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The Agriculture of Early India

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Summary and Keywords

South Asia possesses a unique Neolithic transition to agricultural domestication. India has received far less attention in the quest for evidence of early agriculture than other regions of the world traditionally recognized as "centers of domestication" such as southwest Asia, western Asia, China, Mesoamerica, South America, New Guinea, and Africa. Hunter-gatherers with agricultural production appeared around the middle of the Holocene, 4000 to 1500 BCE, with the cultivation of domesticates and a correspondingly more sedentary lifestyle emerging at this time. Two thousand years ago South Asia was inhabited by farmers, with densely populated river valleys, coastal plains, urban populations, states, and even empires. While some of the crops that supported these civilizations had been introduced from other regions of the world, a large proportion of these crops had local origins from wild plants native to the subcontinent.

As a case study for the origins of agriculture, South Asia has much to offer archaeologists and environmental scientists alike for understanding domestication processes and local transitions from foraging to farming as well as the ways in which early farmers adapted to and transformed the environment and regional vegetation. Information exchange from distant farmers from other agricultural centers into the subcontinent cannot be ruled out. However, it is clear that local agricultural origins occurred via a series of processes, including the dispersal of pastoral and agro-pastoral peoples across regions, the local domestication of animals and plants and the adoption by indigenous hunter-gatherers of food production techniques from neighboring cultures. Indeed, it is posited that local domestication events in India were occurring alongside agricultural dispersals from other parts of the world in an interconnected mosaic of cultivation, pastoralism, and sedentism. As humans in South Asia increasingly relied on a more restricted range of plant species, they became entangled in an increasingly fixed trajectory that allowed greater food production levels to sustain larger populations and support their developing social, cultural and food traditions.

Keywords: archaeobotany, domestication, paleoethnobotany, Neolithic, South Asia, rice, millet, sedentism, seasonality

Introduction

South Asia, primarily comprising the sub-Himalayan countries of Bangladesh, India, Sri Lanka, and Pakistan, has recently entered global awareness as an important region of agricultural origins (Fuller & Murphy, 2014, 2016; Bates, Petrie, & Singh, 2017A; Bates, Singh, & Petrie, 2016; Morrison, 2016). Although the evidence is still patchy, as India has received far less attention in the quest to understand the origins of agriculture than other regions of the world traditionally recognized as "centers of domestication" such as western Asia, China, Mesoamerica, and South America (Barker, 2006), South Asia is now thought to possess a unique Neolithic transition to agricultural domestication (Balter, 2007; Purugganan & Fuller, 2009; Larson et al., 2014; Murphy & Fuller, 2014). Two thousand years ago the subcontinent was inhabited by a complex patchwork of farmers and hunter-gatherers, with densely populated river valleys, coastal plains, urban populations, states, and even empires. While some of the crops that supported these early societies had been introduced from other regions of early Neolithic agriculture, a large proportion of these crops had local origins from wild plants native to the subcontinent (Fuller & Murphy, 2014; Kingwell-Banham et al., 2015).

Palaeo-environment of South Asia

Critical for the understanding of the beginnings of agriculture in any region is an appreciation of how environments in the past differed from modern ones and how this may in turn have affected the distribution of wild plant progenitors and human cultural adaptations. There is now clear evidence for fluctuations in rainfall levels during the Holocene in South Asia, which can be connected with shifts in vegetation, but it remains poorly understood how these may or may not relate to the origins and spread of agriculture (Asouti & Fuller, 2008; Chen et al., 2014; Madella & Fuller, 2006; Shi, Li, & Wilson, 2014; Yang et al., 2014). Aridification, or increasingly drier conditions, that started at the end of the mid-Holocene occurred gradually to the mid-4th millennium BC, and reached near modern levels before 2000 BC (Fuller & Madella, 2001; Prasad & Enzel, 2006; Prasad et al., 2014A, 2014B; Ponton et al., 2012). The sudden increase in aridity starting around 2200 BC and lasting until 1900 BC, has also been noted for some other world regions, including the Near East and for South Asia (Chew, 2005); however, the Rajasthan pollen sequences suggest that this may represent an acceleration of trends that were already underway in South Asia at this time. An increase in savannah or grassland habitats is thought to have occurred during the dry period, from *ca*. 3500 BC to 2000 BC (Giosan et al., 2012, 2013). The grassland ecosystems of the savannah would have been a habitat well suited to pastoralism. From a local level there is considerable variance in precipitation over the short term (annual to decadal), and the strength of the Indian summer monsoon varied significantly over time (Balbo et al., 2014; Dixit et al., 2014; Nakamura et al., 2016). Nevertheless a period of relatively more stable monsoons between 2000 and 1000 BC on the Indian peninsula (Ponton et al., 2012; Prasad et al., 2014A, 2014B; Sarkar et al., 2015; Giosan et al., 2017) may have favored the development of settled agricultural communities over large parts of India (e.g., Roberts et al., 2016).

There is also clear evidence for anthropogenic manipulation of the landscape during the mid-Holocene on the subcontinent. A few pollen cores from South Asia have included quantification studies of the micro-charcoal, from the Thar Desert, including Lunkaransar, revealing a clear increase and high levels of charcoal starting at *ca*. 7000 to 6000 BC and declining by *ca*. 4000 BC. This pollen core evidence suggests new anthropogenic burning regimes during this period, likely attributed to the substantial presence of Mesolithic hunter-gatherers inferred from the microlithic sites, often found on stabilized dunes (Biagi & Kazi, 1995; Kashyap, 2006; Misra, 1989; Misra & Mohanty, 2001; Shinde et al., 2004; Ajithprasad, 2004). A similar peak in micro-charcoal is also seen in the Nilgiri Hills of South India prior to 3500 BC (Sutra et al., 1997), and work near Lahuradewa indicates substantial landscape burning dating back to the Late Pleistocene/Early Holocene (Sharma et al., 2004; Singh, 2005). Indeed, such burning regimes may have played a role in encouraging new plant growth and attracting wild game to hunt, similar to burning strategies employed by modern tribes today (Saha, 2002; Pyne, 2001, 2006).

These cycles of anthropogenic burning may have also been part of a strategy to encourage the management of rice floodplain environments for the promotion of wild rice (*Oryza nivara*, *Oryza rufipogon*, *Oryza officinalis*), which were being utilized, a key component of the hypothesized "proto-*indica*" pathway to rice cultivation (Fuller & Qin, 2009). Another likely anthropogenic signal in the environment is the emergence of the modern "climax"-type sal (*Shorea robusta*) forests in eastern Madhya Pradesh in the late 3rd millennium BC (Chahuan, 1996, 2000, 2002). Increases in *Madhuca indica*, with its edible flowers (traditionally fermented to wine), and *Shorea robusta*, which favors coppicing and the establishment in previously burnt swidden fields (Sivaramakrishnan, 1999, pp. 211–235), suggests a response to such changing anthropogenic practices as the spread of agriculture (Kingwell-Banham & Fuller, 2012).

Issues in South Asian Archaeobotany

Despite over fifty years of study in the field of South Asian archaeobotany (reviews in Fuller, 2002, 2006, 2011; Murphy & Fuller, 2016), the process of plant domestication and establishment of agriculture in the subcontinent still remains poorly understood. This lacuna in the published literature, as previously mentioned, is due in part to a lack of focus on the Neolithic agricultural roots of the subcontinent due to the strong preoccupation in South Asian archaeology with research on the Indus civilization (also called the Harappan civilization).

However, other challenges also present themselves including a lack of direct, empirical archaeobotanical evidence, in part because few native domesticates have been recognized when compared with other areas of the world (see Fuller, 2007A; Fuller et al., 2014), and indigenous domesticates recovered to date are still inadequately documented (Fuller, 2006). For many taxa, reliable characteristics for diagnosing domestication have yet to be established, and inferences about domestication are hindered by limited study of modern comparative material. A key change with domestication is loss of natural seed dispersal (Harlan, De Wet, Price, & Glen (1973); Fuller, 2007A; Fuller et al., 2016; Bates et al., 2016). With domestication comes seed size change. This seed size change has recently been documented empirically in several taxa including *Vigna* spp., especially mungbean (*V. radiata*) (Fuller & Harvey, 2006; Fuller et al., 2014), Horsegram (*Macrotyloma uniflorum*) (Fuller & Murphy, 2017; Murphy & Fuller, 2017), Pigeon pea (*Cajanus cajan*) and Rice (*Orzya sativa* subspecies *indica*) (Fuller et al., 2014).

Another challenge is that early farming may have produced seasonal or intra-annual mobility (shifting cultivators) making an archaeological signal difficult to recognize and detect (Fuller, 2006; Kingwell-Banham & Fuller, 2012). For most of India, the first well documented and archaeobotanically sampled archaeological sites were already the villages of sedentary farmers with domesticated crops (Figure 1).

Earlier initial stages and processes of cultivation and domestication most probably began among fairly mobile groups. However, these "sites" are harder to document due to their ephemeral nature.

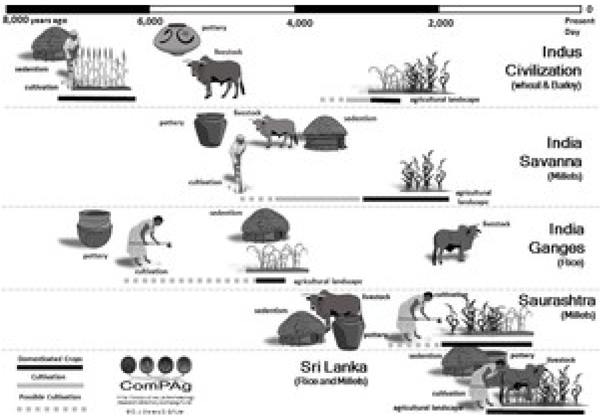

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Figure 1. Schematic diagram of comparative timelines of traditional centers of agricultural origins from West Africa, the Levant, and India from the Savannah and Ganges regions

(Modified from Fuller et al., 2015, Figure 2 Image courtesy of Chris Stevens).

Wild Progenitors and Geographical Origins

Although archaeobotanical evidence for the transitions from foraging to farming remains elusive in the subcontinent, the bio-geographical proof of wild progenitors (ancestors of crops), together with their occurrence early on in regional Neolithic traditions, argues for their local, independent origins and subsequent domestication in India (Fuller & Murphy, 2014; Murphy & Fuller, 2016). Speculation on the regional foci of plant domestication in South Asia has been based upon recent botanical documentation of wild crop progenitors, which normally grow in/or near the deciduous woodland and the savannah, thus including Gujarat, the South Deccan, the western Himalayan foothills, and the Ganges basin (Figure 2) (Asouti & Fuller, 2008; Fuller & Korisettar, 2004, pp. 123–126; Fuller, 2011, p. S248; Fuller & Murphy, 2014, 2017).

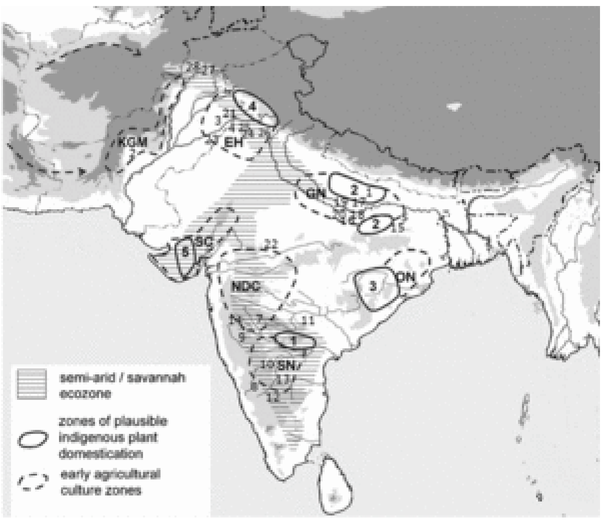

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Figure 2. Map of agricultural origins on the Indian subcontinent. (EH) Eastern Early Harappan, (GN) Ganges Neolithic, (ON) Orissa Neolithic, (SC) Sorath Chalcolithic

It is likely that these local domestication events were combined with agricultural dispersals through an interconnected mixture of cultivation, pastoralism, and sedentism. Therefore, with the relatively recent growth in archaeobotanical data collection and syntheses in South Asia (Fuller, 2002, 2011; Fuller & Murphy, 2014; Saraswat, 2005; Bates, Singh, & Petrie, 2016; Bates, Singh & Petrie, 2016) it is now possible to postulate five probable zones of indigenous plant domestication in India located near or within different regional Neolithic traditions (Figure 2). It is likely that these regions in South Asia underwent transitions from hunting and gathering to the independent cultivation of locally available species. The landscape of India was changed through the migration of farmers to earlier established cultivation centers as both groups transferred knowledge and Banas Culture, (NDC) North Deccan Chalcolithic, (SN) Southern Neolithic and (KGM) Kili Ghul Mohammad. Sites. Regions of plausible crop domestication: (1) South Deccan, (2) Middle Ganges and/or Vindhyas, (3) Upper Mahanadi, (4) Foothills of the Indo-Gangetic Divide, (5) Saurashtra or Southern Aravallis. Zones of early farming Neolithic/Chalcolithic culture areas: 1. Lahuradewa 2. Mehrgarh 3. Kunal 4. Tigrana 5. Senuwar 6. Mahagara 7. Paithan 8. Hallur 9. Inamgaon 10. Kodekal 11. Utnur 12. Budihal 13. Sanganakallu 14. Daimabad 15. Chopani-mando 16. Kunjhun-II in Son River Valley 17. Damdama 18. Mahadaha 19. Sarai Nahar Rai 20. Jhusi 21. Hulas 22. Kayatha 23. Lunkaransar (pollen core) 24. Masudpur VII 25. Masudpur I 26. Bahola 27. Qasim Bagh 28. Kanispura.

and crops and livestock between these cultural traditions on the subcontinent. This process of migration and exchange led to an increasing diversity of crops in India. Indeed, a testament to this process is the fact that before the Early Historic period the subcontinent possessed a greater diversity of grain crops than any other world region (Fuller, Castillo, & Murphy, 2016).

Seasonality of cultivation is another important issue, which has been discussed for some time (e.g., Possehl, 1986; Meadow, 1989; Weber, 1991; Fuller & Madella, 2001), and most recently reviewed by Petrie and Bates (2017). Indigenous crops of South Asia, and those from elsewhere in the tropics, such as Africa, or monsoon Asia, such as China, tend to be grown in in the summer rainy season. In India this is traditionally referred to as *kharif* cultivation, with crops planted in July and harvested from October. These crops are normally short-day plants, programmed to flower and set seed as days shorted toward the end of summer, (Willcox, 1992). An alternative seasonality is followed in the normal cultivation of crops of Near Eastern origin, which are planted around October and November and harvested from March, and tied to flowering as days lengthen (Willcox, 1992). Such crops include wheats, barley, lentil, pea, chickpea, grasspea, flax, and safflower. In their Near Eastern homeland, this tied their seasonality to winter rainfall, whereas in the Indus region these often came to rely on winter to spring river floodplain water and elsewhere in India on residual soil moisture or irrigation. The interplay and combination of these two seasons of cultivation was a major dynamic in the history of agricultural production in South Asia, characterizing key chronological transitions and regional differences.

Northwest

The evidence from the Neolithic site of Mehrgarh, located to the west of the Indus River Valley in Baluchistan, provides the earliest evidence from South Asia for local plant and animal domestication processes (Costantini, 1984, 2008; Costantini & Lentini, 2000; Jarrige, 2008; Jarrige, Jarrige, & Quivron, 2006; Shinde, 2016). The foundations of a settled agricultural village economy here, by *ca*. 6000 BC, were introduced domesticates, namely wheats (emmer, einkorn, bread wheat), barley, goats and probably sheep (Meadow & Patel, 2001). The choice of site location, on an alluvial fan, follows a pattern of site location common to the Pre-Pottery Neolithic tradition further west through Iran and into the West Asian Fertile Crescent (Petrie & Thomas, 2012). While barley, sheep, and goat are all wild populations in the region, and it is possible they contributed some genetic admixture, the fully fledged package suggests introduction of agro-pastoralist tradition migrating from further west. In addition the predominance of non-shattering cereals ears, both wheats and barley (Costantini, 1984), which took millennia to evolve in western Asia (Fuller et al., 2012, 2014), indicate a completed domestication process rather than the midst of a local trajectory. Local domestications, however, did take place, which included humped zebu cattle (*Bos indicus*) and tree cotton (*Gossypium arboreum*) by *ca*. 5000–4500 BC (Meadow & Patel, 2001; Fuller, 2006). This early cotton was a perennial managed as a tree or shrub and analogous to fruit tree crops rather than annual cereals (Fuller, 2008). The shorter-lived staple crop subsistence, together with initial caprine herds, were therefore non-native. Other crops of West Asia origin, and with winter seasonality—such as lentil, pea, chickpea, grasspea, and flax—are not in evidence until later (after 4000 BC, and for most taxa after 3000 BC), making it unclear whether these represent secondary diffusion from western Asia.

Evidence for livestock, with its pastoral links, has its roots in the northwest of the subcontinent. Sheep and goats possess no wild progenitors in India, yet faunal evidence for both has been recovered from the earliest sites in the northwest region (Korisettar et al., 2001). The weight of the genetic and archaeozoological evidence for zebu cattle suggests that they were domesticated in the northwest in the Indus region and subsequently spread throughout peninsular India, perhaps between 3500 and 2500 BCE (Chen et al., 2010).

The Indus-Ganges Upper Alluvium

The upper reaches of the Ganges and the Indus river systems are joined into one greater alluvial, which has a history of river shifts between the two systems, up to as recently as the later Pleistocene, by which time the Yamuna headwaters had shifted from flowing toward the Indus to the Ganges (Giosan et al., 2012). This region is also a climatic transition zone, representing a region of reliable monsoon summer rainfall in contrast to regions in the Indus Valley further west where some westerly winter rains and spring to summer river floods are more important sources of water (e.g., Dixit et al., 2014). In cultural terms this area represents that Eastern Domain ("Sothi-Siswal") of the Harappan civilization (1999, 2002), east of which were contemporary Gangetic Neolithic cultures. This area includes the upper Ghaggar-Hakra Palaeo-River Valley, also referred to as the Sarasvati-Drishadvati Valley, which was an important area of settlement during the Indus period (Nath, 2017). This area was also most likely a center of early cultivation and, quite plausibly, indigenous crop domestication (Fuller, 2006, 2011; Fuller & Murphy, 2014; Murphy & Fuller, 2016).The earliest agricultural settlements, with hard evidence for crops, in this region date to *ca*. 3200–2800 BC, during the Ravi Phase of the Early Harappan period, also referred to as the Formative Period by Nath (2017). Recent research has found Formative and earlier Neolithic levels underlying several Harappan sites, and radiocarbon dates indicate such Neolithic levels date back to at least 4500 BC (Nath, 2017), although Nath speculates that the transition from Mesolithic foraging to cultivation in this region could be as old as *ca*. 5500 BC. Unfortunately, archaeobotanical investigations are so far lacking, although apparently domesticated sheep, goat, and cattle were present. Claims for domesticated pig and water buffalo are not yet substantiated by detailed archaeozoological publication. Nath (2017) speculated that the earliest farming was based on introduced winter crops, as characterized regions west of the Indus, but the possibility of indigenous crops, better suited to monsoon rainfall and representing an independent domestication process, deserves consideration.

Starting from around 3000 BC, the available archaeobotanical evidence would suggest that both winter and summer crops were already part of the agricultural system at these sites (Petrie & Bates, 2017; Bates et al., 2017B). The winter crops were those of western Asian origin, including wheat and barley but also pulses (lentil, pea, chickpea, grasspea). But these introduced species appear to have been alternated seasonally with potentially local domesticates that were cultivated in summer. This archaeobotanical evidence would imply that monsoon crops were already available as cultivars, perhaps from this region in an as yet undocumented presedentary period or else from areas to the east, in the Himalayan foothills near the Upper Ganges and Yamuna rivers. These native crops included Indian pulses such as horsegram, and mungbean, which could have a western Himalayan origin as well as one on the peninsula (Fuller & Harvey, 2006; Fuller & Murphy, 2017). By 2500 BC or shortly thereafter there is evidence for size change in mugbean and horsegram, suggesting local domestication processes that had started earlier. The evidence for millets, plausibly also already domesticated, include little millet (*Panicum sumatrense*), sawa millet (*Echinochloa frumentacea*), and perhaps yellow foxtail (*Setaria pumila)* (see, e.g., Weber & Kashyap, 2016; Petrie & Bates, 2017), and we would expect these to have begun at least 1,000 years before the first half of the 3rd millennium BC (on the analogy of measured domestication rates in other crops, see Fuller et al., 2014). The presence of some rice, although morphologically wild, also suggests some local rice cultivation had begun before the Harappan period (by 2500 BC) (Bates et al., 2017A), which fits arguments of a protracted period of nondomestication exploitation of "proto-indica" rice (Fuller & Qin, 2009; Fuller et al., 2016B). This is prior to evidence of contact with other Indian millet centers suggesting local domestication processes from some indigenous crops took place in this region. *Vigna aconitifolia* from Mature Harappan Masudpur I (2500–2000 BC) and ivy gourd (*Coccinia grandis*) at Early Harappna Masudpur VII (3000–2500 BC) are the earliest finds yet in South Asia (Bates et al., 2017A; Petrie & Bates, 2017), and the evidence suggests that these crops may also originate in this region. However, the beginnings of these inferred domestication processes and the earliest village settlements remain obscure.

Kashmir Neolithic

In the Western Himalayan-Hindu Kush regions of India and Pakistan the prehistoric cultural complex dating to around 3000 BC has been loosely called the "Northern Neolithic" (Possehl, 1999; Coningham & Young, 2015), possessing a rich agricultural tradition with little Harappan cultural influence despite its geographical proximity. Similarly, the earliest-dated Neolithic site, Kanispura, in the Baramulla district in the northwest of the Kashmir Valley, has origins from 3300, continuing up to 2100 BCE. Agriculture is present from the first ceramic Neolithic levels at Kanispura with evidence for cultivation of barley and some emmer wheat (Mani, 2008) with little evidence of domesticated sheep and goats. By the first half of the 3rd millennium BC, wheat became the dominant food crop, along with some pulses, and by the later 3rd millennium BC the proportion of domesticated animals had risen with the introduction of cattle and chicken (Spate et al., 2017). The excavated site of Qasim Bagh in the Kashmir Valley has wheat and millet grains radiocarbon dated to the Neolithic phase, 2,000–500 BC. The foundations of agricultural production in the 3rd millennium BC appear to be western Asiatic in ultimate origin (wheat, barley, winter pulses, sheep, and goat), with summer crops and additional diversity added from *ca*. 2000 BC onward (Stevens et al., 2016). In some of the lower valleys to the west, such as Swat in Pakistan, rice may have already been present from *ca*. 2500 BC, but this was presumably proto-indica, much like that in the Eastern Harappan domain (Silva et al., 2015). Spate et al. (2017) suggested that based upon the archaeobotanical evidence from Qasim Bagh, the region was integrated into the wider sphere of exchange of crops in the mountainous regions of South and Central Asia as early as 3,000–2,000 BC, but evidence for clear links with Central Asia as opposed to the Indus valley date to after 2000 BC (Fuller, 2006; Stevens et al., 2016).

Middle Ganges Neolithic and the Origins of Indian Rice

This region has long been highlighted as a possible center of domestication due to its recognized continuous occupation from the Mesolithic and late Paleolithic cultures through to the Neolithic (Sharma et al., 1980; Lukacs, 2002; Pal, 1994, 2008). The archaeobotanical evidence would suggest the likelihood that some millet cultivation may have occurred alongside rice cultivation in the Ganges Valley Neolithic (Saraswat, 2005; Harvey & Fuller, 2005; Fuller, 2006; Fuller & Murphy, 2014). One of the challenges in understanding the archaeological record of this region is dating, with reported early Holocene dates (between 7000 and 5000 BC) based on wood charcoal from several sites being cited as evidence for early agriculture, even associated with non-native crops such as wheat and barley (e.g., Pal, 2008; Nath, 2017). More skeptical, short chronologies adhere to the limited direct radiocarbon dating of crop remains and suggest that cultivation of introduced crops such as wheat and barley is not older than around 2500 BC, and earlier dates on wood charcoal are unlikely to be associated with fully agricultural societies (e.g., Fuller, 2006, 2011, Fuller et al., 2014).

One of the early sedentary sites, which appears well dated, is Lahuradewa. It possesses ceramic vessels by *ca*. 7000 BCE (Singh, 2010, p. 176; Tewari et al., 2006, 2008), making them the earliest ceramics in South Asia, as well as the earliest evidence for systematic rice use. This site was located adjacent to an oxbow lake (Figure 3) but formerly sat on a meander channel of a tributary of the Ganges river.

Click to view larger

Figure 3. Lahuradewa excavations view to the Oxbow pond

(photo taken by D. Q. Fuller, 2006).

The rice exploited here was likely an early form of non-domestication cultivation or wild rice management, focused on annual *Oryza nivara* (see GUJARAT section; Fuller, 2011; Fuller & Qin, 2009), as morphological data are consistent with wild rice until assemblages of the 2nd millennium BC.

Livestock, introduced early in the 2nd millennium BCE from the Northwest to the central Ganges region, formed the basis for a mixed agro-pastoral economy. By this time domesticated livestock had become widespread, with goats appearing at the site of Senuwar by *ca*. 2200 BCE and cattle widespread on Neolithic sites from at least 2000 BCE onward (Singh, 2010, pp. 171–172). Disentangling the scope to which wild bovines (specifically, wild water buffalo, gaur, and *Bos namadicus* aurochs) were present and hunted on the Ganges plains remains difficult to determine. Two foci of genetic diversity are suggested for zebu cattle, one focused east of the Indus Valley, and one cluster focused around the Indus valley (Chen et al., 2010). Introduced cattle from the Indus or its western hilly flanks represents an original domestication, and as the introduced cattle was spread by pastoralists, they would have interbred with native wild aurochs on the Ganges plains, which were hunted and being pushed to extinction by competition from their domesticated counterparts.

Perhaps the biggest issue in Ganges Valley Neolithic archaeology is when rice was cultivated, fully domesticated, and when the transition from Mesolithic foraging to Neolithic farming should be placed (see discussions in Harvey et al., 2006; Tewari et al., 2008; Pal, 2008; Singh, 2004, 2010; Fuller, 2006, 2011; Fuller & Murphy, 2014). Sampling at the Neolithic site of Senuwar recovered wheat, barley, lentils, grasspea, and peas from the end of the first phase. These taxa are absent from the beginning of the site when rice (*Oryza sativa*) and small millet(s) (including *Setaria pumila*, syn *S. glauca*) were present (Saraswat, 2004, 2005). This implies that a rice-millet subsistence system was already established before other crops were introduced from the west, although whether these millets or indeed the rice were domesticated at this point is unknown. Fully domesticated rice has been recovered from Mahagara dating to *ca*. 1800–1400 BC (Fuller et al., 2016B). Nevertheless, it was after the adoption of crops and animals from the west that Neolithic village living really thrived on the Ganges plains. Sedentary villages become widespread during the 2nd millennium BCE, many located along rivers above the flood level (Figure 4), suggesting that rainfed cultivation could be carried out beyond the reach of floods, while river water may have supported winter crops such as wheat and barley.

Click to view larger

Figure 4. Mahaagara Neolithic settlement on the banks of the Belan River during lower water levels of winter

(photo taken by D. Q. Fuller, 2001).

Subsequently craft specialization and urbanism emerged during the early 1st millennium BCE.

The "proto-*indica* hypothesis" (Fuller et al., 2010B; Fuller, 2011; Choi et al., 2017) resolves an apparent paradox: the issue of deep genetic divergence from the subspecies *japonica*, which appears to predate domestication and thus suggests a different wild progenitor population. Several genetic loci have identical shared mutations indicating strong selection pressure during, or just after, domestication occurred. This would imply that domesticated *japonica* rice donated its genes, through hybridization, to the ancestor of *indica* rice, which in turn was derived from a distinct phylogenetic background (Fuller & Qin, 2009; Fuller et al., 2010B; Sweeney & McCouch, 2007). This genetic evidence suggests that the exploitation of wild-type proto-*indica* populations using some type of management or cultivation that along with hybridization with fully domesticated *japonica* would have led to the creation of improvements in these plants for the farmers.

It is posited that rice would have been seasonally harvested from wild stands, by either the paddling or basket-swinging methods, which also beneficially served to re-seed the stands without artificial selection (as defined by Hillman & Davies, 1990, as non-domestication cultivation). Human removal of competing weed species, possibly through burning during the dry season after harvesting was completed, would allow the wild rice stands to be extended. Early finds of Harappan rice, such as at the site of Kunal, may represent an extension of proto-*indica* into the upper Ganges and Indus tributaries, and it is in this context, or in nearby northern Pakistan, that the introduction and hybridization of *japonica* are thought to have taken place (Fuller & Qin, 2009; Stevens et al., 2016).

Until recently there was little evidence in India for rice spikelet bases, which can provide a clear trait of morphological domestication—as spikelet bases indicate a reliance on human threshing and dispersal of the non-shattering rice. At the site of Lahuradewa, there are a couple of green-harvested immature spikelets (as illustrated in Tewari et al., 2008; Fuller, 2011), suggesting that these specimens could be from wild-gathered rice (see Fuller et al., 2007). New evidence from Bates et al. (2016) has shown that rice was being exploited as early as the Harappan period (Petrie et al., 2016; Bates et al., 2016, p. 5). Specifically from the site of Masupdur VII, Hissar District, Haryana, wild-type rice spikelet bases, dating from the mature Harappan phase, were the dominant form (76%) present, and by the Late Harappan phase wild spikelet bases were no longer present (Bates et al., 2016, p. 6). At the site of Masupdur I, Hissar District, Haryana, from the mature Harappan period there were proportionately more wild-type than domesticated spikelet bases (Bates et al., 2016, p. 6). The first non-shattering, domesticated spikelet bases are known at Mahagara dating to 1800–1600 BCE (Fuller et al., 2010A, 2014; Fuller, 2011). This empirical evidence supports the rapid increase in the amount of exploitation of domesticated rice over time, with a marked increase in the Late Harappan era (after 2000 BC) and would support the proto-*indica* domestication hypothesis from the Gangetic region (Bates et al., 2016).

Grain metrics also offer additional empirical evidence for this theory showing grain size changes consistent with domestication only starting in the 2nd millennium BCE. If this scenario is correct, then one could expect to see concomitant increases in rice grain size if indeed the Gangetic rice-growing soils had been managed via tillage, as was the early cultivation of cereals elsewhere in the world, including early Chinese rice (Fuller et al., 2012, 2014; Fuller & Allaby, 2009). The north Indian rice assemblages that have been analyzed to date suggest a directional increase in grain size (grain breadth) during the 2nd millennium BCE, with an even more pronounced increase in the 1st millennium BCE (Fuller et al., 2014), which would suggest that systematic tillage of rice fields was only adopted with domesticated hybrid rice sometime after 2000 BC.

While rice crops were greatly enhanced by the appearance of the hybrid *indica* form replacing the native, morphologically wild, proto-*indica* variety, other introduced domesticates also increased crop production. At this time, winter crops from the Indus Valley were introduced, including wheat, barley, and possibly lentil (Saraswat, 2004, 2005). Pulses, such as mungbean and horsegram arrived around 2000–1800 BC from the Deccan. Mungbeans are present in the Eastern Harappan zone before 2000 BC and the current morphometrics on seed size hint that mungbeans were already fully domesticated at this point (Fuller & Harvey, 2006), whereas those to first arrive in the Ganges plain are small seeded, suggesting a different source, such as from the Deccan. These would have been introduced prior to seed size increase in the Deccan, which is dated to 1500–1000 BC (Fuller, 2011).

An important set of crops native to northern India but still poorly documented are cucurbitaceous vegetables (Decker-Walters, 1999; Fuller, 2006, Table 3), including cucumbers (*Cucumis sativus*), snake gourd (*Trichosanthes cucumerina*), bitter cucumbers (*Momordica* spp.) and ivy gourd (*Coccinia grandis*). Huts and other human habitation areas in the early villages of the Ganges would have offered an ideal habitat for a variety of gourds (snake gourds, luffas, ivy gourds) to be established as creepers after having been transplanted to these anthropogenic environments from their forest-edge habitats.

Linguistic evidence for these species may be indicative of borrowing from an extinct agricultural language of northern/Gangetic India (Fuller, 2003, 2007B). Although *Cucumis* sp. seeds have been reported fairly widely, specific identity remains elusive, and several wild species are possible. Ivy gourd or *Coccinia grandis* has been recovered from Hulas in the upper Ganges basin, since around 1800–1300 BC, and from Senuwar IB, around 1750–1300 BC. Earlier evidence from Masudpur VII in Haryana from before 2500 BC (Petrie & Bates, 2017) suggests that this crop's origins lie in the Indo-Ganges upper alluvium like several other crops (see The Indus-Ganges Upper Alluvium).

Evidence from the Upper Ganges Valley and the Middle Ganges, as at Senuwar, indicates that by the early 2nd millennium BCE some crops of African origin had been adopted in the region, including hyacinth bean, possible cowpea, and sorghum, while evidence for pearl millet and finger millet are absent before the late 2nd millennium BCE (Fuller, 2003; Saraswat, 2004).

Gujarat

In western India, Gujarat and parts of Rajasthan, evidence for local plant domestication is entwined with the introduction of livestock (sheep, goat, and zebu cattle) from the Indus Valley, west of the Thar Desert from the middle of the 4th millennium BCE, leading to the establishment of agro-pastoral village cultures, such as the Ahar tradition in Rajasthan (the Mewar region) or the Sorath Harappan of the Saurasthra region (Misra, 2007; Patel & Meadow, 2017). While the Gujarat region was incorporated into the expanding influence of the Indus civilization from about 2500 BCE, evidence for a local transition to food production dates to a millennium earlier with the Padri, Anarta, and Pre-Prabhas archaeological cultures, referred as Chalcolithic and starting *ca*. 3500 BC (Ajithprasad, 2004, 2011; Shinde, 2004; Weber & Kashyap, 2016; García-Granero et al., 2016). The cultivation of indigenous pulses, at least urd bean (*Vigna mungo)*, and little millet (*Panicum sumatrense*) seems clear (see Weber, 1991; Fuller, 2006), these may have grown along with several *Setaria* spp. and/or browntop millet (*Bracharia ramosa*) (Kingwell-Banham & Fuller, 2014; García-Granero et al., 2015, 2016), and the pulse horsegram (*Macrotyloma uniflorum*) (García-Granero et al., 2016; Fuller & Murphy, 2017).

There is limited evidence for the cultivation, or at least consumption, of wheat and barley in this region at least from *ca*. 2500 BC (Weber, 1991; García-Granero et al., 2015), although finds from Loteshwar that are thought to be earlier could be intrusive (García-Granero et al., 2016). By Late Harappan times, after 2000 BC, there is increased evidence for winter season pulses, pea, lentil, and grasspea, but most agriculture appears to have been focused on monsoon period cultivation. Thus despite the introduction of livestock from the west/Indus region, plant subsistence appears to have been largely based on indigenous traditions.

Over the course of the Chalcolithic and Harappan era the range of *kharif* (summer) crops diversified, including more pulses, millets, and rice. By the late Harappan period mungbean (*Vigna radiata*) was grown alongside urd and horsegram. It is likely that this part of India was the first in Asia to have local cultivation of African crops such as pearl millet and sorghum adopted by 2000–1700 BC (Fuller et al., 2011; Weber & Kashyap, 2016). Debate over the evidence for finger millet (*Eleusine coracana*) continues (Boivin & Fuller, 2009; Fuller, 2013A). The first cultivated of *Setaria italica*, introduced from China, may be of similar age, despite some claims for earlier presence (Stevens et al., 2016). Some rice may have been grown in this region in late Harappan times, although confirmation through direct AMS-dating of rice to this period is needed (Fuller et al., 2010B; Madella, 2014; Pokharia et al., 2011; García-Granero et al., 2015). Whether this rice was an early *indica* form introduced from the Ganges or *japonica* introduced down the Indus from a northwestern entry to the subcontinent is uncertain at this point (Fuller, Castillo, & Murphy, 2016).

Southern India

The Deccan plateau of South India, a large arid region rich in Neolithic remains, has been postulated as another plausible center for indigenous plant domestication. Nevertheless, livestock appear to have been introduced to the region, including cattle, sheep, and goat—all of which may have spread with pastoralist groups through a savannah corridor zone that linked this area to Gujarat or Rajasthan (Fuller, 2011; Fuller & Murphy, 2014). Neolithic food production likely began around the 3rd millennium BCE, as indicated radiocarbon dates from the sites of Kodekal and Utnur, and likely continued to about 1000 BCE (Boivin et al., 2008, pp. 179–180; Fuller et al., 2007; Roberts et al., 2016). This Southern Neolithic zone largely overlaps with the area of the modern-day states of Karnataka and sections of Andhra Pradesh and Tamil Nadu (Figure 2). Ashmounds were a distinctive cultural phenomenon of the Southern Neolithic appearing *ca*. 3000 BCE. The best-documented ashmound sites are Utnur, 2600–2400 BCE

(Allchin, 1963; Fuller et al., 2007) and Budihal, 2300–1700 BCE. Ashmounds are now known to have been formed over a fairly short period of time (a few human generations), their formation the result of repetitive, symbolic dung-burning episodes. Ashmounds are visible features on the landscape and may have acted as an important foci for social life, including goods exchange, cattle trading, communal feasting, social and ritual gatherings, and possibly exchange of marriage partners between different groups (Figures 5, 6) (Allchin, 1963; Boivin, 2004; Boivin et al., 2008; Fuller & Murphy, 2014; Johansen, 2004, 2014; Paddayya, 1993, 2002).

Click to view larger

Figure 5. Utnur ashmound

(photo taken by D. Q. Fuller, 1997).

Click to view larger

Figure 6. Small ashmound site at Godekal, with two men for scale

(photo taken by D. Q. Fuller, 1997).

Similarities can noted between South India's Neolithic ashmounds and other cattle-centered, millet cultivating societies in parts of southern Africa, such as Botswana, South Africa, and Zimbabwe, dating from 500 CE to the 17th century, where mounds of cattle-dung ash are also known (see Huffman et al., 2013). This tends to suggest a centrality of cattle in annual rounds of social mobility, social exchanges such as marriage, and ritual calendars.

Direct dates on specimens from several crop species have confirmed the antiquity of cultivation in South India dating to at least 2000 BCE (Fuller et al., 2007, p. 773), but with presumed origins in earlier cultivation from at least 1,000 years earlier. As a growing number of Southern Neolithic sites have been investigated for archaeobotanical plant remains (Cooke & Fuller, 2015), with the result of similar patterns of recurring assemblages of mungbean (*Vigna radiata*), horsegram (*Macrotyloma uniflorum*), and two millets (browntop millet [*Brachiaria ramose*] and Bristley foxtail millet [*Setaria verticillate*]) have been consistently recovered, providing support for the hypothesis for a "basic Neolithic package" of the Deccan (Fuller et al., 2001; Fuller, 2011; Boivin et al., 2008; Fuller & Murphy, 2014).

Murphy and Fuller's (2017) work on seed testa thinning using high-resolution x-ray computed tomography at the UK synchrotron has demonstrated seed coat thinning between 2000 BC and 1200 BC, in southern Indian archaeological horsegram. Thus, it is likely that the evolution of thinner seed coats took place during the 2nd millennium BCE and that seed coats were fixed in terms of thickness before the early centuries CE when they were fully domesticated (Murphy & Fuller, 2017).

The savannah habitat corridor, located through the center of the Indian peninsula today likely formed as aridification took hold after 3500 BC and reached its maximum extent by around 2000 BC (Prasad et al., 2014A; see also Fuller & Korisettar, 2004). This would have facilitated the movement through this region of pastoralists with livestock such as sheep, goat, and cattle (from *ca*. 3000 BC). This subsistence was combined with the millet and pulse crops domesticated from the local flora, by at least 2000 BC, and plausibly earlier (Fuller, 2011; Fuller, Castillo, & Murphy, 2016; Fuller & Murphy, 2017). It would appear that non-native crops such as wheat and barley and perhaps grasspea (*Lathyrus sativus*), which appears by 1900 BC (and after 1500 BC some crops of African origins) suggest the translocation of crops over the course of the Southern Neolithic moved through this corridor. At the site of Sanganakallu these introduced Near Eastern cereals were confirmed by AMS dating as having been cultivated with native millets and pulses (Fuller et al., 2007). Thus, this evidence suggests that although an indigenous domestication pathway based on locally domesticated species is likely (Fuller et al., 2001; Fuller & Korisettar, 2004), firm evidence for its initial phases is still needed (Morrison, 2016).

Livestock were likely domesticated in the northwest in the Indus region and subsequently spread throughout peninsular India, perhaps between 3500 and 2500 BCE (Chen et al., 2010). The extent to which native wild plants were converted into crops via the spread of pastoralist food production remains uncertain. In a similar vein, it remains uncertain to what extent local foragers turned to plant cultivation and adopted pastoralism, although some northwestern influence from pastoralist migration appears likely. Historical linguistic evidence provides evidence for some early Dravidian speakers in Gujarat (e.g., Fuller, 2007B; Southworth & McAlpin, 2013). The potential of interaction between local hunter-gatherers and immigrant pastoralists requires new archaeological investigations throughout peninsular and western India.

Current evidence establishes that wheat and barley were in the northern peninsula, at the Narmada Valley between 2500 and 2000 BCE, and 500 years earlier in Rajasthan in the Ahar culture (Misra & Mohanty, 2001; Kajale, 1996; Hooja, 1988). Wheat and barley can be associated with a shift toward sedentary communities south of the Narmada River; these include the Savalda and Daimabad (including a Late Harappan cultural facies), precursors on the northern Peninsula of the Malwa culture, as well as from period IIB in the Southern Neolithic culture (*ca*. 2000 BC). This would represent a “food choice” model with the addition of wheat and barley into existing cultivation regimes rather than becoming the core or staples of the diet (Fuller, 2003, 2005).

South Indian Neolithic sites based upon crop cultivation and seasonal pastoral mobility show a transition toward increased sedentism around 2000 BCE and perhaps as early as *ca*. 2200 BCE for some sites (Fuller et al., 2007, p. 755), along with population growth and drier climatic conditions (Boivin et al., 2008; Ponton et al., 2012; Fuller, Castillo, & Murphy, 2016). Using proxies of organic matter and mineral magnetism from a well-dated sediment core CY from the Godavari delta plain, Cui and colleagues (2017, p. 10) suggest that human activity led to significant vegetation deterioration in the semi-arid Deccan Plateau during the Chalcolithic cultural period (Cui et al., 2017, p. 10). This new evidence would suggest a significant increase in the human impact on the natural environment since the start of the Chalcolithic cultural period owing to what they suggest are both increase in human populations and possibly also the improvements in agricultural practices (Cui et al., 2017, p. 10). It is likely that this shift occurred as seasonally mobile, pastoral societies who had been engaged in seasonal slash-and-burn agriculture had begun to become permanently sedentary (Kingwell-Banham & Fuller, 2012). Slash and burn, as an agricultural technique, would have required less human investment and would have been most favorable with low population densities and a focus on herd maintenance. It would appear that the centrality of the ashmounds of South India revolved around cattle for their symbolism and aspects of their settlement patterns. However, this cattle focus was complicated by the emergence of agricultural villages, as seen in the decrease in new ashmound construction witnessed over the duration of the Neolithic, particularly after 2000 BCE (Boivin, Korisettar, & Fuller, 2005, for further discussions on ashmounds see Allchin & Allchin, 1997; Paddayya, 1973, 2002). Many of these sedentary village sites were located on hilltops; their construction involved creating artificial platforms and terracing, often over the top of earlier ashmounds (Figures 7 and 8).

Click to view larger

Figure 7. Settlement area on north side of Velpumudugu with stone "terrace" feature visible on the surface

(photo taken by D. Q. Fuller, 1998).

Click to view larger

Figure 8. Settlement area with stone feature on surface at Hireguda (area A)

(Photo taken by D. Q. Fuller, 2003).

We know that occupation at many of these ashmound sites would have been seasonal due to the episodes of dung burning. In contrast, the evidence for habitation during the cultivation season remains elusive to archaeologists prior to sedentarization around 2000 BCE. Sedentism, which was based on local indigenous agriculture, became established and thrived, providing an opportunity and venue for winter cropping to become adopted. While agricultural activities were occurring, it is likely that hunting and gathering continued to play a critical role in the economic welfare of some Neolithic populations and that the hunting of wild fauna continued into the Iron Age (Bauer et al., 2007). Future research objectives should be to locate and document these presedentary period sites in order to investigate the origins of livestock and crop cultivation in South Asia.

Cotton (*Gossypium*) has been recovered from some Southern Neolithic sites much later, with cotton being directly dated to 900 BC at the site of Hallur. Thus, based upon the presence of cotton and evidence of the local traditions of textile production suggested by spindle whorls from the mid 2nd millennium BC there is strong evidence to confirm the presence of a textile tradition later in the Southern Neolithic (Boivin et al., 2008, p. 189). A non-subsistence cash crop such as cotton suggests the production of commodities for trade, with the techniques of spinning and weaving, as well as the crops cotton and flax likely diffusing from the Indus region starting from the middle of the 2nd millennium BCE (Fuller, 2008). The second half of the 2nd millennium BCE also saw the first clear evidence for the cultivation of tree crops, such as mango, jackfruit or *Citrus*, in South India as well as on the plains of the Ganges (Kingwell-Banham & Fuller, 2012), highlighting long distance connections in the diffusion and development of orchard arboriculture.

Taken together there appears to have been at least four waves of diffusion of domesticates into South India, livestock at *ca*. 3000 BC, winter cereals at *ca*. 2000 BC, commodity crops, textile techniques, fruit trees, and some African domesticates from 1500 BC, and finally rice and kodo millet in the 1st millennium BCE. The earliest rice in peninsular India is attested by just a few grains in the latest levels at the site of Inamgaon dating to *ca*. 1000 BC (Dhavalikar et al., 1988; Sankalia et al., 1984; Vishnu-Mittre, 1976), but at later archaeological sites there is the widespread adoption of rice (e.g., Kajale, 1989; Fuller et al., 2010B). These dates must be accepted with caution due to problems with early radiocarbon dating undertaken in the subcontinent (see Barker, 2006; Coningham & Young, 2015, p. 24). The final wave, including rice, was accompanied by new high status serving traditions, from the Gangetic north, notably the thali plates (seen as widespread and classically Indian today) initially were associated with the spread of products, such as pottery types of Northern Black Polish Ware, and other traditions, such as religions influences from northern India (Allchin, 1959; Fuller, 2005; Fuller, Castillo, & Murphy, 2016).

Ceramics and Food Traditions

By 2000 BC sedentary villages, preserved as mounds, were widespread and dependent upon an agricultural base. In the Ganges, food production included many introduced crops and animals that had spread from the west under the influence of the Indus civilization and were accompanied by adopted ceramic types that probably correspond to serving traditions, such as dish-on-stand pedestaled plates in the Ganges (Tewari et al., 2008). By contrast the spread of wheat, barley, and other winter crops to the Indian peninsula seems to have been accompanied by necked jars (Fuller, 2005). In southern India, crops and vessels from the northwest have been hypothesized to relate to liquid forms of consumption such as beers (Fuller, 2005). The ceramic connection between the Ganges and the Indus, by contrast, points to the serving of products such as loaves, cakes or flat breads. This highlights the fact that despite growing similarities across India in terms of the range of crop plants available and the evidence for interregional trade and cultural flows within South Asia, some cultural differences were maintained or even intensified in terms of how foods were prepared and served. Increased crop diversity across the Indian subcontinent in the 2nd and 1st millennia BC led to shared trends including population growth, state formation, and urbanization. This brought with it trade and increasing sharing of cultural traditions, including what some historians of India have referred to as the “Aryanization” of southern India, mainly in the first millennium CE (e.g., Stein, 1998, p. 100). Despite this, food traditions remain distinctively different in North and South India (Fuller, Castillo, & Murphy, 2016).

Compared with other types of material culture, pottery appears to relatively rapidly mirror cultural changes in South Asian society; this is perhaps due to the central role of ceramics in cuisine ideologies and legacies of preferences and taste. When ceramic types remain static for extended periods of time this may demonstrate stability in subsistence and when they begin to change, this may demonstrate a slow adjustment or adaptation of novel foodstuffs to established cooking traditions. As the subcontinent is located at the junction between two different traditions—the boiling-focused cuisine of eastern Asia and the oven-focused cuisine of western Asia—South Asian cooking practices are of special interest (Fuller & Rowlands, 2011; Fuller, Castillo, & Murphy, 2016). As in western Asia, far western South Asia possessed an aceramic Neolithic, with the presence of clay- domed ovens in the early levels of Mehrgarh (Possehl, 1999). These provide evidence for a baking tradition with the making of flour and the roasting of other foodstuffs, which would be in line with the adoption of cereals such as wheat and barley from western Asia (Petrie et al., 2010; Fuller, 2006). This is in contrast to the Middle Ganges Valley, where there is evidence for ceramics at an earlier date than Mehrgarh before there was evidence for agricultural dependence (Fuller, 2011; Tewari et al., 2008). This provides a parallel to east Asia, with the adoption of ceramic use by Late Pleistocene hunter-gatherers (Jordan & Zvelebil, 2009; Kuzmin, 2013). Perhaps this phenomenon may be explained by the requirements for fish and shellfish cooking with ceramics (Craig et al., 2013; Lucquin et al., 2016), with this ceramic technology being later applied to the processing of bitter nuts and likely tubers as well (Fuller & Rowlands, 2011). Although little is known about the subsistence practices of the early Holocene in the Ganges, use of fish and other aquatic resources seems likely alongside the collection of native wild rice (*Oryza nivara, O. rufipogon*, *O. officinalis*).

A wide variety of pottery shapes from peninsular India exists, from spouted vessels to perforated pots and handled wares to shallow dishes. Fewer forms have been removed from the ceramic assemblage than were added to it, and thus culinary diversification may be presumed (Korisettar et al., 2001). A consideration of the southern Neolithic ceramic sequence compared in relation to ceramic data from the northern peninsula would suggest that some forms may have traveled southward, while other types travelled northward (Fuller, 2005). As already noted the spread of tall, restricted-neck jars from North to South suggests a new range of liquid-related functions were adapted into the existing culinary repertoire, including perhaps fermented grain drinks. Thus different regions of South Asia have distinctive trajectories in terms of both the evolution of agricultural and culinary repertoires.

Conclusions

The long-standing impact of the agricultural origins in South Asia has been the beginnings of sedentism, an increase in population size, increased reliance on a limited range of domesticated food items, and an expansion of material technologies, such as ceramics (Fuller et al., 2014). Local domestication events in India were occurring alongside agricultural dispersals from other parts of the world in an interconnected mosaic of cultivation, pastoralism, and sedentism (Fuller, 2006, 2011). We have highlighted the likely importance of indigenous plant domestication processes, focused on millets and pulses that took place in south Deccan, Saurashtra Peninsula, and the upper alluvial reaches of the eastern Indus tributaries. However, introductions of crops and livestock from the West Asian center of domestication (the “Fertile Crescent”) played a decisive role in the origins of food production in the Indus region and in the diversities of crops and livestock throughout Neolithic South Asia. The Ganges basin played an important role in the origins of rice, but fully domesticated rice, and rice-centered agriculture appear to have developed after the introduction of some genotypes from eastern Asia.

There is still much poor documentation in terms of the beginnings of cultivation throughout South Asia. Evidence is better for the era when sedentism emerged, and agricultural economies became well established, which in most regions took place in the 3rd or the 2nd millennium BC. This suggests that origins are to be found in more ephemeral remains of more seasonal occupations and more mobile forager-pastoralism societies. This suggests parallels to the primary pastoral expansion in the African Sahara (Manning & Timpson, 2014) and Arabia during the mid-Holocene (Boivin & Fuller, 2009). It is also likely that there were recurrent transitions from shifting cultivation (slash-and-burn systems) to fixed field systems that took place with increasing sedentism (Kingwell-Banham & Fuller, 2012). During or shortly after this transition some interplay between summer and winter cultivation seasons became important, providing for a basis for both risk management and intensification in agriculture. Pulses and cereals came to be cultivated in both these seasons and provided not only the foundations for agricultural economies that allowed for the growth of populations and sedentism but also for distinctive regional cooking traditions; this ultimately provides the background for the diverse and distinctive cuisines of historical South Asia. The several parallel patterns of agricultural emergence in South Asia and the cultural interactions between them may help to account for how such a high degree of agricultural biodiversity, such as broad range of crop species, became established and maintained in South Asia.

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