Stone Mullers: A Hand Operated Tool from Vadnagar

Disha Seth[1] **and Abhijit S. Ambekar**[1]

[1]. Excavation Branch – V, Archaeological Survey of India, 3rd Floor, VUDA Bhawan, Near L and T Circle, Karelibaug, Vadodara, Gujarat – 390 018, India *(Email: dishaseth9@gmail.com; abhijeetasi@gmail.com)*

Received: 16 July 2023; Revised: 23 October 2023; Accepted: 29 November 2023
Heritage: Journal of Multidisciplinary Studies in Archaeology 12 (2024): 509-523

Abstract: *The techniques involved in food processing are considered as one of the most essential part of the survival strategy. The querns, mullers, and pounders are the archaeological finds that document these activities. Mullers, like querns, are important tools in the realm of food processing and are utilized on the flat surface of a quern. The study focuses on the usage of the muller stone unearthed during the Vadnagar excavation. Observations are made on the variations in the size of the mullers, and attempts are made to establish a correlation between these fluctuations and changes in both the food crop and environmental conditions.*

Keywords: Mullers, Querns, Grain, Grinding, Archaeobotany, Agriculture, Climate

Introduction

Stone mullers are elongated tools specifically designed for grinding on querns that have a flat surface. Sometimes, these objects may possess heavier extremities and their form is smoothened by continuous use. They typically exhibit a cylindrical or square shape, with rectangular, plano-convex, bi-convex, or squarish sections that vary depending on the intensity of utilization. The evolution and development of tools provide valuable insights into technological advancement and adaptation to the needs of past societies. It has been observed that mullers may have undergone various modifications as they adjusted to different materials, processes, and functional needs. As Ghosh (1989) states the most probable type of rudimentary mullers to have appeared during the Mesolithic period, which was characterized by a hunting-gathering lifestyle. Initially, they may have been made crudely and mostly used just for basic grinding and processing. These mullers would have had a simple elongated shape and may have been made from river pebbles. To ensure optimal performance of the muller stone, it will employ two distinct movements: a reciprocating motion and a dragging motion on a quern or grinding surface. However, the mullers possess distinct functionality compared to ordinary pebbles or rubbles, since they allow for back-and-forth motion to be performed with just one hand. These mullers require the use of both hands to grasp them from both ends and roll them along the flat surface of the quern. Sankalia (1977) suggests that one rationale for the development or evolution of legged

querns from saddle querns is the utilization of the space between the legs to keep the muller in place, thereby limiting the risk of misplacement.

Figure 1: Stone Mullers from Vadnagar

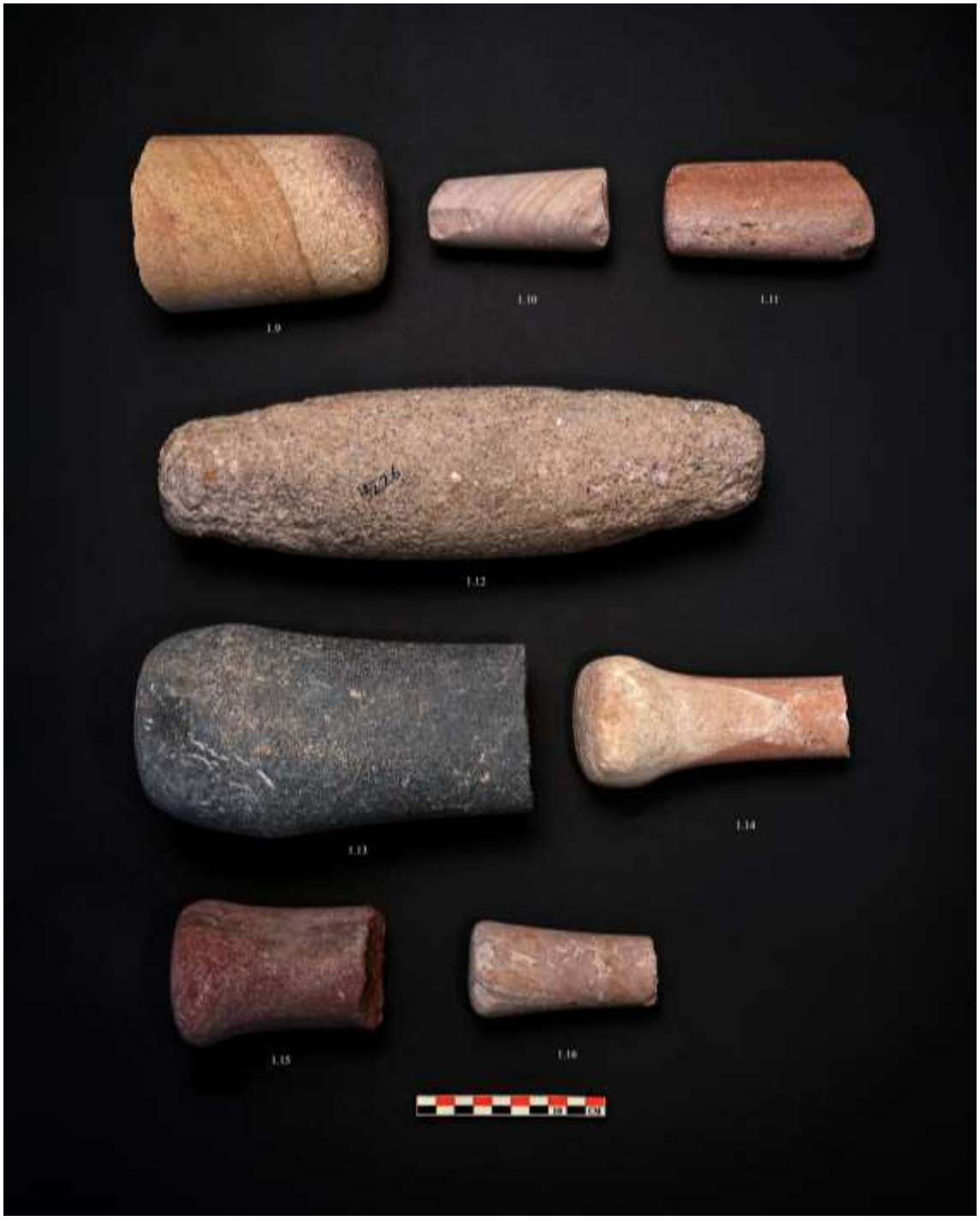

Figure 2: Stone Mullers from Vadnagar

After the basic objective was met, the concept of enhancing functionality emerged. As agriculture progressed and food processing became more efficient, mullers needed to be refined in order to improve their grinding capabilities. This involved shaping the mullers deliberately to have smooth surfaces and weighted ends, which would facilitate the grinding process. The refinement was driven by the exchange of new ideas and constant contact with the foreign world (Dhavalikar 1999).

Figure 3: Stone Mullers from Vadnagar

According to Ghosh (1989), the earliest records of the muller can be traced back to the Neolithic period, which represented the beginning of a sedentary lifestyle. They have been recorded in the archaeological record since the Neolithic-Chalcolithic times, although they have existed in a basic form since the Mesolithic period. Following that,

Muller emerged as a consistent feature during the pre-Harappan, Harappan, and post-Harappan periods, enduring throughout the subsequent historical periods to the present day. Mullers usually appear on coarse-grained stones, suggesting a deliberate choice as the rough surface facilitates the processes of grinding, pounding, and crushing. Flaking and pecking markings are observed on the surface of certain specimens, indicating the shaping of the raw material block.

Figure 4: Stone Mullers from Vadnagar

Figure 5: Stone Mullers from Vadnagar

Mullers are recorded in several ancient sites such as Lothal, Adam, Nagarjunkonda, Taxilla, Pauni, Ahar, Bhokardhan, Nagara, Kanewal, Kuntasi, Nageshwar, Rangpur, Devnimori, Dholavira, and Prakash (Rao, 1979; Nath, 2016; Sarkar, 2006; Marshal, 1975; Nath, 1998; Sankalia, 1969; Deo, 1974; Mehta, 1970; Mehta, 1980; Dhavalikar, 1996; Hegde, 1990; Rao, 1963; Mehta, 1966 & Thapar, 1967). These artifacts date back to the Harappan period and continue to be found in the early Historic and medieval periods. The excavation at Vadnagar has uncovered a diverse range of stone artefacts, including notable food processing tools such as querns, mullers, and pounders. Food processing artefacts in Vadnagar are commonly crafted from stones such as sandstone, granite, basalt, schist, and quartzite. Within the realm of food processing equipment, in addition to the quern, another significant component is the muller. There is only a

single specimen of muller (Reg. No 9563) that stands out because of its remarkable Mauryan polish, which is particularly noteworthy for its shiny and polished appearance. The glossy appearance of this finish bears resemblance to the finishes commonly seen in Mauryan art.

Figure 6: Stone Mullers from Vadnagar

Figure 7: Stone Mullers from Vadnagar

Documentation

A total of 87 mullers were reported throughout the excavation conducted during the field season from 2019 to 2022. The mullers are produced from sandstone, quartzite, and basalt stones. Typically, two primary shapes have been seen - a muller with a circular, oval, or elliptical cross-section, featuring heavier ends like a dumbbell, and a cylindrical shape with a circular or oval cross-section (Figures 1-7, Table 1).

Table 1: Description of the mullers found from the Vadnagar excavation

Sl. No.	Period	Dimension (in cm) (length x breadth x thickness) or (diameter x Length)	Description	Material and Colour
1.1	II	10.09x5.91x3.88	Broken fragment of muller, biconvex section and surface is highly polished, resembling with Mauryan polish art.	Sandstone of pale brown colour (5YR 5/2)
1.2	IIIA	9.42x5.84x4.57	Fragment of muller, oval shape having rounded sides with heavier plano-convex section.	Sandstone of medium gray colour (N5)
1.3	IIIA	11.10x4.82x3.76	Fragment of muller, dumb-bell shaped end and heavier oval section.	Sandstone of grayish orange pink (5YR 7/2)
1.4	IIIA	15.31x6.43x4.87	Fragment of muller, cylindrical shaped, having oval cross section and the surface is polished, possibly because of continuous use indicating some specific grinding activities.	Sandstone of medium light gray (N6)
1.5	IIIA	8.06x10.42	Fragment of muller, exceptionally thick, cylindrical in shape, dumb-bell shaped end and oval section.	Sandstone with very pale orange colour (10YR 8/2)
1.6	IIIB	10.18x7.03x3.83	Fragment of a muller, plano-convex section.	Quartzite of pale reddish brown colour (10R 5/4)
1.7	IIIB	11.33x5.01x4.42	Fragment of muller, oval section, tapering ends.	Sandstone of very pale orange (10YR 8/2)
1.8	IIIB	11.10x6.21x3.22	Fragment of muller, rectangular section, smooth surface.	Quartzite of pale red colour (5YR 6/2)
1.9	IVA	12.46x8.85x6.75	Fragment of a muller, cylindrical shaped, circular section.	Sandstone of grayish orange (10YR 7/4)
1.10	IVA	4.39x9.541	Fragment of muller, oval	Sandstone of

			shaped and tapering sides.	grayish orange pink (5YR 7/2)
1.11	IVA	10.99x4.95x3.86	Fragment of a muller, plano-convex section, a flat side, possibly because of continuous use.	Sandstone of grayish orange pink (5YR 7/2)
1.12	IVA	8.56x31.5	Muller, biconvex profile and round cross section.	Quartzite of light olive gray (5Y 6/1)
1.13	IVB	10.05x19	Fragment of muller, heavier end and plano-convex section.	Sandstone of medium gray colour (N5)
1.14	IVB	14.76x6.97x6.02	Fragment of muller, dumbbell shaped ends and oval section.	Sandstone of very pale orange colour (10YR 8/2)
1.15	IVB	7.64x10.84	Fragment of muller, heavier end and circular in section.	Sandstone of grayish red colour (5R 4/2)
1.16	IVB	9.82x4.95x3.81	Fragment of muller, oval cross section and heavier ends.	Sandstone of grayish orange pink colour (5YR 7/2).
1.17	IVB	13.69x5.74x4.69	Fragment of muller, cylindrical shaped and circular section.	Sandstone of grayish orange pink (5YR 7/2).
1.18	IVB	5.48x13.05	Muller, circular cross section and smooth surface, cylindrical shape.	Sandstone of pale brown (5YR 5/2).
1.19	V	12.15x4.50x3.68	Fragment of muller, circular cross section, heavier end and cylindrical body.	Sandstone of pale orange colour (10YR 8/2).
1.20	V	16.14x5.31x4.26	Fragment of muller, oval section, cylindrical body and concave profile.	Sandstone of moderate orange pink colour (10R 7/4).
1.21	V	8.91x21.4	Fragment of muller, circular section, cylindrical shape and tapering end.	Sandstone of very pale orange colour (10YR 8/2).
1.22	V	8.91x17	Fragment of muller, circular section, cylindrical shape.	Basalt of medium gray colour (N5).
1.23	V	15.38x6.82x6.04	Fragment of muller, oval cross section and cylindrical shape.	Quartzite of pale red colour (5R 6/2).
1.24	V	12.52x6.80	Fragment of muller, circular	Sandstone of

			section and cylindrical shape with heavier end.	grayish orange pink colour (5YR 7/2).
1.25	V	8.28x5.85x4.06	Muller, plano-convex section and smaller in size comparatively. Possibly it was used to rub against the quern.	Quartzite of grayish red colour (5R 4/2).
1.26	V	8.88x5.025x4.94	Muller, cylindrical shape and oval cross section.	Sandstone of grayish red colour (10R 4/2).
1.27	V	11.36x4.51x3.96	Muller, cylindrical shape and lenticular cross section. Possibly was rubbed against the quern.	Sandstone of pink reddish brown colour (10R 5/4).
1.28	V	5.01x7.68	Fragment of muller, oval section, heavier end (like dumb bell).	Sandstone of light olive gray colour (5Y 6/1).
1.29	V	6.31x7.41	Fragment of muller, cylindrical shape and has oval cross section.	Sandstone of moderate pink colour (5R 7/4).
1.30	V	6.28x29	Broken muller, cylindrical body and circular cross section.	Sandstone of pale red colour (5R 6/2).
1.31	V	32x10.39x7.24	Fragment of a large muller, cylindrical body, tapering end and oval cross section.	Quartzite of pale yellowish brown (10YR 6/2).
1.32	VI	8.82x4.64x3.79	Muller, oval cross section, smooth surface.	Sandstone of light brownish gray (5YR 6/1).
1.33	VI	14.56x6.53x6.02	Fragment, muller, cylindrical body, smooth surface and oval cross section.	Sandstone of grayish orange pink colour (5YR 7/2).
1.34	VIV	7.76x4.30x4.25	Muller, triangular cross section and cylindrical body.	Sandstone of pale red colour (5R 6/2).
1.35	VI	15.21x7.12x6.15	Muller, oval cross section, tapering side and cylindrical body.	Dolerite of medium gray colour (N5).
1.36	VI	12.37x8.49x4.55	Fragment, muller, circular section and cylindrical body.	Sandstone of grayish pink colour (5R 8/2).

1.37	VI	12.96x7.15x4.92	Fragment of muller, oval cross section, heavier end and elongated body.	Sandstone of moderate red (5R 5/4).
1.38	VI	21.8x9.22	Fragment of muller, circular section, tapering towards one end and cylindrical body.	Sandstone of pale red (5R 6/2).
1.39	VI	9.66x38	Broken muller, circular section and cylindrical body.	Sandstone of pale red purple (5RP 6/2).
1.40	VI	12.6x52	Muller, circular cross section with exceptionally elongated, cylindrical body of biconvex profile with tapering ends roughened unfinished ends and heavier in size.	Sandstone of light brown colour (5YR 6/4).
1.41	VII	22.5x7.92x6.04	Muller, oval section and a flattened surface and thick end.	Coarse grained sandstone of very pale orange (10YR 8/2).
1.42	Talus	16x7.05x5.25	Fragment of muller, circular cross section, cylindrical shape and tapering end.	Quartzite of pale red (5R 6/2).
1.43	Talus	15.07x7.51x6.41	Fragment of muller, oval section and cylindrical body with tapering end.	Sandstone of medium light gray (5Y 7/2).
1.44	Talus	8.37x25.5	Fragment of muller, cylindrical body having tapering sides and circular cross section.	Quartzite of grayish orange (5YR 7/2).

Discussion and Conclusion

The findings at the site indicate that the initial forms of stone mullers are predominantly cylindrical, with some displaying heavier ends resembling dumbbells. This may be attributed to their prolonged continuous usage. The shape of the mullers remained unchanged throughout period III, with an average length of 13.8 cm. The thickness might vary based on the degree of application and utilization. During the Rampart period (Period II), an intriguing example of muller may be observed, which exhibits a glossy polished surface similar to the Mauryan polish art.

Mullers undergo an increase in thickness and weight during subsequent periods, with this change becoming particularly noticeable starting from the early phase of period IV.

In this period, the mullers had a simple cylindrical shape with heavier ends and a biconvex section that continued throughout. The majority of the assemblage consists of a coarse-grained type of stone, which implies that it was used for grinding. The mullers discovered at various sites exhibit a resemblance to the Vadnagar specimens. The mullers unearthed in Lothal are characterized by their unique attributes, including a slightly curved and flat bottom surface of granite, schist, and sandstone. The mullers reported from multiple sites such as Nagarjunkonda, Pauni, Bhokardhan, Nagara (Mehta, 1970), Dholavira (Bisht, 2015), and others exhibit circular sections and a cylindrical shape that tends to have dumbbell-shaped ends, resembling those found in Vadnagar. Taxilla has documented cylindrical mullers with a barrel shape, featuring a flat underside and abrasion in the middle. Another type is the one characterized by a rectangular, plano-convex, or elliptical section, which has been documented in Nageshwar, Prakash, and Ahar. Furthermore, mullers with heavier extremities or dumbbell-shaped extremities have also been reported in various other sites, including Nagarjunkonda, Maheshwar, Adam, and several other sites. The presence of dumbbell-shaped ends serves two purposes. Firstly, if the width of the quern is smaller than the length of the muller, it will result in the middle surface wearing out more quickly, leaving the ends with additional weight. Secondly, the heavier ends help maintain a balanced weight distribution, allowing for greater force to be exerted in the middle, thereby enhancing the crushing process.

Table 2: Variations in Thickness of Mullers Across Different Cultural Periods

Thickness (cm)	**Periods**								**Total**
	II	**IIIA**	**IIIB**	**IVA**	**IVB**	**V**	**VI**	**VII**	
0-4.9	1	3	3	3	3	8	4	0	25
5-9.9	0	2	0	2	8	23	18	3	56
10-14.9	0	0	0	0	1	1	1	0	3
15-19.9	0	0	0	0	0	0	0	0	0
20-24.9	0	0	0	0	0	0	0	0	0
>25	0	0	0	0	0	0	0	0	0
Total	**1**	**5**	**3**	**5**	**12**	**32**	**23**	**3**	**84**

The most common type of section found in Vadnagar's mullers is often round or oval, perhaps designed to facilitate efficient grinding. However, other sites have also documented rectangular section mullers, suggesting their potential usage for reciprocating motion or as pounding tools.

Statistical Distribution of Mullers: Based on the statistical distribution of the reported mullers, the mean thickness was approximately 6.27 cm (Table 2, Figure 8). Curiously, the mullers' size diminished towards the end of period V, indicating a decline in the number of saddle querns and their replacement likely with rotary querns. The shifting observed suggest a probable change in the dietary habits or food choices resulting from significant fluctuations in climatic and environmental conditions. Based on the

archaeobotanical data, the population began to change their agricultural preferences starting from the beginning of period VI. As a result, they adopted new methods of food processing.

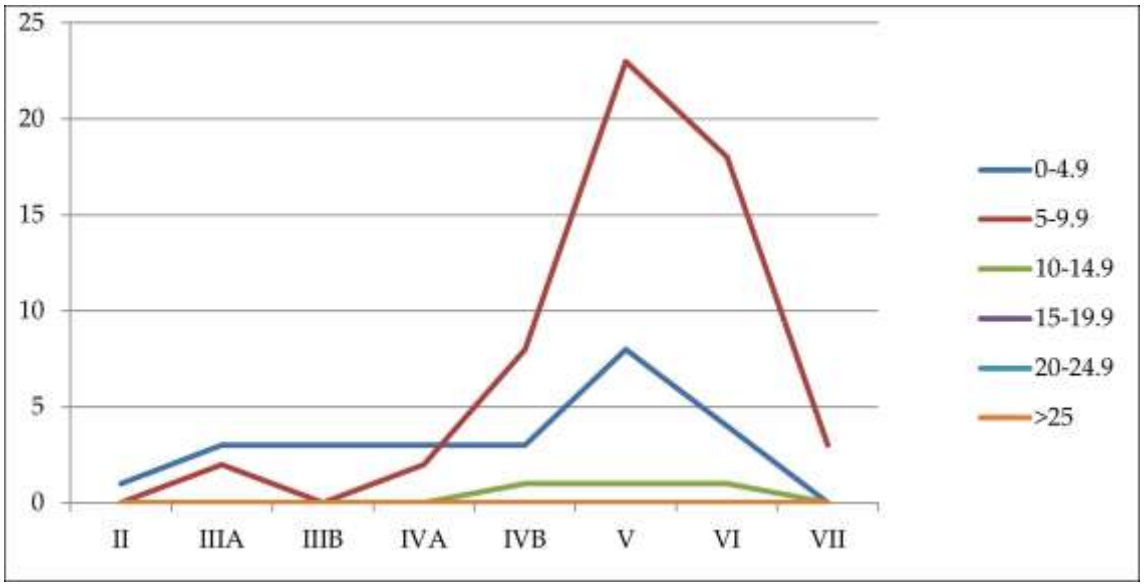

Figure 8: Thickness/Diameter of Mullers Across Different Cultural Periods

The climatic modelling and archaeo-botanical investigation have yielded fascinating results. Climate reconstruction has been made based on studying *Bellamya bengalensis* which is a typical lake or riverine near-surface water inhabitant mollusc, with 1–3 years' lifespan. The *Bellamya* shells are excellent proxies for lake palaeo-environmental conditions and climate parameters, viz., seasonality, paleo-humidity etc. The early Kshatrapa (early part of 1st century to 250 CE) and Mid-to-late Solanki (950–1300 CE) periods experienced ~800–1000 mm annual rainfall, much higher than today. Rainfall in early post-Kshatrapa period (400–500 CE), however, was similar to that of today. Variation in the Indian summer monsoons (ISM) of different settlement periods at Vadnagar was constrained by both bulk and isotope sclerochronology (seasonality) of molluscan shells. The isotope data, supplemented by other climate proxies and historical texts, suggest that each of these periods flourished during a good ISM phase e.g. between 1st century CE and 3rd century CE (mid-Roman warm period - RWP), 6th-7th century CE (mid-Dark age cold period - DACP), and 10th -13th century CE (Medieval warm period -MWP). Conversely the arid/hyper-arid phases witnessed decline in material culture between 14th -17th century CE, craftsmanship, and/or increased social instability. Effective adoption of various water conservation means during weak monsoons by the successive inhabitants led the sustenance of the city for such a long period (Sarkar et.al 2023).

Similarly, archaeo-botanical data indicate the sufficient water availability during the Historic and Medieval periods, allowing crop production dominated by large-grained cereals (C_3 plants). However, during the post-Medieval period (14th -17th century CE) a resilient crop economy based on small-grained cereals (C_4 plants) dominated the

scenario, representing a human adaptation to prolonged weakening of monsoonal precipitation (Pokharia et.al 2024). Isotopic and phytolith data from Vadnagar provide a clear signal of local environmental conditions and how they changed over two millennia from the early Historical period to the early post-Medieval eras. Significantly, these changes are congruent with palaeo-climate studies from the northern Indian subcontinent, especially indicating weaker summer monsoon precipitation associated with the Little Ice Age. The archaeo-botanical evidence for agriculture from the site suggests a resilient agricultural system, with a diverse cropping system that shifted to a highly drought tolerant millet-focused regime in response to the weakened ISM from ca. 1400 CE.

By examining the relationship between climate and archaeo-botanical studies, it becomes apparent that there was a change in agricultural practices beginning in the 14th century CE. This change can be attributed to the usage of larger mullers, which were likely used for tasks such as removing chaff from pulses and making paste from grains, millet, or cereals. The larger and more robust mullers yielded a finer quality of flour, which is particularly suitable for wheat, pearl millet, gram flour, and other similar grains.

References

Bisht, R. S. 2015. *Excavation at Dholavira*. Archaeological Survey India (Unpublished). New Delhi.

Deo, S. B., A. M. Shastri and R. S. Gupte. 1973. *Excavations at Bhokardhan (Bhogavardhana)*. Nagpur University. Nagpur.

Dhavalikar, M. K., M. R. Raval, and Y. M. Chitalwala. 1996. *Kuntasi: A Harappan emporium on West coast*. Deccan College Post-Graduate Research Institute. Pune.

Dhavlikar, M. K. 1999. *Historical Archaeology of India*. Books and Books. New Delhi.

Ghosh, A. 1989. *An Encyclopaedia of Indian Archaeology.* Munshiram Manoharlal Publishers Pvt. Ltd. New Delhi.

Hegde, K. T. M., K. K. Bhan, V. H. Sonawane, K. Krishnan, and D. R. Shah. 1990. Excavation at Nageshwar Gujarat: A Harappan shell working site on the Gulf of Kutch. in *Maharaja Sayajirao University Archaeology Series No. 18.* The Maharaja Sayajirao University of Baroda. Vadodara.

Marshal, J. 1975. *Taxilla: An illustrated account of Archaeological excavations*. Bhartiya Publishing House. Varanasi.

Mehta, R. N. 1970. Excavation at Nagara. *Maharaja Sayajirao University Archaeology Series No. 10.* The Maharaja Sayajirao University of Baroda. Vadodara.

Mehta, R. N. and S. N. Chowdhary. 1966 *Excavation at Devnimori: A Report of the Excavation conducted from 1960 to 1963*. The Maharaja Sayajirao University of Baroda. Vadodara.

Mehta, R. N., K. N. Momin, and D. R. Shah. 1980, Excavation at Kanewal: Report of Excavations conducted at Kanewal Taluka Khambhat Dist. Kheda, Gujarat from 6th January, 1977 to 30th January, 1977. *Maharaja Sayajirao University*

Archaeology Series No. 17. The Maharaja Sayajirao University of Baroda. Vadodara.

Nath, A. 1998. Further excavation at Pauni 1994. *Memoirs of the Archaeological Survey of India No. 97*. Archaeological Survey of India. New Delhi.

Nath, A. 2016 *Excavation at Adam (1988-1992) –A City of Asika Janapada.* Archaeological Survey of India. New Delhi.

Rao, S. R. 1979 *Lothal: A Harappan Port town (1955-62)*. Vol. I. Archaeological Survey of India. New Delhi

Rao, S. R., B. B. Lala, B. Nath, S. S. Ghosh, and K. Lal. 1963. Excavation at Rangpur and other explorations in Gujarat. *Ancient India. Bulletin of the Archaeological Survey of India number 18 and 19*. New Delhi.

Sankalia H.D. 1969. *Excavation at Ahar (Tambavati) (1961-1962)*. Deccan College Post-Graduate and Research Institute. Pune.

Sankalia, H. D. and S. B. Deo. 1957. Saddle querns and stratigraphy. *Journal of the Royal Asiatic Society of Great Britain and Ireland* 3-4: 9-12.

Sarkar, A., T. Sengupta, A. Ambekar, R. Bhushan, A. P. Dimri, A. D. Mukherjee, A. Sharma, M. C. Liang, P. S. Jena, A. Chakraborty, P. Sanyal, A. Dabhi, and N. Juyal. 2024. Climate, human settlement, and migration in South Asia from early historic to medieval period: Evidence from new archaeological excavation at Vadnagar, Western India. *Quaternary Science Reviews 324* (5). DOI:10.1016/j.quascirev.2023.108470.

Sarkar, H. and B. N. Misra. 2006, *Nagarjunkonda*. Archaeological Survey of India. New Delhi.

Thapar, B. K. 1967. Prakash 1955: A Chalcolithic site in the Tapti valley. *Ancient India, Nos. 20 and 21.* New Delhi.