2

The Natural Environment, the Neolithic Revolution and the Indus Civilization

2.1 The Neolithic Revolution: Agriculture

When archaeologists in the nineteenth century began establishing an order of sequence among the stone tools they found at various prehistoric sites, they arranged them roughly according to their appearance. The tools found with the smoothest surfaces, they held to be the latest, and so the stage in human progress when these were made was designated 'neolithic' or the 'New Stone' age. The rougher tools, on the other hand, were assigned to the 'palaeolithic' or 'Old Stone' age. Since smoothness could only have been achieved by continuous grinding, it was thought that the stones must have initially attained their smoothness when these were used to grind grain, and so a link between them and the rise of agriculture came to be postulated. V. Gordon Childe (1892–1957), building on this postulate and on much archaeological work already done at early sites in West Asia, proposed the designation 'Neolithic Revolution' for the entire process of the beginning and early diffusion of the cultivation of plants, and, in a subsequent but complementary phase, of the domestication of farm animals. Since Childe's time, our knowledge of the early history of agriculture and pastoralism has grown immensely; yet the major elements of his thesis have stood the test of time fairly well.

In Childe's time, the means of determining prehistoric dates and even sequences were extremely limited; but it had been found from a study of the strata exposed in excavations, that the earliest traces of agriculture and animal domestication belonged to an age subsequent to the passing away of the (last) Ice Age. This conclusion has been reinforced by the mass of discoveries made since then. After the last Ice Age passed its peak 20,000 years ago (18000 BC), the coolness began to wane, though with some intervening declines of temperatures, especially during the 'Younger Dryas', 11000–950 BC. With the Holocene setting in around 8000 BC, a long warming phase ensued. It is only about the time of this change, or a little earlier, that the earliest traces of agriculture have been found.

The exact relationship between this climatic change and the coming of agriculture has provoked much discussion. It is likely that the modern human had, already in the Pleistocene, increasingly supplemented his diet of animal flesh with not only edible fruits and roots, but also a wide range of edible seeds of wild grasses and other plants. It is not impossible that many seeds, in time, began to be deliberately put into the ground by humans to propagate some wild plants over a larger area, so that their own food supply might increase. Yet all such plants everywhere could not be converted into cultivable crops. We have already seen in Chapter 1.3 that the likelihood was small that any single species of plants could possess a very extensive range within Eurasia during the Pleistocene; and this implies that the wild ancestors of the early cultivated plants were also confined to relatively small areas. The earliest centres of cultivated crops in the Old World were, on our present evidence, just two: one, a part of southwest Asia comprising Palestine, Lebanon, Syria, Eastern Turkey and Iraq, where wild varieties of wheat and barley were turned into cultivated crops; and the other, Central East China, where rice was domesticated with an equally early appearance of neolithic tools. In the former zone, cultivation seems to have begun by 9000 BC; in the latter by 8000 BC. It may, in general, be assumed that when in the tropical and sub-tropical regions the Ice Age aridity was replaced by greater rainfall, the edible wild cereal-grasses began to flourish more and more, and became a larger and larger source of food supply for humans. It was at this critical stage that at a few places people began to save seed, soften the land by a stick ('hoe') in order to drop it into the softened ground, protect the plant from predators and harvest the seed as grain when it had ripened. They began to select seeds that might grow into better plants, and so, by repeated processes of selection, the wild plant became domesticated, often losing the capacity of self-propagation. (See *Figure 2.1* for change from wild einkorn wheat to cultivated einkorn.) Such plants diffused mainly by human action, and so agriculture expanded from its two earliest

(subsequently more) centres of plant domestication into more and more extensive regions.

So far, there is no strong evidence that the cultivation of any major food crop originated within India in those remote times, so that the exact conditions of climate and physical environment in which the original conversion of wild into cultivated crops took place is of not much concern to us here. We need to be rather more concerned with how agriculture diffused to and within India, and what role the environment played in determining the zones that were first affected by the diffusion.

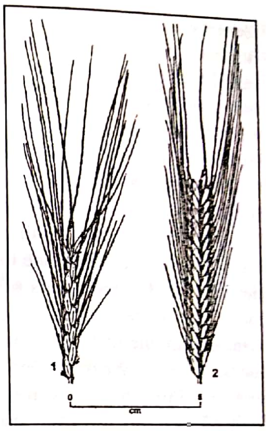


FIGURE 2.1 Einkorn wheat: (1) Wild; (2) Cultivated (the same scale). After Possehl.

The Indus basin forms climatically part of a region of low rainfall extending from the Mediterranean in the west to the Aravallis in the east. The Indus river and its tributaries by their floods and deposits of silt made it an area where, in early Holocene, bush and wild grasses could grow. It was thus ideal for the cultivation of cereals like wheat and barley, though none of the wild varieties of wheat (einkorn, emmer and hard) are known from any locality in the region. This makes certain what chronology suggests, namely, that wheat and barley cultivation came to this region from southwest Asia. The earliest evidence of cereal cultivation in the Indus basin is provided by Mehrgarh (Period I: pre-ceramic), situated on the Indus plain just below the Bolan Pass (Baluchistan). Here, all the three cultivated varieties of wheat we have mentioned (einkorn, emmer and hard) and three varieties of barley (including six-row naked barley) are found in the seventh millennium (7000–6000) BC. This is the earliest firm date for the arrival of agriculture in the Indian subcontinent.

The Gangetic basin, especially in its central and eastern parts, receives heavy rainfall, and, for this reason, is a suitable area for rice cultivation. Wild rice (*Oryza rufipogon*) is widely distributed in the

Gangetic basin, as well as in the Indus region and Gujarat. But there is no proof that the cultivated rice (*Oryza sativa*), especially the race called *indica*, has originated from any variety of wild rice found in India. This is because not only is domesticated or partly domesticated rice attested from the middle and lower Changjiang (Yangzi Kiang) basin in China even before 8000 BC, but also because at the site of Majiabing (Hemudu culture phase), the remains of *indica* rice dominate over those of *japonica* at about 5000 BC, or earlier, in the ratio of 7:3, and at about 4,500 BC still in that of 6:4. These facts make Central East China the best candidate for being the original centre of cultivation of both the major races of domesticated rice, *indica* as well as *japonica*. The two claims for early dates for cultivated rice in the Ganga basin, the first of the range of 6719–5010 BC for Koldihwa in the Belan valley, and the second of *c.* 6109 BC for Lahuradeva in north-east Uttar Pradesh, have been treated with some scepticism for apparently good reason; it is likely that the Vindhyan neolithic in the Belan valley began, with rice as a cultivated crop, only around 3000 BC, if not still later. Further east, cultivated rice is found at Punda Rajar Dhibi (Period I) in West Bengal, possibly dating to a time before 2000 BC. A case can thus be made on present evidence of the spread of *indica* rice from the lower Changjiang basin to the Ganga basin, both of which had a humid climate with plenty of sheets of standing water and floods from rivers in the summer, thus furnishing the most suitable environments for rice cultivation.

When wheat and barley began to be cultivated in the Indus basin before 6000 BC, and rice in the Ganga basin some 3000 years later, the cultivated area in relation to the whole area must still have been extremely small. Wheat and barley were being raised in small oases (of which Mehrgarh was one) in a vast expanse of scrub and desert within the Indus basin, and rice in equally small clearings, perhaps created by slash-and-burn methods, in the heavily forested Ganga plains. Nature in the beginning could hardly have been affected by these puny enterprises.

These oases and clearings were, however, bound to expand in time, partly because agriculture created sedentary conditions and the birth-rate in such conditions is higher than among gatherers and foragers, and so the expanding population sought new settlements; and

partly because changes in cropping occurred, providing a larger food supply and so possibly helping to bring about a shift of population from gathering-and-foraging to cultivation. At Mehrgarh we see in Period II (5000–4000 BC) an addition of bread wheat and shot wheat to the races of wheat cultivated. These varieties apparently proved so productive that after 4000 BC the cultivation of einkorn wheat was abandoned, while emmer wheat met this fate later on. As for barley, the cultivation of two-row hulled barley was abandoned after 5000 BC in favour of the six-row variety. On the other hand, cotton was domesticated in Period II, that is, before 4000 BC; and this was probably the first act of domestication (witnessed at Mehrgarh) of a major fibre-plant in the Old World.

2.2 The Neolithic Revolution: Pastoralism

The rise of the pastoral sector in human economy was, as already noted, an important feature of the Neolithic Revolution, side by side with the rise of agriculture. The first wild herbivores to be domesticated in West Asia, the region of origin of wheat and barley cultivation, were the caprines (goats and sheep). The wild goat, being a fast climber, is native to steep, rocky landscapes; the wild sheep, able to run faster, can subsist in open, less hilly areas. The native habitats of both the species were therefore confined to the elevated zone between the Mediterranean and the western edge of the Indus plains; and their original domestication, therefore, seems to have occurred within this zone. Their worldwide spread is the work of man; and in most areas where they are now found, they would not have survived without human protection. The earliest evidence of goat domestication comes from Levant (Syria and Palestine), datable to before 8000 BC; the domesticated sheep appears there around 7000 BC. But at Ghar-i Mar (Aq Kupruk II) in Afghanistan, both sheep and goat are reported to have been domesticated by *c.* 7500 BC.

In the Indian subcontinent, at Mehrgarh in Period I (7000–5000 BC), both the wild goat and wild sheep, apparently captured from the neighbouring hills, are represented in the bone remains; but so is the domesticated goat as well. Quite significantly, there is evidence that the sheep was here domesticated from local wildstock, since there is a gradual reduction in its skeletal size. Goat and sheep were apparently kept to provide meat (and milk?) and, only later on, wool (in the case of sheep). They could be fed by simply setting them in man-created herds to graze on the land.

The more crucial development turned out to be the domestication of cattle. At Mehrgarh in its Period I (7000–5000 BC), the remains of bones, in a large proportion, are those of wild species only, and among these the wild ox (*bos primigenius*) is also represented. Yet, bones of the humped or *zebu* cattle are also found; and there is, in succeeding phases, a growth in their number and a diminution in their individual size—a characteristic mark of the process of domestication. Genetic studies have suggested that there are two strains in *zebu* cattle, one ('Z2') going back to 12,900–6,700 BC, the other ('Z1') to 5,600–600 BC. Both are found mixed in India, but the 'Z2' strain is more predominant in Southeast and East Asia, and the 'Z1' in all lands to the west, though to both zones the *zebu* had been almost certainly taken from India. It is possible that the *zebu* was a very young species when it began to be domesticated, though it was only by 3000 BC that its great value could be fully realized. This was when the cart and the plough came into use in the Indus basin. Then, the hump proved its real value: it not only secured stability for the yoke, but also enabled the maximum tractive power to be obtained out of the ox. It was a happy accident for India, then, that nature had produced, possibly not many millennia before the onset of the Holocene, a humped ox in a unique small sub-species, which man then multiplied and spread all over the Eurasian and African tropical and sub-tropical world.

The story of the domestication of the water buffalo in its early stages lies outside India. A strong and fierce animal in its wild state, its remains are found at early neolithic sites in Central East China before 6500 BC; and when the ploughshare definitely appears there, as at Majiabing around 4000 BC, it becomes certain that the buffalo, being the only beast there able to pull it, must have already been domesticated. Indeed, in rice cultivation, with much of the work to be done in standing water, the buffalo is the most suitable work animal. If rice cultivation spread from China to India, then the domesticated buffalo could also have been introduced here along with it: a transmission of the methods of its domestication is quite likely, since the wild buffalo was already present in India. Curiously, however, the early archaeological

evidence for buffalo domestication does not come from the Gangetic basin, where from the conditions of natural environment one would have expected it, but from northwestern India: from Kashmir neolithic, 2500–2000 BC, and from the Indus culture sites of Balakot (near Karachi) and Dholavira in Kachchh, of about the same date. However, there is considerable difficulty involved in distinguishing the remains of the wild from those of the domestic buffalo; and it is possible that even as late as 1000 BC, the bulk of the buffalo population in India was still wild.

So long as the domesticated caprines and cattle were kept by their human masters merely or mainly as meat-stores, their numbers probably remained limited, with the young animals mostly killed, and only some kept alive to reach adult age for breeding purposes. In such circumstances, the ground needed for grazing would have remained relatively small. When sheep's wool and goat's or cow's milk became a consideration, the preservation of a large number of adult stock, especially female, might have become necessary. Still, the total population of domestic stock would have remained small, and, with cultivation mainly done with human labour alone, the area seized from forest or bush for cultivation and grazing would not have made much of a change in the natural environment.

2.3 The Symbiosis of Agriculture and Pastoralism, and the Indus Civilization

While plant cultivation and animal domestication were both unique modes of human intervention in the domain of nature, their great potentialities remained unrealized so long as their paths remained separate. The paths could remain so separate that there were possibly a few cases of diffusion of only one, without the other, into some regions. If the bones of dogs, *zebu* cattle, buffalo and sheep at the non-agricultural Mesolithic site of Adamgarh in the Narmada valley, *c.* 6000 BC, are all those of domestic animals and not of animals in the wild, a process of exclusively pastoral diffusion must be acknowledged. This is still clearer in the case of another Mesolithic site, Bagor in the Aravallis (Mewar), where in Phase I (5365–2650 BC), the domesticated animals included sheep, goats, *zebu* oxen and pigs, with sheep and goats predominating; and yet there is no sign of agriculture.

What happened around 3300 BC or earlier in Iraq, and around 3000 BC in the Indus basin and in the Helmand basin (a region shared by Iran and Afghanistan), was the combination of a number of innovations which created for the first time a symbiosis between agriculture and cattle-rearing. A major discovery, which could, by the very complexity of it, have scarcely been made simultaneously at more than one place, was that of castration as a means of making the male ox, or bull, tractable enough to be controlled by man. Once this practice diffused, the ox could be made to carry loads and draw the plough. Another discovery, the vertical cart-wheel, came almost about the same time to make the bullock-cart possible in Iraq, and the Indus and Helmand basins.

One can see from archaeological evidence how in the so-called Early Indus cultures (*c.* 3200–2600 BC) cattle-use changed. At Balakot (near Karachi) in the Amri-Nal culture of this period, cattle were still kept for meat, and so the bones are predominantly of young animals. At Jalilpur (in the Punjab) in the contemporary Kot Diji culture, the bones of oxen are generally of animals which had attained full size and so had obviously been used for work for quite some time before slaughter. At Kalibangan (north Rajasthan), in the same phase, were discovered traces of a ploughed field with furrows, so that the oxen must have now been used to draw ploughs. Even if there can be some question about the antiquity of this field owing to the rather unlikely straight alignments of furrows and cross-furrows, there is no doubt that when oxen were used to draw carts, their use in drawing ploughs must always be inferred. In any case, toy-ploughs have been found in the mature Indus Civilization sites of Banawali (Haryana) and Jawaiwala (Bahawalpur) (2500–1900 BC). With the simple plough, the human capability to cultivate the soil practically doubles, as has been estimated on the basis of the replacement of the hoe by the plough in parts of Africa, where the process has been observed in modern times. Cattle-rearing thus, for the first time, became a pillar of agriculture, and grew in scale on the basis of this relationship.

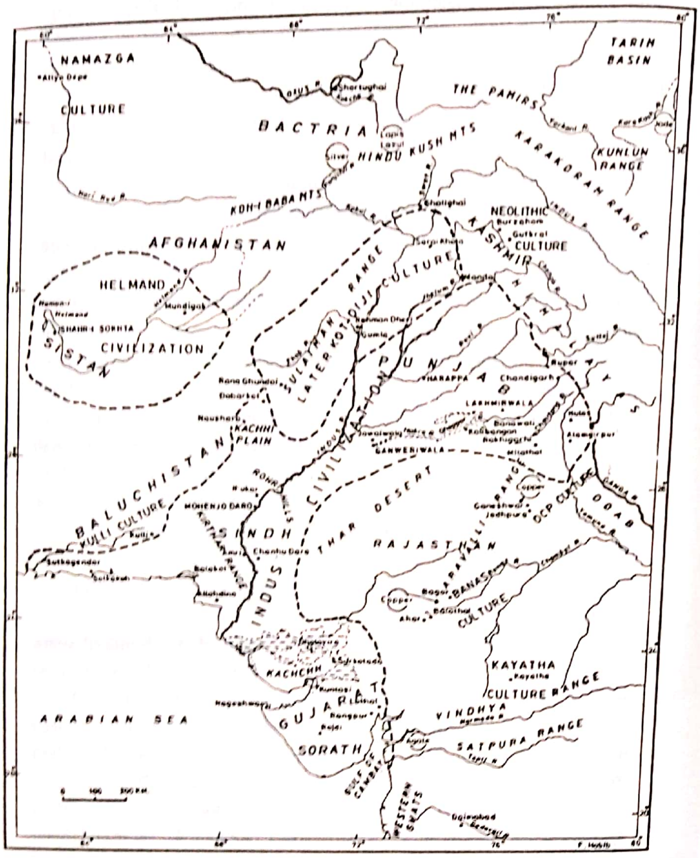
The traces of cart-ruts in pre-Indus levels at Harappa and finds of terracotta models of cart-wheels, cart-frames and oxen at Jalilpur (Kot-Diji phase) show that ox-drawn carts could now, before 2600 BC, supplement load-carrying oxen. Incidentally, pack-oxen were

used in large numbers to carry goods of bulk in long-distance trade in India by the itinerant Banjaras in medieval times. Whether carrying loads on its back or drawing carts, the ox in its new domestic incarnation contributed greatly to the transport of goods of bulk, and so brought about a radical change in the scale of transport.

These developments in turn led to the possibility of the creation of a surplus in agriculture, that is, the production of more food and other produce (e.g., a fibre-crop like cotton) than was required for minimum subsistence by the primary producers themselves. The coming of ox-based transport made possible the transfer of such surplus produce from villages to other centres. This development was the basis of what Gordon Childe called the Urban Revolution. Rulers, presiding over the control of force, extracted the surplus from the countryside, and distributed it among their retainers and servants (in return for services performed) and among artisans and merchants (in lieu of the goods they produced for or sold to the rulers). The non-agricultural settlements formed by these classes grew in time into larger settlements that became towns and cities. In Afghanistan the Helmand Civilization (2700–2100 BC), containing the city of Shahr-i Sokhta, and in India the Indus Civilization (2500–1900 BC), with its great twin cities of Harappa and Mohenjo Daro, represent culminations of this process of simultaneous evolution of the state and town. (See *Map 2.1* for principal sites of the Helmand and Indus Civilizations.)

These changes, coming within a span of five hundred years or so comprising the first half of the third millennium BC, helped to alter man–nature relationships over large areas. In the territories of the Indus Civilization the people who lived in the towns, given the sizes in area that the urban sites occupy, could hardly have numbered less than 250,000. And if we assume that, given the level of agricultural productivity at that time—the crop specialization for double-crop agriculture had not yet been established (see below, Chapter 2.4)—at least fifteen persons in villages were required to maintain one person in the towns, then the total Indus population could not have been less than 4 million. This would mean a density of nearly six persons per square kilometre in the Indus basin and Gujarat, which would be only one-thirtieth of the population density in the region today (though about one-eighth of the density around 1901). From our vantage-point we must recognize the

MAP 2.1 The Indus Civilization and Contemporary Cultures



duality of the situation. On the one hand, such density represented an enormous advance over the sparseness of the earlier pre-plough population over such a large territory; on the other, we are reminded that the density was still low and the landscape was still dominated by large tracts of wilderness. Fierce wild animals were probably never far away

from the small village settlements of the Indus region. Among the beasts which caused much alarm to the Indus people were, in the order of frequency of their appearance on the Indus seals (as worked out by I. Mahadevan), the elephant (55 seals), the rhinoceros (39), the tiger (16) and the wild water buffalo (14), all of whom are now extinct in the region. (See *Figures 2.2–6* for seals carrying representations of these animals and the crocodile.)

There is yet another aspect of the increase in population we have to consider. People, after the adoption of agriculture, were not actually dispersed at the same rate of density over the land, but were concentrated in villages and towns where they lived in close proximity to each other; they became, therefore, more prone to contagious diseases than when they were scattered in small groups as hunters and foragers. Their diet too changed, as they now ate less and less of meat.

FIGURE 2.2 Four wild animals (rhinoceros, water-buffalo, elephant and tiger) around a horned deity: seal from Mohenjodaro. After Possehl.

FIGURE 2.3 Wild elephant on Mohenjodaro seal (Mackay/Possehl)

FIGURE 2.4 Tiger on Mohenjodaro seal (I. Mahadevan)

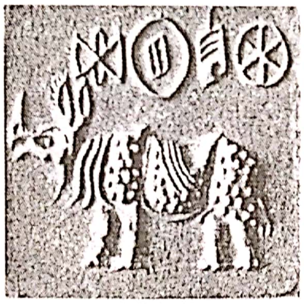


FIGURE 2.5 Rhinoceros on Mohenjodaro seal (I. Mahadevan)

FIGURE 2.6 Crocodile and fish, Mohenjodaro tablet (I. Mahadevan)

This undoubtedly affected their physical appearance and health. In pre-neolithic burials at Sarai Nahar Rai in central Uttar Pradesh, datable to *c.* 8000 BC, the mean adult height for men was found to be 180 cm and of women 170 cm, both being large-boned. Their life-span was probably not long, however, for at Mahadaha nearby, in the same cultural phase, the average life of thirteen persons has been determined to lie between 19 and 28 years, but on average perhaps closer to 19. In a 'proto-neolithic' phase, when agriculture had still not been established but women were probably more widely engaged in gathering and eating seeds and roots, it has been deduced from skeletons at Lekhahia in Mirzapur District, Uttar Pradesh, datable to *c.* 3000–2700 BC, that men were still as tall as before at Sarai Nahar Rai, but women's mean height had shrunk to 162 cm and they were turning gracile. And out of thirteen persons whose age of death could be determined, eleven had died before reaching the age of 25 years. On the western borderland, at Mehrgarh, south of the Bolan Pass, after agriculture and pastoralism had been adopted, we see a steady deterioration of health between Mehrgarh Phase II (previous to 4300 BC) and Phase III (4300–3800 BC, when copper came into use). Examinations of burials showed a fall of life expectancy from 31 years to 24, a rise of death rate from 33 to 42 per thousand, and a rise of the under-5 child mortality rate from 360 to 452 per thousand. The rise of the child mortality rate apparently put pressure on women to produce more children; so the fertility rate climbed from 4.5 to 5.8 per female. Such detailed analyses are not available for the Indus Civilization burials; but out of 90 burials at the Indus-phase cemetery at Harappa, only thirteen were found to be older than 55 years at the time of death; and fifteen were below 17 years of age. Dental studies have shown that women got far less meat to eat than men, and this too must have affected their health.

2.4 Climate and the Indus Civilization

Fifty years ago some commonsense assumptions could have been easily made about the climate during the period of the Indus Civilization. Since in that period forest and bush were more extensive than now, it could be argued that more water was retained after rainfall and flood, and this therefore added to what may be called secondary precipitation. In other words, on the whole, the average rainfall should have been higher than today. But this could not possibly have amounted to a substantial excess, because the remarkable drainage systems of Mohenjo Daro and Harappa would have been immediately choked if the rainfall received there was on the scale of what it is now, say, in western Uttar Pradesh. Suggestions of physical changes were indeed raised in speculations about a great flood overwhelming the cities, or, alternatively, about a huge lake formed by some obstruction that ultimately submerged Mohenjo Daro. H.T. Lambrick duly refuted these arguments in a careful critique.

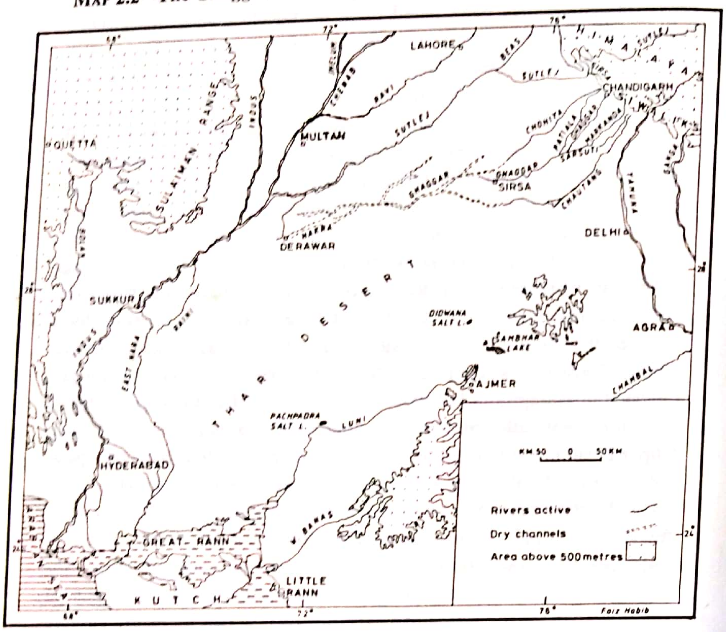
In the last fifty years the science of Climatology has developed very greatly. Estimates of variations in temperatures, and of 'wet' and 'dry' periods or cycles of heavy and light monsoons, have been made on the basis of studies of pollen found on banks and floors of natural lakes, and from excavation of ice-cores in Tibet, with results correlated with other climatic movements and the earth's orbital and rotational vagaries. As we shall see in our *Note 2.1*, the conclusions drawn from the data by several sets of researchers have by no means been uniform, and a large part of the evidence is still consistent with the view that the climate of the Indus basin during the period of the Indus Civilization was largely similar to what it is now, with rainfall in the short term varying as much as it does today. At the same time, there is another body of evidence that points to the onset of a dry phase of some duration beginning around 2000 BC or somewhat later, in the very last days of the Indus Civilization. It is argued that this dry phase brought about a succession of droughts under whose impact Indus agriculture collapsed; and this is invoked to explain the rapid decline and then the virtual disappearance of human settlements in the plains of western Punjab and Sindh after *c.* 1900 BC. In another variant of the hypothesis, Bryson and his fellow past-climate modellers suggest that it was really the decline in the volume of river discharge, consequential upon a southward shift in the monsoon during the 'Indus Event' (2100–1500 BC) caused by volcanic dust, that destroyed the backbone of the flood-based agriculture of the region, and so put an end to the Indus Civilization.

The argument, once we overlook the divergences in the evidence out of which it has emerged, is attractive enough. But the difficulty in accepting it is that around the very same moment, *c.* 2000 BC,

agriculture in the Indus basin actually underwent a substantive improvement, as has been noted by R.H. Meadow and others. This improvement came in the form of the specialized cropping system for the two seasonal harvests that has continued till today. Already to the varieties of wheat and barley grown at Mehrgarh, the Indus Civilization had added pulses (gram, field-pea and lentils) in the list of its food crops. These additions were particularly important since pulses enrich the soil with nitrogen. But there was yet a heavy preponderance of crops that grow much better in the rabi or spring-harvest season; and these crops, if sown for kharif (autumn-harvest), would give very inferior yields. In Gujarat, on the other hand, the three millets, bajra, ragi and jowar, were sown; and these grow well in kharif rather than rabi. For some reason, Gujarat did not yet take to the rabi-oriented food crops of the Indus basin. This situation in both areas radically altered around 2000 BC, when rice cultivation extended to western Panjab (attested at Harappa in both late-phase Indus and Cemetery-H levels), Kashmir, Swat valley and territory south of the Bolan Pass. At Hulas in Upper Doab (west Uttar Pradesh), in very early 'Late Harappan' (post-1900 BC) levels, the crop list is extremely impressive with wheat, barley and pulses for rabi, and rice, jowar and ragi millet, and other crops for kharif. Simultaneously, the cultivation of 'rabi' pulses spread to Late-Indus Gujarat. All of this means that now the peasants in the Indus region and adjacent zones had at their disposal specialized crops separately suited for the rabi and kharif seasons, which increased substantially the yield of the land in both harvests. As for the hypothesized decline in the range of floods in the Indus basin during 2100–1500 BC, it may be observed that rice, which appears during this very period among the crops of the region, thrives in flooded fields, and so this itself would be an argument against any great setback to flood-agriculture having taken place at the time. Moreover, it is noticeable from the 'modelled' river discharge that the volume of water discharged in more recent times has been much less than the calculated one for 2100–1500 BC; and yet flood agriculture continued to thrive in the Punjab and Sindh in these late times.

Another suggestion, now made slightly less stridently than a few years ago, has been that the dry phase setting in around 2000 BC greatly disturbed the Indus basin river system by causing the drying up

MAP 2.2 The Ghaggar–Hakra System and the Indus Basin



of the Sarasvati river, which, taking the course that now bears the names of Ghaggar and Hakra, had flowed on to the sea parallel to the Indus. However, all the affluents of the Ghaggar–Hakra, including the Chautang, rise in the Siwaliks or, in the case of the Ghaggar itself, in the lower Himalayan slopes, so that however heavy the rainfall, it could not possibly have provided enough water for the Ghaggar–Hakra to cut an independent course all the way down to the sea through the Sindh desert. We can only concede that in order to sustain the numerous Indus (and some post-Indus) settlements in the Bahawalpur territory of Pakistan, the Ghaggar–Hakra must have carried water up to the point that its dry channel can be traced (see *Map 2.2*). The gradual drying up of the lower sections of the channel may indeed have been due to no other

factor than the drawing away of the water of the Ghaggar affluents and the Chautang river through bunding by peasants of the Haryana plains down the centuries. By and large, there is no reason to believe that the Indus river system during the time of the Indus Civilization was fundamentally different from the one described in the Rigvedic 'river hymn' composed about a thousand years later (*c.* 1000 BC); this hymn contains the earliest enumeration of the Indus tributaries (*Extract 2.1*).

TABLE 2.1 Chronology

The chronology below is based mainly on calibrated radio-carbon dates, to the extent calibration is available. They are given here in years BC, not in terms of BP (Before Present, i.e. Before 1950), or of years ago. All dates are approximate.

	BC
Peak of last Ice Age	18000
Cultivation of wheat and barley begins in Southwest Asia	9000
Cultivation of rice begins in Central East China, before	8000
Conventional date of beginning of Holocene	8000
Domesticated sheep and goats, Ghar-i Mar, Afghanistan	7500
Cultivation of wheat and barley begins at Mehrgarh	7000–6000
Zebu oxen domesticated at Mehrgarh, before	5000
Use of oxen for traction begins in Indus basin, with cart and plough	3000
Rice cultivation (Vindhya neolithic) begins	3000
Shahr-i Sokhta, city in Seistan, established	2700
Harappa and Mohenjo Daro (Indus Civilization) established as cities	2500
Limited domestication of buffalo, Kashmir and Indus basin	2500
Beginning of dry phase (?); conversion of Indus agriculture to planting of separate crops for the spring and autumn harvests	2000
End of the Indus Civilization	1900

Extract 2.1
***Rigveda*, Book X, Hymn 75**

The River Hymn

1. The singer, O ye Waters, in Vivasvan's place, shall tell your grandeur forth that is beyond compare.
   The Rivers have come forward triply, seven and seven. Sindhu [Indus] in might surpasses all the streams that flow.
2. Varuna [god] cut the channels for thy forward course, O Sindhu, when you ran to win the race.
   You speed over precipitous ridges of the earth, when you are Lord and Leader of these moving floods.
3. His roar is lifted up to heaven above the earth: he puts forth endless vigour with a flash of light.
   Like floods of rain that fall in thunder from the cloud, so Sindhu rushes on bellowing like a bull.
4. Like mothers to their kine, like lowing cows with their milk, so, Sindhu, unto you the roaring rivers run.
   You lead as a warrior king your army's wings when you come in the van of these swift streams.
5. Please attend to this hymn of praise, O Gangā, Yamunā, Sarasvatī [Sarsuti], O Shutudri [Sutlej] and Parushni [Ravi].
   With Asiknī [Chenab], O Marudvridhā [Maru-wardwan in Kashmir], with Vitasta [Jhelum], O Ārjīkīyā [Ayak] with Sushomā [Sohan], hear my call.
6. First with Trishtāmā you are eager to flow forth, with Rasā [Panjkora], and Susartu and Shvetyā [Swat] here.
   With Kubhā [Kabul], and with these, Sindhu, and Mehatnu, you seek in your course Krumu [Kurram] and Gomati [Gomal].
7. Flashing and whitely-gleaming in her mightiness, she moves along her ample volumes through the realms.
   Most active of the active, Sindhu unrestrained, like a dappled mare, beautiful, fair to see.

Ralph T.H. Griffith's translation, from his *The Hymns of the Rgveda* (1896, Indian reprint Delhi 1971, pp. 587–88). The translation has been modified in order to restore the arrangement of the names of the rivers as found in the original text, and to make the English simpler. Modern river names where different are put within square brackets. The Trishtāmā, Susartu and Mehatnu cannot be identified, but they could be any of the

streams carrying different names today which flow into rivers that join the Indus from the west.

Note 2.1
Reconstructing Climate History

Climate may be defined as the generalized condition of the weather (temperature, precipitation, wind, etc.) of a place or region as experienced in the course of the seasonal cycle within a full solar year, and repeated, with some variations, over a fairly long period of years. On the basis of the average of daily temperatures and total precipitation (which includes water deposited by rainfall, snowfall, hail, sleet and mist) in a year, the climate of a region may be described as cold, temperate or warm, and as dry or wet. **Climatology** is the science that studies climates and investigates how the particular climatic conditions of a region are brought about. While the position of a place in terms of latitude, indicating its distance from the Equator and the Poles, and altitude, that is, its height above sea-level, as well as its geographical situation, e.g., proximity to sea, open plain or mountain surroundings, may be treated as more less fixed or constant factors, there are others, such as ocean currents (warm or cold) and winds (monsoons, cyclones, etc.), that affect both temperature and precipitation on land surfaces in a varying or uneven manner. Changes in temperature and precipitation have been regularly recorded in many countries for the last 150 years (in India since 1796, initially with a recording station at Madras), and it is therefore possible to understand the interlinking of different factors that go to create the weather existing at a particular time and place.

Such regularly or continuously recorded information is not available for earlier periods. Since climatic changes occur usually over long spans of time, it often becomes necessary to use evidence which has to be largely **archaeological** in character. The most direct means is to excavate the ground, demarcate the various strata, date the material found there by ^{14}C and other methods, and establish what kinds of plants grew or animals lived at the time of each stratum. Plants can be particularly identified by surviving pollens (or their fossils), the study of which is called **palynology**. Since different plants are known to flourish in different climates, palynology plays an important role in determining what kind of climate prevailed when the stratum from which the pollens are retrieved was formed. Where a natural lake is fed from a geographically well-defined catchment area, changes in its size can correspond to changes in precipitation. The lake's earlier extent can be established by remains of plants that grew on its banks, but also additionally by soils formed by earlier lake-floors, and, in the case of a saline lake, earlier evidence of salinity in the soil. Another way of measuring annual weather fluctuations, dating back to a maximum (so far) of 7,000 years ago, is associated with **Dendrochronology**, or the study of sequences of tree-rings. Tree-rings form annually, and their size is affected by temperature and precipitation. Tree-rings in living trees form patterns which can be successively linked to those of older trees (dead, surviving as dry wood, or in fossilized form), and so an annual chain with each tree-ring dated to a year can be constructed indicating the prevalence of favourable or unfavourable conditions for plant growth in particular years. Up till now, no dendrochronological evidence has been obtained for India directly, but indirect inferences may be drawn from what we know from studies of tree-ring in other regions.

Another 'proxy' precipitation gauge is provided by the permanent ice accumulations such as cover large parts of Greenland and the Tibetan plateau in China. The temperatures prevalent on the Tibetan plateau exercise a great influence on the movement of the Indian southwest monsoons. Boring in the Guliya ice-core in the Western Kunlun Shan range, not far from the Kashmir border, has enabled a curve of temperature changes there to be constructed, from over 134,000 years ago to the present. Rather more complex is the use of data for temperature changes in Iceland (derived from iceberg melts) to build up a monsoon curve for northern India, AD 1000–1950.

Evidence for changes in the sea-level provides another indication of climatic changes. When the past sea-level is found to have been high, it is an indication of warm and wet conditions on the land; and when low, cold and arid conditions are to be assumed. The alterations in the sea-level and, consequentially, in the coastlines can be determined by finds of shells, corals and other marine matter. When such matter is found above the present coastline and is duly dated, one can naturally hold the sea-level to have been higher at that time than it is today. On the other hand, the intertidal and shallow-water material encountered at terraces in the present ocean floors bears testimony to lower sea-levels at earlier times. From such evidence a curve has been drawn of the possible sea-levels on India's west coast from about 13,000 BC to about AD 500. The traces in sediments of planktonic fauna and flora which thrive in upwelling waters in the Arabian Sea are taken to be another index of monsoon strengths, enabling a monsoon curve to be constructed from about 17,000 BC. Finally, discoveries made in distant places can be used to deduce corresponding changes in the Indian climate. Since the sea-level remains the same all over the world, any measurement of sea-level in the Atlantic or Pacific should apply to India as well, subject to possible local tectonic changes.

There may be a time when the diverse data and inferences drawn from these and other sources would all be fitted into a precise and accurate frame. But at the moment the divergences in the evidence (and the deductions drawn from it) are many, and some at least are seemingly irreconcilable. One can see this in the evidence presented for the Indus basin and adjacent regions of India from about 4000 BC onwards. As G.L. Possehl points out, botanical evidence from different Indus sites is consistent with the view that the climate in the period of the Indus Civilization (2500–1900 BC) was very similar to what it is today. Yet Gurdip Singh's work on the Didwana salt basin and other Rajasthan lakes suggested that there was much greater rainfall than today in the period 3000–1800 BC, whereafter a sharply arid phase began,

which essentially continues to this day with the exception of an interval, 1400–1000 BC, when precipitation had briefly increased. More precise work, with many more carbon dates, undertaken at the Lunkaransar Lake in Rajasthan showed that fairly wet conditions continued down to as late as *c.* 1200 BC, whereafter, passing through a phase of desiccation, the lake ran absolutely dry, *c.* 600 BC; it revived around AD 200. The Nal Sarovar in Gujarat, on the other hand, experienced an extremely wet phase from about 3000 BC to *c.* 500 BC! Similar discrepancies prevail among monsoon estimations. The Guliya ice-core, from the pattern of temperature shifts it discloses, suggests a high level of monsoon rainfall continuing until about 4,500 BC, then a decline to low, moderate rainfall, 4000–2500 BC; a dip thereafter, but from *c.* 800 BC a continuous improvement till the present day. This is in conflict with the 'upwelling' planktonic evidence, which shows a decline in monsoon strength from 1560 BC to AD 500 with just one slight upward movement, around the first century BC. In other words, hardly any of the reconstructed monsoon curves coincide.

In view perhaps of such contrary evidence obtained from direct archaeological data, the case is being canvassed for what is rather misleadingly called 'Archaeoclimatology', or, more properly, 'Macrophysical Climate Modelling'. Mainly worked out by Reid A. Bryson and his group, it is a 'top–down approach', determining the temperature and precipitation history for each position on the globe given the known changes in the earth's orbit and orientation (determining the 'insolation', i.e. the amount of solar radiation received per unit of earth's surface), variations in atmosphere composition and the known large-scale relationships between various climatic phenomena. When, however, one comes to the actual reconstruction of past temperature and precipitation histories (as has been done by Bryson and his colleagues for the vicinity of Harappa, the major city of the Indus Civilization in the Panjab), questions arise about the actual weight to be given to individual climate determinants and about the validity of certain assumptions. For instance, in the case of the history of river discharge and precipitation around Harappa, it is assumed that there was a great burst of volcanic activity which, during the 600 years (2100–1500 BC), greatly clouded 'atmospheric transparency' and so reduced temperatures worldwide (the alleged 'Indus Event'). Though there is some evidence of volcanic ash being deposited at certain sites during this period, its exact implications are debatable. Guesses naturally divest the detailed modelling of its objective nature and undermine its credibility, especially since the attempt is otherwise held to be independent of detailed archaeological fieldwork.

The presence of discrepancies in the current results from both archaeological work and theoretical modelling should by no means be taken to imply that research into past climates need not be pursued, or that model-making ought to be abandoned. Many findings of Climatology in respect of the past have been established beyond dispute. In time, as archaeological methods are refined and theory is made more comprehensive and precise in its approach, problems on which there appears to be no agreement today may yet be resolved in not too distant a future.

Note 2.2

Bibliographical Note

David R. Harris (ed.), *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, London, 1996, contains contributions by notable scholars in the field with much reference to changes in the natural environment; important material on India will be found in Chapters 22 and 23. Gregory L. Possehl, *The Indus Age: The Beginnings*, New Delhi, 1999, is a massive work that assembles much systematically treated material on the physical environment, climate, agriculture, animal domestication and wild life in the Indus period. In Nayanjot Lahiri (ed.), *The Decline and Fall of the Indus Civilization*, Delhi, 2000, some of the reprinted articles touch on issues of climate change and cropping.

On the climate, Yoshinori Yasuda and Vasant Shinde (eds), *Monsoon and Civilization*, New Delhi, 2004 (especially Parts II and III) has material relevant for this chapter. If one sets aside the Aryan and Sarasvati fixation of most contributors to B.P. Radhakrishna and S.S. Merh (eds), *Vedic Sarasvati*, Bangalore, 1999, some chapters towards the end of the volume may be found useful in that they report on work being undertaken on various aspects of Holocene climate history. The latest publication of the Bryson team on the Indus climate seems to be the paper by Rita P. Wright, Reid A. Bryson and Joseph Schuldenrein, 'Water Supply and History: Harappa and the Beas Regional Survey', *Antiquity*, 82 (2008), pp. 37–48.

Readers who wish to refresh their knowledge of the history of the times dealt with in this chapter, may consult *Prehistory*, Chapter 3, and *The Indus Civilization*, both belonging to the People's History of India series.