



Renewed Archaeological Research in Singida Region, Central Tanzania

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Abstract Archaeological research in central Tanzania, chiefly in the Singida Region, has only been sporadically conducted, with the focus of such investigations being mostly on rock art and Later Stone Age (LSA) material. Here, we report preliminary results from renewed research expeditions conducted in the Singida Region. In 2021 and 2022, we located 31 archaeological sites in Ikungi District, excavated an open-air site (Nkungi) and a rock shelter

(Itramuka), and uncovered well-stratified cultural sequences containing lithics, ceramics, and metallurgical remains, as well as human remains and animal bones. The recent archaeological discoveries in the region revealed a rich and composite archaeological heritage, encompassing scatters of archaeological artifacts, stratified deposits, and rock shelters with preserved deposits and rock art. These sites are embedded in a varied landscape that, in itself, should be preserved for their geo-heritage. Our renewed research also emphasizes the importance of local community engagement, specifically with traditional landowners, to ensure the sustainability of this multi-disciplinary research project.

- Archaeological time period: Holocene, Iron Age
- Country and region discussed: Singida Region, Tanzania

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Résumé La recherche archéologique en Tanzanie centrale, principalement dans la région de Singida, n'a été menée que de manière sporadique, l'accent étant mis principalement sur l'art rupestre et le matériel de l'âge de la pierre le plus tardif (LSA). Nous présentons ici les résultats préliminaires de nouvelles expéditions de recherche menées dans la région de Singida. En 2021 et 2022, nous avons localisé 31 sites archéologiques dans le district d'Ikungi, fouillé un site en plein air (Nkungi) et un abri sous roche (Itramuka), et mis au jour des séquences culturelles bien stratifiées contenant des lithiques, des céramiques et des restes métallurgiques, ainsi que des restes humains et des ossements d'animaux. Les récentes découvertes archéologiques dans la région ont révélé un patrimoine archéologique riche et composite, comprenant des objets archéologiques dispersés, des dépôts stratifiés et des abris sous roche avec des dépôts préservés et de l'art rupestre. Ces sites sont intégrés dans un paysage varié qui, en soi, devrait être préservé pour son géopatrimoine. Nos nouvelles recherches soulignent également l'importance de l'engagement de la communauté locale, en particulier des propriétaires fonciers traditionnels, pour assurer la durabilité de ce projet de recherche multidisciplinaire.

Ikisiri Tafiti nyingi za kiakilojia zilizofanyika ukanda wa katikati mwa nchi, hususani mkoani Singida zimefanyika kwa kusuasua sana, na kwa kipindi kirefu hakukuwa na tafiti za aina yeyote mkoani humo. Miongoni mwa tafiti chache zilizofanyika ukanda wa Singida ziliegemea na kujikita zaidi kwenye michoro ya mapangoni na kwa kiasi kidogo sana kwenye Zama za Mawe za Muhula wa Mwisho. Tuliama kwa makusudi na dhati kabisa kukufua tafiti za Akiolojia katika ukanda huu na kubaini uwepo wa masalia ya

zamadamu wa kale zaidi, Zana za Mawe za Muhula wa Kati na hata zama za kipindi cha Historia. Visukuku na masalia ya zana za mawe yaliyogundulika mwaka 2021-2022 baada ya kutafiti na kuchimba maeneo 31 ya Nkungi na Itramuka yaliyopo kijiji cha Siuyu, wilaya ya Ikungi yameonyesha dhahiri kushabihiana sana na ushahidi mwingine wa utamudani wa kale kipindi cha zama za mawe za Mwanzo, Kati na muhula wa Mwisho katika maeneo mbalimbali kam vile kwenye mapango, miambani na karongo yaliyosheni urithi lukuki wa kiakilojia. Katika harakati za kufufua na kuboresha tafiti zetu ukanda huu, tuliama kufanya kazi na wenyeji wa mkoa huu, hususani Wanyaturu ili nasi tujifunze kutoka kwao na pia kuweza kuwaelimisha juu ya umuhimu wa kuhifadhi urithi wetu wa malikale kwa ustadi madhubuti. Vivyo hivyo, utafiti huu sasa utafungua milango ya tafiti nyingi zaidi na endelevu za kiakilojia mkoani Singida na kanda ya kati kwa ujumla wake.

Keywords Tanzania · Archaeology · Middle stone age · Later stone age · Iron Age rock art · Heritage conservation

Introduction

The archaeological record of Tanzania is globally renowned, with famous localities such as Oldupai Gorge, Laetoli, Peninj, Magubike, and Mumba being recognized for their essential contributions to the study of human biological and cultural diversification (Bushozi, 2023). However, apart from Magubike and Iringa (Willoughby, 2006), most of the country's archaeological sites and ongoing excavations are conducted in northern Tanzania within the East African Rift Valley. The lack of Stone Age data from most other regions of Tanzania, even after a century of pioneering human origins research, hinders our understanding of the evolution of *Homo sapiens*, the development of the Middle and Later Stone Ages (MSA and LSA, respectively), and the climatic and environmental context influencing both human morphological and technological changes since the Pleistocene.

A major hurdle faced by Tanzanian scholars is the lack of available research funding from sources both within Tanzania and from international agencies that often refuse to fund “high-risk” archaeological pilot studies in favor of projects focused on well-established archaeological localities, some of which have

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five decades or more of archaeological research history. Nevertheless, pilot studies are crucial to the longevity and sustainability of archaeological research, not only in Tanzania but also across Africa, especially if we are to fill in the human origins research and geographic “gaps.”

The Singida Region of Central Tanzania (Fig. 1) is an area critically understudied in terms of known archaeological sites, concurrent projects, or publications, especially in comparison to the MSA and LSA bearing sites of northern, and to a lesser extent, southern Tanzania (Itambu, 2023; Miller et al., 2020).

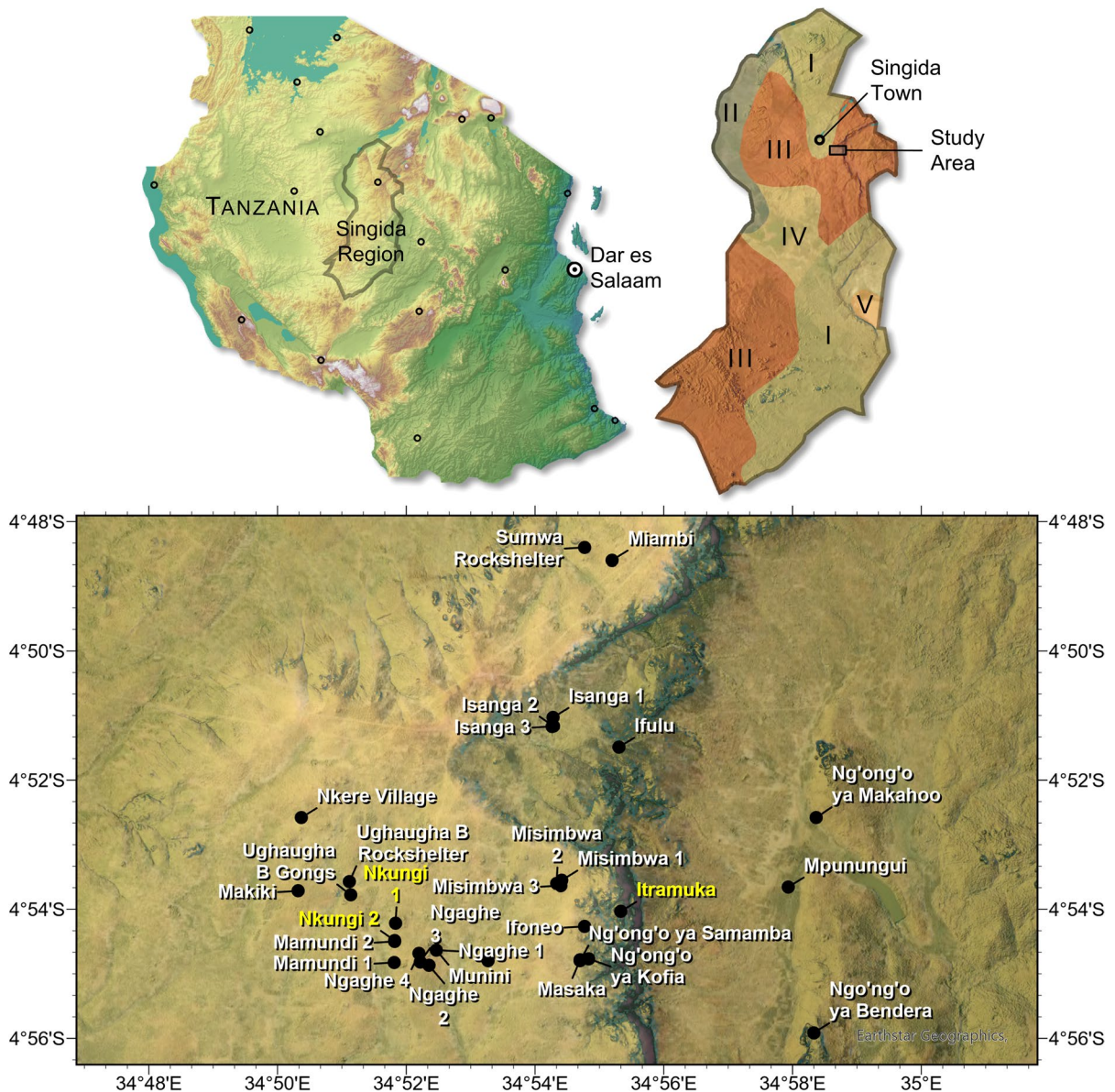


Fig. 1 Location of Singida region in Central Tanzania (Top). Singida is within the Somalia-Maasai Regional Center of Endemism (White, 1983) and contains the following African ecoregions (Olson et al., 2001): I. Southern *Acacia-Commiphora* Bushland and Thicket. II. Zambezian Flooded Grass-

land. III. Central Zambezian Miombo Woodland. IV. Itigi-Sumbu Thicket. V. East African Halophytics. The Mugori rift escarpment separates the Mugori Valley from the Turu/Rimi plateau (Bottom)

Singida has never been the subject of systematic excavations even though there are multiple, locally well-known rock shelters with abundant rock art and surface lithic scatter and faunal remains (Itambu, 2023; Itambu & Hongoa, 2016; Masao, 1976, 2007). However, recognition of the importance of the area's cultural heritage by the Ministry of Natural Resources and Tourism of Tanzania (see Masao, 1982; Ekeke, 2009; Itambu, 2015, 2023), along with funding from the American Council of Learned Societies, the Max Planck Society, and Gerda Henkel Stiftung, and support from the Tanzanian Department of Antiquities, makes Singida a highly promising region to conduct systematic archaeological research to further our understanding of this region's human history.

We report on our 2021–2022 field seasons near the villages of Siuyu and Misimbwa in the Ikungi District of northeastern Singida (Fig. 1), with a focus on two rock shelters, Nkungi and Itramuka. Initially, we set out to assess the area's rock art resources and develop recommendations for cultural resource management in Singida. Funded by the University of Dar es Salaam, the initial phase of our work ran in January 2016 (Itambu & Hongoa, 2016). We subsequently embarked on systematic excavations of Singida rock shelters in July and August of both 2021 and 2022 as training for University of Dar es Salaam undergraduate archaeology students. It was during these excavations that we recognized the importance of the archaeological record at sites like Itramuka and Nkungi when we unearthed many artifacts and faunal remains. However, night-time looting during the 2021 field season forced us to conduct salvage excavations which led to the discovery of multiple human remains, including a complete *H. sapiens* cranium from the Itramuka salvage excavation trench (Itamuka Hominin 01, Fig. 2). The detailed analysis of the data recovered from our excavations is underway, and the anticipated results will help to better understand the emergence and behavior of Pleistocene *H. sapiens* in this region and the archaeology of Central Tanzania in comparison to other parts of the country, and more-broadly across eastern Africa. In this paper, we summarize the recently discovered Singida sites containing rock art, faunal remains, and archaeological material. Perhaps more importantly, we also present our community-based heritage conservation outreach programs that we conducted in Singida Town during the 2021–2022 field seasons.

Regional Setting

The Singida Region lies at the southwestern extremity of the East African Rift System (EARS), also known as the Gregory Rift, which is characterized by raised blocks and fault scarps forming significant morphological features in the area. The depressions between the uplifted blocks contain deposits ranging in age from Miocene to modern, with the youngest being alluvial fans and talus slopes that form the present-day landscape of the region (Schaniel, 1982). In most parts of the study area, the rock shelters occur mainly in the highlands and are commonly scattered along Precambrian granite rock outcrops (Itambu et al., 2018; Schaniel, 1982). Generally, Singida's undulating landscape is punctuated by small boulder outcrops and rocky hills of granite with relief of up to 30 m high (Ekeke, 2009; Oliech, 1975). These rocky outcrops, overhangs, rock shelters, and caves may have formed the canvas for prehistoric and historic painters (see Itambu et al., 2023).

Our research focused on Singida's eastern axis in the Ikungi District, specifically in areas adjoining the Turu/Rimi plateau in Siuyu, Mugori, and Mungaa Wards. The Ikungi District is one of five that forms the Singida Region (Ekeke, 2009; Itambu, 2023; Itambu & Hongoa, 2016; Itambu et al., 2018). The Ikungi District is within 4 to 6° latitudes south of the equator and between 34°45' to 35°45' East of Greenwich meridian. All the archaeological sites are found in the eastern part of Ikungi District (see Fig. 1).

The Singida Region, as much of central Tanzania, is a land of plateaus and isolated rocky hills with very sparse vegetation. The Ikungi District is dominated by bushland and wooded grasslands and scattered bushes, while *Acacia-Commiphora* bushland is evident along the Rift valley. Generally, ground cover is dominated by short grasses such as *Hyparrhenia* spp., *Heteropogon contortus*, *Aristida kenyensis*, *Harpachne schimperi*, *Eragrotis* spp., and *Dichanthium* spp. which thrive in semi-arid zones. The woodland vegetation, which occurs in Ngimu, Misughaa, and Mang'onyi, includes trees such as *Acacia tortilis*, *A. drepanolobium*, *Euphorbia*, *Eucalyptus globules*, *Brachystegia* spp., and *Cassia* spp.

Most of Singida has an arid climate with rainfall decreasing from north to south. The average annual rainfall ranges between 500 and 800 mm. The highest and more reliable rainfall is recorded in the

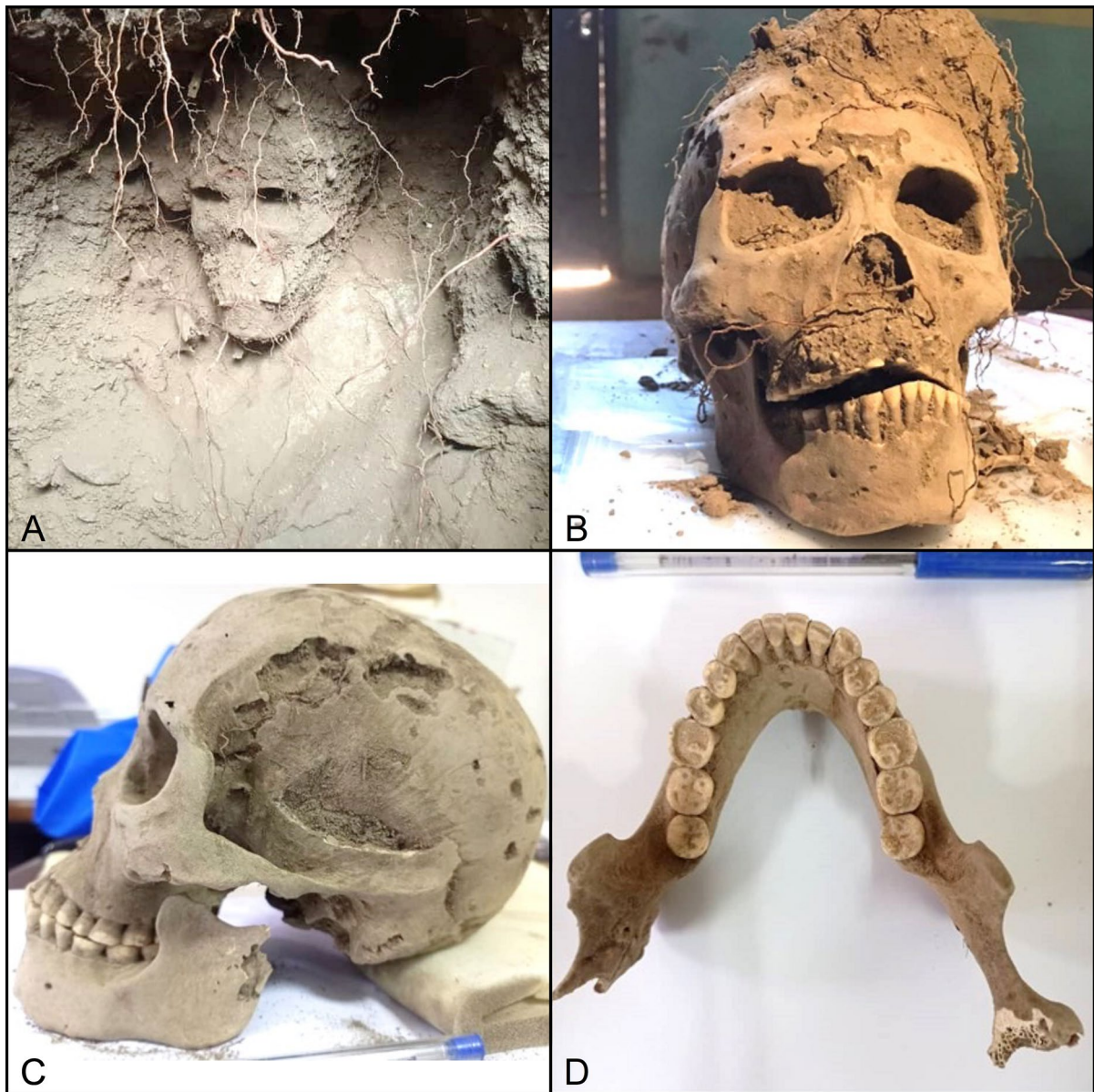


Fig. 2 The cranium and mandible of Itramuka Hominin 01 recovered in 2021. **A** In situ cranium exposed during salvage excavations. **B** Freshly excavated cranium and mandible. **C**

Lateral view of the left side of the cranium following sediment removal and preparation for osteological analysis. **D** The mandible with complete adult teeth

north, where it exceeds 800 mm, while the lowest rainfall of 500 mm is usually recorded in the western part of the Manyoni district. The rainy season occurs from mid-November to late April or early May (Ekeke, 2009; Itambu, 2023; Masao, 2005; Minja, 2007; Oliech, 1975).

Culture History of Singida

Tanzania's central plateau contains abundant rock shelters underneath Precambrian granitoid outcrops and kopjes, all of which have some form of rock art (Ekeke, 2009; Itambu et al., 2018; Kessy, 2005; Mahudi, 2008). The most famous being the

UNESCO World Heritage Kondoa Irangi Rock Paintings in Kondoa District of Dodoma Region. Rock art in Singida was first documented by western scholars in the 1930s (Culwick, 1931), and extensive survey during the 1934 to 1936 Deutsche Afrika-Expedition recorded 76 rock art sites across northern Singida (Kohl-Larsen & Kohl-Larsen, 1938, 1958). This expedition, led by Ludwig Kohl-Larsen (b. 1884 – d. 1969), sketched and traced paintings and performed some of the first archaeological excavations of the rock art sites. Due to Kohl-Larsen's work being published in German, few Tanzanian archaeologists have studied his publications, and many of the sites documented were not referenced on maps nor recorded with accurate or thorough details that would allow scholars to locate the sites today.

Odner (1971) recorded 17 Later Stone Age (LSA) sites in Iramba District, northwestern Singida, while Masao's archaeological survey between 1976 and 1979 covered an area of 64,000 km² across Dodoma and Singida and documented LSA assemblages and rock art sites. Between 2005 and 2007, Masao (2007) conducted additional surveys in Singida and revisited sites identified during the 1976–1979 field seasons. Across both expeditions, Masao recorded more than 50 new sites in Singida and Dodoma (Masao, 2007), highlighting the archaeological potential of Central Tanzania and the necessity for systematic excavations in the area. The pioneering work by Masao (1976, 2007) influenced both Mahudi (2008) and Itambu and Hongoa (2016) to conduct further research in Northern Singida, which resulted in the discovery of 31 new archaeological sites.

Most of the extensive archaeological work in Central Tanzania was conducted by Soper (1968) and Soper and Golden (1969). However, their work had two major limitations: first, their research focused mostly on the northern part of the region, and second, they put emphasis only on understating the LSA cultures of the region by studying lithics. Soper and Golden (1969) argued that the northern Singida lithic artifacts are part of a microlithic flake industry due to the frequency of flakes, blades, and microliths. Accordingly, they argued that direct percussion-anvil technique was employed and tool-makers selected fragments of suitable shape for use (see Soper & Golden, 1969:21; Masao, 1976:330). However, recent investigations by Itambu and colleagues in 2023 recovered Early and Middle Stone Age technocomplexes in

Ikungi District that could re-write the archaeology of the region (Itambu et al., 2023).

Later, Masao (2005) concentrated his research on LSA archaeology, with an emphasis on cultural adaptation strategies by central Tanzanian prehistoric communities. Several of these studies reported and documented rock paintings, but mainly concentrated on the Usandawe and Kondoa Irangi rock paintings (see Soper & Golden, 1969; Leakey, 1983; Kessy, 2005). Recently, the Kondoa region has received relatively heavy attention due to the conservation and preservation of heritage sites (Bwasiri & Smith, 2015). As all previous archaeological studies in the Singida Region focused on its northern, central axis, largely ignoring the eastern part of Singida, we decided to fill this gap by surveying the eastern part of the region. In doing so, we identified 31 new potential archaeological sites with surface scatter or rock art (Supplementary Table 1). Unfortunately, many sites in Singida have been left unprotected by the responsible patrimony conservation authorities, even though this region has some of the most well-preserved rock art sites. Moreover, the Singida Region is home to many undocumented archaeological sites which we are now exploring with continued systematic surveys and controlled excavations at newly reported localities.

Site Descriptions and Methods

This study focuses on surveys and excavations within Singida's Ikungi District, specifically at the Nkungi and Iramuka rock shelters following their discoveries during earlier field surveys (Itambu, 2023). There have been few archaeological excavations in this area even though most of the isolated granitoid kopjes, rock shelters, caves, and overhangs have abundant rock art and surface scatter (see Kessy, 2005; Mahudi, 2008; Ekeke, 2009; Itambu et al., 2018). There is also a personal connection to this region, as Dr. Itambu was born in Singida, spent nights sleeping under rock shelters while growing up a hunter-forager, and was inspired by the local rock art to pursue a degree in archaeology. His relationship with the local people and intimate knowledge of the landscape allowed him to investigate new archaeological localities while revisiting previously identified sites that need controlled archaeological excavations and systematic documentation.

Nkungi

Nkungi (4°54'08" S, 34°51'56" E) is a group of open-air sites found about a kilometer west of Siuyu Village at 1680 m a.s.l. The site is surrounded by Precambrian granitoid outcrops and kopjes, the most famous being Ng'ongo A Urimi boulder ("Tongue-Rock" in the Turu language) (Fig. 3). We decided to place test excavations adjacent to Ng'ongo A Urimi because of abundant grinding stones, potsherds, and lithics scattered along the surface. We excavated three trenches at 10 m (Trench I), 20 m (Trench II), and 100 m (Trench III) from Ng'ongo A Nkungi boulder and another about 200 m away from Ng'ongo A Urimi (Fig. 4). Excavations took place in July 2021.

As these were the first excavations centered at Nkungi, we removed vegetation and cleared the top 5 cm of soil before establishing a permanent site grid. In this process, we excavated 10 cm before exposing several artifacts, including lithics, faunal remains, pottery, and land-snail shells. In Trench I, we excavated up to 320 cm and recovered abundant lithics, but very few faunal remains. In Trench II, we excavated to 225 cm and uncovered human skeletal remains (Table 1), lithics, land snail shells, and potsherds. In Trench III, we excavated to 170 cm and uncovered possible MSA lithic artifacts in Layer 180–200 cm (Fig. 5), while other lithics, Iron slag, and potsherds were found in Layers 100–170 cm. Lithic analysis is ongoing but some preliminary information is presented as supplementary information (Table S2, S3).

During excavations, we recorded, removed, sieved, and sorted four stratigraphically separate contexts differentiated based on color and texture. Where contexts were more than 15 cm thick, they were removed in arbitrary horizontal spits of 10 cm depth. To maintain close spatial control of excavation units in both trenches, excavation proceeded in the lower levels in Trench I following arbitrary layers up to 320 cm deep until we reached sterile layers. All excavated contexts were recorded, planned, and photographed in detail during excavation using the single context recording technique. Excavated archaeological deposits were dry sieved on-site through a 0.5 mm mesh. On-site sorting into basic analytical categories (flaked stone, bone, charcoal, etc.) followed sieving. Sediment samples were also regularly taken

(column sampling in trenches) for a variety of future palaeoenvironmental analyses, including macrobotanical remains (30 g), plant wax biomarkers (30 g), and phytoliths (50 g).

Itramuka

Itramuka (4°54'02" S, 34°55'20" E) is a large rock shelter (315 m²) located 5 km east of Siuyu Village and situated along the Mugori rift escarpment overlooking Mugori Valley. The site is on the escarpment's slope in a woodland and has an approximate elevation of 1670 m a.s.l. Itramuka consists of the rock shelter and three overhangs, two exterior overhangs, and one posterior overhang. The shelter faces southeast and east and is roughly 5.5 m deep, 7.5 m wide, and 7.5 m high from the modern drip-line to the back wall. There is a large rock (slab) underneath the shelter, which is climbable and may have been used by ancient artists as scaffolding to paint the images high up on the shelter (Itambu et al., 2018). Work there (August 2021) followed excavations at Nkungi and used the same recording and excavating processes. Upon returning to the site after the first day of survey, however, we came across the consequence of site vandalism and looting, driven by the popular myth in Tanzania that the rock paintings were made by German colonialists. It is locally believed that German colonialists hid precious gems when abandoning the region following the 1919 Paris Peace Conference and Treaty of Versailles. The notion that the rock art signifies landmarks that Germans used to hide their precious gems and coins is not restricted to Singida and occurs in other parts of Tanzania with similar rock paintings (see Itambu, 2013, 2015, 2017; Itambu & Hongoa, 2016; Itambu et al., 2018; Itambu & Bushozi, 2022; Bushozi, 2022; Itambu et al., 2023; Itambu & Gallinaro, 2025). Similar tales are known from other African rock art contexts (e.g., Solomon et al., 2025). A large haphazard trench was dug under the rock shelter by local looters which drastically disturbed archaeological remains. Thus, our research operated as salvage archaeology to the patrimonies of this region.

We returned to Itramuka in 2022 to undertake controlled and systematic excavations, whereby a 1 × 1 m test pit and a 2 × 1.5 m trench were placed under the rock shelter. We dug in arbitrary spits of 20 cm to

Fig. 3 Ng'ongo A Urimi (“Tongue-Rock”) boulder, a central feature of the Nkungi cluster of sites. It was here that archaeological sites were first recognized in 2020. **A** View from the northwest. **B** View from the southeast



bedrock, which appeared at 160 cm deep (Fig. 6). The excavated soil was sifted through 5 mm screen wire-mesh to recover cultural materials of different sizes. Photographs were taken for every level in each unit and when features were observed. Plans were made at the

end of every level and on appearance of a feature. At the end of each excavation, profile maps were drawn from at least two sides of the unit to show the different layers based on soil content, compaction, texture, bioturbations, and coloration. Artifact distribution, stratigraphy,

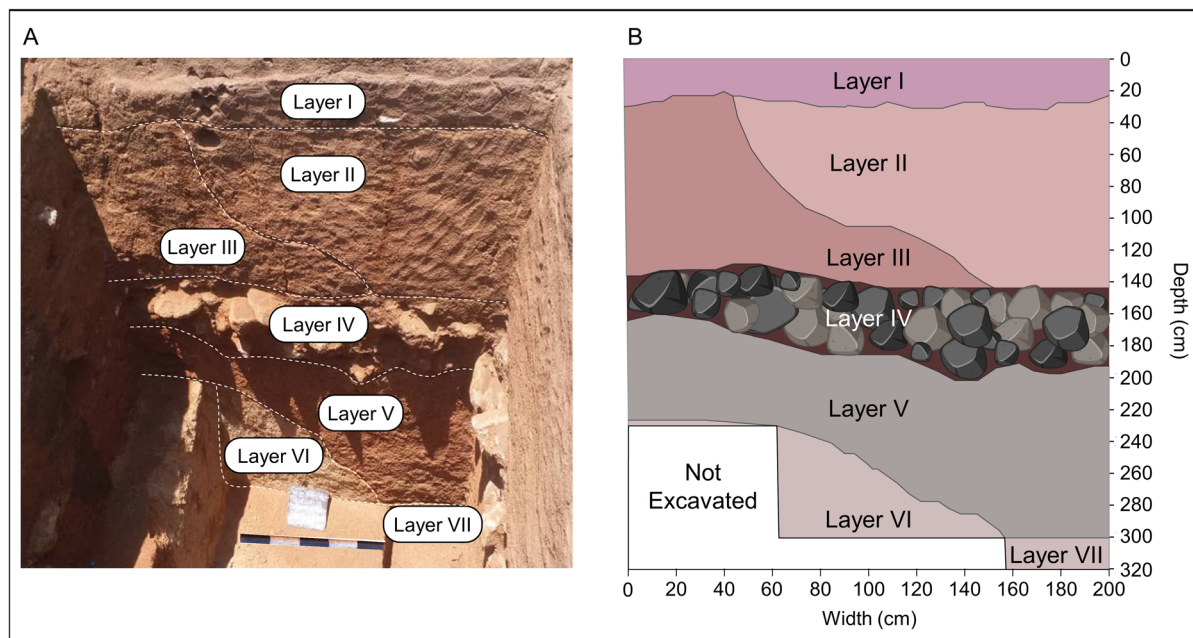


Fig. 4 Excavations at Nkungi Trench I in 2021. **A** Photograph and **B**. stratigraphic profile of Trench II

Table 1 Carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope ratios and calibrated age ranges for Nkungi and Itramuka human remains

Lab ID	Sample ID	Material	Trench	Level	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. AIR)	Calibrated range (2σ)
001	Nkungi 01	Human molars (2) and premolars (5)	II	130–140 cm	-8.4 ± 0.4	14.6 ± 0.1	-
002	Nkungi 02	Human molars (3), premolars (2), and mandible (1)	II	140–150 cm	-7.8 ± 0.3	13.1 ± 0.2	1411–1472 AD
003	Nkungi 03	Human molars (3)	II	150–160 cm	-8.8	15.5	1406–1450 AD
004	Itramuka 04	Human fragmented humerus (2 pieces)	IV	100–120 cm	-18.3 ± 0.3	12.2 ± 0.1	2341–2151 BC
005	Itramuka H 01	Human right mandibular molar (1)	IV	130–150 cm	-18.2 ± 0.7	11.8 ± 0.1	2454–2204 BC

floor plans, and features, in addition to other contextual information, were documented in field notebooks, excavation forms, as well as on graph sheets.

Lithic Analyses

Initial sorting and cataloging of archaeological materials were carried out in the field. The recovered

materials were sorted into the following broad categories: lithics, pottery, faunal remains, land snail shells, iron slag, metallic objects, beads, and daubs. All recovered materials were thereupon transported to the University of Dar es Salaam for further sorting and cataloging. Lithics from both surface surveys and excavations were analyzed using the lithic artifact typological and technological attributes developed by

Fig. 5 Potential MSA flakes and scrapers recovered from the Nkungi I trench between 300 and 320 cm. Lithic analysis is ongoing



Mehlman (1989) as it is the most typical and comprehensive typological scheme for northeast and central Tanzania (Kessy, 2005; Masao, 1976; Soper

& Golden, 1969). Initial classification of lithics fell under six broad categories: cores, flakes, blades, debitage, points, and scrapers. Further details on



Fig. 6 Excavations under the Itramuka rock shelter. **A** Northern wall profile showing the upper stratigraphy. **B** Close-up of the northern profile highlighting the “column sampling” for multiproxy palaeoenvironmental analysis

lithic analyses are presented in the Supplementary Information.

Pottery

We adopted a multidimensional approach for pottery analysis that focused on stylistic and decorative motifs and attributes, such as vessel part, vessel type, metric details (thickness and rim diameter), surface finish, decoration technique, decoration placement, and decorative motifs.

Rock Art

Strict protocols of recording based on digital resources (e.g., Domingo, 2014; Jalandoni, 2021; Solomon et al., 2025) were employed to identify rock art motifs, including those that are highly faded and almost invisible to the naked eye. This was accomplished using digital techniques of color enhancement such as DStretch® (Harman, 2005), and quantitative and qualitative analysis of evidence at various scales, from micro (single motifs) to macro (regional). This approach facilitated an integrated interpretation of rock art within the context of the broader material culture and archaeological landscape. At the same time, we investigated natural and anthropogenic

degradation processes (Gallinaro & Zerboni, 2021; Zerboni et al., 2022) in order to determine propose mitigation strategies that is now the basis of medium- and long-term actions for implementing adequate and sustainable rock art management.

Radiocarbon Dating and Isotope Analyses

Samples for stable isotope analyses and radiocarbon dating were collected from vertical columns between 10 and 240 cm in Nkungi Trench 2 and in Itramuka Trench 1 from between 100 and 120 cm and in the salvage excavation trench. Samples were not collected in the lower most levels because they contain pieces of weathered granite rock and stone rock slabs that were likely eroded and buried to form conglomerates.

For isotope analysis of collagen, bone samples were extracted using a modified Longin (1971) method. Samples were measured using a Thermo Scientific Flash 2000 Elemental Analyzer coupled to a Thermo Delta V Advantage mass spectrometer at the Isotope Laboratory, Max Planck Institute of Geoanthropology (Jena, Germany).

Bone and tooth samples for dating were physically and chemically pre-treated at the Radiocarbon Laboratory of the Max Planck Institute of Geoanthropology (Jena, Germany) and measured with a

MICADAS AMS system at Ionplus, Dietikon, Switzerland. Calibrated ages were calculated using the OxCal v. 4.4.4 software (Bronk Ramsey, 2001) and the northern hemisphere calibration curve IntCal20 (Reimer et al., 2020). Full details on radiocarbon dating and isotope analyses are presented in the Supplementary Information.

Preliminary Archaeological Results

Nkungi

In all Nkungi trenches, the sediments vary between reddish grey and brownish-red in color with silt sandy-clay texture dominated with dense archaeological artifacts throughout. Trench 1 is mainly composed of conglomerate sediments and reddish clays, with some greyish deposits between 100 and 200 cm. The lower most levels consist of yellowish-brown sediments and contain microlithic tools, land snail shells, and rodent bones. Sediments from Trench II exposed valuable information lacking in Trench I. These include bioturbations and a horizontal line of gravel across the trench at 160 cm depth. The upper levels of Trench II (Fig. 4a) are comprised of reddish-brown silt soils, which could be alluvial in origin, as well as rich organic matter and charcoal, and contain potsherds and Iron Age materials. In the lower section of Trench II (Fig. 4b), between 200 and 240 cm, sediments are greyish to brown-red silt sand that form conglomerates with the weathered granite rocks. This lower unit also contains micro-lithics, carbonated bones, land snail shells, and ochre.

A total of 4246 lithics were collected in the three Nkungi trenches (see Supplementary Information). Scrapers were the most common type accounting for over 38.3% of the assemblage ($n = 1628$). Cores were the second most abundant type ($n = 1236$, 29.1%), while points were the rarest ($n = 14$, 0.3%). Flakes ($n = 1135$, 26.7%) and blades ($n = 122$, 2.9%) were distinguished separately despite Mehlman's typology (1989) classifying these as debitage. Debitage was not analyzed in detail but simply counted ($n = 111$, 2.6%), weighed, and separated from the other artifacts. A few non-flaked stones such as hammer stones, anvils, and mortars pestles were found only in the upper levels of Trench II (40–60 cm) (Fig. 7).

Nkungi Trenches I and II also yielded pottery. A total of 23 potsherds were collected, but due to their fragmentary nature, only 10 pots, making up 48.5% of the total recovered sherds, were analyzed in detail. Of these, only three pieces of decorated pottery had diagnostic features and were identified as being typical of an early Iron Age tradition. The rest were all plain potsherds and seemed to be of recent times. Nevertheless, the presence of pottery remains in the Nkungi area suggests a long antiquity of pot usage, as they are still used contemporarily for cooking and ritual purposes, and as food and beverage storage containers. Thus, pottery remains are likely broken pots that were used for cooking or storing food in the shelters.

Nkungi also provides some of the only Holocene human remains in the region. The Nkungi material consisted of human molars from two individuals which were excavated from Trench II between 140 and 150 cm (Nkungi 02) and between 150 and 160 cm (Nkungi 03). These two samples are about 500 years old, dating to between 544 and 478 calBP (Table 1). Additionally, Nkungi 02 and 03 yielded $\delta^{13}\text{C}$ values of -7.8‰ and -8.8‰ , respectively, and $\delta^{15}\text{N}$ values of 13.1‰ and 15.5‰ , respectively. These values suggest that the Nkungi individuals were consuming a mix of C_3 and C_4 -based foods.

Itramuka

The Itramuka deposits consist of three distinct soil levels: (1) darkish-brown, silt, clay loam; (2) light grey sand clay; and (3) yellow-brown silt clay. The upper levels from 10 to 40 cm contain lithics and potsherds. Level 60–100 cm contains few lithics but a high concentration of animal and human bones and land snail shells. The bottom levels, from 120 to 160 cm, yielded animal bones, ostrich eggshells, and lithics but also high concentrations of gravel, small roots inclusions (rootlets), and some charcoal pieces. A total of 110 lithics were recovered and are dominated by flakes, blanks, debitage, scrapers and blades. Because we were forced to conduct salvage excavations at Itramuka, we focus here on the discovery of the human remains, including the complete *H. sapiens* cranium from the salvage excavation trench (Itramuka Hominin 01, Fig. 2) and the site's rock art.

The Itramuka samples were recovered in Trench 1 from between 100 and 120 cm under the rock shelter.

Fig. 7 Ochre mortar or anvil recovered at Nkungi Trench II (140–150 cm deep). Grinding and crushing marks are indicated by the notch on the tool's surface



A human humerus (Itramuka 04) and a mandibular molar (Itramuka Hominin 01) date to between 4404 and 4101 calBP (Table 1). Itmamuka 04 and Itmamuka Hominin 01 yielded $\delta^{13}\text{C}$ values of -18.3‰ and -18.2‰ , respectively, and $\delta^{15}\text{N}$ values of 12.2‰ and 11.8‰ , respectively. These $\delta^{13}\text{C}$ values suggest that the Itmamuka individuals had a diet rich in C_3 foods. Moreover, as the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of these individuals are slightly lighter than those from Nkungi, it suggests that they were likely hunter-foragers that were not supplementing their diet with domesticated C_4 cereal crops like the people from Nkungi.

The discovery of new rock art sites and the preliminary analysis of the complex rock art palimpsest of Itmamuka initiated a renewed study of rock art in the area. Rock art has consistently been a significant research focus since the initial investigation of Singida and surrounding areas. However, the first application of contemporary digital technologies in 2022 (Fig. 8) has demonstrated the high potential

for comprehensive and in-depth analysis of rock art evidence, resulting in a notable increase in identified motifs. This future study can significantly contribute to the reconstruction of cultural dynamics and the formulation of effective strategies for sustainable development.

The Itmamuka site contains an intricate display of rock art paintings representing naturalistic, geometric, and amorphous or abstract animals and humans (Fig. 8), among the most interesting in the region. The paintings at this site belong to hunter-forager rock art traditions (Itambu, 2023). The panel on the shelter contained more than 50 clearly visible images, while the panel on the overhang had 35 clearly visible images (Itambu 2022). The paintings are in monochrome, weak red color, and painted with fine brushes. A few white paintings are also present. The painted images are in both frontal and profile aspects and naturalistic and geometric forms. Single and scenic images occur at this site too. The subject matter

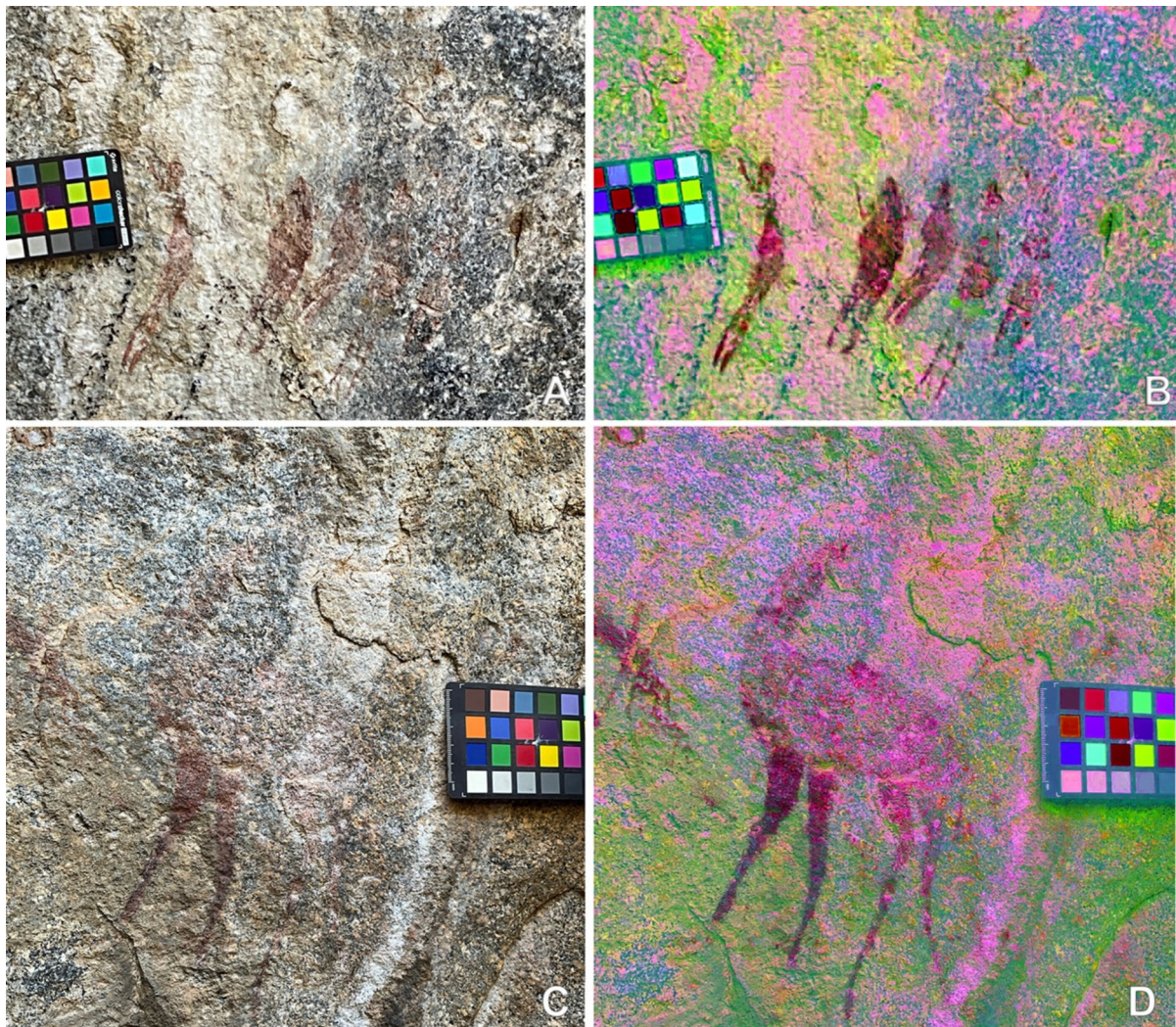


Fig. 8 Itamuka rock paintings. **A** Original photo of stylized humans. **B** DStretch® enhancement (CRGB) of Panel A. **C** Original a giraffe. **D** DStretch® enhancement (CRGB) of Panel C

includes human figures, wild animals, and geometric designs. Human figures dominate and are all in stylized form. Of particular interest is a line of about 35 human images with rounded heads, arguably men, and some of which are carrying sticks. The western end of this line of human images circles an antelope. Also of interest is a large human figure with a round head with spikes painted in outline. The hands of this human figure originate from the neck, and one can argue that this monstrous figure could be a form of the beginning of ancient belief systems, with this figure possibly being a deity or a symbolic belief system regarding life after death (Itambu 2022, 2023).

As it was observed by Itambu (2023), the panel on the overhang is largely composed of naturalistically painted images of wild animals. Giraffes are represented by four images, one jackal, two wildebeest, and many antelopes.

Heritage and Outreach

One goal of this project is to ensure the sustainability of archaeological research through community outreach and knowledge mobilization. We continue to make this research more relevant and beneficial

to Singida's local communities, mainly to promote awareness of conservation and preservation of heritage resources in Singida while educating people on the importance of archaeological science and the dangers of looting or damaging historical sites. The fragile balance between economic development and conservation of the natural and cultural heritage in the area is deeply affecting the archaeological landscape with unregulated economic activities, including diffuse opportunistic quarrying, mining, and agricultural practices, as well as looting of artifacts and damaging of rock art and archaeological context. We are carrying out a set of medium and long-term actions to mitigate the damage and risks to the natural and cultural heritage through a multidisciplinary and participatory approach (Itambu & Gallinaro, 2025).

To stop vandalism and looting of rock art sites, we invited key stakeholders to the sites to assist excavations and in the promotion of conservation awareness in the region. We partnered with local village authorities when collecting, documenting, conserving, and developing Singida's cultural heritage resources. Beyond elder stakeholders, this provided an exceptional opportunity for secondary school students to experience archaeological fieldwork. Moving forward, we plan to continue local community engagement by disseminating findings and infographics in Kiswahili and Kinyaturu, and by engaging with local farmers, schools, and government bodies, conveying the goals and gathered knowledge of this project before any formal excavations.

This engagement with stakeholders has a dual purpose, however, as this *transfer of knowledge* goes in both directions. By considering the views and information from the local people on what they think about rock art features, we found that some elders still have connections and attachments (as sacred sites for rites of passage, rituals, and sacrifices) with the art tradition (Bantu speakers' art). For example, at Nkere Village, Siuyu Ward (4°52'35" S and 34°50'22" E), we discovered six archaeological sites in 2021; two have rock paintings depicting elands, giraffes, and elephants; two with rock engraved features (cupules/deep holes and gongs); and two characterized by a scattering lithics, potsherds, and iron slag that could be ideal locations for future archaeological excavations. More importantly, the rock art appears to belong to the "hunter-foragers" art tradition (Itambu, 2023; Masao, 1976). However, while the rock

paintings refer to a well-established tradition in the area, the engraved features remain puzzling, and ethnographic inquiries could not ascertain the meaning and motivation behind this petroglyphic art.

Our surveys did not yield enough ethnographic information mainly because residents were unsure who originally made the rock art. On one hand, it is possible that the cupules, for instance, were made by German colonial geologists when studying the local geology or when exploring and prospecting for minerals and heavy metals in Singida. On the other hand, one interviewee did suggest that the cupules could perhaps be of the same age as the rock paintings. Nevertheless, going forward, we plan to discuss the rock art with the local Sandawe people who are the contemporary hunter-foragers living in and around Ikungi District.

Beyond local engagement, we invited the Antiquities Division of the Tanzanian Ministry of Natural Resources and Tourism, represented by the Conservator Dr. Christowajja Ntandu, to participate in fieldwork and community conservation outreach programs. Administrators from the University of Dar es Salaam, specifically the Vice Chancellor Prof. William Anangisye, were also invited and played a crucial role in the planned conservation and protection of archaeological sites. Dr. Anangisye was instrumental in providing public education stressing the importance of management and conservation of heritage patrimonies across Tanzania. As Nkere is one of the most important sites in the area due to surface scatter of in situ lithics and pottery, in addition to the well-preserved rock art, this region warrants management and conservation by the Antiquities Department. The entire region is also a key locale to the nearby Singida-Arusha highway and could act as a potential hub and touristic destination in the region. Because of its proximity to Singida town, Nkere has high archaeological potential especially if it can elevate archaeo-tourism in the region.

Conclusion and Future Directions

The project is an interdisciplinary study of the archaeological landscape of the central region of Tanzania, specifically as it relates to human occupation and resource use from the Late Pleistocene through the Holocene. A core goal has been to create synergistic collaborations between researchers from the University

of Dar es Salaam, communities from Singida, and administrators from governing bodies to outline heritage management strategies and plan for sustainable archaeological projects in the region. All research activities involve both undergraduate and graduate students from the University of Dar es Salaam, in addition to local community members, in the design and implementation of survey, excavation, and post-excavation initiatives. We are formulating new research groups consisting of experts in archaeology, anthropology, geology, paleoenvironmental studies, and museology from several international institutions.

Our 2022 excavations have already produced data necessary to generate and address hypotheses relating to MSA and LSA land-use across variable ecosystems and whether changing tool technologies relate to the exploitation of specific environmental niches in Later Pleistocene-Holocene Singida Region. We also believe that our early results underscore the potential of this region to provide important insights into human lifeways for a generally understudied area of Tanzania. For instance, our isotope data show changes in food consumption through time, but we need to build upon this to get a better understanding of the differences in land-use strategies between different populations. Future studies on isotopes, lithics, ceramics, and rock art will ideally speak to the transition from hunting-and-gathering to farming by the communities in central Tanzania. Another field season was conducted in 2024 with further seasons planned for 2025 and 2026, with the goal of fully excavating the sites discovered in 2022 and 2023.

The preliminary excavations at Nkungi open-air site and at Itramuka rock shelter show the potential of these sites for further chronological studies as well. For example, several dating methods could be implemented to construct the chronology of human/faunal occupations beyond the radiocarbon limit. ESR dating, combined with Uranium-series on large herbivore dental enamel, has already provided reliable chronology to MSA levels in other non-volcanic African regions (Ben Arous et al., 2020, 2022; Val et al., 2021). As the Singida Region has numerous granite/granitoid rock shelters that could impact the implementation of so-called trapped charges dating methods because of high dose-rate (e.g., ESR, OSL), it must be field-tested at a larger-scale, multi-dating methods program in near future before being widely adopted in central Tanzania.

Finally, post-fieldwork meetings and video conferencing have ensured that all team members, students, and local community shareholders are being kept informed of generated data and results. This coordination allows for the prompt dissemination of knowledge, specifically those produced through national and international workshops, conferences, and publications in peer-reviewed journals, for example. A significant part of the dissemination is dedicated to the local community and different local stakeholders, such as with public presentations in Swahili. Follow-up lectures presenting our results are constantly being conveyed in various villages across much of northern Singida. In the long term, we hope to boost heritage management strategies, specifically to increase potential archaeo-tourism opportunities to discover archaeological sites.

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Data Availability All data produced by this study are found in Table 1 and in the supplementary materials.

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