Seeds of urbanism: palaeoethnobotany and the Indus Civilization

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Palaeoethnobotanical evidence reveals that there was increasing emphasis on greater varieties of species and cropping practices in the changing subsistence of the Indus civilization: agricultural intensification is discussed in relation to social and environmental changes.

Key-words: Indus, Harappa, Rojdi, botanical remains, food agriculture, cereals

Within the Harappan or Indus Valley Civilization located in northwest South Asia, a dramatic shift towards more localized cultural units and away from urban complexes is thought to have begun at the end of the 3rd millennium BC. The reasons for decentralization and localization are still debated, but explanations often assume that a changing agricultural system was a causal factor in these processes (Kenoyer 1991; Jarrige 1985; Possehl 1986). This paper will focus on recently collected palaeoethnobotanical data from two sites, Harappa and Rojdi, which allow us to examine changes in agriculture during this critical time, and to understand how these changes are related to shifts in the socio-economic structure. Analysis suggests that while the types of plants at the two sites differed, the agricultural strategies in both places were changing in similar ways. The argument to be proposed is that the same socio-political and environmental issues were affecting inhabitants at both sites, and that even though Harappa and Rojdi represent very different types of occupation in different kinds of environment, their agricultural strategies were nonetheless modified in a manner not unlike one another. In turn, the way the agricultural strategies change suggests that they were a result of cultural change, and not its cause.

The Indus Civilization

At its height, around 2600 BC, the Indus Civilization included nearly a thousand sites dispersed throughout northwestern India and Pakistan, ranging from village farming communities and small towns to several fully developed city complexes housing large populations, with tens of thousands of people (FIGURE 1). These larger communities had houses with uniform-sized bricks, granaries, massive city walls, gateways, and extensive areas of craft production (Kenoyer 1991; 1998; Possehl 1990; Jacobson 1986). Many of the craft products were standardized and distributed throughout the Indus region. The subsistence system consisted of food production with domesticated plants and animals, some hunting, fishing, and wild plant gathering (Meadow 1991; 1996). Supplying the demand for raw materials, food and finished products was a major mechanism in integrating the widely dispersed settlements (Kenoyer 1991). Similarities in pottery, weights and seals are strong evidence for a shared ideology and suggest the existence of an administrative system to oversee the manufacturing and distribution of goods (Kenoyer 1991; 1998; Glover & Ray 1994).

About 2000 BC, cultural integration begins to break down. We see a rise in regional systems that were no longer held together by a single ideological or socio-economic system, associated with an increase in settlements and the abandonment of many larger urban sites (Shaffer 1993; Possehl 1990; Kenoyer 1991). These fragmented, regional cultures, that are

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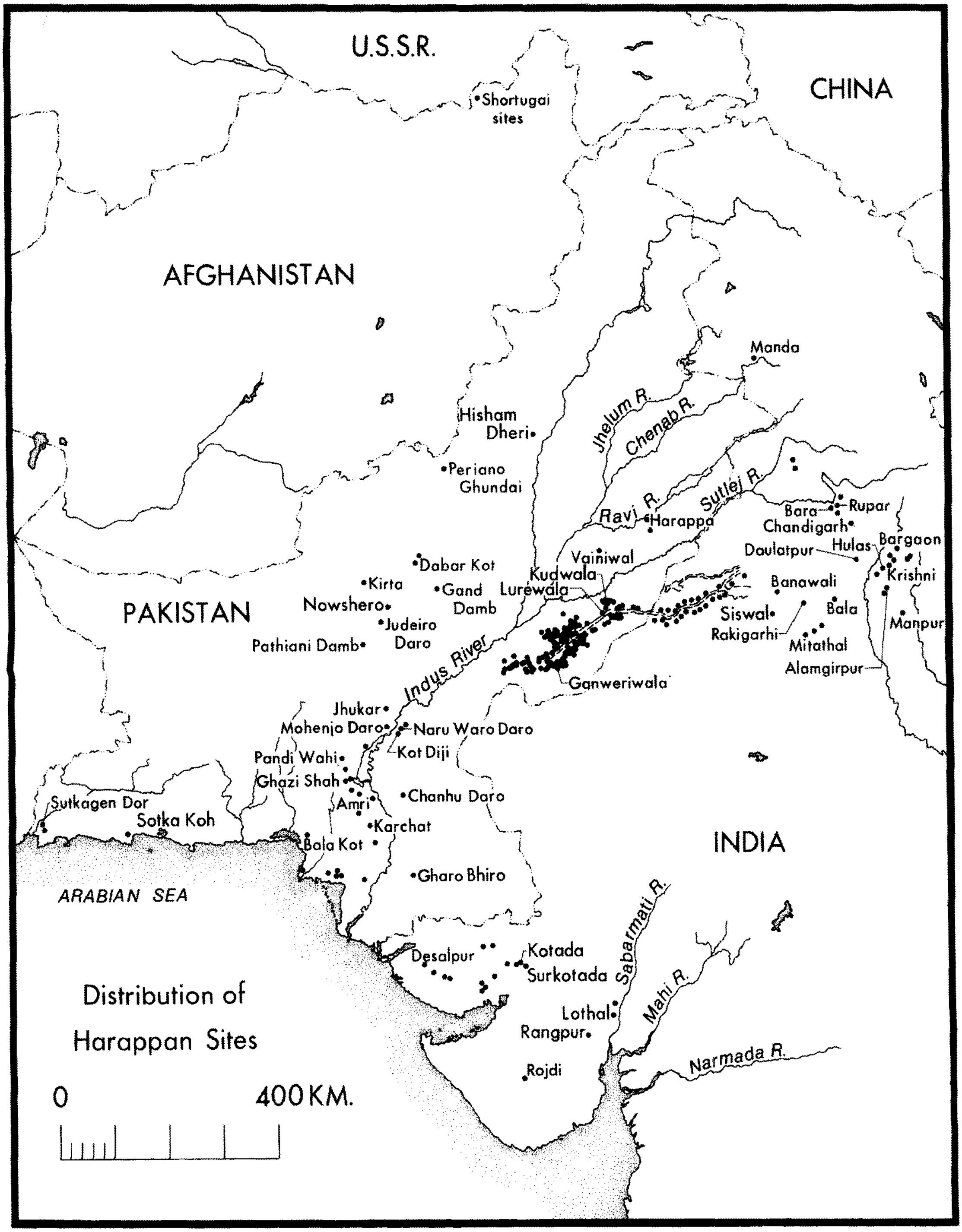

FIGURE 1. *The location of Harappa, Rojdi and other Harappan sites in northwestern South Asia. (Sources: Possehl & Raval 1989; Weber 1991).*

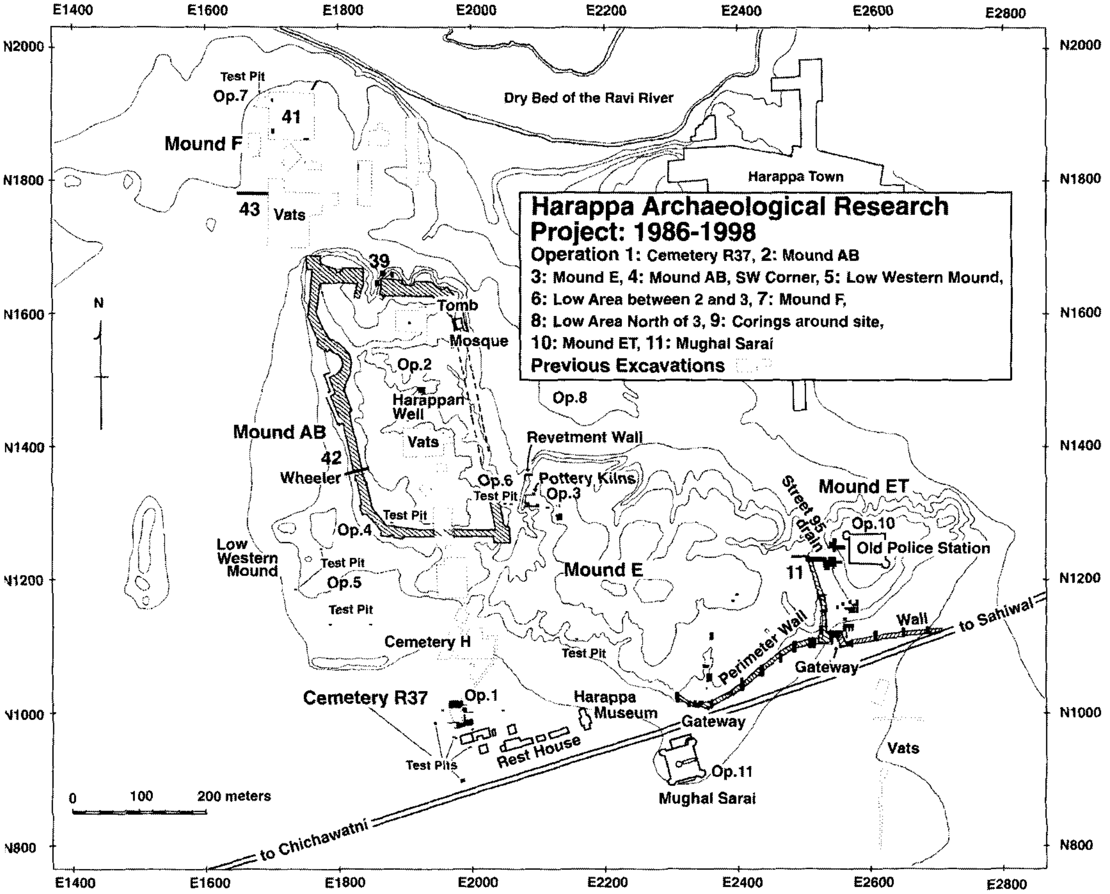

FIGURE 2. *Map of Harappa. (Map from HARP/dapted from Meadow* et al. *1996.)*

referred to as Late Harappan, occur at a time when the inhabitants of the large urban centres lost control of the trade networks that had helped integrate this vast region (Kenoyer 1991; 1998; Glover & Ray 1994). Disruptions and shifts in agricultural production play a prominent role in explanatory models of the Late Harappan (Possehl 1993). It is argued that there was a decline in traditional crops which fed the large population centres, at the same time as the emergence of new agricultural techniques and crop plants that spurred the development of local, independent communities (Jarrige 1985; Kenoyer 1998). Although explanations for these disruptions in the agricultural base tend to be regional in nature, they point to widespread causes such as tectonic movement or changes in moisture patterns (Kenoyer 1991; Allchin 1995; Chakrabarti 1997). These in turn may have caused changes in river patterns, resulting in flooding and sedimentation. Crop failure would have been followed by settlement abandonment. Population dislocations, disrupted trade networks and new agricultural strategies would have then produced new, localized political units (Kenoyer 1998).

The sites of Harappa and Rojdi

Harappa and Rojdi are sites that span the Harappan–Late Harappan transition and where excavations were systematic, extensive and interdisciplinary. Palaeoethnobotanical reconstruction from these sites allows us to compare agricultural strategies from an urban and a ru-

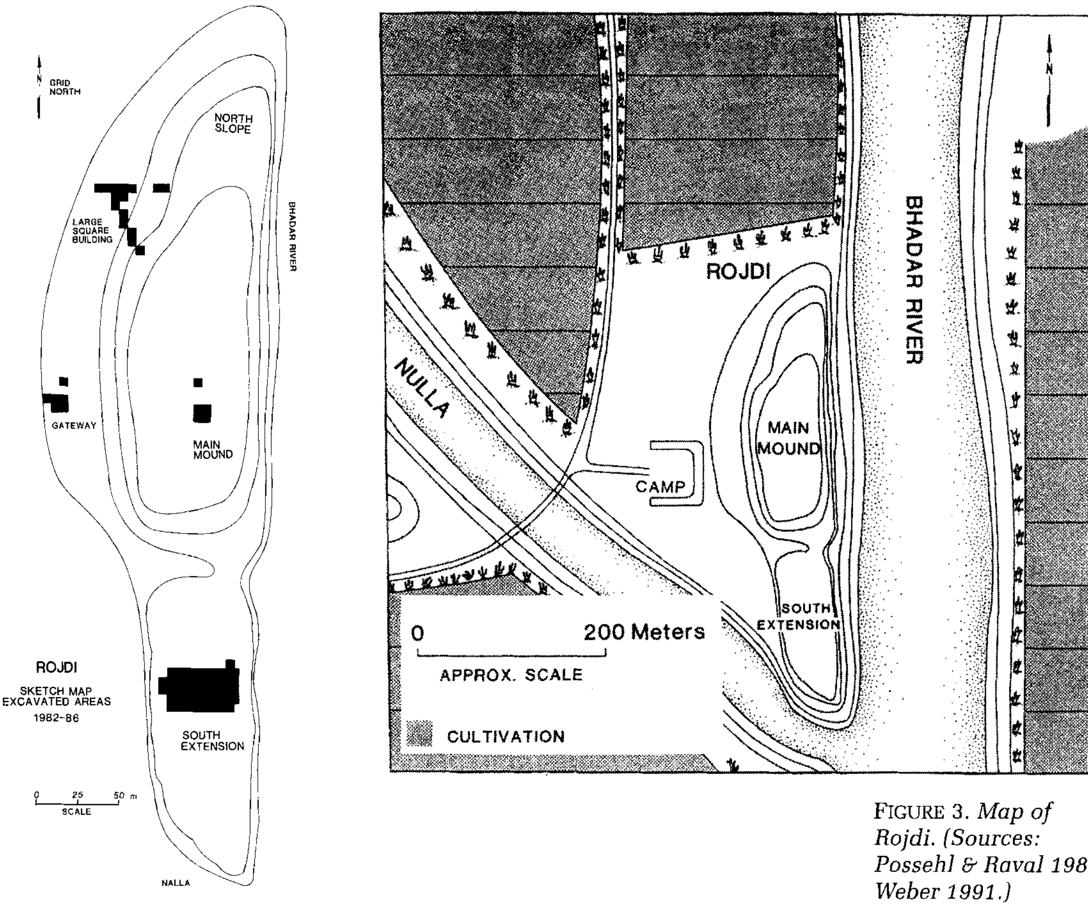

FIGURE 3. *Map of Rojdi. (Sources: Possehl & Raval 1989; Weber 1991.)*

ral community where the focus on particular plants differed, yet where the same natural and cultural processes that were affecting all of Harappan society were at work. Most existing reconstructions of Indus Civilization subsistence draw on data from a number of sites that can be overlapped to produce an agricultural sequence (see: Costantini 1985; 1987; Kajale 1984; 1991; Meadow 1989; 1996; Jarrige 1985; Possehl 1986; Saraswat 1992; Vishnu-Mittre & Savithri 1982; Lone *et al.* 1993). Unfortunately, this means incorporating data from different types of sites, excavated at different times using different methods, or where varied collection and analysis strategies were employed. Harappa and Rojdi not only span the time period in question, but in both places a palaeoethnobotanical research design was used that included intensive and systematic analysis of the soil. In addition, quantitative techniques have been used to track plant frequencies across space, through time and by context to counteract the inherent biases in the data. Although these two sites are our best source of consistent and unbiased data, obviously common patterns identified here will need to be tested, using similar methods and techniques, at other sites.

The site of Harappa (FIGURE 2) was the first known city of the Indus Civilization, and covering 150 hectares, it remains one of the largest. It is one of only five large urban centres identified within this civilization (Kenoyer 1998). The site was linked to both near-by towns and villages and the more distant cities by trade and ideology (Kenoyer 1998). The occupation at this site began at least as early as 3300 BC and continues at present (Kenoyer 1998; Meadow, Kenoyer & Wright 1996). The most recent excavations at Harappa began in 1986 and continue today. Though these excavations have exposed only a small portion of the settlement, all of the major mounded areas of the site have been trenched. Using modern techniques and methods, a significant amount of new information has been uncovered over these past 13 years that have provided new data on its formation, character, evolution and decline (see: Meadow *et al.* 1994; 1995; 1996).

Centrally located between two major tributaries of the Indus River, and based on a winter cultivation strategy using wheat and barley, Harappa served as a production hub and depot for both local and regional trade items, including agricultural products. It lies in the highlands, an environment in the northernmost area of this civilization. With good rainfall and fertile soils, this area can have abundant harvests. Over time, and with growth, the inhabitants built new, walled neighbourhoods until, at its height, Harappa became a fully developed city complex, housing at points a population in excess of 35,000 people (Kenoyer 1998). Based on city layout, the styles of painted ceramics, inscribed seals and weights, the inhabitants of this site shared the same culture seen in other Indus civilization sites. Harappa is not only the 'type' site of this civilization but it is one of the most important; any trends identified here have significance for the culture as a whole.

Due to the collection and dating of carbon samples over the last 13 years, a good chronology now exists for Harappa. The first identified occupation at Harappa belongs to the Early Harappan Period from 3300 to 2600 BC. The Harappan Period extends from 2600 to 1900 BC and can be subdivided into building phases 3A (2600–2400 BC), 3B (2450–2200 BC), and 3C (2200–1900 BC). This is followed by the Late Harappan Period which lasts till about 1700 BC. Changes in the artefacts, ecofacts and architecture have been documented that support the perception that the Late Harappan period featured a more localized and less integrated political-economic system (see: Kenoyer 1998; Meadow *et al.* 1996).

In contrast to Harappa, Rojdi was a town, whose planned architecture and Harappan-like artefacts are found alongside localized characteristics in its material remains (FIGURE 3). The artefacts found at Rojdi are stylistically divergent from those representing other Harappan regional populations, yet still part of the larger Harappan cultural whole (Possehl & Raval 1989). Located in an arid, shrub savanna environment, Rojdi lies in the southernmost region of this civilization. Its location along the Bhadar River, in the geographical centre of Saurashtra (Gujarat, India) places it in a peripheral region of the Indus Civilization, a region based on summer crops such as millets (Weber 1991).

Based on its size of 7 ha, and the kinds of architectural features it exhibits, Rojdi was a farming community, trading and interacting with other sites in its region (Dhavalikar 1995). While some sites in Saurashtra, like Lothal (Rao 1979) and Rangpur (Rao 1963), contain artefacts and demonstrate city planning that more clearly places them within the socio-political system of this civilization, other sites are like Rojdi with a greater mix of local and regional styles (see Possehl & Raval 1989). Based on the coexistence of local and Harappan styles of material culture at these sites and others, there is clear evidence that the Harappans established control over parts of Gujarat (Dhavalikar 1995; Allchin & Allchin 1982). Artefacts recovered from Rojdi clearly demonstrate the inhabitants were part of this larger regional culture, interacting with other local and regional settlements. Fortified cities like Dholavira (Bisht 1989; 1991), situated on a small island in the Rann of Kutch, probably controlled the flow of goods between peripheral regions like Saurashtra (including sites like Rojdi) and the core areas of the Indus plain (Kenoyer 1998).

All distinct areas of this walled town were trenched, producing a comprehensive database representing the full spatial and temporal range of activities occurring at Rojdi. Three ceramic phases (A, B and C), were distinguished according to fabric, design and shape (Herman 1989). Over time, a decrease in the quality of the ceramic fabric (the appearance of thicker, cruder ware) is accompanied by an increase in the quality and refinement of the decorative elements, indicating greater local influence (Herman 1989). At the same time there is a series of occupations or architectural levels, each with a range of structures, two for Rojdi A, two for Rojdi B and one for Rojdi C. Though there are some variations in the building style for these levels, the overall pattern suggests an expansion in the settlement toward the south at the time of Rojdi C.

The shifts in architecture and ceramics correspond nicely to the radiocarbon chronology developed for this site. Multiple carbon sam-

plant taxon	cropping season	Harappa	Rojdi
cereals			
wheat (Triticum)	W	T-I	–
barley (Hordeum)	W	T-I	T-III
rice (Oryza)	S	T-III	–
millets			
Eleusine	S	T-II	T-I
Panicum	S	T-II	T-I
Setaria	S	–	T-I
pulses and vegetables			
peas			
Pisum	W	T-II	T-II
Cicer	W	T-II	–
Lathyrus	W	T-II	T-II
lentils (Lens)	W	T-II	T-II
gram			
Dolichos	S	–	T-II
Phaseolus	S	–	T-II
Vigna	S	T-II	T-II
Medicago	S	T-III	T-II
oilseed and fibre			
linseed (Linum)	W	T-II	T-II
mustard (Brassica)	W	T-II	T-III
cotton (Gossypium)	S	T-II	–
fruits			
melon (Cucumis)	S	T-III	T-III
date (Phoenix)	S	T-II	–
jujube (Zizyphus)	W	T-II	T-II
grape (Vitis)	S	T-II	–

W = winter/spring-harvested; S = summer/fall-harvested; T-I = tier I plants; T-II = tier II plants; T-III = tier III plants.

TABLE 1. *Main cultivated plants recovered from Harappa and Rojdi.*

ples from secure contexts were collected from all areas of the site (Possehl & Raval 1989). Rojdi was occupied from about 2500 to 1800 BC. Both Rojdi A (2500–2300 BC) and Rojdi B (2300–2000 BC) fall into the Harappan Period, while Rojdi C (2000–1700 BC) represents the Late Harappan Period. During the Late Harappan period, shifts in architecture and ceramics point to an increased influence of local, non-Harappan elements at a time of settlement expansion and population growth (Possehl & Raval 1989).

Most Indus civilization sites are small settlements like Rojdi, rather than large ones like Harappa. Although artefacts recovered from Rojdi suggest it is not a typical Harappan settlement (see Chakrabarti 1997), it was occupied during the time periods in question (including the transition to the Late period), the occupants were interacting with inhabitants of other sites in the region, and both the artefactual and ecofactual records demonstrate significant shifts, just as can be identified at the same time at Harappa.

Agricultural, change and the archaeobotanical record

Agricultural products are made by people who select land, crops and production strategies they perceive as appropriate (Hastorf 1993). These strategies can be reconstructed through proper palaeoethnobotanical analysis (Pearsall 1989; Hastorf 1993; Gremillion 1997).

Two agricultural strategies occur in South Asia, and are believed to have been present in the Harappan civilization (Meadow 1989; 1991). Each is represented, respectively, at Harappa and Rojdi (TABLE 1). One strategy involves crops sown in the autumn, harvested in the spring and fed with winter rains and is found in prehistory in northwest South Asia (Baluchistan, Bannu Basin, Sind, Punjab, Swat, Kashmir). Crops include barley, wheat, oats, peas, lentils, chickpea, jujube, mustard and grass pea. The second strategy centres on plants sown in summer and harvested in the fall, making use of summer monsoon rains. Prehistorically, the summer sown plants (millets, sorghum, rice, cotton, dates and gram) were used most often in Gujarat and western India (Saurashtra, Kutch, Rajasthan, Maharashtra).

Cities in the Indus Valley, like Harappa, are thought to have been based on the winter strategy (Meadow 1991; Kenoyer 1989). This strategy is the older of the two, based on local or West Asian species and dependent on an irrigation system (Costantini 1990; Weber 1991; 1996). The summer strategy is, and was, based on a variety of millets, plants regarded as very hardy, drought-tolerant and capable of growing in poor soils (Weber 1998: 267). This was the prominent strategy in Gujarat and at sites like Rojdi. The summer strategy was developed later than the winter strategy, and has been linked with pastoralism (Weber 1998: 270; Mehra 1997). As time passed, more sites in all areas incorporated both strategies, although the emphasis was often on the strategy better suited to the local environment.

At both Harappa and Rojdi, thousands of litres of soil were systematically collected and floated from a variety of locations and features, yielding tens of thousands of carbonized seeds, representing dozens of species (TABLE 2). The strategy was to sample as wide a variety of contexts as possible and to sample these contexts multiple times. In order to maximize the value of the archaeobotanical material while minimizing the inherent biases in this kind of database, samples were systematically collected and analysed from each phase and within each context. If activities relating to the manipulation of plant products can be assumed to have been distributed systematically with respect to context type, then the samples need to represent as many different structures and features as possible (Hillman 1981).

Like artefacts, seeds can be identified, their spatial and temporal distribution determined and their uses inferred. Combining existing knowledge regarding archaeobotanical data with the context of the material to be analysed permits the palaeoethnobotanist to determine if, how and when a plant was being used (Dennell 1974; 1976; Thomas 1983; Miller 1997; Hastorf & Popper 1988). With additional information about plant morphology, place of origin, geography and growing requirements, the palaeoethnobotanist can reconstruct what the surrounding habitat may have looked like and what plants might have been available to the site's inhabitants during each phase of occupation (Doggett 1989; Harlan 1976, 1992; Hillman & Davies 1990; Vavilov 1992). The basic assumption is that when a large, systematically analysed sample that represents all occupations equally is used (as has been done at these two sites), then trends and regularities that are identified for each period tend to reflect patterned behaviour for that period.

The preservation of carbonized seeds and seed fragments has been very good at both sites. Seeds were recovered from most of the flotation samples represented in each database. Fewer than 5% of the samples from either site failed to contain seeds. The average density of seeds at the two sites is significantly different (TABLE 2). At Harappa, there was an average of nearly 40 seeds per litre of soil, eight times that of Rojdi, with an average of 5 seeds per litre of soil. Density often reflects the intensity of accidents leading to seed preservation. The more

	Harappa	**Rojdi**
no. of samples analysed	66	284
no. of seeds identified	23,231	6256
no. of edible taxa identified	33	29
average seed density per litre of soil	40	5

TABLE 2. *The archaeobotanical data base at Harappa and Rojdi.*

intense the activity involving that type of plant or the more the activity involves fire, the higher the density of seeds in the archaeobotanical sample (Pearsall 1988; 1989; Sullivan 1987; Miller 1988). Harappa was the more substantial occupation and therefore more likely to have had abundant, intensive and continuous trash deposition. Seeds at Harappa would have experienced a more rapid burial, leading to an enhancement of organic preservation and concentrations of specific species. This process may also account for why Harappa yields a greater variety of species, including most of those found at Rojdi as well as those specific to Harappa.

At both Harappa and Rojdi the most common crops were cereals, followed by pulses and vegetables, and finally oil-seed, fibre and fruit plants. A three-tiered, hierarchical model of plant-use can be constructed for each site (TABLE 1). The model can be imagined as an inverted pyramid (FIGURE 4), with the topmost 'layer' representing the most abundant species, as well as those most critical to subsistence (referred to as Tier I plants). At Harappa, wheat and barley were the mainstay of the agricultural system and top the hierarchy. Grains of these winter/spring harvested cereals are found in nearly every sample, implying extensive use of these species (TABLE 3). On average they make up 80% of all recovered material from a given sample. Their relatively high abundance within most assemblages suggests greater importance than other taxa. The second tier of the hierarchy at Harappa includes cultivated crops of lesser importance. These include lentils, linum, grape, pea and grass pea, dates, zizyphus, cotton and some millets. The third level or Tier III plants consists mostly of wild species with a few minor crops like gram, rice and melon. While rice phytoliths and a few carbonized rice grains have been recovered from each occupation at Harappa, rice appears to have played a minor role in their agricultural strategy. Rice

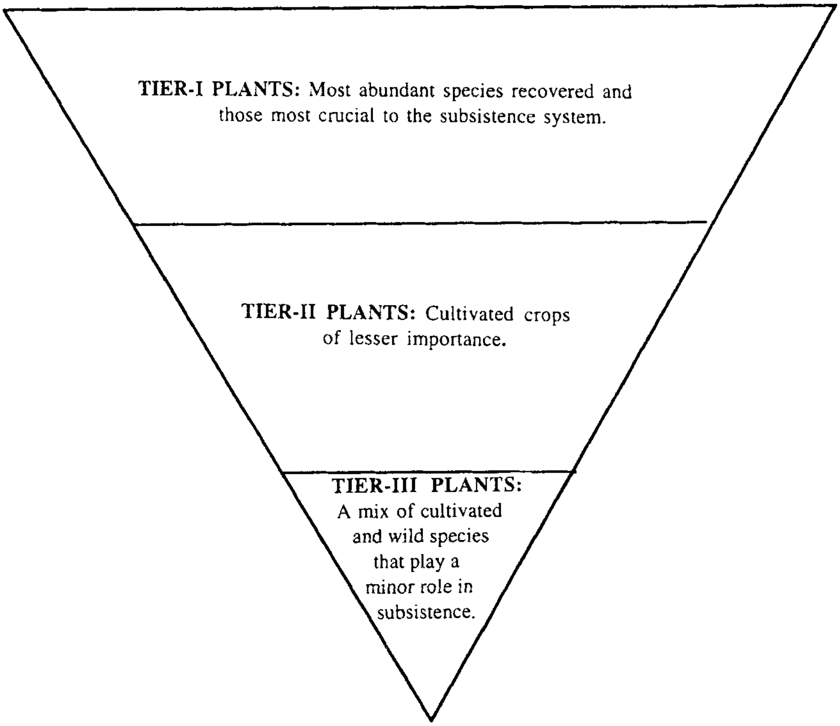

FIGURE 4. *Three-tiered model demonstrating the importance of food plants in prehistoric South Asia. See* TABLE *1 for reference to species that represent these categories for Harappa and Rojdi.*

cropping was probably not well suited to the environment surrounding Harappa, just as it is not the prominent plant cropped today.

At Rojdi, millets are the dominant cereals and are at the top of the hierarchy. These summer/fall harvested plants were recovered in over half of the samples and make up the largest category of crop plants (TABLE 1). Barley was less important and takes its place in the third tier. No wheat or rice was recovered from Rojdi. As a whole, the second and third tiers at Rojdi are similar to those at Harappa, and involve most of the same taxa. A multi-cropping strategy is discernible at each site from the earliest occupation, although the emphasis was on the season that better suited their particular environment, and multi-cropping intensifies over the course of each occupation.

This inverted pyramid model also works for the agricultural practices found in each region historically. In the Punjab, where Harappa is located, and in Gujarat, where Rojdi is located, the types and proportions of species have remained fairly stable over time with little variation from what has been identified during Harappan times. Both Rojdi and Harappa demonstrate that there has been a great deal of continuity in the cropping strategy for their particular region over the last 4000 or so years.

This is not to say that the dietary system has not undergone some change. Both sites show a continuous process of incorporating new species into the cropping system, but new species neither suddenly appear in large numbers, nor do they significantly alter the existing subsistence strategy (Weber 1998). Whether it is the summer-cropped plants being incorporated into the system at Harappa (e.g. gram, linseed and millets), or the winter-cropped plants at Rojdi (e.g. peas and lentils), all initially played a minor role in the dietary system. Over time, most of the new species increase in number, implying a greater role in the diet, yet the process seems to have been gradual. Further, existing species are not greatly reduced with the introduction of these new crops. There seems to be an overall pattern throughout the Indus Civilization toward gradually broadening and intensifying the agricultural system by cropping plants more intensively throughout the year and by using a greater variety of plants during any given season.

While neither site shows any sudden or rapid change in its use of plants, some significant changes were taking place during the transi-

	Harappan Period		Late Harappan Period	
	Harappa	Rojdi	Harappa	Rojdi
ubiquity				
wheat (Triticum)	85	–	90	–
barley (Hordeum)	85	–	88	–
millets				
Eleusine	–	45	–	9
Panicum	–	44	–	18
Setaria	–	19	–	56
density				
wheat (Triticum)	26	–	3	–
barley (Hordeum)	22	–	5	–
millets				
Eleusine	–	6	–	0·1
Panicum	–	0·8	–	0·1
Setaria	–	0·1	–	0·9
relative percentage				
wheat (Triticum)	44	–	34	–
barley (Hordeum)	35	–	41	–
millets				
Eleusine	–	40	–	2
Panicum	–	18	–	3
Setaria	–	2	–	37

Ubiquity is the percentage of samples from which a specific taxon was recovered. Density is the number of seeds per litre of soil. Percentage is the relative abundance of a specific taxon in a given assemblage.

TABLE 3. *Crop production of the main cereals from the Tier-I plant category at Harappa and Rojdi. The table presents the shifts in plant occurrence within this category during the transition from the Harappan period to the Late Harappan period.*

tion to the Late Harappan Period. A similar percentage decline in seed density occurs at both sites, with a 62% decline at Harappa and a 70% decline at Rojdi. This is closely related to the changing richness of edible plants found at each site. Richness is the number of different edible plant taxa found in a flotation sample and hence measures the diversity of food plants (Rocek 1995). At Harappa and at Rojdi, the overall average was almost three times as many edible taxa per total number of edible plant fragments recovered per flotation samples during the Late Harappan Period than the earlier periods. A wider range of crops was being cultivated at both sites during the Late Period.

If we focus on only the main cereal grains found at each site, those taxa that account for the majority of the recovered seeds in most samples and top the hierarchy in each model, an interesting pattern emerges (TABLE 3). At Harappa, the wheat and barleys account for over 70% of the recovered food plants. At Rojdi, the millets account for over half of the recovered crop plants. At both sites these cereal crops remain relatively stable, though the percentage of food crops relative to other kinds of plants declines nearly 5% during the Late Period (TABLE 3). At both Rojdi and Harappa, a significant shift from one existing taxon to another within the cereals category can be identified as occurring during the transition to the Late period. It is worth noting that at neither site does rice, a crop long associated with the Late Harappan period, become a prominent plant (see Kenoyer 1998). Rice can be found quite early at a number of sites, including Harappa. But it is never found in large quantities, even at Lothal (Rao 1963) and Rangpur (Rao 1979), suggesting it played only a minor role in the subsistence system of all regions (Weber 1991). The shift to rice as a primary food grain, mainly found in environments associated with summer monsoon rains, occurs after the beginning of the onset of the Late period (see: Jarrige 1985; Weber 1992; Kenoyer 1998).

At Harappa the shift from one taxon to another is seen in the wheat–barley record. There is a gradual increase in the number of wheat and barley species cultivated at Harappa, but the majority of the wheats are consistently shot wheat (*Triticum sphaerococcum*) and bread or club wheat (*T. aestivum/compactum*), while most of the barleys are either 6-row naked 'shot' barley (*Hordeum sphaerococcum*) or 6-row hulled barley (*H. vulgare*). At the earliest occupation, barley is the dominant grain. During the Harappan Period, wheat increases in ubiquity, density and percentage until it becomes the most common species at Harappa (TABLE 3). Yet during the Late Period, wheat declines and barley once again becomes the dominant cereal.

At Rojdi, like Harappa, there is an increasing variety of cereal grains, though in this case it is millets (*Table* 3). Many of these species — like Sorghum, which is introduced near the end of the Harappan occupation — never account for a significant portion of the archaeobotanical record (Weber 1998). In fact, three millets, finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*) and foxtail millet (*Setaria italica*), make up the majority of the food grains representing both the Harappan and Late Harappan Periods. Yet such measurements as ubiquity, density and percentage of seeds per sample all show a shifting pattern of occurrence (see Weber 1991 for a detailed account of Rojdi archaeobotanical record). Finger millet and little millet, which figure prominently during the Harappan Period, decline in the Late Period, while foxtail millet is the dominant plant in this Late Period but appears in very small numbers in the earlier periods. There is clear evidence that, as in the case of Harappa, a significant shift in plant usage or crop-processing activiteis occurred around 2000 BC amongst existing species.

Continuity and change in the agricultural strategy are patterned similarly at each site. Is this similarity related to the breakdown in the socio-political system that led to the decentralization seen in the archaeological record at around 2000 BC? And if it is related, how is it related?

Explanations for continuity and change

Similar shifts toward agricultural intensification at both Harappa and Rojdi, at about the same time, suggest that region-wide events were at work. A common cause of agricultural shifts, one that can affect all aspects of society, is change in the climate and environment. Climate, for example, influences site location and tends to delimit the parameters of subsistence and settlement patterns. Any change in climate could have drastically altered the way people lived, driven them to another area or dramatically affected access to productive resources. Climate and environment of the subcontinent during the Harappan times have drawn interest and provoked controversy since the earliest excavations in the Indus Valley (Misra 1984; Misra & Rajguru 1989; Possehl 1997). Environmental change has played an important part in many theories about Harappan society (e.g. Raikes & Dyson 1961; Possehl 1986; 1997). Based on a combination of palynological lake-bed studies (Singh 1971; Singh *et al.* 1972; Singh *et al.*1990) and ancient vegetation reconstruction based on charcoal analysis (Thiebault 1988; Seth 1978), it appears the vegetation was not that different from today. The beginning of the 2nd millennium may have ushered in an overall drying trend in South Asia (Possehl 1997), although there are indications that some regions may have experienced an increase in the amount of rain in the summer months (Kenoyer 1991; Weber 1992; 1993). Although there is no firm agreement on what the climate was like, or how it might have changed during the course of the Indus civilization, there does seem to be a consensus that the decentralization and localization of Harappan society displayed in the Late Harappan Period were closely related to changes going on in the environment — the results of both natural events and human activity (Shaffer 1993; Weber 1996; Possehl 1993; 1997; Kenoyer 1998). A combination of shifts in river systems and in climate led to many Late Harappan settlements being established along newly stabilized river systems (Kenoyer 1991). Yet these new settlements depended on crop plants already incorporated into their agricultural strategies.

While environmental conditions may have had a direct impact on Harappan settlement systems, their effects on agricultural production at Harappa and Rojdi are less evident. All the shifts in plant use at these sites are toward species that grow in similar environments. No significant climatic shift is necessary to explain them. Although the emphasis on certain plants changes over time, at neither site do plants disappear from the archaeobotanical record, implying that whatever was acquired or used was kept in the dietary repertoire. This tendency may reflect a style of decision-making particularly suited to matters of agriculture, in that once a plant is added to the cropping system, especially in the marginal environments that abound this civilization, it is unlikely to be removed. Changes in agricultural strategies and patterns of plant use, while subject to climatic and hydrological constraints, are generally too complex to be reduced to shifts in the environment. An increase in weedy species and a decline in crop-seed density may be more closely related to an increase in population and a denser network of villages and towns, producing some form of environmental degradation, like overgrazing, overwatering of fields and deforestation.

The cereals found at both sites were being grown for both grain (for people) and straw (for animals), and are the key to understanding changing agricultural strategies. The environment constrains which crops are grown and when they are planted, but it is the cultural factors leading to crop choice that are more likely to provide an explanation of changes in plant occurrence at each site.

Barley is a more drought-resistant plant needing less water than wheat, it has a shorter growing season and can grow in a more saline soil (Miller 1986; 1997). Further, barley has softer straw, and requires milling to remove the husks, meaning that it is better suited for animal fodder than for human consumption (Miller 1997). When given a choice, people in South Asia traditionally grow wheat or rice for human consumption and barley for fodder. Wheat was most common at Harappa between 2600 and 2000 BC, during the period of integration. This was when the city was most densely populated and when agricultural and herding activities may have been occurring farther from the site. In fact, there may have been greater reliance on food products coming in from outlying areas just as there was on long-distance trade goods. Storage areas like the central 'granary' found at Harappa would have been in use at this time (see Vats 1940). In an urban setting, with more people living in close proximity to one another, agricultural fields may have been located farther from the site. Settlements in areas like Cholistan along the ancient Hakra River (FIGURE 1) may have contributed grains of wheat and barley to the large urban sites like Mohenjo-Daro, Ganweriwala and Harappa (Kenoyer 1991; Mughal 1997). Because greater distances were involved, fewer varieties of plants were being exploited, or at least fewer varieties were being brought into the city. The grains that were being brought in to Harappa were more likely for human consumption than for fodder. These grains were probably stored centrally and then redistributed to the inhabitants of the city under the direction of élites.

In contrast, the agricultural strategy during the Late Period at Harappa involved a greater variety of plants at a time when fodder crops like barley were increasingly important. Therefore, the transition to the Late Period may have been associated with the increasing importance of cattle, or the practice of herding closer to the city, or even, possibly, increasing use of dung for fuel, a practice that often leads to the charring of seeds in archaeological contexts (Miller & Smart 1984).

Similarly, the choice in millets at Rojdi may be related to increasing importance of fodder plants. Finger millets, which are so common at the early levels of Rojdi, are more often grown for human use, while foxtail millet, the dominant grain of the Late Harappan Period, is commonly grown as a fodder. Samples from the early levels contain mostly cleaned charred seeds, which are often taken to represent a single food plant, with a few wild, weedy species mixed in. This seems to indicate that their deposition was related to food processing activities. In contrast, samples from the Late Harappan Period show an increase of wild grasses mixed in with the millets and a greater variety of taxa, all suggesting that these grains were being grown as a fodder and entered the site as part of a fuel. At Rojdi there appears to be an increase in both cattle and in agricultural activity, evident in the fact that more nearby land was disturbed. During the shift to the Late Harappan Period, we see far less arboreal pollen (implying fewer trees), less charred wood in hearths, more weedy species, more crop variety and an increased dependence on millet-cropping (Weber 1991).

There is good evidence that over-exploitation of resources was affecting the landscape and environment of Rojdi, and possibly even Harappa. Yet there is no evidence for any dramatic or sudden shift in plant occurrence or use. Rather than being a direct cause of social change as proposed by some scholars (see Wheeler 1953; Fairservice 1971), it seems more likely that human-induced degradation to the environment simply increased the rate at which the local habitat was being exploited. With nearly 6600 sq. km of available farm land around Harappa (Fentress 1982) and a decrease in trade or introduced food goods during the Late period, more nearby land would have been exploited. Over time, though after the transition to the Late period, this would dramatically affect the landscape and any cultures residing in the area.

Of course, the patterns I have identified at each of these sites may only coincidentally seem similar, and by themselves only represent local processes. But when the data-sets are viewed together, a case for region-wide patterns is strongly suggested. Similar patterns of change at two far-flung Harappan sites, involving different plant species, in contrasting types of environments and representing such different kinds of communities, is a circumstance that should not be ignored, but tested and debated. The data from these sites suggest that changes in the agricultural system that occurred around 2000 BC were similar throughout this civilization, regardless of the region in which settlements were located, or whether they were urban or rural. At both sites, shifts in cereal use were associated with continued efforts at broadening and intensifying agricultural strategies. While the identification of a pattern involving agricultural intensification has been developed for the Kachi Plain, where a sequence from the sites of Mehrgarh, Nausharo and Pirak shows a shift toward multi-cropping in the Late Period (Jarrige 1985; Kenoyer 1998; Chakrabarti 1997), it is only from the sites of Harappa and Rojdi that shifting dependence of existing crops has been identified. This may be due to the kinds of analysis being employed at different sites. Crop choice at Harappa and Rojdi inclined in all periods toward species better suited for their environment. In the Late Harappan period, as the socio-economic system became less centralized, a greater range of economic, food-oriented activities occurred in each community. Though there is at present little archaeological evidence for patterns of grain storage and redistribution, it is predicted that further excavation will reveal they were also changing at this time. A shift from large central storage facilities to the more traditional mud-plastered bins associated with individual houses would likely be associated with an increasing emphasis on local farming in the Late period. In the end, the increase in local herding and agricultural activities would more intensively have affected the local environment. Smaller communities, less dependent upon imported goods, would probably have been more successful.

Conclusion: a model for change

Just as we see the culturally integrated Harappan civilization fragmenting into decentralized regional cultures, the sites of Harappa and Rojdi are demonstrating change of their own. Not only can shifts in the material record and settlement data be identified at these sites, but agricultural strategies can also be seen to be evolving. While the palaeoethnobotanical data suggests that there was a long history for multi-cropping involving the same species found in each respective area today (Weber 1992; Kajale 1991), there was a continuous, though gradual, effort to broaden and intensify the cropping strategy through an increased dependence on more species grown more regularly throughout the year. While there was a greater variety of species being grown, the intensity of use of most crops was declining. The most significant change in crop use occurred within the cereals category, considered Tier I plants. Rather than being associated with a major environmental or climatic event where survival was the underlying goal, changing proportions of existing species in the archaeobotanical record reflect the kinds of choices people make as a result of an altered socio-economic situation. The data from these two sites suggest that the agricultural strategy in the Late Harappan period was one better suited for local consumption needs and less based on regional systems of the Harappan period. While changes in agricultural production and cropping strategies are linked to corresponding shifts seen in the material record at both sites, these changes should be seen as an indicator of, rather than as an instigator for, cultural change. While the trends identified here are based on only two sites, they demonstrate, first, the complexity of the agricultural strategies employed by the Harappans and, second, that significant though subtle changes were occurring during the transition to the Late period. It is only through continued, careful work at these sites and others like them, that this proposal of shifting crop choice and its relatonship to cultural and environmental change can be understood and better explained.

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