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ENVIRONMENTAL FACTORS IN THE DECLINE OF THE INDUS–SARASVATI CIVILIZATION

*Michel Danino**

Abstract

It is now widely accepted that climatic and environmental factors played a significant part in the decline of the Indus-Sarasvati civilization. While climatic studies from the 1970s to 1990s tended to support the view that a marked trend towards aridity had set in even before the civilization's urban or Mature phase, more recent studies have pushed this shift to the end of the second millennium BCE, which coincides with the end of the Mature phase (2600-1900 BCE). This is also the time when, in the east, the Sarasvati dwindled to a minor seasonal river, while floods appear to have been caused by a shifting Indus in the west. Other possible causes include the pressure put on remaining forests by intensive industrial activities. In any case, the archaeological evidence records the abandonment of hundreds of Harappan sites in the Sarasvati's basin (which includes today's Cholistan), and an eastward movement of Late Harappan settlements.

Background

The decline and disappearance of the Indus-Sarasvati Civilization in its urban form has been an enduring object of speculation. In the absence of any corroborative archaeological evidence, barbarian (and generally "Aryan") invasions have been firmly ruled out as a potential cause. Alternative scenarios include political, socioeconomic or environmental

* *Guest Professor, Indian Institute of Technology, Gandhinagar, Gujarat.*
Author of "The Lost River : On the Trail of the Sarasvati" (Penguin India, 2010),
This paper is an adaptation and revision of two earlier papers on the same theme.

factors, the first two of which are untestable in the present state of our knowledge. As regards the last, considerable data on the environmental and climatic conditions of the northwest of the Indian subcontinent before, during and after the Harappan age has accumulated in recent decades.

Although some archaeologists have warned against the pitfall of attributing disruptions in the course of ancient civilizations and cultures to "environmental determinism," the impact of environment and climate can no longer be ignored either. The prolonged drought that affected, in 2200–2100 BCE, large parts of Africa,[1] China,[2] North America,[3] Near and Middle East,[4] probably causing the collapse of the Akkadian empire,[5] is a case in point. The case of the Indus-Sarasvati civilization remains complex, partly because of apparently conflicting views on what kind climate and environment prevailed in its Mature or urban phase. Although John Marshall remarked in 1931 that the extensive use of fired bricks at Mohenjo-daro pointed to a wetter environment,[6] later archaeologists disagreed and found little or no evidence for a climate significantly different from today's. As the late Gregory Possehl wrote in 2002, "The climate of this region [Greater Indus Valley] was not markedly different in the third millennium BCE from the one we have today."[7]

Can recent evidence decide which school of thought is right?[8]

Was the Harappan climate as dry as today's?

Among the studies leading to the conclusion that the Harappan climate and environment were hardly different from today's, the following have been often cited:

- Gurdip Singh's 1971 palynological study of three lakes of Rajasthan envisaged a wet climate during the Mature phase followed by a sharp decline in rainfall around 2000 BCE.[9] However, Shaffer's and Lichtenstein's[10] recalibration of his radiocarbon dates pushed the wet phase to Early Harappan times, leaving the Mature phase in an already marked trend to aridity.

- R.A. Bryson and A.M. Swain, also from lakes of Rajasthan, reached a conclusion similar to Singh's.[11] But here again, recalibration pushed the phase of higher rainfall "to a pre-Mature Harappan period."[12]

- M.B. McKean, studying pollen and sediments in the region of Balakot, found nothing suggesting that "the climate during the protohistoric period in Las Bela was decidedly wetter than at present."[13]

- In 1983–85, an Indo-French mission explored an area of Haryana and Rajasthan between the Ghaggar and the Chautang; from a study of sediments in paleobeds, geologist Marie-Agnès Courty concluded that "Yamuna-like rivers ... stopped flowing in the study area well before the Protohistoric period."[14]

- In 1995, M.A. Geyh and D. Ploethner[15] carried out an isotopic study in a 100 km-long section of the Hakra's floodplain in Cholistan, close to the Indian border, and came up with dates ranging from 11000 to 2700 BCE.[16] This suggests that shortly before the Mature phase, the Hakra stopped flowing in this section.

- In 1997, S.M. Rao and K.M. Kulkarni conducted isotope studies in water drawn from wells in western Rajasthan along the bed of a "defunct river" and found no recharge after about 3000 BCE.[17]

- In 1999, Y. Enzel and eight colleagues analyzed sediments of the now mostly dry lake of Lunkaransar and found that it held water in 8000 BCE, began to decline around 4000 BCE and dried up by 3500 BCE.[18]

Or was it wetter?

More recent studies have pointed to the opposite conclusion, including a more intense monsoon in Mature Harappan times:

- In 1983, R.J. Wasson et al. studied the Didwana lake of Rajasthan and found that "freshwater, high lake level conditions prevailed" between 4000 and 2000 BCE.[19] This precisely includes the Mature Harappan phase.

- In 1996, P.D. Naidu, studying planktonic foraminifers from the Arabian Sea, found that the upwelling, and therefore the south-west monsoon, was at its lowest from about 1500 BCE to AD 800.[20]

- In 1999, Ulrich von Rad et al. studied sediments in the Arabian Sea off Karachi, and concluded that "precipitation decreased in southern

Pakistan after 4000-3500 yr BP,"[21] i.e. after 2000 BCE, which agrees with the preceding study.

- A year later, Netajirao Phadtare examined pollen and peat in the Garhwal Himalayas and found evidence of "a warm, humid climate, with highest monsoon intensity" from about 4000 to 2500 BCE; after 2000 BCE, there was "a sharp decrease in temperature and rainfall." Phadtare cited five independent studies (not part of our list here) from other regions that support "a decrease in the strength of the Southwest monsoon about 4000 cal yr BP."[22]

- In 2003, M. Staubwasser et al. analyzed planktonic oxygen isotope ratios off the Indus delta. Their findings revealed climate changes during the last 6,000 years, "with the most prominent change recorded at 4.2 ka BP," along with "a reduction in Indus river discharge." They observed, "The 4.2 ka event is coherent with the termination of urban Harappan civilization in the Indus valley."[23]

- In 2006, Anil K. Gupta et al. synthesized research on the monsoon and other climatic inputs from many sources including their own. "It appears to us," they concluded, "that the arid phase in the Indian subcontinent started ca 5000-4000 cal yrs BP coinciding with a stepwise weakening of the SW monsoon ... The arid phase might have intensified ca 4000-3500 cal yrs BP as has been in the Himalayas, western peninsula and northwestern India, and ended ca 1700 cal yrs BP, when the SW monsoon was the driest."[24]

- In 2008, Rita Wright et al. used models of archaeoclimatology to plot the intensity of the monsoon and river flow in the region of Harappa. They found that "around 3500 BC the volume of water in the rivers increases, and the rivers flood," until "from around 2100 BCE; the river flow [in the Beas] begins to fall." Around Harappa, "a 600-year period of reduced rainfall [sets in] after 2100 BC," leading to "an unexpected agricultural crisis."[25] Those two dates roughly bracket the Early and much of the Mature phases.

- In 2010, Prasanta Sanyal and R. Sinha synthesized a large number of studies of the Indian Summer Monsoon across north India over long ages; commenting on the records of lakes in the Thar Desert, they

observed that "Didwana and Lunkaransar playas were completely desiccated at 3–4 ka."[26]

- An international team led by Liviu Giosan studied in 2012 the climatic as well as fluvial conditions before, during and after Harappan times. They confirmed the now dominant view that "precipitation from both monsoon and westerly sources that feed rivers of the western Indo-Gangetic Plain decreased since approximately 5,000 y ago, and was at its lowest after approximately 4,000 y BP. ... as aridity intensified, monsoon-augmented floods became less frequent and/or less intense."[27]

- Also in 2012, M. Berkelhammer led an international team to study variations in the oxygen isotopes of a stalagmite from a cave in Meghalaya. They observed a "dramatic event ... - 4000 years ago when, over the course of approximately a decade, isotopic values abruptly rose above any seen during the early to mid-Holocene and remained at this anomalous state for almost two centuries." This suggested either "a shift toward an earlier Indian Summer Monsoon withdrawal or a general decline in the total amount of monsoon precipitation." The study's "tight age constraints of the record show with a high degree of certainty that much of the documented deurbanization of the Indus Valley at 3.9 kyr B.P. occurred after multiple decades of a shift in the monsoon's character...."[28]

- A 2013 study by Anjum Farooqui, A.S. Gaur and Vandana Prasad of the palaeoenvironment at two sites of southern Saurashtra showed "low precipitation and arid climatic conditions - 2000 BCE,. During this period the dominance of evergreen and moist deciduous arboreals from both the sites do not show equilibrium with the prevailing dry/arid climate and therefore, the pollen assemblage here represents the remnants of wetter middle Holocene vegetation in the region. ... The moister climatic conditions and comparatively rich forest cover around the Saurashtra coast was one of the main attractive reasons for the expansion and settlement of Harappans...."[29]

- In 2014, Yama Dixit, David A. Hodell and Cameron A. Petrie, studying the sediments of a palaeolake in Haryana (at Kotla Dahar), detected "ca. 4.1 ka marking a peak in the evaporation/precipitation ratio in the

> lake catchment related to weakening of the ISM [Indian Summer Monsoon] ..., suggesting that climate may have played a role in the Indus cultural transformation. ... Taken together, the records from Kotla Dahar, Mawmuluh [in northeast India], and the Arabian Sea provide strong evidence for a widespread weakening of the ISM across large parts of India at ca. 4.2–4.0 ka. The monsoon recovered to the modern-day conditions after 4.0 k.y. ago, and the event lasted for ~200 yr (ca. 4.2–4.0 ka) in this region."[30]

More studies have been quoted on both sides.[31] It is understandable that focusing on different regions and using different approaches (sediments, pollen, plankton, palaeowaters, etc.) should lead to apparently diverging results. Nevertheless, the trend of most recent studies has been to observe "a decrease in the strength of the Southwest monsoon about 4000 cal yr BP,"[32] that is, towards the end of the urban Harappan phase. For example, Dorian Q. Fuller, while cautioning against hasty conclusions,[33] points to a series of "marked events of sudden aridity,"[34] with the last one taking place around 2200 BCE, the severe worldwide drought I mentioned above:

> A climatic event cannot be blamed simplistically for [Harappan] collapse and de-urbanisation, but Quaternary science data make it clear that we cannot accept a view of climatic and environmental stability since the mid-Holocene in the region (as promoted by Possehl ...).[35]

This may now be regarded as the current consensus, quite in tune with the worldwide drought noted at the start of this paper. It is clear that this prolonged period of reduced rainfall must have considerably strained the Harappans' monsoon- and flood-dependent agricultural production.

Circumstantial evidence

Early archaeologists pointed to the extensive use of baked bricks at Mohenjo-daro, Chanhu-daro and Harappa as a clue that climate was wetter; it was answered (by Mortimer Wheeler,[36] for instance) that baked bricks were more likely a flood-mitigating device. The depictions on Indus seals of animals like the elephant, the tiger, the rhinoceros or the water buffalo were seen as so many clues to a moister and greener environment; it was objected in reply that the depiction of a particular animal did not

prove its existence at the site, and that the above-mentioned animals were still seen in parts of the Indus valley till recent decades or centuries.

However, positive evidence emerged at Kalibangan in the form of bone remains of the elephant, the one-horned rhinoceros (recently confirmed at Karanpura, also in Rajasthan[37]), the water buffalo and the river turtle. In Bhola Nath's opinion, "the remains of these animals show that the climate at that time was more humid than the arid climate of present day."[38] The presence of the rhinoceros, in particular, "strengthens the geological evidence that the desert conditions of this area are of recent origin."[39] Similar evidence came from Gujarat, where P.K. Thomas observed that the animal

> *is identified from a large number of Harappan and Chalcolithic sites ... [and] inhabited a major part of the Gujarat plains in the protohistoric period. ... The identification of large herbivores like rhinoceros, wild buffalo and probably wild cattle at many of the Gujarat Harappan sites suggests that the ecological conditions were more congenial for animal life during the protohistoric period in Gujarat.*[40]

These considerations clearly point to a greener environment during the urban phase. If so, could human activities have played a part in its degradation? Mortimer Wheeler's suggested that the Harappans were "wearing out [the] landscape"[41] by overexploitation of their natural resources, particularly forests, for their brick, pottery, bronze and seal-making industries; intensive agriculture for the consumption of the city dwellers combined with overgrazing by numerous herds of cattle and goats would have added to the pressure on an already strained environment. Walter Fairservis attempted a calculation of the amount of fodder consumed by the cattle used by Mohenjo-daro both as a source of food (dairy products and meat) and for ploughing. His conclusion was:

> *The inhabitants of the mature period at Mohenjodaro would have grown only about one-fourth of their fodder needs. It follows that the remaining three-quarters had to be obtained by foraging in the surrounding forests and grasslands. This formidable assault on the indigenous flora most certainly affected the ecology and had an adverse effect on the land and aided the spread of the active floodplain.*[42]

The Sarasvati

An important environmental change affecting the Indus-Sarasvati Civilization in its eastern domain was the desiccation of the Ghaggar-Hakra system, which was home to some 360 sites of the Mature Harappan period,[43] the best known of which include (from east to west) Farmana, Rakhigarhi, Banawali, Bhirrana, Kalibangan and Ganweriwala. This river system located in the Yamuna-Sutlej interfluve, and identified since the mid-nineteenth century by generations of geographers, geologists, Indologists and archaeologists with the Sarasvati River of the Rig-Veda, dried up in stages, probably owing to a tectonic uplift of its basin, which deprived it of contributions from the Sutlej and the Yamuna, leaving only seasonal streams in its upper reaches.[44] As V.N. Misra put it, "The large number of protohistoric settlements, dating from *c.* 4000 BCE to 1500 BCE, could have flourished along this river only if it was flowing perennially."[45]

Studies of settlement patterns have showed that between 2000 and 1900 BCE, the central basin of the Ghaggar basin was deserted by the Mature Harappans; thus Kalibangan, in northern Rajasthan, has no Late phase. A crowding of Late Harappan settlements took place in following centuries along the Shivaliks' foothills, besides migrations eastward into the Ganges Valley and possibly southward to the Aravallis and the Vindhyas.

Recent geological studies have broadly confirmed this scenario sketched in the early 1980s.[46] In 2009, H.S. Saini et al. studied buried channels in the northwestern Haryana Plains and documented "the existence of channel activity during the mid-Holocene ... in a part of the Haryana plains"; by mid-Holocene is meant a "second fluvial phase ... represented by a palaeochannel segment whose signatures are dated between ~ 6.0 and ~ 2.9 Ka,"[47] after which a depleted Ghaggar was left. The dates bracket the Indus civilization.

The same year, reviewing findings on the Ghaggar-Hakra, Peter Clift concluded, "Provisional age data now show that between 2000 and 3000 BCE, flow along a presently dried-up course known as the Ghaggur-Hakkra River ceased, probably driven by the weakening monsoon and possibly also because of headwater capture into the adjacent Yamuna and Sutlej Rivers."[48]

The above-mentioned 2012 study led by Liviu Giosan (of which Clift is a co-author), apart from confirming a steep decline in the summer monsoon circa 2000 BCE, observed, "The most spectacular case of climate-controlled landscape transformation is the Ghaggar-Hakra system, which became ephemeral and was largely abandoned."[49] In a later comment on their paper, Giosan et al. clarified, "Our research points to a perennial monsoonal-fed Sarasvati river system with benign floods along its course."[50]

There is thus a broad consensus here too, although these last two studies have cast doubt on the existence of glacial sources for the Ghaggar in Mature Harappan times, reducing it to a rain-fed river. This was strongly refuted in 2013 by K.S. Valdiya[51] and further defended by Giosan et al.,[52] but as the issue ultimately makes little difference to the existence of a perennial river during Harappan times – albeit one already on the decline and of modest dimensions – we may leave this debate out of the present discussion.

Regionwise Discussion

As far back as in 1968, Wheeler wrote presciently, "The decline and fall of an immense, evolved and, on any showing, long-lived civilization as that of the Indus valley archaeological are inevitably a tangled and contentious problem. ... For a civilization so widely distributed as that of the Indus no uniform ending need be postulated."[53] More recently, Yama Dixit et al. put it thus: "The Indus settlements spanned a diverse range of environmental and ecological zones; therefore, correlation of evidence for climate change and the decline of Indus urbanism requires a comprehensive assessment of the relationship between settlement and climate across a substantial area."[54]

This should be warning enough against proposing a single environmental mechanism – reduction of the monsoon or the loss of the Sarasvati – for the final break-up of the Harappan urban order. Yet it is tempting to propose the following regionwise possibilities, albeit as a speculation:

- In the eastern region, the desiccation of the central Sarasvati basin accelerated towards 2000 BCE, leading to its almost complete

abandonment and a concentration of Late sites at the foot of the Shivalik Hills, in the Ganga–Yamuna Doab, and in Cholistan.[55] This loss of one of the two major lifelines of this civilization must have been a major factor in its deurbanization. As Dilip Chakrabarti puts it, "To a considerable extent the process [of weakening of the political fabric of the Indus civilization] must have been linked to the hydrographic changes in the Sarasvati-Drishadvati system."[56] Whether or not the loss of the river system was caused by a long drought, the two phenomena together certainly compounded the severity of the situation, as might have an overuse of natural resources.

- The Indus basin suffered no such loss, perhaps in fact more destructive floods if, as has been assumed, the part of the Sutlej that flowed into the Sarasvati shifted to the Beas, eventually swelling the Indus's waters: "An increase in water and sediment discharge of that magnitude [provoked by the westward shift of the Sutlej] would have had dramatic effects downstream in the Lower Indus Basin,"[57] according to Louis Flam. This might help explain the near complete absence of Late Harappan sites in this region: they may have been either washed away or buried under sediments.

- On the Makran coast, Harappan outposts like Sutkagen-dor and Balakot are now over 50 km inland. G.F. Dales, who excavated Balakot, suggested that "a sudden rise in the Arabian Sea coastline of West Pakistan apparently took place sometime around the middle of the second millennium. This resulted in a disastrous increase in the already serious floods in the major river valleys...."[58] There is independent geomorphologic evidence of relatively rapid uplifts of the Makran coast,[59] which perhaps left these Harappan ports high and dry, disrupting their trading functions.

- The Rann of Kachchh has an environmental history of its own. Home to several sites including Dholavira, its northern border may have been part of the Sarasvati's estuary (the present Nara channel). There is also archaeological[60] as well as textual evidence that the Rann was, in Mature Harappan times, a "shallow arm of the sea,"[61] and therefore navigable (Greek records suggest that it was still partly so in the first century BCE[62]). It ceased to be so probably owing to tectonic uplift and a lowering

of the sea level. Be that as it may, if at some point the "metropolis" and major trading centre that Dholavira was found itself cut off from the sea route, its very survival as a city must have been challenged.

- ❖ Similarly, satellite photography and sedimental studies have shown that the sea level near Lothal was higher in the third millennium than it is today, lending strong support to the interpretation of the site's huge basin as a "dockyard."[63] A receding shoreline may have spelt doom for the town's maritime function.

- ❖ The rest of the Gujarat domain of the Indus-Sarasvati civilization, together with northern Maharashtra, was not affected by changes in the Sarasvati and the Indus basins, or by the retreat of the Arabian Sea, but would have felt the impact of the 2200 BCE drought. More so, it would have been affected by the disruption of the trade networks in the other regions, which probably led to a collapse of the Harappan industries.

Other possible contributing factors include disruptions in commercial exchanges with the Iranian plateau, Magan, Dilmun, Mesopotamia and BMAC, socioeconomic tensions, sheer geographical overstretch, and a falling apart of the various Harappan regions.[64]

Taking all factors discussed above together, it is difficult on current evidence to decide which ones are causative and which ones contributory. However, it now seems firmly established that climatic and environmental disruptions played a major part in the decline and final break-up of the Indus civilization. Environmentalists have been warning that Ganga may turn into a seasonal river in the 21st century; we must hope that, despite current trends, wisdom will prevail and all mitigating steps will be taken to make sure that the twenty-first century CE does not turn out to be a repetition – of course on a much larger scale – of the twenty-first century BCE.

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