water sources made the delta especially suitable for cereal cultivation, animal husbandry, and other subsistence activities. It became an arena of the development of a distinct form of the Neolithic (Baird et al., 2023) (Figure 2).

The Neolithic sequence in the Çarşamba delta of the Konya Plain is accurately captured through an arrhythmic model, as defined by Guiliane (2001), characterised by alternating periods of rapid growth (“booms”) and contraction or crisis (“busts”). The first boom, occurring between 8700 and 7600 BC, is manifested at such sites as Boncuklu Höyük or Pınarbaşı. It is marked by the emergence of solid farming in incipient communities beyond the Taurus Ridge, reflecting innovative settlement and subsistence strategies. This was followed by a bust between 7600 and 7100 BCE, a period of unforeseen consequences in which the local Neolithic potential was considerably constrained. A second boom from 7100 to 6300 BCE is well exemplified by the settlement at Çatalhöyük, characterised by a unique combination of social, technological, and architectural modalities created by a large community with an ability to withstand environmental and social stresses. However, the subsequent bust between 6300 and 6000 BC ultimately represents the failure of these adaptive systems and the ultimate demise of the Konya Plain Neolithic. Interestingly, it contributed to the spread of Neolithic groups over larger areas, both within and beyond Central Anatolia. This arrhythmic perspective emphasises that the Neolithic adaptation to the Çarşamba and May riverine and deltaic conditions was non-linear, with cycles of innovation and collapse driving long-term social and ecological transformations.

The beginnings of the Early Holocene sequence in the Konya Plain can be seen at the site of Pınarbaşı (e.g. Baird 2013 et al., Watkins, 2017), which dates back to the Late Pleistocene. It is dated to the 11,000–8,500 BC and provides important context for the emergence of Neolithic lifeways in the Konya Plain. These are highly mobile or seasonally settled hunter-gatherer communities whose lifeways predate the incipient Neolithic developments. The site is closely linked to the Çarşamba River system, which offered reliable freshwater, wetland resources, and access to diverse ecological zones. The site reflects long-term human engagement with riverine and wetland environments, including hunting, fishing, and plant gathering. This sustained familiarity with the Çarşamba landscape created the ecological and cultural foundations upon which later Neolithic adaptations emerged. Despite continued occupation under post-Younger Dryas warming conditions, there is no clear evidence for agriculture or animal domestication, indicating strong continuity in foraging lifeways. Pınarbaşı thus provides ample evidence for long-term hunter-gatherer adaptation in the Çarşamba River corridor and forms an essential contextual backdrop to the later emergence of farming practices at nearby sites such as Boncuklu Höyük. It highlights how the Çarşamba River functioned as a long-term axis of human occupation and adaptation, ultimately supporting the locally grounded transition to Neolithic lifeways in the Konya Plain.

The first boom in the development of the indigenous communities in the Konya Plain is documented at the site of Boncuklu Höyük (e.g. Baird et al., 2010 and 2018). The site dates back to the period ca. 8300–7600 BC and was also located within the Çarşamba delta system, which provided reliable water, diverse resources, and ecological stability during its occupation. The settlement represents a locally rooted community of transformed hunter-gatherers who gradually adopted elements of Neolithic lifeways—such as increased sedentism, plant cultivation, and animal management—while maintaining strong continuities with earlier foraging traditions.

Rather than being a result of direct colonisation from the Fertile Crescent, Boncuklu Höyük reflects a local trajectory of Neolithization, shaped by the unique adaptation to the delta landscape. In this sense, the Çarşamba delta functioned as a key ecological niche that enabled early experimentation with Neolithic practices and laid the groundwork for later, more complex settlement, in particular Çatalhöyük. This environmental setting enabled gradual experimentation with Neolithic lifeways, making Boncuklu a key reference point for understanding local pathways to Neolithization in Central Anatolia, clearly distinct in comparison with the core zones of the Fertile Crescent.

The Boncuklu Höyük community practised low-level food production, including the cultivation of cereals and the management of animals, while hunting and foraging remained important components of subsistence. Architecture consisted of small, modest mudbrick structures, reflecting limited household autonomy and relatively low population density. Social organisation at Boncuklu appears to have been strongly egalitarian, with little evidence for social differentiation or wealth accumulation. Ritual practices were closely integrated into domestic contexts, including burials beneath house floors, indicating tight social bonds and continuity within households. Material culture shows restrained symbolism and limited long-distance exchange, though there is evidence for early obsidian use within regional networks (e.g. Baird et al., 2010).

Except for the Boncuklu Höyük settlement, the Çarşamba delta has a broader network of small to mid-sized settlements, including sites like Karhane Höyük, Karaca Höyük, and Ürümdü Höyük (Massa et al., 2019 and 2020). This indicates a considerable dispersal of the Neolithic communities occupying not only high-profile mound sites but also smaller, low-lying locations that were often buried by later alluvial deposits or overbuilt by Bronze and Iron Age settlements. While fertile deltaic soils supported semi-permanent farming settlements, evidence from the steppe margins and nearby highlands points to more mobile or seasonal occupations, particularly at the beginning of the Neolithic sequence. These patterns indicate adaptive strategies in which early farming groups balanced intensive exploitation of fertile alluvial land with more flexible settlement in less productive or marginal zones.

The second major and pronounced boom in the development of the Çarşamba deltaic environment is the highly elaborated settlement at Çatalhöyük. It was occupied in the period 7100-5950 BC (e.g. Hodder, 2014, Marciniak et al., 2015). The Early Neolithic sequence is often labelled as the classic phase, lasting from the settlement's beginnings until ca. 6300 BC. The inhabitants lived in clusters of approximately 30 to 40 individual houses arranged in the form of an agglutinative pattern. The house was pretty standardised and was built of mudbricks and had neither windows nor doors. It was accessed from the roof in its southern part, which also served as a chimney. The house had one main room, usually divided into two parts. The walls, platforms, and floors were systematically plastered over, and the walls were often decorated. The house often had one or two side rooms used for storage. The superimposed houses were constantly reused and reoccupied through the centuries, indicating the sustainability of this social organisation. The group buried their dead underneath the house floor and platforms (e.g. Hodder, 2011; Mazzucato, 2016).

The major transformation of the settlement and its inhabitants took place around 6300 BC, emerging from a long sequence of cumulative shifts in social practices, economic strategies, and architectural routines that had been unfolding for centuries (e.g. Czerniak, Marciniak, 2022; Kuijt, Marciniak, 2024). These gradual changes - visible in increasingly diversified subsistence activities, shifts in animal management, modifications in household organisation, and a loosening of long-standing architectural traditions - ultimately created a threshold effect that destabilised the settlement's social fabric. Their cumulative impact generated a profound reconfiguration of community life, followed by a rapid decline in occupation intensity. The final phase was marked by a departure from earlier building practices, reduced investment in house rebuilding, increased architectural variability, and a breakdown of the agglutinative layout. These developments were revealed by the ongoing work of the team led by me (in cooperation with Lech Czerniak in 2001-2008) in three occupational zones - TP, TPC and East Areas. Following this change, the remaining inhabitants over the next three centuries, instead of dense clusters of abutting buildings, lived in several distinct occupational zones made of dispersed clusters, at times with significant rebuilding, and at other times with abandoned areas. It also involved the construction of light shelters with randomly scattered fire installations. Evidence from across the settlement indicates that pulses of human occupation caused micro-settlement drift over time, shifting laterally across the tell and its surroundings (Marciniak et al., 2015; Czerniak & Marciniak, 2022).

These two phases of the Çatalhöyük occupation mark profoundly different modes of adaptation to the Çarşamba deltaic environment and climate changes taking place throughout the 7th millennium BC. The adaptation in both periods was very complex and developed at the intersection of several factors, including the origin of the inhabitants, their cultural profile and social arrangements, procurement of a range of resources, exploitation of the settlement's immediate zone, subsistence, farming and husbandry practices, and the like. There is no room to discuss all the variables in any detail here, but I will focus on some, which in the most distinct way impacted the character of the respective adaptations. These can be grouped in two intertwined blocks: (i) the character of the local community, including their wellbeing and ancestry, as well as relations with the past and contemporaneous communities; and (2) the relationship of the local community to the surrounding environment, both built and natural.

As indicated by oxygen stable isotope analysis, individuals from the classic phase are virtually identical and fall within the annual winter-to-summer range for central Anatolia. These data are consistent with inhabitants spending their childhood in the same approximate area. This indicates that the settlement was founded by local inhabitants, well familiar with the Konya Plain environment. They were, however, significantly exposed to the influences from the Fertile Crescent, from the period following the demise of large megasites towards the end of the 8th millennium BC. The more mobile or nonlocal individuals appeared towards the end of the classic phase of Çatalhöyük occupation between 6700 and 6300 cal BC. These comprise individuals coming from the Konya Paleolake basin, further north or at a higher latitude. These migration dynamics predate a fundamental shift at the site around 6300 BC (Pearson et al 2023). This local origin of the Çatalhöyük community is further corroborated by the genetic studies, confirming only limited gene flow from populations in the Zagros and Levant (Marciniak, 2021; Özdöl Kutlu et al., 2015; Yüncü et al., 2025).

This stability and sustainability of the Çatalhöyük inhabitants was secured by the specifically designed cultural resistance mode, embedded in a long-lasting understanding of the region, sustained through strategic exploitation of the ecologically rich Çarşamba alluvial plain. The socio-cultural system represented by the Çatalhöyük community comprises an autochthonous culmination of regional Neolithization processes, built around several constituent elements, including aurochs, obsidian, clay, and distinctive death rituals, which formed their foundational identity. Sometime later, these communities dynamically integrated exogenous elements (notably domestic sheep and cereals) into existing frameworks, demonstrating adaptive syncretism while maintaining essential Anatolian socio-cultural integrity.

I would argue that the *modus operandi* of the Çatalhöyük community can well be grasped by the concept of antifragility, as defined by Nassim Nicholas Taleb, where systems thrive amid volatility (Taleb, 2012). With dense populations, expanding animal husbandry, organised fields, and ritual interdependencies, Çatalhöyük's individual elements (like resource procurement or tensions between different sections of the settlement) were inherently fragile. Yet collectively, these components formed a system that improved through shocks. Agricultural adaptations to ecological shifts, spatial reconfigurations during internal pressures, and ritual cohesion during scarcity weren't merely resilient; they leveraged stressors to innovate, diversify, and strengthen. Thus, volatility—whether demographic, environmental, or social—has not weakened but enhanced Çatalhöyük's complexity, embodying antifragility: where the sum of fragile parts creates a whole that gains from disorder. The dynamic state of equilibrium characterising this social structure was inherently fragile—easily shaken, broken, or destroyed—yet sustained by imposed egalitarianism as its overlying principle (Hodder, 2022). This framework functioned through the network itself as an active agent, mediating relationships via hybrid interdependencies (contrasting mediators with intermediaries) to prevent disruptive shifts toward undesirable trajectories.

Human Adaptations

Key stabilising practices included maintaining symmetry among diverse elements, fostering cross-cutting sodalities and neighbouring communities as foundational social units, and deliberately interrupting continuity through rituals of filling, breaking, covering, and hiding. Further, the integration of domestic and ritual spheres, alongside internalised behavioural codes, reinforced this precarious balance, allowing the intertwined relational system to persist despite its inherent vulnerability. Most likely, the settlement also held pronounced religious significance, with symbolic and imagistic representations embedded in both the material culture and the spatial organisation of houses, suggesting that ritual and ideology played a central role in maintaining social cohesion and collective identity (Whitehouse, Hodder, 2010).

Being exposed to the innovations and new technologies coming from the Fertile Crescent, the local community demonstrated a clear pattern of selective technological adoption. Flint tool technology was integrated only very reluctantly, indicating cultural resistance (Özdöl Kutlu et al., 2015). Similarly, pig husbandry was entirely rejected (Arbuckle et al., 2012). This differential adaptation—whether through rejection, reluctance, or postponed integration—highlights how the community navigated innovation to protect social cohesion and cultural identity while responding to regional pressures. A particularly interesting delay in adopting major Neolithic innovations and related technologies involves domestic cattle, cattle husbandry, and the consumption of cattle products, including milk (Arbuckle, Makarewicz, 2009). Extensive zooarchaeological studies indicate that cattle were domesticated around 8000 BCE in various locations across northern Mesopotamia (Zeder et al., 2006). However, the emergence of domestic cattle in Central Anatolia was significantly delayed. Fully domesticated cattle were confirmed at Er Baba (dating to 6600 BCE)—a small settlement approximately 100 km west of Çatalhöyük. Sites like Yumuktepe in Cilicia, along with Gürcütepe and Tell Halula in the upper Euphrates basin, have been identified as possible places of origin. Notably, domesticated cattle appeared abruptly at Çatalhöyük only around 6400–6300 BCE (Arbuckle, Makarewicz, 2009).

After the middle of the seventh millennium BC, Çatalhöyük was exposed to a gradually increasing fragility that brought the settlement closer to a social and ecological tipping point. The imposed egalitarian strategy faced mounting difficulties in effectively managing internal pressures and maintaining a complex socio-ritual system based on nested and cross-cutting networks. These challenges were compounded by a growing population, partly due to the influx of nonlocal individuals, indicating the increasing integration of the Çatalhöyük community into broader regional networks (Yüncü et al., 2025). These were further composed by the increasing independence of individual households, and the intensification of agricultural practices, including the spatial organisation of potential crops and the exploitation of distant ecozones such as the Nenezi Dağ obsidian sources.

At the same time, social and economic changes altered traditional patterns of relatedness, as evidenced by decreasing co-burial relatedness (Yüncü et al., 2025), while the growing importance of domestic cattle—including the introduction of milking—brought humans into closer contact with animals, increasing exposure to zoonotic pathogens. Tensions may have arisen between the southern and northern sectors of the settlement, while redundancy and excessive practices—such as wall paintings, large figurines, and communal feasting—added further strain on social and material resources. Throughout this period, residents continued to maintain extensive external networks, reflecting both the persistence of long-range connections and the pressures of sustaining a highly integrated yet increasingly fragile settlement system. As the settlement population grew, it faced several mounting challenges.

These included difficulties in maintaining the complex social ritual system, which was based on nested and cross-cutting kinship networks. This system was breaking down, as evidenced by the departure of kin groups from households and the accommodation of non-relatives instead.

Ultimately, the previously robust system collapsed, and the Çatalhöyük community underwent a considerable transformation. In the last three hundred years of the settlement occupation, in the period 6300-6000 BC, it was in a state of disintegration, accompanied by an attempt to rebuild the coherence of the remaining portion of inhabitants. Its population shrank considerably, and a majority of people left the settlement, moving to other parts of the Konya Plain and beyond.

The concepts of bifurcation and hysteresis, as introduced and developed by Dutch ecologist Marten Scheffer (2001, 2009), provide an adequate theoretical framework to grasp the nature of the last three centuries of the Neolithic settlement at Çatalhöyük. Bifurcation refers to the harmful and unforeseen consequences of the demise of the complex and long-lasting system. The concept of hysteresis refers to restoring some parameters of the hitherto dominant system but involves no return to what these parameters previously corresponded to. Its nature can be understood as some kind of synchronisation of different elements previously making up the settlement, as a non-equilibrium phase. It is characterised by three intertwined elements: (i) the splitting of a larger/earlier whole into smaller and separate units, (ii) reassembling earlier elements, and (iii) exploring the redundancy.

The consequence of this process was the emergence of what can be called the bifurcated village at Çatalhöyük. It was no longer a compact settlement with clustered houses occupied by a thousand or so inhabitants (Kuijt, Marciniak, 2024). The remaining portion of the local community inhabited several residential clusters on top of the main part of the settlement and in different spots in its immediate vicinity. The most important element of this dispersed settlement comprised a public quarter made of a set of non-domestic buildings placed around a plaza (Filipowicz, Marciniak, 2024). This final phase of the settlement occupation also involved more individualised forms of farming and husbandry and changes in the exploitation of the immediate environs.

During a time of community destabilisation after 6300 BC, the Çatalhöyük community continued to apply the policy of avoidance, which worked so well in an earlier period. However, this strategy proved to be largely unsuccessful in the new period. Examination of the frequency of different pottery forms in the region shows that ceramic assemblages at various sites became increasingly differentiated when compared with the Çatalhöyük tradition, which chose not to adopt them. A particularly striking feature of the Neolithic settlement at Çatalhöyük is the absence of painted pottery, creating a distinct contrast with contemporary regions. While painted vessels emerged in the neighbouring Lakes District toward the end of the 7th millennium cal BC and proliferated rapidly across that region, Çatalhöyük's community never adopted them (Özdöl Kutlu et al., 2015). Moreover, the inhabitants simultaneously diverged significantly from Cappadocian lithics traditions, as evidenced by finds at Köşkhöyük and Tepecik-Çiftlik. Unlike Cappadocia, where flake and percussion blade industries dominated, Çatalhöyük did not introduce and maintain pressure-blade traditions as standard. Similarly, flint was systematically avoided at Çatalhöyük and almost never used for projectile manufacture (Özdöl Kutlu et al., 2015). Another interesting development comprised the production of a new 'Gastropod Ware' group using clay from sources in the close vicinity of the settlement (Bordaz & Bordaz, 1982). This indicates a distinct focus on the exploitation of local resources in this period. It further corroborates a pattern of procurement of local resources, as has already been recognised in the case of clay for mudbrick production, wood for both timber and fire, and sheep and goat husbandry practices (Marciniak, 2021).

This final phase of the Çatalhöyük occupation corresponds with the abrupt climatic event that occurred at ca. 8,200 BP in the Early Holocene and was triggered by the glacial drainage of freshwater into the North Atlantic. The work carried out at the site (Roffet-Salque et al., 2018) indicates the region around Çatalhöyük experienced annually drier (4% reduction) conditions and weak cooling. Climatic unease appears to have contributed to the above-presented practices, exposing vulnerabilities in a settlement system.

Human Adaptations

Initial attempts at adaptability were largely unsuccessful as immediate responses to these changing conditions. Short-term adjustments in subsistence strategies, resource use, or settlement organisation did not sufficiently mitigate the effects of environmental pressure. Although there are indications of a more long-lasting, transformed form of adaptability—reflecting gradual adjustments aligned with broader climatic changes—these transformations were ultimately constrained by structural and environmental limits.

The adaptation potential has been considerably constrained by the considerable changes in the relationship between the Çarşamba delta and the Çatalhöyük settlement during its last phase of occupation. Situated on the edge of a low-lying alluvial plain feeding into the Konya Paleolake, Çatalhöyük's final occupation sequence unfolded within a landscape characterised by retreat of the Lake, active sedimentation, episodic flooding, and the development of fertile soils that supported intensive agriculture.

The transformative potential of Çatalhöyük in its final phase was therefore short-lived and ultimately unsuccessful. While the community demonstrated an ability to modify practices over time, these changes did not lead to a sustainable reorganisation of the settlement. The cumulative effects of environmental stress, reduced resilience, and limited adaptive success culminated in the eventual abandonment of Çatalhöyük, marking the end of its long and complex occupational history. The final three hundred years of the Çatalhöyük occupation represent both the culmination and decline of Neolithic lifeways, marking the end of the Neolithic trajectory while laying the foundations for a new socio-economic mode conventionally defined as the Chalcolithic.

Overall, the Neolithic Çatalhöyük in its final three hundred years of occupation provides an instructive case for examining resilience, adaptability, and transformative potential in the face of climatic stress. The local population exhibited limited resilience, as growing environmental instability increasingly strained subsistence systems and social organisation.

Science–Policy Interface in the Konya Plain

The Early Holocene adaptation to the riverine and deltaic environments can firmly be regarded as a unique form of cultural heritage of the Neolithic communities, reflecting the development of human competencies in managing dynamic landscapes. In some deltas, these adaptations led to long-term success, while in others, such as in the case of the Çarşamba deltaic environment in the Konya Plain, they ultimately failed. The retreat of the Konya Paleolake and its delta environment represents a large-scale environmental transformation that communities were unable to fully mitigate. Nevertheless, the highly elaborated mode of existence developed by Konya Plain communities, and their multifaceted attempts to respond and revive their existence in the rapidly changing circumstances, provide particularly insightful evidence of resilience, adaptive strategies, and the limits of human-environment interactions in the Early Holocene.

The archaeological heritage of the Early Holocene occupation of the Konya Plain refers to strategies of confronting transformations and threats imposed by natural and cultural factors and the ability to respond amid the rapid acceleration of these processes. In the period following the Neolithic, local communities had to respond to dynamic alluvial processes that had significantly shaped their landscape. This distinctively closed basin was primarily fed by several rivers and smaller seasonal streams originating from the surrounding plateaus. These waterways have deposited thick layers of alluvium—composed of sand, silt, clay, and occasional gravel—across the plain, gradually creating fertile soils suitable for agriculture. Flooding events were particularly important in the Bronze Age.

They deposited layers of fine sediments across the floodplain, creating levees, terraces, and low-lying depositional areas. These processes not only renewed soil fertility but also occasionally buried Early Holocene sites, settlements and corresponding landscapes. In addition, human activities during the Bronze and Iron Ages interacted closely with these natural alluvial processes. Early irrigation practices, canal construction, and land management modified water flow, accelerating both localised erosion and deposition in different parts of the plain. The resulting alluvial stratigraphy often shows alternating layers of natural sedimentation and anthropogenic deposits, reflecting the interplay between environmental processes and human adaptation (Boyer, Roberts, Baird, 2006).

More recent developments, including the emergence of irrigation systems, agricultural expansion, and settlement construction, have further interacted with natural alluvial processes. Irrigation canals and diversion of watercourses have modified sedimentation patterns, sometimes accelerating erosion in some areas while promoting deposition in others. These combined natural and anthropogenic processes have produced a complex stratigraphy, where archaeological layers are often interbedded with alluvial sediments, posing both challenges and opportunities for the study of past human occupation.

The water availability in the Konya Basin has been increasingly manipulated during the twentieth and twenty-first centuries to support agricultural production and mitigate the effects of drought (Topak, Acar, 2010). Since the late 1960s, groundwater levels have declined sharply, primarily as a result of intensive overpumping for irrigation. This sustained extraction has significantly altered the basin's hydrological balance, raising concerns about long-term water security and environmental degradation.

In response to recurring drought conditions, various water-management strategies have been implemented (e.g. Topak, Acar, 2010). These include the use and modification of the natural channel connecting the Beyşehir Basin to the Konya Basin, as well as the construction of artificial channels and waterways designed to transfer water from surrounding mountainous areas into the hotter and drier interior of the basin. While these interventions have temporarily alleviated water shortages, they have also increased dependency on engineered solutions.

An informative account of the processes provides the recent history of the Hotamış Lake. It was once the largest wetland in the Konya Plain, playing a crucial role in regional hydrology and ecology, but it has now almost completely disappeared. Its decline was largely driven by human interventions aimed at redirecting and exploiting local water resources to support development projects and political priorities in other areas. As a result of these interventions, Hotamış Lake experienced a dramatic reduction in surface area, shrinking by approximately 27 per cent between 1990 and 2000, a trend that ultimately contributed to the near-total loss of this important wetland system (Durduran, 2022, Figure 3).

Looking ahead, the future of water management in the Konya Basin requires a shift toward more sustainable practices. Achieving a balance between environmental constraints and human needs is essential, emphasising the protection of groundwater resources, the efficiency of water use, and long-term resilience to climatic variability. Natural threats to the region include its inherently low precipitation rates, which limit water availability and increase vulnerability to prolonged dry periods. These conditions are further exacerbated by climate change, which intensifies droughts and places additional stress on both the environment and the region's archaeological sites. Within this context, cultural threats arise primarily from unsustainable irrigation practices that deplete groundwater resources and alter landscapes, potentially damaging or even submerging archaeological remains.



Figure 3. Hotamiş Lake today

In addition, unsanctioned human activities—such as unauthorised construction, looting, and changes in land use—pose direct risks to the preservation and integrity of the region’s invaluable archaeological heritage.

The scarcity of water at the end of the Early Holocene brought the development of Neolithic communities in the Konya Plain to a halt, forcing settlements to decline or relocate. This historical precedent serves as a cautionary example for the present day, as the region now faces similar environmental pressures and constraints. Modern water shortages, driven by climate change, prolonged droughts, and unsustainable groundwater use, are threatening the livelihoods of contemporary communities.

These recent rapid environmental transformations directly and considerably challenge the preservation of its rich archaeological heritage. Archaeological sites, including those dating back to the Neolithic, are highly sensitive to environmental conditions. Declining water levels and the drying of former riverbeds not only alter the landscape but can also destabilise soil layers, increase erosion, and expose buried cultural deposits to damage. At the same time, human responses to water scarcity—such as expanded irrigation, land modification, or settlement relocation—can inadvertently threaten these sites, just as shifting environmental conditions did in the past. In this context, the history of water stress in the Konya Plain offers both a warning and a guide. Understanding how early communities adapted—or ultimately failed to adapt—to environmental challenges provides critical insight into the interactions between humans and their landscape. Today, integrating this knowledge with careful water management and heritage protection strategies is essential to prevent both the depopulation of the plain and the irreversible loss of its invaluable archaeological record. The science – policy interface in the Konya Plain is also another important dimension. The presence of Çatalhöyük in this region – one of the world’s best-renowned archaeological sites – dominated the discourse on archaeological heritage, its interpretation and public perception.

As the site is rightly presented as the most important archaeological site in the region, with the focus of regional, national and international stakeholders, this inevitably led to underestimation, undervaluation and overlooking other sites and a lack of understanding of the complex nature of archaeological heritage.

As a consequence, much of the Konya Plain's broader archaeological landscape remains outside the interest of scientific inquiry. These so-called "marginal landscapes" are less constrained by established archaeological narratives, making them more open to alternative, non-scientific interpretations and perspectives. This disparity highlights how the production of knowledge and the prioritisation of certain sites shape not only academic understanding but also the cultural and social framing of heritage in the region (Kuzucuoğlu, 2017). The archaeological landscapes of the Konya Plain also exhibit clear patterns of targeted damage, reflecting both historical and ongoing human interventions. One prominent example is the widespread reuse of ancient architectural elements, commonly referred to as spolia (e.g. Roberts, 1983). This practice involves the systematic removal and repurposing of building materials from earlier structures. In the Konya Plain, spolia encompasses a broad spectrum of behaviours, ranging from practical recycling to symbolic or status-driven appropriation. In addition to spolia, many sites have suffered looting, with artefacts and architectural fragments removed from their original contexts. Such activities often disrupt the stratigraphic and cultural integrity of the sites. In this context, the term spolia or spoliation serves as a convenient shorthand for a range of complex behaviours in the region, encompassing both socially sanctioned and illicit forms of interaction with the archaeological record. These practices underscore the vulnerability of the Konya Plain's cultural heritage and highlight the critical need for careful documentation, protection, and interpretation of its material remains.

Emerging Research Directions

The dynamic nature of the Early Holocene adaptation in the Çarşamba deltaic environment, alongside the long-lasting tradition of research, underscores the need to enhance and elaborate key research priorities across two major dimensions: (1) human–environment interactions, particularly in relation to crisis situations, and (2) long-term sustainability. With regard to human–environment interactions, these priorities comprise (i) scaling of interactions, (ii) responses to climate-induced environmental changes, and (iii) consequences of the climate-induced environmental changes on morphotypes of domestic plants and animals. With regard to long-term sustainability, these priorities involve (i) conceptualising the prosperity, crisis management, and community building, (ii) coping with the change and re-arranging the resilience and sustainability models, and (iii) food procurement and subsistence practices.

The first aspect of the human–environment interactions comprises grasping the scaling of interactions. Human–environment interactions in the Early Holocene Çarşamba delta occurred at multiple scales, ranging from the local household and settlement level to regional networks of resource procurement and exchange. Local interactions included the management of water, soils, and domesticated plants and animals, while broader interactions encompassed trade in raw materials, such as obsidian, and the movement of agricultural and technological practices across the Konya Plain. Understanding these different scales is essential for assessing how communities adapted to environmental variability and organised themselves socially and economically in response to ecological opportunities and constraints.

The second aspect comprises responses to climate-induced environmental changes, encompassing both long-term and short-term processes. Neolithic communities in the Çarşamba delta were repeatedly confronted with gradual climatic shifts, such as Early Holocene warming and longer-term aridification trends, as well as abrupt events including droughts and fluctuations in the Konya Paleolake levels.

Human Adaptations

These environmental changes had a direct impact on settlement patterns, resource availability, and subsistence strategies. In response, communities adopted flexible strategies, such as relocating settlements closer to more reliable water sources, diversifying subsistence practices, or intensifying the exploitation of specific ecological niches. These adaptive behaviours illustrate the dynamic feedback between human societies and environmental stressors, highlighting both the resilience and the vulnerability of Neolithic communities in the face of climatic instability.

The third, under-researched aspect comprises morphometric changes in plants and animals, domesticated outside the Konya Plain, in response to changing climatic and environmental conditions. Changes in climate and landscape affected not only human behaviour but also the biological characteristics of plants and animals under human management. Morphometric analyses of early domesticated cereals and livestock reveal adaptations to altered temperature regimes, precipitation patterns, and soil conditions, reflecting the combined influence of environmental pressures and selective human practices. For instance, early cereals may have developed increased robustness under semi-arid conditions, while livestock populations adapted to local pastures and microclimates. These biological responses highlight the co-evolutionary relationship between humans, cultivated plants, and domesticated animals, illustrating how environmental pressures shaped Neolithic lifeways in the Çarşamba plain.

These challenges should be addressed through well-designed research agendas supported by a suite of innovative and interdisciplinary methods. Occupational dynamics in the Çarşamba River region can be analysed across multiple spatial scales, including the immediate site zone, the microregional context, and the broader regional landscape. These patterns are shaped by the interplay of environmental constraints and social factors and can be reconstructed through the integration of geomorphological analyses with airborne prospection techniques. Together, these approaches enable the identification of site distributions, settlement hierarchies, and changing patterns of landscape use over time.

Understanding occupational change requires careful attention to both long-term climatic trends and short-term environmental events. High-resolution chronological frameworks make it possible to distinguish gradual transformations from abrupt disruptions, thereby clarifying the timing, scale, and character of environmental stressors and their influence on settlement patterns and subsistence strategies. At the site level, shifts in settlement location, intensity, and structure reflect adaptive responses to a combination of environmental and social pressures. Such changes may indicate variations in population density, seasonal mobility, and the organisation of domestic, ritual, and economic spaces, offering insight into how communities managed risk and responded to fluctuations in resource availability.

The application of geometric morphometrics (GMM) to plant and faunal remains, together with advanced genetic methods, enables researchers to track subtle ecological and cultural responses to environmental change, offering valuable insight into the co-evolution of human communities and their surrounding landscapes.

These aspects—occupational patterns, chronological resolution, and faunal and plant analyses—can be effectively investigated through interdisciplinary linkages and methodological innovation, combining archaeology, geomorphology, paleoenvironmental research, and advanced modelling, including the growing significance of AI solutions. Such integrated approaches enable a holistic understanding of human adaptation by bringing together environmental, social, and technological factors across multiple spatial and temporal scales.

With regard to sustainability and resilience, the first aspect concerns the enhanced understanding of periods of prosperity and strategies of crisis management. A substantial portion of the Early Holocene occupational sequence in the Konya Plain corresponds to a phase of relative prosperity, during which communities, while increasingly confronted with emerging crises, were engaged in the reconstruction of their social, economic, and organisational systems. During this process, the emphasis was placed on maintaining stability while adapting to the failure or transformation of previously dominant modes of life.

With regard to understanding the redesign of foundational community structures and coping with change, the clearly under-researched issue comprises grasping the communities' engagement in the reorganisation of social arrangements, including household relations, networks of cooperation, and mechanisms of decision-making. This reconfiguration sought to enhance resilience, support collective action, and balance internal social pressures under changing environmental and demographic conditions. Beyond social reorganisation, communities also redesigned their cultural and institutional foundations, ensuring continuity with local traditions while simultaneously adapting to external environmental, climatic, and social changes. This embeddedness within established traditions facilitated the transmission of knowledge and practices, even in the face of shifting external circumstances.

With regard to food procurement strategies and subsistence practices, adaptation also extended to subsistence systems, as communities adjusted hunting, gathering, cultivation, and early animal management strategies in response to environmental variability, resource scarcity, and population pressures. These changes illustrate the dynamic interplay between ecological opportunity and human innovation.

Although a variety of methods have already been applied to study these issues in the region, the heuristic potential of some approaches has yet to be fully explored. These include ancient DNA (aDNA) and stable isotope analyses, including haplotype and Y-chromosome, as well as strontium and oxygen studies. Interdisciplinary approaches combining aDNA with stable isotope data shall provide critical insights into population origins, migrations, and mobility patterns. Haplotype and Y-chromosome analyses reveal genetic lineages, while strontium and oxygen isotopes offer information on geographic provenance and movement across landscapes, enabling researchers to reconstruct how communities interacted with their environment and neighbouring regions.

A complementary approach employs ancient DNA (aDNA) alongside carbon and oxygen isotope analyses to examine dietary practices, resource use, and social organisation, including kinship and relatedness arrangements. Carbon isotopes provide evidence of plant consumption and agricultural strategies, while oxygen isotopes reflect water sources and mobility. Together, these methods allow the reconstruction of subsistence strategies and ecological adaptation at both the household and community levels.

Conclusions and Recommendations

The Neolithic of southwestern Asia can be understood from a *longue durée* perspective as a process of cumulative adaptations unfolding over almost four millennia. Its development was cyclical and shaped by the spread of incipient Neolithic communities and lifeways beyond the core Fertile Crescent, as local hunter-gatherer groups engaged with, adopted, and transformed several innovations from the region within their own environmental and cultural contexts. Local communities continuously responded to cyclical climate changes and ongoing landscape transformations, which contributed to an accumulative and transformative character of the Neolithic, where each phase of adaptation was built upon preceding experiences.

Our understanding of the nature and dynamics of these transformations, and their regional iterations, is in its infancy. There is certainly a need to explicitly conceptualise and adopt a comparative analysis of this process. In particular, it is required to study the use/adoption/rejection of different technologies and innovations as an outcome of the cultural and social embeddedness of the local community; to grasp the distinct characteristics of local communities; and to scrutinise changes imposed by climate change and the corresponding responses of the local environment.

The Carsamba deltaic environment in the Konya Plain provides a remarkable case of the study of human adaptation, representing a long-lasting sequence of the Early Holocene occupation. Here, local hunter-gatherers were transformed through engagement with emerging Neolithic lifeways and adaptation to changes in the ecological and hydrological conditions of the Çarşamba River estuary area. Over time, however, the unique Early Holocene sequence came to an end, driven by climate change, landscape transformations, and the progressive scarcity of water, which collectively undermined the sustainability of Neolithic settlements in the region. This demise marks the end of the final boom of the incipient Neolithic in southwestern Asia, illustrating the limits of local adaptation in the face of considerable environmental stress. The case of the World Heritage site of Çatalhöyük exemplifies how the study of human adaptation can be conceptually framed and research-driven to enhance understanding of its Outstanding Universal Value (OUV). As both a tangible and intangible heritage, Çatalhöyük demonstrates the interplay between environmental challenges, technological innovation, and social organisation that shaped long-term human adaptation in Central Anatolia. The Konya Plain currently faces significant water management challenges due to the declining groundwater table, primarily resulting from long-term overextraction for agriculture, irrigation, and other human activities. This modern crisis mirrors, on a different scale, the challenges faced by the Early Holocene communities in the region, who had to adapt to the gradual retreat of the Konya Paleolake and the transformation of delta environments. While Neolithic populations attempted to develop strategies of dealing with water availability, the scale and intensity of contemporary water use may exceed the natural regenerative capacity of the basin. This comparison underscores the importance of sustainable water management, linking historical resilience and adaptive strategies to the pressing environmental and social demands of the semi-arid landscape.

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Bringing Together Perspectives on Prehistoric Heritage in Island Southeast Asia

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General context

A major field for prehistoric research

Southeast Asia, and more specifically its island part (Fig. 1), has made a considerable contribution to our understanding of human history for nearly a century and a half. It was indeed in Java that the discovery of *Pithecanthropus*, the 'ape-man', took place (Dubois, 1994), a foundational event for paleoanthropology, at a time when only the earliest Neanderthal fossils attested to the existence of other human forms before our species. These fossils, described as belonging to the *Homo erectus* group (Mayr, 1950; Widianto, 1993), have also documented the significant variability of this taxon since it arrived in the islands more than one and a half million years (Ma) ago (see for example Sémah, 1986 & Fig. 2). The Southeast Asian archipelagos have also yielded a wide diversity of material assemblages reflecting the technical behaviors of ancient populations, particularly lithic industry, including evidence of the first diffusion of the Acheulean tradition (e.g. cleavers and handaxes, see Fig. 3) into the islands at the dawn of the Middle Pleistocene (Sémah et al., 1992). More recently, the antiquity of symbolic representations has been highlighted, notably those found in the caves and rock shelters of Sulawesi and Borneo (Brumm et al., 2021; Aubert et al., 2018), which are among the oldest known worldwide. Finally, some of the soundest discoveries certainly relate to the crossing, between 1 and 0.7 million years ago, of marine biogeographical barriers (Fig. 1) previously thought to be impenetrable to populations predating the main expansion of *Homo sapiens* at the end of the Late Pleistocene (Brumm et al., 2010; van den Bergh et al., 2016). Current hypotheses place these crossings at the origin of highly endemic human forms such as *Homo floresiensis* (Brown et al., 2004; Fig. 4) and *H. luzonensis* (Détroit et al., 2019).

A heritage linked to major current challenges

These diverse elements of a rich prehistoric heritage found in the archipelagos are intimately linked to the natural environment and its evolution during the Quaternary period. It is established that the earliest human expansions towards the southeastern margins of the region took advantage of eustatic sea-level drops (see Voris, 2000), which widened or created land bridges, allowing access to a nascent Java Island that is currently shaping up (see also Sémah et al., 2021). It is likely as well that these earliest inhabitants of the archipelagos had to adapt their way of life to new environments (e.g., volcanic islands in formation) and ecosystems, learning to exploit their resources. Adaptation, both biologically and culturally, was also necessary, not only to the climatic changes that marked the Quaternary period but also to the profound associated landscape transformations, such as the phases of forest regression and development, or the paleogeographic impact of cycles of emergence and submersion resulting from sea-level oscillations that could exceed one hundred meters in amplitude.

These few examples, far from being an exhaustive list, are sufficient in themselves to illustrate the parallel between past situations revealed by prehistoric research and the multiple challenges facing the concerned countries in insular Southeast Asia. These challenges are linked to an inherently fragile natural regional context, due to a position at the continent-archipelago interface and to an intense volcano-tectonic activity, as well as to a high sensitivity to climatic events amplified by global change, as exemplified by currently multiplying catastrophes.

But it also involves challenges related to the management of human activities in the broadest sense of the term, such as forestry, conservation of ecosystems and biodiversity, or management of biological and mineral resources.

Prehistoric heritage: a valuable dimension for a sustainable conservation and development policy

Certainly, understanding the main phases of human history provides valuable insight into humankind's capacity for adaptation and resilience, and into the resilience of its societies. However, particularly in the region under consideration, the full integration of prehistoric heritage is likely to play a driving role as an element of a sustainable development policy. Regarding fieldwork itself, it is clear that the field to be explored remains vast, often in quite difficult conditions, and that the pace of discoveries, considered over the long term, is intense. The integration mentioned above should allow for a better identification of the scientific questions to which priority should be assigned and, consequently, for better planning of the allocation of efforts in terms of training, human and financial resources.

In parallel, it is important to develop participatory initiatives that can leverage the often unspoken knowledge of communities regarding prehistoric sites, thereby optimising fieldwork and, above all, involving local societies in knowledge development (Sémah et al., 2025; Biets et al., 2025). Such an approach also easily leads to the identification of fundamental narrative elements that must be considered in initiatives to protect and promote heritage for all audiences, often going far beyond a simple concern for the conservation and development of the cultural resource.

For example, highlighting the link between past humans and their natural environment through Palaeolithic rock art (Fig. 5) is at least as important as demonstrating that those found in the Wallacea Islands are probably the oldest in the world. Similarly, without limiting ourselves to the prehistoric significance of a discovery, it can prove very useful to connect the past and the present. A stratigraphic record along a watercourse can simultaneously express its value through its paleoecological and chronological significance, as well as its connection to the very importance of the water resource in the cultural traditions and daily life of the local population, thus doubly justifying the importance of the conservation plan.

Within this perspective of dialogue at the intersection of research, heritage, and development, we will present below some examples illustrating the importance of an interdisciplinary—or even transdisciplinary—approach to the study of Prehistory in insular Southeast Asia. These examples highlight the value of a genuine synergy between the immense regional potential for our understanding of human history in general and for a structured approach to a policy for conservation and sustainable development.

Humans are facing ever-changing landscapes and climate

A continuous evolution during the Quaternary period

Often considered a major but primarily contextual element of human history, climate and paleoenvironment occupy a prominent place here, linking prehistoric heritage and the perception of natural heritage. Geotectonic phenomena have always been decisive in the formation of landforms and basins. Quite often, as on the island of Java (e.g., the Sangiran dome), their combined action has resulted in the deposition, uplift, and subsequent erosion of thick volcano-sedimentary sequences, which can thus yield a rich record of fossils and artefacts, as well as a chronostratigraphic reference (e.g. Sémah, 1986, op. cit.).

Human Adaptations

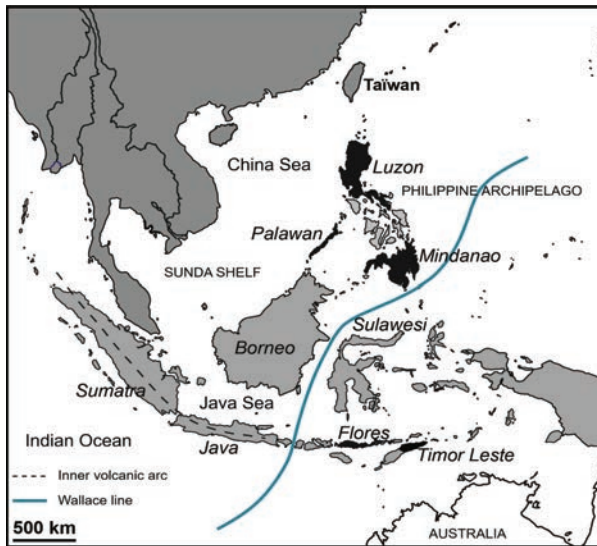


FIGURE 1. Map of the concerned area



FIGURE 2. Sangiran Dome human fossils, Central Java.

Climate has also played a major role. The glacial-interglacial cycles (ranging from a few tens of meters in amplitude during the Early Pleistocene to over one hundred meters once the conditions characteristic of the Middle Pleistocene were established) led to veritable paleogeographic revolutions and profoundly impacted biogeographic patterns. Climate also shaped the spectacular karstic landscapes, originating from limestone massifs, which contain a large part of the prehistoric heritage, like in Maros Pangkep (Sulawesi), Sangkulirang – Mangkalihat (Kalimantan) or Gunung Sewu (East Java). Finally, climate determined the development, positive or negative, of the hydrographic network and numerous ecosystems, such as the various forest formations (e.g. A.-M. Sémah, 1986). The constituent elements of the environmental context are often at the mercy of even a limited modification of one of the factors mentioned above, and even more so of a catastrophic event. This observation remains fundamental to any narrative initiative concerning the paleoecological context of prehistoric populations.

Humans as witnesses

The context described above was crucial for human expansions in insular Southeast Asia. It is for this reason that we must place the environment at the heart of a heritage-based approach that integrates culture and nature, past and present. Some studies now describe a Sunda Plateau that remained above water until the middle of the Middle Pleistocene (Husson et al., 2019), substantially altering the simple model associating the crossing of the plateau with glacial periods in high latitudes. Nevertheless, reaching the forming island of Java approximately 1.5 million years ago (likely a collection of islands and islets during the Early Pleistocene) must have involved crossing straits that emerged during these same glacial periods. The colonisation entailed adaptation to diverse environments. For example, to reach the islands of the Sunda volcanic arc at the edge of insular Southeast Asia, humans had to cross vast coastal areas covered by mangrove and back-mangrove forests (Fig. 6).

This environment offered rich resources but required adaptation in order to exploit them. Furthermore, different forest formations covered the land: while tropical rainforest dominated during interglacial periods, glacial periods were marked by a clear opening of the landscape (linked to a marked seasonal contrast), which certainly facilitated the structuring of territories (A.-M. Sémah, 1986, op. cit.; A.-M. Sémah et al., 2010; A.-M. Sémah & Sémah, 2012).



FIGURE 3. Palaeolithic handaxe, Koboran river terrace, Punung (Gunung Sewu karst, East Java) (picture Semenanjung)



FIGURE 5. Warty pig picture from Leang Tedongnge (South Sulawesi), dated older than 45,500 years (Brumm et al., 2021) (picture courtesy Adhi Agus Octaviana)



FIGURE 4. Reconstitution of *Homo floresiensis* by E. Daynès (picture courtesy E. Daynès for HOPsea exhibition, Musée de l'Homme, 2007)

Thus, in the Sangiran dome in Java, evidence can be found of the importation of rocks, raw materials for artefacts, collected from several tens of kilometres away. The adventure of *Homo erectus*, who thus became the first island dwellers in human history, was followed, at the dawn of the Middle Pleistocene (around 1 million years ago), by the equally spectacular journey of the first humans to cross the major marine biogeographical barriers of the region.

Such expansions are now documented on the islands of Flores (artefacts actually already reported in the 1970s, and later a human mandible, Brumm et al., 2010 and van den Bergh et al., 2016, op. cit.), Luzon (a rhinoceros carcass bearing butchery marks and stone flakes, a human humerus; Ingicco et al., 2018; Cosalan et al., 2025), and more recently Sulawesi (stone artefacts, Budianto Hakim et al., 2025). It seems beyond doubt that these crossings were facilitated by the narrowing of the marine barriers, which nevertheless remained far too deep to allow the formation of land bridges. However, the vectors involved (e.g., winds, currents, natural rafts, such as entire sections of mangrove detached from the coast) remain mysterious.

Both the still limited distribution of discoveries and the need for further progress in understanding paleoenvironments (land and forest fragmentation, establishment of terrestrial and marine barriers; paleo-regimes of winds and currents) make it difficult to establish credible models.

In any case, it appears essential to approach this question from an interdisciplinary perspective, considering:

- the causes and processes of the conquest of new environments (or territories), separated by marine or ecological barriers. This approach can include cultural elements such as constraints related to inter-group competition, simple curiosity, and the attraction of resources reflected in messages from the other side (birds, floating carcasses, etc.). Still, it can also be done from a comparative perspective, examining the behaviour of other animals, primarily non-human primates.
 - particularly in archipelagic zones, the required frequency and volume of migrations, which, beyond a single “accident,” prove essential for the biological establishment of a population in a specific area;
 - from this latter perspective, the analysis of the stages of human group settlement in such areas. For more recent periods, the results of genetic analyses can shed light on the process of colonisation of new territories.
- 2.3. Humans as actors on earth...

The second scientific and heritage aspect related to climate, the environment, and landscape involves humans not only as observers but also as actors. The oldest sites are not the most relevant in this case. This is not to suggest any inability on the part of humans to observe their environment or even to act upon it, as *Homo erectus* amply demonstrated their cognitive abilities. However, leaving a lasting mark on the environment most often requires concerted action. This social organisation was likely only possible within relatively large groups such as those thought to have characterised the wave of *Homo sapiens* who colonised the Old World during the second half of the Late Pleistocene.

Many elements of the prehistoric heritage in the archipelagos refer, more or less directly, to this role of “environmental engineer” played by social groups. Important for prehistoric research, they can significantly influence our understanding of the impact of human societies, both positive and negative, and on the need for conservation. Examples include forest exploitation and organised deforestation, such as the introduction of rice cultivation in Sulawesi nearly 3,500 years ago (Zhenhua Deng et al., 2020) or the use of kilns for iron production in Kalimantan around 2,000 years ago (Hartatik et al., 2023). Such sites may prompt reflection on the impact, positive or negative, of human-made innovations. This highlights, for example, the added value of traditional forest gardens in Kalimantan (Mulyoutami et al., 2009), which include rattan plantations (an industrial resource), compared to oil palm plantations, which are partly responsible for the recent flood disaster in northern Sumatra.

2.4. ...as well as for the conquest of ‘seascapes’

Here we will focus on one of the crucial scientific questions: the colonisation of what is commonly called a “seascape,” an organised act which occurred much later than the ancient ‘natural’ crossings of wide seas. Our species probably invented navigation and subsistence on the high seas (e.g., deep-sea fishing) around 60,000 years ago (O’Connor et al., 2011). This innovation was certainly developed in the eastern islands of Indonesia and Timor-Leste, and it enabled the early colonisation of Australia (Gandini et al., 2025). It is interesting to note that such advances are closely linked to the exploitation of forest formations that provide essential material resources (timber, lianas) and, certainly, to the development of coastal forest management (mangroves, swamps, beach forests).



FIGURE 6. Mangrove forest, Lipuun Point, Palawan Island, Philippines (picture Semenanjung)



FIGURE 7. Denticulated artefact from Song Terus cave, East Java (Gunung Sewu karst) made with a mangrove shell collected quite far from the site, c. 9000 years ago. Width = 2.6 cm. (picture Semenanjung)

Researchers, like ordinary citizens, are thus led to delve deeper into major questions such as the origin and spread of such traditions, to search for their traces, both fossil and contemporary, thereby contributing to answers in terms of both scientific discovery and conservation initiatives. We will mention here two examples of heritage value related to this issue:

- Understanding the pattern of the population ‘redistribution’ that occurred during the paleogeographic revolution of the early Holocene, which saw sea levels rise by more than one hundred meters in a few thousand years; understanding as well the connection that groups who then colonised the interior maintained with the coast (Sémah et al., 2004; Fig. 7).
- But also recognising the value they deserve for cultural traditions linked to subsistence and the protection of the environments and species that sustain them, such as the harvesting of edible mangrove shellfish (for example, in Sumatra, Burgos & Dillais, 2012) or the responsible harvesting of cetaceans from Flores (Sudikan et al., 2024). The latter is indeed a source of food security and a balance of trade between the people of the coast and the people of the inland.

Human evolution and adaptation

The first islanders and their classical evolutionary model

The ‘Pithecanthropus’ represent the most famous dimension of the prehistoric heritage of insular Southeast Asia, and of Indonesia in particular. Fossils discovered since the late nineteenth century in Java are abundant and fairly widely distributed chronologically between the Lower Pleistocene and—probably—the beginning of the Upper Pleistocene (see Falguères et al., 2016; Yokoyama et al., 2008; Sémah, 1986, op. cit.). This record has led researchers—and the messages associated with the discoveries—to focus on an “evolution” within the *Homo erectus* subgroup, often described as linear (e.g., Widiyanto, 1993, op. cit.). This evolution would have led an early-emerging group with archaic characteristics (sometimes called ‘Meganthropus’) to a more classic *H. erectus* (such as the Trinil fossil) and then to a derived form (the Solo people), the final stage before extinction in an evolutionary process sometimes compared to ‘Neanderthalization’ (cf. Teilhard de Chardin, 1937).

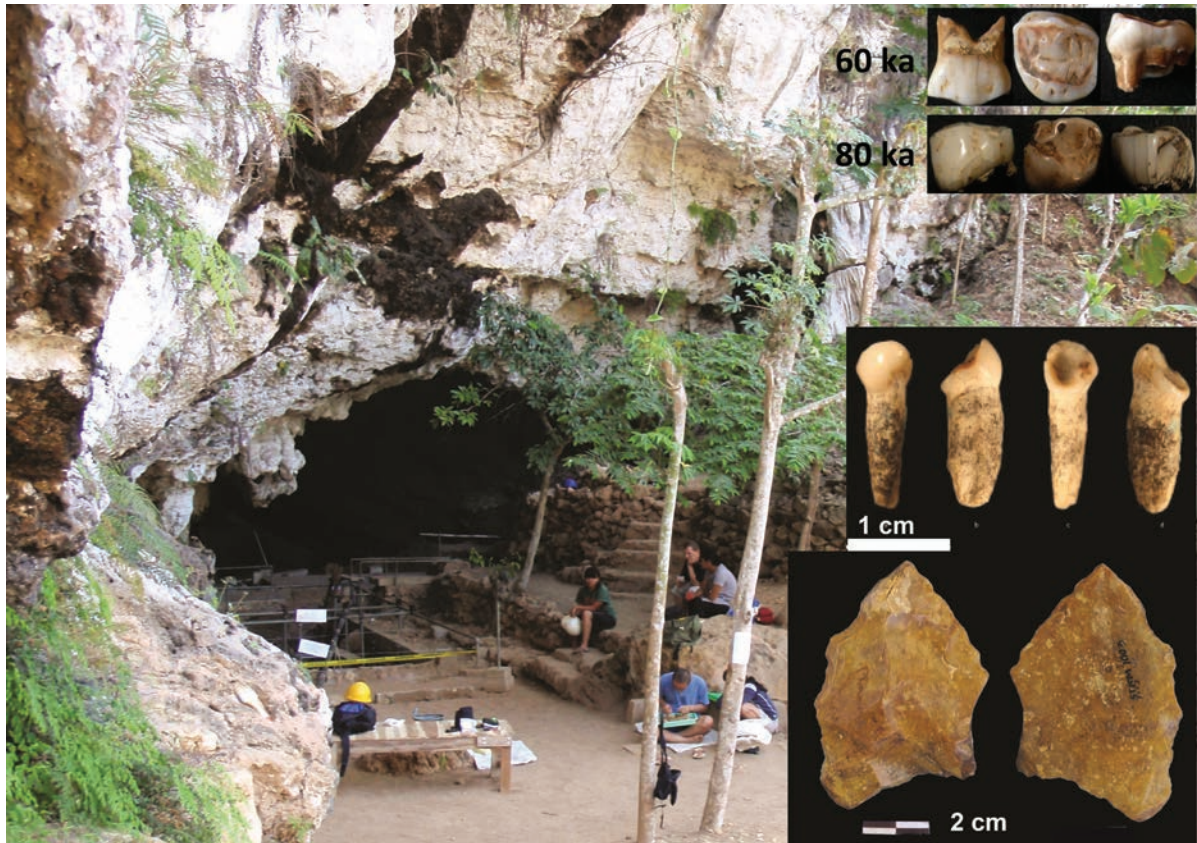


FIGURE 8. Song Terus cave, East Java (Gunung Sewu karst)

Upper right: Human deciduous teeth related to derived *Homo erectus* (lower, c. 80 ka) and *H. sapiens* (upper, c. 60 ka)
 Lower right: Siamang (*Symphalangus*) tooth and flake implement (c. 120 ka)

The mechanisms of the local extinction of *H. erectus*, its replacement by *H. sapiens*, and even its coexistence during the Late Pleistocene remain a significant scientific challenge (see Noerwidi et al., 2023; Fig. 8).

Indeed, this 'linear' model sheds important light on the fossil record. Its clear relationship with the chronology of fossils and sites lends it credibility regarding the role played by island endemism in the evolution of Javanese fossils. However, it is partly contradicted by the intensity of contacts at the mainland-archipelago interface, as reported by geological and paleoenvironmental studies, and even archaeological discoveries. These latter findings, particularly at the transition between the Early and Middle Pleistocene, describe exchanges with the mainland that preclude considering the expansions toward the island of Java as a one-way journey. For example, at this time there were faunal 'turnovers' involving the arrival of many new taxa (Sondaar, 1984), or even the emergence of the first traces of the spread of the Acheulean tradition towards the archipelagos (Sémah et al., 1992, op. cit.; Simanjuntak et al., 2023), all of which may have involved more complex contacts in human groups.

A complex but attractive settlement model

Both the orientation of field and laboratory research, the narrative elements relating to heritage and the need for conservation cannot ignore the directions suggested above, some of which may prove to be of major importance.

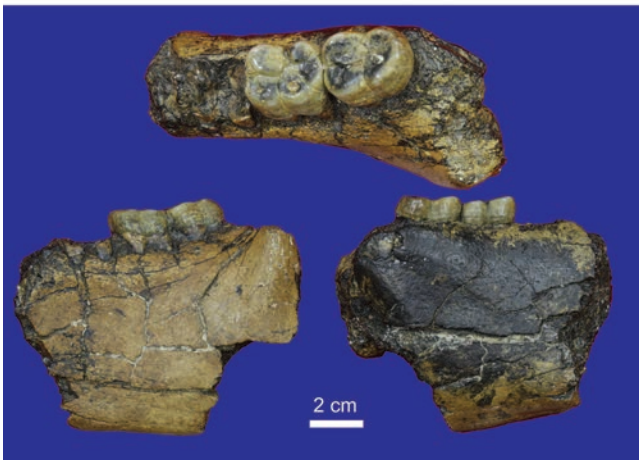


FIGURE 9. *Gigantopithecus* sp. mandible Semedo, Central Java (picture courtesy Harry Widiyanto)

They lead us to consider not only Java Island but also the Southeast Asian archipelagos as a whole, in all their dimensions as a crossroads of biodiversity. Regarding the human lineage itself, it is important to consider the probable diversity among the hominins that reached Java during the Early Pleistocene. The question of the status of ‘archaic’ fossils is currently being debated, particularly by distinguishing the genus *Meganthropus* and its possible links with representatives of the lineage predating *H. erectus*. (Zanolli et al., 2019; 2025). This debate suggests, for example, considering the origin of endemic human forms such as those discovered on Flores (both the mandible from the Soa River basin and the more recent fossils of *H. floresiensis*) and the persistence (or reappearance) of ancestral traits, for example, in *H. luzonensis* (Détroit et al., 2019, op. cit.).

It also seems worthwhile to try to understand this diversity in the island populations, their origin, and the mechanisms of their establishment from a broader contextual perspective that goes beyond the human lineage alone, including in particular the Asian great apes. This requires taking into account the evolution of climates and landscapes discussed earlier, as well as the dependence on or the adaptation to various environments. Paleontological studies under such a perspective are still few in number, but promising. They are focusing on approaches to coexistence in separate ecological niches or on cohabitation within the same landscape among different taxa. These findings are likely to shed light on the circumstances that enabled the simultaneous presence of *Meganthropus* and *H. erectus*, particularly at the Sangiran dome in Java.

This approach is similar to that undertaken in the Great Lakes area in East Africa regarding the contemporaneity of the genera *Homo* and *Paranthropus* and the environmental impact on *Homo*’s dispersals (Maslin et al., 2014). It should be extended to more detailed studies concerning the occurrence of the gibbon (*Hylobates*, gibbon found at Trinil as early as the Middle Pleistocene (Ingicco et al., 2014), but also in later faunal assemblages, see Fig. 8), *Pongo*, and *Gigantopithecus*, whose earliest island remains were discovered in central Java at Semedo (Noerwidi et al., 2016; Fig. 9).

The connection here is clear: the need for ecosystem preservation, a better understanding of the biotopes specific to great apes, and their history. The protection of orangutan populations is currently a crucial issue in Southeast Asia, inextricably linked to research on their origins and ecology.



FIGURE 10. Maros points (“Toalian” assemblages), Maros Pangkep karst, South Sulawesi (picture courtesy Archaeological Laboratory Universitas Hasanuddin)

Genetic studies (Nater et al., 2017) on the most recently described species in North Sumatra (*Pongo tapanulensis*) demonstrate a much younger differentiation from *P. pygmaeus* from Borneo compared to that from their close neighbours from Sumatra (*P. abelii*), bringing us back here to questions of circulation on the Sunda shelf during the Pleistocene.

Converging perspectives

Primarily, as suggested in Part 1.2. and 1.3, the window that prehistoric heritage opens to society is related to the perception, over time, of our environments' fragility, of the impact of human activities on ecosystems and the resources they offer, and of the capacity for adaptation and resilience of humankind and its societies. The very long-term perspective also drives us to enlarge our respectful approach to human diversity. Time allows us to acknowledge, through adaptation and behaviours, the very human features of a large diversity of ancient groups, finding, for example, 'modernity' in the 3D symmetry of a c. 1 Ma old handaxe (Fig. 3) or in the realism of an animal picture drawn in a cave tens of thousands of years ago. However, such an insight that reaches deep into the past cannot simply lead to the assumption that learning from the past helps define a policy for the present and future, or, even more simplistically, suggest that the goal for the future is to return to a supposedly ideal, Garden-of-Eden-like past. The most important contribution of research in Prehistory is to contribute to a holistic approach to the interactions between the human group and its environment. Such an approach appears even more critical when dealing with areas where isolation is the rule, such as the Southeast Asian archipelagos, where we find a juxtaposition of diverse forms of adaptation that can sometimes persist for a long time. Conspicuous examples are numerous. Within the prehistoric record, they can be related to the pattern of the sites or to the recovered movable heritage, such as the remarkable specificity of the Toalian lithic assemblages (see, for example, Budianto Hakim & Nur, 2009 & Fig. 10).

Such examples entail consideration of other, multiple heritage dimensions related to environment and culture -including living heritage- hence fostering an actual interdisciplinary approach. And it is precisely here that research activities, which are most often conducted in collaboration with local communities, can fully benefit from an actual collaboration and include a part of transdisciplinarity, merging the scientific approach of heritage, the traditions (e.g. Oosterbeek, 2025), and of course a deep local knowledge of the landscape, seascape and of the sites. In that sense, bringing together all the actors capable of delivering a message about heritage and conservation initiatives can help achieve sustainability.

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02

Pleistocene and Holocene Studies

The Faya Palaeolandscape - an intact fossil landscape that documents the deep and varied history of the human-nature relationship in Southeast Arabia

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Introduction

The UNESCO World Heritage Convention was established in 1972 to identify globally natural and cultural sites with outstanding universal value to all humans and to safeguard these sites as part of the world heritage of mankind (UNESCO, 1972). The convention is among the most widely ratified international treaties and can be considered highly successful, given ratification status and a World Heritage List that in 2025 contains 1248 inscriptions. Despite an increasing number of World Heritage properties, biases of the list have been identified repeatedly, considering geographic, chronological, thematic and site type representation (Ashworth et al., 2007; Graham et al., 2000; Smith, 2006; UNESCO, 1994). One fundamental issue identified was the strict separation of natural and cultural sites in the original convention text. Following consultations and discussions, experts suggested the inclusion of the category cultural landscape among others to bridge the gap between nature and culture and to recognise the broad range of values landscapes can possess (Rössler, 1995). In 1992, the proposed changes were accepted by UNESCO (UNESCO, 1992).

In the fifty years that have passed since the World Heritage Convention was adopted, the perception of what heritage can constitute has significantly changed. Maintaining the convention's goal of being universal and representing all human heritage thus requires constant reflection on and adoption of the definition of World Heritage. One important step towards increasing representativity was the global strategy launched by the World Heritage Committee in 1994. Besides extending geographic representation, the global strategy aimed at extending the definition of World Heritage to include non-monumental sites and cultural traditions to better reflect the full spectrum of global natural, cultural and mixed heritage sites (UNESCO, 1994).

One programme launched in the context of the global strategy was the World Heritage Thematic Programme Human Evolution: Adaptations, Dispersals and Social Developments (HEADS). With the action plan approved for the programme in 2010 (UNESCO, 2010), HEADS represents a consequent continuation of initiatives geared towards filling in gaps in the World Heritage List and contributing to the implementation of a multidimensional concept of heritage. Goals of the HEADS programme include the development, establishment and sharing of solid and science-based knowledge about the origin of cultural diversity in early prehistoric sites. HEADS further aims at defining a strategy for international and interdisciplinary cooperation among researchers to foster recognition of early prehistoric sites and cultural traditions within the UNESCO World Heritage context (Sanz, ed. 2011).

The HEADS programme considers a very long period, which in terms of cultural expressions begins 3-2.5 million years ago, years ago, with the occurrence of the first stone tools (Harmand et al., 2015; Plummer et al., 2023). If the biological evolution of Hominins is added, this time frame extends to several million years (van Holstein and Foley, 2017). Fundamental processes, including biological, social and cultural evolution and their respective interaction with climate-driven environmental change, have significantly shaped human history in this extensive time frame. For most parts of this time frame, hominins have been an integral part of the natural environment. They exploited hydrological, organic and mineral resources of the landscapes they inhabited.



Figure 1. Overview of the northern end of Jebel Faya. View towards the west. Please note the gravel plain in front, the anticline in the centre and the red sand dunes of the northern Rub' al-Khali in the back behind the mountain. (Photo: Sharjah Archaeology Authority).

Climate change through time constantly shaped these environments, and archaeological records indicate that humans were able to respond to these changes through cultural, social and biological adaptation (Jagher and Le Tensorer, 2011; Pilaar Birch and Miracle, 2017). The prevailing view considers humans adapting to their inhabited environment. However, human interactions with the landscapes can also be expected to have led to adaptive responses by the inhabited environments (Laland et al., 2001). Hence, the opposite process, an environment adapting to human interaction, seems equally possible if the duration of human interactions were long enough. Known examples potentially contributing to the formation of anthropogenic landscapes prior to the invention of agricultural and landscape architectural practices include landscape management by fire (Singh et al., 1981), species-specific hunting practice (Martin et al., 2025), environmental impact through animal husbandry (Arbuckle and Hammer, 2019) and mining activities (Negrino et al., 2005).

The mutual dependency between humans and their inhabited environment is a significant aspect in human evolution that formed the foundation for many milestones in humanity's history. Given an explicit interplay between the natural and cultural spheres in addition to the non-monumental character of the archaeological and palaeoenvironmental records, this important aspect in our history is not easy to address in the World Heritage context. This paper, however, argues that one promising option is the merging of the cultural landscape category with a deep time, diachronic perspective.

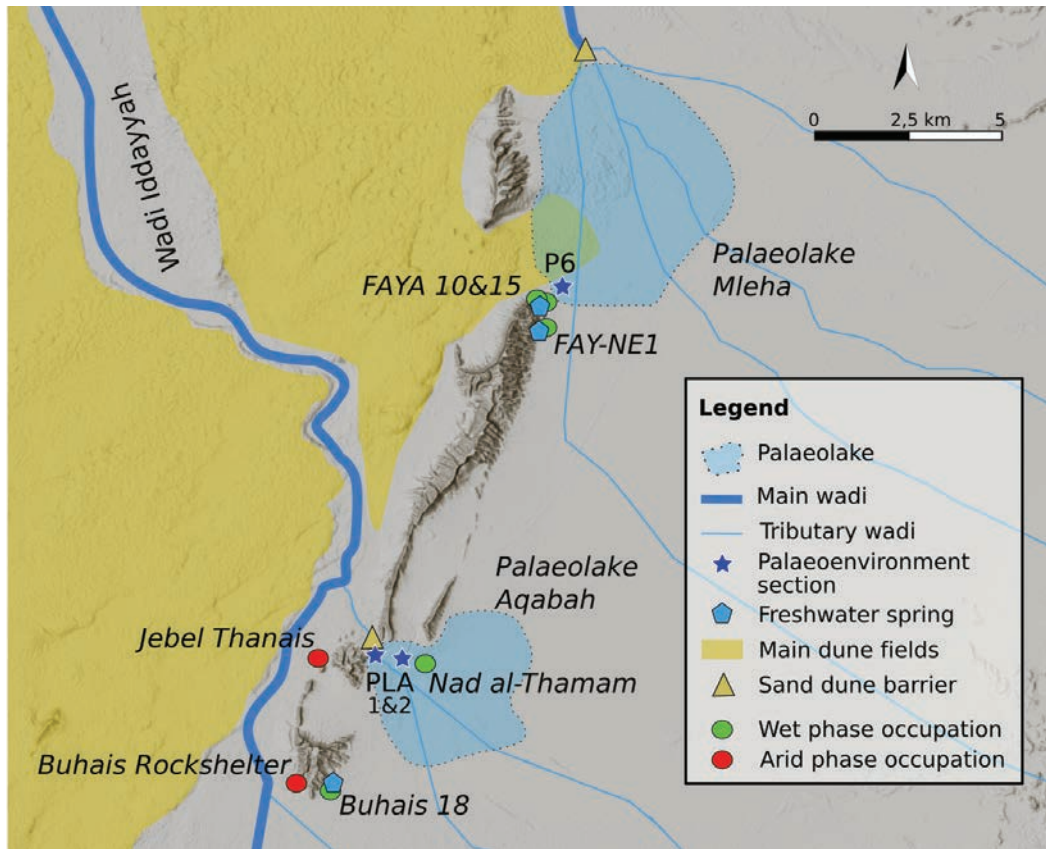


Figure 2. Map showing the archaeological sites of the property (circles), palaeoenvironmental sections (stars), hydrological features (wadis, springs, playas) and the location of the sand dunes. (Map: KB).

Fundamental to approaches considering complex systems of interdependencies is the availability of deep archaeological and palaeoenvironmental records from within a defined region. This enables the required diachronic perspective, allows tracing evolutionary processes through time, and developing solid regional perspectives on migration, subsistence, and environmental change. This paper provides a case study from the World Heritage site Faya Palaeolandscape in the Emirate of Sharjah, UAE, to contribute to the understanding of long-term human adaptations and cultural developments in arid zones in relation to climate change and from a regional perspective.

Geographic Setting

The World Heritage property Faya Palaeolandscape is located in the central region of the Emirate of Sharjah, United Arab Emirates (Fig. 1). The property's core zone covers an area of 29,000 hectares and is dominated by three geomorphological features. A 15 km long, north-south oriented anticline structure forms the backbone of the landscape and separates the sand dunes of the northern Rub' al-Khali to the west from the relatively well-vegetated inland gravel plain to the east (Fig. 2).

The increased biomass in the plain is linked to the hydrological system of the region, which due a tectonic driven inclination drains surface and underground water from the Hajar Mountains westwards towards the mountains of the anticline structure.

The anticline acts as a barrier for water and concentrates accessible water sources along the mountain front while also refilling the underground freshwater reservoirs located in the gravels of the plain. Additional features of the hydrological system in the region include artesian springs and a temporary lake, so-called playa formations, both along the eastern side of the anticline (Fig. 2).

The anticline structure is not only a key component of the local hydrological system but also a lithic raw material for the production of stone tools. The mountains are composed of Late Eocene to Miocene limestone formations, which contain rich sources of chert (Fig. 3). Chert is a significant mineral component of the property that attracted early prehistoric societies. Considering early human hunter-gatherer and pastoral nomadic groups, further important geomorphological features linked to the limestone formations of the anticline structure in the Faya Palaeolandscape comprise rock shelters and small caves as key settlement locations in the landscape that provide shelter from sun, rain, and sandstorms, for example.



Figure 3. Different sources of lithic raw material (chert) in the Faya Palaeolandscape. Chert in the primary context can be found embedded in the limestone, either in bands (left) or in nodules (lower right). Secondary sources of chert include weathered nodules deposited in sediment structures of the property (upper right). (Photos: KB).

The sand dunes, the plain and the mountains of the Faya Palaeolandscape provide together a mosaic of ecological conditions. Such a setting can be considered an advantage for mobile hunter-gatherer societies, given access to a wide range of flora and fauna communities. The different ecological settings (sand dunes, gravel plains, mountains) respond differently to the often-unpredictable precipitation, which allows mobile human groups to react flexibly in terms of land use. In combination with the local hydrological system, the geomorphological setting in the Faya Palaeolandscape attracted repeated prehistoric settlement for a long period reaching back at least about 200,000 years (Bretzke et al., 2022). The increased biomass in the plain is linked to the hydrological system of the region, which due a tectonic driven inclination drains surface and underground water from the Hajar Mountains westwards towards the mountains of the anticline structure.

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The sand dunes, the plain and the mountains of the Faya Palaeolandscape provide together a mosaic of ecological conditions. Such a setting can be considered an advantage for mobile hunter-gatherer societies, given access to a wide range of flora and fauna communities. The different ecological settings (sand dunes, gravel plains, mountains) respond differently to the often-unpredictable precipitation, which allows mobile human groups to react flexibly in terms of land use. In combination with the local hydrological system, the geomorphological setting in the Faya Palaeolandscape attracted repeated prehistoric settlement for a long period reaching back at least about 200,000 years (Bretzke et al., 2022).

Archaeological research

The Faya Palaeolandscape contains seven excavated sites reflecting early prehistoric settlement in the region (Fig. 2). This paper concentrates on the two oldest sites representing the settlement history of the property between about 200,000 and 16,000 years ago. Archaeological and palaeoenvironmental research in the property, including excavations at sites FAY-NE1 at Jebel Faya and Jebel Buhais Rockshelter, was part of a long-term collaboration between Sharjah Archaeology Authority (UAE) and the Department of Early Prehistory and Quaternary Ecology of the University of Tübingen (Germany). This collaboration was initiated in 1995 and focused on the region's early prehistoric archaeology. Systematic research into the history of palaeoenvironmental conditions was later added through a collaboration with the Human Origins and Palaeo Environments (HOPE) group at Oxford Brookes University (UK).

FAY-NE1

Archaeological excavations at the rock shelter site FAY-NE1 were conducted between 2003 and 2017 (Fig. 4). There are two main sequences excavated. One on the terrace in front and a second below the modern rock shelter (Bretzke et al., 2014). The two sequences could be stratigraphically connected, and a joint chrono-cultural framework for the seven Pleistocene occupation phases recovered at the site could be established (Armitage et al., 2011; Bretzke et al., 2022; Bretzke et al., 2025). Integration of results from palaeoenvironmental research conducted in archaeological as well as archaeologically sterile sediment layers at the site enabled conclusions about environmental settings during phases of site occupation and site abandonment (Bretzke et al., 2013). Besides the Palaeolithic occupation phases that are the focus of this contribution, the site also bears records representing Holocene occupation during Late Palaeolithic, Bronze and Iron Age periods, indicating that the site continued to attract human settlement (Uerpmann et al., 2013).

Key chronometric results from the site include determining the age of the first occupation phase at approximately 200,000 years ago, identifying occupation of the site about 170,000 years ago and repeated occupation phases between 130,000 and 80,000 years. The 170,000 years ago occupation phase is of particular importance, given that this period is globally recognised as a significant glacial phase that is thought to have caused hyper-arid conditions in Arabia (Anton, 1984; Markowska et al., 2025). Repeated occupation phases between 130,000 and 80,000 years ago, on the other hand, fall into a time frame of increased precipitation in Arabia with evidence for lake formations, permanently flowing rivers and pan-Arabian distribution of favourable living conditions, including the greening of Arabian deserts and connected human populations (Breeze et al., 2016; Parker, 2009; Petraglia et al., 2020).



Figure 4. Overview of site FAY-NE1 at Jebel Faya. (Photo: Sharjah Archaeology Authority)

Poor preservation conditions for organic materials in the sediments limited the recovery of cultural remains to lithic artefacts at Faya. Despite this limitation, detailed studies of typological and technological characteristics of the comprehensive lithic artefact assemblages from the different layers enabled several important conclusions. Among the most remarkable results are evidence of lithic traditions shared with sites in eastern Africa (Armitage et al., 2011) and evidence of locally continuous development of material culture between approximately 170,000 and 80,000 years ago (Bretzke and Herkert, 2023).

Linking traditions in the production of stone tools between Southeast Arabia and Eastern Africa for the time frame 130,000-120,000 years ago represented a paradigm shift at the time of publication in 2011 (Armitage et al., 2011). Models delineating human expansion out of Africa previously argued that the so-called northern dispersal route out of Africa via the Nile valley and the Sinai Peninsula was the most likely route, given a terrestrial connection between Africa and the Levant in addition to modern human fossils found in sites such as Skhul and Qafzeh (Garrod and Bate, 1937) dating between 135,000-100,000 years ago (Grün et al., 2005). Archaeological evidence supporting a pre-60,000 exchange between Africa and the Levant, however, is scarce. Records from either region show primarily distinct typo-technological traditions suggesting independent developments (Wurz and van Peer, 2012). Evidence from site FAY-NE1 provided the first empirical evidence for an early (pre-60,000 years ago) expansion phase along the so-called southern dispersal route out of Africa via the Bab al-Mandeb and southern Arabia. The records from Jebel Faya demonstrate that the story of the global expansion of our species cannot exclusively be told through a northern route perspective. Southern Arabia bears additional information contributing to the understanding of this key milestone in the history of humanity.

The second topic the site FAY-NE1 contributes to with new data is the question of the timing of occupation in and adaptation to desert environments in the Palaeolithic period. Of note in this context is the observation of shared technological traditions in the 170,000- and 125,000-year occupation phases, in particular the combination of Levallois technological systems, blade production and bifacial reduction. The two occupation phases fall into phases of increased precipitation and favourable conditions. The timing of these occupation phases in site FAY-NE1 indicates an extended technological continuity in the region. Although subsequent settlement phases evident in the site show some degree of change in lithic traditions, the records reflect shifting preferences within a common spectrum of technological solutions rather than significant breaks and new traditions (Bretzke and Herkert, 2023). This continuity can be traced in the archaeological records of the Faya Palaeolandscape until approximately 80,000 years ago. While assemblages from the earlier parts of this phase (ca. 130,000-120,000 years ago) share several characteristics with assemblages from other sites in Arabia, the youngest Palaeolithic assemblage from FAY-NE1 dating to approximately 80,000 years ago is significantly different from contemporaneous assemblages in other parts of Arabia (Bretzke et al., 2025). While the limited archaeological records prevent final conclusions, it is possible that this shift from a pan-Arabian distribution of shared technological characteristics about 130,000-120,000 years ago to localised characteristics at about 80,000 years ago is linked to climate change from widespread lush conditions in the earlier part to increasingly challenging conditions towards the end of the last interglacial. Moreover, the specific hydrological system of the Faya Palaeolandscape (see below) enabled continuous settlement in the region with an impact on adaptive processes in human culture and behaviour that led to the observed localisation of cultural characteristics.

In sum, the Pleistocene records from site FAY-NE1 show repeated occupations of hunter-gatherer groups and technological continuity between 170,000 and 80,000 years ago. While earlier occupation phases between 170,000 and 120,000 years indicate a connection to East Africa, subsequent occupation phases reflect local evolutionary processes, including the development of adaptive strategies in increasingly desiccating desert environments of Southeast Arabia and the development of local traditions.

BUHAIS ROCKSHELTER

The site is located about 15 km south of FAY-NE1 at the southern end of the anticline structure (Fig. 2). Excavations at the site were first conducted in the 1990s to document Iron Age burials (Jasim, 2012). The underlying Pleistocene sediments at the site remained unexcavated until 2017, when systematic Palaeolithic excavations were initiated by the joint project of Sharjah Archaeology Authority and Tübingen University. During four excavation campaigns between 2019 and 2024, field teams excavated four archaeological horizons in the 15 m wide and 2 m deep rock shelter (Fig. 5). The main excavation area was located under the modern shelter roof and on the slope in front. Big blocks of roof fall, which are related to the erosion of the rock shelter, protect a 1,70 m deep sediment deposit, which reflects a mixture of local limestone debris and blown-in sand. These sediments contained archaeological records representing Middle Palaeolithic occupation phases about 125,000 and 60,000 years ago and Upper Palaeolithic occupation phases about 35,000 and 16,000 years ago. Similar to FAY-NE1, sediment geochemistry prevents preservation of organic materials, which limits find categories to lithic artefacts.

The site's chrono-cultural stratigraphy extends the FAY-NE1 sequence into the terminal Pleistocene, a period traditionally thought to be too arid to allow habitation. Besides evidence for the timing of human habitation in the region, further key results of the Buhais archaeological sequence include evidence for repeated technological breaks between 80,000 and 16,000 years ago. This potentially indicates multiple colonisation phases by culturally distinct hunter-gatherer societies.



Figure 5. Overview of site Buhais Rockshelter.(Photo: KB)

One important observation in this context includes a departure from previously preferred Levallois stone tool technologies towards non-Levallois techniques about 60,000 years ago. The occurrence of a preference for non-Levallois technological systems has similarly been observed in site SD1 in Wadi Surdud near the Red Sea coast in Yemen (Delagnes et al., 2012). In contrast, contemporaneous sites in the central and northern parts of the Arabian Peninsula show a continuation of Levallois technological systems at this time. This provides evidence for West-East connected populations in southern Arabia, while current records suggest that this southern technological sphere was disconnected from the central and northern parts of Arabia 60,000 years ago. Such a pattern corresponds to models delineating a southern expansion route out of Africa via southern Arabia and the formation of a Basal Eurasian Population (Lazaridis et al., 2014; Martínón-Torres and Lalueza-Fox, 2025).

A second important result of the research at Buhais Rockshelter is the estimation of human presence in the region pre- and post-dating the Last Glacial maximum, a phase of supposedly hyper-arid conditions in Arabia due to the maximum extent of the global ice cover about 20,000 years ago. The site's archaeological records demonstrate that humans have been able to settle in Southeast Arabia just before (ca. 35,000 years ago) and just after (ca. 16,000 years ago) this environmentally challenging period. Moreover, details from the analysis of the recovered assemblages demonstrate that this occupation phase is characterised by the occurrence of typical Upper Palaeolithic technology, a phenomenon that has previously observed and chronometrically dated in only one other site on the entire Arabian Peninsula (Rose et al., 2019).

The two main Palaeolithic sites in the Faya Palaeolandscape (FAY-NE1 at Jebel Faya and Buhais Rockshelter at Jebel Buhais) provide substantial evidence for human presence in Southeast Arabia during the late Middle and Late Pleistocene periods between 200,000 and 16,000 years ago. This time frame covers substantial changes in climatic conditions, ranging from periods with permanently flowing rivers and lake formations to phases of desiccation and hyper-aridity. The archaeological records of the Faya Palaeolandscape indicate that humans were indeed able to settle in this region during most of these climatic conditions.



Figure 6. Examples of palaeoenvironmental sections sampled in the Faya Palaeolandscape. Top row: Mleha-P6 (lacustrine-aeolian-fluvial deposits), Wadi Iddayyah (fluvial deposits), Buhais Rockshelter (archaeological deposits). Bottom row: Faya dune (aeolian deposits), Faya sinter (spring deposits). (Photos: KB).

Palaeoenvironmental research

While archaeological research dominated the fieldwork activities of the Sharjah-Tübingen joint project in the Faya Palaeolandscape, contextualisation of archaeological records with information on local environmental conditions had additional priority. The long-term systematic search for useful deposits was fundamental for accumulating significant data to securely identify and analyse the past living conditions of Palaeolithic hunter-gatherer groups. The geomorphologically mosaic landscape allowed sampling from a wide range of hydrological processes such as fluvial and lacustrine deposition in wadis and topographic depressions, as well as mineral precipitation at freshwater springs along the anticline structure (Fig. 6). Processes linked to sand dune movement, dune stabilisation and reactivation of dunes have also been studied in the Faya Palaeolandscape to provide insight into arid phases.

Key results include evidence for human occupation phases being aligned with evidence for reactivation of the local hydrological system (Bretzke et al., 2013). Most strikingly, there are multiple sequences indicating water availability in the Faya Palaeolandscape in several time frames when global climate records rather point to arid conditions (Fig. 7). Examples include the Jebel Aqabah and Jebel Mleha palaeolake deposits dating to approximately 55,000 and 30,000 years ago (Parton et al., 2010), deposits indicating wadi reactivation in Wadi Iddayyah and at site Mleha P6 dating to approximately 60,000, 35,000 and 20,000 (Mueller et al., 2023) and sinter deposits indicating active freshwater springs at approximately 60,000 years ago (Holzkämper and Mangini, 2008).

Conclusion

Archaeological and palaeoenvironmental research in the Faya Palaeolandscape revealed multiple occupation phases under changing climatic conditions during the late Middle and Late Pleistocene (ca. 200,000-16,000 years ago). Besides timing of these occupation phases, determining their local environmental context is an important achievement. Global climate models and data often contrast with local palaeoenvironmental records. Partly, this can be linked to differences in the basic data incorporated in the global models. Spatial resolution is one issue, but the scarcity of consideration of local groundwater systems in global models probably adds more to the differences. This paper aimed to show the value of local palaeoenvironmental records and that these should be systematically targeted to allow more valid conclusions about the habitability of desert landscapes.

The HEADS program identified the colonisation of new environments and dispersals as important narratives in early human history to be included in the World Heritage list (HEADS, 2011). Colonisation of the desert is an example of a new environment, and achieving this is a milestone in human evolution since arid zones pose specific challenges for human occupation, most notably the scarcity of organic resources as well as an often-unpredictable distribution of freshwater sources. The Willandra Lakes Region in Australia is one example of early human occupation of a desert environment on the World Heritage List.

Thirty years of systematic field work in the Faya Palaeolandscape (Emirate of Sharjah, UAE) provide additional evidence indicating early human occupation of Arabian desert environments 170,000 and 120,000 years ago (Bretzke et al., 2022). These occupation phases are associated with stone tool assemblages similar to contemporaneous assemblages from East Africa, providing first empirical evidence for the existence of the so-called southern dispersal route out of Africa (Armitage et al., 2011).

Data from the property further demonstrates that Southeast Arabia was not only a region of transit but also home to an evolving population, as seen in the continuation of technological traditions in Faya until about 80,000 years ago (Bretzke and Herkert, 2023; Bretzke et al., 2025). The Faya Palaeolandscape exemplifies the situation in southeastern Arabia and provides important anchor points for debates about early occupation and adaptation to desert landscapes and early modern human dispersals. Other regions in Arabia, such as the Nefud Desert in northern Saudi Arabia, provide an additional perspective (Petraglia et al., 2012). The human-environment relationship in the Nefud is clearly pulsed, and occupation is linked to phases of high groundwater stands during periods of increased precipitation (Groucutt et al., 2021). In southeast Arabia, in contrast, local geo-hydrological conditions enabled a more continuous occupation due to buffered water availability in phases of decreased precipitation, which allowed the continuation of settlement and the effect of human adaptability.

Human Adaptations

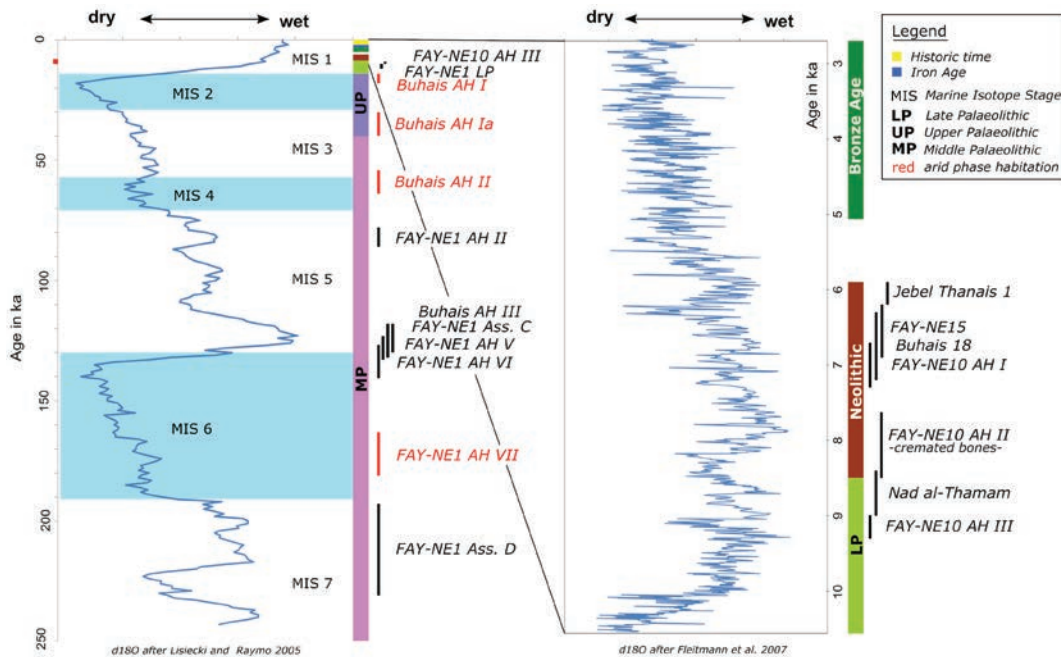


Figure 7. Global climate signals derived from changes in delta 18O values and dated archaeological records from sites of the Faya Palaeolandscape. Please note that names in red indicate an occupation phase when the global climate signal suggests arid conditions.

It is argued here that adaptability is an outstanding human attribute and an important part of our heritage. Currently, this key characteristic is not adequately considered in World Heritage contexts. Given that our species initially evolved in a savanna grassland setting and eventually managed to survive in almost all ecological settings on Earth, the importance of adaptability for our history cannot be overstated. However, examining this successful evolutionary history requires long and well-dated sequences of combined archaeological and local palaeoenvironmental records in different ecological settings. The Faya Palaeolandscape is one example that demonstrates that systematic long-term interdisciplinary research can indeed provide a solid scientific foundation for the consideration of adaptability as a key characteristic of humans. It should be noted that this topic is far from being exhaustively covered by the Faya Palaeolandscape example. Further important sites, which provide great promise when evaluated in terms of their potential for contributing to narratives of adaptability, desert settlement or dispersal, are known from the Nefud Desert (Groucutt et al., 2021), the el-Kowm region in the Syrian Desert (Boëda and Muhesen, 1993; Le Tensorer, 2004), and oases in the Egyptian Sahara (Kindermann and Bussmann, 2025). In addition, the arid regions of Central Asia and the American continent can also be considered important areas for comprehensive research on this topic.

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Safeguarding Sudan's Ancient Art: Exploring the Significance, Documentation, and Preservation of Epigraphic and Rock-Art Sites, with a supplement on Heritage of the Central Atbai

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Part I: Rock art and Epigraphy in Sudan

The Republic of Sudan and its generally dry climate is the perfect laboratory for the study of rock art and inscriptions. In regions where there has been adequate surveying, almost every province of Sudan exhibits rock art sites, from the Red Sea Coast to Darfur, providing a great deal of information on the habitation, symbolism, and culture of ancient Sudan. From neolithic cattle cultures, Kushite kingdoms, to medieval camel nomads, the rock art of Sudan tells the long human history in a changing climatic and political landscape. Understandably given our archaeological map of Sudan, the majority of known sites emanate from the Nile Valley itself (Karberg, 2019), and are thus connected to the urban populations from riverine ancient Nubia. As a visual and symbolic category of evidence, rock art is of vital importance to communicating the thoughts, predilections, and symbolism of prehistoric populations. In later historic periods, rock art cements ideologies of religion, territory, and ritual in the landscape.

Beyond this evidence class of rock art, the data from inscriptions (epigraphy) in historic periods has proved essential to modelling the history of Sudan, from the territorial extent of its polities to their ideologies, as well as the paths of trade routes and expeditions. 'Graffiti' in the relevant discourse of the Nile basin has a flexible definition compared to explanations of non-consensual marking common in the ancient Mediterranean (Keegan, 2014), and there are no overtures of consent or this constituting vandalism as is commonly considered in modern discourse. Accordingly, this discussion eschews the term in favour of considering all such productions as 'rock art'. Only when executed on artificial stone edifices like temples and pyramids at Musawwarat es-Sufra or Meroe is the term commonly used (Kleinitz, 2014).

The common element across these evidence classes is the execution on the medium of natural stone, integrating the living landscape and rock itself into the human story. With numerous rock outcrops from sedimentary, igneous, and metamorphic provinces of Sudan, the ancient artist had no paucity of rock surface upon which to make their mark. More tellingly, however, is the suitability of the surface itself to inscriptions and rock art (Paner, 2020). Vertical faces of finely grained rock were favoured, and highly friable and soft layers, within Nubian sandstone for example, were not suitable for the production of rock art.

Rock art records across Sudan

Since the earliest archaeological expeditions of what might be called 'Nubiology', the recording of rock art has taken place throughout Sudan. Nineteenth century expeditions focused on the Nile corridor itself, with a number of expeditions noting the myriad rock art sites in Lower Nubia and the Third Cataract region in particular. Generally rock art received little interest compared to written inscriptions on stele, tombs, and temples (Lepsius, 1859). This of course should be balanced with the local perspective, with most rock art sites being known to local Sudanese communities as part of long oral traditions and social memory. Some rock art or epigraphic sites, for example at Tombos, despite being millennia old, do feature in contemporary folklore and are elements of meaning in the landscape (Davies, 2012, p. 29 n.3).



Fig. 1: Long-horned cattle from the Atbai, site AS19.27 (© Atbai Survey Project).

With the advent of the Nubian Salvage Campaign (1962-1972), rock art recording across Sudan became much more systematic, with dedicated survey campaigns documenting the rock art within the confines of their concessions in Lower Nubia. This salvage campaign coincided with the geography of what is probably the greatest density of rock art in Sudan in the Second Cataract region, with the high number of productions being influenced by the copious rock walls as far south as the Batn el-Hajjar (Engelmayer, 1965; Almagro Basch & Almagro Gorbea, 1968; Suková, 2011a; Suková, 2011b; Resch, 1967; Vila, 1975-1985; Piotrovski, 1983; Hellstrom & Langballe, 1970; Otto & Buschendorff-Otto, 1993). Some of these salvage campaign surveys have still not published their rock art, or only recently has the rock art been published from sustained archival work (Padró, 2015). Whatever the case, these studies pushed Nubian rock art to the fore where before rock art of the Nile Valley was focused on catalogues from Upper Egypt and the adjacent deserts (Winkler, 1938; Červíček, 1974). Following these campaigns in Nubia, common themes and chrono-cultural styles emerged, but broader analysis devoted to meaning and context generally remained beyond the remit of projects which needed to work exceptionally quickly with the rising waters of Lake Nubia or Lake Nasser. This same ‘salvage campaign’ logic also involved the publication of rock art in the Fourth Cataract rescue campaigns, a similarly rocky landscape in a cataract context (Kleinitz, 2012).

Thematically, zoomorphs (animals) dominate the rock art record of Sudan, followed by anthropomorphs engaged in various activities (static; hunting; herding; engaged in other actions) (Paner, 2020). Zoomorphs are in particular a hallmark of prehistoric and neolithic occupations throughout the region. Zoomorphic representation extend into later periods, where their forms resemble similar representations on Kushite media such as tombs, temples, pottery, and other decorated artefacts (Török, 2002). The theme of cattle (Fig. 1) is particularly important in prehistoric rock art, and when compared to the primacy of cattle in the archaeological record of burials, suggests a cultural esteem for this animal that was above and beyond its status as a food-bearing domesticate. Some rock art shows cattle body modification, demonstrating an affinity to this contemporary practice occurring in Sudan and Ethiopia (Dubosson, 2018; Polkowski, 2021).

This symbolism in the rock art pervades every region of northern Sudan, from Darfur to the Red Sea and Nile Valley, indicating a common cultural expression of neolithization across the region. Wild fauna is also encountered at many sites, such as ibex, ostriches, felines, elephants, giraffes and rhinoceroses. Enigmatic geometric symbols, such as concentric circles defy any certain interpretation (Hamdeen & Polkowski, 2018), but belong to earlier phases of rock art production, sometimes dated to the epipalaeolithic. The zoomorphic themes are so prevalent that they are used to designate chronological styles, namely the ‘hunter period’, ‘cattle period’, and ‘camel period’. All these styles have poorly demarcated dates but correspond to pastoral neolithic to the Middle Nubian Period in the case of ‘cattle period’, and First Millennium CE and later in the case of the camel period (Karberg, 2019; Cooper, 2024).

In later historic periods, rock art productions extend their subject matter. Anthropomorphs and religious iconography, including the depiction of gods, are known from a number of sites. Motifs such as feet express votive and ritual behaviour on the part of the artists (Kleinitz, 2008; Polkowski, 2025). With the formalization of art in times of Egyptian, Kushite, and medieval Nubian polities in Sudan, the repertoire extends to similar iconography as found in formalized temples or palaces, from geometric symbols and gods, to boats and rulers. Widely debated amongst these productions are three unique images from the site of Miseeda, depicting a person brandishing a spear, an elephant, and a lion (Osman and Edwards, 2011, pp. 66, 328–329).

They are sometimes argued to be a production of the Kerma period (c. 2500–1550 BCE). The pecked imagery is delicately infilled and has no direct parallels to any other productions in Sudan. Rock art productions from Christian and medieval Nubia are known at a number of sites, which include religious iconography such as images of crucifixes and symbols of Church complexes (Kleinitz & Olsson, 2005; Osman & Edwards, 2011, p. 152).

Later imagery comprising of complex panels of repeated geometric motifs on cave walls has sometimes been connected with magical practice and ‘rock shrines’ (Varadzinova, 2017, pp. 246–247). Other typical ‘late’ features from the First Millennium CE and Medieval periods include camels (Paner, 2020) as well as wusum, geometric images of camel brands, a distinctive repertoire of signs connected to the identical livestock brands still used by pastoralists across Sudan (MacMichael, 1913). These wusum are often featured at rock art sites which display ‘late’ features like camels, a domesticate generally found in the First Millennium CE.

Frequently, the rock art of Sudan is compared to other Saharan contexts, particularly Egypt. This seems quite logical when one considers the subject theme, style or form, as well as execution in the rock itself in pecked or incised relief. Upper Egyptian contexts in particular show a great deal of similarity, especially in the common incised or pecked execution and the thematic matter (Huyge, 2003). Some authors note such a thing as ‘Middle Nubian style’ in later productions of the Third and Second Millennium BCE within Sudanese and Egyptian geographic contexts (Gatto et al., 2007; Budka, 2024).

It seems likely that some contexts in the more distant deserts also shared stylistic similarities with further regions beyond Nubia. The rock art of the southern Atbai for example seems to share some similarity in content and execution to the Ethiopian Highlands (Cooper, 2024). Červíček (1978) espoused a common Afro-Arabian style especially in prehistoric productions of zoomorphs and anthropomorphs and even geometric imagery, something which has been noticed by many authors who have worked on prehistoric rock art in both continents.

Some rock art sites stand above others in the number of images and chronological breadth. Perhaps the most notable here is the site of Sabu (Osman & Edwards, 2011), a site that displays a long chronology from prehistoric pastoralist imagery, Middle Nubian productions, New Kingdom Egyptian inscriptions and representations, to medieval motifs from Christian Nubia, as well as camel imagery. Located along the length of a small wadi not far from the Kajbar cataract, the site was clearly an important stopping point on riverine itineraries and also an established 'special place' for local communities, which were attracted to produce rock art on the same surfaces as their ancestors.

Debates: From Meaning and Practice to Chronology and History

If rock art sites are quite well-known across Sudan, much more difficult has been the question of why, with respect to why ancient people created such rock art as an enduring and repeated cultural output. In this respect rock art has been much more useful as an index of habitation than it has for delineating the thought and practices of ancient people. Where rock art sites are found in the landscape we may reasonably assume (transhumant) habitation and thus build a picture of occupation in a given area.

The question of meaning and related social practices around rock art sites is much more difficult to grasp, an issue that is much greater than the body of evidence in Sudan and is common to rock art studies around the world. Where ethnographic observation has allowed in the neighbouring regions of Africa, all sorts of meaning and symbolism is embedded in rock art practice, from personal devotion and territorial marking, to communicating mythologies, to divination and rain-making (Fernández, 2011; Russell, 2012; Le Quellec, 2004; Varadzinova, 2017). Due to these myriad explanations, Le Quellec (2004, p. 67) warns against reading rock art too specifically without recourse to direct ethnographic observations. This leaves the interpretation of ancient rock art in a rather difficult situation.

Unfortunately here, relatively few rock art sites have enough associated material remains to be able to reconstruct exactly what sort of practices may have taken place at a site coeval to the production of rock art. As many rock art sites are situated at conducive habitation sites, that is shelters protected from the wind, or situated along prominent trade routes or transhumant corridors, it may be ventured that rock art was executed alongside normalized human behaviour and economic activities. This also explains the propensity for rock art at well-sites and oases, for example at Bir Murrat or Jebel Rafit in the Atbai (Welsby, 2020; Cooper et al., 2025), and Selima Oasis in the Western Desert (Kröpelin, 2024). The exception here may be specific sites where rock art was produced as part of votive and ritual behaviour. At Jebel Umm Rowag for example, Kushite rock art depicting the king, a bird, an ankh, and other geometric symbols sits alongside strewn sherds on a hilltop, suggesting some as yet unknown sacred landscape and ritual importance for the site (Welsby & Sjöström, 2006). Feet graffiti, for example, found equally at natural rock art sites and temple contexts, may be a specialized expression of religious behaviour found at both natural rock art sites and temple contexts (Ashby, 2020, p. 227; Cooper & Vanhulle, 2019, p. 4).

It would be premature to preclude any specific social acts or events as the origins of rock art production without further material evidence of related practices. Hunting or pastoralist herding may well have spurred rock art creation, so too highly-specific social ceremonies relating to the content in the rock art itself. In this logic, particularly troubling is the meaning of anthropomorphs in rock art, which are sometimes depicted as part of a longer production of zoomorphs, but sometimes just depicted by themselves engaged in little discernible activity.

Did these productions represent real individuals or stand-ins in rituals? Or memorializations? Rock art studies has recently emphasized the previously ignored aspect of the individual and artist in rock art creation (Dowson, 1988; Lewis-Williams, 1995; Willcox, 2018), which when studied reveals the great complexity and intentionality that went into the production of rock art. This produces a much more nuanced image of rock art production than catalogues of repeated images would have us think, and allows for deliberate, idiosyncratic, and meaningful productions for each individual and community.

If establishing meaning for individual images frustrates archaeological interpretations, just as vexing for rock art studies is the issue of chronology and dating. There is no direct absolute dating of rock art in Sudan, with the closest method being proxy methods such as the OSL dating of sediments covering rock art. For example, at the site of Bir Nurayet this method has established that cattle imagery may have been produced as late as the late Third Millennium BCE (Bobrowski et al., 2013). Frequently, broad chronologies can be established based on stylistic methods and superimpositions (Huyge, 2003). Techniques for dating carbon binders in painted rock art have not yet been trialled in Sudan (Levchenko et al., 2018).

With well-established climatic periods of the African Humid Period, rock art can sometimes be broadly dated in desert contexts through the identification of specific fauna, especially when analysed alongside style. The identification of cattle rock art at desert sites indicates prior fertile conditions before the termination of the African Humid Period c. Fourth and Third Millenniums BCE (Bobrowski et al., 2014; Cooper & Vanhulle, 2023). Larger fauna like elephants and rhinoceroses, when found in desert contexts, likewise belong to earlier climatic periods when identified in desert contexts. When these desert pastoral neolithic rock art sites are combined, they tell a story of significant climate collapse and ecological change c. Fourth and Third Millenniums BCE. Cattle pastoralists left the desert, with ensuing demographic changes leading to peopling of the Nile refuge, and ensuing adaptation to drier mobilities for desert populations.

When similar imagery is found in other media, this can somewhat aid in chronological evaluation. This procedure has been attempted for example with respect to a cattle depiction on C-Group pottery and stele (Hafsaas, 2020), which has a resemblance to similarly infilled cattle depictions at rock art sites with V-shaped horns and identical contours for the cattle legs and body (Gatto et al. 2009, p. 19). Similar arguments have been used for ‘Kerma cattle’, arguing for a common style across various media for roughly the late Third and entire Second Millenniums BCE (Polkowski, 2021). Another point of comparison here are the ostriches present on the rock boulder at Khor Rafit (Cooper et al. 2025, Fig. 18F), some of which bear a precise resemblance to the ostriches reproduced in local First Millennium CE Eastern Desert Ware pottery (Barnard 2008, p. 15). Here, the angularity of their form (in-filled triangle) and the depiction of their tails is identical in both rock art and the pottery decoration. These points demonstrate that rock art was only one expression of common visual vernaculars possibly situated along chronological and cultural lines.

Epigraphy & Inscriptions

Epigraphy, sometimes considered synonymous with the category of ‘inscriptions’ are a frequent element of sites in Sudan, especially on the Nile Valley. The earliest epigraphic sites are connected with the Egyptian imperialism, a small number of Old and Middle Kingdom inscriptions in northern Sudan, and a much greater presence across Sudan in the New Kingdom. Auenmüller (2019) has recently mapped the entirety of known Egyptian inscriptions in Sudan, with clear distributions across colonial centres and cataracts of Lower Nubia. A single exception to this pattern of Egyptian inscriptions is a single epigraphic document connected to the Kerma culture in the Eastern Desert (Cooper, 2018; Davies, 2020).

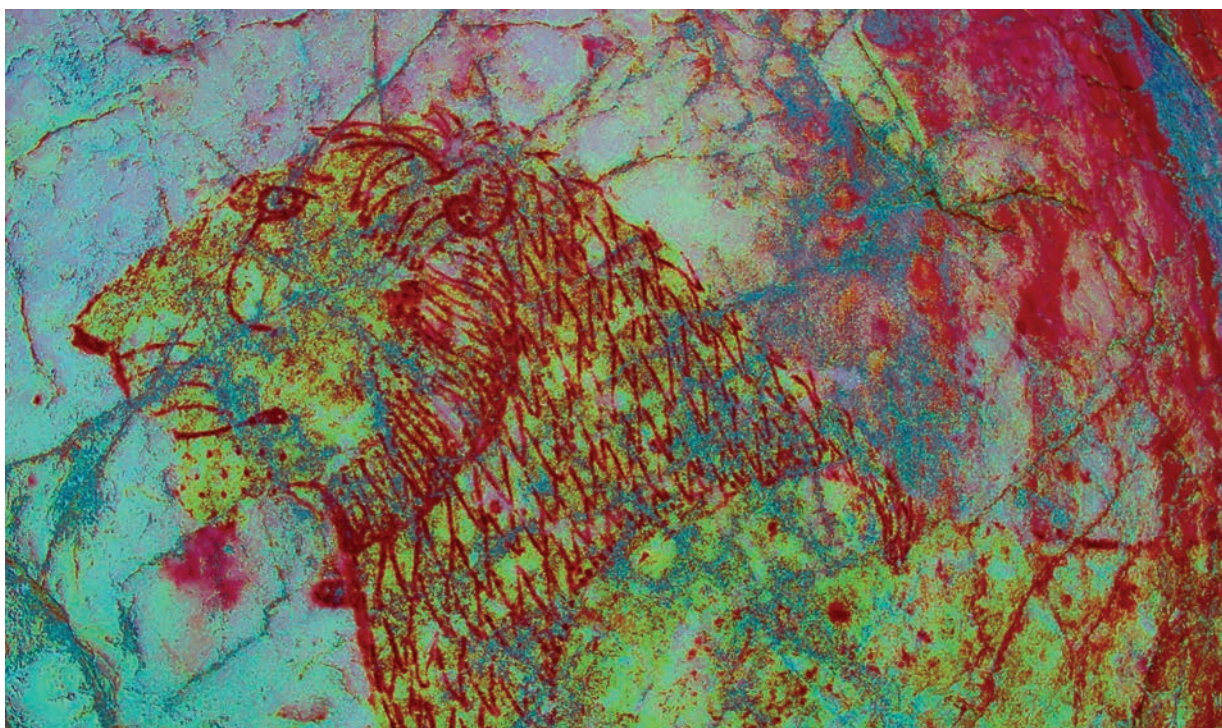


Fig. 2: An image of a lion flanking the inscription of Thutmose III at the Hagar el-Merwa, one of the many New Kingdom productions at the site. The original red ink has been enhanced using Dstretch software ©. Courtesy of the Sudan Archaeological Research Society and reproduced with permission of Vivian Davies.

At a small rock shelter in the Korosko Road (KRP 14), a king of Kerma commissioned an inscription in a style otherwise Egyptian, indicating the need for Kerma to represent its territoriality in an Egyptian epigraphic format.

The phase of New Kingdom expansion and imperialism in Sudan (c. 1500-1000 BCE) coincided with a number of new executions on the Sudanese Nile and in the deserts, from Wadi Halfa to Kurgus (Davies, 2017; Davies, 2020). The inscriptions at Kurgus, executed on a conspicuous quartz outcropping (the 'Hagar el-Merwa'), mark the southernmost extension of Egyptian conquests in Sudan (Davies, 2017). The texts and imagery themselves demonstrate that the rock art and inscriptions as the southern boundary stele of Egypt's newly conquered Nubian empire, warning against the transgression of Nubians 'Nehesy' further north (Fig. 2). Other inscriptions on the surface of the Hagar el-Merwa are connected to the individuals who joined these military campaigns under kings Thutmose I, Thutmose III, and Ramesses II.

In fact the social act of a military campaign explains the *raison d'être* of many Egyptian inscriptions in Sudan (Auenmüller, 2019), where the inscription is commissioned by an official, and takes on a biographical nature for the literate officials involved in the military campaigns. These inscriptions frequently mark the rocky banks of cataracts and surrounding areas of fortresses (cf. Hintze & Reinecke, 1989), delineating zones of Egyptian activity in a foreign land.

The successive Kushite dynasties have an uncertain status in the record of rock inscriptions. Napatan (c. 750-270 BCE) inscriptions, the period when Nubians employed Egyptian hieroglyphs as their form of literate expression, are infrequent on natural rock. By far one of the most significant Napatan inscriptions on natural rock is the inscription on the pinnacle of the holy site of Gebel Barkal, the religious and political centre of the Napatan Kingdom.

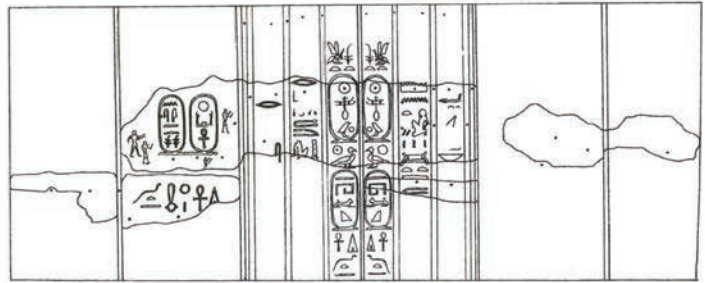


Fig. 3: The Taharqa inscription at Jebel Barkal, courtesy of Timothy Kendall and National Geographic (C) and documented by Hazel Findlay and Madeleine Cope. After Kendall (2004: 34-35).

Here, high above the temples of Amun on the pinnacle, kings Taharqa and later Nastasen constructed an inscription which communicates his titulary (Kendall, 2004) (Fig. 3). Nail holes in the rock surface suggest the original hieroglyphs were designed to be decorated with gold-leaf, creating a dazzling sight across the mountain of Jebel Barkal. This extraordinary inscription demonstrates the great lengths ancient artists went to create inscriptions in their landscape.

Inscriptions from the Meroitic period (c. 270 BCE-400 CE), when inscriptions are reproduced in the indigenous language and script of Meroitic, are known from a number of sites from the Eastern Desert to Gebel Geili in the Butana. The Jebel Qeili inscription, carved on a rock wall next to a small mountain in the Butana desert, stands out as one of the most importance Meroitic tableau in rock. The panel shows a formalized Kushite production depicting King Shorkaror (c. 1st Century CE) smiting the foreign enemies, aided by an uncertain solar deity (Hintze, 1959, p. 190). The image, produced in the distant southern Butana away from major Meroitic population centres, was almost certainly a boundary marker, and has been interpreted as marking out the southern border of the Meroitic kingdom along desert routes to Kassala. These images sat alongside productions of zoomorphs in red paint (Onderka, 2022) in a 'cave shrine' at the foot of the jebel, alongside a figure of the god Amun.

The state of surveying: gaps in the record from East and West

The rock art of the Sudanese Nile, owing to the aforementioned salvage campaigns and records, is generally well-known and evaluated in the relevant literature. The same cannot be said for rock art sites in the Eastern and Western deserts, where difficult terrain, local conditions, and general lack of interest has prevented proper elucidation of rock art sites (Fig. 4). Known rock art sites are a direct result of archaeological survey areas and concessions, and certainly does not represent the total distribution of rock art sites across Sudan. There are still many rock art sites yet to be documented, but it may be said that areas such as the Second Cataract and Lower Nubia represent particularly important concentrations of rock art.

The Atbai Desert of Eastern Sudan is a case in point, and demonstrates the issues with our state of knowledge on Sudanese rock art. Only a small number of surveys have worked in this desert, and the vast distances, huge amount of 'rock canvasses', and exceptionally difficult terrain have meant that most rock art sites surely remain undiscovered. Surveys directed by Alfredo and Angelo Castiglioni, as well as the Atbai Survey Project and the Sudan Archaeological Research Society have barely touched the surface of what may be one of the largest rock art complexes in the Eastern Sahara (Castiglioni et al., 1998; Welsby, 2020; Cooper & Vanhulle, 2019 and 2023).

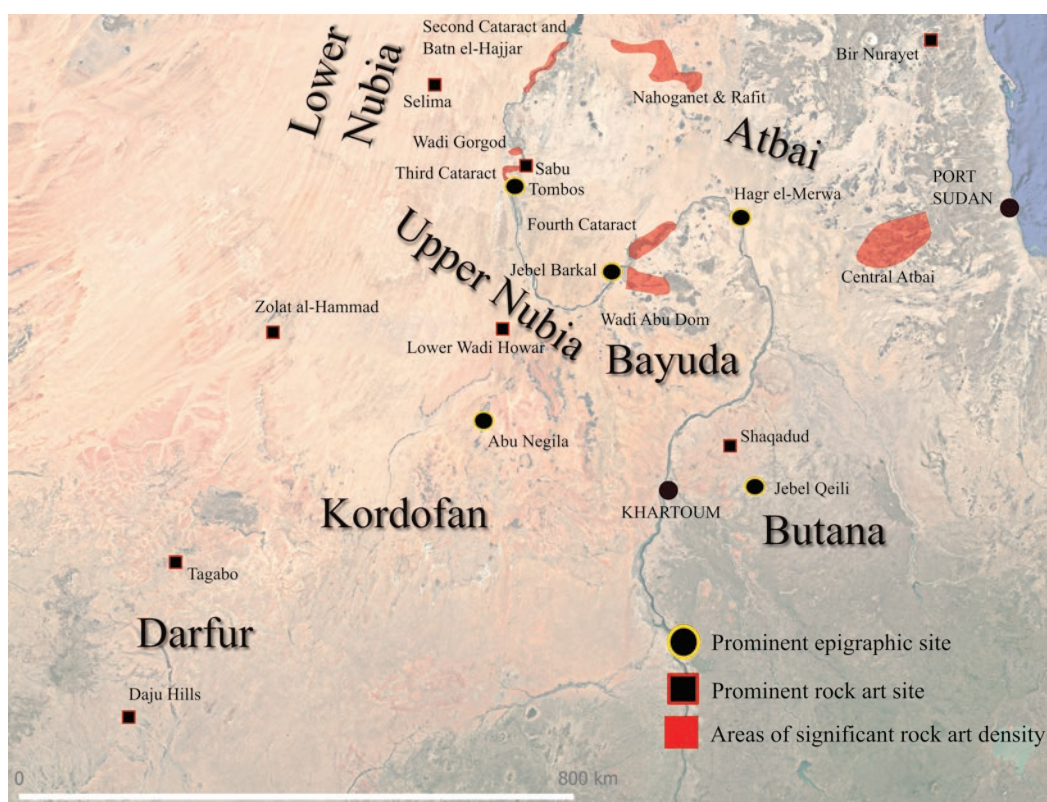


Fig. 4: Major rock art and epigraphic sites and areas mentioned in the text.

Numerous cattle rock art sites are found on inselbergs and rock shelters (Fig. 4), and none of these survey remits had the ability to produce one hundred percent coverage within their survey areas, giving the impression of a landscape punctuated by rock art with extraordinary regularity. Only the northwestern parts of the desert in the area of Wadi Gabgaba have received significant attention, and numerous other areas have had no prospections at all. Truly unique rock art sites, such as exceptional tableau of boats, and painted cattle, were found across this area of the northern Atbai (Cooper & Vanhulle, 2023). In two seasons alone, the Atbai Survey Project discovered 23 new rock art sites around Jebel Nahogamet and Nasb Enat.

The same paucity of knowledge occurs with respect to Western Sudan and the mountainous massifs of Darfur and Kordofan. Arkell (1937) and Balfour Paul (1955) delineated some rock art sites in northern Darfur, both showing cattle representations. Later productions include horses and camels at Jebel Sirgu, alongside which were carved wusum. The surveys of the University of Cologne expedition recorded rock art sites further north at Zolet el-Hammad and Burg et Tuyur, Selima Oasis, and the Wadi Howar region (Kröpelin, 2004).

Jungrathmayr (1961) encountered rare images of painted horses in southern Darfur and Jebel Dajo. In Kordofan, rock art was also described in the areas of Abou Sofyan, including cattle, ostrich and anthropomorphs, as well as later productions of camel and wusum (Gratien, 2013). The mountain massifs of Darfur are huge by any reckoning, and no systematic surveys have endeavoured to canvass all the rock art of the region, making it extremely likely that systematic surveys would produce a great deal of rock art sites. In the southern regions of Sudan, very little has been reported. There are some rock tableaux at Jebel Moya in Gezira state (Babiker, 1984), and a number of rock art tableau are reported just over the Ethiopian border in Benishangul (Fernández, 2011). Beyond logistics, political difficulties and conflict in these regions prevent comprehensive survey records.

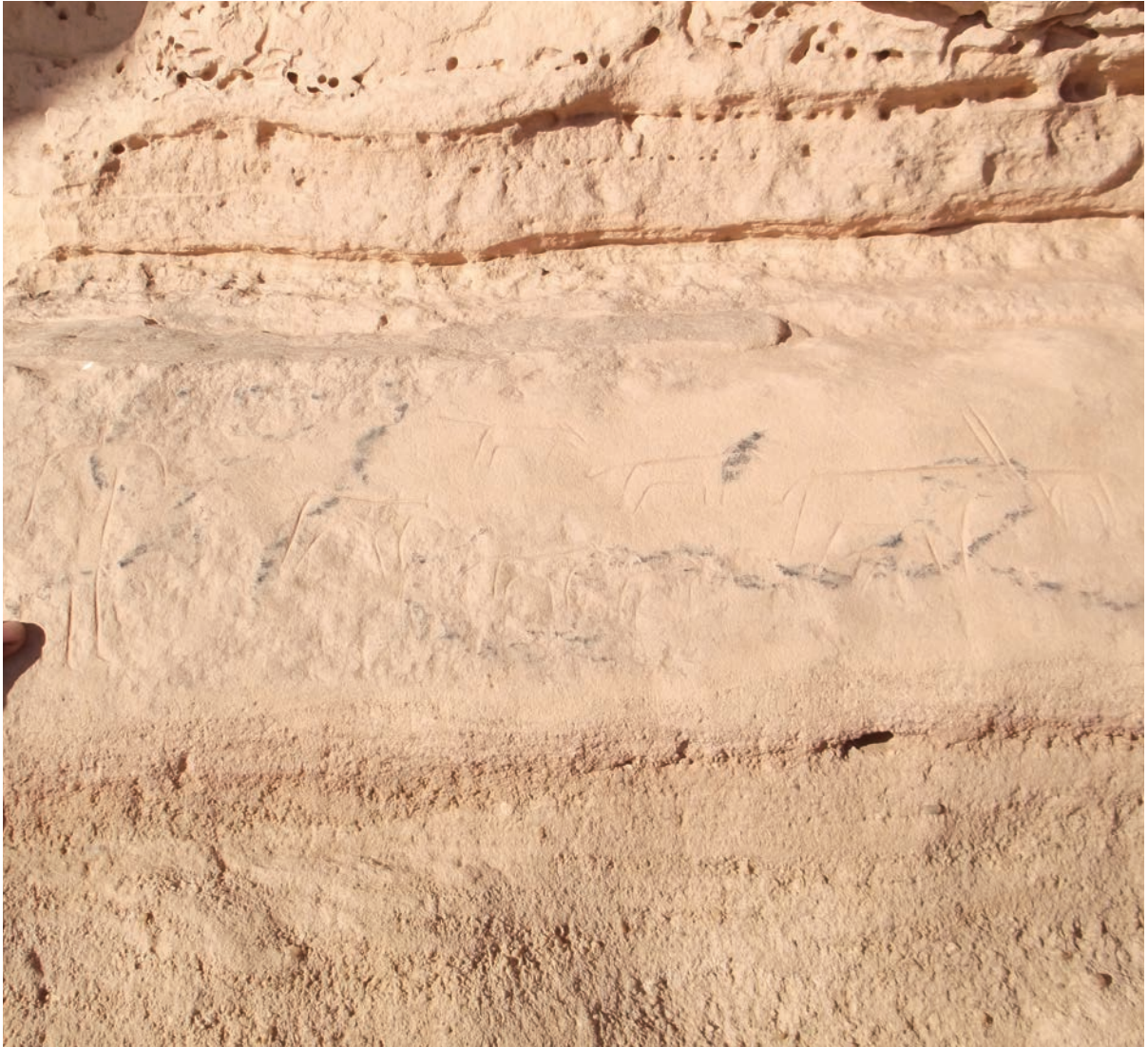


Fig. 5: Vandalism of rock at site AS18.25, with modern Arabic graffiti obscuring an ancient representation of a hunting scene © Atbai Survey Project.

The same paucity of evidence is probably true also for the epigraphic record in these peripheral regions. Surveys in the Atbai Desert have added evidence of New Kingdom inscriptions connected to Egyptian gold-mining expeditions (Davies, 2020), but the large expanses of desert and rock make it impossible to delineate exact travel routes and feel confident that we have found anything close to the entire record of pharaonic inscriptions in this desert (Castiglioni et al. 1998; Davies, 2020). Medieval Arabic inscriptions are rarely attested in Eastern Sudan at gold-mining sites, the Beja ‘capital’ of Khor Nubt, and Red Sea harbour sites like Badi on the Red Sea coast (Hinkel, 1992; Oman et al., 1998). There is some evidence of inscriptions in Western Sudan, for example the Old Nubian inscription at Abu Negila in Kordofan (Ochala, 2011), linking the medieval Nubian polity to the regions to the west. This demonstrates the likelihood that further inscriptions connected to Nile polities may yet be found in Kordofan and Darfur.

Heritage outcomes & protection

Across Sudan, rock art sites remain a difficult category of site type for heritage management and conservation. The reasons for this are obvious and relate to the lack of built above-ground heritage at rock art sites, thus attracting far less attention than settlement, temple, and cemetery sites in terms of conservation and management. Rock art sites are often situated in isolated locations, and generally located some distance from major sites so are not considered as part of bona fide built-up archaeological sites. Only infrequently do the rock art sites receive protection from dedicated site guardians (Ar. ghafir).

Even at distant rock art sites hundreds of kilometres from the nearest settlements there is evidence of modern vandalism of ancient rock art (Cooper & Vanhulle, 2023) (Fig. 5). Various motivations have been anecdotally levelled for their destruction and vandalism, from boredom, itinerant gold-mining operators, to outright iconoclasm of ancient depictions and their various ideologies. These threat profiles differ remarkably where the rock art or epigraphy is part of an established urban archaeological context, for example at Tombos or Gebel Barkal, where the protection outcomes may better align with local management policies at those sites, embedded in local community's landscapes, and are even part of tourist itineraries. To add to these threats, a significant proportion of Sudan's rock art and epigraphic sites are now underwater as part of the Aswan and Merowe dam projects. This fact strengthens the urgency that authorities, international and domestic, should have in consideration of protecting extant rock art sites across the country.

Current threat profiles pose serious conservation problems in desert contexts, exacerbated by our still poor record of rock art sites in desert regions. Management policies in such contexts might be better oriented to the broader unit of the 'landscape' and hypothetical national parks rather than an individual rock art sites (cf. Kuper, 2007), which are far too numerous to be managed as individual sites or tableaux. In such contexts, rock art sites would sit alongside many other local archaeological sites, often pastoralist in nature, which could be managed and visited as part of inspections and tours by heritage officials. Ideally this would be achieved with or by local groups who have local site knowledge, regularly utilize the area, and attach meaning and significance to their local landscape (cf. Macleod, 2000; Bradshaw et al., 2025). This would be almost mandatory in pastoralist transhumant settings in Eastern and Western Sudan, where local nomadic groups could be engaged to manage and monitor larger areas of significant rock art nodes. Other site conservation methods like signage or fencing seems generally incongruous with local community expectations and pastoralist corridors, excepting cases where rock art tableaux are truly brittle or nationally significant.

Heritage elucidation and interpretation of rock art for the public remains a complex prospect. Rock art and epigraphy can have limited meaning to non-experts, especially if the scenes communicate highly symbolic themes or contains a written inscription. Where applicable on putative 'tourist trails', this may call for the elucidation of rock art contexts in the forms of heritage interpretation (signs, pamphlets, other materials) to convey meaning to the modern public. On the other hand, obvious heritage signage is sometimes considered undesirable by experts as it signals the import of the site to prospective vandals. Clearly broader heritage education is necessity for these sites to be integrated into heritage management and tourism. Desert safari tourism, often focusing on rock art sites, is a key component of heritage tourism in neighbouring countries of the Sahara and Arabia (Keenan, 2002; Senbeto, 2020) and there is every reason that this could also be conducted in this region to the benefit of local communities and also heritage conservation outcomes. The attention that tourism brings, along with economic benefits, brings upon its own threats to heritage, but these threats pale in comparison to that of contemporary gold-mining (Cooper, 2021).



Fig. 6: Relocated rock inscriptions from the Lake Nubia salvage campaign in the gardens of the Sudan National Museum. Photo: Author.

It is the opinion of the author that safari-heritage tourism conducted by responsible and local operators would of benefit to heritage protection in most rock art contexts. Beyond the rock art sites themselves, significant natural beauty in these dramatic and rocky deserts will likely also be of allure to tourists. Particularly troubling is the prospect that many rock art sites are being destroyed before there is any chance to scientifically record these sites.

A novel concept in this conversation is the repositioning of rock art and epigraphic tableaux from the Nubian Salvage campaign within the gardens of the Sudan National Museum (Fig. 6). Motivated by the incoming floodwaters and obscurity brought about by the dam, individual blocks of natural stone have been excavated, repositioned and re-erected in a suitable natural setting for the broader public. While de-contextualized, this provides an everlasting record where the alternative was destruction. Likewise, missions on the Fourth Cataract salvage campaign conducted a similar procedure, moving entire rock art panels out of the floodwaters (Paner, 2020).

Part II: The Wadi Amur and Wadi Agwampt: Considerations for a World Heritage listing in the Central Atbai

The Eastern Desert of Sudan, the Atbai, is a vast pastoralist zone typified by rock art sites, goldmines, and numerous tumuli belonging to indigenous pastoralist populations.

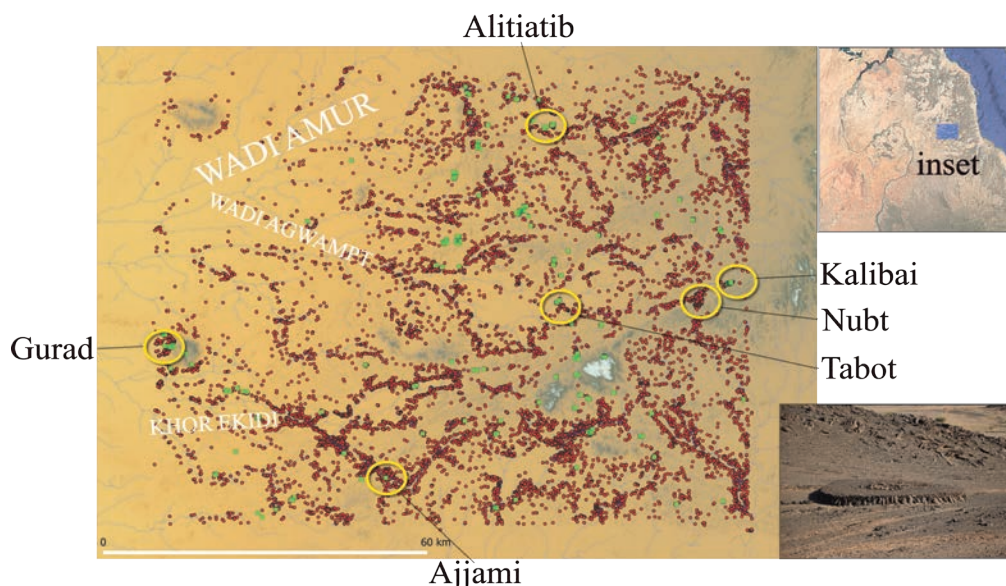


Fig. 7: Mapping the heritage of the Central Atbai from the Atbai Survey Project remote sensing campaign. Red corresponds to tumuli, green to domestic structures (nomadic settlements and goldmines). © Atbai Survey Project.

Compared to the Nile Valley, the Atbai is very poorly surveyed, but projects in recent decades have shown the great archaeological potential of the region. Continued surveys in Eastern Sudan by the Atbai Survey Project conducted both on the ground and through satellite remote sensing have demonstrated the importance of the specific region of the Central Atbai around the Wadi Amur and Wadi Agwampt.

Before these surveys, individual sites across the area such as Khor Nubt, Tabot, Kalibai, and Alitiatib were recognised as important settlements connected to the historical Blemmyes and Beja, the indigenous pastoralist groups from the First Millennium CE and later (Cooper, 2021; Krzywinski, 2012; Krzywinski et al., 2020).¹ With new systematic remote sensing data, we are able to fill in these gaps, and delineate a vast pastoralist zone heavily occupied from prehistory to the medieval period. Together, these studies show an archaeological landscape unique its density, diversity, and chronological breadth when compared to other Saharan and Sahelian pastoralist landscapes (Fig. 7).

Alongside ancient gold-mining sites, rock art contexts, and prehistoric cemeteries, this area should be considered a truly unparalleled and multi-period pastoralist landscape, telling the story of human adaptations to dryland environments, as well as the formation of nomadic political centres, being the heartland of the Blemmyean polity in the First Millennium CE. With no World Heritage sites dedicated to pastoralist archaeology in Eastern Sudan, or Sudan in general, this proposal here delineates a wide region important to the history of the Blemmyes and Beja as well as the history of Islam and gold-mining in Sudan.

This proposal was previously discussed by Norwegian scientists with respect to the Beja capital site of Nubt (Krzywinski et al., 2017), and has been proffered in internal reports submitted to the National Corporation of Antiquities and Museums by the Atbai Survey Project (Cooper, 2025). The exceptional diversity and density of sites in the region, especially in the First Millennium CE, warrants inclusion as a World Heritage landscape of extraordinary scientific potential.

From remote sensing surveys, the Atbai Survey Project has identified the broad contours of the local archaeology, allowing us to situate these finds in its broader context. The most notable feature in terms of frequency and visibility in the landscape are disc-shaped tumuli, locally called *akerataheil*, typically dated to the First Millennium CE (Krzywinski, 2012; Cooper et al., 2025). As is common in nomadic pastoralist contexts, these are often situated evenly across the landscape, delineating the main transhumant and pasturing corridors used by ancient nomads. There are, however, zones of ‘hyper-dense’ clusters of *akerataheils* situated at a number of key sites, most notably Khor Nubt (Krzywinski et al., 2020) and Khor Tidityu-Ekidi (Reinold & Ahmed, 2008).

New clusters have been identified through remote sensing at Jebel Gurad (n=401) and Khor Kokreb (n=3254), one of the largest clusters in Eastern Sudan in terms of numbers. Across the entire region of the Wadi Agwampt and Amur, the count of *akerateheils* is 27,853 spread across a grid of 113x91 km². This remote sensing tells the story of a highly utilized pastoralist landscape, a Beja ‘capital region’, without comparison in desert Sudan.

The site of Khor Nubt is one of the most important sites in the region, and instrumental to the history of the Blemmyes and Beja in the First Millennium CE. The site with its large burial ground is truly unique in the archaeology of Eastern Sudan for a number of reasons. It contains the largest *akerataheil* in the region, some c. 20m in diameter, likely delineating the royal burials of Blemmyean rulers in the First Millennium CE (Krzywinski et al., 2020). It is also one of the few ‘urban sites’ across the region, with extensive remains of domestic structures, a possible fortified structure, and a mosque, described as one of Sudan’s earliest (Ahmed, 2019). Local inscriptions attest to an Arabized elite at the site as early as the 9th century CE (Oman et al., 1998), making it one of the most important early centres for Islam in Sudan, in a context where Christian kingdoms still dominated the Nile Valley.

A Coptic text from 761 CE mentions that a place called “Noubt” was the capital of the Beja, pointing to the site’s certain status as the capital of the Beja in this period (Hagen, 2009). A likelihood is that this site of Nubt is identical to a place called Hajar described by medieval Arab geographers as the seat of the Beja king (Vantini, 1975, p. 457).

Similarly exceptional ‘semi-urban’ Blemmyean sites are known throughout the Wadi Amur and Agwampt basins, at Alitiatib, Jebel Gurad, Tabot, and possibly other sites, demonstrating exceptional archaeological profiles in landscapes usually characterized as being dominated by tent-dwelling nomads (Cooper, 2019). These sites might suggest a vast zone of ‘agropastoralist’ potential across the region, where nomads produced a mixed subsistence economy defined by a balance of agriculture and pastoralism. Beyond this, rock art sites at Khor Ekidi, Rawai, and Nubt (Krzywinski et al., 2020; Reinold & Ahmed, 2008), and surely as yet undiscovered sites demonstrate the breadth of human activity from the prehistoric to the medieval period. In practical terms, this area has been discussed in the context of World Heritage listing by Norwegian led-teams as part of their fieldwork at the site of Nubt with local authorities in Eastern Sudan. Newer fieldwork would expand the area of interest to a rough box shape encompassing the Wadi Amur and Wadi Agwampt watersheds, delineating an area roughly between the watershed divide of the Sudanese Red Sea Hills and as far west as Jebel Gurad (Fig. 7).

This area would encompass a vast archaeological zone comprising prehistoric and First Millennium CE burials, multi-period gold-mining settlements, at least five rock art sites, and core settlements belonging to the Blemmyean polity of ancient Eastern Sudan. There is no analogous area of unique potential in the Sudanese deserts, and this area would represent not only a unique human adaptation to Sudanese-Saharan environments, but earmark a key zone of Eastern Sudan for heritage preservation and interpretation.

The theme of heritage protection could not be more urgent in this context. Eastern Sudan is witnessing a gold-mining boom as a result of increasing gold-prices, with artisanal mining in particular having a deleterious effect on archaeological profiles. While it is difficult to quantify the damage, whole sites across Eastern Sudan, especially ancient gold-mines, have been demolished. In deflated desert surfaces, vital laboratories of surface remains comprising prehistoric debitage has also been destroyed. Within this specific Agwampt-Amur area, modern gold-mining remains a significant problem, with ancient gold-mining sites (Klemm & Klemm, 2012; Cooper, 2019; Castiglioni & Castiglioni, 2020) having been frequently destroyed

This has been assessed even within this area, especially in the central and southwestern regions near Ariab and along the Wadi Agwampt (Cooper, 2025). The Atbai Survey Project has identified approximately 18 new ancient gold-mining settlements in this region, almost all of which bear some signs of destruction from modern operations. The positive story here is the rescue surveys conducted before the Ariab mine in the southwest of the region, where dedicated surveying allowed for an assessment of local gold-mining and archaeological profiles (Reinold & Ahmed, 2008). In other regions where artisanal mining is being conducted, there has been no or very brief reconnoitres (Adam, 2019; Fakhri, 2024). Heritage listing this area would ensure that at least one sub-region of the pastoralist Eastern Sudan remains protected and attracts the attention of local and international authorities.

With significant clusters of modern Beja nomadic camps across the region, mostly Amarar but also Bishareen and Hadendowa Beja, any World Heritage listing proposal and management should be discussed with Beja communities. Beja communities, as transhumant people, are highly involved in land-management and know local sites and lore, so would be integral to any world heritage listing success.

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From Documentation to Digital Reassessment of Lower Nubian Rock Art Heritage

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Introduction ¹

Lower Nubia represents a geographical, historical, and cultural mixture of people, processes, and dynamics that are attested archaeologically and epigraphically in the Middle Nile Valley region, between modern Sudan to the south and Aswan to the north, encompassing the majority of contemporary southern Egypt. The region has attracted significant archaeological interest since the early decades of the 19th century. Still, peaks in surveys and excavations can be recognised alongside important land modifications and economic choices that deeply impacted the region, its people, and their culture.

The building of the two Aswan Dams had the greatest impact on Lower Nubia. Both the ethnographic and archaeological heritage were affected by the decision of a more regular control over the Nile River, which was needed for economic reasons and development demands. While it was neither possible nor desirable to stop the country's development, especially in the hope that people could benefit from these innovations, a better way to address the landscape changes has been advocated from many quarters. This paper will deal with a specific topic that, for many reasons, is peripheral to such a wide picture. Rock art is not usually described as monumental, and its visibility can be challenging. Still, in Lower Nubia, it plays an important role in understanding the region's deep past and culture.

Recent research shows that rock art heritage is a significant addition to the history of a landscape, not only from a chronological perspective but also because of its cultural, symbolic, and practical meanings. However, Lower Nubian rock art sites have now almost completely disappeared beneath the waters of Lake Nasser, or, if they still exist, are almost impossible to reach, document, and study due to the socio-political situation around them. Therefore, a general reassessment of what has been done and is currently being researched will be the core of this contribution. The analysis of rock art sites, their relationship with the surrounding landscape, and the approaches to them by travellers, archaeologists, and ethnographers, integrated with a critical assessment of the history of research, highlights the need for new perspectives and approaches that can benefit from contemporary technologies and improved knowledge [Fig. 1].

History of Research

Explorations, tours and journeys along the Lower Nubian Nile Valley began in the early 1800s.² Interests and curiosity about rock art and inscription sites can be traced back to various approaches and significant differences during those decades. However, a scientific perspective on them can be first identified only in Richard Lepsius' work (Lepsius et al., 1897-1913). Before this important publication, it was possible to detect mentions of rock art sites, very brief and non-detailed descriptions, general geographical contexts, and sporadic drawings of panels.³ Usually, rock inscriptions could be copied, but drawings of rock art panels are not attested. However, scattered mentions of rock drawings and inscriptions can be found in the travel reports and diaries of explorers, diplomats, and early Egyptologists. Their main interests were devoted to larger sites or monuments, but they also noticed less evident evidence which might have been visible, imposing or simply easily detectable.⁴

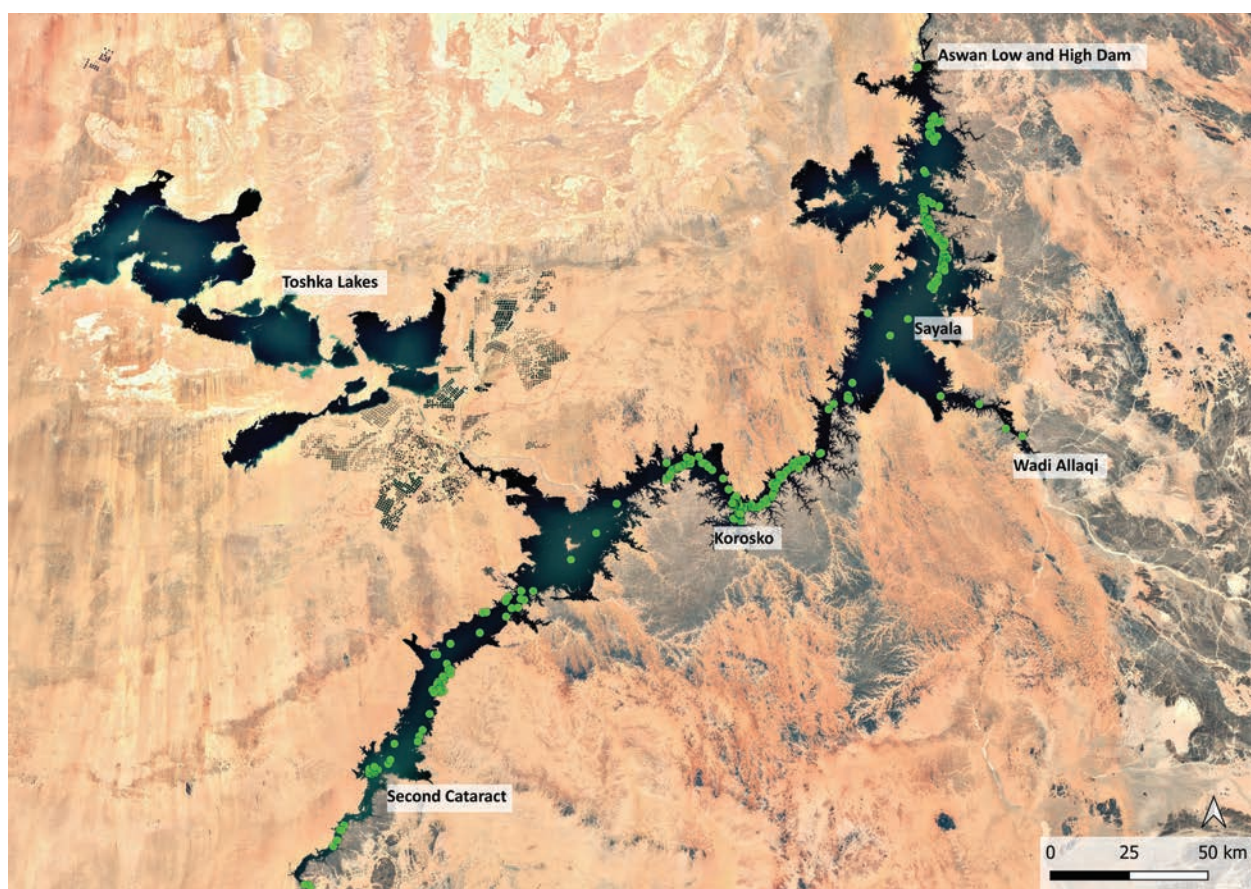


Fig. 1. Satellite image showing the extension of Lake Nasser (December 2025) with location of rock art sites in Lower Nubia as documented according to available bibliography.

In some cases, this evidence was considered less important or meaningless, like in a brief comment by Alessandro Ricci, who noticed the consistent presence of rock art and inscriptions near major monuments (Salvoldi, 2018, p. 228). The presence of rock art and inscription sites was also noted during travels in the deserts (Caillaud, 1821; Brehm, 1855). Still, the information is very imprecise and general, with few drawings and detailed descriptions. It must be noted that, in general, the study of rock art was still in its infancy, and more imposing monuments received major attention, following a trend observed in other Mediterranean areas.

By the mid-19th century, greater knowledge of ancient Egypt, especially its written records, sparked a new interest in inscriptions and epigraphy. This can be easily observed in Lepsius' work, as already stated.

1- This paper derives from a contribution presented during the Workshop "National-International Meeting on Cultural Heritage of Human Adaptations", organised by UNESCO and held at the American University in Cairo in February 2025. I want to thank Dr Nuria Sanz, Clara Epperlein, and Dr Hebatallah Ibrahim for inviting me and organising the conference. I would also like to express my gratitude to all the speakers for the fruitful and wide-ranging discussions, which provided useful thoughts that have been included in this paper.

2- It must be noted that in the brief history of research provided below, a selection of contributions is discussed. Reports and volumes describing rock art sites in the Eastern and Western deserts, even in Lower Nubia and the Etbai, have not been included, as the main interest here is the Lower Nubian Nile Valley.

3-Burckhardt 1819 does not show descriptions of rock art or inscription sites.

4-Bankes as described in Usich 2002; Linant de Bellefonds as reported in Kurz 2002.

Lepsius devoted long sections of his volumes to rock inscriptions and less conspicuous remains: his collection represents one of the most important testimonies of texts which have not been documented more recently, and his descriptions are usually quite detailed and precise in terms of palaeography. However, they lack important information, such as dimensions, technique, superimposition, and the precise location of the inscribed panel within its larger context.⁵ This trend will continue for decades after Lepsius, and the same considerations apply to other areas in Egypt and Lower Nubia.⁶

New approaches arose at the beginning of the 20th century, which also marked the first turning point in the history of modern-day Lower Nubia with the building of the Aswan Low Dam (1898-1902). Both William M.F. Petrie and Jacques de Morgan, together with Archibald Sayce, collected and described hundreds of rock inscriptions and some rock art panels in the First Nile Cataract region (Petrie, 1888; de Morgan et al., 1894). However, they didn't document them in Lower Nubia because they didn't travel there. A consistent interest towards this kind of evidence is shown by Arthur Weigall, who described many rock art and inscription sites, although briefly. He usually provided a hand-drawn sketch or a picture of the panel(s) (Weigall, 1907). In his attempt to describe the general state of preservation of Lower Nubian archaeological heritage and to open opportunities for specialised scholars to work on challenging evidence, Weigall noted the location of the panels in relation to other monuments or sites and hoped for extended research to be undertaken. A different approach was shown by George Reisner, who, a few years after Weigall, began the Archaeological Survey of Nubia (ASN) with a keen interest in cemeteries. In the resulting volumes, he cited some rock art sites in the main text and also located some "rock drawings of animals" on the maps he published (Reisner, 1910). However, both the descriptions and the locations are imprecise and cannot be used to understand the types of drawings, techniques, and panel dimensions. C.M. Firth, who continued the ASN until the end of the 1920s, rarely mentions rock art and inscription sites.⁷

A similar picture emerges in Emery and Kirwan 1935, since their main interests were cemeteries and settlements. Their chapter devoted to "Inscriptions" only lists ostraca, funerary stelae, and inscriptions on objects.

Explorations and journeys, not always driven by archaeological interests, but mentioning rock art sites in their reports and field notes, continued during the 1940s and 1950s.⁸ A notable turning point occurred at the end of the 1930s, when important contributions by Hans A. Winkler and J.H. Dunbar appeared. Winkler focused his attention on larger and distinct geographical contexts beyond Lower Nubia, but his research was pioneering and remains an important achievement in this field (Winkler, 1938 and 1939). Dunbar, on the other hand, analysed Nubian rock art from typological and chronological perspectives, with an interest in the development and evolution of stylistic characteristics and specific groups of drawings and figures (Dunbar, 1941). He also devoted some observations to the geographical contexts, but information on the locations of the sites and more details about the panels he showed as pictures in the tables is lacking. In fact, some of them should have been located in regions later surveyed by other projects, according to the toponyms Dunbar used to locate the panels. However, when searching for them in the pertinent publications, no trace of them could be found.⁹ Was the geographical label too general? Was the panel already destroyed or flooded when later investigations were undertaken? Was it overlooked (which might be a possible explanation, as direct observation and personal experience still teach)?

5- Siegel et al. 2024, as an example of the issues Lepsius arose.

6- See, as an example, Floyer 1892 and 1893: while travelling in the Eastern Desert and the Red Sea Coast, Ernst Floyer (a British engineer), described rock drawings scattered on rock surfaces along the wadis he crossed, but again, descriptions are not extensive.

7- Rock drawings are cited once in Firth 1912. Rock inscriptions to the west of Dakka are cited in the 1915 volume, while the final volume of the series (Firth 1927) devotes plate 12 to pictures of rock inscriptions, with their general locations provided.

8- See, as an example, the descriptions of sites to the west of the Dehmit region by von der Esch 1944. Although very general, the sites could be relocated and visited by the Wadi el-Hudi Expedition in recent years (<https://wadielhudi.com/weenak/>).

9- See, as an example, the panel published in Dunbar 1941, pl. IX, fig. 34 and referred to in Nicolini and Gatto 2023, p. 297.

Differences in the documentation can be observed across previous decades, and advances in the interpretation and attention to rock art and inscription sites have been noted. The quality and reliability of information must always be critically analysed. Still, they represent important factors in achieving greater knowledge, alongside easier access to photographs and drawings. Despite the lack of a consistent standard of quality across the publications, data collected during the final decades of the 19th century and the first half of the 20th century remain fundamental to the general reconstruction and analysis of Lower Nubian heritage.

The Second World War interrupted almost all activities, which resumed after the Aswan High Dam was planned at the end of the 1950s. The need for advanced infrastructure, better control over the Nile, modernised agriculture, and stable electricity availability represents the bulk of the work on the new dam. However, both the Egyptian government and UNESCO, as an international institution, soon understood the consequences the dam would have for the Lower Nubian and Sudanese people, landscapes, and historical heritage. Anthropological and ethnographical implications have been the subject of extensive research, which has underlined the complex relationships among people, environment, and politics from the 1960s to today.¹⁰ The landscape itself has been and continues to be analysed from geological, faunal, climatic, and hydraulic perspectives, since Lake Nasser remains the largest artificial lake in the world and continues to expand westward into the so-called Toshka Lakes.

Focusing on rock art and inscription sites, it must be noted that, for the very first time in Lower Nubian research, they were the specific subject of interest of several epigraphic and archaeological projects (Nicolini, 2025, table 3). While in some cases the whole project focused on documenting and studying rock art sites, in many others, team members devoted their efforts to epigraphical surveys. They didn't participate in excavations or analyses of findings. This resulted in an extensive documentation of rock art sites, with hundreds of rock panels photographed and drawn, thousands of rock figures and scenes described and discussed. As for rock inscriptions, they were photographed, transcribed, and translated to a greater extent than in the past, especially when it is possible to compare editions. A variety of publications resulted from the campaign's activities, both in English, for the official reports (V.A.A., 1963 and 1967), and in other languages for longer, more detailed volumes.¹¹

Methodology played an important part in understanding the documentation systems used by the projects, which were not common to all of them and thus should be considered separately. However, to sum up some of the strategies adopted and their achievements or results, it can be noted that:

- Short reports from the field were rarely published due to a lack of time, energy, and awareness of the rising level of the Nile, which made the projects rush to document as many sites as they could;
- Pictures and photographs were extensively taken, even with very hazardous approaches:¹² they are usually published in black and white, but in some cases, coloured images are known (Suková, 2011a). Their quality is not always sufficient to make assumptions or interpret the rock panel(s) they show. They are not always published extensively, and it can be argued that the original photos are kept in archives spread across many countries and institutions. Digitisation is not uniform, and the lack of complete archives is a major issue in the study of rock art and inscription sites.

10- Valenti 2018, with previous bibliography.

11- see the complete bibliography in Marchetti et al. 2019 and Nicolini 2025.

12- See a famous picture from the Czechoslovak Project: <https://medievalsaiproject.wordpress.com/2016/01/18/czechs-in-the-middle-nile/>.

- Drawings, on the other hand, can be extremely useful. However, issues arise when, in some cases, they were completely handmade and thus can be considered sketches that do not always match the written description of the panel(s) (See Curto et al., 1987). In the least scenario, drawings were copied directly from the rock surface, but the procedure required a lot of time and could not be performed extensively. Finally, it has been pointed out that some drawings did not represent the actual sequence or location of the figures/scenes, as they show a sort of “collage” of rock art subjects collected from various surfaces, even when the figures/scenes are located at a distance from one another and put together.¹³ The published drawing is not useful for rock art analysis. Lastly, not every panel or figure was drawn, so some inconsistencies should be expected.
- Plans and maps with the location of rock art and inscription sites and the distribution of panels and figures were provided, but precision and details varied.
- Rock art locations are described in detail, with observations on the landscape, environment, and other characteristics which were noted and considered important. This point is fundamental to reconstruct the geographical context of the sites and their relationships with other archaeological evidence.
- Technical aspects of rock art panels, such as dimensions, technique and superimpositions, are rarely described and clearly discussed. This is mainly due to time restraints and other issues, as previously pointed out, together with the large number of panels clustered or scattered throughout the concession areas. It nevertheless represents a major bias when reconstructing the region’s overview of rock art.

Rock art and inscriptions were deeply embedded in the Lower Nubian landscape, testifying to a strict connection among cultural and historical evidence and their environment. The concentrations documented in specific areas and khors show how important this heritage was. Most interestingly, the lack of rock art sites along the Nile Valley can be explained in different ways. In fact, some sections were not surveyed from this point of view, or were not surveyed at all, because the projects working there focused on specific sites and did not have the time, personnel, or knowledge to devote to epigraphic documentation. Other traits of the Nile were surveyed by boat, and the description of rock art panels is inconclusive, too general and insufficient to say more than their number and the drawings visible from a distance. It is possible, however, that rock art and inscriptions were absent from areas avoided by research and data collection: unfortunately, this cannot be ruled out with certainty, and thus it is highly challenging to draw general conclusions about the distribution of the evidence, as data are limited.

Even if bias and issues have been described and discussed, it is important to reaffirm the importance of the UNESCO campaign and the efforts made to document and preserve the Lower Nubian cultural heritage.

¹⁴ The shared aim of the campaign and its promotion by UNESCO must always be kept in mind for its archaeological achievements and international importance. It is possible to reconstruct, study, and analyse Lower Nubian history and archaeology, mainly thanks to the efforts of the projects and teams involved in the campaign, their funding institutions, and UNESCO, the leading guide of the activities. Without the campaign, the only data we could rely on were those collected before 1960, and they have already been described. Most importantly, the UNESCO campaign showed how international cooperation could work toward a shared aim, even when political, strategic, and economic interests interfered with the peaceful coexistence of people and countries worldwide.

¹³- This is mostly true for many panels in Váhala and Červíček 1999, as noticed by Suková 2011b.

¹⁴- On the contrary, see Carruthers 2022.

After the UNESCO campaign: reassessment and critical analysis

The publication of the UNESCO Campaign results continued in the decades following its official end, but heterogeneity and differences can be traced throughout the volumes devoted to rock art heritage. This is one of the reasons which explain the reassessment undertaken by researchers involved in the study of Lower Nubian rock art and its relationships with the Egyptian sites and imagery.

In recent years, scholars have focused on Lower Nubian rock art, benefiting from new technologies and approaches, the development of research on Egyptian rock art sites, and the creation of large corpora and databases of sites, panels/tableaux, and figures (Suková, 2011a and 2011b; Johansson, 2014; Varadzinová, 2016; Fernández-Toribo, 2020; Bietak, 2023, pp. 358–364). The comparative analysis has helped trace the chronological evolution of specific rock art motifs. It has shown their development from the Predynastic period (or even earlier periods) up to the Roman and Coptic periods. The usual starting point is that Egyptian and Nubian rock art share many aspects and, most importantly, can be interpreted in similar ways. When detailed analysis is undertaken, however, differences emerge and cannot be underestimated: visual traditions, cultural traits, and symbolism differ between Egypt and Lower Nubia, leading to different perceptions and meanings of the final artistic product (Połkowski and Förster, 2022; Połkowski, 2023; Förster et al., 2025).

One of the most important aspects that recent research has underlined is the lack of consistency in the available data and information, both published, accessible in archives, or digitised. Data are essential for reconstructing the ancient landscape and the distribution patterns of archaeological sites, even if their reliability needs to be critically evaluated. If data are not provided, though, issues arise and finding them proves challenging. The Heritage and Threat project (HeAT) aimed to document the archaeological heritage of Lower Nubia, and rock art sites were integral to its outcomes.¹⁵ The project offered a complete analysis of the archaeological and epigraphical record of the UNESCO campaign, based on published data. This core dataset, spanning from the Palaeolithic to the Late Roman Period, was analysed and integrated with previous surveys and excavation results, satellite imagery, CORONA images from the 1960s, and topographical maps in a GIS platform. A digital reconstruction of the landscape and spatial analysis of rock art sites was discussed and compared with available datasets and other research to get a general overview of the distribution and characteristics of the sites. The resulting database, completed with as much information as possible (bibliography, dimensions, chronology, type and level of documentation, location and regional details, description), represented an important achievement. Despite the team's efforts, mistakes and inconsistencies in the data can be noticed. Some sites could not be located in the initial stages of the project because publications could not be accessed, and archival data were not digitised.

New Perspectives

When analysing the amount of data concerning Lower Nubian rock art, there should be no great wonder that the commonest approach adopted by contemporary scholars was to systematise and standardise the data using databases and digital repositories. GIS-based projects have also improved our knowledge of the landscape and original archaeological contexts, and have contributed to the integration of datasets that are now easily accessible and manageable for archaeologists (cartography, topography, aerial, satellite, and radar imagery).

15- Marchetti et al. 2019; see also the WebGIS platform accessible at <https://www.orientlab.net/orientdams/orientgis-map/>.

The general situation, at the moment, is quite inconsistent. Positive updates and advances, both methodological, analytical, and technical, have resolved some issues, but challenges are still present:

- Partially published reports are still in the process of being published or updated, but not for every project. The passing of many scholars directly involved in the UNESCO campaign is not only a loss for archaeology but also represents a lack of memory and testimony for present and future generations. Some series of reports, which were presented in such a way, have never been completed.¹⁶
- In other cases, volumes were accomplished decades after the archaeological campaigns.
- Archives are not always easily accessible, digitised, open access, or clearly located.
- Unpublished archival data have not been (usually) compared with the published materials. When this was done, the results showed bias, issues, and gaps that could not have been expected otherwise.
- In many cases, data have not been re-analysed in recent years. This suggests that we are still basing our knowledge and analysis on outdated, unverified, or uncritically discussed information, thereby making the scientific value of the research not suitable for peer review publications.
- Available information is not completely shared in a general database, although technology could offer stable and accessible solutions.

What can be done in the near future? As discussed in the previous paragraphs, it is now fundamental to have access to any data already collected, and technology allows us to share, use, and verify all kinds of data. It takes funding, time, effort, and devices; supervision is required to ensure that the work is done consistently and that information is not lost.

Such research requires an international team of leading scholars in the field, as it cannot be carried out alone or in a small group. Too much data needs revision, and experience in different chronological periods is required. Data needs to be mastered accordingly, which implies building technical and digital infrastructure to host, store, analyse, and share datasets and information.

This work could be facilitated through UNESCO, which could help access archives and find international collaborations. Communication is also essential: social media is now strategic for promoting activities and enhancing cooperation at various levels. Building on what has already been done, making it available to a larger public, and working on it with new perspectives are key approaches to continue research on Lower Nubian rock art and inscription sites.

It is widely believed that this heritage is almost completely lost, which is true if its environment and relational connections are considered. We can, and we must work on a large amount of data, with the aims of preserving the memory of what has been flooded or destroyed, reconstructing it with digital tools and methods, and improving fieldwork research, which is still possible in the deserts surrounding Lake Nasser. The region, in fact, is still affected by dramatic environmental and climatic changes, but archaeological research can help mitigate such threats and raise broad awareness.

16- See the ones pertaining to the rock art in the region of Sayala.

Lower Nubian rock art heritage can still play an important role in the archaeo-epigraphical history of the Nile Valley because it is embedded in its landscape and can serve as a means of reconstructing the environment and its history. Although inconsistent and scattered, data and information still exist and need collection, revision, and sharing. Rock art testifies to the people who created it, their behaviour and their adaptations. A better understanding of the cultural and environmental dynamics of Lower Nubia is crucial to the analysis of Egypt, Sudan and the deserts. Preservation of memory is a starting point: strategies for enhancing, engaging with, and safeguarding this heritage must become part of archaeological and international research on this subject.

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Within the Landscape of Prehistoric Rock Art: Insights from Dakhla Oasis

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Setting the scene: Oasian landscapes

The southern oases of Egypt's Western Desert – Dakhla and Kharga – together form a singular region long celebrated for its biological, geological, historical and archaeological significance, and it is therefore little wonder that they feature on UNESCO's Tentative List. These verdant islands have always acted as focal points within a vast landscape oscillating between hyper- and semi-arid extremes over the last tens of thousands of years (Fig. 1). Owing their lushness to the subterranean waters of the Nubian Aquifer, the oases have perpetually supplied resources vital for life, even when the surrounding lands degraded into barren, waterless badlands, particularly during prolonged dry spells. Undoubtedly, the more expansive desert is rich in archaeological vestiges stretching back to the Early Stone Age. Yet, the oases are singularly abundant in such traces, particularly those of Holocene provenance.

Both Dakhla and Kharga are remarkable for their extended post-Pleistocene chronological sequences, spanning the last 10,000 years. From the mobile groups of Epipalaeolithic hunter-gatherers, who 're-occupied' the Western Desert at the onset of the Holocene, through the first herders or pastro-foragers, later goat and cattle pastoralists, to ancient Egyptian colonisers, and then inhabitants of the dynastic, Ptolemaic, and Roman periods, the first Christians of Coptic times, and finally Muslims settling the region after the Arab annexation of Egypt, the oases have conserved an extraordinary array of evidence across all these epochs. Yet what renders the oases particularly captivating is the immense corpus of images and inscriptions etched on the rocks, which illuminates these sequences from a wholly different vantage point.

Rock art, however, differs from many other archaeological forms in that it rarely lends itself to precise chronometry. More often than not, one must contend with uncertain dating. Yet even amidst this ambiguity, the breadth and diversity of imagery, such as that at Dakhla, allow us to apprehend its profound chronology. It seems fairly certain that, to some degree, it represents all major Holocene periods, although only rarely can specific timeframes – exact millennia, let alone centuries – be confidently ascribed to individual petroglyphs on the basis of secure external evidence (but see Polkowski 2021). This chronological conundrum has shadowed rock art research in the Western Desert since its inception (cf. Riemer 2009), and despite the inexorable passage of time, it remains a persistent challenge.

Nonetheless, the last two decades have seen notable advances, yielding significant insights into the diverse rock art traditions recorded in the oases and the broader Western Desert. In this paper, I seek to provide a concise characterisation of some prehistoric rock art in Dakhla, offering reflections on both the opportunities and the constraints inherent in the research, and to consider the place of rock art within the landscape – not merely as a feature embedded in past networks of meaning and action, but also as a form of heritage warranting careful stewardship.



Fig. 1. The green and yellow landscape of Dakhla Oasis. Photo by the author.

Discovering petroglyphs in Dakhla

Given the abundance of rock art in Dakhla, the wider world became aware of its existence relatively late.¹ Individual finds were reported in the 1920s, yet the first comprehensive account emerged in the late 1930s in the form of a study by Hans A. Winkler (1939). The German scholar, one of the founding fathers of rock art research in Egypt, documented a number of sites along the Ghubari road, linking Kharga with Dakhla, and integrated his discoveries into the cultural-historical stylistic sequence he had already established from other regions of the country. The discovery immediately put Dakhla on the map, but the upheavals of World War II, which also claimed Winkler's life, initiated a hiatus in field research.

Yet Winkler's two-volume monograph was never forgotten and continued to serve successive generations of scholars as a fundamental point of reference, keeping the Oasian petroglyphs vividly alive. Actual rock art recording in Dakhla, however, did not resume until Anthony Mills' Dakhleh Oasis Project (henceforth DOP) entered the scene in the late 1970s. In its early years, the project, concerned not only with all manifestations of human activity in the past but also extending its scientific interests beyond archaeology, focused on surveying vast expanses of the oasis. It soon became evident that the sandstone zones preserved large numbers of rock images from diverse periods, and that proper documentation would require an additional task force.

1- For the most recent and comprehensive history of rock art research in Dakhleh, see Polkowski 2024b, pp. 10–20.

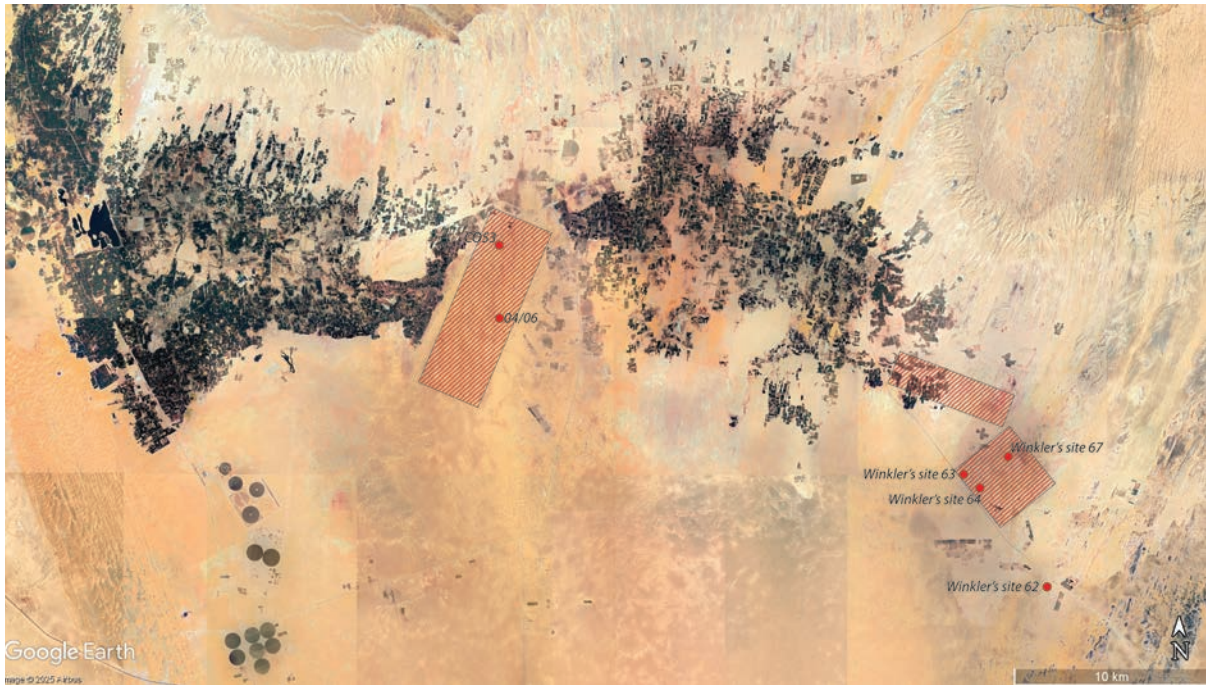


Fig. 2. Map showing the principal areas of rock art research, with selected sites mentioned in the text indicated.

For this reason, the DOP Petroglyph Unit, spearheaded by Lech Krzyżaniak, was established during the 1984/1985 season (Krzyżaniak and Kroeper 1985). This marked the beginning of systematic and sustained rock art research in the oasis, in contrast to all previous attempts, which, though extremely valuable, were largely limited to brief, one-off visits, whether by Winkler, Harding King, or Herbert E. Winlock.

Before the 2000s, most rock art known from Dakhla came from its eastern margins, typically along the Darb el-Ghubari corridor. Krzyżaniak's survey gravitated towards extensive playas lying north of the modern tarmac road, itself laid over the historic Ghubari route. This 'palaeo-oasis' soon revealed a remarkable concentration of prehistoric imagery, although sites bearing historical petroglyphs were also repeatedly encountered (Kaper and Willems, 2002). At the threshold of the twenty-first century, the Petroglyph Unit broadened its scope to encompass the central and southern reaches of the oasis. The outcome was the identification of nearly 300 new rock art localities; had fieldwork not been abruptly curtailed in the wake of the 2011 revolution, which brought about a prolonged absence of permits, this figure would almost certainly have been substantially higher (Polkowski, 2024a).

Hundreds of rock art sites are now known from Dakhla (Fig. 2). The 'palaeo-oasis' is particularly rich in prehistoric petroglyphs, hosting the largest concentration of the distinctive 'exaggerated anthropomorphs' – Dakhla's signature motif (Polkowski, 2024b, pp. 69–118). The south-eastern corner of the oasis proper contains a far more heterogeneous cluster of sites, where prehistoric imagery coexists with dynastic, Graeco-Roman, and post-antique depictions. Similarly diversified is the assemblage of sites recorded on the sandstone ridge in central Dakhla. This intermingling of different rock art traditions is a hallmark of the oasis landscape, presenting both methodological and analytical challenges as well as a testing ground for interpretive endeavours (Polkowski, 2015). Dakhla is an intricate palimpsest, and so is its rock art (Polkowski, 2016).

Prehistoric sequence vs rock art

One of the Dakhleh Oasis Project's achievements has been the establishment and ongoing refinement of a Holocene chronological sequence, spanning both prehistoric and historical periods. For the latter, this involved synchronising the oasis's sequence of developments and events with that of the Nile Valley and beyond. This was no simple task, yet some external sources and standardised nomenclature were already available. The situation was very different for Dakhla's Holocene prehistory, about which almost nothing was known prior to the DOP's engagement. When Winkler (1939) first presented his findings, he relied on his own ethno-styles, the 'Earliest Hunters' and 'Early Oasis Dwellers', to attribute rock art chronologically. By the time Krzyżaniak began his research, however, a scaffolding of the general chronological system had already been laid out by Mary McDonald, and the challenge he set for the project was to weave the rock art into this newly constructed sequence.

The periodisation, gradually elaborated and now widely accepted, divides the Holocene Stone Age in the Dakhla region into several phases, equating them with distinct cultural units (McDonald 2016). The earliest of these, the Epipalaeolithic or Masara, is associated with hunter-gatherers occupying the oasis c. 8250–6900 cal. BCE. The subsequent Bashendi culture (c. 6600–5600 cal. BCE) is likewise conceived as hunter-gatherer in nature, yet differs markedly from its predecessor through the employment of the bifacial technique in lithic tool production. The close of the 7th millennium BCE, corresponding to the late Bashendi A phase, most likely saw the introduction of domesticated animals – cattle and goats – although this remains inferred indirectly and has so far been confirmed only for the later sixth millennium BCE, during the Bashendi B phase (c. 5500–3900 cal. BCE). Communities of this period diversified their subsistence toolkit, merging hunting and foraging with herding. As the development of Bashendi B roughly coincided with a general trend of aridification in what is now the Western Desert, these multi-resource pastoralists must have become increasingly mobile, seeking water and pasture to sustain their herds. The prehistoric sequence culminates in the Sheikh Muftah culture, 'emerging' from its predecessor sometime in the 4th millennium BCE (Warfe and Ricketts, 2019). This late Neolithic cultural unit is habitually considered to represent the archaeological traces of herders, the last indigenous inhabitants of Dakhla, who were encountered by the ancient Egyptians in the first half of the 3rd millennium BCE, when the oasis gradually came under Egyptian colonisation.

The development of our knowledge of both the prehistory and history of Dakhla has gone hand in hand with a steady increase in the number of known rock art sites. Although the goal articulated by Krzyżaniak, namely a closer correlation between rock art types and established cultural units, has not yet been fully realised, substantial progress has already been made. This is equally true for petroglyphs of the historical periods, as illustrated by images associated with pharaonic watch posts dated to the late Old Kingdom (Kaper and Willems, 2002; Polkowski, 2024b, pp. 187–202). Among the prehistoric petroglyphs, one group of images stands out as being broadly linked to a specific chronological horizon, the exaggerated anthropomorphs, possibly created by Bashendi-related communities between the 7th and 5th millennia BCE.

Beauty canon, style, or non-human being? A glimpse of the exaggerated anthropomorphs

We owe the first recorded mention of these highly conspicuous motifs to Winkler (1939), who deemed them "the main discovery" of the season. Indeed, the images he encountered seemed entirely singular, resisting any connections to other examples in Egypt's rock art. Almost a century later, the picture remains remarkably similar: this type of anthropomorph is confined to a narrow swathe stretching between the oases of Dakhla and Kharga, and the territories of Meri and Chufu to the south, with no comparable imagery to be found elsewhere (Polkowski and Nourhan, in preparation).



Fig. 3. Exaggerated anthropomorphs at Winkler's site 62. Photo by the author.

What makes these figures so unique is their bodily build, combined with a range of peculiar stylistic solutions (Fig. 3). The images typically present silhouettes in which exaggerated lower body parts are paired with a schematically rendered upper structure, although occasionally the latter is portrayed with considerable detail. The voluminous lower half assumes a variety of forms, such as oval or rectangular, and may include the feet or vestigial legs. By contrast, the upper section is organised around a central vertical axis, to which elements such as breasts, arms, jewellery, and the head may or may not be attached. Most figures are partially depicted in profile, yet a small proportion of the anthropomorphs is rendered fully en face (Polkowski 2024b, pp. 72–77). One particular feature, which also immediately drew Winkler's attention, is a protrusion at waist level that, more often than not, resembles a pregnant belly. Although it appears on just over one-third of the anthropomorphs, it nevertheless seems to be the principal meaningful feature, one over which much ink has already been spilt.

For Winkler, these 'pregnant women' were simultaneously regarded as 'goddesses', an interpretation that is no longer widely acknowledged (James 2012). It also appears that not all of the more than 200 Dakhla figures should be deemed female, as some specimens, typically slimmer and bearing additional waist appendages, may in fact represent males (Fig. 3). This distinction is particularly evident in the pairings of exaggerated anthropomorphs, in which one of the two is consistently much thinner.



Fig. 4. An anthropomorph and two giraffes, all depicted as pregnant, at site CO53. Photo by E. Kuciewicz.

A dozen such pairs are known from Dakhla, and, together with similar expressions in other regions, they indicate that this pattern is meaningful, particularly since, in some instances, the figures are connected by a line.

The emphasis on pregnancy and the probable male-female pairings has long suggested that the domain of fertility and sexuality was central to the meaning of these images. A detailed interpretation remains difficult, but on a general level, it seems that the figures articulated important aspects of their makers' knowledge and understanding of the world, in which procreation, unsurprisingly, may have been considered vital (Polkowski 2024b, pp. 100–118). Whether the figures represent the human community of their makers or other-than-human mythological entities is far from clear, but this distinction is perhaps secondary to the overall tenor of the rock art, which guides the observer toward certain truths paramount for the prehistoric communities. That these images were not simple statements of fact about procreation, but possibly conveyed more complex ideas, is supported by assemblages such as the one at site CO53, which features a pregnant anthropomorph alongside pregnant giraffes (Figs 2, 4). Can such a juxtaposition, surely intentional, emphasise an understanding of the world as shared by humans and animals, and their mutual responsibility for it as custodians with equal rights? The answer to this question is not straightforward, but the frequent, apparently non-hostile co-presence of animals alongside the exaggerated anthropomorphs invites consideration of an interpretation in which the relationship between the two groups would be ontologically distinct from modern conceptualisations.



Fig. 5. A procession of animals and exaggerated anthropomorphs at site 04/06. Photo by the author.

A story of humans and animals

The question of who stood behind the creation of the exaggerated anthropomorphs remains a critical one. We still lack any direct means of dating this corpus of rock art, and interpretation must therefore rest on indirect lines of inference. One of the most persuasive arguments for linking these images to communities inhabiting the oasis during the mid-Holocene Bashendi period emerges from observations of spatial patterning, namely the recurrent proximity of rock art localities to archaeological sites attributed to mid-Holocene hunter-gatherers (Bashendi A) and pastro-foragers (Bashendi B). Such co-presence of imagery and material vestiges cannot, in itself, be taken as unequivocal proof. Yet its repeated occurrence, documented for example in eastern Dakhla (McDonald 1993, pp. 45–46) and at Meri (Riemer 2006), lends the pattern considerable interpretative weight. On this basis, the exaggerated anthropomorphs and accompanying figures may therefore have been created around the sixth millennium BCE, if not earlier, although some voices argue that they should be regarded as motifs continuing into the fifth or fourth millennia BCE, possibly linked to the Sheikh Muftah cultural horizon (Kuper 2016; Moustafa 2023).

Another line of argument comes directly from the rock art itself. The exaggerated anthropomorphs are often depicted alongside animals, many of which have long disappeared from the region. Four major taxa are recognised in the Dakhla corpus, each appearing in assemblages with exaggerated figures: giraffe (*Giraffa camelopardalis*), oryx (*Oryx dammah*), gazelle (*Gazella dorcas*, Nanger dama), and ostrich (*Struthio camelus*) (Fig. 5). It is especially the presence of giraffes that may point to a considerably more humid climate, and thus to a period closer to the Holocene climatic optimum, although it must be borne in mind that the depiction of a species in a given area does not automatically indicate that it actually inhabited that region. The giraffe provides a telling example, as not a single bone of these large mammals has ever been found in the wider Dakhla-Kharga region (Polkowski 2024b, p. 128).

Yet the giraffe is the most frequently depicted animal in the oasis, represented by over 300 petroglyphs (Fig. 6). These are followed by more than 200 oryxes, nearly a hundred ostriches, and almost two dozen gazelles (Polkowski 2024b, pp. 124–132). These species appear alongside exaggerated anthropomorphs in a variety of configurations, occasionally all at once. Nonetheless, no animal is as consistently paired with anthropomorphs as the giraffe, suggesting it held a particularly significant role for past communities in Dakhla and the wider Western Desert. The earlier example of pregnant giraffes positioned beside an expectant woman stands as a singular illustration of this meaningful relationship (Fig. 4). Anthropomorphs are frequently depicted alongside giraffes and other animals, giving the impression of joint processions and a more general sense of human-animal equality (Polkowski and Nourhan, in preparation) (Fig. 5).

This ontological equality can be understood in multiple ways. In some compositions, anthropomorphs and animals not only co-occur but also converge in appearance, with the former occasionally assuming a subtly zoomorphic character. The procession-like arrangements present both types of figures as coordinated, even harmonious, hinting at something more profound than a mere metaphorical framing of human and animal co-existence in the arid savannah. Given that the only species depicted alongside these anthropomorphs are those living in herds and seasonally migrating across vast distances in search of water and food, one might venture the assertion that the choice of species conveyed a deeper sense of connection between humans and animals. This connection was not only about observed similarities in lifestyle but possibly also about the rock art makers' awareness of their lived experience of shared participation in the world. They, too, lived in gregarious communities and relied on seasonal mobility, yet this experience was literal rather than metaphorical: people and animals crossed paths daily, sustained a variety of relations, and explored the same landscape (Polkowski, 2024b, pp. 151–169).

Of course, today we can only apprehend the most basic rudiments, if at all, of the potential narratives and knowledge articulated by this rock art. Likely only a fraction of the petroglyphs that have survived to the present are at our disposal, and many lack contextual data that could allow for a more detailed account. At the same time, the figurativeness, as well as its contrasting non-figurative qualities, is always conveying something, not only to us, the modern viewers, but also to the people of the past who came to the oasis long after the prehistoric depictions were created and forgotten. Because rock art has the power to elicit responses (Darnell, 2009), palimpsests can form, serving as enduring testimony to diachronic dialogues inscribed upon the rocks.

Inter-temporal conversations without words

When, in the first half of the 3rd millennium BCE, the ancient Egyptians gradually intensified their interest in the Western Desert and cautiously embarked upon the colonisation of the oases, Dakhla was still inhabited by indigenous herders. Whether these communities continued to produce petroglyphs remains uncertain, although this is by no means improbable (Polkowski 2024b, pp. 220–223). What is beyond doubt, however, is that the oasis already abounded in rock art from earlier times, imagery that was likely better preserved and more readily visible than it is today. The newcomers from the Nile Valley, together with the inhabitants of the oasis in subsequent periods, thus moved within a landscape long since transformed and visually saturated. How this densely tattooed terrain was conceptualised remains largely elusive, yet one thing seems certain: prehistoric images on the rocks were encountered with some regularity, and the petroglyphs had ample opportunity to exert their influence (Polkowski, 2020).



Fig. 6. Giraffes and an oryx at site C0178. Photo by the author.



The very fact that many rock art localities are populated by petroglyphs from visibly different periods is already telling. This becomes especially apparent along ancient routes, where individual hills are at times densely covered with images and inscriptions accumulated over centuries (Lazaridis, 2019). At the oasis's eastern gateway, along the Darb el-Ghubari, places such as Winkler's site 63 offer a particularly eloquent example of an unfolding palimpsest. Here, prehistoric exaggerated anthropomorphs share the limited surface of a hillock with much later Coptic images and texts, as well as Arabic magical inscriptions, and many more. It may be tempting to explain such dense cohabitation of images solely by the exposed nature of these sandstone outcrops and their strategic placement along a well-travelled route. Yet it is equally plausible, perhaps even more so, that the presence of earlier figures actively invited later travellers to add their own marks and thus join an ongoing visual dialogue. Rock surfaces crowded with petroglyphs and inscriptions set side by side thus form microcosms of the oasis itself, material testimonies to the *longue durée* of human engagement with the Dakhla landscape.

Sceptics might argue that such palimpsestic accumulations of images simply reflect a scarcity of space, where the available surface, rather than the pre-existing motifs, dictated placement. In certain instances, this may indeed be the case. Yet our research has revealed a number of assemblages in which interactions between images appear so deliberate that they cannot easily be dismissed as mere practical or random choices.

One notable class of petroglyphs frequently associated with older imagery comprises depictions of feet and sandals (Polkowski, 2018a). These podomorphic figures are repeatedly positioned either over or beside prehistoric motifs, even when ample ‘empty’ space is available (Fig. 7). In some cases, the feet or sandals are juxtaposed as closely as possible to existing images, as if their makers sought to exploit the proximity while carefully avoiding any harm to the older depictions.

A telling example comes from eastern Dakhla, where two exaggerated anthropomorphs were complemented with sandals, only marginally intruding upon the left arms of the figures (Fig. 8). The manner in which these podomorphs are integrated suggests a purposeful and meaningful intervention by the maker, who must have reconceptualised the encountered imagery through the prism of his/her contemporary knowledge. What exactly motivated such gestures, and how dynastic and later rock art makers reinterpreted these pre-existing petroglyphs, may remain elusive. Yet the recurrent nature of the phenomenon strongly implies that ancient visitors did not remain inert or indifferent to older images.

We have documented numerous instances in which not only anthropomorphs, but also animals – oryxes and giraffes, for example – were overlain or juxtaposed with feet and sandals (Fig. 9).

The latter seem to have been an especially apt image-type for such interventions, perhaps because they embodied the makers more directly and efficiently than most other motifs (Polkowski, 2024b, pp. 283–291).

The irony of the situation lies in the fact that dialogues between images and earlier images or texts created in the past are today treated as particularly informative and even desirable, whereas a closely related phenomenon is also observed in the present, and it must be clearly singled out and condemned. Contemporary dialogues on the rocks are labelled vandalism, and even if they, too, convey something about their makers and intentions, there can be no room for accepting such practices. Yet Dakhla and the wider Western Desert abound in disquieting examples of conversations with rock art initiated by modern visitors. I therefore conclude this paper by turning to the important issue of rock art protection.

Rock art’s paradox: between persistence and vulnerability

Petroglyphs are created in a medium of remarkable endurance – rock. In principle, this should secure their longevity, a promise they often fulfil by surviving into modern times, not infrequently in strikingly good condition.

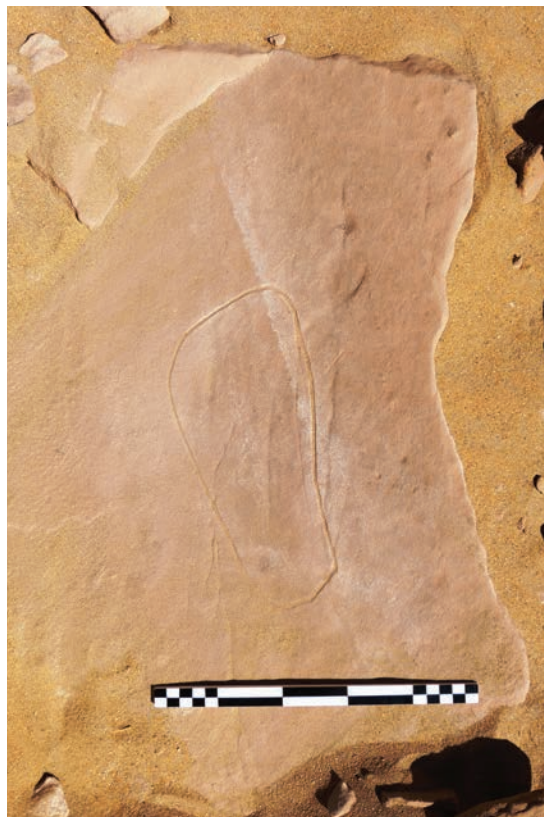


Fig. 7. An exaggerated anthropomorph superimposed by a sandal-outline depiction at site C037. Photo by the author.

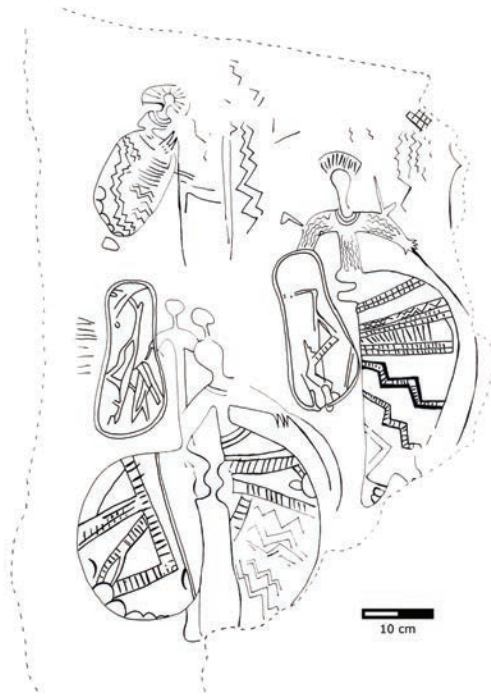


Fig. 8. Elaborate anthropomorphic figures juxtaposed with later-added sandal depictions. Site 61-39/E3-2. Drawing by L. Krzyżaniak.



Fig. 9. A composition consisting of an anthropomorph and several zoomorphic figures, one of them superimposed by a sandal image. Photo by E. Kuciewicz

Yet the very act of carving them into exposed stone surfaces also renders them highly visible, even conspicuous, particularly in places close to routes of passage. Nor are seemingly remote locations immune to attention. Precisely because petroglyphs are visible and readily approachable, they invite responses from passers-by, who, much like their ancient and historical predecessors, sometimes choose to add their own material interventions to these stone canvases. Seen from this perspective, the situation in Dakhla, and in the wider Western Desert more broadly, gives cause for concern (Riemer, 2009, p. 44).

Rock art vandalism in the region has been reported with troubling regularity over the years (Riemer 2011, pp. 215–220), and a number of sites in Dakhla rank among the most severely affected (Polkowski, 2018b). The spectrum of damage is broad, ranging from drawings and inscriptions added on or beside existing petroglyphs to the outright destruction of entire sites by grave robbers. The latter frequently employ heavy machinery to remove boulders and expose the bedrock beneath, in the hope of locating concealed entrances to rock-cut tombs (Polkowski 2024a).

In contrast to graffiti makers, whose interventions usually veil rather than erase rock art, grave robbers frequently bring about the total disappearance of petroglyphs. The catalogue of threats facing Oasian rock art is, however, far more extensive, with some of the most serious pressures stemming from agricultural expansion and infrastructural development (cf. Riemer, 2020). The construction of new tarmac roads in the vicinity of previously secluded rock art sites not only disrupts the broader archaeological setting but also renders these places readily accessible. Under such circumstances, effective protection becomes exceedingly difficult, and the gradual accretion of visitors' graffiti is, regrettably, to be expected.

Equally consequential is the process of land reclamation, which in and around Dakhla has accelerated markedly over the past decade. The establishment of farms in desert terrain poses a threat to a wide spectrum of archaeological vestiges, rock art included. Winkler's site 62 (Fig. 3), situated along the Darb el-Ghubari outside the oasis proper, provides a telling example.



Fig. 10. The area surrounding Winkler's site 62 as seen in late 2024. One of the prehistoric stone-hut sites currently under threat is visible in the foreground. Photo by the author.



Fig. 11. One of the early Holocene stone-hut circles damaged during terrain modification for agricultural use. Photo by the author.

Human Adaptations

For many years, embedded in a largely undisturbed landscape, it has in recent times become almost encircled by newly established farmlands. While the petroglyphs themselves have thus far escaped direct damage, the archaeological context that once framed them has been almost entirely effaced (Fig. 10). This includes several rare sites preserving traces of Epipalaeolithic stone huts, some of which may already have vanished by the time this text reaches the reader (Fig. 11).

Land reclamation projects in Dakhla have never reached such a scale, nor advanced at such a pace, as they have over the past two to three years. Between 2024 and early 2026 alone, sites such as Winkler's sites 63, 64, 66, and 67 have been encroached upon by newly established cultivation farms, and access to many rock art-bearing hills has become severely hampered, if not altogether precluded. The Oasian petroglyphs and rock inscriptions, together with their archaeological contexts, now stand on the brink of extinction, rendering their documentation and protection more urgent than ever.

Their future, however, ultimately depends on local and national stakeholders, who must first recognise the value of this exceptionally fragile heritage. Without their active engagement, much of Dakhla's rock art is likely to vanish in the near future, while for many sites it may already be too late. Rock art offers unique insights into the history of the Western Desert, and this precious testimony should not be sacrificed, even while recognising the importance and rationale of agricultural, settlement, and infrastructural development in the oasis.

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Merimde Beni Salama (west Delta): challenges and potential for protecting and preserving prehistoric heritage

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Prehistoric sites, often invisible or with seemingly marginal surface material remains, can be the hardest to protect; yet they need protection. Within a programme of site management that seeks to share old and new found knowledge, together with providing physical measures that bind and preserve areas into the future, site management initiatives have been instigated at the two sites focal to the two papers shared within this document paper. Merimde Beni Salama and Nubt are, in the textbooks, two of the most archetypal sites in Egyptian prehistory, yet beyond academia and some university classrooms, they are rather poorly known, and their importance is not recognised. With no investigations since the early 1980s, both had lacked active on-site research that led to growing knowledge and awareness. In 2013 (Merimde) and 2018 (Nubt), the author was involved in new projects in these locations, raising new questions, introducing new methods, and implementing programmes of site management. Aimed at ensuring that new investigations were coupled with protective measures, crucial given that the sites sit today next to the ever-expanding modern floodplain in the northern and southern Egyptian Nile Delta and Valley, respectively. The particular value of these sites, the potential knowledge still within them, and the measures we need to take to protect them are shared over two working papers. Some measures are now in place, others are ongoing. Hopefully, the background, progress, and unique status of these sites are accessible here and demonstrate how they are equally important to more visible archaeologies, with much still to tell about the beginnings of more permanent human and animal lifeways within Egypt.

Two presentations were given in Cairo, the first on the Neolithic and also Palaeolithic heritage of Merimde Beni Salama, the second on Nubt, a multi-period landscape, which includes some visible monumental features – a small non-funerary pyramid and two tumuli, thought to be associated with the Predynastic-Early Dynastic period. Merimde is on the western side of the Delta, a Delta not even formed when human groups passed through the area in the Palaeolithic, and Nubt, in the Naqada region, is in the southern Egyptian Nile Valley, in modern-day Qena province, and about an hour north of Luxor by car today.

Merimde Beni Salama: the past, present and future of the Neolithic settlement and its hinterland

Merimde Beni Salama (hereafter ‘Merimde’) is a crucial site, and well-known academically, for being the first site with domestic architecture in northeast Africa, where gradually human groups adapt to year-round settled lifeways, growing cultivated cereals and farming cattle, pigs, goat and sheep, yet maintaining a dietary contribution from wild fowl, mammals and fish, and from plants. This is unique in this corner of Africa for this time (from c. 5000 BC), albeit a much later development than is seen in the Fertile Crescent.

The Neolithic is not, however, the earliest evidence from Merimde; there is evidence also for an earlier period of activity by anatomically modern humans, and this is by the Middle Palaeolithic (exact dates tbc; Schmidt, 1981; Rowland and Tassie, 2015). This is much less well-known, although the work of the survey team that first identified the archaeological remains as prehistoric took place already in the late 1920s and through the 1930s (Junker, 1928; Menghin, 1932). Unfortunately, for the Palaeolithic there are as yet no scientific absolute dates here because this period pre-dates the scope of radiocarbon measurements and requires dating by Optically Stimulated Luminescence (OSL), not yet available in Egypt.

Dating thus far can be anchored only in the knowledge from portable OSL profiling carried out on site by T. Kinnaird, which confirms that the stratigraphy is undisturbed and that these layers are substantially earlier than the Neolithic surface of the settlement noted above.

Background

Merimde is indeed unique for its combination of the earliest human-built living structures and adaptation to settled lifeways; however, it is not the only Neolithic site in northern Egypt. The other sites are in the Faiyum - the early and late Fayum Neolithic (albeit with no evidence of a settlement at all, only storage), el-Omari, on the eastern fringe of the Delta, Sais (modern Sa el-Hagar) with some similar traits, albeit slightly later, and Minshat Ezzat in the eastern Delta, which has only been very partially investigated. See Figures 1 and 2 for satellite images and also a reconstruction map of the Delta, which includes a number of Neolithic and earlier prehistoric sites in the area. The reconstruction map includes the cluster of Palaeolithic and Neolithic sites close to Merimde.

The site was located in 1928 (Junker, 1928, 1929, 1930, 1932, 1934 and 1940) as part of the Austrian WestDelta Expedition, during a period of growing interest in prehistory within Egypt; el-Omari (Debono and Mortenson, 1990) and the Faiyum (Caton-Thompson and Gardner, 1934) had been subjected to investigations during the early-mid 1920s already (see background to these sites in the introduction in Rowland and Bertini, 2016). The earlier prehistory of the region was included within a larger Nile Valley survey by Sandford and Arkell (Sandford and Arkell, 1933), with a key environmental thread, and in which it was clear that during the Palaeolithic, the Nile was quite a different river (see Hamdan et al., in press), and that the Delta did not exist. Schmidt, working at the site in the late 1970-80s (Schmidt, 1981), conducted a very brief survey which located – and only intentionally aimed to collect – complete Middle Palaeolithic tools, which were duly published. A conversation with G.J. Tassie clarified that no broader survey had been undertaken at the time. Fig. 3 shows a plan of archaeological activity at Merimde.

The grey zone reflected past views on the extent of the Neolithic site, but recent work by the author of this paper and colleagues shows that it extends, in fact, further west, to the limits shown in the two blue areas. This includes Palaeolithic as well as Neolithic archaeology. The blue areas themselves indicate findspots as part of the Deutsches Archäologisches Institut (DAI) work note, where Schmidt collected complete Middle Palaeolithic tools. The rectangle immediately to the east marks the Wadi el-Gamal, where the author and team conducted surveying and excavation between 2014 and 2019.

The first tranche of investigations took place before the Second World War and have been published in summary articles and reports (Junker and Menghin, entries herein), but, of course, many more people were involved, both Egyptian nationals and foreign nationals. However, the associated archives (consulted by the author and colleagues in Berlin from 2013-16 as part of the TOPOI project, [The Neolithic in the Nile Delta | Topoi](#)) provide a much more accurate account. These archives provide names of participants, both local people living in Beni Salama village and the archaeological teams from Quft, whose families had begun working in archaeology in the last quarter of the 19th century (for example, Quirke, 2010; Rowland, 2014).

The second rounds of activity took place in the 1970s-80s, with Hawass, Hassan, and Gautier's (1988) work focusing on the ancient environment and pinning down the chronology, and with Eiwanger for the German Archaeological Institute (Eiwanger, 1984, 1988 and 1992). The latter began to look into greater detail regarding the site's use phases and the development of the earlier work.



Fig. 1: satellite image of the delta

This phasing, chronological refinement, and investigations into types and location of activities, regional and inter-regional contacts, and reconstruction of the environment have been ongoing since 2013 with the author's team of specialists from Egypt and outside (Rowland and Phillipps, 2012; Rowland and Tassie, 2015; Rowland and Bertini, 2016; Rowland, 2021; Hamdan et al., in press).

Determining the size of the archaeological area

Merimde, including the hinterland and areas now known, is substantially larger than previously thought. Rowland and Bertini (2016, Fig. 2) detail the areas the work has investigated, as sketched out above. However, several of these areas have been under cultivated fields for more than 40 years at the time of writing. Two geophysical surveys in 2013 and 2015 (2013 - Rowland and Bertini, 2016, Fig. 5; Rowland, 2021, Fig. 1) captured the extent of the archaeology on non-cultivated land, although due to cultivation including fruit trees, this could not be extended outside of these areas. Regardless of this fact, it is important to document where the archaeology of the 1920-30s and 1970-80s was located, as although it is doubtful that more can be investigated, it is not impossible, and with the large grid of 10 x 10 m squares originally laid out by Junker, it is known that the team had originally intended to investigate more areas (for the larger areas investigated by various missions see Rowland and Bertini, 2016, Fig. 2). Eiwanger and team's work investigated further to the east of Junker's initial areas and after the initial season opened up a range of areas that presented us evidence for various phases (MBI-V, Early, Middle and Later, with the later phase constituting phases III-V).

This work was likewise ground-breaking as it added a great amount of evidence to what we already knew about the chronology of the site, although there has never been a complete profile located at the site. Eiwanger's publications enable serious consideration of changing spaces for different activities over time (as explored in Rowland, 2022).

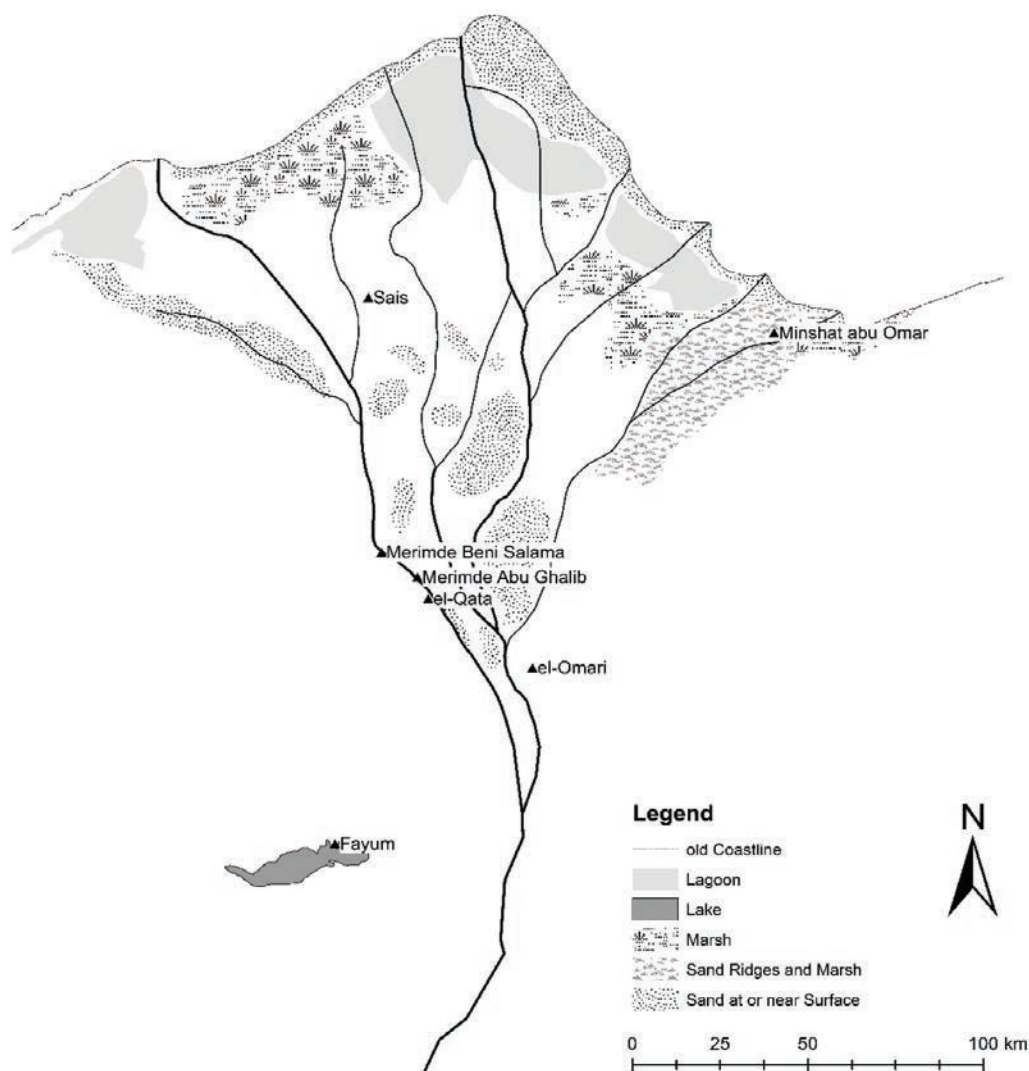


Fig. 2: Reconstruction Map of the Delta

The geophysical survey, as noted above, on and around protected archaeological land had detected areas that had been investigated previously, identified by spoil heaps, for example, as well as areas that had never been investigated, as evidenced by circular pits and possible structures. These areas are highlighted in Rowland and Bertini (2016, Fig. 5) and include archaeology on both sides of the modern asphalt road, with text excavations in both areas confirming that the archaeology includes Neolithic evidence. The Wadi el-Gamal, which is also highlighted in Rowland and Bertini (2016, Fig. 2 in yellow) to the west of the Merimde archaeological land, was investigated firstly with a surface survey in 2014 and then through test trenches in 2015 and 2016, and it is in this area that surface and sub-surface Neolithic and Palaeolithic finds were identified. A large proportion of the area investigated is no longer accessible; however, slightly to the west, test investigations have confirmed further archaeological potential. The area directly south – the current football pitch – appears to be extant, although the land directly south is largely cultivated, and the land to the south is being quarried; this land will ultimately be brought under cultivation.

Outside of this main site and hinterland area, there is also a much broader landscape of human presence dating back to the Middle Palaeolithic, potentially earlier, the Neolithic, and later. Finds relating to these areas were made during earlier survey work by Junker (1928), Sandford and Arkell (1933), and again during the current author's work (notably Rowland et al., 2009). The changes in this area between c. 2009, during one of the author's first visits, and 2013, when the author started a new project and the team returned for the first geophysical survey, were huge. There had been wide open spaces that had been targeted for geophysical survey, but the land had been cultivated with vines and trees and was no longer accessible.

Environment

Past and present climate change are crucial with ongoing work at Merimde as well as elsewhere. Our new techniques, new fieldwork and the new applied to the old (samples) all contribute towards our knowledge as to the environment of the Palaeolithic and then Neolithic at the time, albeit snapshots of the past. New and former work contribute to our extraordinary knowledge of Merimde. Butzer's (1960) work can be favourably compared with the recent studies post environmental continuous coring and on-site analysis of open trenches by Mohamed Hamdan, and hand auger coring by Judith Bunbury. This allows for the reconstruction of profiles of the ancient environment at the site (Hamdan et al., in press). Bunbury's recent volume on the Nile drew on her period of time with our project to facilitate her reconstructions of the Merimde environment as published (Bunbury, 2019).

Looking again to the wider prehistoric environment, Hamdan (Hamdan et al., 2016) examined and analysed sites including modern quarries from c. 20 km further north (Rowland and Tassie, 2015) and was able to relate this past landscape to the current one as visible in 2016 on the Wadi el-Gamal and Merimde to help consider the now largely invisible prehistoric landscape.

Other crucial sources include wood charcoal analysis as undertaken by Alan Clapham on wood charcoal from the Eiwanger excavations in the late 1970s/early 1980s, which enables us to see the varied presence of species of trees, which help with our interpretations concerning the natural environment. Work on macro-botanical remains by Mennat-Allah El-Dorri further helps us to get beyond a simplistic view of the importance of emmer and barley as cultivated species, but in fact allows for glimpses into the potentially deliberate use of field weeds, and of the wider diet of those who lived at Merimde, including various pulses and the exploitation of wild plant resources (El-Dorri pers. comm.).

The modern climate, including climate change exacerbated through human activity, is an important considerations that hinder the preservation of materials today due to increasing cultivation of the fields around this site, which leads to rising (and falling) water tables, which ultimately wreak havoc on fragile organic, as well as artefact remains.

Unique features

To round up with the key unique features, Merimde has domestic architecture associated with domesticated species and cultivated crops. This is not static over time, but growing in size, shifting, with a mobile element, and persisting in maximising the hinterland for the acquisition of wild species (fish, fowl, mammals) and for the grazing of domesticated species. Storage grows in size over time, to quite huge lidded baskets, unusual in comparison to other sites.

At Merimde, there is also evidence of cemetery and burials outside the cemetery areas of the Neolithic and Predynastic (including Badawi et al., 2016). It was one of the first sites with radiocarbon measurements to anchor the chronology (Uppsala series, 1950s), with dating a key aim and achievement in the 1970-80s and the 2000s. The first AMS radiocarbon measurements were run in Poznań by the current project (Rowland, 2022).

At this time period in Egypt, there is a slowly increasing interaction between sites, but, interestingly, the widest range of ceramic fabric types, as discovered through the comparative research of Emmit (2017 and 2020), is at Merimde. This suggests that Merimde might have been the site with the greatest amount of contact with other areas at this time.

Merimde has been the subject of persistent geoarchaeological investigation by Butzer (1960), which is, to some extent, supported by on-site investigations since 2013 by Hamdan (see Hamdan et al., in press). It is still possible to reconstruct the locations of the Middle Palaeolithic terraces and the local environment in the Wadi el-Gamal, and more broadly, as deposits here also tell us much about the closest river at the time. Merimde is exceptionally rare in that it is an open site with in situ evidence of the Middle Palaeolithic. This area is quite unknown within wider Middle Palaeolithic research, which is important, as it very much forms a land bridge between Africa and the Levant, and out to the Mediterranean, and is important within discussions of the Nile corridor – and other - routes out of Africa (e.g. Leplongeon, 2021; Vermeersch, 2020).

There is some small change for further investigating, although thankfully before one area was taken out of commission, a rescue operation was permitted so that a large amount of evidence (lithics, ceramics, other small finds, environmental and OSL samples) could be excavated, and detailed analysis of environmental data made from the open trenches made by the geoarchaeologist M. Hamdan.

The changing modern landscape can introduce additional complexities: during the 1920s-30s excavations, the site was very much within a desert environment; by the 1970s, it was at the desert edge; and today it is within the cultivation, with land reclaimed for the cultivation of plants with local, national, and international reach.

What can be done for the future

As noted elsewhere, there were rescue excavations in 2015 and 2016 on the Wadi el-Gamal, and this material, together with that from excavations on either side of the asphalt and in the lower reaches (or terraces) of the Wadi, is currently being investigated by an interdisciplinary team. This is constantly providing new data in terms of the date of use of certain areas, and interpretations regarding the seasonality of use of the Wadi el-Gamal in particular, and how it relates to the lower land often described as the main site, which we now know to be quite a false view perpetuated for all too long.

Materials, including plant and animal remains as well as artefacts from earlier excavations, are available in collections for analysis. Some analyses have already been undertaken, and as methods advance, smaller and smaller sample sizes are required, which is much more sustainable.

The increasing cultivation around the site has also led to a rise in the water table, which is negatively affecting the finds being made in today's excavations. Organic material, including animal bones and plant remains, is often found in very fragmentary condition, if at all.

Human Adaptations

So, although archaeological contexts and methods are ever improving, the combination of the inability to extract suitable organic material and the limited analytical methods available in Egypt hinders the research that can be done. However, given the possibilities for analysis of material in various European and North American collections, there is still much that can be done, has been done, and will be done.

What is really important, to bring this section on Merimde to a close, is that we continue with our commitment to publicise and publish on the full extent of the team who worked at Merimde and ultimately led to the research, to the investigations, and brought artefacts, ecofacts and structure to life again for us. Publications on this aspect of our work are hugely important, as they reflect the truths about how our knowledge has been created and by whom (Rowland, 2014).

In 2016, the team (with support from the American Research in Egypt's Antiquities Endowment Fund) constructed a low (0.80-1.0 m) demarcation wall around three sides of the main archaeological area of Merimde (the fourth side had to be left due to the rising costs for materials). An on-site guardians' room was also constructed to enable greater on-site presence, providing shelter for guardians in various seasons and a suitable on-site work area for future fieldwork. This helps maintain oversight of Merimde throughout the year. Two information panels – one on the Palaeolithic at Merimde and the other focused on the Neolithic- were installed at the site, close to the road, in August 2024.

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Revisiting the Naqada region in the 21st century: approaches, results, and experiences on the Naqada Regional Archaeological Survey and Site Management Project Revisiting (a) Naqada: Potential and Protection for the Predynastic–Early Dynastic Heritage of Nubt

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Abstract

Prehistoric sites, often invisible or with seemingly marginal surface material remains, can be the hardest to protect; yet they need protection. Within a programme of site management that seeks to share old and newly found knowledge, together with providing physical measures that bind and preserve areas into the future, site management initiatives have been instigated at the two sites focal to the two papers shared within this document. Merimde Beni Salama and Nubt are, in the textbooks, two of the most archetypal sites in Egyptian prehistory, yet beyond academia and some university classrooms, they are rather poorly known, and their importance is not recognised. With no investigations since the early 1980s, both had lacked active on-site investigations that led to growing knowledge and awareness. In 2013 (Merimde) and 2018 (Nubt), the author was involved in new projects in these locations, raising new questions, introducing new methods, and implementing programmes of site management. Aimed at ensuring that new investigations were coupled with protective measures, crucial given that the sites sit today next to the ever-expanding modern floodplain in the northern and southern Egyptian Nile Delta and Valley, respectively. The particular value of these sites, the potential knowledge still within them, and the measures we need to take to protect them are shared over two working papers. Some measures are now in place, others are ongoing. Hopefully, the background, progress, and unique status of these sites are accessible here and demonstrate how they are equally important to the more visible ones.

The Predynastic in the Nile Valley and Delta

The 4th millennium BC in the Nile Valley and Delta is seen as a time of great change. Since the 6th millennium BC and through the 5th millennium BC, the Fayum and Delta (see Rowland on Merimde, this volume) are increasingly settled, first seasonally and then more permanently. In the Nile Valley, from c. 4400–3800 BC sites especially associated with Middle Egypt are often still referred to as ‘Badarian’ after the modern regional name, and although this was once considered region-specific, over the past 15 years increasing evidence is being found over a wider geographical area (including at Elkab, Rowland et al., 2009; Claes et al., 2014) that suggests it is a wider-spread cultural phenomenon rather than a localised ‘culture’.

- Nubt itself can be seen as one of the most important sites of the 4th millennium BC in the Nile Valley alongside Hierakonpolis to its south and Abydos to the north, although Nubt has been subject to less active fieldwork over the decades. Evidence from Nubt includes extensive finds that suggest links with Nubia as well as east to the Red Sea coast and further afield. Urban zones and sacred landscapes are again under investigation through new fieldwork together with archival research, and the site and wider region stand to bring much information to the understanding of the processes that the community of Nubt, and the communities of the Naqada region, lived through in a transformational period in Egypt.

The Naqada region

For archaeologists focused upon the formative periods of Egyptian civilisation, the name ‘Naqada’ is synonymous with the Predynastic period and the thousand-year period before the unification of Egypt at c.3000 BC. Naqada can be and is used to express the ‘culture’, often presented as homogeneous inside the Nile Valley and later in the Delta (Ciałowicz, 2016), and references are made to people as ‘Naqada people’ and ‘Naqadans’ (Mączyńska, 2017). Naqada is associated terminologically with Predynastic and Early Dynastic chronology, i.e. Naqada I, II, III and the internal steps, which is used widely (Kaiser, 1986; Hendrickx, 2006; Hartmann, 2016). The Predynastic in the Nile Valley has been under investigation for more than 100 years, and together with Nubt, the sites of Hierakonpolis (to the south) and Abydos (to the north) are of great importance during this period. These sites have seen substantial and sustained archaeological investigation over many decades, but ironically, given the familiarity with the term ‘Naqada’, comparatively little fieldwork has been conducted at Nubt and in the Naqada region. Flinders Petrie and his team of foreigners and Egyptians conducted the first and most wide-scale excavations on the site during one season in 1894-95 (Petrie and Quibell, 1896).

Subsequent work was carried out in the 1970s and 1980s by an Italian mission from the Università Napoli Orientale (Barocas, 1989 and 1986; Fattovich, et al 2007; Fattovich, 2001), and by Fekri Hassan for Washington State University (Hassan et al., 1980; Hassan and Matson, 1989) which included wider survey work in the region (e.g. Hassan et al., 2021; Holmes, 2018). Finds and archives from these investigations are distributed across the globe, particularly relating to the 1890s investigations. In recent years, there has been a real uptake of research into the legacy data from Nubt, from individuals and larger collaborations (a few very select examples include Brémont et al., 2025; Di Pietro, 2020; Droux, 2024; Kuronuma, 2017; Lhoyer, 2025; Tassie† et al., 2024; van Wetering, 2020; and at neighbouring Ballas, Vanthuyne, 2022). These projects concern the archaeological heritage of Nubt and, in some cases (e.g. Tassie† et al., 2024), the wider Naqada region, and they include various research into those who worked with and for Petrie, and ultimately were responsible for excavating contexts and uncovering finds. Although there are unsurprisingly very few photographs from the time of Petrie’s work, data has been brought together from the Petrie journals and notebooks and are accessible for researchers both via the Petrie Museum of Egyptian and Sudanese Archaeology (e.g. Stevenson, 2020), but also presented within the chronological context of Petrie’s work within Stephen Quirke’s thorough *Hidden Hands* (2010; also see Droux., 2024). Nubt is also known as Petrie’s Naqada site, and there has been much discussion elsewhere about the various sites to which the name Naqada has been attributed by scholars (e.g., Tassie† et al., 2024). Here, the nomenclature of ‘Nubt’ will be used for Petrie’s Naqada site, with Naqada referring to the wider geographical area within modern Qena province, within which are prehistoric sites, including Predynastic/ Early Dynastic, which it is important to consider together when thinking about the unique heritage value of the region.

The 4th millennium. BC is the period during which we see changes that have been described as showing increasing social complexity, expanding exchange between settlements as well as between regions, both internal and external to the Nile Valley. Although the Naqada region and indeed wider Qena province include finds and sites of all periods, from the Palaeolithic onwards (e.g. Taramsa Hill in Qena, Vermeersch et al., 2015; for multi-period research see Stevenson and van Wetering [eds], 2020), over more than 140 years of research in the Naqada region, much of the focus of research, certainly archival, has been upon the Predynastic period.

The current mission, the Naqada Regional Archaeological Survey and Site Management Project, began in 2018 with a regional survey to establish the extent of surface remains in the areas today (often pottery sherds and chipped stone artefacts). In 2019, in our second season, a training initiative was undertaken, and a site management plan was instigated, enclosing two key archaeological areas with low demarcation walls of the type employed at Merimde. Other measures already in place include guardians’ rooms and information panels in Arabic and English.

Ancient Nubt: scope, visibility and scale

The unique heritage of Nubt is today visible in its eastern part across three key archaeological zones, as shown in Fig. 1 (map courtesy of J. van Wetering). In the north (Pyramid Spur) is an area of dynastic importance, with a 3rd Dynasty (mid-3rd mill. BC) non-funerary pyramid, surrounded by graves of the New Kingdom and later date (mid-2nd mill. BC onwards), as determined through artefacts and inscriptions, with earlier activity yet to be determined. This area was walled with funding from the Newton-Mosharafa Institutional Links' Programme (a collaboration between the University of Edinburgh and the French University in Egypt, co-PIs, this author, and F. Hassan) as part of a prehistory training initiative with MoTA inspectors at Nubt and at Merimde. The pyramid has had a condition assessment carried out by conservator H. Jaeschke (2024) and subsequent cleaning (2025) with Jaeschke and our team from Quft and Nubt, which has elucidated the architectural structure. Petrie investigated the structure in his 1894-95 season (Petrie and Quibell, 1896, pp. 34, 65, pl. LXXXV).

The central part of the site comprises the Temple Spur (Temple of Seth), South Town Spur (the main urban zone) and a number of cemeteries of varied dates (see Fig. 1). The temple has only been investigated in so far as the Middle Kingdom and New Kingdom evidence is concerned, carried out by the team of Petrie in the 1890s. Given surface finds around the temple, however, which will be returned to below, it is feasible that earlier shrines existed in this same place, as is known elsewhere in Egypt, e.g. Tell Ibrahim Awad in the eastern Delta, where earlier shrines were overlain by later temples of the Old Kingdom-Middle Kingdom (van Haarlem, 2019).

The urban zone, although disturbed by previous investigations, still has much potential for future research, including plans to use micromorphology to enhance the detail about the types of activities being carried out, the raw materials present, and the environmental processes by which they arrived at the site. Test trenches excavated in the course of planning the location of demarcation walls revealed the first settlement remains at Nubt in 40 years, including redeposited material that may relate to Petrie's investigations.

The third and southernmost area of the site (Fig. 1) includes cemeteries, one of the most significant areas in terms of the Predynastic, being the very southeastern area of the site, Cemetery N T North and N T South, which Petrie referred to as his cemetery T (Petrie and Quibell, 1896, p. 24, pl. LXXXII). This burial area, also reused in a later period, is sometimes referred to as 'elite', given the well-provided burials. The latter use was possibly in relation to/wish to be associated with this early area of ritual significance. Nearby, just a short distance to the west, are two undated tumuli, although thought to be of Predynastic date. Their similarity to Nubian tumuli has been noted (Gatto pers comm), and upcoming investigations will hopefully add new evidence to support or refute the early date.

Monumental heritage is easier in some ways to protect, or at least isolate, due to its visibility, albeit demanding in terms of conservation. Alongside the pyramid and tumuli, the most prominent features at Nubt are the now mainly mud-brick remains of the temple (Petrie and Quibell, 1896, pl. LXXXV), and New Kingdom rock tombs that lie west of the north-south running asphalt road, parallel to Nubt.

Surveys, such as those carried out in the 1970s/80s and today, are crucial for establishing the hinterland and buffer zones of Nubt, and beyond that, the sites of the wider region can be added. The location, in terms of its proximity to the wadis of the Eastern Desert and its links to the Red Sea Hills, Coast, and the wider world, is known here through finds and ongoing research into past finds and archives, as well as new research and perspectives, which will elucidate interrelations across sometimes considerable distances.

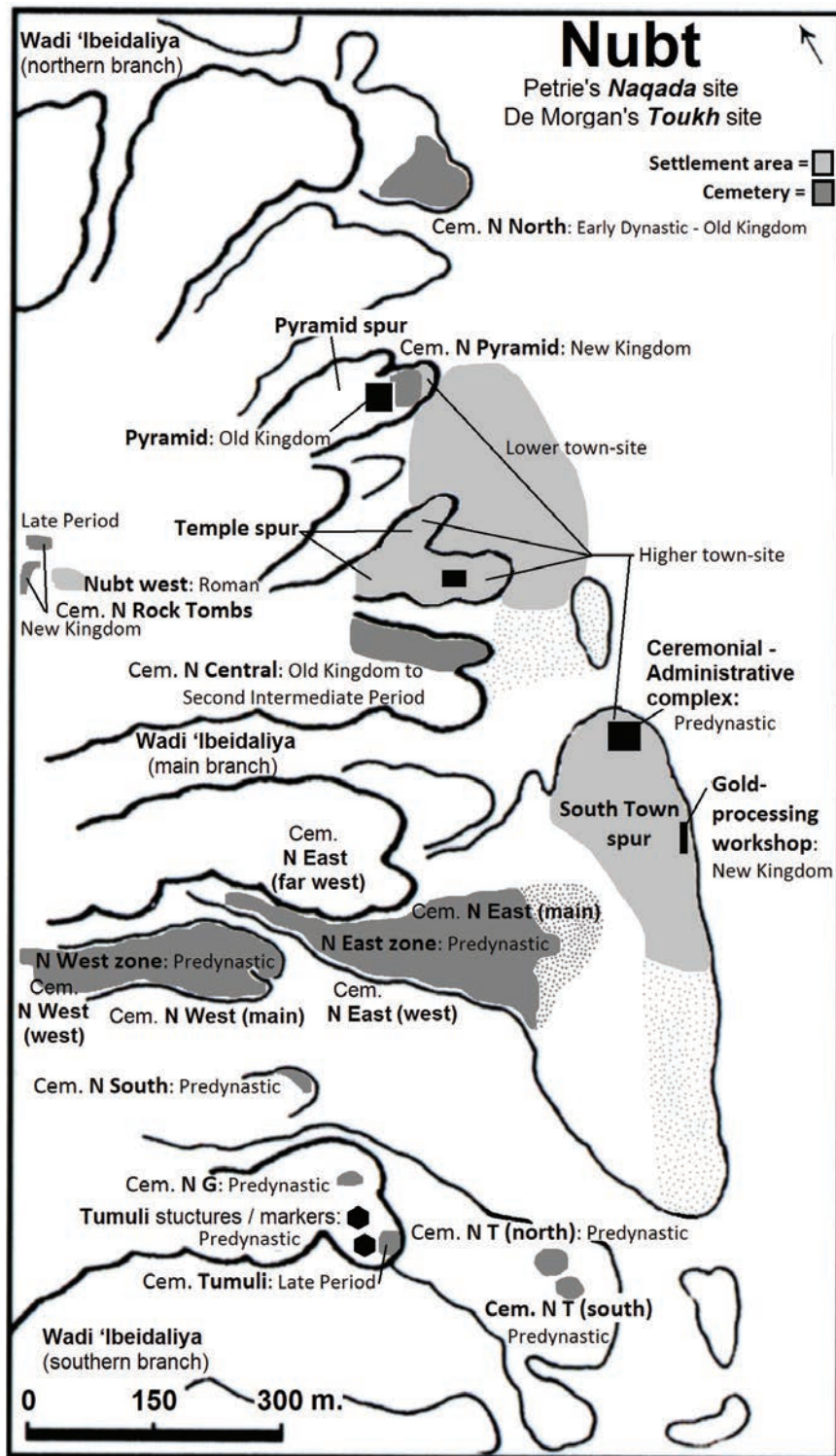


Fig. 1. Map by J. van Wetering.

Human Adaptations

Environment

Before considering the value of the natural heritage in prehistory, it is worth mentioning an area of natural importance here today, on a small gezira just east of the temple mound, which is a haven for birds. Surrounded by reeds and halfa grass, it will be important to preserve this area within an educational initiative, making links with species of birds that were important in the ancient history of the site.

Key in the history of Nubt is the reason why, after c. 3000 BC, the more northerly area of Zawayda is prominent, (Fig. 2) including tombs with stairway access (Petrie and Quibell, 1896, pp. 1-2). The use of this area to the north, bearing in mind that Nubt remains very much in use, could relate to the migration of the local river branch to the east. Future environmental coring in collaboration with M. Hamdan (as at Merimde) is planned to ascertain how the site looked in the 4th millennium. BC, particularly in the earliest period of settlement, and how it changed over a millennium.

The wider region has great potential for contributing to research into the Pleistocene lakes and dams of the Nile River, again in collaboration with M. Hamdan. Research by Vermeersch and Van Neer (2015) and by Leplongeon (2021) details these, and our collaboration with M. Hamdan. This will be hugely important to understanding the landscape and environment within which people experienced life here tens of thousands of years ago in the Palaeolithic, and relates to the unique environmental value of the area.

Future potential for Nubt and the Naqada region

Ongoing archival research is essential and is ongoing, and the work of Brémont et al (2025), Di Pietro (2020), Droux (2024), Kuronuma (2017), Lhoyer (2025), van Wetering (2020), and at neighbouring Ballas, Vanthuyne (2022), continue to bring new perspectives to how we think about the site of Nubt and the wider region, with diaries, journals and photographs from previous investigations alongside the artefacts themselves.

This archival work alone will continue to enhance our understanding of the first people settling at Nubt and in the Naqada region, and how the social environment changes over the crucial period of the 4th millennium. BC.

However, it is through new fieldwork on the ground that we can achieve a lasting and digital record with geomagnetic surveys and photographic (and other) means of creating 3D reconstructions of surfaces as well as monuments to produce lasting, accurate images of the site as it is in the 2000s. New investigations through sampling (coring as well as micromorphology) and excavation bring totally new data, and the potential for vastly new interpretations of the natural as well as social environment.

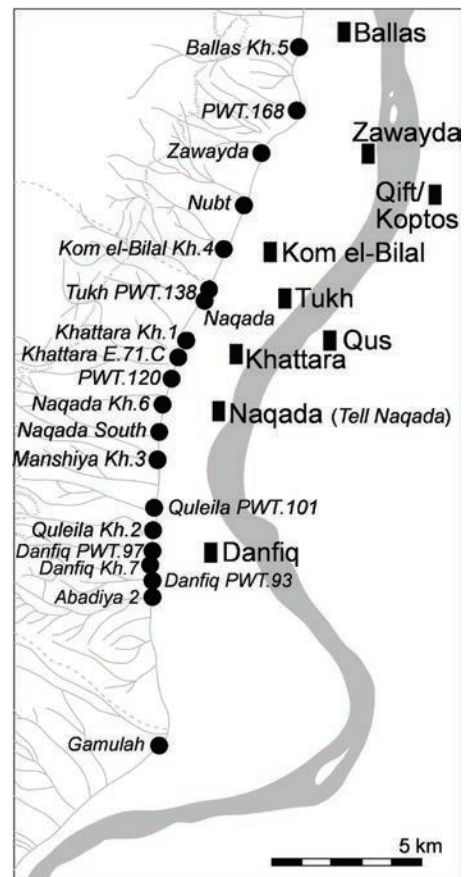


Fig. 2. Map by J. van Wetering.

Protective measures, as described above, together with initiatives to share information and memories of previous projects at Nubt, through co-creation with our MoTA colleagues and the wider community at Nubt and beyond, will be fundamental to the future of the site. The memory of people, both those active in the region during the Palaeolithic, the first settlers, and those who have worked at the site from Lahun, from Quft, and from the local villages themselves with Petrie and Quibell (1896), as well as in the 1970s and 1980s are all crucial within past and future research.

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The Palaeolithic Rock Art of Qurta (Upper Egypt)

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Abstract

The rock art sites of Qurta, located along the east bank of the Nile in Upper Egypt, constitute the first securely dated occurrence of Pleistocene parietal art in North Africa. Scientific investigations, including Optically Stimulated Luminescence (OSL) dating of sediments covering engraved panels, place the production of the Qurta petroglyphs at approximately 17,000–15,000 cal BCE. The rock art is dominated by large, naturalistically rendered depictions of wild animals, especially aurochs, but also includes highly stylised anthropomorphic figures. This paper presents an extensive overview of the characteristics of the Qurta rock art, its archaeological and geomorphological context, and the evidence underpinning its dating. It further situates the Qurta rock art within the broader framework of contemporary Egyptian, North African and Eurasian rock art traditions.

Introduction

Rock art represents one of the most compelling bodies of evidence for human symbolic behaviour in prehistoric societies. Yet, establishing reliable chronologies for rock paintings and engravings remains notoriously difficult. Particularly, the dating of Palaeolithic rock art has long been one of the most contested issues in prehistoric archaeology. Unlike portable artefacts, rock art is often undated by stratigraphy or lacks direct association with occupation layers. Consequently, chronological attribution has historically relied on indirect methods, and for much of the twentieth century, stylistic analysis formed the backbone of rock art chronology. Debates over dating are not merely technical. They have profound implications for our understanding of the cognitive, social and cultural development of early human populations. A well-known example is the discovery of the Altamira cave paintings in northern Spain in the late nineteenth century. Initially dismissed as forgeries due to their sophistication and perceived incompatibility with contemporary views of ‘primitive’ humans, the paintings were only accepted as Palaeolithic decades later, only after subsequent discoveries of cave art across Franco-Cantabrian Europe ultimately vindicated a Pleistocene age (see, e.g. Bahn 2016, pp. 12–20).

More recently, the open-air engravings of the Côa Valley in Portugal, discovered in the 1990s, reignited debates about the dating of rock art, which were instigated and intensified by political and economic factors surrounding plans to flood the valley for hydroelectric development (Ferreiro, Gonçalves and Costa, 2013). While stylistic comparisons suggested an Upper Palaeolithic age, scientific dating attempts produced conflicting results. Ultimately, a combination of stylistic analysis, archaeological context and refined dating methods supported a Palaeolithic date (Aubry and Sampaio, 2008; Aubry et al., 2010; Figueiredo et al., 2014). Similarly, claims for the existence of pre-Holocene rock art in North Africa were questioned or rejected throughout the twentieth century (Huyge et al., 2011, p. 1185). This long-standing paradigm has been fundamentally altered by the discovery, systematic study and science-based dating of the Upper Egyptian rock art site of Qurta, located on the east bank of the Nile, just north of the Kom Ombo plain.

History of research

The rock art sites of Qurta were first discovered in the 1960s by the Canadian Prehistoric Expedition, directed by Philip E.L. Smith (1964; 1965; 1967; 1968a; 1968b; 1976; 1985). The mission, sponsored by the National Museum of Canada and the University of Toronto, was one of the many that responded to the UNESCO appeal for the salvage of the monuments of Nubia threatened by the construction of the Aswan High Dam. Its primary objective was to investigate and document prehistoric remains in and around the Kom Ombo plain, an area undergoing extensive transformation due to the resettlement of Nubian populations displaced by the dam. From October 1962 until April 1963, the Canadians, building on earlier survey work in the area between 1919 and 1924 by the French engineer and prehistorian Edmond Vignard (1885–1969), excavated prehistoric settlements in the northern part of the Kom Ombo plain. The area most intensively investigated was Gebel Silsilah North, a roughly triangular tract of wasteland of about one km², corresponding to a gap in Gebel Silsila East formed by a former Pleistocene stream channel of the Nile. During this period, preparations were underway for the construction of the new Nubian villages of ‘Allaqi and Qurta (erroneously named ‘Korsha’ in Smith, 1967, p. 199). Sixteen Palaeolithic sites were found in this area, yielding, according to the discoverers, five distinct lithic industries. It was on the occasion of this work that the presence of rock drawings on the adjoining rock cliffs was spotted. They represent a large variety of wild animals, executed in a naturalistic style unlike any other known rock art tradition from the Egyptian Nile valley or adjacent deserts to the west and east. Often only briefly mentioned in his published reports, Smith (1964; 1965) nevertheless speculated about a potential high antiquity of these petroglyphs but immediately faced heavy criticism (e.g. Resch, 1967, p. 26). Ultimately, he abandoned this idea and assumed that they were ‘of Holocene age like most or all of the art known to date in northern Africa’ (Smith, 1985, p. 364).

These rock drawings subsequently fell into near oblivion, and it seems that since their discovery in 1962–1963, archaeologists have not visited the site again. As a result, the rock art of Qurta was all but ignored in the scientific literature.¹ In 2005, the sites were relocated by the Belgian Archaeological Mission of the Royal Museums of Art and History (Brussels). This renewed interest followed the discovery in 2004 of a previously unknown rock art locality at el-Hosh (see *infra*), on the opposite bank of the Nile, displaying comparable naturalistic animal representations. Under the direction of the late Dirk Huyge (1957–2018) and the present author, the Belgian mission returned to Qurta with the aim of conducting a systematic and comprehensive study of the rock art. Between 2007 and 2014, intensive surveys resulted in the identification of three principal rock art sites, each comprising several localities with dense concentrations of engravings (Fig. 1). The entire corpus was recorded and documented using both manual tracing and high-resolution digital photography, including RTI and 3D-photogrammetry for selected panels (Hameeuw, Devillers and Claes, 2016). In addition, a geomorphological survey aimed at a better understanding of the environmental setting in which this rock art must have functioned, but also provided important clues with regard to its scientific dating.²

1- A rare example in which the site is mentioned is Wilcox (1984, p. 33).

2- For previously published reports on the work of the Belgian mission at Qurta, we refer to Huyge 2008a; 2008b; 2009; 2018; Huyge and Claes 2008; 2012; 2015; Huyge and Ikram 2009; Huyge and Vandenberghe 2011; Huyge et al. 2007; 2011; 2012.

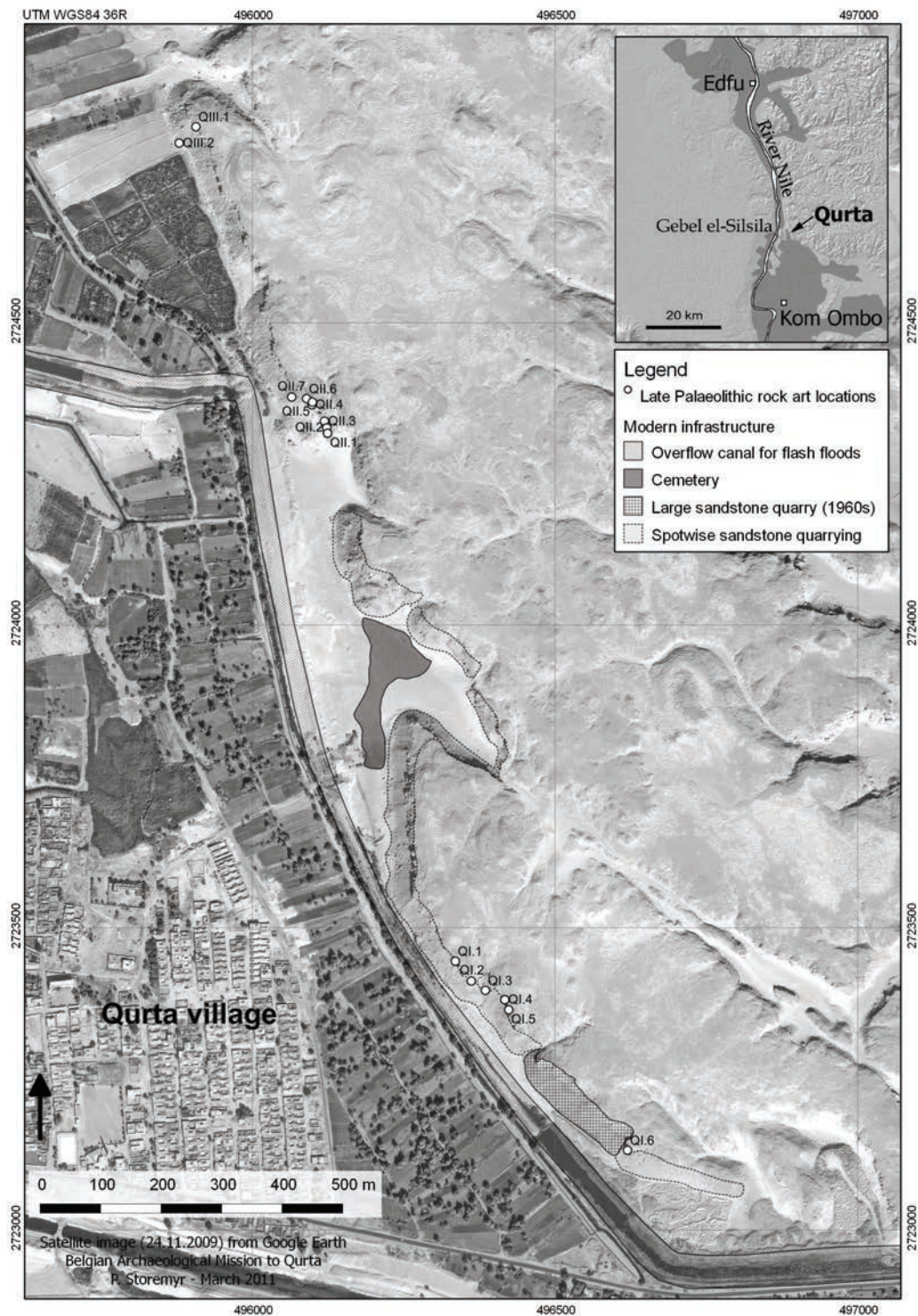


Fig. 1. – Map of Qurta showing the location of the three rock art sites (Map by Per Storemyr, © Royal Museums of Art and History).



Fig. 2. – Qurta II, locality 4, panel 2 showing several representations of wild bovids. Dimensions of the panel: 1.10 × 1.75 m (© Royal Museums of Art and History).



Fig. 3. – Detail of panel 1, Qurta I, locality 1 showing several representations of wild bovids (© Royal Museums of Art and History).

Nature of the rock art

As stated above, three rock art sites were identified (Qurta I, II and III), stretching out along the Nubian sandstone cliffs bordering the alluvial plain. With an altitude of about 35 m to 45 m above the current floodplain, the drawings are generally located on the upper half of the escarpment, although a small number occur on large boulders scattered on the slope of the cliffs, some of which have likely been displaced from their original positions. All these drawings are covered by an advanced and dark patination and/or rock varnish. Located in the open air, they were exposed to wind and rain, resulting in deep traces of intensive weathering and erosion.

Animals and anthropomorphs

Of the nearly 200 individual motifs (Table 1), most feature distinctly naturalistic animal figures, of which bovids are by far the most common, accounting for nearly 75% of the total number of representations. Their physical appearance, in particular their pronounced musculature, broad muzzles and lack of an udder – instead, male genitalia are explicitly depicted in at least three cases –, clearly identifies them as wild cattle (*Bos primigenius* or aurochs; Figs 2–3). Other represented species include birds, hippopotami, gazelle, fish and perhaps a single bubal hartebeest (Fig. 4). They are depicted in a variety of sizes, shapes and poses (see Huyge and Ikram 2009 for detailed descriptions). Alongside these zoomorphic representations, there are also a few hybrid, non-figurative and abstract motifs, as well as a small number of highly stylised human figures (Figs 5–6).

Subject	QI	QII	QIII	Total	%
Bovid (cattle)	93	37	7	137 (117)	74.1
Bird	2	6	4	12 (7)	6.5
Hippopotamus	2	4	-	6 (3)	3.2
Gazelle	3	-	-	3 (2)	1.6
Fish	1	-	1	2 (2)	1.1
Hartebeest	-	1	-	1 (0)	0.5
Indeterminate animal	6	5	1	12 (12)	6.5
Human figure	2	7	-	9 (7)	4.9
Sign	2	-	1	3 (1)	1.6
Total	111	60	14	185 (151)	100.0

Table 1. – General composition of the Qurta rock art assemblages. The total counts include ‘definite’, ‘probable’ and ‘possible/uncertain’ identifications. The number of ‘definite’ identifications is indicated between brackets.

The latter display a female outline, characterised by pronounced buttocks but lack other anatomical features such as head or limbs (Huyge 2018). Their schematic appearance contrasts sharply with the carefully modelled animal depictions and appears to hold a particular position within the visual system of the rock art. This combination of naturalistic animal representations and schematic anthropomorphs is one of the distinctive features of the Qurta rock art.

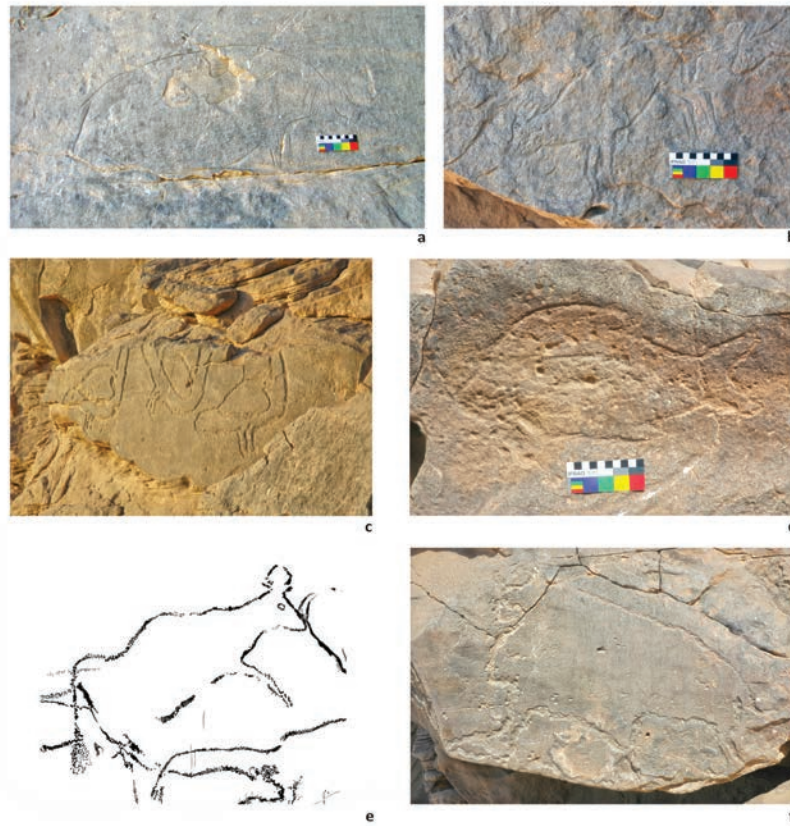


Fig. 4. – Different animal species represented in the rock art of Qurta: (a) hippopotamus (Qurta II, locality 3, panel 1); (b) Dorcas gazelle (Qurta I, locality 4, panel 1); (c) anatids (Qurta II, locality 3, panel 2, length of the panel is about 1.10 m); (d) fish, probably a moonfish (Qurta I, locality 3, panel 1); (e) probable bubal hartebeest (Qurta II, locality 5, panel 1, length of the animal is about 1 m); (f) hybrid creature (Qurta II, locality 6, panel 1, length is about 0.70 m) (© Royal Museums of Art and History).



Fig. 5. – Tracing of panel 1, Qurta II, locality 3 showing six anthropomorphs superimposed by a large bovid. The length of the bovid is 1.86 m (© Royal Museums of Art and History).

Style, composition and technical aspects (Fig. 7)

The engravings are characterised by a high degree of naturalism, with careful attention to anatomical proportions, posture and movement. This stands in glaring contrast to the rather static rock art depictions typical of Predynastic Egyptian rock art. Figures also lack an obvious organisation and should, in general, be considered as isolated images rather than arranged into narrative scenes. They are oriented in multiple directions, and it is not uncommon for an animal's head to be facing upwards or downwards. The fact that they may be conceived as independent motifs, rather than components of structured compositions, could indicate that the mere act of representing a motif was in itself meaningful.



Fig. 6. – Detail of three of the anthropomorphs of Qurta II, locality 3, panel 1 (© Royal Museums of Art and History).

Furthermore, many animals are drawn with a great deal of dynamism (arched backs, bent or flexed legs), representing motion or other behavioural aspects. In this respect, too, the Qurta rock art differs markedly from later Egyptian rock art traditions. Another remarkable aspect of these drawings is their scale. Bovids frequently exceed 80 cm in length, with the largest specimen measuring over 1.80 m! In Predynastic rock art, this type of animal is traditionally depicted on a much smaller scale. Rock paintings have not been identified at Qurta, and the rock art production only consists of pecked and engraved images. In certain cases, both techniques are combined for the creation of a single figure, while some are even executed almost in bas-relief. Natural features of the rock surface, such as cracks and relief variations, were sometimes deliberately incorporated into the imagery to suggest anatomical details or movement.



Fig. 7. – Characteristics of the Qurta rock art: (a) Dynamic poses (Qurta II, locality 4, panel 1); (b) orientation in multiple directions (Qurta I, locality 3, panel 1); (c) integration of natural features: back part of this bovid is rendered by a large natural crack in the rock surface (Qurta II, locality 6, panel 1); (d) bas-relief (Qurta II, locality 5, panel 1); (e) images are pecked and/or engraved (Qurta I, locality 1, panel 1); (f) some images are deliberately left incomplete (Qurta I, locality 1, panel 1); (g) scratches over the head and neck of certain animals (Qurta II, locality 2, panel 1) (© Royal Museums of Art and History).

In addition, some figures appear deliberately incomplete or bear clusters of scratches, particularly around the head and neck. Such features should undoubtedly be interpreted as symbolically meaningful rather than technically accidental.

Archaeological and geomorphological context

Drawing on the work of the Canadian Prehistoric Expedition as well as that of the Yale Prehistoric Nubia Expedition (1962–1965) in the Kom Ombo plain, it is clear that the Qurta rock art sites form part of a densely occupied Late Palaeolithic landscape. Nearby open-air and floodplain sites, such as GS-2B-II (Phillips and Butzer, 1973) or GS-III (Smith, 1966 and 1967) – the latter is located at only a short distance of the Qurta I rock art site – have yielded substantial lithic assemblages and faunal remains as well as some incised sandstone fragments (Smith, 1985, p. 364, n. 3), demonstrating the existence of engraving traditions among Late Palaeolithic Nile Valley populations. The majority of these sites, including GS-2B-II and GS-III, are now attributed to the Ballanan-Silsilian cultural complex (17,000–16,000 cal BCE; see e.g. Vermeersch, 1992, pp. 134–136; Schyle and Uerpmann, 1996, pp. 93–96; Midant-Reynes, 2000, pp. 54–55).³ In addition to the lithic artefacts, numerous animal bones were uncovered in these hunting and butchering camp sites, suggesting the ancient inhabitants of the Kom Ombo plain were hunters and fishermen who primarily exploited the varied natural environments of the Nile floodplain for their subsistence. Their diet consisted mainly of aurochs, hartebeests, a few antelopes, hippopotamuses, several species of water birds and fish (Churcher, 1972; Peters, 1990; Linseele and Van Neer, 2009, pp. 49–54). With the exception of the hartebeest, of which only one (probable) representation has been identified, the faunal spectrum recovered from these habitation sites closely mirrors the animal repertoire depicted in the Qurta engravings. This correspondence strongly suggests that the rock art was produced by, or at least closely associated with, the same hunter-fisher communities inhabiting the Kom Ombo plain during the terminal Pleistocene period. In this respect, it is probably also significant that, as stated above, the rock art is located on the upper half of the cliffs, offering, as such, a panoramic view over the Late Palaeolithic hunting grounds.

These habitation sites are located almost exclusively along the seasonal overflow channels of the Nile, facilitating the exploitation of the different natural environments bordering the river and seasonal floodplain channels (woodlands), the local wadi systems and floor plains (grasslands, thorn-savanna and semi-desert shrubs), and the desert margins (Butzer and Hansen, 1968, pp. 86–195). However, desert species such as Dorcas gazelle, Barbary sheep or the Nubian wild ass are present in the faunal remains as well as in the rock art, though in very limited amounts,⁴ typical desert ungulates such as ibex, oryx or addax are conspicuously absent. This may indicate that the Late Palaeolithic inhabitants of the Kom Ombo plain hardly relied on the available desert resources, most certainly because of the extreme aridity during the Late Pleistocene (Huyge, 2009, pp. 112–115).

Dating the Qurta rock art

In addition to their archaeological context and close association with the Late Palaeolithic habitation sites in the Kom Ombo plain, the intrinsic characteristics, heavy patina and extensive weathering, as well as their marked stylistic divergence from Holocene Egyptian rock art, provide solid lines of evidence to propose a pre-Holocene age for the Qurta rock art.

3- In 2008 a surface concentration of flint scatters was discovered at the foot of the rock cliffs at Qurta III. Some eighty artifacts were collected, including several small cores and tools that are definitely of Late Palaeolithic affinity. In 2009, a similar scatter was discovered in the alluvial plain just south of Qurta II. Here, more than 1,100 lithic artifacts were collected, including a large number of microlithic tools that comprises in particular segments and arched backed, as well as trapezoid backed and truncated types, many with ogival butts. The tool composition at both sites, in particular the microlithic elements, refer to parallels in the late Pleistocene assemblages of the Kom Ombo plain between approximately 20,000 and 10,000 BCE.

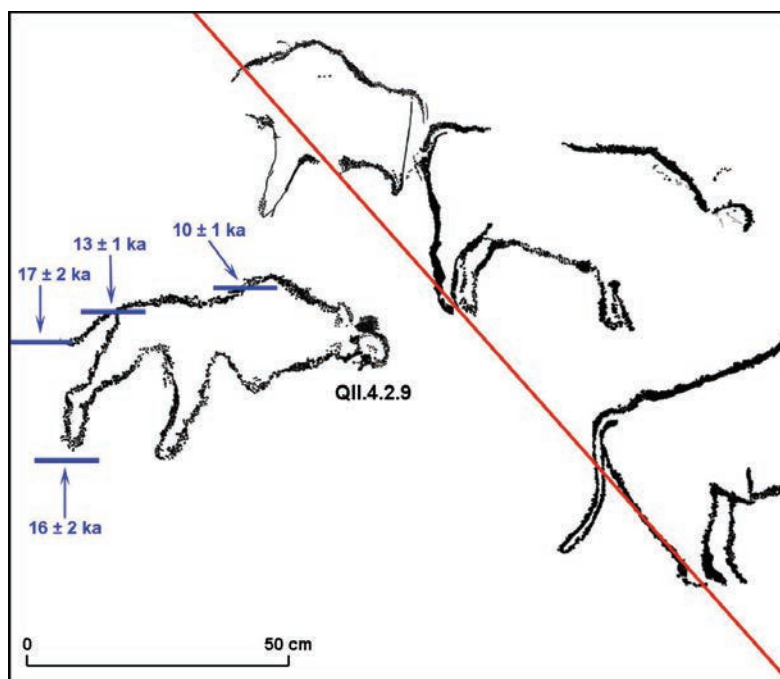


Fig. 8. – Detail of tracing of panel 2, Qurta II, locality 2 with indication of the obtained OSL ages. The red line indicates the top of the sediment accumulation (© Royal Museums of Art and History).

If the creation of these images can be attributed to the hunters and fishers of the Ballanian-Silsilian culture, this would mean that this rock art is more or less contemporary with European rock art from the last Ice Age. Indeed, many stylistic and thematic similarities can be discerned, especially with the Late Magdalenian rock art of Europe (c. 13,500–11,000 cal BCE), which is particularly clear with respect to the stylised and schematic anthropomorphs that are extremely reminiscent of the so-called ‘headless women’ of the Lalinde/Gönnersdorf type. Numerous striking similarities also exist in the aurochs representations (Huyge, 2008, p. 292; 2018; for more elaborate comparative analyses, see Otte, 2014; Guy, 2025).

During fieldwork at the site of Qurta II in 2008, several rock art panels were identified that were still partially buried under a thick layer of sediment accumulations overlain by rockfall debris originating from the scarp. Petrographic thin sections indicated that these sediments were of wind-blown origin, deriving from the Wild Nile palaeofloodplain through aeolian reworking, which made them ideally suitable for Optically Stimulated Luminescence (OSL) dating. Samples taken at panel QII.4.2 yielded depositional ages ranging in date from $10\text{ka} \pm 1$ to $16\text{ka} \pm 2$. The sequence of these dates is fully consistent with the stratigraphical position of the different samples (Fig. 8). As such, these dates provide a secure minimum age for the engravings and confirm their Late Pleistocene attribution. Their true age remains as yet unknown, but given their advanced degree of surface weathering, their actual age is likely to be significantly higher than the obtained minimum ages (Huyge et al., 2011; 2012; Huyge and Vandenberghe, 2011).



Fig. 9. – Example of a rock drawing of a wild bovid at el-Hosh, locality ATB-11 (© Royal Museums of Art and History).



Fig. 10. – Adel Kelany (MoTA) posing next to a rock drawing of a wild bovid at Wadi Abu Subeira (photo by Dirk Huyge).

The rock art of Qurta in a regional and (inter)continental perspective

The rock art of Qurta stands apart from all later prehistoric and dynastic Egyptian rock art traditions. Its purpose and motivation remain, for the time being, open questions and subject to active research. The focus on wild animals and their naturalistic representations suggests, in any case, an intimate knowledge of and perhaps also reverence for the fauna that sustained the Pleistocene populations responsible for the creation of this rock art. Their location high on the sandstone escarpments overlooking the hunting grounds in the floodplain could indicate a ritual dimension, perhaps tied to hunting magic or symbolic control over animal resources (Huyge, 2009, pp. 114–115), but additional data are needed to answer such questions. Fortunately, two conspicuously similar rock art sites are known from the same area and display a comparable repertoire of rock art, both from a thematic and stylistic point of view. At locality ATB-11 at the site of el-Hosh (Fig. 9), located a few kilometres north of Qurta on the opposite side of the Nile, an assemblage of 37 petroglyphs was recorded, dominated again by depictions of wild cattle, but fish and a single anthropomorph are also present (Huyge, 2009, p. 113; Huyge et al., 2011, p. 1190; Huyge, 2018, p. 421). Further south, a larger collection of similar rock art was also discovered by the Egyptian Ministry of Tourism and Antiquities (MoTA) at different locations in the wadi Abu Subeira, just north of Aswan (Fig. 10). It is composed exclusively of wild animals but displays a wider variety of species, comprising, besides a large number of bovids, also fish, birds, hippopotami, ibex, gazelle, camels, African wild dog, bubal hartebeest and Nubian wild ass (see, e.g. Storemyr et al., 2008; Kelany, 2014; Kelany, 2023, pp. 270–273). In the early 2010s, more depictions of wild animals were discovered in the al-Zolma rock shelter in the northern Sinai, which are currently under study by an Egyptian Mission of the MoTA. Animals such as ibexes, oryx, dromedaries, equines, ostrich and potentially also gazelle and/or antelopes are depicted in combination with two schematic human figures (Zboray, 2012; Huyge, 2018, p. 421). Whether these images are also of Pleistocene age remains to be confirmed, but it seems very likely.

It is clear that the rock art at Qurta is not an isolated case, and besides the three above-mentioned sites from Egypt, at least two similar sites are known from the Libyan coast. At Caf Eligren, several rock drawings of aurochs, also depicted in a naturalistic style, may also date to the late Pleistocene (see Huyge et al., 2011, p. 1191 for more information and further references). The recently discovered Libyan site of Kaf Tahr may be another occurrence where such rock art was produced (Marini, de Faucamberg and Katab 2010), while paintings in the cave of Ifri n'Ammar (Morocco) are also dated to the Late Palaeolithic (e.g. Eiwanger, 2003). In Afalou Bou Rhummel (Algeria), numerous clay figurines representing animals and humans were excavated from Upper Palaeolithic contexts (Hachi et al., 2002). Strictly speaking, the latter are not rock art but add to a North African Palaeolithic artistic tradition that was much more widespread than was previously known.⁵ The close similarities of the Qurta petroglyphs with European Palaeolithic rock art have already been stressed, but stylistically comparable rock depictions of potential Pleistocene age are also known from the Eurasian continent. At Gobustan (Azerbaijan), naturalistic animals occur in combination with stylised female figures at several open-air sites (e.g. Sigari, 2013).

Although the contemporaneity of some of these sites remains to be established, their close resemblances and often even clear formal similarities to the rock art of Qurta raise various challenges and questions regarding trans-Mediterranean cultural-artistic interaction, exchange, (direct?) contact or even an (northern) African origin of certain motifs.

Conclusion

The rock art of Qurta represents a landmark discovery in the recent history of Egyptian and, even more broadly, African archaeology. Its robust chronological framework, backed by science-based dating, securely places it within the Late Palaeolithic. As such, these petroglyphs currently constitute the earliest scientifically confirmed parietal rock art in North Africa. This has fundamentally challenged long-held assumptions that such traditions were absent from the region prior to the Holocene. In stylistic, technical and thematic terms, the Qurta corpus reveals a highly developed artistic tradition that reflects the ecological realities of the Late Pleistocene Nilotic environment as well as the intricate symbolic and cognitive world of its inhabitants. From a regional perspective, Qurta stands apart from all later Egyptian and Saharan rock art traditions. In addition to various stylistic elements, the total absence of domesticated animals separates it both chronologically and culturally from Holocene pastoralist and Predynastic rock art. Within a broader comparative framework, the repertoire of the Qurta rock art reveals a level of sophistication that, in addition to its many stylistic and conceptual similarities, resonates with contemporaneous Palaeolithic art traditions beyond the African continent, in particular in its combination of naturalistic drawn animal representations and stylised schematic anthropomorphs.

5- Much older finds, dating back to the Middle Stone Age and showing graphic expressions, are known for quite some time from the southern part of the African continent. Examples include the Apollo 11 cave in Namibia (stone plaques with painted animals) or the Wonderwerk and Blombos caves in South Africa where engraved ochre and stone plaques were discovered (for an overview, see Bednarik 2013).

While the mechanisms underlying these similarities – whether independent innovation, long-distance interaction, or deeper shared traditions – remain open to debate, the Qurta rock art compels a reassessment of Africa's role in broader discussions of Late Pleistocene artistic expression. As the body of comparable sites in Egypt, North Africa and parts of Eurasia has grown considerably in recent years, the emerging data hold significant potential to refine our understanding of the emergence, development and regional diversity of early graphic traditions and cognitive symbolic behaviour. In this respect, the Qurta engravings are a crucial reference point for future investigations into the deep history of human visual culture.

Acknowledgments

The author expresses his gratitude to all the persons who have contributed to the field work of the Belgian mission, in particular its director, the late Dirk Huyge (1957–2018). The research at Qurta was executed with the kind permission and support of the Egyptian Ministry of Tourism and Antiquities and its local inspectorates at Aswan and Kom Ombo. Funding was provided by the Research Foundation Flanders (grant 1.5.002.03) and the William K. and Marilyn M. Simpson Endowment Fund of Yale University, Department of Near Eastern Languages and Civilisations. Administrative and logistical support was kindly offered by the Netherlands-Flemish Institute in Cairo and Vodafone Egypt.

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Preliminary Results of the International Conference on the Cultural Heritage of Human Adaptations : from the scholars' perspective

The International Conference on the Cultural Heritage of Human Adaptations held from the 17th to the 20th of February in 2025 is the result of a close collaboration established by the Supreme Council of Antiquities (SCA) and the UNESCO Regional Office for Egypt and Sudan. This conference aimed to bring together leading international and national experts to explore key aspects of prehistoric heritage, including rock art, early human occupations, evidences of climate change adaptations, and paleolandscapes.

Through a multidisciplinary approach, the conference examined how past human societies adapted to their environments, interacted with changing landscapes, and developed unique cultural expressions. Special emphasis was placed on the archaeological significance of Egypt and Sudan, particularly regarding to Paleolithic and Neolithic sites, rock art manifestations, long- sequence cultural sites.

One of the key objectives of this gathering was to discuss how these scientific insights can inform heritage management policies and contribute to the process of updating the Tentative List World Heritage sites in Egypt while assessing the role of the predynastic sites in the definition of the outstanding values of Egyptian Heritage. The conference provide a platform for exchange between archaeologists, geologists, heritage managers, and policymakers, fostering dialogue on best practices for the documentation, conservation, and sustainable management of prehistoric sites. By engaging experts from diverse disciplines and covering a wide geographic scope, this event seeked to highlight the Outstanding Universal Value (OUV) of prehistoric and early historic sites, reinforcing the need for their recognition, protection, and integration into contemporary heritage conservation framework.

Workshop

Based on the case studies presented, and to offer a list of suggestions to the National Authorities, scholars proposed establishing thematic clusters of sites and related narratives that merit national or international documentation, research, conservation, and, eventually, international recognition .¹

The results of the discussion agreed to establish 4 categories of analysis:1) Palaeolithic, 2) Neolithic, 3) Rock art, 4) Predynastic/early dynastic periods. Participants analysed the importance of these sites, their potential for thematic and comparative studies, and outlined strategies to enlarge the existing national records. Moreover, some of those sites could be considered by National Authorities as possible future candidates for the UNESCO Tentative lists.

Group 1: Palaeolithic

- Dr. Nicholas Conard (Chair)
- Dr. Karin Kindermann (Reporter)
- Dr. Maria Gatto
- Dr. Jan Kuper
- Dr. Knut Bretzke
- Dr. Mohamed Hamdan

1- Dr. Nuria Sanz, Clara Epperlein, and Hebatallah Ibrahim, from the UNESCO Regional Office in Cairo, coordinated the workshop and prepared the conclusions of the working groups.

Group 2: Neolithic

- Dr. Arkadiusz Marciniak (Chair)
- Dr. Dorian Fuller (Reporter)
- Dr. Jacek Kabaciński
- Dr. Joanne Rowland
- Ms. Hebatallah Ibrahim
- Dr. Mohamed Hamdan

Group 3: Predynastic and Historic

- Dr. François Semah (Chair)
- Dr. Mohamed Kenawi (Reporter)
- Dr. Mohamed Elhassan
- Dr. Mohamed Nsreldein
- Prof. Intisar El-zein Soghyroun
- Prof. Mostafa Atallah

Group 4: Rock Art

- Dr. Paweł L. Polkowski (Chair)
- Dr. Serena Nicolini (Reporter)
- Dr. Julien Cooper
- Mr. Wouter Claes
- Dr. Hesham Hussein
- Mr. Adel Kelany

Group 1: Palaeolithic (Pleistocene Hunter-Gatherer adaptation)

Sites to be considered

Early Stone Age (ESA)

A. Sai Island (Early Settlement along the Nile)

Middle Stone Age (MSA)

- B. Bir Sahara/Bir Tarfawi (Pleistocene lakeshore hunter-gatherers)
- C. Sodmein Cave (Settlement Sequence Red Sea Hills)
- D. Taramsa/Nazlet Khater (Pleistocene Mining and Workshops)

Late Stone Age (LSA)

E. Wadi Kubbaniya/Qurta (Terminal Pleistocene Nile Refugium and Vision)

2. League

F. Djebel Sabaha (Adaptation and Conflict of Late Hunter-Gatherers)

Human Adaptations

A. Sai Island – Early Settlement

Chronology:

ca. 100,000 – 3000 BCE

Evidence of early human habitation from the Palaeolithic period (stone tools and settlement traces), and Neolithic presence (ca. 5000–3000 BCE) with pottery, grinding stones, and burial sites, indicating early settled communities.

Narrative

Sai is a large island on the Nile (12 x 5.5 km) situated between the second and third cataracts in Upper Nubia. It is the most oversized island on the River Nile. Sai Island is an exceptional testimony to early human occupation in this part of Africa, notably by *Homo erectus* and *Homo sapiens*.

It is also well known for the Pharaonic and Kerma culture sites. It is one of the rare sites in the entire NE-Africa showing a long occupational history in a stratigraphic context extending from the Middle to the Pleistocene, and also providing early attested evidence for the use of colour worldwide.

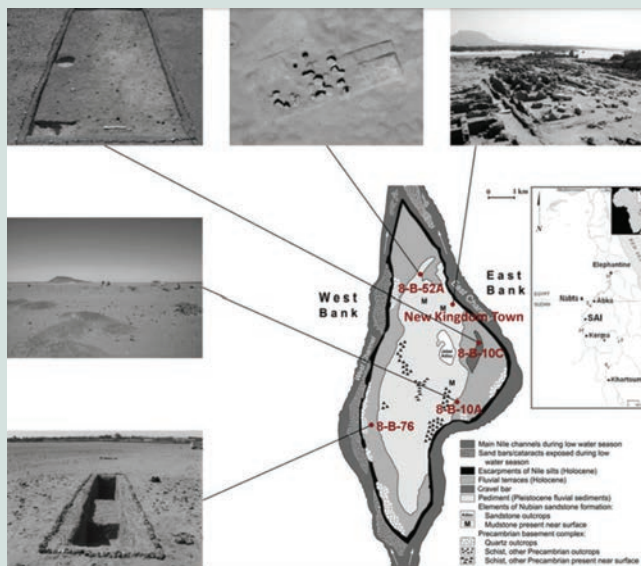


Fig 1. Map of Sai Island showing the archaeological sites (after Garcea & Hildebrand 2009).

B. Bir Sahara/Bir Tarfawi – Pleistocene lakeshore hunter-gatherers

Chronology

Middle Stone Age/Pleistocene, and Late Stone Age/Pleistocene dates between (ca. 135,000 ± 21.6 – 41,000 BP)

Narrative

Bir Sahara and Bir Tarfawi are significant prehistoric archaeological sites located in the Western Desert of Egypt. These sites provide valuable insights into early human adaptation, climate change, and settlement patterns in the region.

- Intensive geological research based on stratigraphic sedimentology has been conducted.

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Fig 2. The Location of Bir Tarfawi and Bir Sahar is in the south of the Western Desert, west of Toshka and Nabta Playa.

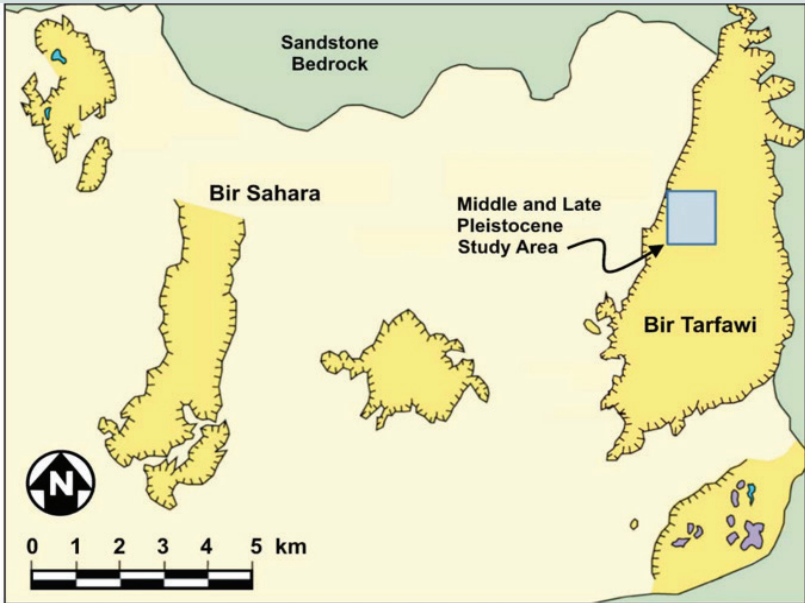


Fig. 3. Bir Tarfawi and Bir Sahara area erosional basins. The yellow areas are deflationary depressions that contain Middle and Late Pleistocene sediments

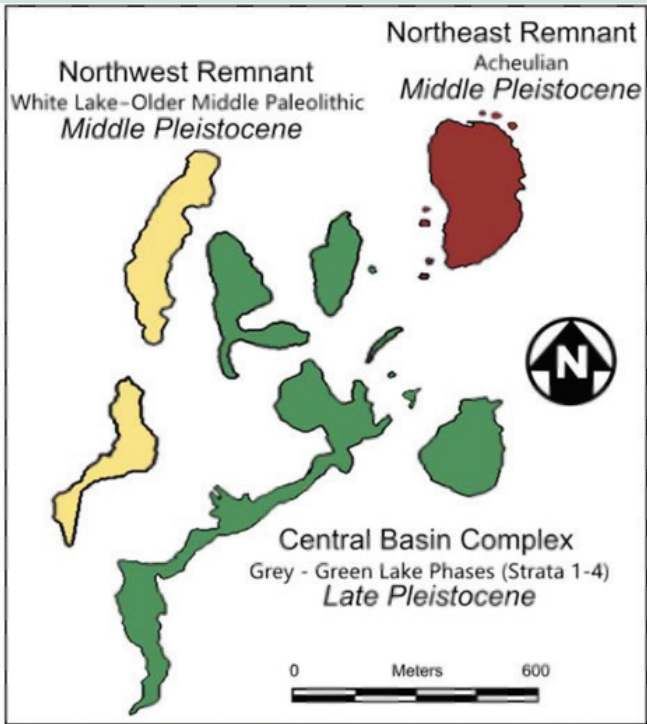


Fig. 4. Map highlights the Middle and Late Pleistocene sedimentary remnants in Bir Tarfawi (Middle Pleistocene sediments associated with Acheulian artefacts are brown, Middle Pleistocene sediments associated with Middle Palaeolithic artefacts are yellow, and Late Pleistocene sediments with Middle Palaeolithic artefacts are green)



Fig. 5. Map showing the location of Sodmein Cave, Tree Shelter Cave and Saqia Cave

C. Sodmein Cave – Settlement Sequence Red Sea Hills

- Sodmein Cave
- Tree Shelter Cave
- Saqia Cave

Chronology: 123,000 $\pm$ 15 – 86,000 $\pm$ 9 BP

The Sodmein Cave is one of the rare living sites in this time frame in north-eastern Africa; it comprises a key site for the reconstruction of Late Pleistocene human-nature interaction.

The sequence — more than 4m in thickness, containing stratified human occupation debris — indicates that Sodmein was visited regularly by humans during the Pleistocene and later during the Holocene (Kindermann et al., 2013). During an archaeological survey conducted by the universities of Cologne and Leuven, such a new open-air site associated with Pleistocene lacustrine deposits in proximity to the Sodmein Cave was discovered. The recorded lithic artefacts, which eroded out of the sediments, can be attributed to the Middle Stone Age (MSA). It is located about 40km north-north-west of the seaport Quseir in an isolated Tertiary limestone complex (Djebel Umm Hammad/Djebel Duwi) of the Red Sea Mountains.

- The Sodmein Playa is the first instance in the Eastern Desert of Egypt to demonstrate Pleistocene human occupation in association with a lacustrine environment.

D. Taramsa/Nazlet Khater – Pleistocene Mining and Workshops

Series of sites

Chronology:

Nazlet Khater: 35,100 – 30,360 BP

Taramsa: 68,600 $\pm$ 8000–38100 $\pm$ 1400BP

Narrative

Human chert extraction over 100,000 years and human remains. Nazlet Khater is an archaeological site located in Upper Egypt that has yielded evidence of early human culture and anatomically modern specimens dating to approximately thirty to fifty years ago. Excavations at the Nazlet Khater 2 site in 1980 yielded the remains of two human skeletons.

Taramsa 1 is a key site in Northeast Africa, bearing witness to a long sequence of change culminating in the emergence of Upper Palaeolithic blade technology.

Human Adaptations

Most significant is the dating of the earliest stage of the transition to around 60,000 years ago, suggesting that the Lower Nile Valley was an early core area for the origin of the Upper Palaeolithic of Eurasia (Van Peer et al., 2010). On the left bank of the Nile, south of the town of Qena in Upper Egypt, several chert extraction sites in the desert near the village of Taramsa have been the focus of archaeological explorations since the 1980s (Vermeersch et al., 1995). The site of Taramsa-1 is one of them. It was discovered in 1985 during a survey by the Belgian Middle Egypt Prehistoric Project of Leuven University (Vermeersch et al., 1987). It was registered as site E85/2. The team carried out excavations in 1989, 1991, and 1994 (Vermeersch, 2002).

Taramsa 1 cannot be considered a residential site, but over the ages it was a resource exploitation site that was of great importance to hunter-gatherer groups who found refuge in the nearby Nile Valley. Of the latter, however, no remains have been found to date, perhaps because the sediments in which they might be contained are either covered by younger Nile deposits or eroded.

The site of Taramsa 1, therefore, has a unique place in Egyptian prehistory. Indeed, no other site in Egypt has revealed evidence of such a long later Pleistocene human occupation. Indeed, on this site, human activity can be followed from MIS 5 up to the period of MIS 3, albeit with numerous periods of absence of exploitation, which may have been associated with the disappearance of the population in the Nile valley due to unfavourable environmental conditions. No other site can trace the successive techniques used in the processing of stone raw materials.

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Fig 6. Mapshowing the location on Taramsa

E- Wadi Kubbaniya/Qurta – Terminal Pleistocene Nile Refugium and Vision

Series of sites

Narrative

Abstract

Wadi Kubbaniya is a significant Late Palaeolithic archaeological site located in Upper Egypt, approximately 30 kilometres northwest of Aswan, on the western bank of the Nile River. This area, characterised by a dried-up streambed (wadi), was once a fertile region that supported early human settlements. Archaeological excavations at Wadi Kubbaniya have uncovered diverse and sophisticated stone implements used for hunting, fishing, and plant processing, dating back to approximately 17,000–15,000 BC. These findings offer valuable insights into the subsistence strategies and daily lives of Late Palaeolithic communities in the region.



Fig. 7 Map showing the location of Kubbaniya

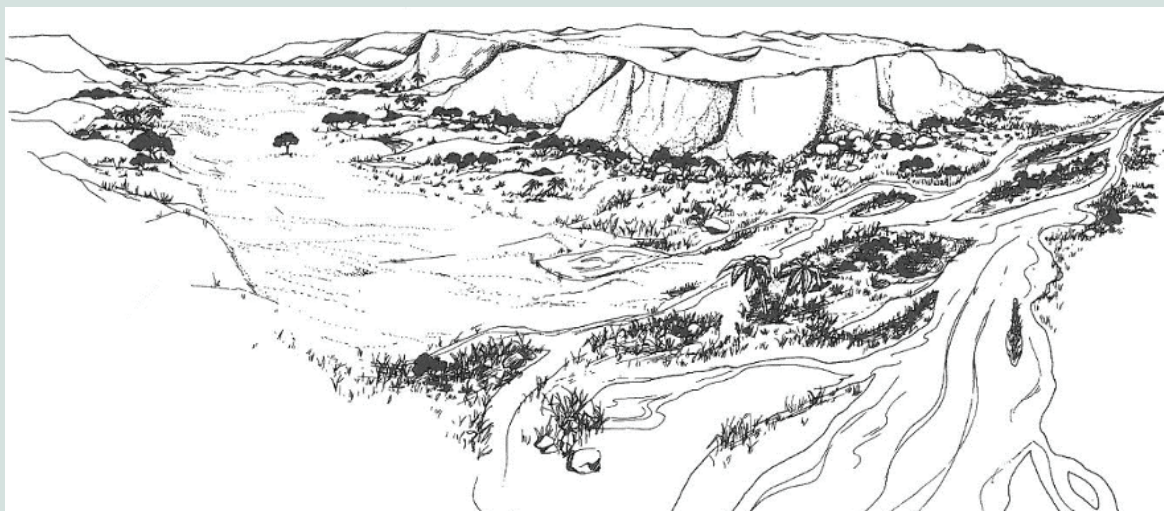


Fig. 8. A drawing illustrating the site of Kubbaniya



Fig. 9. Map showing the location of Qurta south of Edfu, Aswan

F- Djebel Sahaba – Adaptation and Conflict of Late Hunter-Gatherers

Chronology:

13.000 BP – Terminal Pleistocene

Narrative

Djebel Sahaba is a prehistoric cemetery in the Nile Valley (now submerged in Lake Nasser), near the northern border of Sudan with Egypt in Northeast Africa. It is associated with the Qadan culture. It was discovered in 1964 by a team led by Fred Wendorf. Since their discovery, the Jebel Sahaba skeletons have been repeatedly re-evaluated by anthropologists seeking to determine the circumstances of their deaths. As of the most recent study (2021), it seems most likely that the war (dating to c. 12th millennium BC) was driven by resource scarcity due to climate change. Tribes of the Qadan culture partook in a series of raids and ambushes against one another with projectile weapons - mostly light arrows, but also much heavier arrows or throwing spears.

The site is often cited as the oldest known evidence of warfare or systemic intergroup violence. However, as of 2021, the earliest documented evidence of interpersonal violence appears to be the partial remains of a skeleton in Wadi Kubbaniya from 20 ka.

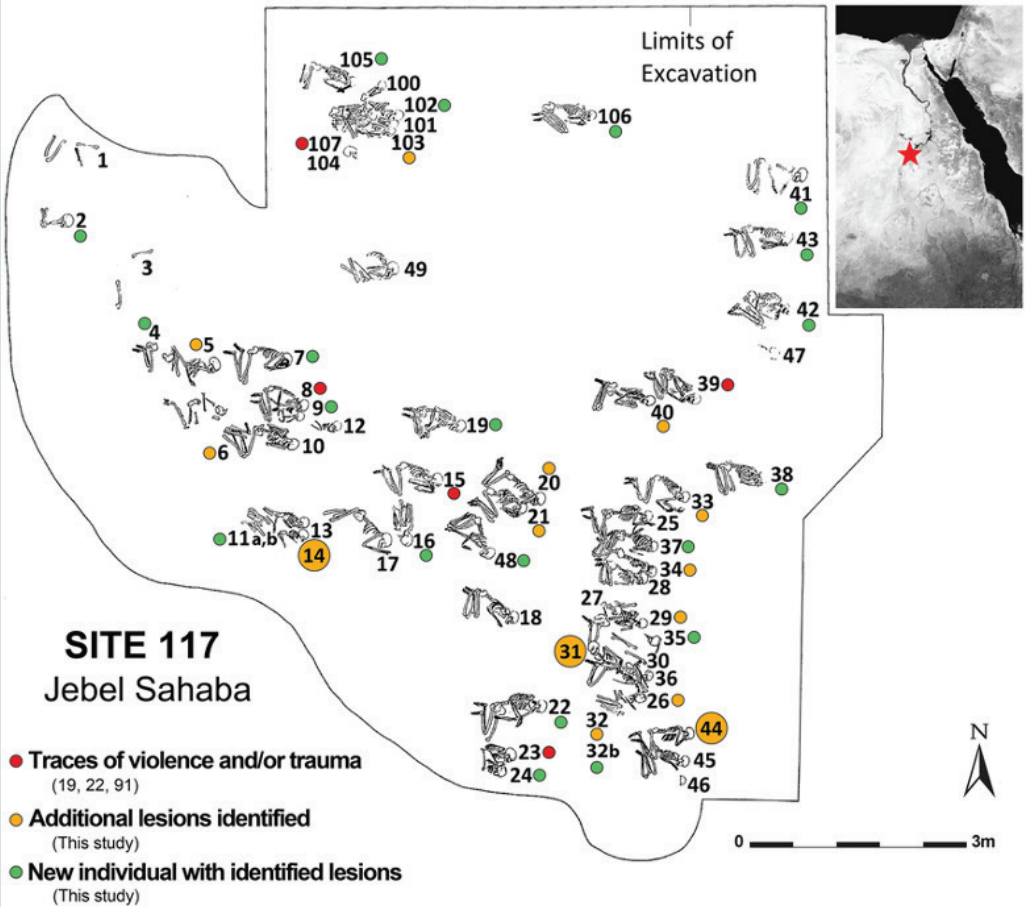


Fig. 10. Jebel Sahaba

Human Adaptations

Group 2 – Neolithic

Nile Delta Neolithic and origins of Nilotic agricultural societies

Series of sites

A1 Merimde Beni Salama

A2 Sais

A3 El-Omari

A4 Tell es Samarra

A5. Maadi

A6. Tell el Farkha

Chronology: 5000 BC to 3000 BC

Narrative

These sites preserve evidence for a key transformative period in the human occupation of the Nile valley. This includes the establishment of Nilotic agriculture and pastoralism, sedentary village occupation, and the development of long-distance supply networks for rare materials not locally available (e.g., copper, lapis lazuli, upper Egyptian stones). This new cultural ecology provided the context for the emergence of social, technological, and artistic innovations, including the construction of housing structures, the first three-dimensional sculptural work in the Nile valley, and the first beer production.



Fig. 11. Example of Merimde Beni Salama with 2 core areas with a surrounding buffer zone of 2 sq. km

Key points to develop in the narrative

- Arrival of domesticated cereal agriculture
- Arrival of domesticated animals
- Sedentism emerges in the Nile Valley
- First villages with architecture, including storage facilities
- Interregional trade, including the import of exotic raw materials, such as copper, Lapis, obsidian, and upper Egyptian stone types

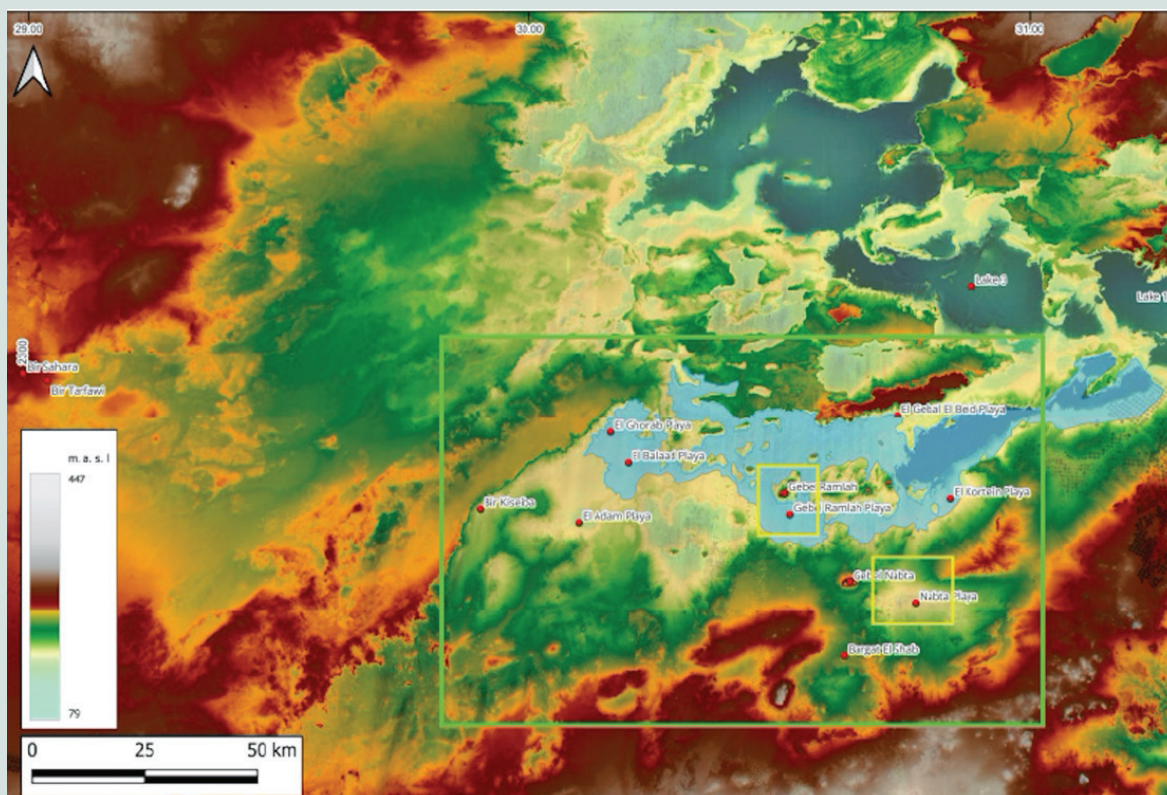


Fig. 12. Map of the southern part of the Western Desert showing the key sites (with red dots), wider areas for preservation in yellow; buffer zone in green.

- Adaptive settlement of the alluvial plains based on raised “turtleback” mounds with the exploitation of wetland resources and cultivation of autumn alluvial deposits around these mounds. This becomes the basic, recurrent settlement system throughout the Egyptian Nile valley during subsequent pharaonic periods.
- First Beer production in the Western Delta, Egypt.
- The earliest sculptural practices in Egypt, including human and animal clay models from Merimde and Elite “rule” statues from Tell el Farkha, were adorned with gold and Lapis.

B. Nabta Playa and Gebel Ramlah lake adaptations of hunter-gatherers and early pastoralists of the Sahara

Series of sites

- B1. Nabta megalithic constructions and sacred mountain
- B2. Gebel Ramlah palaeolakes
- B3. Gebel Ramlah ceremonial centre
- B4. Berget El Shab Playa
- B5. El Adam Playa
- B6. El Gebel El Beid Playa
- B7. El Kortein Playa

Human Adaptations

Chronology: Two main phases of adaptation.

- (1) Green Sahara Hunter-gatherers, 11,000-8200 BP
- (2) Early Pastoralists, 8000 BP-5500 BP

Narrative

This cluster of sites in the desert of Southwest Egypt illustrates the long-term dynamics of climatic shifts from wetter to drier conditions, as well as human adaptations to a landscape with seasonal lakes and summer grasslands. Through this sequence, we see the transformations of human economies and social systems, including the adoption of livestock and nomadic pastoral adaptations, and long-distance trade, including material from the Nile, the Red Sea coast, and the Sudanic savannas. These transformations include the marking of the landscape with stone-built monuments and formal cemeteries, as well as evidence for the recognition of calendrical cycles and their astronomical indicators.

Key elements

- The sequence illustrates long-term climatic shifts and human adaptations to the Sahara Desert.
- The sequence illustrates the increasing long-distance interconnectivity of human groups
- Specialised hunting of Sahelian smaller faunae, esp. dorcas gazelle (1)
- No fishing, but some mollusc use (1)
- Wild grass gathering and intensive processing (1)
- Early ceramics (1)
- Evidence for creation houses for seasonal settlement (1)
- Adoption of sheep, goat and cattle (2)
- Discussion of the role of these pastoralists and African wild cattle in contributing to the African cattle population
- Increasing investment in ceremonial behaviour, and marking of the landscape through monumentality
- Evidence for the recognition of calendrical cycles and astronomical alignments
- Emergence of formalised burial practices, cemeteries, and individualised primary internments
- Recognition of age differences with a dedicated Neonate cemetery
- Evidence for long-distance trade contacts, e.g. red sea shells, Nile oyster, amazonite beads, ivory

C. Sahelian Neolithic and origins of savannah agriculture

- C1. El Shaneinab
- C2. Shaqadud
- C3. Kasm el Ghirba 23
- C4. Jebel Moya
- C5. Kadero
- C6. el Ghaba
- C7. Al Khiday
- C8. Jebel Sabaloka
- Add Mahal Teglinos [near Kasala]

Chronology, 11000 BP- 4000 BP

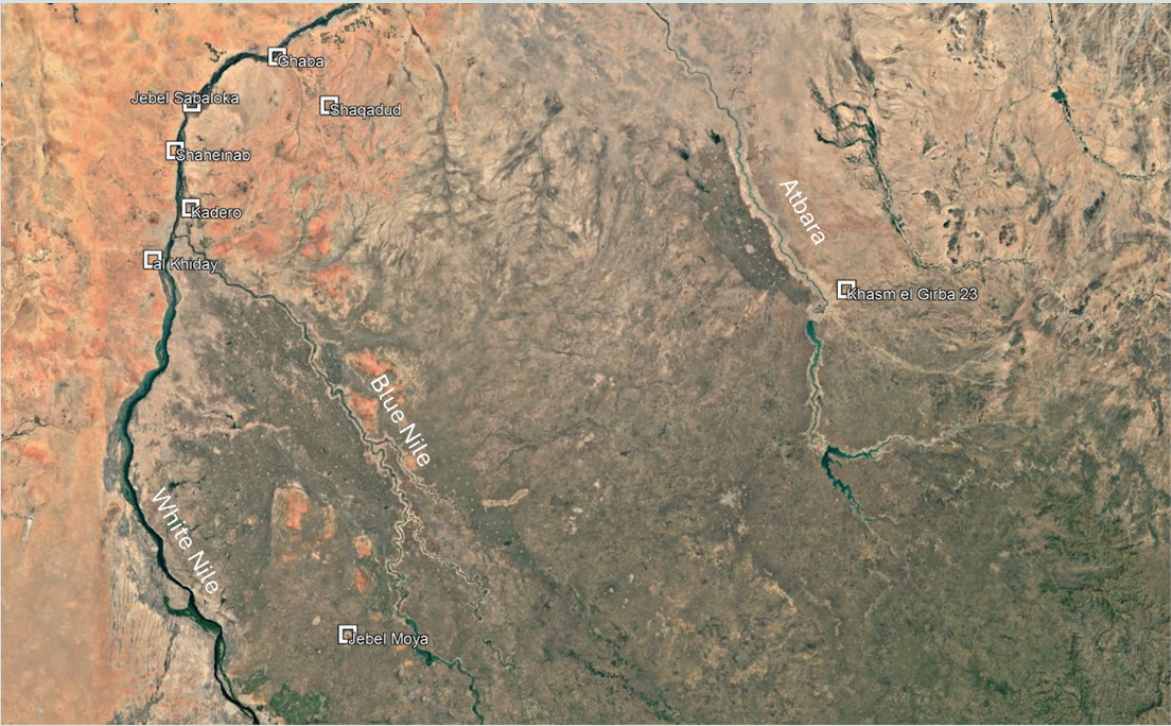


Fig. 13. Map of the series



Fig. 14. Jebel Moya site with its buffer zone in green

Narrative

This series of sites, located to the north, south, and east of Khartoum, encapsulates key adaptations and transformations that laid the basis for the adaptation of the African savannahs, including pastoralism and agriculture. In the Early Holocene, we see the emergence of specialised Nilotic hunter-gatherer fishers, who developed long-term settlements along the Nile for fishing, combined with savannah hunting and gathering. We see the emergence of ceramics as a new hunter-gatherer adaptation to intensive food processing. Formal burial and cemeteries first appear in Africa. In the Neolithic period, after 7000 BP, various sites capture the arrival of domesticated animals and the incorporation of pastoral adaptations into savanna lifestyles.

In comparison, some communities also begin cultivating plants based on the native *Sorghum bicolor*, which undergoes domestication by 5000 BP. This era sees increasing long-distance cultural interconnectivities in trade materials and social differentiation in graves with accompanying grave goods and personal ornaments. 4000 BP evidences the full integration of sorghum agriculture and pastoralism. This nomination also includes key sites in the history of prehistoric archaeology in Africa, including El Shaheinab, where a sub-Saharan/Sudanic Neolithic was first defined in the first half of the 20th century, and Jebel Moya, the most extensive prehistoric cemetery excavation in Africa before the First World War.

Key points:

Two phases: hunter-gatherers and agro-pastoralists

- The sequence illustrates long-term climatic shifts and human adaptations to the savannas
- The sequence illustrates the increasing long-distance interconnectivity of human groups
- Nilotic Hunter-gather fishers, with site stability/ sedentism
- Hunter-gather burials and cemeteries
- Early ceramics for intensive food processing and storage
- Emergence cultivation
- Adoption of livestock, Spread of sheep, goats, and cattle
- Cemeteries with grave goods
- Indication of the last distance, e.g. amazonite beads
- Integration of livestock and sorghum in agricultural economies

Group. 3 – Predynastic and Historic

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- Dr. Mohamed Kenawi (Reporter)
- Dr. Mohamed Elhassan
- Dr. Mohamed Nsreldein
- Prof. Intisar El-zein Soghyroun
- Prof. Mostafa Atallah

A. Early Centres of Power in Africa

During the fourth millennium BCE, early polities developed in the Greater Nile Region, namely in Upper Egypt and Lower Nubia, which can be considered the earliest in Africa.

Serial sites

- A1. Abydos
- A2. Naqada
- A3. Hierakonpolis
- A4. Qustul
- A5. Kerma
- A6. Predynastic/Early Dynastic rock art of Upper Egypt and Lower Nubia

Chronology: ca. 4000- 3000 BC

Key points:

The Egyptian polity is known as the earliest territorial state in human history, based on agriculture, sedentarism, and highly stratified power and society along the Nile, while the Nubian polity developed from a pastoral, mobile tradition that produced a diffused power and a less hierarchical political system. It is one of the earliest forms of alternative power known worldwide.

These areas share a common cultural background and are shaped by their geographical peculiarities, yet linked by a strong interplay among themselves and with the wider geographical sphere (including the Red Sea coast, Africa, the Mediterranean, and the Near East).

Rock art produced in those cultural contexts has symbolic, cosmological, and ideological meaning, and it was used at the peak of state formation in Egypt as a visual representation of political power. The most critical site in this respect is Nag el-Hamdulab in Aswan. These specific sites are selected for their unique evidence of urbanism, social and political complexity, and exceptional funerary landscapes.

A1. Abydos is one of the most sacred cities in ancient Egypt, with the longest ritual landscape sequence, including a large necropolis, the earliest royal Egyptian Governors and later a pilgrimage centre. It represents the dawn of organised civilisation. During the Predynastic era, Abydos was a vital settlement and burial site. The area known as Umm el-Qa'ab, situated in the low desert west of the Nile, contains numerous tombs from this period. Cemetery U, in particular, dates back to the Predynastic times and provides valuable insights into early Egyptian burial practices. Adjacent to it, Cemetery B houses royal tombs from the First and Second Dynasties, indicating the site's continued funerary significance.

A2. Naqada is a significant prehistoric archaeological site in Upper Egypt, known for its role in the development of early Egyptian civilisation. It was a major cultural centre during the Naqada period (ca. 4000–3000 BCE), which is divided into three phases: Naqada I, II, and III. This period saw advancements in social organisation, craft production, and trade, ultimately leading to the formation of the early Egyptian state.

Human Adaptations

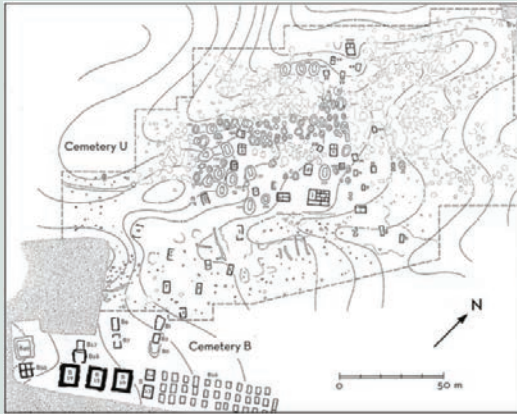


Fig. 15. Map of Abydos showing the layout of the early royal tombs and their associated subsidiary graves, offering a glimpse into the mortuary landscape of Predynastic Abydos. (Cemeteries B and U, Umm el-Qa'ab. Cemetery U dates to the Predynastic period; Cemetery B is the location of the First- and Second-Dynasty royal tombs. (courtesy of the DAI, Orient-Abteilung, Berlin)

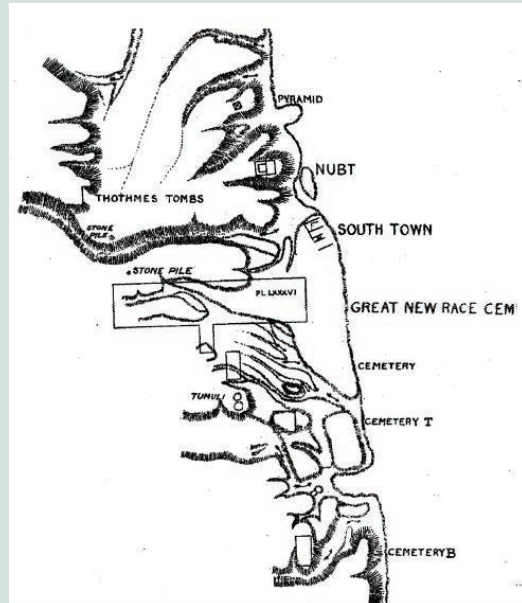


Fig. 16. Excavated sites in the Naqada area (After: Petrie 1901; Petrie and Quibell 1896)

A3. Hierakonpolis (modern Kom el-Ahmar) is one of the most important archaeological sites of early Egypt, serving as a major political and religious centre during the Predynastic period (circa 4000–3100 BCE). It was the capital of Upper Egypt and played a crucial role in the unification of Egypt. The site is known for its large elite tombs, the Narmer Palette, and evidence of early temple structures, reflecting the development of a complex society and the formation of the state in ancient Egypt.

A4. Qustul is an archaeological site in Lower Nubia, near the Egypt-Sudan border, associated with the A-Group culture (circa 3800–3100 BCE). Excavations at Qustul uncovered royal tombs and artefacts, including an incense burner with iconography resembling early Egyptian symbols of kingship. This suggests that Nubian rulers may have played a role in the development of early Egyptian statehood, indicating cultural and political interactions between Nubia and Predynastic Egypt.

A5. Kerma, an important archaeological site in present-day Sudan, was the capital of the Kerma culture (circa 2500–1500 BCE) and one of the earliest complex societies in Africa. It was a thriving town with temples, cemeteries, and markets, showcasing a long history of human occupation and adaptation to environmental changes along the Nile from prehistory to historic periods. The site provides the earliest evidence of pottery production, animal domestication, urbanisation, and early forms of political organisation. As the first ancient Nubian kingdom, emerging around 3500 BCE and flourishing in later centuries, Kerma was a powerful rival to Egypt. It is particularly known for its monumental architecture, including the distinctive Deffufa structures, elaborate royal burials, and advanced craftsmanship. Additionally, Kerma offers some of the best archaeological records for population mobility and pastoralism in the region. The kingdom played a significant role in trade and political interactions with Egypt, especially during the Middle and New Kingdoms, until Pharaoh Thutmose I conquered it around 1500 BCE.

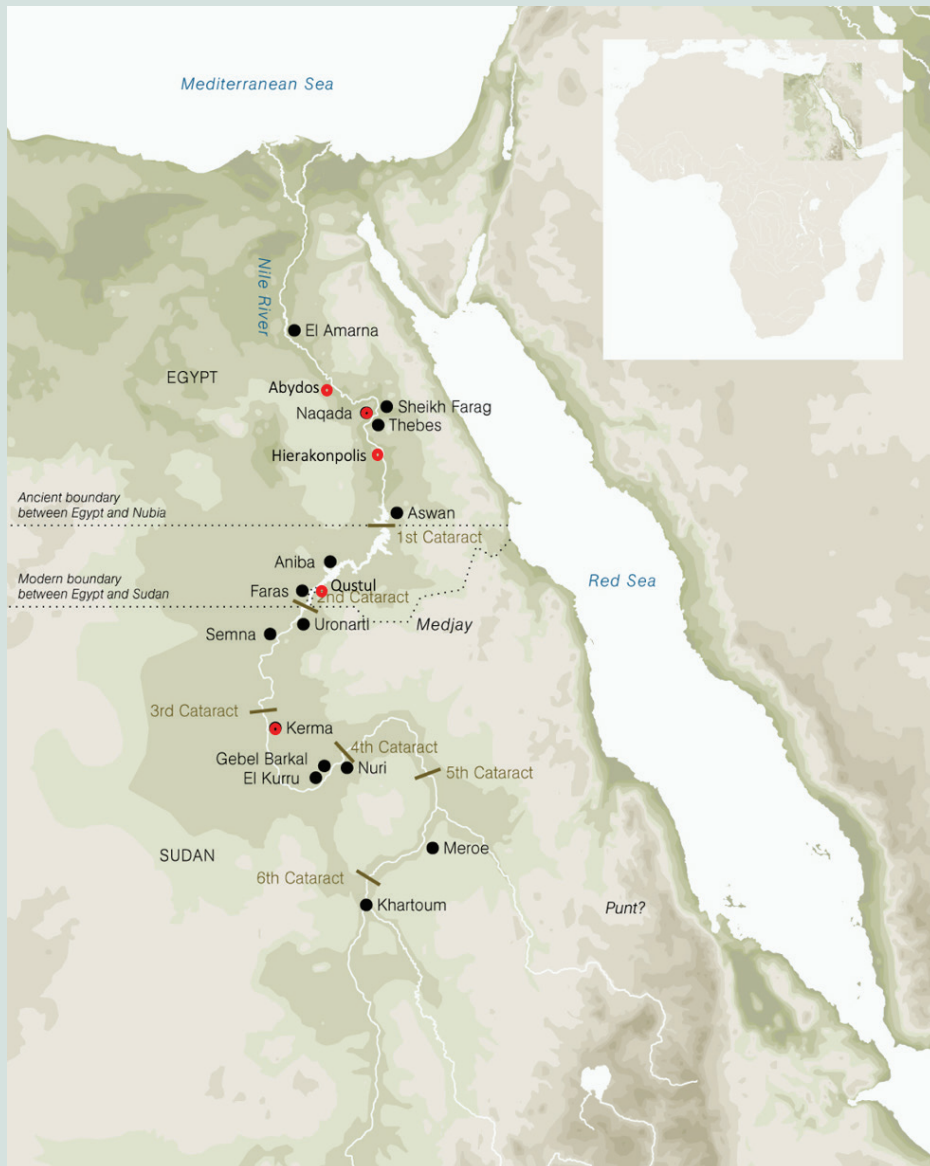


Fig.17. Map showing the location of the Predynastic sites

Human Adaptations

A6. Predynastic/Early Dynastic rock art of Upper Egypt and Lower Nubia provides valuable insight into early symbolic expression, religious beliefs, and sociopolitical developments in the region. These engravings, found on cliffs, rock shelters, and wadi walls, date primarily from the late fourth millennium BCE but have earlier origins. Rock art from this period serves as an essential record of early visual culture, bridging the transition from prehistoric expression to the formalised iconography of Dynastic Egypt.

Important sites for Predynastic and Early Dynastic rock art in Upper Egypt include Wadi Hammamat, El-Hosh, Gebel Tjauti, Gebel Silsila, and Wadi Abu Subeira, and in Lower Nubia, key sites such as Qustul, Sayala, and Sabu Jaddi, where engravings of boats, animals, human figures, and early hieroglyphic symbols reflect ritual, trade, and emerging elite power.

Group 4 – Rock Art

- Dr. Paweł L. Polkowski (Chair)
- Dr. Serena Nicolini (Reporter)
- Dr. Julien Cooper
- Mr. Wouter Claes
- Dr. Hesham Hussein
- Mr. Adel Kelany

A. Pastoral rock art of the Eastern Sahara

Series of sites (Egypt, Sudan and Libya)

- A1. Southern Upper Egypt: Wadi Rasras
- A2. Southern Upper Egypt: Hadi
- A3. Northern Atbai: Bir Nurayet
- A4. Gebel Uweinat

Chronology: ca. 6000–2000 BCE

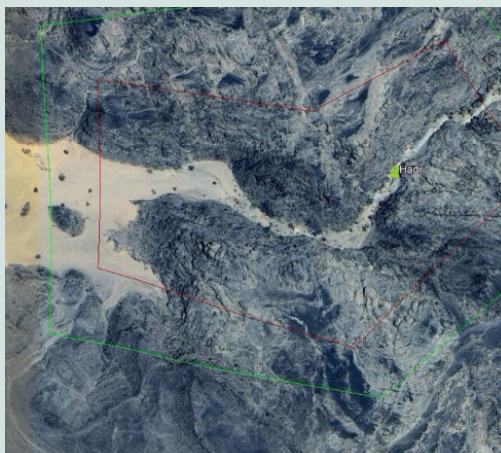


Fig. 18. Hadi

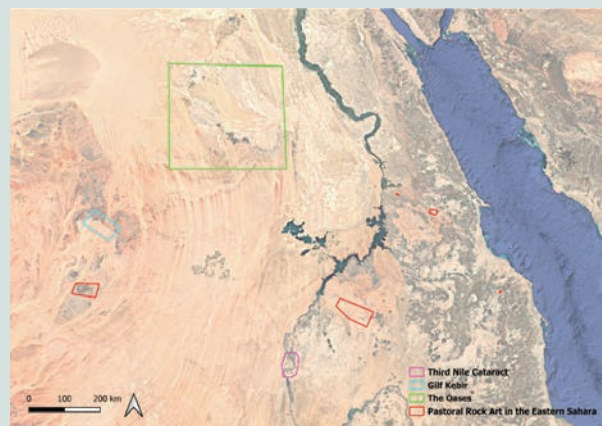


Fig. 19. Map of Overall Regions



Fig. 20. Gebel Uweinat



Fig. 21. Wadi Rasras

Narratives:

The pastoral rock art of the Eastern Sahara tells the story of significant and fundamental shifts in human subsistence strategies and adaptation to changing climatic and environmental conditions. These transformations are expressed through a rich and varied tradition of rock art creation that continued for several millennia, testifying to the strong and intimate relationship between humans and their animals, particularly cattle. Apart from the clear aesthetic qualities of many of these rock depictions, which are by no means inferior to their counterparts in the Central Sahara, the sheer quantity and vast distribution of these rock art sites, scattered across the Egyptian and Sudanese deserts, roughly between latitudes 20°N and 25°N, provide deep and detailed insights into the ancient pastoral landscape, as well as the mental and symbolic worlds of these nomadic communities.

These sites and rock art sequences represent the only remaining traces of otherwise ephemeral pastoralist cultures that existed during a period of advancing—and sometimes dramatic—climate change. Moreover, the disappearance of this culture played a significant role in the peopling of the Nile Basin and the eventual emergence of complex societies in Egypt and Nubia during the 4th and 3rd millennia BCE.

Key points:

- Adoption of livestock, cattle in particular
- Huge quantities of rock art are distributed over vast areas
- Diversity of stylistic and formal expressions: from petroglyphs to paintings
- Interconnectedness of rock art, landscape and environment, and its various features such as pastoral cemeteries and remains of campsites
- Indication of long-distance connectivity, cultural exchange and developments, social organisation and interaction
- Links with the Horn of Africa, the Central Sahara, and the Nilotic peoples south of Central Sudan
- Importance of pastoral ‘cattle culture’ for cultural developments in the Nile valley in the 4th and 3rd millennia BCE

B. Interrelated rock art landscapes of the oases

Series of sites

- B1. Farafra: Wadi el-Obeiyid
- B2. Djara cave
- B3. Kharga: Northern part
- B4. Dakhla: Central and Southeastern parts
- B5. Khufu area
- B6. Meri area

Chronology: ca. 7000–2000 BCE



Fig. 22. General map

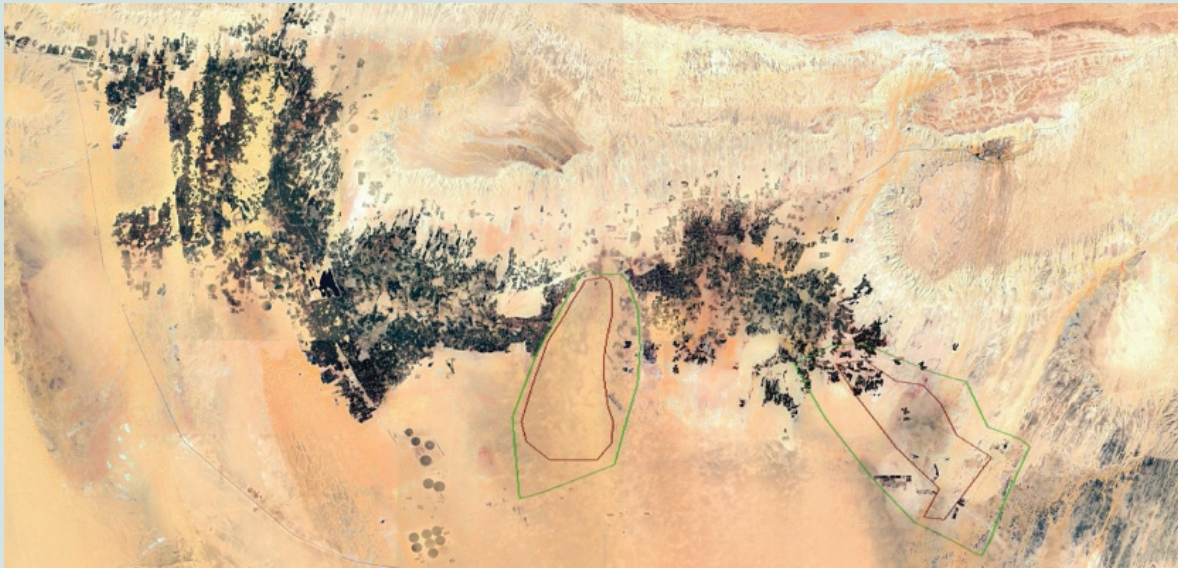


Fig. 23. Dakhla Oasis

Narratives:

The rock art traditions of the Western Desert oases are unparalleled, both in their content and subject matter, as well as in their potential to enhance our understanding of the social lives and knowledge systems of mid-Holocene inhabitants within a specific and challenging environmental and landscape setting. This unique archaeological record tells the story of human adaptation within the constrained oasis environment. Rock art, found across all the major oases of the Central Western Desert, testifies to past human mobility and interconnections. Alongside habitation sites, it forms an ideal laboratory for investigating mid-Holocene communities and their complex life-worlds, which extended between the fertile oases and the surrounding arid deserts. The diversity of forms, themes, and styles within these rock art traditions also provides insights into early artistic developments and symbolism, the significance of which is not always clearly understood but is unique to this region. Few other areas in Northern Africa hold such key archaeological resources, allowing us to understand human adaptation and resilience, as well as socio-cultural developments and environmental change, in one of the world's most challenging landscapes. As this rock art faces significant threats from both human activity and environmental factors, its protection is of the utmost importance for future generations.

Key points:

- Unique style and content of rock art corpora found in the oases
- A long sequence of continued rock art creation and associated archaeological sites from hunter-gatherers to the first pastoralists
- Rock art provides insights into material culture (e.g., clothing of anthropomorphic figures), economy (hunting vs pastoralism), relationships with the animal world, landscape (rock art placement), and ways of being (e.g., sedentarism vs mobile lifestyles)
- Rock art as a testimony to interactions with the 3rd-millennium Nile valley settlers

C. Gilf Kebir rock art landscape

Series of sites

- C1. Wadi Sura I: Cave of Swimmers
- C2. Wadi Sura II: Cave of Beasts
- C3. The foothill area between the caves
- C4. Wadi Ras

Chronology: ca. 6500–3500 BCE

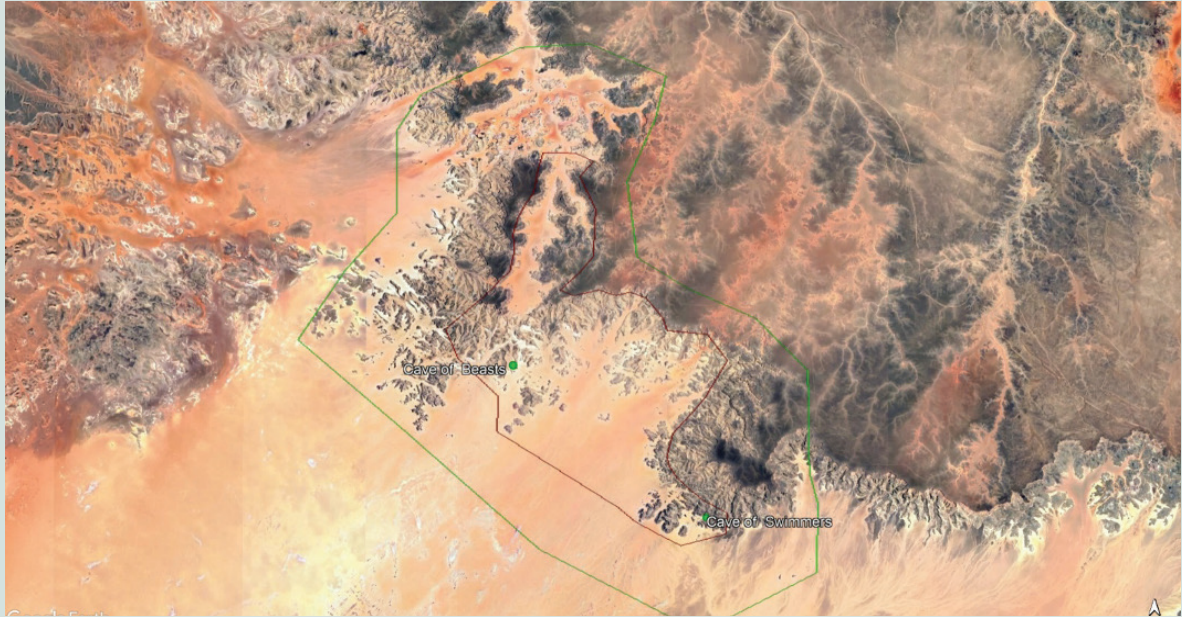


Fig. 24. General map

Narratives:

Pleistocene and Holocene Studies

With its combination of mysterious headless ‘beasts’ and thousands of human figures, depicted in a vast array of different styles, postures and compositions, the rock art of Gilf Kebir represents a truly unique and grandiose corpus of images, distributed across the foothills and adjacent wadis of the Gilf Kebir plateau, which is located in the extreme and dramatic outskirts of southwestern Egypt. The area is best known for two caves, containing extraordinary and complex paintings which seem to date to a pre-pastoralist occupation phase of the region. This rock art, therefore, offers a rare glimpse into the lives of hunter-gatherer communities living in the area, as well as the social and religious aspects of their life-worlds. The Gilf Kebir rock art exhibits an exceptional level of artistry, unmatched by other Egyptian or Eastern Saharan rock art traditions. Apart from rock art, the area is densely covered with other archaeological remains and can also be distinguished by an outstanding landscape setting. As such, it serves as a unique laboratory for the study of prehistoric societies, their visual expressions and beliefs, alongside opportunities for research into interconnections and relationships with Central Saharan archaeology and rock art.

Key points:

- Unique style and content of rock art attributed to hunter-gatherer communities of the Mid-Holocene
- Rich archaeological context for rock art sites
- Outstanding landscape with a rich geomorphology
- Laboratory for investigating past communities’ relationships with a changing environment and climate
- Exceptional history of research, both before WWII and in recent times

D. Rock art landscapes of the Third Cataract Series of sites

- D1. Gebel Gorgod
- D2. Kagbar
- D3. Wadi Sabu
- D4. Geddi
- D5. Nauri
- D6. Miseeda
- D7. Tombos

Chronology: ca. 7000 BCE–1500 CE

Narratives:

The Third Cataract of the Nile offers a unique landscape of human activity, and rock art is one of its exemplary manifestations. Rock art sites in this region include Miseeda, Kagbar, Wadi Gorgod, Tombos, and most eminently, the site of Sabu. The rock art in this region is unique for its breadth of subject matter and its chronology. The pastoral Neolithic is found, as are successive rock art productions from the Kerma culture of Middle Nubia, Pharaonic Egyptian productions from the Egyptian 'colonial' period of the New Kingdom, and numerous panels from Christian Nubia and late medieval times.

Spread across a rocky cataract landscape, the rock art is a witness to the productions of local groups and the ephemeral travellers who traversed this difficult reach of the Nile River.

The number of panels at Sabu is unique among rock art sites in Sudan, with hundreds spread across the wadi, including tableaux from the dynastic and post-Meroitic periods. The region is severely impacted by gold mining, with modern artisanal mining encroaching on rock art sites in several sectors. A further possible impact comes from proposed dam projects, such as the Kagbar dam. With many of the most productive regions of rock art from the Nubian Nile being already flooded (Lake Nasser/Nubia, Fourth Cataract), it is paramount to protect one of Sudan's last productive zones of riverine rock art. Alongside all this rock art sit several well-surveyed sites from the same chronological horizon, filling our picture of an enduring and adapting Nubian landscape. This cultural landscape remains unique to the present period and is part of the traditional lands of the Mahas Nubian people (Dar Mahas).



Fig. 25. General map



Fig. 26. Sabu

Human Adaptations

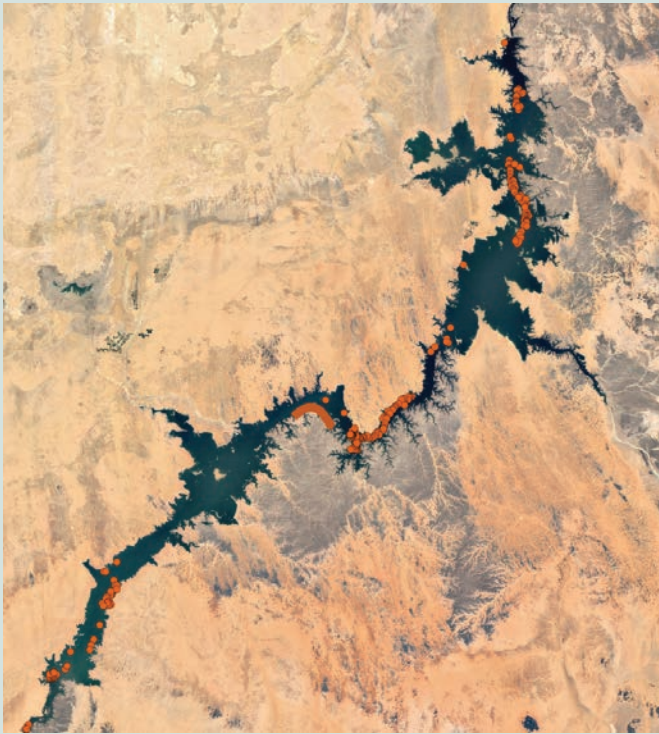


Fig. 27. Sabu General Map showing the rock art locations

Key points:

- A vast number of rock art sites, and a large number of panels at individual rock art sites
- One of the most exceptionally long chronologies at individual rock art sites, with Sabu being preeminent
- A unique landscape laboratory of the Nubian past, showing the changing symbolic language of successive phases of Nubian civilisation (Neolithic, Kerma, Christian Nubia)
- One of the last surviving large rock art landscapes on the Sudanese Nile after the destruction of archaeological sites in Lake Nasser and the Fourth Cataract zones
- Indicates the growing power of empires and states in Sudan: Kerma; Pharaonic Egypt; Christian Makuria/ Nobatia

E. Lower Nubia: Preserving the memory of rock art sites as a shared heritage: A bridge between past, present, and future

Extension: The entire extension of Lake Nasser, from the Low Aswan Dam in the north to the Second Nile Cataract Region in the south

Chronology: ca. 7000 BCE–1500 CE



Fig. 28. Third Cataract region

Narratives:

The exceptional value of Lower Nubian rock art heritage lies in its uniqueness, both in the extensive regional documentation it has received and in the richness of its technical and iconographic details, offering a vast diachronic perspective. From a landscape perspective, Lower Nubian rock art sites were primarily recorded along the Nile banks, yet significant clusters have also been identified in desert wadis, extending several kilometres inland. This region plays a crucial role in research on Egypt and Sudan, particularly in cultural and anthropological studies. The interconnections between people, landscapes, and artistic and epigraphic traditions are evident throughout the region, making them a central focus of archaeological research and future discoveries. Most Lower Nubian rock art sites were documented during UNESCO's Salvage Campaign in the 1960s. While many sites are now submerged, numerous rock art panels were preserved and are currently housed in Aswan, New Kalabsha, and New Dakka.

It is possible that some rock art sites were not completely submerged and may still offer research opportunities in the future. Ongoing reassessments of published data, particularly within epigraphic documentation projects, have yielded valuable new insights, revealing both connections and distinctions between the Egyptian repertoire and Upper Nubian sites. Further archival research remains crucial for refining our understanding of this extraordinary heritage. It should be recognised as a shared cultural memory—one that serves as a foundation for both the present and future of the region's people.

Key points:

- The best-documented rock art complex on a regional scale in Lower and Upper Nubia
- Preserved rock art panels provide an opportunity to develop visitor tours and reconstruct the original geographical context
- A vast number of rock art sites, with numerous panels at individual locations
- Both significant links and differences between the Egyptian and Upper Nubian rock art traditions: cultural traditions and meanings can be traced and analysed in a diachronic perspective
- Shared efforts to document and preserve the rock art evidence serve as testimony to international cooperation

F. Khor Nubt – Wadi Agwampt – Amur Area, a Pastoral Capital Region

F1. Khor Nubt

F2. Wadi Agwampt

F3. Wadi Amur

Chronology: 1st Millennium CE.



Fig. 29. Map showing the location of the area Khor Nubt–Wadi Agwampt–Amur Area

Narratives:

This region is a unique testament to the intense use of a desert landscape by nomadic pastoralists. Centred around the Wadi Agwampt and Amur wadi systems, this desert space exhibits different types of archaeological profiles characteristic of the deserts of Northeast Africa, from desert camps to gold mines and Arabic inscriptions and rock art (including the sites: Nubt, Kalibai, Alitiatib, Gurad, Tabot, Ajjami and Eikidi). The region is under severe threat of goldmining, and much of the area has not been surveyed. It tells the story of the construction of a vast nomadic ‘capital region’ in the arid Red Sea Hills of Eastern Sudan. The site of Nubt acted as the capital of the Blemmyes, the nomads who dominated the deserts of Eastern Sudan and Upper Egypt. The site is a unique witness to the formation of a nomadic kingdom and is essential to the story of Islamization in Sudan.

The nomadic archaeology of the surrounding region demonstrates the emergence and transformation of camel nomads in their environment, as they constructed large, unprecedented camps in the valleys. With international connections evident in the archaeological record (the Roman Empire, the Arab-Islamic Caliphate) and numerous gold mines, this region is a unique microcosm of ancient nomadic lands in Northeast Africa.

Key points:

- The best-documented rock art complex on a regional scale in Lower and Upper Nubia
- Incredibly dense occupation in the mid-First Millennium CE, which includes the most extensive burial grounds in Eastern
- Sudan (both in size of tumuli, and number across the landscape) (cf. the red dots on my remote sensing campaign)
- Capital of the Blemmyes in late antiquity at the site of Khor Nubt
- Largest pastoralist domestic occupations in the region at the settlements of Nubt, Kalibai, Tabot and Alitiatib
- Some of the earliest evidence of Islam in the region (Arabic inscriptions, mosque)
- Diverse rock art sites from the pastoral Neolithic and late antiquity (Eikidi, Rawai)
- Goldmines dating to various periods of ancient history
- Natural potential in vast acacia forests along the wadis



03

**Documentation and Registration of
Traditional Knowledge on Agrobiodiversity
Preservation in Drylands**

Traditional Texts – Agricultural and Food-Related Traditional Knowledge (Dried Okra, Upper Egyptian Kishk, Preservation of Dates and Palm Products)

Dr. Neveen Abdelfattah Hassan Hassan, Director, National Gene Bank, Egypt

Introduction explaining the rationale of the text, as well as the methodology applied to intangible cultural heritage in Egypt in relation to food, including the methodological approach used in the inventory sheets:

Food-related intangible cultural heritage represents a foundational element of Egypt's cultural identity and a vital resource for sustainable livelihoods, food security, and environmental resilience. Traditional food systems in Egypt have evolved over centuries through interactions among communities and diverse ecological contexts, including the Nile Valley and Delta, oases, desert margins, coastal zones, and pastoral landscapes. These systems encompass agricultural knowledge, food processing and preservation techniques, culinary practices, and associated oral traditions, all of which contribute to the conservation of agricultural biodiversity and the sustainable use of natural resources.

In recent decades, intangible cultural heritage related to food in Egypt has faced growing challenges stemming from climate change, environmental degradation, socio-economic transformations, and the weakening of intergenerational transmission. In response, this national initiative seeks to document and inventory food-related intangible cultural heritage as a strategic entry point for safeguarding, revitalisation, and integrating traditional knowledge into sustainable development and climate adaptation policies.

This initiative is grounded in the principles of the 2003 UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage, which affirms that safeguarding aims to ensure the continued viability of living heritage through community participation, respect for cultural diversity, and recognition of communities as primary custodians of their heritage. Accordingly, inventorying is approached as a participatory, ethical, and dynamic process, rather than a purely technical exercise.

Methodological Approach

The applied methodology is based on community-based and participatory documentation, ensuring the active involvement of heritage bearers—including farmers, fishers, pastoralists, rural women, cooks, and elders—throughout all stages of the inventorying process. Communities participate in identifying heritage elements, defining local classifications, validating documented information, and prioritising safeguarding needs.

Documentation combines qualitative field methods, including semi-structured interviews, participant observation, and the recording of oral expressions related to food and agriculture, with standardised inventory forms aligned with UNESCO guidelines. These forms capture key information on the identification of elements, their cultural, social, and environmental functions, modes of transmission, current viability, and associated risks.

A multidisciplinary approach integrates perspectives from intangible cultural heritage studies, anthropology, agricultural and food sciences, and environmental studies, enabling a holistic understanding of food-related heritage and its role in biodiversity conservation, climate resilience, and sustainable livelihoods.

For inventorying purposes, food-related intangible cultural heritage is classified into flexible and interrelated domains, including traditional agricultural and fishing practices, seed conservation, food processing and preservation, culinary knowledge, food-related rituals and social practices, and associated oral traditions. This classification remains adaptable to local contexts and community-defined categories.

Safeguarding Orientation

Inventorying is conceived as an initial and enabling step within a broader safeguarding framework. The outcomes of this process are intended to support intergenerational transmission, inform education and awareness-raising activities, strengthen community recognition, and facilitate the integration of traditional food-related knowledge into national strategies for food security, sustainable development, and climate change adaptation.

Name of the Element:

Drying Okra Fruits into Strings (Garlands) in Upper Egypt: A Traditional Practice for Off-Season Food Preservation

Short Description of the Element:

The practice of drying okra fruits into strings in Upper Egypt is an element of Intangible Cultural Heritage, as it embodies inherited traditional knowledge and skills for food preservation using natural resources and sustainable methods. This knowledge is practised within local communities and transmitted orally and through hands-on experience across generations. It contributes to strengthening local food identity and food security, while fully respecting human rights and environmental sustainability requirements.

Detailed Description of the Element:

The practice of drying okra fruits on strings, locally known as okra strings or okra garlands, is among the oldest methods of vegetable preservation in Upper Egypt. It remains in use today in the governorates of Aswan, Qena, Luxor, and Sohag. This practice emerged from the need of rural communities to secure vegetables outside their growing season, within a hot climate historically reliant on self-sufficiency and with limited access to modern preservation technologies.

Human Adaptations

The process begins with the careful selection of small to medium-sized local okra pods that are tender, non-lignified, and free from pest damage, as these possess greater resilience and dry more effectively without significant loss of quality. The pods are lightly washed and left to air-dry to remove surface moisture. They are then threaded onto cotton strings or natural fibre cords using a needle, with slight spacing between the pods to allow adequate air circulation. Care is taken to insert the thread through the stem end or the middle of the pod without splitting it, to preserve its natural structure.

The okra strings are hung in shaded, well-ventilated areas, such as balconies or beneath house roofs, away from direct, intense sunlight. They are left to dry for 7 to 14 days, depending on climatic conditions. During this time, the strings may be rotated or repositioned to ensure even, uniform drying. Once thoroughly dried, the pods become lightweight and firm in texture, and their colour shifts to a dark green with brownish tones, without any signs of spoilage or sliminess.

After drying, the okra strings are either kept hanging inside homes or dry storage spaces, or the pods are removed and stored in cloth bags or earthenware containers. They are later used in cooking during the winter months. The dried okra is typically broken by hand and added directly to dishes, imparting a concentrated flavour that is characteristic of traditional Upper Egyptian cuisine.

This practice represents a living model of intangible heritage knowledge linked to local food security and the sustainable management of agricultural resources.

Second: Indicators of Local Food Security Associated with the Practice

The following indicators may be used for scientific or developmental assessment:

1. Availability Indicators

- Existence of a traditional practice for preserving vegetables outside the growing season (Yes/No).
- Number of dried okra strings produced annually per household.
- Storage shelf life (in months).

2. Access Indicators

- Household reliance on self-produced okra.
- Reduced the need to purchase vegetables outside the harvest season.
- Storage cost (negligible or near-zero cost).

3. Utilisation Indicators

- Continued use of dried okra in food preparation.
- Diversity of cooking methods using dried okra.
- Local food acceptability and taste preferences.

4. Stability Indicators

- Regular annual practice of okra drying.
- Ability of the practice to continue without modern technologies.
- Intergenerational transmission of knowledge.

5. Cultural Sustainability Indicators

- Women's participation in the drying practice.
- Association of the practice with local food identity.
- Continued use of the local terminology for the practice ("Okra Strings / Garlands").

Third: Field Documentation Form for Drying Okra into Strings

Title of the Form:

Field Documentation Form for a Traditional Food Preservation Practice: Drying Okra into Strings

Section (1): General Information

1. Governorate:
2. Village/Hamlet:
3. Date of Documentation:/...../.....
4. Name of Documenter:

Section (2): Knowledge Bearer Information

5. Name (optional):
6. Age:
 - Under 30
 - 30–45
 - 45–60
 - Over 60
7. Gender: - Female - Male
8. Role: - Homemaker - Farmer - Both
9. Number of years practising the method: years

Section (3): Description of the Practice

10. Local name of the practice:
11. Type of okra used: - Local (Baladi) - Hybrid - Don't know
12. Selected pod size: - Small - Medium - Large
13. Type of thread used: - Cotton - Natural fibre (palm/loofah) - Other:
14. Drying location: - Balcony - Inside the house - Storage area - Other:

Human Adaptations

Section (4): Drying Process Details

- 15. Drying duration: days
- 16. Exposure to direct sunlight: - Yes - No
- 17. Are the strings turned during drying? - Yes - Sometimes - No
- 18. Indicators of full drying according to local experience:.....

Section (5): Storage and Use

- 19. Storage method after drying:
- 20. Typical storage duration: months
- 21. Period of use: - Winter only - Throughout the year
- 22. Method of use in cooking:

Section (6): Significance and Continuity

- 23. From whom was this practice learned?
- Mother - Grandmother - Elder family member - Other:
- 24. Is the practice still maintained within the family? - Yes - No
- 25. Do you believe it is important to safeguard this practice? - Yes - No
- 26. Additional notes:

Alignment of the Practice of “Drying Okra into Strings” with UNESCO Criteria for Intangible Cultural Heritage

1. Definition of Intangible Cultural Heritage

(Article 2 of the 2003 UNESCO Convention)

UNESCO Text:

“The ‘intangible cultural heritage’ means the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognise as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity.”

Alignment:

Drying okra into strings is a living traditional practice that continues to be actively carried out to this day.

- It is based on inherited knowledge and skills, including the selection of okra pods, stringing techniques, and appropriate timing for drying.

- The practice is transmitted orally and through hands-on experience within the family, particularly through women.
- It provides Upper Egyptian communities with a strong sense of local food identity and seasonal continuity. The practice clearly falls within the definition of Intangible Cultural Heritage as set out by UNESCO.

2. Domains of Intangible Cultural Heritage

(Article 2, Paragraph 2)

Relevant Domain(s):

This practice belongs to multiple UNESCO-recognised domains:

a. Social Practices, Rituals, and Festive Events

- A collective practice embedded in everyday life.
- Closely linked to agricultural seasons and harvest cycles.
- Carried out within a social and family-based framework.

b. Knowledge and Practices Concerning Nature and the Universe

- Demonstrates detailed knowledge of natural air-drying processes.
- Reflects local understanding of climate, ventilation, and humidity.
- Relies on natural resources without industrial or chemical intervention.

c. Traditional Culinary Practices (a practically recognised sub-domain)

- Directly connected to food preparation and consumption.
- A core ingredient in traditional Upper Egyptian winter cuisine.

-The practice belongs to all three domains, with primary emphasis on social practices and knowledge related to nature.

3. Criterion of Living Nature of the Element and Intergenerational Transmission

UNESCO Text:

“The element must be living and transmitted from generation to generation.”

Alignment:

- The practice has been continuously maintained for decades without interruption.
- Knowledge transmission typically follows the pattern:
Grandmothers → Mothers → Daughters
- It is learned through practice rather than written instruction.
- The dried okra continues to be actively used in everyday cooking.

- A living, continuously practised element.

4. Criterion of Cultural Identity and Sense of Belonging

UNESCO Text:

"Intangible cultural heritage contributes to the promotion of cultural identity and a sense of belonging."

Alignment:

- Dried okra is a distinctive marker of Upper Egyptian cuisine.
 - It is locally known by specific vernacular names ('Okra Strings', 'Garlands').
 - It is associated with family memories, seasonal cycles, and domestic life.
 - It symbolises self-sufficiency and household-based economy.
- Strongly reinforces a clear local cultural identity.

5. Criterion of Mutual Respect and Human Rights

UNESCO Text:

"The element must be compatible with existing international human rights instruments."

Alignment:

- A peaceful and non-discriminatory practice.
 - Causes no environmental or social harm.
 - Practiced voluntarily within the community.
 - Enhances women's roles without exclusion or coercion.
- Fully compatible with human rights and human dignity principles.

6. Criterion of Sustainability and Development

(A contemporary principle in the implementation of the Convention)

Alignment:

- Requires no external energy or fuel.
 - Generates no waste or pollutants.
 - Reduces food loss and post-harvest waste.
 - Strengthens local food security and resilience.
 - Contributes directly to the Sustainable Development Goals:
 - SDG 2: Zero Hunger
 - SDG 12: Responsible Consumption and Production
- An environmentally and food-sustainable heritage practice.

7. Criterion of Local Community Participation

UNESCO text:

Safeguarding of the element must be carried out with the participation of the communities, groups or individuals concerned.

Alignment:

- The local community constitutes the primary stakeholder of the element.
- Community members are simultaneously:
 - practitioners,
 - custodians, and
 - transmitters of the element.
- The practice does not rely on external institutions for its continuity.
- Documentation and safeguarding activities can be undertaken with the free, prior and informed consent of community members.
- The principle of community-based safeguarding is fully applicable.

8. Risks and Threats to the Element (for Safeguarding Purposes)***Potential challenges***

- Changes in food consumption patterns.
- Increasing reliance on frozen and industrially processed foods.
- Weakening of knowledge transmission to younger generations.
- Decline in the cultivation of local (traditional) okra varieties.
- The identification of threats strengthens the safeguarding file and does not undermine the viability of the element.

9. Proposed Safeguarding Measures (in accordance with UNESCO principles)

- Audio-visual documentation of the practice and associated knowledge.
- Inclusion of the practice in local and national intangible cultural heritage programmes and inventories.
- Encouragement of rural women to continue practicing and transmitting the element.
- Integration of the practice into local food security and sustainable development initiatives.
- Documentation of local terminology, techniques and variations of the practice.

Name of the Element

Preparation of Upper Egyptian Kishk: Traditional Knowledge and Practices for Food Preservation in Upper Egypt

Short Description of the Element

Upper Egyptian kishk is a traditional food product prepared in Upper Egypt using locally grown wheat and fermented milk (laban rayeb), which is naturally dried for year-round use. The practice represents an integrated system of traditional knowledge related to fermentation, drying, and storage, and constitutes a sustainable local method for food preservation that ensures food availability outside the harvest season.

Detailed Description of the Element

The preparation of Upper Egyptian kishk is practiced within rural households, predominantly by women, with the participation of family members, during the summer season when climatic conditions are suitable for drying. The process begins with the careful cleaning and soaking of locally grown wheat until it softens without germinating. The wheat is then mixed with fermented milk, and a measured amount of salt is added.

The mixture is left to ferment naturally for several days, with daily stirring, relying on sensory knowledge and experiential judgment to determine the appropriate level of fermentation. Once fermentation is complete, the mixture is ground and kneaded, then shaped into small discs or balls. These are gradually dried under sunlight, while being protected from dew and humidity. During this stage, the pieces are turned daily to ensure even and uniform drying.

After complete drying, the kishk is stored in earthenware containers or cloth bags and later used in the preparation of traditional dishes, most notably kishk soup, which occupies a central place in Upper Egyptian winter cuisine.

Communities, Groups, and Individuals Concerned

- Rural households in the governorates of Upper Egypt (such as Aswan, Luxor, Qena, and Sohag).
- Rural women as the primary bearers and practitioners of the knowledge.
- Elder community members who transmit experience and skills to younger generations.

Transmission of Knowledge and Continuity

Knowledge related to the preparation of Upper Egyptian kishk is transmitted orally and through practice within the family, from mothers and grandmothers to daughters, through direct participation and seasonal engagement. This knowledge does not rely on written recipes, but rather on inherited sensory skills and experiential learning, which reinforces its deep connection to local identity and cultural continuity.

Social and Cultural Functions

- Ensuring household food security throughout the year.
- Strengthening family solidarity through collective work.
- Safeguarding Upper Egyptian food identity.
- Using local resources through sustainable practices.

Compatibility with Human Rights and Sustainable Development

This practice does not conflict with human rights or human dignity. It relies on natural, low-impact methods, contributes to reducing food loss and waste, and aligns with the principles of sustainable development.

Risks Threatening the Element

- Declining reliance on traditional foods.
- Increasing spread of ready-made and industrial food products.
- Decreasing interest among younger generations in the practice.

Proposed Safeguarding Measures

- Audio-visual documentation of the practice.
- Integration of the practice into local food heritage programmes.
- Encouragement of intergenerational knowledge transmission.
- Support for community-based initiatives aimed at safeguarding traditional food practices

Second: Field Documentation Form for Upper Egyptian Kishk

Title of the Form

Field Documentation Form for an Intangible Cultural Heritage Practice: Preparation of Upper Egyptian Kishk

Section (1): General Information

1. Governorate:
2. Village/Hamlet:
3. Date of documentation:/...../.....
4. Name of researcher/documenter:

Section (2): Knowledge Bearer Information

5. Name (optional):
6. Age:
 - Under 30
 - 30-45
 - 45-60
 - Over 60
7. Gender: - Female - Male
8. Role in the practice: - Preparation - Supervision - Knowledge transmission
9. Number of years practicing kishk preparation: years

Section (3): Knowledge and Ingredients

10. Type of wheat used: - Local (Baladi) - Improved local - Other
11. Type of milk used: - Fermented milk (Rayeb) - Buttermilk - Other:
12. Is salt added? - Yes - No
13. Preparation tools used: - Earthenware vessels - Hand mill (quern) - Modern tools - Other

Section (4): Preparation Process

14. Duration of wheat soaking: days
15. Duration of fermentation: days
16. Indicators of completed fermentation according to local knowledge:
17. Form of kishk: - Discs - Balls - Other
18. Drying duration: days
19. Drying location: - Rooftop - Courtyard - Balcony - Other

Section (5): Storage and Use

20. Storage method after drying:
21. Typical storage duration: months
22. Methods of use: - Soup - With bread - Other:

Section (6): Transmission and Continuity

23. From whom did you learn this practice?
 - Mother - Grandmother - Elder family member - Other
24. Is the practice still maintained within the family? - Yes - No
25. Do younger generations participate? - Yes - Sometimes - No

Human Adaptations

Section (7): Significance and Safeguarding

26. Importance of kishk for the household:

Food-related Economic Cultural All of the above

27. Main challenges facing the continuation of the practice:

28. Suggestions by the knowledge bearer for safeguarding the practice:

Section (8): General Notes

29. Additional remarks:

Declaration

I hereby confirm that the information provided is accurate to the best of my knowledge and that participation in this documentation is voluntary.

Name of the Element

Traditional Knowledge and Practices of Date Preservation and Palm Cultivation in Siwa Oasis

Short Description of the Element

The traditional knowledge and practices of date preservation in Siwa Oasis constitute an integrated system developed by the local community to manage the abundance of date production and ensure long-term storage. These practices rely on sun drying, pressing, and storage in traditional containers and facilities, reflecting an adaptive response to the arid oasis environment. They represent a fundamental component of the oasis's food, economic, and cultural heritage.

Detailed Description of the Element

Palm cultivation and date preservation in Siwa Oasis are closely linked to an inherited agricultural and knowledge cycle transmitted across generations. After harvesting, dates are sorted according to their level of maturity into semi-dry dates (ajwa) and dry dates.

Semi-dry dates are partially sun-dried to reduce moisture while maintaining softness. They are then layered and pressed into earthenware vessels or wooden containers and, in some cases, covered with a thin layer of locally produced Siwan olive oil to prevent excessive drying and mold formation.

Dry dates are subjected to full sun drying until their moisture content is sufficiently reduced to allow long-term storage. They are stored in burlap sacks or baskets made from palm fronds, placed inside mud-built storage rooms characterised by natural ventilation and stable temperatures.

All stages of preservation rely on sensory knowledge and experiential judgment to assess dryness levels and appropriate storage timing, without the use of modern measuring instruments.

Communities, Groups, and Individuals Concerned

- Date palm farmers in Siwa Oasis.
- Siwan households.
- Elder community members as bearers of traditional knowledge.
- Women participating in sorting, preservation, and storage processes.

Transmission of Knowledge and Continuity

Knowledge related to date preservation is transmitted orally and through practice within families and the wider community, through participation in harvest seasons and preservation activities. Younger generations acquire this knowledge through observation and hands-on involvement, ensuring its continuity in everyday life.

Social and Cultural Functions

- Ensuring year-round food security.
- Supporting local and household economies.
- Safeguarding oasis identity and cultural distinctiveness.
- Reducing food loss and waste.

Compatibility with Human Rights and Sustainable Development

These practices are carried out voluntarily and peacefully, relying on natural resources and low-impact techniques. They contribute to sustainable consumption, protection of agricultural biodiversity, and alignment with the principles of sustainable development.

Risks Threatening the Element

- Introduction of modern industrial storage methods.
- Declining participation of younger generations.
- Climate change and its impact on date production.

Proposed Safeguarding Measures

- Audio-visual documentation of preservation practices.
- Support for intergenerational transmission of knowledge.
- Encouragement of continued use of traditional tools and methods.
- Inclusion of these practices in agricultural and food heritage programmes.

Second: Field Documentation Form on Palm Cultivation and Date Preservation in Siwa Oasis

Title of the Form

Field Documentation Form for an Intangible Cultural Heritage Practice: Palm Cultivation and Date Preservation in Siwa Oasis

Section (1): General Information

1. Location: Siwa Oasis
2. Village/Agricultural Area:
3. Date of documentation:/...../.....
4. Name of researcher/documenter:

Section (2): Knowledge Bearer Information

5. Name (optional):
6. Age:
 - Under 30
 - 30–45
 - 45–60
 - Over 60

Human Adaptations

7. Gender: - Female - Male
8. Role(s): - Cultivation - Harvesting - Preservation - Storage - Multiple roles
9. Number of years working with palm cultivation: years

Section (3): Palm Trees and Dates

10. Type/variety of palm:
11. Harvest period: - Early - Medium - Late
12. Approximate production quantity:

Section (4): Date Preservation Methods

13. Type of dates: - Semi-dry (ajwa) - Dry
14. Preservation method used:
 - Sun drying
 - Pressing
 - Oil preservation
 - Traditional storage
15. Drying duration: days
16. Type of containers used: - Palm fronds - Burlap - Wood - Earthenware

Section (5): Storage

17. Storage location: - Underground - Household room - Mud-built storage
18. Typical storage duration: months
19. Methods of protection against spoilage or insects:

Section (6): Food Uses

20. Uses of preserved dates:
 - Direct consumption
 - Cooking
 - Grinding
 - Local trade

Section (7): Transmission and Continuity

21. From whom did you learn these practices?
 - Community
 - Grandfather/Grandmother
 - Mother
 - - Father
22. Are these practices still carried out?
 - Yes
 - Sometimes
 - Rarely
23. Participation of younger generations:
 - Active
 - Limited
 - Weak

Section (8): Significance and Safeguarding

24. Importance of date preservation for the family/community:

- Food-related
- Economic
- Cultural
- All of the above

25. Main current challenges:

26. Suggestions by the knowledge bearer for safeguarding:

Section (9): Notes

27. Additional remarks or local terminology:

Declaration

I hereby declare my consent to the documentation of this practice for cultural and research purposes.

Name/Signature (optional):

Date:/...../.....

Traditional Agricultural Knowledge for Seed Preservation and Exchange in Egypt's Coastal Areas and Border Governorates

First: Environmental and Cultural Context

Egypt's coastal areas and border regions are characterised by water scarcity, irregular rainfall, and soil salinity. These conditions have led local communities (Bedouin and oasis communities) to develop traditional systems for seed preservation that ensure:

- Continuity of rain-fed agriculture
- Conservation of local landraces
- Exchange of seeds among families and tribes
- Strengthening of local food security

Within this context, seeds are not merely agricultural inputs, but constitute social and cultural capital.

Second: Main Crops and Seeds Traditionally Preserved

- Local barley (Matrouh, Sinai)
- Sorghum (South Sinai, New Valley)
- Millet (limited rain-fed areas)
- Local wheat (traditional landraces)
- Legumes (local fava beans, lentils, chickpeas)
- Vegetable seeds (pumpkin, okra, pepper)

Third: Traditional Seed Preservation Methods

1. Careful natural drying

- Ears or cobs are left:

- On the plant until full maturity, or
- Dried under direct sunlight

- Away from moisture

- Popular knowledge: "Seeds can only be preserved when they are completely dry."

Human Adaptations

2. Storage in traditional containers

- Sealed earthenware vessels
- Leather containers (in some Bedouin environments)
- Cloth or jute sacks

- Earthenware allows air circulation and prevents condensation.

3. Storage in pits and clay structures

- Clay-lined pits inside houses
- Sealed with clay or ash

4. Use of ash and sand

- Mixing seeds with:
 - Plant ash, or
 - Fine sand
- To deter insects

5. Preservation within ears or cobs

- Seeds are kept unthreshed inside ears or cobs to enhance protection and longevity.
- Barley and Wheat:
- Sometimes preserved without threshing.
- Maise:
- Cobs are hung.
- Natural preservation within their original protective covering.

6. Elevated storage

- Hanging bags or bundles:
 - From house ceilings
 - Away from rodents

Fourth: Knowledge related to seed selection (selection criteria)

Criterion	Traditional interpretation
Full grain	Strong germination capacity
Size of the ear/spike	Higher productivity
Drought resistance	Long-term sustainability
Success of the previous season	Practical field-based test

- Seed selection is carried out prior to storage.

Fifth: Seed Exchange (the social system)

1. Family exchange

- Among relatives
- Without monetary compensation

2. Tribal exchange

- During:
 - Agricultural seasons
 - Communal gatherings
- Seed-for-seed exchange

3. Safety seeds

- Seeds kept:
 - For emergencies
 - For drought or lean seasons

Agricultural gifts

- Seeds form part of:
 - Dowries
 - Reconciliation processes
 - Hospitality practices

Sixth: Preventive knowledge

- Periodic inspection of stored seeds
- Removal of damaged or infested grains
- Re-drying when necessary

Seventh: Scientific interpretation of traditional knowledge

Practice	Scientific Basis
Complete drying	Reduction of water activity, limiting microbial growth
Use of ash	Alkaline medium acting as a natural insect repellent
Storage in ears/cobs	Natural protective envelope reducing pest exposure
Earthenware containers	Thermal stability and breathability

Eighth: The role of seed preservation in food security

- Agricultural self-reliance
- Safeguarding genetic diversity (local landraces)
- Reduced dependence on external markets
- Enhanced resilience to climate change

Ninth: Heritage value (UNESCO)

Domains

- Knowledge and practices concerning nature and the universe
- Traditional agricultural practices

Fulfilled criteria

- Living practice
- Intergenerational transmission
- Clearly defined local identity
- Environmental sustainability

Name of the Element:

Traditional Knowledge and Practices of Seed Preservation and Exchange in Egyptian Agricultural Communities

Brief Description of the Element

The traditional knowledge and practices related to seed preservation and exchange in Egypt constitute a transmitted system of agricultural expertise developed by local communities to ensure the continuity of farming, food security, and the safeguarding of agricultural biodiversity. These practices rely on natural drying, storage in traditional containers, and the social exchange of seeds, reflecting a long-standing and balanced relationship between human communities and their natural environment.

Detailed Description

Traditional seed preservation practices are widespread across diverse agricultural environments in Egypt, particularly in coastal areas, border governorates, oases, and rain-fed regions, where seeds represent an indispensable resource. These practices encompass seeds of cereal crops such as barley, sorghum, and local wheat varieties, as well as legumes and vegetable seeds adapted to local environmental conditions.

Following the full maturation of crops, seeds are manually selected according to traditional criteria that include grain fullness, the strength of the ear or cob, and the plant's resistance to drought and pests. The seeds are then naturally dried under sunlight or in well-ventilated spaces until they reach an appropriate level of dryness for storage. They are stored in clay or earthenware vessels, mud jars, cloth or jute bags, or kept within the ears and cobs themselves. In some cases, seeds are mixed with plant ash or fine sand as a preventive measure against insects.

These practices extend beyond preservation to include a social system of seed exchange among families, relatives, and tribes, either through reciprocal sharing or seasonal gifting. This system strengthens social cohesion and ensures seed diversity and continuous adaptation to local environmental conditions. It is based on trust and shared knowledge, and within it seeds are regarded as cultural and social capital as much as agricultural resources.

Concerned Communities, Groups, and Individuals

- Farmers in rural areas
- Bedouin communities in Sinai and Matrouh
- Oasis communities in Siwa and other oases
- Small-scale agricultural households
- Elders as primary bearers of traditional knowledge

Transmission of Knowledge and Its Continuity

Knowledge related to seed preservation and exchange is transmitted orally and through practice within families and communities, particularly through seasonal participation in harvesting, selection, and storage. Younger generations acquire these practices through observation and hands-on involvement, ensuring their continuity across generations.

Social and Cultural Functions

- Ensuring the continuity of local agricultural practices
- Supporting household and community food security
- Safeguarding the genetic diversity of crops
- Strengthening cooperation and social solidarity

Compatibility with Human Rights and Sustainable Development

These practices are carried out voluntarily and peacefully and do not conflict with human rights. They rely on local resources and low environmental-impact methods, contributing to the sustainable use of natural resources and supporting the achievement of sustainable development goals.

Risks Threatening the Element

- Increasing reliance on commercial hybrid seeds
- Declining intergenerational transmission of knowledge
- Loss of local crop varieties
- Accelerating impacts of climate change

Proposed Safeguarding Measures

- Field-based, audio, and visual documentation
- Support for community seed banks
- Encouragement of traditional seed exchange practices
- Integration of traditional knowledge into agricultural development programmes

Second: Field Documentation Form for Seed Preservation and Exchange

Form Title:

Field Documentation Form for an Intangible Cultural Heritage Practice:

Traditional Seed Preservation and Exchange in Egypt

Section (1): General Information

1. Governorate:
2. District/Village:
3. Agricultural environment: - Rain-fed - Oasis - Border - Coastal - Delta
4. Date of documentation:/...../.....
5. Name of researcher/documenter:

Section (2): Knowledge Bearer Information

6. Name (optional):
 7. Age: - Under 30 - 30–45 - 45–60 - Over 60
 8. Gender: - Female - Male
 9. Agricultural role: -Seed exchanger - Seed keeper - Herder - Farmer
- Number of years of experience: years

Human Adaptations

Section (3): Type of Seeds

11. Type of crop: - Vegetables - Legumes - Wheat - Sorghum - Barley
12. Local variety (if any):
13. Reason for preserving this variety:
 - Family tradition - Nutritional quality - Drought resistance

Section (4): Seed Selection and Drying

14. Method of seed selection:
 - From the largest ears/cobs - From the healthiest plants
15. Drying method:
 - On the plant - Air drying - Sun drying
16. Approximate drying period: days

Section (5): Storage

17. Storage method:
 - Inside ears/cobs - Cloth bags - Earthenware vessels
18. Protective additives:
 - No additives - Sand - Plant ash
19. Storage location:
 - Elevated place - Storehouse - Household

Section (6): Seed Exchange

20. Are seeds exchanged? - Yes - No
21. Method of exchange:
 - Seasonal lending - Exchange - Gift
22. Timing of exchange:
 - During social occasions - After harvest - Before planting

Section (7): Continuity and Change

23. Is the practice still ongoing? - Rarely - Sometimes - Yes
24. Participation of younger generations: - Weak - Limited - Active

Section (8): Significance and Challenges

25. Importance of seed preservation for the community:
 - All of the above - Cultural - Economic - Food-related
26. Main current challenges:
27. Safeguarding proposals from the perspective of the knowledge bearer:

Section (9): Notes

28. Local terms or specific practices:

Declaration

I hereby declare my consent to the documentation of this practice for cultural and research purposes.

Name/Signature (optional):

Date:/...../.....

First: General Principles of Traditional Seed Storage

Before adopting any specific storage method, popular knowledge observes a set of fundamental rules:

- Thorough drying of seeds after harvest (to the extent that breaking the grain reveals no moisture).
- Selection of sound, healthy seeds free from infestation.
- Storage in shaded, well-ventilated places, elevated above ground level.
- Addition of natural insect-repellent materials (such as ash, oven dust, aromatic herbs).

These principles are common to all of the following methods.

Second: Storage in Earthenware Vessels

1. Storage in earthenware jars/pots (zir or qolla)

Geographical spread: Delta, Upper Egypt, oases

Crops: Wheat, maize, fava beans, lentils, chickpeas

Storage procedure

1. The crop is thoroughly sun-dried.
2. The earthenware jar is cleaned and completely dried.
3. A thin layer of:
 - Fine ash, or
 - Dry sand
 is placed at the bottom.
4. Layers of seeds are added, with a small amount of ash between each layer.
5. The mouth of the jar is closed with a clay lid or thick cloth.
6. In some cases, it is sealed with clay to prevent air and insects from entering.

Underlying scientific basis

- Porous earthenware allows limited air exchange, reducing condensation.
- Ash absorbs moisture and destroys insect larvae.
- Thermal insulation of clay helps maintain stable temperatures.

Advantages

- Reduces infestation by weevils
- Preserves seed viability
- Locally available and low-cost

Limitations

- Limited storage capacity
- Fragile and breakable

Third: Earthen Pit Storage (Underground Storage)

Storage in the earthen pit (jern)

Geographical spread: Upper Egypt, old rural areas

Crops: Wheat, barley, sorghum

Description

- The jern is a cylindrical or oval pit dug in dry, elevated ground.
- It is lined with lime or fired clay.

Human Adaptations

Storage procedure

1. Lining the pit with a layer of clay mixed with straw.
2. Leaving it to dry completely.
3. Filling it with dry grains.
4. Covering the surface with a layer of straw.
5. Sealing the opening tightly with clay.

Underlying scientific basis

- Underground insulation provides stable temperatures.
- Reduced oxygen levels limit insect activity.
- Airtight sealing prevents rodents.

Advantages

- Storage of large quantities
- Low cost
- Protection from high temperatures

Limitations

- Risk of moisture if constructed in low-lying land
- Difficulty of frequent opening

Fourth: The Traditional Shouna (Collective or Household Storehouse)

The shouna (storehouse)

Geographical spread: Delta, Upper Egypt

Crops: Wheat, maize, rice

Description

- A simple structure made of mud or sun-dried bricks.
- Raised floor and thick walls.

Storage procedure

1. Raising the grains off the ground using:
 - Wooden beams
 - Stone slabs
2. Laying a layer of straw.
3. Stacking sacks or loose grain.
4. Covering the roof with straw or palm fronds.

Underlying scientific basis

- Elevation reduces ground moisture.
- Thick walls provide thermal insulation.
- Natural ventilation reduces mold growth.

Advantages

- Suitable for large quantities
- Enables collective storage
- Easy access

Limitations

- Susceptible to insects if poorly managed
- Requires periodic maintenance

Fifth: Storage in Burlap and Natural Fiber Bags

Burlap sacks (jute bags)

Geographical spread: All regions

Crops: Legumes, maize, cereals

Storage method

- Filling sacks to approximately 80% capacity.
- Hanging them or placing them on raised platforms.
- Dusting with ash or adding repellent herbs.

Advantages

- Good ventilation
- Easy transport

Limitations

- Lower protection against insects
- Sensitive to humidity

Sixth: Storage Using Herbs and Natural Materials

Storage with insect-repellent materials

Geographical spread: Upper Egypt, oases

Examples

- Neem leaves
- Wormwood (Artemisia)
- Harmal (Peganum harmala)
- Basil
- Bay leaves

Method

- Placing dried herbs between layers of seeds, or
- Hanging them inside the storage space.

Scientific basis

- Volatile oils act as insect repellents.
- Reduction of weevil and fungal activity.

Seventh: Other Less Common Methods

Storage in pods or ears

- Storing maize on the cob.
- Hanging cobs from roof beams inside houses.
- Reduces insect penetration.

Storage in sand

- Burying small containers in dry sand.
- Commonly used for small seeds.

Traditional Methods and Knowledge for Drying Seeds Prior to Storage (Example: Onion Crop)

First: What is Solar Drying of Seeds?

Solar drying is the process of reducing the moisture content of seeds using sunlight and natural airflow, with the aim of:

- Preventing mold and fungal growth
- Reducing insect infestation
- Preserving seed viability for planting in the following season

Egyptian farmers traditionally described good-quality seeds as:

“They break, not bend,”

meaning that a properly dried seed snaps rather than bends—an accurate vernacular test of residual moisture.

Second: General Principles of Solar Drying

These principles apply to all seeds, with variations in duration and technique.

1. Appropriate timing

- Immediately after harvest
- During sunny days with low humidity
- Preferably from morning until before sunset

2. Location

- Rooftops of houses
- Ground surfaces covered with mats or burlap
- Elevated areas away from moisture

3. Protection

- Light covering at night to prevent dew formation
- Protection from birds and animals

4. Turning and aeration

- Daily turning, or twice daily, to ensure uniform drying

Third: Solar Drying of Onion Seeds

1. Characteristics of onion seeds

- Very small-sized seeds
- Highly sensitive to excessive heat
- Rapid loss of viability if improperly dried

2. Traditional method practiced in Egypt

Stage One: Drying of umbels (flower heads)

1. Onion plants are left in the field until umbels fully mature and black seeds appear.
2. Umbels are cut and tied into small bundles.
3. Bundles are hung upside down in a sunny, well-ventilated place for 3–5 days.

Purpose:

Gradual drying without exposing seeds to intense direct sunlight.

Stage Two: Seed extraction

4. After initial drying, umbels are rubbed by hand.

5. Seeds are cleaned from chaff and plant residues.

Stage Three: Light solar drying

6. Seeds are spread in a very thin layer on:

- Mats
- Cotton cloth

7. Seeds are exposed to sunlight for 1–2 hours only per day.

8. Seeds are gently turned.

9. The process is repeated for 2–3 days.

Very important:

- Onion seeds must not be left under strong sunlight for the entire day.

3. Popular indicators of onion seed dryness

- Seeds do not stick together when pressed between fingers.
- They produce a light sound when poured.
- They display a shiny black color rather than a dull appearance.

Scientific interpretation

- Onion seeds contain delicate oils that are sensitive to heat.
- Excessive temperatures damage the embryo inside the seed.
- Gradual, staged drying preserves vital enzymes and germination capacity.

Common mistakes to avoid

- Exposing onion seeds to intense sunlight all day
- Storing seeds before complete drying
- Drying seeds directly on damp ground
- Leaving seeds uncovered at night (dew exposure)

This practice clearly reflects traditional knowledge related to nature and the universe, combining empirical observation with environmentally adapted techniques, and forms an integral part of traditional agricultural practices within the framework of Intangible Cultural Heritage.

First: Subterranean Water Channel Systems (Aflaj / Qanats)**1. Aflaj (Qanat / Foggara)**

Geographical distribution:

- Siwa Oasis
- Bahariya Oasis
- Dakhla and Kharga Oases

Description

- Underground water channels that convey water from a groundwater source (spring/aquifer) to agricultural fields.
- Operate entirely by natural gravity.

Human Adaptations

- Composed of:
 - A mother well (water source)
 - A horizontal tunnel
 - Vertical shafts for ventilation and maintenance
 - A water outlet leading to cultivated land

Heritage characteristics

- Protect water from evaporation.
- Ensure equitable water distribution.
- Managed collectively according to customary local rules.

Significance for agricultural diversity

- Enable multi-layered cultivation systems (date palms – fruit trees – vegetables).
- Contribute to long-term water sustainability in arid environments.

Second: Natural Spring Channel Systems (Ain / Sāqiya / Canal)

2. Irrigation through spring-fed channels

Geographical distribution:

- Siwa
- Fayoum
- Oases

Description

- Water emerges from a natural spring and is then directed through small open channels.
- Channels are traditionally constructed using:
 - Clay
 - Stone
 - Limestone

Distribution system

- Water allocation based on time shares (by hours or parts of the day).
- Each farmer has a clearly defined turn recognised by customary practice.

Third: Traditional Mesqas in the Nile Valley and Delta

3. Mesqas (Traditional irrigation channels)

Geographical distribution:

- Nile Delta
- Upper Egypt

Description

- Secondary channels branching off from main canals.
- Convey water to small agricultural plots.

Traditional characteristics

- Water was historically lifted using:
 - The shaduf
 - The saqiya (water wheel)
 - The tanbour

Significance

- Organisation of collective irrigation.
- Reduction of water loss.
- Support of traditional agricultural cycles.

Fourth: Allocation and Rotation Systems (Irrigation by Hawali)**4. Irrigation by Hawali (rotational basin irrigation)**

Geographical distribution:

- Upper Egypt
- Oases
- Some areas of the Delta

Description

- Division of land into “hawali” (basins).
- Water is directed to each basin at a designated time.

Control mechanisms

- Clay or stone outlets.
- Small earthen embankments.

System advantages

- Prevents excessive water use.
- Allows cultivation of different crops according to their specific water requirements.

Fifth: Stone Channels in Sinai**5. Stone Floodwater Channels****Geographical distribution:**

- Central and Southern Sinai

Description:

- Dry-stone channels constructed to collect rainwater and seasonal floodwater.
- The channels direct water toward agricultural terraces.

Significance:

- Utilisation of scarce water resources.
- Protection of soil from erosion.
- Support for the cultivation of olive trees, fig trees, and barley.

Sixth: Integrated Irrigation Systems in the Oases

6. Orchard-Based Channel Systems

Geographical distribution:

- Siwa Oasis
- Dakhla Oasis
- Kharga Oasis

Description:

- A network of small channels within cultivated orchards.
- Water is distributed across the three traditional agricultural layers.

Heritage value:

- Balanced and equitable water distribution.
- Support for agricultural biodiversity.

Seventh: Social Governance of Irrigation Channels

7. Customary Water Management Systems

- Presence of a Sheikh al-Maa' (water master) or a designated water distribution authority.
- Customary rules governing the cleaning and maintenance of irrigation channels.
- Social sanctions applied in cases of violation.

This governance system constitutes an important form of intangible cultural heritage, reflecting collective knowledge, social organisation, and customary law.

Importance of These Systems for Assessment and Evaluation

These systems may be translated into assessment indicators such as:

- Existence of an operational traditional irrigation system (Yes/No).
- Number of channels in use.
- Regularity of community-based maintenance.
- Linkage to the cultivation of local and indigenous crop varieties.

Name of the Element

Traditional Agro-Climatic Knowledge and Practices Related to Seasonal Determination and the Timing of Irrigation and Cultivation (“Naw’ al-Najm”) in the Egyptian Oases

Brief Description of the Element

The traditional agro-climatic knowledge and practices locally known as “Naw’ al-Najm” constitute a hereditary environmental calendrical system used by oasis communities in Egypt to determine appropriate timings for cultivation, irrigation, pollination, and harvesting. This system is based on the observation of astronomical, climatic, and biological indicators, ensuring sustainable adaptation to desert environments and reflecting a historically balanced relationship between humans and nature.

Detailed Description

Oasis communities in Egypt—particularly in Siwa, Kharga, Dakhla, and Farafra—have developed a sophisticated system of knowledge for observing climate patterns and agricultural seasons known as “Naw’ al-Najm.”

The term refers to the observation of the rising or setting of a star or constellation at specific times of the year, serving as a natural indicator of seasonal change and suitable agricultural practices.

This system relies on accumulated empirical knowledge rather than academic astronomical measurement. Farmers associate the appearance of a particular “star” with changes in temperature, daylight length, wind direction, and the behavior of plants and animals. Based on these indicators, decisions are made regarding the sowing of cereals and vegetables, the organisation of irrigation cycles, and the timing of date palm pollination and tree pruning. These practices help reduce agricultural risks such as frost, heat stress, and root rot.

The knowledge system is not limited to astronomical signs alone; it encompasses an integrated set of meteorological and biological indicators, including nighttime cold, daytime warmth, shadow length, flowering of specific plants, and the activity of insects and birds.

This knowledge is transmitted orally and through practice, via agricultural proverbs and seasonal collective work, and forms an essential component of the cultural and economic identity of oasis communities.

Concerned Communities

- Farmers in the oases of Siwa, Kharga, Dakhla, and Farafra
- Oasis farming households
- Elders as primary bearers of traditional knowledge
- Users of traditional irrigation systems

Transmission of Knowledge and Continuity

Naw’ al-Najm knowledge is transmitted orally and practically within families and communities through participation in farming and irrigation activities and through direct observation of nature. Younger generations acquire this knowledge through experience and mentorship, ensuring its continuity and adaptive capacity in changing environmental conditions.

Social and Cultural Functions

- Organisation of the annual agricultural calendar
- Rationalisation and sustainable use of water resources
- Reduction of climate-related agricultural risks
- Strengthening social cohesion and intergenerational knowledge transmission

Compatibility with Human Rights and Sustainable Development

These practices are exercised voluntarily and peacefully, do not conflict with human rights, rely on non-polluting natural observations, and contribute to climate adaptation and the sustainable use of natural resources, in line with sustainable development principles.

Risks Threatening the Element

- Accelerating climate change
- Exclusive reliance on modern agricultural calendars
- Declining role of elders in knowledge transmission
- Weak written documentation

Proposed Safeguarding Measures

- Field-based, audiovisual documentation
- Integration of traditional knowledge into agricultural extension programs
- Support for intergenerational knowledge transmission
- Establishment of local registers for traditional agricultural calendars

Guidelines for the Documentation and Registration of Traditional Knowledge on Agrobiodiversity Preservation in Drylands

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Introduction

Recent studies indicated that Traditional Knowledge of local communities is central to agrobiodiversity management in dryland regions. Traditional communities have developed time-tested practices for conserving soil and water, including intercropping, crop diversity management, locally adapted agriculture, irrigation, drought-resistant cropping, water harvesting, and diverse planting strategies that promote ecological resilience and food security. These sophisticated systems enable them to adapt to hostile environments. Most of these agrobiodiversity adaptation practices involve either not adding fertilisers to the soil or fertiliser application using manure (Shsoil Arma, 2017; Withchew and Hailemichael, 2019; Beldados et al., 2024).

Traditional Knowledge has several advantages in agrobiodiversity. Relevance includes preserving landraces, supporting sustainable ecosystems, promoting food security, and encouraging farming practices and local communities. Traditional Knowledge enabled the conservation of local edible crop varieties that are resilient to local pests and periodic environmental oscillations. Traditional communities practice the cultivation of several crops (polyculture) and agroforestry, which promotes soil fertility and expands agricultural landscapes, thereby favouring the growth and multiplication of insects and pollinators. Traditional Knowledge enhances food security through polyculture, as it allows certain crops to survive even when others fail due to climate change, drought, rainfall shortages, locust invasions, or disease, thereby ensuring the community's continued food supply (Belachew, 2017; Belachew and Hailemichael, 2019). Local food cultures, traditional cousins, and local farming methods are often linked to the area's biodiversity, which supports the sustainable cultivation of resilient crops.

In dryland environments, the indigenous knowledge of inhabitants played a pivotal role in soil and water conservation, ecological adaptation, predicting periods of environmental stress, and promoting resilient dryland agriculture. In dryland ecology, water is conserved through sophisticated water management systems, including the construction of wells, water harvesting, and the creation of agricultural terraces. Similarly, the productivity of agricultural soil is maintained through terracing, crop rotation, strip cropping, planting windbreaks, and the application of animal manure and compost to enhance soil organic matter.

Traditional knowledge fosters adaptation to arid and semi-arid conditions through people's interactions with the local environment over several hundred years. Dryland-inhabited communities have also developed a complex understanding of environmental indicators, including predicting rainy seasons, monitoring plant and animal behaviours, and detecting famine, drought, and early warnings of crop failures. All these accumulated experiences within the community helped dryland agriculture become more resilient to the impacts of climate change (Morketa, 2024; Mulat, 2013).

Traditional knowledge is transmitted from one generation to the next through oral traditions, experience, and, nowadays, through the integration of modern knowledge. Traditional wisdom, in most instances, is transferred through community leaders and elders in the form of rituals, beliefs, stories, songs, proverbs, folklore, cultural values, community laws, and agricultural practices (CBD, 2016; Sharma, 2017).

Conceptual Framework: Definitions and relation to global and regional frameworks

“Boosting the agricultural production to feed the increasing world population and , at the same time, managing ecosystem sustainability is the greatest challenge that the scientists, farming community, and policymakers face in the present scenario. (Sherma, 2017:454)”

The idea reflected by Sherma (2017) above highlights the challenges and paradoxical relationships that scientists, farmers, governments, and international organisations face in ensuring predictable access to basic food necessities while also protecting the world’s biodiversity. The two ideas have a very intricate relationship to the extent that securing one, food, can be at the expense of the other, biodiversity conservation. The core assumption in dryland ecosystems is that traditional knowledge plays a crucial role in shaping how biodiversity is managed and preserved, thereby reinforcing ecosystem sustainability and enhancing agricultural productivity. Traditional knowledge directly impacts biodiversity conservation. As indicated in the diagrammatic representation of the conceptual framework (Chart 1) and the subsequent definition of the core concepts below, biodiversity can be considered the bridge between the community’s knowledge system and the outcomes. In drylands, biodiversity supports ecosystem sustainability and promotes agricultural productivity. Ecosystem sustainability and agricultural productivity are concurrently reinforcing.

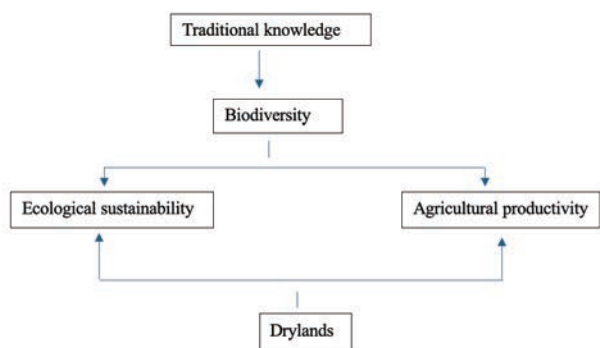


Chart 1: Conceptual framework chart to indicate the interrelationship between TK and biodiversity, ecological sustainability, and agricultural productivity in drylands.

Explanation of the conceptual framework:

1) Traditional Knowledge (Independent Variable): includes traditional soil and water preservation, farming practices, and community-ecosystem interactions in dryland environments.

2) Biodiversity (Mediating Variable): encompasses wild plants, crop landraces, livestock, and the community knowledge employed for the preservation and sustainable use of resources (e.g., agroforestry, terracing, traditional soil treatment mechanisms, intercropping, etc.).

3) Dryland (Contextual/Moderating Variable): An environmental context manifested by low and unpredictable rainfall, a high degree of climatic irregularity, and a vulnerable ecosystem. Dryland, as a moderating variable, is determined by the relationship among the other variables.

4) Ecosystem Sustainability (Dependent Variable): the result of long-term management of the ecosystem employing traditional knowledge. These can include soil productivity, water conservation, and ecological resilience.

5) Agricultural Productivity (Dependent Variable): the outcome of indigenous knowledge practices on biodiversity as manifested in enhanced crop productivity, animal husbandry, and food security.



Traditional knowledge (TK): Traditional knowledge has several synonymous expressions, including ‘indigenous knowledge’, ‘folk knowledge’, ‘local knowledge’, ‘people’s knowledge’, ‘traditional science’, or ‘traditional wisdom’. It is a knowledge archive of the inventions, traditional technologies, and adaptive practices of indigenous and local communities worldwide, developed over generations and passed down through oral and experiential learning. Traditional Knowledge is entwined with the cultural and spiritual identity of social groups and manifests differently from one community to another and from region to region. It is an adaptive, dynamic, and problem-specific reaction to environmental, economic, and social problems. There is a wealth of data among indigenous communities concerning local ecology, ethnobotany, agriculture, medicinal plants, and sustainable environmental management that can be tapped for the benefit of present and future generations (Sherma, 2017; Swiderska et al., 2018).

Origin, transmission, scope, nature, and ownership are key characteristics of traditional knowledge. The concept of origin in Traditional knowledge is rooted in centuries-old traditional wisdom and practices of local people regarding their environment and subsistence strategies. In some communities in Africa, Asia, North and South America, the record goes back to prehistoric times, as evidenced by cave art, rock art, and symbolic expressions. The idea of transmitting traditional knowledge embodied the mechanism of transferring age-old wisdom to subsequent generations through rituals, stories, songs, proverbs, and engaged experiences. The scope encompasses the diversity of themes in traditional knowledge, agrobiodiversity, ecological knowledge, tool-making, health, navigation, and other forms of expression. The principle of nature deals with the living culture, encompassing both change and continuity, in the context of cultural, economic, and ecological factors. Ownership of the traditional knowledge is communal. The local community is the custodian of the accumulated wisdom and cultural practices (CBD, 2016; Swiderska et al., 2018).

Biodiversity: The word “biodiversity” emanates from two words: “bio,” meaning life, and “diversity,” meaning variability. All living things on our planet, including a variety of plants and animals, insects, fungi, bacteria, and microorganisms, as well as the genetic diversity within them, are components of biodiversity. Biodiversity refers to the life that flourishes on land, in the air, in the water, in valleys, in mountains, in rainforests, in deserts, in caves, in hot springs, or on glaciers. Diversity in any species or variety, including the human species, is important because it is highly related to survival and sustainability. This is one of the main reasons why we must be conscious of biodiversity. It is also a source of vital, life-giving elements, like food, clean water, fresh air, and medicine, and offers cultural, economic, spiritual, and intrinsic benefits. A well-sustained biodiversity regulates the climate, supports ecosystem resilience, and deters social and environmental catastrophes, such as epidemics, famines, and droughts (CBD, 2016; FAO, 2025).

Dryland: A dryland is an arid or semi-arid part of the surface of the earth with a scarce water supply, limited rainfall amount, and high rates of evaporation. These areas cover more than 40 per cent of the Earth, mainly characterised by deserts, grasslands, savannas, the Sahel, scrublands, and cultivated areas, and provide a significant portion of the global population with specific agricultural techniques known as dryland farming. Despite water scarcity, the areas possess a variety of ecosystems that support farming through the management of soil and water runoff, the planting of drought-resistant crops, the conservation of soil moisture, crop rotation, and fallowing. The United Nations Environment Program expressed that drylands in tropical and temperate areas can be subdivided into dry sub-humid lands, semi-arid lands, arid lands, and hyper-arid lands.

The areas are evolving land masses, and their evolving and dynamic nature is determined by the entanglement between climate, rainfall, soil, and plant cover. In comparison to other ecosystems, drylands are very susceptible to climate change (Parker, 2007; FAO, 2025).

According to recent studies, for instance, approximately 96 to 97% of Egypt is classified as dryland or desert and semi-desert. Most of the agricultural produce of the land is from the remaining 3-4% of the fertile land along the Nile Valley and the Nile Delta. In neighbouring Sudan, the estimate of dryland is about 75-80%, with fragmented and limited cultivable land (FAO, 2016; Morsy, 2022).

UNESCO has been at the forefront of advocating for and mobilising efforts in global biodiversity conservation through initiatives such as the World Network of Biosphere Reserves and the Man and Biosphere (MAB) program, as well as by acknowledging and designating World Heritage Sites. The World Network of Biosphere Reserves promotes a balance between the conservation of biological diversity and the sustainable use of resources. UNESCO's perspective in acknowledging the intertwined nature of cultural and biological diversity in the nomination, ratification, and continuous monitoring of World Heritage sites with outstanding universal value has been an effective tool in safeguarding traditional knowledge, innovations, and biodiversity. The organisation relies on awareness creation, education, scientific study (through the Earth Network), bridging traditional knowledge (LINKS), restoring ecosystems, and partnerships with other organisations and international agreements, such as the Kunming-Montreal Global Biodiversity Framework, as key mechanisms and an implementation framework in its regional and global biodiversity agenda (UNESCO, 2025).

The Kunming-Montreal Global Biodiversity Framework is a vision and a roadmap for 2030, aiming to allocate 30% of the world's land area as a protected zone and regenerate another 30% of the depleted terrestrial, lacustrine, and coastal ecosystems. This roadmap was adapted by the 15th Conference of the Parties to the Convention on Biological Diversity (COP15). As a partnering organisation, UNESCO is exerting efforts to implement the initiatives through its designated World Heritage sites (UNEP, 2023; UNESCO, 2025).

Similarly, in 2019, the United Nations' Food and Agriculture Organization (FAO) initiated a scheme to mainstream biodiversity across Agricultural Sectors. The objective of the scheme is to mitigate the adverse effects of agriculture on biodiversity and promote sustainable agricultural practices, with a focus on conserving and regenerating landscapes, ecosystems, and biological resources. This strategy acknowledges indigenous people and local communities as primary suppliers in the food chain and their significant contribution as custodians of biodiversity. As one of the signatory parties to the Kunming-Montreal Global Biodiversity Framework, the FAO, through its biodiversity knowledge hub, shares its data resources on biodiversity and mechanisms for implementing food security and sustainable development goals in the agricultural sector (UNEP, 2023; FAO, 2025).

FAO is playing a pivotal role in international efforts to preserve biodiversity and promote the sustainable utilisation of drylands. These efforts conform with the objectives of the United Nations Convention to Combat Desertification (UNCCD), the Sustainable Development Goals (SDGs), and the Convention on Biological Diversity (CBD). Conservation of genetic resources, promoting sustainable use of agrobiodiversity, regenerating depleted ecosystems, sustainable use of dryland forests and rangelands, supporting climate adaptation and water and soil management, and linking biodiversity to global food security and livelihoods are basic tasks of the organisation (FAO, 2025).

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), commonly referred to as the "IPCC for Biodiversity," is an independent organisation established in 2012 to provide policymakers with scientific assessments on biodiversity, ecosystems, and their benefits.

IPBES acts as the essential link between science and policy for the preservation of biodiversity and its sustainable use. The landmark work of IPBES is the 2019 Global Assessment Report, which warned that close to one million plant species are endangered of extinction (IPBES, 2025).

In 2015, United Nations Member States enacted a universal call for action as part of the 2030 Agenda for Sustainable Development. The Sustainable Development Goals comprise seventeen sections, and the goals related to biodiversity conservation are SDG 14: Life Below Water and SDG 15: Life on Land. The first emphasises the protection and management of water-living or lacustrine species, while the latter focuses on the conservation, restoration, and sustainable use of terrestrial ecosystems by ceasing deforestation, combating desertification, and preventing biodiversity loss. Conserving biodiversity, sustainable resource management, averting species loss, and addressing biodiversity issues in national policy frameworks are key pillars of the two SDGs (UNGA, 2025).

3. Methodological Approaches: Techniques for identifying and classifying Traditional Knowledge

Identifying, classifying, documenting, and analysing traditional knowledge requires methodological approaches that take into consideration the nature of culture, geographical context, and ethical values, while also employing thorough approaches for academic and scientific purposes. In thematic areas such as dryland agriculture, biodiversity preservation, and the study of indigenous knowledge, researchers most commonly employ a combination of qualitative, participatory, and analytical techniques (Table 1 below summarises methodological tools for identifying, classifying, and validating Traditional Knowledge).

Ethnographic studies and participant observation are the primary methods for collecting data on indigenous knowledge. Participant observation, along with individual and focus group interviews, serves as a component of ethnographic studies, enabling researchers to document the tangible and intangible heritages and experiences of traditional communities. These broad anthropological approaches have been proven effective in understanding traditional agricultural practices, biodiversity management, and water harvesting techniques, which have been in practice for centuries. It is strongly recommended to actively participate with community leaders and the local inhabitants while documenting traditional knowledge for various purposes. Participatory approaches include individual interviews, focus group interviews, and Participatory Rural Appraisal (PRA).

The participatory approach underscores the partnership between the scientist and the community. These methodological approaches mitigate biases that can potentially be introduced by researchers and ensure the accommodation of local community perspectives. In the study of drylands, researchers are expected to utilise tools that include historical timelines, seasonal calendars, knowledge of climate change patterns, and biodiversity management practices (Altieri and Merrick, 1987; Asfaw, 2022).

Currently, ethnobotanical and ethnobiological approaches are also being increasingly employed for ecology-specific studies. Ethnobotanical methods, such as free listing, transect walks, vernacular, English, and scientific name listing, and classification of plant resources, soil type studies, ecological markers in drylands, and biodiversity conservation, can provide a detailed picture of our study areas (Asfaw, 2022).

No.	Methodological Approach	Objective	TK Category	Application
1	Ethnography	Recording current practices	Symbolic, implicit, explicit	Soil conservation, water harvesting, terracing, and traditional farming
2	Individual interviews	Social narratives	Acquired or ancestral knowledge	Edible plants selection, climate markers
3	Focus group interview	Knowledge validation	Communal and shared knowledge	Land administration and use practices
4	Participatory Rural Appraisal (PRA)	Joint knowledge production	Geographic and seasonal knowledge	Seasonal calendar, famine and drought management strategies
5	Transect survey	Integrate knowledge into the environment	Environmental and Regional knowledge	Soil category, plant types, vegetation zones
6	Ethnobotanical study	Appreciate plant use	Ecosystem knowledge	Edible plants, medicinal plants, and biodiversity
7	Historical documents	Change and continuity over time	Periodic adaptive experience	Climate change, survival mechanisms
8	Mapping	Natural resource availability and use	Organisational knowledge and space use knowledge	Land management, sacred forest, agroforestry
9	Archival study	Triangulate results	Historical and documented knowledge	Historical perspective of the land tenure system.

Table 1: Methodological tools for identifying, classifying, and validating Traditional Knowledge

4. Ethical Principles (EPIC) for Documenting Traditional Knowledge

FAO, CBD, UNESCO, IPBES, and organisations and conventions that advocate for and work on the conservation of biodiversity in drylands commonly agree on basic ethical principles (RPIC) in the systematic documentation, analysis, and application of indigenous knowledge. The abbreviation EPIC stands for Equity, Prior Informed Consent, Intellectual Property Rights, and Custodianship. The word “equity” refers to the idea and principle that what is acquired through recording, understanding, and utilising local and traditional knowledge should be rationally shared within the local community. The concept entails acknowledging society as a knowledge producer or a major actor participating in the study, rather than considering it as an informant. In dryland regions of the world, local communities offer indigenous edible crops, medicinal plants, soil conservation practices, water-harvesting techniques, climate change coping mechanisms, and traditional farming practices. In such contexts, “equity” addresses the practical benefits to knowledge holders, including capacity building, improved access to resources, and recognition in policy documents and scholarly outputs (CBD, 2016; WIPO, 2025).

Prior Informed Consent (PIC) ensures that members of a local community who are the targets of study are fully informed of the objective, approach, significance, and potential negative outcomes of traditional knowledge documentation-based projects. All necessary information must be provided in the local language and in accordance with culturally acceptable norms, and knowledge providers must agree willingly before data collection begins. For dryland farming practices, for instance, community leaders and farmers must agree to audio recording oral traditions or spiritual knowledge. Similarly, farmers should have prior information about their landraces, indigenous seed breeds, and planting cycle knowledge, which may be stored in seed banks or herbaria, published in hard and soft copies. In cases where the collected data may be transferred to third parties, such as educational institutions and external organisations, prior consent is necessary (WIPO, 2025).

Intellectual Property Rights (IPR) in relation to the documentation of traditional knowledge on agrobiodiversity preservation acknowledge that indigenous knowledge is a collective intellectual property of the community that must be protected from biopiracy or illegal exploitation and governed by customary laws. In traditional dryland farming practices, indigenous landraces, seed breeding knowledge, local fertilisers, and strategies for managing pests and drought resistance are part of centuries-old practices that may possess significant scientific and economic value. It is, therefore, recommendable to respect international agreements outlined in the CBD and the Nagoya Protocol on Access and Benefit-sharing. The central idea in both frameworks, CBD and the Nagoya Protocol, requires the approval of the community for patents in local landraces (CBD, 2016).

Decision-making over archives, access, sharing, and restriction of traditional knowledge and agrobiodiversity belongs to local communities, which are the primary custodians. The local community regulates access to and distribution of its resources, provides protection for sensitive, consecrated, or restricted practices, and controls the documentation and dissemination of knowledge. Some knowledge about plants, for example, can be gender-specific, which necessitates community approval before it is documented. Spiritual traditions related to sacred forests and agroforestry, as well as knowledge of traditional medicine, can be sensitive and restricted (Asfaw, 2022; WIPO, 2025).

4.1 Data validation

The data validation process of traditional knowledge must emanate from its nature and manifestation. By nature, traditional knowledge is communal, experiential, and most often verbally transmitted; thus, its validation depends on constant cross-checking, triangulating facts, and implementing participatory processes. The validation process must also ensure cultural acceptance, ethical compliance, and respect for social norms. Community-based validation, Triangulation of data, ecological and spatial validation, and ethical validation are the four main components of data validation in the study of indigenous knowledge and biodiversity. The concepts embedded in these four categories are discussed below (CBD, 2016; Asfaw, 2022; WIPO, 2025).

- Community-based validation is the main approach for authenticating the accuracy and relevance of the collected data. It is a mechanism for acquiring consensus within the community regarding knowledge collected from individual interviews. In community-based validation, researchers can employ group review sessions with knowledge holders and agreement-building workshops on interpretations, conclusions, and recommendations to validate age- and gender-sensitive knowledge.
- Data triangulation involves integrating multiple approaches and sources to validate the vigor and relevance of the data. Researchers can employ methodological triangulation, including individual and group interviews, participant observation, and PRA approaches. Source and temporal data can be cross-checked by consulting local community leaders, local institutions, and historical documents.
- Ecological and spatial validation is a ground-truthing approach that utilises traceable methods to corroborate knowledge acquired from the community. Some examples of ecological and spatial validation methods include a transect walk to check landraces and landscapes, field verification of farming practices, traditional terraces, soil types, and sacred forests.
- Ethical validation confirms that data collection is in accordance with the principles and standards of EPIC. Compliance with EPIC standards involves obtaining prior consent during validation sessions, securing approval from knowledge holders for data archiving and sharing, and verifying the exclusion or restriction of sensitive traditional knowledge.

4.2 Data Storage Systems

Data storage systems for TK must ensure the proper conservation, accessibility, and control of data by the custodians. TK data storage, unlike conventional data, should accommodate various formats, including audio, video, photographs, maps, and symbolic elements. Researchers can utilise multiple types of repositories: community-based repositories, digital repositories, hybrid repositories, and legal repositories (Kansa et al., 2005).

- Community-based knowledge repositories are directly controlled by their custodians, minimising the risk of mismanagement by external users. Local cultural centres, locally administered seed banks, and community archival centres are some examples in this category.
- Digital storage of TK provides managed access and preservation of data for an extended period. Community Biodiversity Registers and Indigenous Knowledge Digital Libraries are currently playing pivotal roles as digital storage of TK in major research institutes of the world. Multilingual records, Metadata tagging, and tiered access controls (public, confidential, and restricted) are among the primary features of digital storage.
- A hybrid data storage system combines physical storage in local institutions with controlled digital back-ups. This approach is particularly recommendable for remote and inaccessible regions of the globe. In this storage system, researchers must prioritise local control of knowledge alongside external capacity building and ensure that offline copies are available in areas with poor internet access.
- TK data storage system must be in accordance with national, regional, and international legal frameworks, policies, and conventions. Researchers must ensure that data storage agrees with the Nagoya Protocol on Access and Benefit-Sharing, national biodiversity regulations, and the customary laws of the land.

5. Field Applications and Case Studies

For a practical application of the guidelines for documenting and registering traditional knowledge on agrobiodiversity in drylands, two communities are selected: the Konso from Ethiopia and the Siwa from Egypt. The Konso are a Cushitic-speaking community that inhabits a harsh, unfavourable landscape characterised by high rates of soil erosion and steep sloping terrain. The Konso people live approximately 600 km within the Konso administrative zone in the Southern Nations, Nationalities, and Peoples' Region of Ethiopia. The society is renowned for its construction of traditional terraces, intensive farming practices, cultivation of crops such as sorghum, finger millet, and maize, and its unique socio-cultural organisation centred on autonomous councils of elders (Belachew, 2017).

Much of the geographical location of the Konso Zone is situated on a hilly metamorphic plateau that blocks the northeast-southwest extension of the central East African Rift System, which runs from Syria in the north to Mozambique in the south. The metamorphic rocks break down into soils with poor and low-yielding properties. The vegetation zone of Konzo is classified as belonging to the Acacia-Commiphora type, which is typical of a Semi-arid environment (Friis and Demissew, 2011). To adapt and cope in this hostile environment, the local inhabitants practice indigenous soil conservation by building stone terraces. The local people were able to transform their environment into a remarkable cultural landscape, which enabled them to conserve soil and water (Gashure and Wana, 2023).



Figure 1: Traditional agricultural terrace in Konso zone (Photo taken, 04/12/2022) Credits: “Nasseif Azmy”.

Konso was inscribed at a UNESCO World Heritage in 2011 as an unique “cultural landscape” that demonstrates generations of tradition, resilient adaptation to a rough semi-arid and dry environment through elaborate stone terracing, which exemplifies deep social organisation, skills, and an active heritage of agroforestry that sustains the people (UNESCO, 2011). The traditional knowledge of stone terracing is traditionally transmitted from generation to generation, where elders (especially males) are the core centre for this knowledge transfer to the subsequent generations. Both male and female youngsters primarily assist the elders by collecting stones and preparing the land. On their way, they will learn how to place stones on top of each other, fitting them to the contour line, and how to fix and compact the stones with soil (Beldados et al., 2024).

The Konso people, in adjustment to climate change variabilities, have established different types of farming systems, such as terraced landscapes, agroforestry, and intercropping, as well as physical and biological soil and water conservation practices. In the Konso farming system, when a failure occurs in one crop because of climate change, the damage is minimised because the farmer can still harvest from other agroforestry or intercropped crops. In agroforestry, trees are planted based on their resilience to climate change and the benefits they provide to the inhabitants. Each tree has varied advantages, including its role in soil and water conservation, income generation, as a source of food, fodder, construction materials, medicinal value, ritual significance, and enhancing soil fertility (Belachew, 2017; Belachew and Hailemicael, 2019).

Local community leaders state that the terraces have been cultivated for approximately six generations, which is equivalent to around 300 years. In 2022, archaeologists excavated a terraced rock shelter to a depth of 80 centimeters. The charcoal fragments from the site were dated using radiocarbon. The dating results indicate that the rock shelter was in use as a place of occupation around 1195–1235 BP and 704–950 BP (over 800 years ago) (Beldados et al., 2024).

The second example of efficient application of traditional knowledge for agrobiodiversity preservation and dryland farming is the Siwa Oasis agro-ecological system in the Western Desert of Egypt. Siwa is often cited as an example of sustainable practices and the management of crop variety, soil fertility, and water conservation, which have been employed for generations in a hyper-arid environment, utilising local knowledge. The Siwa oasis is located 750 km to the west of Cairo, the Capital city of Egypt, and is inhabited by the Berber people, who speak a Berber tongue called the Siwi language. The place is naturally and culturally endowed with attractions like the Temple of the Oracle, where Alexander the Great was named the son of Zeus; several salt lakes, 'Cleopatra's bath'; Mountain of the Dead (Gebel el Mawta), a rock-cut tomb from the Ptolemaic and Roman times; Great Sand Sea, chains of landscape mainly made of sandstone; Shali Fortress, part of structure of an old mud-brick city (FAO, 2016). The Siwa oasis has very low annual rainfall amount, which is <10 mm/year, a high evaporation rate, saline soils, and plentiful groundwater and springs. The vegetation composition of the area is dominated by date palms and olive trees. Despite the harsh environmental limitations, the Berber people sustained traditional agricultural practice using indigenous knowledge for over two millennia (Parker, 2007; FAO, 2016).

Indigenous date palm variety management, traditional oasis cropping practice, water management and distribution, indigenous soil salt treatment, and the indigenous knowledge transfer system are some of the major features of the traditional knowledge of the Berber community. Local farmers in Siwa maintain a variety of landraces of palm that can adapt to the different salinity levels of the soil and water resources, providing practical benefits in the form of food, forage, and long-distance trade. They also employ criteria such as palatability, salt tolerance, and productivity to preserve the species. The Berber practice employs a multi-layered oasis cropping system, also known as a three-tiered agroforestry system. In the upper layer, date palms are planted. In the middle layer, fruit trees (olive, citrus, and fig) are followed by underwood plants, such as barley, alfalfa, and vegetables. This approach enhances species diversity, creates microclimates that ease the impact of high aridity, and augments the soil nutrient cycle. Furthermore, the multi-layer traditional farming system conserves water and biodiversity (FAO, 2016).

The traditional agricultural systems of the Siwa Oasis in Egypt and the Konso cultural landscape in southern Ethiopia exemplify two different yet complementary pathways by which traditional knowledge maintains the conservation of agrobiodiversity in dryland environments. In Siwa, agrobiodiversity preservation is mainly attained through oasis-based agroforestry practices, where the maintenance of diverse date palm landraces, layered cropping structures, and traditional water allocation practices allowed prolonged yields under extreme aridity and soil salinity.

On the other hand, the Konso system employs landscape-scale soil and water conservation measures, particularly through extensive stone terracing, indigenous soil classification, and crop diversification strategies tailored to steep slopes and irregular rainfall patterns.

While Siwa's traditional knowledge is largely oriented toward water management and crop diversity within a specific oasis ecosystem, Konso's knowledge system works across a broader cultural landscape, encompassing crop production, biodiversity sustainability, and social organisation. Despite these contextual disparities, the two examples illustrate how locally evolved traditional knowledge, entrenched in robust customary social norms, serves as an efficient approach to conserving agrobiodiversity and upholding centuries-long resilience in dryland regions.

6. Recommendations and Way Forward

Under this section, recommendations and a way forward are presented, along with a clear list of ideas proposed as recommendations and directions for the future. The list of ideas is expected to contribute to the development of policy and institutional mechanisms that foster the preservation of indigenous knowledge and effective agrobiodiversity management in drylands.

6.1 List of recommendations

- Local community-centred registration shall be given the utmost priority in the identification, registration and preservation efforts of traditional knowledges on agrobiodiversity. As custodians of their heritage, working with community leaders, farmers, and the council of elders will provide cultural correctness, legitimacy, and sustainability.
- Strict follow-up to ethical standards and legal frameworks shall be given the necessary attention in dealing with indigenous knowledge and biodiversity management. Registration approaches must follow EPIC principles, and national laws and regulations must consider international frameworks, such as the CBD and the Nagoya protocol.
- It is also important to develop a region and knowledge-specific classification approach. Every registration and preservation system must adopt a pragmatic classification of indigenous knowledge based on function and application.
- Manifestations of the traditional wisdom of the global community must be archived utilising hybrid data storage mechanisms, with local communities given the prime right to access and use.
- Indigenous knowledge manifestations on biodiversity management in drylands must be actively incorporated into national policy documents and the economic, cultural and environmental sustainability agenda. Integration promotes the advantage of registering the indigenous knowledge. Nations are encouraged to accommodate the people's wisdom in their dryland improvement initiatives, farming practices and climate change combating programs.
- Continuous investment in local capacity building and knowledge transfer can sustain and encourage indigenous knowledge practices. Local community members and the youth should be given training in digital knowledge and in identifying, registering, storing, and managing data to enhance the knowledge transfer.

6.2 Way forward

- Working towards community participation, trust, and informed consent.

- Future documentation and approval approaches shall integrate multiple methods, including ethnographic, participant observation, ethnobotanical, and ecological methods, as well as validation with active support from the local community.
- Documentation tasks related to indigenous knowledge on biodiversity conservation must adhere to ethical standards and respect the custodianship of the local community.
- Develop infrastructure for a hybrid data archival system authorising owners of the heritage in aspects related to access, management, and dissemination.
- Integrating the indigenous knowledge of the community into development initiatives, research programs, policy manuals, and the protection of the environment.
- Implement a continuous monitoring of the impact of the documented heritage, update based on the evolution of the indigenous knowledge and socio-cultural changes.

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Guidelines for the Documentation and Registration of Traditional Knowledge on Agrobiodiversity Preservation in Drylands

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Introduction: Relevance of traditional knowledge in agrobiodiversity and dry land management

The role of traditional knowledge for sustaining agrobiodiversity is undeniable: traditional farming and agroforestry systems conserve diverse crops, landraces and useful wild plants, acting as in situ “gene banks” and seed reservoirs (Liu et al., 2022; Bhagwat et al., 2008; Turner et al., 2022); it helps maintaining high agrobiodiversity while allowing resource regeneration and soil protection (Mariel et al., 2023); it supports rich medicinal and food plant diversity, closely tied to culture, and especially women’s knowledge (Caballero-Serrano et al., 2019; Mbelebele et al., 2024); it contributes to supply diverse food groups and buffer households against shocks, while using low external inputs and agroecological practices (e.g., mixed cropping, zero tillage, organic inputs) (Pandey et al., 2022; Mariel et al., 2021).

In drylands, traditional knowledge is particularly effective in conserving soil moisture, organic matter, and biodiversity (e.g., oases, qanats, pastoral mobility) (Boerma & Koohafkan, 2004; Mashizi & Escobedo, 2025). It provides evidence-based decisions on what, where and when to plant crops that are highly adapted to drought and poor soils (Biagetti et al., 2022, Lancelotti & Biagetti, 2021). At the same time, in areas where pastoral activities might be dominant, indigenous practices such as traditional enclosures, mobility, and local knowledge-based range management rehabilitate degraded rangelands and conserve biodiversity (Selemani, 2020).

At present, the erosion of traditional knowledge (e.g., ageing holders, policy bias, and marginalisation directly threatens agrobiodiversity and ecosystem resilience (Hailu, 2025; Liu et al., 2022; Mólnar et al., 2023). As such, there is a fundamental need to formally integrate traditional knowledge with modern science, via documentation, and supportive policy frameworks (Albuquerque et al., 2021; Liu et al., 2022; Tarun et al., 2025; Mistry & Berardi, 2016).

In this paper, I will present a conceptual and methodological framework for documenting traditional knowledge relevant to the conservation of agrobiodiversity in drylands, focusing on tools and ethical standards. I will then provide examples on how this methodology can be applied and finish by suggesting some possible ways forward.

Conceptual Framework – Definitions and relations to global and regional frameworks

Traditional, Indigenous and Local Knowledge (TK / IK / LK / ILK) are generally defined as cumulative, place-based knowledge, practices and beliefs of Indigenous and local communities about relationships between living beings (including humans) and their environment, transmitted across generations and dynamically adapted to local conditions (e.g, Tarun et al., 2025).

Several institutional frameworks, including the UN, often mention TK and recognise the need for its protection and integration into policies, albeit with different degrees of detail.

For example, Article 8(j) of the Secretariat of the Convention on Biological Diversity (<https://www.cbd.int/traditional/>), TK is defined as: “knowledge honed over centuries and adapted to local cultural and environmental contexts” (<https://www.cbd.int/traditional/intro.shtml>). Similarly, the Nagoya Protocol operationalises access and benefit-sharing for genetic resources and associated traditional knowledge (Teran, 2016).

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has a dedicated ILK Approach and participatory mechanism to include ILK holders in global biodiversity assessments, using multiple evidence-based (MEB) and shared governance principles (Hill et al., 2020).

FAO defines agrobiodiversity, or agricultural biodiversity, as “[...] the result of natural selection processes and the careful selection and inventive developments of farmers, herders and fishers over millennia’ (FAO, 2004). In this line, it promotes TK-based systems through the GIAHS programme, which explicitly aims to conserve landscapes, agrobiodiversity and traditional knowledge via “dynamic conservation” (Khooakfan & Cruz, 2011). UNESCO frames TK/ILK as intangible cultural heritage and key to biocultural landscapes and sustainability education, aligning with SDGs on poverty, hunger, health, climate, life on land and strong institutions (SDGs 1–3, 13, 15, 16) (Goswami, 2018).

How well is TK integrated into policies?

TK/IK are poorly represented in the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol, and only marginally in Intergovernmental Panel on Climate Change, with a formal recognition of the value of different sources of knowledge, including Traditional/Indigenous Knowledge to improve our strategies of adaptation to climate-change in terms, amongst other things, of Sustainable Development and food production only in AR6 (IPPC, 2022). The Arctic Climate Impact Assessment is more inclusive but remains an exception (Smith & Sharp, 2012). Global calls to include TEK in climate policy largely outpace actual practice (Sutherland et al., 2014; Smith & Sharp, 2012). The UNFCCC Local Communities and Indigenous Peoples’ Platform shows inclusive design but fails to address colonial power asymmetries and risks treating “integration” as a technical fix, not a political issue (Shawoo & Thornton, 2019).

IPBES’ Global Assessment is the first to systematically engage Indigenous and local knowledge, using participatory mechanisms, but still faced major challenges in resourcing, participation, and respecting Indigenous priorities (McElwee et al., 2020). Similarly, CBD instruments (e.g., Akwé: Kon Guidelines, recognition of ILK) create normative space, yet implementation and enforcement remain weak and uneven across countries (Izza, 2025; McElwee et al., 2020).

Key limitations and conditions for effectiveness

Integration is often selective and assimilationist, reducing TK to “data” and stripping its holistic, cultural and spiritual dimensions (Shawoo & Thornton, 2019; Molnár & Babai, 2021). Power imbalances, weak rights protections, and a lack of FPIC and co-governance repeatedly undermine meaningful inclusion (Shawoo & Thornton, 2019; Izza, 2025; McElwee et al., 2020; Gómez Baggethun et al., 2013). Where TEK contributes most effectively, frameworks emphasise eco-production, legal pluralism, and Indigenous decision-making power, rather than top-down “integration” (McElwee et al., 2020).

Ethical and Legal Considerations – Community ownership, intellectual-property rights, equitable benefit-sharing.

Traditional agroecological knowledge underpins seed diversity, landraces and agroecosystems, but raises complex questions about who owns the knowledge, who controls its use, and who benefits.

Intellectual Property Rights

TK is typically communal, intergenerational and place-based, so classical individual intellectual property models fit poorly (Sukardi et al., 2024; Liu et al., 2022). Many authors argue for the recognition of communal intellectual property and “inclusive moral rights” that combine collective moral claims (attribution, integrity, control) with legal protection for genetic resources and knowledge (Oguamanam, 2025). International instruments (CBD, Nagoya Protocol) and national reforms aim to protect TK, but conventional patents and copyrights clash with TK’s collective, timeless nature (Sukardi et al., 2024). Legal scholarship, therefore, promotes sui generis TK/TEK regimes and communal IP categories to address misappropriation and biopiracy (Sukardi et al., 2024). Databases (e.g., TK digital libraries, communal IP registries) can document prior knowledge and custom and help prevent wrongful patents, but risk exposure or appropriation if not governed by communities and linked to clear consent and benefit-sharing rules (Oguamanam, 2025).

Equal access and benefit-sharing

CBD/Nagoya require access and benefit-sharing (ABS): prior informed consent (PIC) and mutually agreed terms for benefits to knowledge-holding communities (Sukardi et al., 2024). However, several case studies highlight persistent gaps: weak PIC procedures, lack of ABS institutions, and limited community participation mean that the benefits often fail to reach Indigenous and local communities (Liu et al., 2022; Rakotondrabe & Girard, 2022). More just models include inclusive moral rights plus enforceable contracts, community protocols that spell out conditions of access and sharing, and support for community-led value chains around TK-based products (Calvet-Mir et al., 2018).

Data sharing, digital commons and data sovereignty

Digital platforms treat traditional agroecological knowledge on landraces as a digital commons: knowledge is collectively governed, openly accessible and protected with copyleft licenses to resist enclosure and seed misappropriation (Calvet-Mir et al., 2018). This approach can support agroecological transitions but must be balanced with data sovereignty and community consent, ensuring communities decide what is shared, under which license, and for whose benefit (Calvet-Mir et al., 2018). Restoration and biodiversity scholars emphasise that TEK partnerships must avoid extractive data practices, respect data sovereignty, and be guided by Indigenous-led ethical codes of conduct (Molnár & Babai, 2021).

Methodological Approaches – Techniques for identifying and classifying knowledge

Community-based participatory research

The traditional approach to capturing traditional knowledge is through ethnography and participatory research. This involves “ground-truthing” models by working directly with local farmers to document crop choices, cultivation calendars, and adaptive strategies.



Figure 1. Examples of traditional ethnographic and participatory research in the framework of the RAINDROPS project (ERC-Stg 759800)

Programs like the FAO's Globally Important Agricultural Heritage Systems (GIAHS) serve as vital repositories for this knowledge, recognising landscapes where communities have co-adapted with their environments over centuries. While these “atlases” of traditional practices are essential for cultural preservation, they present a scaling problem. The data is often highly localised and qualitative, making it difficult to extrapolate general principles that can inform national or global policy.

Published ethnographic data

To bridge the gap between local case studies and global models, Traditional Ecological Knowledge (TEK) from secondary sources and published data can be used to integrate knowledge collected in the field. One such database is in the Human Relations Area File (HRAF). Founded in 1949 at Yale University, HRAF is a nonprofit organisation comprised of universities, colleges, libraries, and research institutions, whose mission is to promote understanding of cultural diversity and commonality in the past and present. Using its data, it is possible to create a robust dataset for cross-cultural comparison of agricultural activities, including those from hyper-arid deserts. By extracting data on agricultural activities from hundreds of distinct cultural groups, researchers can identify cross-cultural patterns that transcend specific geographies.

The “best practice” for modern research: a dual-track approach

While models are inherently simplifications, these generalisations allow us to offer scalable policy suggestions that a single ethnographic study cannot provide. However, these generalisations need to be validated in the field. This is why a dual approach combining generalised models produced through cross-cultural analysis of available data and ground-truthing in the field in collaboration with local farmers is essential. I

Field Applications and Case Studies

In section 2, we have seen how many definitions of TK hint at the fact that it encapsulates centuries or even millennia of experiential wisdom. However, the insights provided by the study of past agricultural systems are not yet fully exploited, albeit potentially providing invaluable data. The RAINDROPS project (funded by the European Research Council) serves as a primary example of a methodology that integrates present and past data together with environmental variables in a cross-cultural perspective to find generalised patterns applicable worldwide. The main focus of the project was to investigate how small-scale farmers successfully cultivated drought-tolerant cereals (especially sorghum and millets) in drylands for millennia, and used these insights to rethink present and future agriculture. The project combined global modelling of environmental constraints on finger millet, pearl millet and sorghum with ethnographic and ethnoarchaeological fieldwork in African and Asian drylands, showing that non-irrigated farming can be viable even where rainfall is lower than 200 mm/year (Biagetti et al., 2021; Ruiz-Giralt et al., 2023a). Traditional knowledge on cultivation practices was extracted from the Human Relations Area Files (HRAF) database. Each ethnographic case extracted from HRAF was then linked to high-resolution environmental variables (e.g. climate, soils, growing-season length). Through Redundancy Analysis (RDA), we quantified how variation in cultivation practices relates to multiple environmental factors simultaneously, identifying which variables best explain the distribution of different cropping systems worldwide (Ruiz-Giralt et al., 2023a). Model outputs were then evaluated and refined using new ethnographic field data collected through collaboration with small-scale farmers, allowing us to check whether statistical relationships derived from the literature matched conditions observed on the ground (Ruiz-Giralt et al., 2023a). This combined literature-based and field-based approach enabled us to downplay simplistic metrics such as total annual rainfall and highlight more informative ecological drivers like growing-cycle duration, soil water-holding capacity and nutrient availability (Ruiz-Giralt et al., 2023a).

The models obtained were then applied to archaeological case studies to understand the time depth of these agricultural practices. As an example, the study by Ruiz-Giralt et al. (2023b) builds on these predictive environmental models for finger millet and sorghum cultivation to reconstruct rainfed agricultural practices through time in North Eastern Tigray. The predictive models were ground-truthed against ethnoarchaeological observations in Gulo Makeda (Tigray, Ethiopia), testing whether predicted conditions match actual contemporary practices (Ruiz-Giralt et al., 2023b). Finally, the same modelling framework was applied to the Aksumite-period landscape around the archaeological site of Ona Adi, where the predictions were evaluated against archaeobotanical evidence, mainly phytolith assemblages (Ruiz-Giralt et al., 2023c). The results suggest that rainfed sorghum and finger-millet agriculture was already established around major Aksumite centres, with phytoliths indicating water-stressed Chloridoideae and Panicoideae grasses through the site's occupation (Ruiz-Giralt et al., 2023b and 2023c). By anchoring environmental and ethnographic models in archaeobotanical remains, the paper shows that archaeobotanical data can turn abstract suitability models into robust reconstructions of ancient cropping systems and demonstrate the deep history of dryland cereal cultivation.

Building on the RAINDROPS framework, new research in collaboration with the UNESCO regional office in Cairo is examining Oasis Agriculture. Preliminary searches in the HRAF database for “oasis” and “agriculture” returned data on 29 cultural groups. In North and Central Africa alone, the data reveal a complex hierarchy of crops. While the date palm is the structural backbone of the oasis (providing shade and a micro-climate), it supports a multi-layered system of cereals (wheat, sorghum) and vegetables. These systems are managed by diverse groups ranging from nomadic pastoralists to sedentary intensive agriculturalists, proving that oases are not static relics but dynamic, multi-use technological hubs. These preliminary data now need to be cross-checked against environmental and archaeobotanical variables to reconstruct the long-term general pattern of agricultural practises in the oasis of Egypt.



Figure 2. Preliminary results of the HRAF search on agriculture in Oases.

Recommendations and Way Forward

As shown in the previous sections, the data needed to achieve the full potential of incorporating long-term traditional knowledge proceeds from different disciplines: ethnography, agronomy, environmental sciences and archaeology. To unify these diverse data streams (ethnographic, archaeological, and environmental), a formal framework is required. The MEB (Multi-Knowledge Approach) was initially proposed as a framework to integrate diverse forms of knowledge – local (LK), traditional (TK), and scientific – for the governance of ecosystems. This approach stemmed from the realisation that amalgamating various knowledge systems, both within and across domains, culminates in enriched perspectives on socio-ecological contexts. Consequently, MEB methodologies prove more adept at generating successful solutions (Tengö et al., 2014).

Multi-Criteria Decision Analysis (MCDA) has emerged as a particularly powerful methodology for decision-making in environmental projects that require careful consideration of trade-offs between socio-political, environmental, and economic impacts. These situations are often complicated by the diverse perspectives of various stakeholders (Huang et al., 2011). MCDA gives an overall outcome by aggregating sustainability scores and using relative importance weights. These are values assigned to a criterion that indicate its importance relative to the other criteria. Such values highly depend on the uncertainty inherent in the data provided by stakeholders.

Developing a centralised repository

The two approaches delineated above can provide a roadmap for developing a web-based, open-access, geospatial database, intended to be accessible to academics engaged in the collection and analysis of long-term traditional knowledge (i.e., archaeologists and historians), as well as to Sustainable Development practitioners at both the supranational and local level. The incorporation of diverse data onto this platform must rigorously adhere to the FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective benefit, Authority to control, Responsibility, Ethics) principles. Additionally, the platform's design should align with the guidelines set forth by the LICCI project concerning novel data collection (Labeyrie et al., 2021). Moreover, any platform collecting TK must ensure the preservation of appropriate Intellectual Property Rights (IPR) and Data Governance, in accordance with the directives outlined by the Research on Indigenous Data Governance Protocols: A toolkit for working with Indigenous Knowledge project (RIDaGoP, 2022)

Human Adaptations

Farmers at the centre

As highlighted in section 3, in order to work within a legal and ethical framework, the participation of local farmers is essential. All projects should work within a framework of collaboration where the research is co-created, and the results and benefits are shared. There are successful examples of how technology can be used to promote the voice of local farmers. For example, the SWIFT project is a four-year, EU-funded research initiative designed to facilitate transitions toward sustainable, balanced, and inclusive development within European rural areas (<https://swiftproject.eu/>). By prioritising the deployment of women-led innovations (WLIs), the project seeks to transform agricultural models through an intersectional, feminist, and human rights-based framework that promotes gender equality. The researchers in this project employ very effective methods, such as participatory video and co-creation spaces, which empower participants with a high level of decision-making authority regarding the information they choose to share. Another very successful example is that of AccessAgriculture, a nonprofit organisation that enables the co-creation and sharing of agrobiodiversity videos, recorded by local farmers for local farmers and available in multiple languages (<https://www.accessagriculture.org/>).

Conclusions

Traditional and Indigenous knowledge and agrobiodiversity are now explicitly embedded in various institutional frameworks, in the UNESCO cultural/educational agendas and the SDGs. These frameworks increasingly emphasise rights (UNDRIP, FPIC), benefit-sharing (Nagoya), and co-production of knowledge as prerequisites for sustainable dryland and agrobiodiversity management. However, these global frameworks only partially integrate TEK, whereby inclusion is uneven and often constrained by power imbalances rather than being fully effective. Part of the problem in this integration lies in the dispersion of data, the unevenness of methodological frameworks to work with such knowledge and the lack of a centralised repository of data that could highlight the general patterns that can be inferred by the analysis of traditional methods. In addition, the integration of long-term data, such as those offered by archaeological studies, is not happening.

Many ancient systems demonstrated greater longevity than modern infrastructure and were often inherently more sustainable, consuming less energy, being easier to operate and maintain, and having more communal governance structures. Today's challenges are clearly not directly comparable to those of the pre-industrial world – and in most cases, ancient solutions cannot simply be reactivated or replicated.

However, designing solutions based on the analysis of short-term data can sometimes lead to negative results (Allen et al., 2022). Therefore, a multi-faceted approach is needed, involving mapping present-day problems and attitudes towards agrifood systems and investigating how past societies responded to the challenge of sustainably managing resources, together with the consideration of the underlying geological and geographical contexts.

This perspective posits archaeological data as the most potent proxies for long-term knowledge. The pertinence of archaeological data in addressing contemporary global challenges is seldom emphasised. Nevertheless, recent scholarly works have consistently highlighted the necessity to consider different knowledge systems in climate change research, including the potential of archaeology and deep historical insights to contribute to the attainment of the United Nations Sustainable Development Goals (UN SDGs) (Allen et al., 2022, Petzold et al., 2020, Kerr 2020, and references therein). A combined approach linking ethnographic, archaeological and environmental data, collected in a centralised repository that is open and follows the FAIR and CARE principles, could be the starting point to move forward. In order for these data to be useful for policy, they need to be analysed following an MEB and MCDA approach

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Documenting Traditional Knowledge and Heritage of Agrobiodiversity to Enhance Conservation

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Traditional agricultural knowledge systems, along with associated crop diversity and cultural practices, are threatened. Globally, crop diversity has declined over the last century, accelerating especially since the mid-twentieth-century green revolution (Khoury et al., 2022). Global populations depend on a narrow range of crops, often grown as monocrops with intensive irrigation, pesticides, and chemical fertilisers (Khoury et al., 2014). It is estimated that today, just 30 crops account for 90% of global edible calories, 60% of which come from wheat, maize and rice (Loftas and Ross, 1995; FAO, 1997). There are, however, hundreds of domesticated crops and at least 7000 edible species, often associated with traditional food and agri-systems (Meyer, DuVal and Jensen, 2012; Diazgranados et al., 2020; Ulian, Diazgranados, Pironon, Padulosi, Liu, Davies, Howes, Borrell, Ondo, Pérez Escobar, et al., 2020; Fuks et al., 2025). A problem, however, is that traditional crops, wild edible species, and associated knowledge are under threat (Kuhnlein et al., 2009; IPBES, 2019).

Locally important traditional crops and agrisystems tend to be underdocumented and underresearched, and are subject to rapid modern change. Furthermore, compared with global commercial crops, local seed varieties are also underrepresented in seed banks (Ramirez-Villegas et al., 2022). However, historic varieties can be particularly well adapted and culturally significant. In situ ‘on farm’ conservation is crucial because it provides the context for crops continuously adapt to future growing conditions (Brush, 2007). As such, conserving agrobiodiversity is critical for both local and global farming systems in the face of future climate change.

Cultural and natural forces create crop diversity; these dimensions are often not integrated in research (Maffi, 2005; Argumedo et al., 2021; Ryan, 2025). Crop diversity includes the range of species grown and the varieties of those species (often called landraces). Crop diversity, on the one hand, reflects adaptation to local soils, climates, and water availability, and, on the other hand, farmers’ preferences. As a result, farmers can maintain several varieties of the same crop for diverse regions. For example, in Ethiopia, farmers maintain several barley landraces (farmers’ varieties) for different food dishes or for their resilience, including some suited to specific soils and others more drought-resistant (Shewayrga and Sopade, 2011). Persisting crop diversity is closely linked to knowledge of cultural uses, varietal naming, cultivation, land use, management, and processing. As such, it is valuable to document all these components that together comprise traditional agricultural systems.

Conceptual Framework

Useful Definitions

● **Agrobiodiversity:** The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the broader environment that support agroecosystems (agricultural, pastoral, forest and aquatic), as well as the diversity of the agroecosystems (FAO, 2006b)

Landrace crops: A widely used definition for ‘landrace’ is ‘a dynamic population(s) of a cultivated plant that has historical origin, distinct identity and, as well as often being genetically diverse, locally adapted and associated with traditional farming systems’ (Villa et al., 2005).

Traditional knowledge (TK): the knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity (CBD, 2018). There are alternative terminologies, such as traditional ecological knowledge, and Local and Indigenous Knowledge.

Biocultural diversity: biological diversity and cultural diversity and the links between them, and Biocultural heritage, the holistic approach of many indigenous peoples and local communities, with knowledge also recognised as “heritage”, reflecting its custodial and intergenerational character, and including, for example, cultural landscapes (CBD, 2018).

Cultural Heritage: Includes the physical (tangible) and/or non-physical (intangible) cultural heritage of indigenous peoples and local communities (CBD, 2018). Many types of cultural heritage mentioned from their broader definition can be connected to agrobiodiversity - including TK and practices linked to plant uses, foods, and their histories, to cultural landscapes and architectural structures. For example, the Konso Cultural Landscape, inscribed by UNESCO in 2011, is famous for many aspects of its cultural heritage, including its agricultural terraces and unique agroecosystems (Beyene, 2013).

FAO ‘Globally Important Agricultural Heritage Systems (GIAHS) Remarkable land use systems and landscapes which are rich in globally significant biological diversity evolving from the co-adaptation of a community with its environment and its needs and aspirations for sustainable development (Agnoletti and Santoro, 2022).

Agricultural and Biocultural Heritage as conceptual frameworks. These terms help provide a heuristic framework for documenting and conserving traditional agricultural practices from a systems perspective and to link natural and cultural heritage conservation approaches. Although agricultural heritage and agrobiodiversity do include some wild species such as weeds, cultivated edible wild plants, and crop wild relatives, they are in some way connected to agri-systems. Biocultural Heritage is a slightly broader term that also includes all wild biodiversity.

Nevertheless, these definitions are not entirely fixed and generally overlap. Crucially, these terms highlight the interconnection among many components of agri-systems, including crop diversity, cultural preferences and management practices, cuisine, landscapes, and local worldviews. The range of the identified components illustrates the wide range of topics that can be addressed when documenting traditional agri-systems and associated knowledge, covering the different dimensions of cultivating crops and transforming them into food, and the wider socio-economic context as well as related material culture (FAO, 2006a; Koohafkan, 2019; Swiderska, Argumedo and Pimbert, 2020).

Agrobiodiversity and International Frameworks: The importance of Local Communities and Indigenous Peoples (LCIP) and associated traditional knowledge in preserving biological diversity, including agricultural, has been highlighted by the Global Assessment Report on Biodiversity and Ecosystem Services, issued by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019).

Agrobiodiversity, connected forms of heritage, and traditional knowledge are critical for addressing several sustainability goals, including SDGs 1 and 10 on ending poverty and inequality, SDG 2 on Zero Hunger, SDG 3 on health and wellbeing, SDG 15 on protecting ecosystems and biodiversity, and SDG 13 on climate action. The achievement of the Sustainable Development Goals is further supported by the adoption of the Kunming-Montreal Global Biodiversity Framework (GBF) during the fifteenth meeting of the Conference of the Parties (COP 15). This framework builds on the prior UN Convention on Biological Diversity (CBD) strategic plans and includes reducing biodiversity loss (target 1) and enhancing biodiversity and sustainability in agriculture (target 10)

Methodological Approaches

Interviews can potentially cover a wide range of components that together comprise traditional agricultural systems. Categories of knowledge and practice related to crops span from cultivation to cuisine, along with related material culture such as irrigation tools, through to cooking technologies and recipes. Some crops also have multiple uses, such as for fodder, crafts or cultural ceremonies or celebrations, and multiple varieties within the same species can be grown for various reasons. Cultivation and irrigation can lead to further questions about land use, whilst factors affecting the stability or threat to systems can entail wider socio-political-economic topics. Knowledge can be differentially held by gender or age, and variations exist between households and villages. Often, plants might be collected as reference material to secure identification and connect local to scientific terms. As a result, traditional agricultural practices and crops are studied and documented across a wide range of disciplines, with varying foci.

As such, methods from many different types of studies can be drawn on to study elements of local agri-systems. Many projects will focus on individual elements of a traditional agricultural system. Documentation of traditional agricultural practices can span recording details about varieties grown, cultivation and land-use practices, crop and food processing, related material culture or cuisine, and information on livelihoods. Projects focused on specific topics or crops might include methodologies that compare multiple villages or regions (Burton et al., 2024). Studies that encompass a wider range of components within agri-systems tend to be locally focused 'place-based' projects – defined by the agri-system itself or the cultural geography (Swiderska, Argumedo and Pimbert, 2020; Bahnasy, 2024).

Some of the disciplines drawn on span anthropology and archaeology, agri- and plant-sciences and development studies, to ethnobotany and ethnoecology. Ethnobotany and ethnoecology are useful interdisciplinary subjects that draw on other subjects and provide a bridge between the cultural and natural sciences (Ryan, 2025). Ethnobotany (the study of plants and people) can provide useful methods for documenting crop varieties, their uses and local naming systems, as well as cultivation and processing. Ethnoecology extends the focus to wider agricultural practices and land-use management. Ethnobotany undertaken by archaeologists (often termed ethnoarchaeology) often focuses especially on detailed observation about crop growing, harvesting and processing, or cooking practices to understand past practices and archaeological remains (D'Andrea et al., 1999; Lancelotti et al., 2019).

Several topics may therefore be addressed within interviews, and the priority that they are given may depend on the local agri-systems context and what types of knowledge or agrobiodiversity are endangered. For example, is the major research focus on a traditional technology, crop, or the whole system, and why? Logistics, time, and resources will add a further need to prioritise questions – for example, the remoteness of a site, the size of a team and capacity for training local partners will vary by project.

As such, no two projects will be identical in terms of methods. As such, some topics could be examined in detail, and some more broadly, for example, all plants cultivated could be inventoried and fewer chosen for specific focus. Finally, interviews can be farm-based, in groups, or in combination, allowing the possibility of covering a wider range of topics, though at varying levels of focus. Furthermore, the specifics of focus should be refined in consultation with local communities as part of the research process, and interview processes should be trialled and refined. Many different topics can be addressed during the interviews, covering topics that connect from farm to plate, and more.

Landrace crops - Traditional crop varieties in semi-arid to arid lands can be particularly important for climate resilience, as historically grown varieties are likely to be particularly well adapted. Crop diversity includes the range of species grown and the varieties of those species (often called landraces). A widely used definition for 'landrace' is 'a dynamic population(s) of a cultivated plant that has historical origin, distinct identity and, as well as often being genetically diverse, locally adapted and associated with traditional farming systems' (Villa et al., 2005). This description reinforces the value of documenting the many components of agricultural systems alongside crop diversity. Depending on the crop and context, species may have just one or a wide variety, and this will influence how interviews are structured.

Land use mosaics - Fieldwork could include studying whether traditional agricultural systems have complex systems and mosaics of land use, or whether they did in the past. Certain species or varieties can suit certain soils; for example, some can grow in poor soils. In other cases, soils will need more management, perhaps by adding manure or ash or by using legumes in crop rotation and intercropping systems (Burton et al., 2024). However, whilst the benefits of local practices like intercropping and soil management are widely cited, they are infrequently documented in any detail (Maitra et al., 2021). The location of crops will also depend on water availability, including how well moisture is retained in different soils, or the depth to water tables and which crops have varieties suited to these locations, varying further by species and varietal tolerances and seasonality.

Cultivation and processing practices – Documenting Traditional Agriculture could include various steps from cultivation to cooking, depending on the focus. Cultivation includes landuse mosaics as well as the tending of plants (weeding, watering). Crop processing steps such as harvesting, threshing, crop cleaning and storage could be documented if they still exist, and otherwise discussed from memory. There can be a wide discrepancy between traditional farming systems, with some elements of traditional practices persisting in some more than others, and with varying processes being replaced by mechanisation, and even within the same system, this can vary by crop (Ryan et al., 2022).

Local and scientific crop terminology - It is important to document local terms for crops as well as botanical terms, and additionally, other local agricultural terms, such as for tools or soils. Vernacular taxonomy and scientific taxonomy commonly differ (Wang et al., 2019; Gros-Balthazard et al., 2023). Local names can be specific to landraces, species, or they can reflect the categories that sit between species and landraces. Local names can also group varieties and species by criteria such as uses, names of foods, or modes of cultivation and habitat (Ryan et al., 2022). Similarly, general terms like 'bean' and 'millet' are often used to refer to specific species, but this varies by country context. Therefore, it is important to document local terms to help conserve local knowledge, and additionally, scientific terms, so that findings can be linked to wider studies about the relevant crops or practices.

Varietal uses - It is important to document any differences in uses between varieties of the same crop. This is because farmers can select local landrace varieties for a very wide range of reasons, such as cooking properties, animal fodder, cultural importance, drought tolerance or sale. For example, in Ethiopia, barley is known as 'king of crops' and many different landraces are grown for specific food dishes (Shewayrga and Sopade, 2011). In north Sudan, the historic landrace varieties of wheat and broad beans were preferred by some local communities for home food due to preferred taste, whereas the newer seeds had greater yield and commercial value (Ryan et al., 2022).

Temporal change - It is also important to document changes in living memory (Nazarea, 2006). In the last 60 years, dramatic changes in dietary roles of many crops are linked to new lifestyles, shifts towards growing commercial varieties, habitat and intergenerational knowledge loss, and wider socio-economic and political shifts (Turner et al., 2011; Eliazer Nelson, Ravichandran and Antony, 2019; Khoury et al., 2022; Ryan et al., 2022; Burton et al., 2024). In this wider context of change, entire species can be partly displaced or lost within a region, with remnants of their former diversity and use surviving patchily. Farmers can be interviewed about present-day crops and practices and asked about changes in living memory. Sometimes a particular historical moment makes comparisons to a particular decade realistic, and otherwise interviews can be structured in a way to inquire about change at various temporal intervals, such as 10, 20, and 30 years ago. These approaches would help reconstruct changes. Oral histories, longer accounts by elderly farmers and members of the community, can develop a wider context, and are important for documenting stories and memories.

Individual or household versus group interviews - with group interviews, it is possible to gather some consensus views, and it is an easy way to summarise some information, such as about crop processing, land use, irrigation or cooking. Women and men and different age groups can hold different knowledge, so households could interview some topics and additionally, some with different arrangements of groups or individuals who are specialists. Group interviews allow greater geographic coverage and a range of questions discussed within the fieldwork timeframe constraints.

Interviews across multiple households or groups are needed for documenting crop diversity and uses, and should include some inventories, semi-structured and structured questions to obtain comparable information (Tardío and Pardo-de-Santayana, 2008; Albuquerque et al., 2014; Martin, 2014). Open-ended questions are suited to understanding practices such as irrigation, storage and landuse. More targeted questions are useful for studying crop diversity, including enough interviews for assessing the range of crop varieties and their uses locally. For comparison, crops can be inventoried in farm visits, in household interviews or in group interviews.

If a number of interviews are undertaken/farms surveyed (e.g., >20), then differences between them can be compared. This may not be possible in all fieldwork timeframes or within project aims, but at least several farm visits/interviews are needed to pick up variability in obtaining a baseline inventory. Differences amongst ages/gender in plant uses, or knowledge can be considered if there are greater numbers of individual interviews, or group interviews organised by age/gender. If interviews are mainly conducted away from the farms, then separate visits to farms could target a detailed listing of crops, uses, locations and practices.

Participatory farm and landscape Mapping – An aim could be to see the relative distribution of land areas, associated crops, and water sources or other practical and cultural features. Different approaches could include free-style drawing or printed maps (e.g., from Google Earth) that could be traced onto. Apps-based approaches also have potential for development, with this approach, for example, trialled in traditional farming systems in Kenya (Davies et al., 2023). Taking multiple photographs is important for documentation, aiding later understanding of the context by forming an archive, as well as providing examples for outputs.

Plant collecting - reference vouchers (collected specimens deposited in herbaria) are essential for confirming plant identifications and as a reference for future researchers and comparison (Martin, 2014). A set of collected specimens could be used to aid discussions in interviews, especially if many interviews are not undertaken on-farm. It is recommended to collaborate with a botanist and herbarium, or otherwise arrange for training for field collecting and a herbarium and/or museum or university collection to house any collection.

Studying links between crops and foods – understanding foodways can be crucial to conserving crops, and crop diversity is essential for nutritional health and food security (Kuhnlein et al., 2009). During fieldwork, which crops are used in which foods, and how these have changed, can be documented. Sometimes, food types can still exist today, but more complex ranges of ingredients were used in the past, hiding a shift in nutritional diversity (Ryan et al., 2022). The traditional knowledge connected to the range of recipes and cooking practices can be essential for conserving and reviving agrobiodiversity, with community-based and participatory approaches being critical (Soliman, 2025). These sorts of biocultural heritage approaches underpinned the study of, valorisation, and UNESCO recognition of wild and domesticated vegetables in Kenya (Safeguarding intangible cultural heritage: traditional foodways of the Isukha community of Kenya - UNESCO Digital Library, 2022).

Participatory Approaches - should include local research priorities and co-design of the research and documentation process, including preferred formats for outputs (e.g. printing, filmed, YouTube, community events, food fairs) or community databases. Additionally, concerning what sorts of data might be included in different types of open-access academic journal formats or repositories. Co-design can include the priority of topics being documented, including, for example, crops or topics of focus. Also, the research team composition, including consideration of local methods of learning, training opportunities, and valuing traditional and ancestral knowledge alongside science, and understanding community-based decision-making and institutions (da Fonseca-Kruel et al., 2019; ‘Co-enquiry and participatory research methods manual | Global Diversity Foundation’, 2020; Swiderska et al., 2022).

Documentation tools – For short response questions, ARC GIS survey 123 (or QGIS equivalent) can be useful, capturing the GPS and the capacity to add photos and some recording. For longer form interview questions, potentially survey forms could be useful, if it is easy to work on laptops or tablets. Otherwise, in some cases, it is still more practical to write answers by hand, but note this involves a later stage of transcribing results into Word and Excel. Even from a software-based form, a later stage of data cleaning will take quite some time (e.g., consistent spelling or ways of noting information).



Figure 1. River Bank crops

These deliberations are particularly relevant for cases of multiple interviews and any planned analysis. The detailed inventoried approaches relating to the botanical information have an aim of ensuring that crop varieties, names, uses, phenotypic information, etc., are well noted. An anthropological approach, particularly for documenting information about practices, can suit longer form text, or other methods such as possible recording, or planned filming of specific activities (de Hek and Ladio, 2019).

Community-focused outputs – journal articles are useful to distribute findings across academic, policy and other institutions and for libraries. Additionally, a wider range of formats also needs to be co-developed with local partners and communities (Swiderska et al., 2022; Spencer et al., 2024). These can have, for example, a greater scope for including greater levels of detail, and more images than other publication formats. Examples could be printed booklets for households (if numbers are realistic in smaller villages), or otherwise, community or cultural centres and schools. There are many potential scenarios, such as local artists providing illustrations for booklets, or written materials being produced in different formats for different age groups, and in different ways for different types of information. For example, some outputs may include information that is relatively technical (e.g. plant descriptions and agronomic) or details of recipes or else local histories and memories (Ulian, Díazgranados, Pironon, Padulosi, Liu, Davies, Howes, Borrell, Ondo, Pérez-Escobar, et al., 2020).

Access to the internet with smartphones is constantly altering the potential options and related costs for storage, and levels of skill needed for filming and curating materials, making online content increasingly an option as well. Content, style, and formats should be co-designed from the start of project development, along with consideration of the longevity of storage solutions. For example, community booklets can include online versions and have copies deposited in libraries. Websites are vulnerable to long-term funding, and online repositories may also be an option for certain materials.

Ethical principles (FPIC) - Free Prior Informed Consent (FPIC) to ask for permission (consent) before interviews and any associated material culture or plant collections with enough information to enable the provider to make an informed decision (International Society of Ethnobiology – ISE, 2006). This should include a detailed description of the project, how any information or collections would be used in the project and any potential future use. Consent can be written or as a verbal agreement if recorded. This includes discussion on the ownership of research results, publication plans and any limitation on access or use and on the sharing of benefits. There are additional considerations if plants are collected, with specific consideration of any potential uses beyond the lifetime of the project, and collaboration with specific plant collecting partners to help facilitate these aspects. Plant collecting incorporates greater consideration of the use of and access to botanical materials, including beyond the lifetime of the project. PIC should also include agreement on sharing of benefits, for example, relating to inclusion in authorship, involvement or employment and education opportunities in the research.

Connecting crops past to present – understanding the backstories of today’s crop diversity can help revitalise and promote them. Knowing if a variety or species has a long regional history of use also helps to underline its potential cultural and resilience value. Datasets can include a wide range of historical and archival sources, as well as published archaeological datasets that indicate which crops are indigenous, ancient introductions, or else more recent (Foaden et al., 1908; Boivin et al., 2014; Fuller et al., 2014; Bouchaud et al., 2018; Veen et al., 2018).

Ethical and Legal Considerations

Working, taking and storing of traditional and indigenous knowledge and CARE Principles

It is vital to protect farmers and Indigenous and Traditional Knowledge (ITK) (Brush, 2007). To aid this, it is important to work with partners who hold key knowledge of local customs and etiquette, laws, protocols, and governance. The ISE Code of Ethics includes guidelines for collaborative research related to ethnobotanical interviews and prior informed consent (International Society of Ethnobiology – ISE, 2006). Collecting and archiving traditional knowledge in general should include participatory research methods, including co-creating local research methods and outputs, co-authorship, respect for local community worldviews, ethics and priorities. In some projects, plants may be collected as ‘voucher’ specimens to aid interviews and for documentation purposes, including potentially to be deposited in a herbarium or museum. For any plant collections, it is important to follow Access and Benefit Sharing (ABS) processes under the Nagoya Protocol (NP) on Prior Informed Consent (PIC) and on associated ITK related to collections. In such cases, it is important to create a PIC process specific to these collections, for determining what their potential future uses may be, for example, purely for facilitating identification and acting as a voucher specimen, for education purposes or for other types of scientific analyses. In the case of crop plants, collecting partners from agricultural or botanical institutions would follow the NP as well as the International Treaty on Plant Genetic Resources for Food and Agriculture Article 9 to protect, promote and realise Farmers’ Rights. Research should aim to align with CARE Principles, which are designed for Indigenous Data Governance, and can be extended for working with Local Communities.

Care principles can be applied to different types of data, including environmental, cultural and any collections such as seeds or material culture (Carroll et al., 2020; Jennings et al., 2023). CARE stands for Collective benefits, Authority to control, Responsibility, and Ethical dimensions. Collective benefits consider the principle of shared scientific and societal benefits

This includes that communities and local participants share rights ownership by co-authorship and acknowledgement, according to their wishes, and co-designed community-based outputs for preserving TK, and potentially other benefits related to farmer livelihoods, food security, including any seed collecting for conservation.

Authority to control includes how PIC should include how community and plant data will be used, stored, and shared. Interview data would often be recommended to be anonymised unless participants and authors request otherwise; this very much depends on the wishes of local collaborators and participants and the local context. Publications should be checked with local co-authors and communities who can retain the right to withdraw information, control of interpretation and data sharing. Responsibility includes consideration of community worldviews, values, checking publications with local collaborators and co-creation of the local report formats. Finally, Ethical dimensions would include listening to and engaging with perspectives on data governance and outputs and conforming to the ethical frameworks of the communities.

Field Applications and Case Studies

SIWA, a study of agrobiodiversity over time (Nabhan, 2007)

This project included a survey of crop diversity through (1) creating an inventory of all crops sold in five fruit and vegetable markets in Siwa's center of commerce; (2) listing all the crop species and landraces at several spring-fed oasis farms, (3) recording in field notes all other crops and livestock seen in four days of field trips, and in August and in January. Siwan folk taxa (Berber dialects) for several crops were noted, including efforts to work on transcription, and these terms were compared with Arabic terminology. Results were compared with available regional archival materials to assess changes over time. The results found continuity and change. The findings created comprehensive overviews of species and varieties present, providing a historical baseline for comparison with future work.

South Lebanon, a study on agri-food System Dynamics, 1920–2015 (El Nour, 2017)

This example focused on agricultural change and is a case study that presents an instance of a researcher being able to spend over a year undertaking fieldwork in detail in one location. The present-day information was also linked with historical approaches and data to put into the context of changing agri-systems over the last century, including the socio-political and economic context and history of agri-development. This provides an insight into the ways ethnographic interview formats can be adapted in relation to types of questions and the overall research time available. This study was based on ethnographic fieldwork in one village in detail, with the fieldwork spanning nearly two years. The methods included participant observation, semi-structured interviews, life stories of practices and work trajectories of elder men, as well as group interviews and exercises documenting wild plants and traditional foods. Many informal meetings were organised with villagers, and often discussions took place in informal settings. About 70 people were interviewed, and 15 in-depth stories were conducted, with ages between 30 and 80, and included both women and men. Semi-structured interview topics included agricultural techniques, mechanisation, wage labour, the land-tenure system, flow of capital, food habits, and local wild plants. Interviews varied between 30 and 90 minutes in length, and took place in various locations (in the agricultural fields, in the houses of interviewees, and in my house in the village). Some thematic interviews were recorded so that the discussions could be transcribed afterwards. Presence in the village allowed the researcher to observe everyday life.

Ethnobotany of Changing crops and foods in North Sudan and writing a community book

(Ryan et al., 2022)

This project looked at long-term crop histories and changes in living memory by conducting ethnobotanical research in Nubian households in the Abri region. Interviews initially included fieldwalks to inventory all crops. Then, a smaller number of crops were focused on, and during interviews with household farmers, all cereals and pulses were inventoried, including asking about their uses and what soils they were grown in. We interviewed as many elderly farmers as possible (aged between 70 and 100) so that we could ask them about crops grown in the middle of the twentieth century. This was an easy timeframe for comparison because during the 1960s-70s, the traditional irrigation was replaced, and new seeds were introduced. The results showed that the main locally important food crops in the mid-twentieth century (like lupins, lablab, cowpea, and barley) have become less important relative to modern wheat and broadbeans.

The changes were complex, spanning the altered irrigation, bird attacks, crop processing issues, and a shifting away from some local food dishes. We surveyed around 30 farms on one island, and groups of farms in various other villages for comparison, using mostly the subset of interviews based on the inventory approach. Word lists of crops, soils, agricultural tools and types of foods were written in local Nubian (in Latin letters) and Arabic. The project considered the whole agri-systems in detail. In the focal region, open-ended interview questions were asked for a wide range of topics (e.g. cultivation and multicropping, landuse, cooking, storage, agricultural tools, and specific processing details for certain crops, such as lupins that need detoxing), and in these cases, often 3 or 4 interviews would be adequate per topic. The project findings were also compared with archival and archaeobotanical datasets showing the crops becoming more minor today had long regional histories, highlighting their resilient traits. At the request of a local teacher during a school visit, a community book was co-created as part of a subsequent funded project. This included lots of pictures and illustrations (based on archival sources). Below is an example of an inventory format for listing crops.

	Today				Past (when?)				Notes on temporal changes
	Grown ?	Uses?	Land area / how irrig	Grown ?	Uses?	Land area / how irrigated			
Crop / variety name									
x									
x									
x									
x									

Other open-ended interviews were transcribed. At the time (2014-2019), interviews were handwritten and recorded to aid checking. This was practical as there was a small research team and project time to write up information back in the UK; also, the wind-blown sand made working on computers difficult. However, this approach was very slow and would be less practical for a larger research team, as such data collection tools would be useful.

Ethnobotany of yams and fonio millet in Guinea, West Africa

These examples provide a case study contrast to the Sudan interviews because they focus on specific species. These are included here to illustrate how the crops being studied can influence the interview format.

Human Adaptations

In these instances, the crops had high numbers of landraces, some of which had different uses and historical trajectories; as such, there needed to be a focus on some questions at the varietal level as well as at the species level. More formalised interview forms were used because there was a wider range of people undertaking interviews. Interviews were in French and local languages. Crop calendars were created, showing when crops were planted and harvested, and further questions included about agri-practices and connected foods. Finally, a few questions aimed to capture information about the changing role of these and other crops over time. We tried 2 ways – the first, ‘which are the priority crops today, and which in the past’ (answering in order of importance) was very useful for tracking shifts. Second, we asked on a scale of 1 – 5 (low to high) – how abundant was x crop today versus 10, 20, 30 years ago – this aimed to get an insight into the timing of temporal change. Unlike in Sudan, there was not a very clear universal timeframe that could be used in a consistent way. These 2 approaches have proved effective at the species and varietal level in interviews. Examples of interview forms are available in the Supplementary information files in papers published from these projects (Burton et al., 2024; Condé et al., 2024).

Date Palms, documenting names

A focus of many different types of research projects and disciplines, date palms are typically central to oasis agri-systems (Bekheet and El-Sharabasy, 2015; Bretzke et al., 2025). Date palms are examples of crops often with multiple varieties, and ethnobotanical research has shown that documenting their names and what these names represent is valuable from several perspectives related to their research, cultural heritage and conservation (Gros-Balthazard et al., 2023). Firstly, some varieties had specific names, whilst other terms were more ‘aggregate’. For example, in Sudan, ‘gaw’ referred to ‘seedling dates’, so in contrast to other names, gaw could represent multiple varieties, and it also represents a fundamentally different mode of cultivation. Archival documents also show this seedling propagation mode (as opposed to clonal) was once widespread in southern Egypt (Mason, 1927). More broadly, the complexity of oasis agriculture requires holistic systems-based approaches, of which documentation of dates and other crops is just one component (Bretzke et al., 2025).

Recommendations and Way Forward

Highlighting the importance of crops in arid regions should be a focus within global initiatives and policy aiming to conserve agrobiodiversity. Preserving agrobiodiversity is crucial for future local and global food security (Schmitz et al., 2021). Varieties in arid lands can be argued to be particularly important as some may have particularly valuable adaptations, which can be illustrated through detailed documentation of crops in their cultural context and traditional knowledge. These locally adapted crops are important to conserve regionally. Studying the depth of their local histories through living memory interviews and comparison with archives and published archaeological records highlights their resilience. Preserving local crops is also globally important as arid-tolerant traits could hold resilience solutions in the face of climate change (Ulian et al., 2020). Despite being increasingly well recognised, linkages between crop diversity and traditional practices are, in practice, little studied and still overlooked. Examples of traditional agri-systems in arid regions provide particularly important examples because of the additional ingenuity involved in managing water resources and the complexity of systems and associated material culture this creates. Finally, documentation is urgently needed because much of the information resides in the memories of elderly farmers and diversity loss and associated TK are increasingly endangered. Local place-based studies are essential for understanding what TK is being lost, the reasons why, how best to document and conserve it, and how to, at the same time, connect this to crop conservation.

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EXAMPLES OF INTERVIEWS

1. INTERVIEW QUESTIONS FROM SUDAN CASE STUDY

The list of questions here were created prior to interviews as an initial guide and basis for discussion, they formed the basis of qualitative interviews, but these topics were then adapted and expanded in the field. More in-depth interviews were undertaken for topics that emerged as very important, such as the sagia waterwheel, cooking methods, sometimes from memories (such as the sagia, prior threshing methods) and sometimes from demonstrations (e.g how cereals used to be ground) or observation. Fieldwork was undertaken over a total of around 9 months, spanning 5 years, led by our Nubian collaborator Mohammed Hassan, interviews were often in Nubian. We walked around farms inventorying crops, and after a very long list (around 60 species – see the supplementary information file in Ryan et al. 2022) we decided to focus on cereals, pulses, and dates palms. This focus meant we could realistically inventory these per farm (there were 5 cereal and 6 pulse species, and different varieties amongst them). In addition, below these questions, in excell, is a basic inventory format developed in the field to aid a checklist for cereals/pulses to also enable a semi quantified approach (forming the basis of some graphs comparing frequency of farmers reporting certain crop uses and changes over time etc), from this approach we could create some basic histograms or frequency of use and types of uses, and understand better the differences amongst farms and over time.

PRELIMINARY QUESTIONS PRIOR TO FIELDWORK, LATER ADAPTED IN THE FIELD

PART 1 A. LIVELIHOODS, FIELDS AND CROPS

- Does your household farm?
- Is farming the most important activity for your household?
- What agricultural activities do you personally carry out?
- In what ways are other people in your household involved with different agricultural activities?(for example, during harvest or different stages of processing)
- What fields do you and your household farm?
- Can you tell me how you came to start cultivating these fields? (Was it your father's? Did you buy it? Was it part of a marriage settlement? Do you rent it? Do you ever rent it out?)
- What are the different types of fields? (E.g. what are the soils (sandy, alluvium?)/ What is the distance from water and how are they irrigated)
- Is there seasonal land created by changes in the height of the river? how is this used? How has this changed in recent years?
- For each season or river phase, what are the main crops or crop mixes you grow in each field type?
- How are crops rotated? (Are there crops grown in the same field in sequence, in different seasons or years?).
- Which crops do you grow most of and why? Is this variable between years? how has this changed in recent years? (between years, since a few years ago when the annual flooding stopped, and twenty years ago)
- What is the difference in importance amongst the different crops? Is this variable between years? how has this changed in recent years?
- Amongst the cereals (maize, wheat, barley, millet, sorghum) which do you grow most of? What is the difference in importance amongst the different cereals?
- Which are grown for food, animal fodder for medicinal purposes or sale in the market? Have you changed the crops you grow and farming methods? When, why?
- How do you protect crops from sand storms?

PART 1B INDIVIDUAL CROPS IN MORE DETAIL

CROP NAME:

- Where and what types of fields are used?
- How many fields are used for growing this crop? What are the sorts of soils and water availability?
- Is this crop irrigated?
- How often and how is this distributed?
- Do you buy seeds in the local market or keep them from earlier harvests?
- How are fields prepared?
- What tools are used? Are these new types of tools or traditional?
- Who does this and when?
- Is chemical fertilizer or animal manure used? Or how important is silt in the Nile water?
- What month is this crop planted? (in some studies using a crop calendar, see Guinea fonio case study example, would be useful to aggregate this information)
- What month is this crop harvested?
- What is the relative importance of this crop? (eg. To other similar crops, or trial a 1=low, 5= high approach)
- Why? For example, is this to do with finance or another reason, is this crop resistant to drought or disease or pests? Is it easy to harvest or process into food?
- How much does this crop yield? How much is harvested compared to what is sown? Is this variable between years? has this changed in recent years?
- Is more than one crop grown in the same field at the same time? (there was very complex multicropping)
- Is this crop grown in the same field in sequence with other crops, for example in different seasons or years? (to understand crop rotations, and natural ways of soil management)
- How is this crop harvested? What are the procedures for threshing, winnowing and sieving? Who does this? Which agricultural tools are used? Are these new types or traditional? Have these processes changed?
- How do you store this crop? Has this changed? (it can be important to study traditional storage where it still exists, as it sometimes can help conserve crop diversity)
- How is crop used? For example, as food for your household or for sale in the market? Is this crop used for animal food? Which parts of the crop are used? Is crop processing waste used for mud bricks or pottery?
- How long does your harvest last your household? Do you share between households? Do you buy in crops like cereals?

DATE PALM CULTIVATION – some crops need crop specific questions

- Do you grow date palms?
- Where do you grow date palms and why?
- Who carries out the process of pollination?
- How many different varieties of dates do you grow?, note names and any cultivar specific information
- When are the fruits harvested? Are there different times of harvest for different uses? Are the dates grown for food, for sale in the market or for animals? How are dates stored? How important is growing dates compared to your other crops?
- Do you keep the leaves? When and how are they used? (they are still important in baskets, but in the past for multiple uses in the home)
- Has use of dates or how you cultivate and process dates changed in recent years?

- Do you grow any other types of fruit trees?
- (questions on taste, yield, and markets could be added)

PART 2 LIVESTOCK

- What types of animals? Who owns them? How are the animals used ?(for example for milk, meat, eggs, hides, manure (dung fertilizer), or use in the home? Are animals sold? Are any animals given as gifts? Are animals important in any events? Where are they kept? Does this change at different times of year? Which animals are fed crops?
- Which crops? and which parts of the crops? (for example grains, straw, the whole plant) Where are they allowed to graze? (areas where they eat wild plants, or directly in fields after harvest ?) – (this helps investigate how fodder and food crops are integrated and the overall landuse patterns and temporal change)
- Are animals used in agricultural activities? For example are they used for manure (dung), plough or transport? Do animals damage crops?
- Have the types of animals you keep or how you feed them or use them changed? How and when?

PART 3 DIFFERENCES AMONG FARMERS AND CHANGES OVER TIME

- In this village, are there some fields used in the past not used today?
- How are fields protected from animals?
- Other than date palms, what other sorts of fruit trees are there? and are these individually owned, shared between households, or can they be used by everyone? (show example pictures)
- Is there food exchange between farmers? What food is locally produced or imported? Is there seed exchange between farmers? What seeds are locally produced or imported?
- Do different villages grow different crops and keep different animals?
- Is Ernetta different because it is an island? (e.g. are there different types of fields or irrigation)?
- Which agricultural activities are organized communally between households or villages?
- How are crops protected from sand storms? Are plant barriers used?
- Does anyone make any use of wild animals such as crocodiles or birds?
- In what ways are changes to the Nile water levels since the dam (2009) changing agriculture?
- How many bad harvest years have there been in the last 10 years?. What is the role of climate or the changes to the Nile since the dam?
- In what ways are the new roads changing agriculture? (such as trade).
- Has the organization of agricultural activities changed?, since when? (e.g. changing technologies)
- Are there any old houses we can visit to see traditional agricultural tools? When did people stop using these tools? / does anyone still use them?

2. INVENTORY TO ENABLE COMPARISON BETWEEN FARMS

Create fields for e.g. Name, age, location, gender, profession, other family information, socio-economic information like professions other than farming, and numbers of animals. Expand, and print on eg A3, and landscape. (or adapt for online forms if possible) and leave space for extra notes on reasons for change and details that emerge. Remember to differentiate whether any varieties mentioned are local landraces or introduced modern varieties – many of both can be present within the same species (e.g. broadbeans had 1 historic local landrace and 2 varieties introduced in the 1970s)

	Present day			Past (mid-twentieth century / specify)			Notes
Crop / variety name	Grown today?	Uses?	Land area & how irrigated	Grown today?	Uses?	Land area / how irrigated	
..							
..							

Make codes to save space – eg. where grown - note e.g riverbank land 1, sagia land 2, garden 3 (for spacing on the form) expand and print and scape/A3. And for uses, eg FD – fodder, F food, M medicinal C celebrations (many crops have multi uses or different uses past to present – eg some crops in Sudan used for food in the past were now mostly for fodder). We could use this table to compare past and present frequency of present/uses.

Additionally, we asked “which crops do you priority today and which did you prioritise in the past”? - this acts as a ‘free listing’ approach, and helped highlight major shifts. From this you can compare the frequency of which crops are mentioned. This is a quick and easy question to ask so can be integrated easily into shorter form interviews. The inventory, and final question were the focus of short form comparative interviews in villages further way from the focal area. We also inventoried local language terminology.

COMMUNITY BOOK – this drew on the results, but expanded information on some topics and was co-written with community members, including about images and illustrations and the design and translation. This process occurred in an additional field season, followed by weeks when books were printed and then distributed to local farmers, in schools in the local town, and then in universities, libraries, and institutions in Dongola and Khartoum. Additional books were printed the following year (around 1600 books, 50 pgs).

2. INTERVIEW QUESTIONS FROM GUINEA CASE-STUDY

Here, the first set of interview forms are focused on one crop – the cereal fonio – it was designed to cope with investigating different uses of multiple landraces. And a second interview sheet was designed to capture some ethnobotanical information about other crops, with the main aim of understanding major temporal changes and fonio in this wider agri-system context (Burton et al. 2022). The fieldwork was a total of 1 month, and focused on 14 villages in one cultural region. In Guinea, the interview format becomes more like a questionnaire format for the wider team to follow it. Sudan was a more anthropology led ethnobotany approach, and place-based. Guinea interviews were more botanical science focused ethnobotany, accompanied by more plant-based data and collections, and there was less time for discussion as more different villages were visited

Secondly, the longer field time in Sudan allowed for ongoing expansion of possible discussions and refinement of approaches. Sudan interviews were with individuals. In Guinea they were mostly group interviews (e.g. 4 households). This helps with rapid information gathering for some interview components, and we needed to introduce this because we decided to make comparisons between lots of locations (due to checking the influence of the changes in altitude and other factors like distances to major towns).

Firstly, FPIC (Prior Informed Consent) + permission to use any photographs (create additional project focused forms)

PART 1. FARMER INFORMATION

(This format suits individuals, households, or group formats)

Name, Age, Gender, family, marital status, role in farming, other professions, and other socio-economic information

Village name, GPS/latitude (best to use an app for consistency)

Role in farming activities

Farm size/how long has it been farmed (inherited, rented etc)

% of farm farmed for focal crops

Note numbers/types of animals kept

PART 2. INITIAL INTERVIEWS FOCUSED ON FOCAL CROP

Table 1: Seasonal calendar (This sort of calendar format could be used for various crops, or specific varieties within a crop, for example we used it for fonio cereal varieties, as farmers grow multiple per farm)

Crops	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1.variety name												
planting												
harvesting												
other:												
....												
2. variety name												
etc												

CULTIVATION AND PROCESSING – document through observation (if possible) and questions

- Description of fonio cultivation (e.g manuring, or fertiliser), tools
- Description of crop processing (e.g. harvesting, threshing, winnowing, weeding, storage, dehusking, grinding, cooking)

Table 2 - Fonio varieties grown – what varieties are grown, what are their uses (useful to print this on landscape or A3)

<u>Local names</u>	<u>French</u> ± <u>Latin</u>	<u>Basic plant description:</u> (height, colour, issues eg, xxx Smaller grain, lose them, bugs like them etc)	<u>Why do you grow this?</u> (i). What are the uses (such as food, animal fodder, or materials), and what are the plant parts uses. (ii) what <u>are</u> the different food uses (such as bread, beer, porridge) (iii) is it grown to <u>sell</u> for household use, or both? (iv) are there other beneficial characteristics?	<u>How is the seed stored, where is it from, is it resown.</u>	<u>Where do you grow this -</u> and is it intercropped with other fonio varieties or crops?	<u>Which are focused on?</u> <u>x- medium</u> <u>xx high (or other ranking method)</u>
..						
<u>Expand</u>						

- Which of the above landraces do you prioritise today? Which varieties were prioritised in the past? (list in order of importance) – what is the reason for any changes? (this can be used to make semi-quantified comparisons)
- Have any landraces disappeared - or nearly disappeared? And have any of their uses changed?
- Has the area of land you use to farm fonio increased or decreased over time? (if so, when did this change and why?)
- How is fonio used with other crops in food dishes – and has its role in the foodsystem changed over time?
- Is fonio seen as part of part of cultural heritage? if so, how?
- Is traditional knowledge being lost – if so what type of knowledge?

2. BRIEF ETHNOBOTANY OF THE WIDER RANGE OF CROPS GROWN ALONGSIDE FONIO, TO CAPTURE CHANGES THROUGH TIME AND THE WIDER AGRI-SYSTEM

- What are the different land areas? – how are they managed? - what are the crop rotations and soil management? Are areas left fallow?
- Describe the cultivation and crop processing

<u>Local names</u>	<u>French + latin</u>	<u>(1) Why do you grow this?</u> (i). Uses + detail plant part per use: Food types (e.g., bread, beer); Animal Fodder, Materials (e.g., construction, crafts); Medicinal; Environmental (e.g., windbreak) Uses; Social) (ii) note if it is grown to sell versus local consumption (iii) For any other beneficial characteristics? (E.g., fast growing)	<u>Overall prevalence/abundance</u> High (4) – Medium (3) – Low (2) – Almost disappeared (1) – not grown (0)					<u>Where is it grown?</u>	<u>NOTES</u> – (i) Reasons for change (ii) are the seeds bought or saved?
			<i>40 yrs ago</i>	<i>20 yrs ago</i>	<i>10 yrs ago</i>	<i>Present-day</i>	<i>future</i>		
..									
.. expand									

NOTES -- leave good spaces at base of pages for extra notes

2. CROPS/VARIETIES AND USES – all species (household or group contexts)

Q What crops do you grow today, why and where – and have these been changing over time (print on landscape, and/or A3 & create good spacing for writing, potentially create short hand for some terms to aid writing, e.g. FD fodder, M medicinal, F food etc)

3. Ranking versus other crops - (name up to 5 for each of the below in order of importance – to calculate a frequency of citation, and aid temporal and geographic comparisons)

- What are the crops you prioritise growing today (and why)?
- What crops did you prioritise growing in the past?
- What are the most important crops grown for food today?
- What were the most important crops grown for food in the past?
- Have any crops/varieties disappeared/why (and when)
- Have they any further comments about changes to agriculture or food systems?
- Do you have any further comments about crop and agricultural changes on your farm ?

4. Open ended conversations with elderly farmers/village elders to provide a longer time depth

What did they grow when they were young, what were the uses? Were the agricultural practices the same or different as today? what have been the changes since then and why?

Methodologies for Documenting Traditional Agricultural Knowledge and Agrobiodiversity in Drylands

Dr. Reem Saad, Anthropologist, Egypt

Introduction: Relevance of traditional knowledge in agrobiodiversity and dry land management

Traditional agricultural knowledge (TAK) is increasingly being recognised as a key element for the conservation and management of biodiversity. Local knowledge, skills, and practices developed over centuries of interaction with specific environments offer valuable and unique contributions in this regard. TAK has been instrumental in preserving and promoting agrobiodiversity, thus enhancing the resilience of agriculture. Unlike ex situ conservation in gene banks, which have been described as “plant mausoleums (that are) isolated from the evolutionary pressures of the real world” (McNeely, 1995, p.23), TAK promotes dynamic in situ conservation, allowing crop varieties and animal breeds to continuously adapt in their natural environments. Practices such as seed saving, crop rotation, and intercropping help maintain a wide genetic base, which is vital for resilience against pests and diseases. This could also mitigate against some of the adverse impacts of climate change. Traditional farming methods often rely on natural processes, such as organic fertilisation through composting and integrated pest management, which enhance soil fertility and overall ecosystem health with minimal chemical inputs. Agrobiodiversity is intrinsically linked to the cultural heritage, food preferences, and spiritual values of local communities. Festivals, rituals, and traditional dishes often require specific local varieties, creating a cultural incentive to continue cultivating and preserving them. In dryland management specifically, TAK offers essential techniques for soil and water conservation, such as specific terracing methods, intercropping systems, and water-harvesting strategies.

Conceptual Framework:

Definitions:

Traditional agricultural knowledge (TAK) is the place-based knowledge developed over the centuries and passed down through generations of rural communities. It is holistic, experiential and adaptive to environmental changes. It is embedded in everyday practices and informs processes of agricultural production and the sustenance of livelihoods (Aksoy, Zühre and Öz, 2020, p. 1).

Agricultural biodiversity refers to “the variety and variability of animals, plants, and micro-organisms on earth that are important to food and agriculture, which result from the interaction between the environment, genetic resources and the management systems and practices used by people. It takes into account not only genetic, species and agroecosystem diversity and the different ways land and water resources are used for production, but also cultural diversity, which influences human interactions at all levels.”¹

Global frameworks:

The importance of TAK is recognised in global policy frameworks. The Convention on Biological Diversity (CBD) was an early instrument to acknowledge the role of traditional knowledge in supporting biodiversity. It emphasises the need to respect, preserve, and maintain the “knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity” (Article 8(j)).

The Food and Agriculture Organisation (FAO) promotes the integration of TAK through initiatives such as the Globally Important Agricultural Heritage Systems (GIAHS), which safeguard traditional agroecosystems and their associated knowledge and culture. It is worth noting that in the Near East and North Africa region, 9 agricultural heritage systems have so far been designated in 5 countries: 1 in Algeria, 3 in Morocco, 3 in Tunisia, 1 in the United Arab Emirates, and 1 in Egypt (the Dates production system in the Siwa Oasis) (FAO, 2025).^{2,3}

Traditional agricultural knowledge (TAK) and agrobiodiversity are discussed, either explicitly or implicitly, in several Sustainable Development Goals (SDGs), most notably SDG 2 (Zero Hunger) and SDG 15 (Life on Land). For instance, Target 2.5 focuses on preserving the genetic diversity of seeds and highlights the importance of “access to and fair and equitable sharing of benefits arising from the utilisation of genetic resources and associated traditional knowledge.”⁴ In a similar vein, Target 15.6 mentions the “equitable sharing of benefits arising from the utilisation of genetic resources.”⁵ While SDG 15 addresses key concerns related to agrobiodiversity, it does not specifically reference traditional agricultural knowledge. Similarly, UNESCO valorises the role of traditional knowledge in promoting biodiversity within local ecosystems, as reflected in its programs and initiatives. For example, the UNESCO Local and Indigenous Knowledge Systems (LINKS) program encourages the integration of Indigenous knowledge into biodiversity and ecosystem policies at various levels. Through advocacy and research, LINKS has raised awareness of the significance of Indigenous knowledge within UN frameworks. The program fosters dialogue between different knowledge holders and emphasises respect for Indigenous knowledge and institutions, supporting Indigenous Peoples in sustaining and transmitting their knowledge.

Methodological approaches

Agriculture in dry lands encompasses a variety of farming practices, social organisation, and local agricultural and ecological knowledge. Correspondingly, methodological approaches vary widely, partly depending on these factors and others such as disciplinary orientations and policy concerns. I present below two case studies of identifying and documenting traditional agricultural knowledge. Both cases are from Egypt, but they address two different forms of agriculture, and they utilise different methodologies. The first is the date palm grove agrosystem. In contrast, the second focuses on smallholders' household agriculture in the Fayoum region, emphasising the role of women's traditional knowledge and practices in conserving agrobiodiversity. In this section, I will outline a methodological approach for documenting Traditional Agricultural Knowledge (TAK) and its connection to agrobiodiversity, particularly suited to smallholder household-irrigated farming systems in the Nile Valley and Delta. It is in this region that most Egyptian rural dwellers live and practice this predominant form of cultivation. The proposed research design utilises an ethnographic approach, complemented by additional qualitative methods.⁶ Before outlining the specific research techniques, I will provide a few contextual remarks on the current state of Egyptian agriculture with emphasis on how recent developments have impacted both agrobiodiversity and TAK. These remarks would hopefully help to clarify the rationale for selecting an ethnographic approach.

1- FAO. 1999. Agricultural Biodiversity, Multifunctional Character of Agriculture and Land Conference, Background Paper 1, Maastricht, September 1999

2- FAO. 2025. “Globally Important Agricultural Heritage Systems (GIAHS)” <https://www.fao.org/giahs/regions/near-east-and-north-africa/en> Accessed on December 16, 2025.

3- FAO. 2025. “Globally Important Agricultural Heritage Systems (GIAHS)” <https://www.fao.org/giahs/regions/near-east-and-north-africa/en> Accessed on December 16, 2025.

4- United Nations. Department of Economic and Social Affairs. Sustainable Development Goals. Goal 2 Targets and Indicators https://sdgs.un.org/goals/goal2#targets_and_indicators Accessed on December 16, 2025

5-United Nations. Department of Economic and Social Affairs. Sustainable Development Goals. Goal 15 Targets and Indicators https://sdgs.un.org/goals/goal15#targets_and_indicators Accessed on December 16, 2025

6- A review article of scholarly research on the role of Traditional Ecological Knowledge in biodiversity conservation in Africa published between 2001 and 2020 found that 60% of the articles used primarily qualitative methods, while 32% used a mix of qualitative and quantitative methods. The great majority of the articles 95% were case studies conducted at the local level (Sinthumule 2003:5)

First, it is important to recognise that, as in many other countries of the global South, the current agrarian landscape in Egypt has been profoundly influenced by neoliberal policies, which have often had significant, generally negative effects on both agrobiodiversity and Traditional Agricultural Knowledge (TAK). A pivotal turning point for rural Egypt was the government's adoption of the Economic Reform and Structural Adjustment Policies (ERSAP) in the early 1990s. These reforms introduced a package of agricultural policies that prioritised export-oriented, investment-driven agriculture, often at the expense of smallholder farmers and subsistence-based household production.

Key measures included the liberalisation of land and water markets, reduction of the role of Agricultural Cooperatives—especially in providing subsidies for agricultural inputs—and the removal of mandatory crop rotation and state-regulated crop delivery. Extension services were also significantly reduced, and subsidies on agricultural inputs were lifted. While these changes freed farmers from some state-imposed restrictions, such as fixed cropping patterns and compulsory crop delivery at state-set prices, they also meant the loss of essential services, financial support, and protection from the vagaries of the market. As a result, agriculture became fully subject to market forces, leading to substantial shifts in farming practices and decision-making.

These policy changes adversely affected agrobiodiversity and led to environmental degradation. For example, the elimination of crop rotation—which previously helped maintain soil fertility—negatively affected the health of agricultural lands. The end of secure tenancy agreements led to higher land rents, prompting tenants to intensify their use of chemical fertilisers and pesticides in an effort to maximise yields and cover higher rents. Additionally, the widespread adoption of high-yielding hybrid seed varieties attracted many farmers. Still, this shift led to a gradual decline in the cultivation and propagation of local seed varieties, ultimately causing their erosion and loss. In addition, the Egyptian countryside has been witnessing a rapid and intense process of social transformation, marked by the spread of education and white-collar employment, waves of labour migration to oil-rich Arab countries and Europe, and the resulting changes in consumption patterns and lifestyle choices. A key shift that greatly influenced agricultural practice was the spread of mechanisation and irrigation.

These changes to traditional agriculture, whether driven by state policies or social change, have led to the erosion of TAK, as it was, in many cases, redundant and ill-suited to the new realities. For example, the women farmers were unable to apply or pass on their inherited knowledge of seed propagation to hybrid seeds, which were mostly sterile and could not be propagated. In a similar vein, the replacement of traditional water-lifting technologies with the diesel-operated pumps has made traditional irrigation knowledge largely redundant.

Despite these ongoing challenges, Traditional Agricultural Knowledge (TAK) continues to play a crucial role in the agricultural practices of smallholder households, helping sustain agrobiodiversity even amid significant threats from neoliberal policies and rapid social change. Much of this knowledge, beyond a handful of clearly defined traditional roles, is often implicit and embedded within everyday cultural practices and social routines.

Given the transformations described above, we will often seek “pockets” or remnants of such knowledge. This is why an ethnographic approach is especially appropriate: it offers a holistic lens, prioritises understanding the meanings that people attach to their actions, and relies on participant observation as its core methodology. This technique emphasises observing actual behaviours rather than relying solely on self-reported information, making it particularly effective for documenting and interpreting TAK in its social and cultural context.



Figure 1. © Nasseif Azmy

Proposed research design:

The research design relies primarily on the ethnographic method, complemented by other qualitative techniques. The research is to be conducted by a trained ethnographer, preferably with some experience in agriculture, who will reside in a village in the Nile Valley or Delta for an extended stay. It is strongly recommended that the researcher be a woman to interact freely with women inside and outside the house. Women possess rich traditional agricultural knowledge, though their contributions to agriculture are often undervalued.

Part of the reason their contributions are not recognised is that their TAK is embedded in wider cultural and social practices. In the gender division of labour of agricultural work, women are responsible for caring for domestic animals and poultry and processing dairy products. Importantly, they perform many tasks during the post-harvest stage. These tasks include seed selection and storage for propagation, which are vital for agrobiodiversity conservation by preserving local seeds. These tasks, however, are mostly conducted within the domestic space, and are thus regarded as part of housework rather than proper agricultural tasks.

Duration: Ideally, the researcher should stay in the field for a full year to observe and record all aspects of the agricultural cycle, including soil preparation, weeding, harvesting, and post-harvest handling of crops. They will need to observe both the winter and summer crops. They will also benefit from observing various social activities, rituals, and religious celebrations, and how these may relate to local agricultural practices. For example, special dishes are often prepared for special social or religious occasions, and these dishes may make use of local wild plants or local varieties of certain crops. Staying for a long time would also give the researcher a chance to observe how traditional knowledge is used to manage risks like droughts or pests, which may only occur at certain times of the year. In addition, a long stay gives the researcher the chance to build rapport and gain the trust of community members, which is indispensable to the success of the research.

Participant observation is the primary research instrument in ethnographic fieldwork. It allows the researcher to immerse themselves in the culture and gain an insider's view of what people actually do, rather than what they say they do. This is the tool through which the researcher would be able to elicit the tacit and implicit aspects of TAK. The researcher is expected to take part in the people's daily activities as much as possible, taking care not to be overly intrusive.

They accompany their key interlocutors while performing the different agricultural tasks, including visits to the market for procuring inputs or selling produce. They would observe while participating in activities such as soil preparation, sowing seeds, manuring, pruning and harvesting. An important aspect of TAK lies in how social relations and communal ties govern access to resources such as land, water, labour and tools. For example, how irrigation rounds are coordinated and what the ways of dealing with water shortages are. It is also important to observe labour patterns, especially forms of labour reciprocity and sharing. Participating in and observing women's daily activities is particularly important, as they possess specialised knowledge crucial to agrobiodiversity conservation.

Interviews: alongside immersion in the community's daily activities, the researcher would conduct in-depth semi-structured interviews with selected individuals to gain deeper insights into specific topics. For example:

- Persons who perform specialised roles, such as those who carry out date-palm pruning and fertilisation;
- Persons with key roles in the social organisation of irrigation, for example, those in charge of coordinating irrigation rounds, or those in charge of organising and overseeing collective works related to irrigation, such as clearing drains.
- Possibly also interviews with religious leaders to inquire about any religious prerogatives or taboos that inform dealing with agricultural resources, as these may have implications for the issue of agrobiodiversity.
- Persons with specialised knowledge on poultry and livestock. For example, in some parts of Upper Egypt, members of a certain low-status tribe possess specialised knowledge that has traditionally made them act as local veterinarians who offer their services to the community.

Oral history: It is beneficial to conduct oral history interviews with elderly men and women to get their views on how the practice of agriculture changed and the ways in which they adapted their knowledge and skills to accommodate such changes.

Recording the data: The researcher takes notes and writes daily, detailed fieldnotes. With appropriate permission, it is recommended to take pictures and make video documents of the different agricultural tasks and the variety of crops and wild plants in the area. Interviews should ideally be recorded and later transcribed.

Data analysis and management: The data is to be coded and analysed with the help of one of the software programs specialised in managing qualitative data. It is recommended to use the software Atlas. TI as it supports the Arabic script.

Research ethics: It is imperative that the researcher/s abide by the basic principles of research ethics. Paramount among these principles is informed consent, in which participants consent to participate in the research after being thoroughly informed of all aspects of the research. They shall also have the right to withdraw at any time. Confidentiality is another critical principle, requiring the researcher (s) to protect participants' personal information through secure data storage and anonymisation. If the researcher is affiliated with an academic institution, they will need to obtain Institutional Review Board (IRB) approval.

Ethical Considerations and equitable benefit-sharing:

There are various ways in which researchers and development practitioners working at the local level can engage in activities to achieve equitable benefit sharing. Capacity-building activities and assistance with establishing direct connections between producers and consumers can be especially empowering to small producers in local communities. Here, I provide two examples of NGOs that engage communities in a fruitful and fair manner. The first is the Egypt-based NGO NAWAYA, which is based in a rural community and is concerned with preserving and promoting Egyptian heritage food systems. They support small-scale farming families through different programs, such as videos and knowledge exchange about sustainable farming. Their projects also include the Community Kitchen, which provides employment for rural women while offering them appropriate training for the creation of menus that preserve agro-food heritage.

The second example is the Tunis-based NGO Association pour la sauvegarde de l'oasis de Chenini (ASOC), which works toward preserving the oasis and its ecosystem. Their model of work with the local farmers is to provide them with technical (and sometimes material) assistance in exchange for the farmers' commitment to practising ecological farming. Another inspiring project they have is the "biodiversity garden", where they planted the local plant varieties of the oasis. This is coupled with a nursery where they propagate these plants and crops and distribute them to community members (Ayeb & Saad, 2013, p. 154).

Field Applications and Case Studies

Case study I

*The date palm grove oasis: A north African agro-system as implemented by Hala Barakat*⁷

This study focuses on the date palm grove agrosystem that has developed over the centuries in the inhabited oases of the North African Sahara. The study adopts an ethnobotanical approach that identifies and characterises date palms within the social and cultural context of the oases. It provides a brief map of date palm groves across different regions of the Sahara and Southwestern Asia. Then it proceeds to an analysis of this system in detailed case studies in three countries: Egypt, Algeria and Chad. Egypt is covered more extensively, with a focus on the oases of Siwa, Bahariya, and Ezbet Doush in Kharga. In each case, the author covers the functional aspects, socioeconomic issues, biodiversity issues, and problems and pressures.

Methodology

The methodology relied mainly on review of the relevant literature, with an eye on how the availability of water wells, the irrigation system, and the rules of water sharing shape and structure this ecosystem. The author had also conducted fieldwork in Ezbet Doush in the Kharga oasis for a previous project. One important aspect of this study is attention to the development of this form of agriculture over time and to the integration of the historical dimension, including references to archaeobotanical evidence showing the very long history of this system, such as literature that dates its existence in Arabia to around 5000 p.b. (Barakat, 1995, p.136). For this paper, it is important to highlight the key features that characterise this system and that illuminate how traditional agricultural knowledge has been translated into practices that sustain this agro-system.

7- Barakat, Hala. 1995

1. Biodiversity: a key feature of the oasis agrosystem is the “intra-specific diversity within the *Phoenix dactylifera*” (Barakat, 1995, p.137). This feature is maintained by the landowners’ efforts to keep several varieties of dates, both for local consumption and for trade. It is this genetic variety that ensured the long-term survival of the date population.

2. Artificial pollination: In order to secure a good harvest in terms of quality and quantity, as well as to determine the variety, human intervention in the pollination process is necessary, as wind pollination is not sufficient for this plant. This is a practice that requires specialised knowledge and skills and is carried out by trained workers who climb the palm to attach the male branches to the female inflorescence using a palm leaf.

3. Water sharing: Water distribution is typically a collective activity in these oases. Wells are rarely individually owned but are usually jointly utilised by multiple landowners, with specific regulations governing the process that vary from one oasis to another (Barakat, 1995, p. 137).

Just as human intervention is essential for maintaining the date palm grove ecosystem, the palm itself plays a vital role in supporting the livelihoods of oasis residents. Every part of the palm is utilised: dates are consumed fresh, dried, or processed into paste, and date wine is crafted from older palms using specialised methods. The trunk serves as material for constructing house doors and, in some regions, for building water collection shafts and devices for raising water. Palm leaves are used to roof ceilings and build fences, while their leaflets are used to make various basketry items. Additionally, the fibrous parts of the leaves are transformed into ropes and sacks (Barakat, 1995, p. 138).

Although significant changes have likely occurred in these regions since the study’s publication in 1995, its value endures due to the comprehensive documentation and analysis of the palm grove agro-system as it existed at the close of the twentieth century. This work contributes to the broader scientific understanding of how this agricultural system has evolved over time. By providing a detailed baseline, the study lays an important methodological foundation for current research aimed at exploring and documenting traditional agricultural practices, with a particular focus on their development over time. Consequently, it is advisable to undertake follow-up research at some of the sites originally covered in the “palm grove” study to update the existing data and assess changes in social, physical, and environmental conditions. It is important here to emphasise that traditional agricultural knowledge is constantly evolving, shaped by ongoing, interconnected changes at multiple levels. Rather than being fixed or static, this knowledge adapts and responds to shifts in environmental, social, and cultural contexts.

Case Study II:

Gender, poverty and agrobiodiversity conservation in rural Egypt and Tunisia as implemented by Habib Ayeb and Reem Saad

This study investigates the links between poverty, gender and biodiversity in rural Egypt and Tunisia, with a focus on highlighting women’s significant role in agrobiodiversity conservation. Women’s traditional agricultural knowledge in Egypt and Tunisia encompasses a range of skills and practices, including seed selection, storage, and exchange, as well as the cultivation of local plant and animal varieties. These practices are deeply embedded in the daily lives and responsibilities of rural women, especially their roles as food providers for their households.



Figure 2. © Nasseif Azmy

Methodology

The study used mainly qualitative techniques, including participant observation, in-depth interviews and focus groups. The bulk of the data was derived from fieldwork conducted by the two authors, Reem Saad (anthropologist) and Habib Ayeb (geographer), in 2004–2005. In Egypt, the fieldwork was carried out primarily in the village of Imam in the Fayoum governorate, while in Tunisia, the fieldwork was mainly focused on the littoral oasis of Chenini, one of the oases of Gabes in Southeast Tunisia.

The duration of the fieldwork spanned almost one year, but we did not actually reside in the fieldwork sites for the whole duration. Although we had conducted extensive research in both locations and were thoroughly familiar with them, not having observed the complete agricultural cycle over the year affected the results. For example, most of the interviews and focus groups in Egypt were conducted in winter, during wheat sowing. Thus, reference to agricultural processes focused primarily on this crop. The timing also coincided with *el-sadda el-shetweyya* (the annual blocking of irrigation water to carry out the maintenance work for canals and drains). This accentuated an already severe water shortage problem in the region.

Key findings:

The study emphasised the gendered nature of traditional agricultural knowledge. Women possess specialised knowledge about local plant species, seed selection, and storage techniques. This expertise is passed down through families and is distinct from the knowledge held by men, which is often more influenced by formal education and external innovations. Tasks such as grain storage, seed selection, and preservation are almost exclusively managed by women. These activities are critical for maintaining local crop varieties and, by extension, agrobiodiversity.

The introduction of hybrid seeds and modern farming methods, often promoted by state and market forces, threatens the survival of local varieties. Hybrid seeds cannot be reproduced by farmers, leading to dependence on external suppliers, reduced agrobiodiversity, and a loss of autonomy for small farmers. We found that there has been an almost complete takeover by hybrid seeds and a fast erosion of local seed varieties.

The remaining pockets where local seeds were still propagated were small family plots managed by women who tend to prefer local (*baladi*) varieties for their taste, suitability for traditional foods, and the control they offer over the production process. Women often manage small plots for household consumption, growing a variety of crops not bound by market standards. They also participate in local exchange networks, sharing seeds and produce, which further supports the conservation and circulation of local varieties. Because of their responsibility for household food security and their vulnerability vis-à-vis market forces, they tend to be risk-averse in their decision-making, which often leads them to maintain traditional, resource-friendly farming methods. This type of behaviour incidentally benefits agrobiodiversity conservation.



Figure 3. © Nasseif Azmy

The study also found that secure land tenure and access to resources enable women and small farmers to engage in long-term planning, which is essential for agrobiodiversity conservation. Insecure tenure, poverty, and resource deprivation disrupt these practices and can force households to abandon traditional methods in favour of short-term survival strategies. Finally, the study argues that empowering women and valuing their traditional knowledge is a more sustainable path to agrobiodiversity conservation than relying on their continued vulnerability or poverty.

Recommendations and Way Forward:

1. Egypt stands out as the only Arab and African country with food sovereignty explicitly enshrined in its constitution, where Article 79 mandates The State to "... ensure sustainable food sovereignty and maintain agricultural biological diversity and types of local plants to safeguard the rights of future generations." This provides a strong institutional foundation for promoting agrobiodiversity with an implicit recognition of TAK. This article, however, needs to be highlighted in public discourse and operationalised to be reflected in concrete agrarian and food policies.

2. It is recommended to establish and strengthen regional networks that facilitate collaboration, experience sharing, and the exchange of best practices among practitioners, researchers, and local communities. Such networks can provide platforms for discussing strategies to preserve TAK and promote local agricultural practices that enhance biodiversity conservation.

3. Valorising Traditional Agricultural Knowledge and raising awareness on the critical importance of agrobiodiversity are key to the preservation and promotion of these two concepts. It is thus recommended to launch advocacy campaigns and sponsor public events that celebrate their value. Drawing inspiration from successful efforts to valorise traditional crafts as valuable heritage, these initiatives should aim to shift public perception and policy attention toward recognising TAK as a vital cultural and ecological resource.

4. Develop targeted training programs for agricultural extension workers that emphasise the value of TAK in promoting biodiversity. These programs should equip extension workers with the knowledge and skills necessary to support smallholder farmers in integrating traditional practices with modern approaches, thereby sustaining agrobiodiversity.

5. Production and marketing cooperatives are essential for supporting artisanal and small-scale agriculture, which often relies on TAK. However, current bureaucratic and legal obstacles disproportionately hinder small farmers—especially women—from benefiting from these cooperatives. Streamline and simplify the process of establishing and joining cooperatives to make them more accessible and effective tools for collective action and knowledge sharing.

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