SARASWATI

THE RIVER PAR EXCELLENCE

Edited by

S. K. Acharyya Kunal Ghosh Amal Kar

THE ASIATIC SOCIETY

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The Sarasvati River: Issues and Debates

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Introduction

The Sarasvati River, though long lost, has kept ink flowing on the front page of our dailies or in the electronic media, but generally for the wrong reasons: Was it a "mythical" river? Are communal forces behind the assertion that there was once a mighty river flowing through Haryana, Punjab, northern Rajasthan and on to the Rann of Kachchh? In reality, those issues were well settled way back in the Nineteenth Century. In the Twentieth, the discovery of the Indus or Harappan Civilization did not immediately affect the Vedic River's status, and most archaeologists readily associated the name of "Sarasvati" with the Ghaggar–Hakra bed. The first part of this paper sums up some basic data on the river and explains why, in the 1980s, the River's accepted identification suddenly became "controversial."

The second part briefly surveys ten of the most recent scientific investigations in the Ghaggar's basin and the issues they have tried to address, such as the existence of a mega-river, contributions to it from the Sutlej and the Yamuna, the chronology of the mega-river's decline and disappearance, the Ghaggar system's fluvial condition during the Mature Harappan period, and the impact of its decline on the Harappan settlements in its basin.

Three Misconceptions

In the mass media, the Vedic Sarasvati River has been the victim of three stubbornly propagated misconceptions: (1) it was a "mythical" river; (2) its imagined existence is the work of "Hindutva" ideology; (3) if at all its ancient course was traced, that was done through satellite imagery. All three statements are seriously flawed, and have contributed to turning the Sarasvati issue into tabloid stuff, stifling healthy academic debate.

Let us deal with these misconceptions, the first two of which are also wilful misrepresentations, before going into the core issue.

(1) There is nothing "mythical" about the Sarasvati, except if we refer to its imaginary presence at Prayag's *Triveni Sangam* (a late tradition, nonexistent in the Vedic literature or even in the Mahabharata), or in the limited sense that right from the Rigveda, India's most ancient text, the Sarasvati river was deified (the only one to be, at that stage) and praised as "the best of mothers, the best of rivers, best of goddesses" (2.41.16). Such a process of deification will be later applied to many other Indian rivers, such as Ganga, of course, which does not mean that they could not be real physical water bodies at the same time. Indeed, the Sarasvati was also described in very physical terms, for instance as full of "great waters" (1.3.12), with an "impetuous," "unbroken, swift-moving" flow (7.95.1) "from the mountain to the sea" (7.95.2). Then there is the well-known *Nadi Stuti* hymn (10.75) in which the Sarasvati is precisely located between the Yamuna and the Sutlej.

The late Vedic literature, on the other hand, such as the Brahmanas, acknowledged that the river

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had broken down, and named “Vinashana” the point of its disappearance, turning it into a sacred site and the starting point of a pilgrimage from there to the source of the Sarasvati in the Shivalik Hills. In still later literature, the river had completely disappeared, was “lost,” and came to symbolize loss. Its name got transferred to a number of minor rivers in the region and beyond, from Gujarat to Bengal, to make sure people would not forget the lost river (all references in Danino, 2010).

In other words, the literature is emphatic that a fairly large river existed, which, for whatever reasons, dwindled and eventually disappeared. It was not a “mythical” river, any more than Ganga is “mythical.”

(2) I showed that the identification of the Ghaggar river as the relic of the Vedic Sarasvati was initially proposed in 1855 by a French geographer, Louis Vivien de Saint-Martin (Danino, 2010: 17–21); he based this identification on recent reports by British topographers of a huge dry bed (the Ghaggar) between the Yamuna and the Sutlej, precisely where the Rigveda located the Sarasvati, and on the presence of a small river named “Soorsuty” or “Sursooty” or “Sarsuti” on a number of earlier British maps, from 1760 onward (Fig. 8.1).

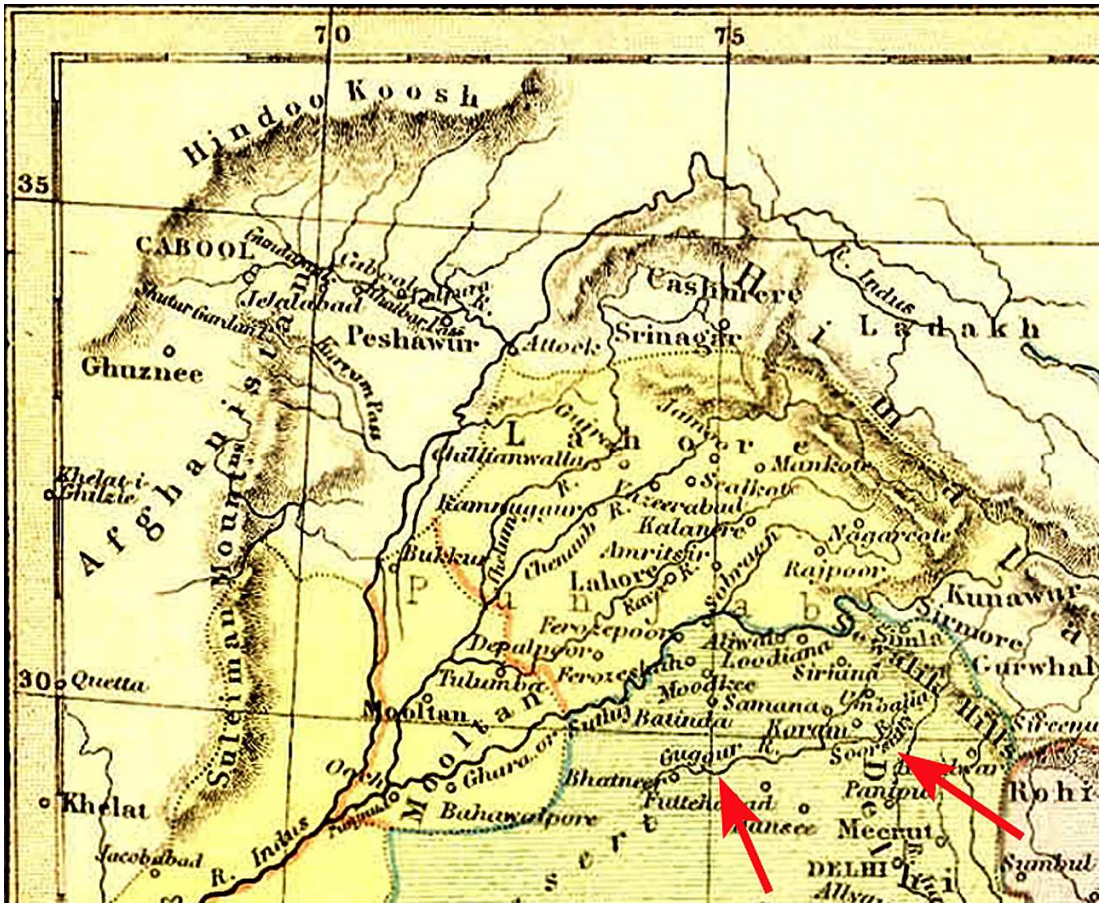

Fig. 8.1. The “Guggur” (Ghaggar) and “Soorsuty” (Sarsuti) marked by the two arrows in this detail of a 1760 British map (Courtesy Prof. Frances Pritchett of Columbia University, www.columbia.edu/itc/mealac/pritchett/00maplinks/ colonial/india1760/india1760.html).

For a second example, let us turn to James Rennell, a British geographer and cartographer, who in 1778 included in his ‘Memoir of a Map of Hindoostan or the Mogul Empire’ the most detailed map of India then available; it showed “Sursooty” meeting the “Caggar” or “Kenker” (Fig. 8.2).

Fig. 8.2. A detail of Rennel's map of 1778, with the Ghaggar and the Sarsuti marked by two arrows. (Courtesy Saraswathi Mahal Library, Thanjavur; map photographed by Michel Danino).

Vivien de Saint-Martin's identification of the Ghaggar–Sarsuti system as the relic of the lost Sarasvati was very soon endorsed by nearly all European Sanskritists of the second half of the nineteenth century, including H.H. Wilson (in 1840), F. Max Müller (1859), C.F. Oldham (1874), M. Monier-Williams (1875), A. Weber (1878). The few dissenters included Edward Thomas (1883) and Alfred Hillebrandt (1891), who proposed to identify the Sarasvati with, respectively, the Helmand or Arghandab of Afghanistan on linguistic grounds; however, seen as irreconcilable with the Rigveda and later Vedic literature, this theory did not find favour with Sanskritists and Indologists of the time.

The trend continued in the twentieth century with such as A.A. Macdonell, A.B. Keith, F.E. Pargiter, Louis Renou, Jean Filliozat, T. Burrow, A.L. Basham and Jan Gonda. Geologists such as R.D. Oldham (1886), or more recently V.M.K. Puri and K.S. Valdiya, joined in, followed by more geographers such as Shamsul Islam Siddiqi (1944) or Herbert Wilhelmy (1969). Archaeologists, beginning with A. Cunningham in 1871 (Fig. 8.3), endorsed the same identification; among many others, let us mention Marc Aurel Stein (1917, 1941) Mortimer Wheeler (1950s), A. Ghosh (1952), J.-M. Casal (1969), Raymond and Bridget Allchin (1982), S.P. Gupta (1989), V.N. Misra (1994), A.H. Dani (1997), B.B. Lal (1997), J.M. Kenoyer (1998), G.L. Possehl (1999), R.S. Bisht (1990s), D.K. Chakrabarti (1990s) and Jane McIntosh (2002) (all references in Danino 2010).

What have all these scholars to do with "Hindutva"? It is sheer dishonesty to project the identification on the ground of a river repeatedly mentioned in India's ancient literature as the work of Hindutva ideology. That identification is the result of serious scholarly work across several disciplines for over a century and a half.

(3) It follows that this identification has nothing to do with satellite imagery. What satellite views

of the region, beginning in the 1970s, facilitated was the identification of numerous palaeochannels, i.e., dried-up beds of ancient rivers and streams, in the Sutlej–Yamuna interfluves, some of which had actually been identified and documented earlier through ground topographic surveys.

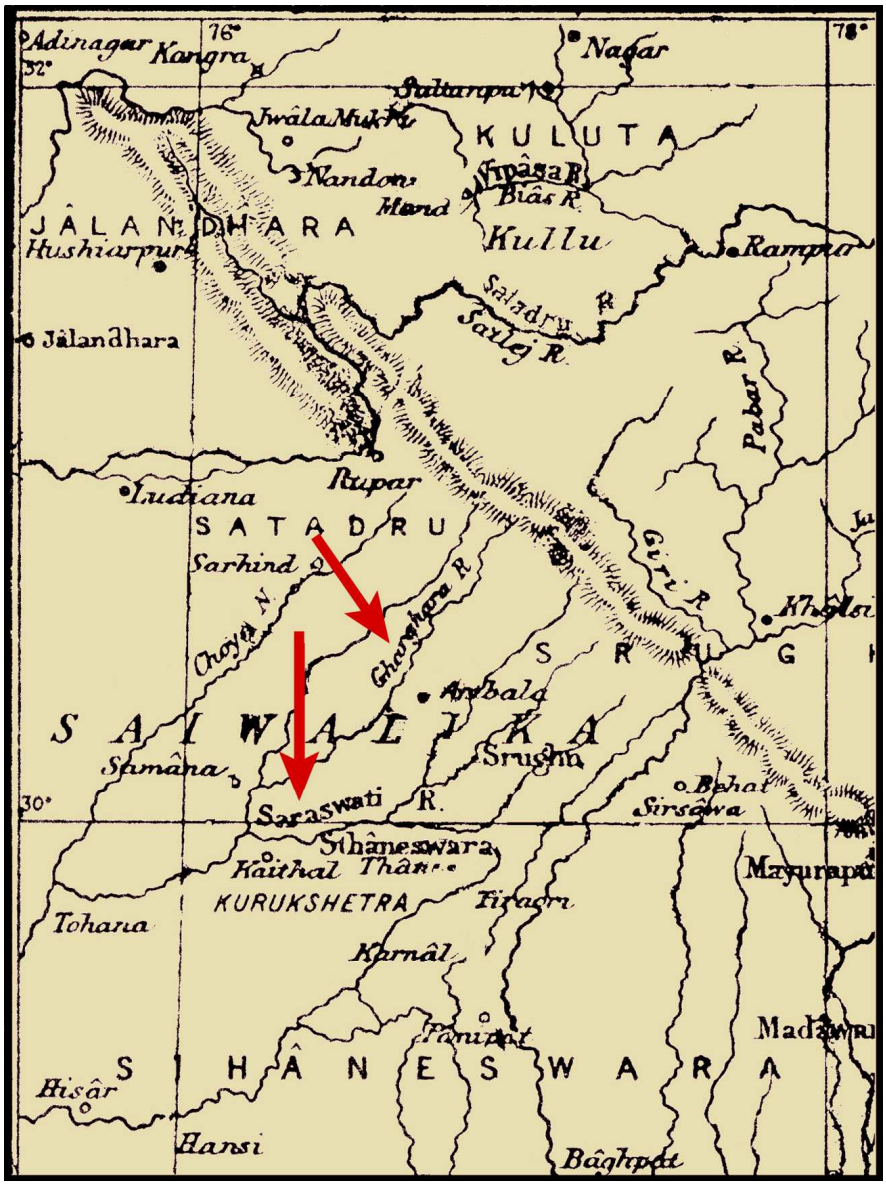

Fig. 8.3. Cunningham's map (1871) showing the Sarasvati and neighbouring rivers.

The Contribution of Archaeology

In the early Twentieth Century, the location of the lost river was regarded as solved. We would never have heard of any serious challenge to Vivien de Saint-Martin's identification if, in the 1920s, the Bronze Age cities of Harappa and Mohenjo-daro had not come to light, soon followed by more settlements of the same culture in the Indus Valley and Baluchistan. The "Mature" or urban phase of this civilization is now dated to 2600–1900 BCE.

In 1941, the celebrated explorer and Sanskritist Marc Aurel Stein conducted an expedition in the then Bikaner and Bahawalpur states (the former is now part of northern Rajasthan, while the latter, today's Cholistan, is an arid region of Pakistan). Stein had accepted the identification between the

Vedic river and the Ghaggar (which flowed into Cholistan under the name of "Hakra"), as an early paper of his makes clear (Stein, 1917), and suspected the extension of the Indus or Harappan Civilization to this region. During his "Survey of Ancient Sites along the 'Lost' Sarasvati River," as he titled his report, he identified several sites of Harappan culture (Stein [1941] 1989; 1942).

After the 1947 Partition, Indian archaeologists, beginning with A. Ghosh, conducted a number of surveys further east, and ended up discovering hundreds of Harappan sites in the Ghaggar's basin. Meanwhile, in 1974, the Pakistani archaeologist M. Rafique Mughal (1993, 1997) identified in Cholistan 171 sites of the Mature Harappan phase. All these surveys put together established that the Sarasvati basin was home to at least 360 sites of the Mature phase—almost a third of the nearly 1,200 known such sites in the totality of the Harappan sphere. Among the larger Harappan cities found in the Ghaggar–Hakra basin are Bhirrana, Rakhigarhi, Banawali (all in Haryana), Kalibangan (Rajasthan) and Ganweriwala (Cholistan) (Fig. 8.4 and Table 8.1; recent surveys have added many sites since this table was prepared).

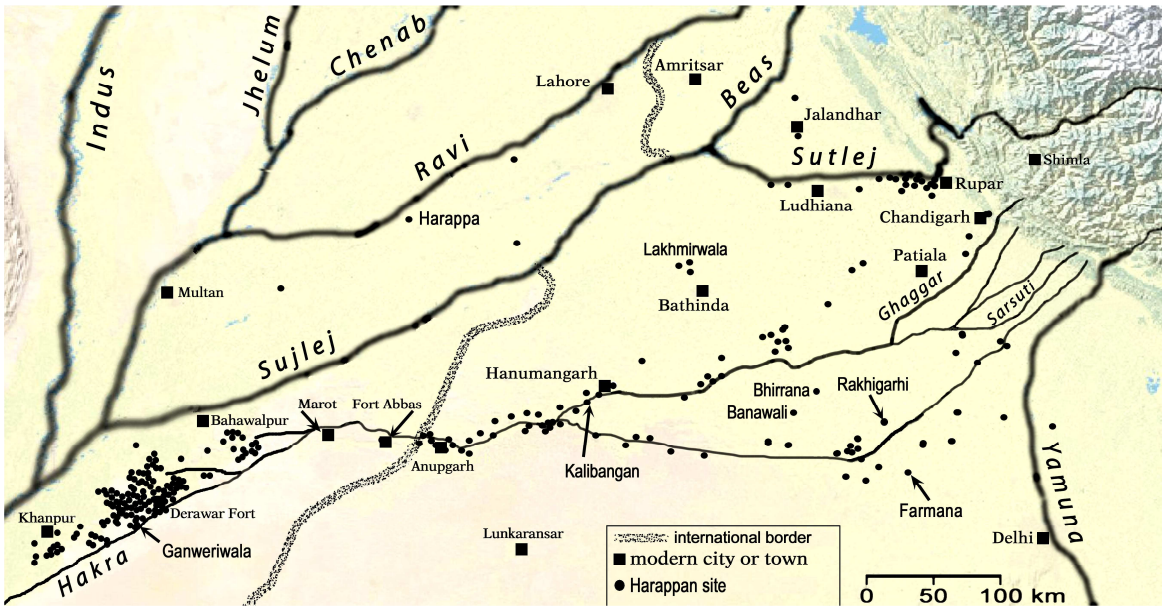

Fig. 8.4. Mature Harappan sites in the Sarasvati basin (map by Michel Danino).

Until then, there was a dominant view among archaeologists and other scholars (although with notable dissenters) that the Harappan Civilization was pre-Vedic or "pre-Aryan," the said Aryans being assumed to have entered India about 1500 BCE, around or after the disintegration of the Indus Civilization. (I will not go here into the many variants of the theory, as they do not concern us at this point.) It is only in the late 1980s that the Sarasvati's potential to bring down those scholarly edifices became clear.

Table 8.1. Distribution of Harappan sites in the Sarasvati basin (Danino, 2010)

Sarasvati Basin (east to west)	Early Harappan	Mature Harappan	Late Harappan	Total
Haryana	558	114	1168	1840
Indian Punjab	24	41	160	225
Rajasthan	18	31	0	49
Cholistan (Pakistan)	40	174	50	264
Total	640	360	1378	2378

The Sarasvati and the Aryan Issue

To begin with, there is an unexpected association between this river extolled in the Rigveda and the hundreds of Harappan sites it (together with its tributaries) nurtured. This prompted S.P. Gupta in 1989 to propose the broader term of "Indus–Sarasvati Civilization," since both rivers had a role in sustaining that civilization. A bigger surprise came from the drastic change in the settlement pattern at the end of the Mature phase (Fig. 8.5): while hundreds of Late Harappan sites, which had reverted to a rural lifestyle, clustered along the foothills of the Shivaliks, the whole central basin (including cities like Kalibangan) was now deserted. This change was datable to about 1900 BCE through numerous Carbon 14 dates.

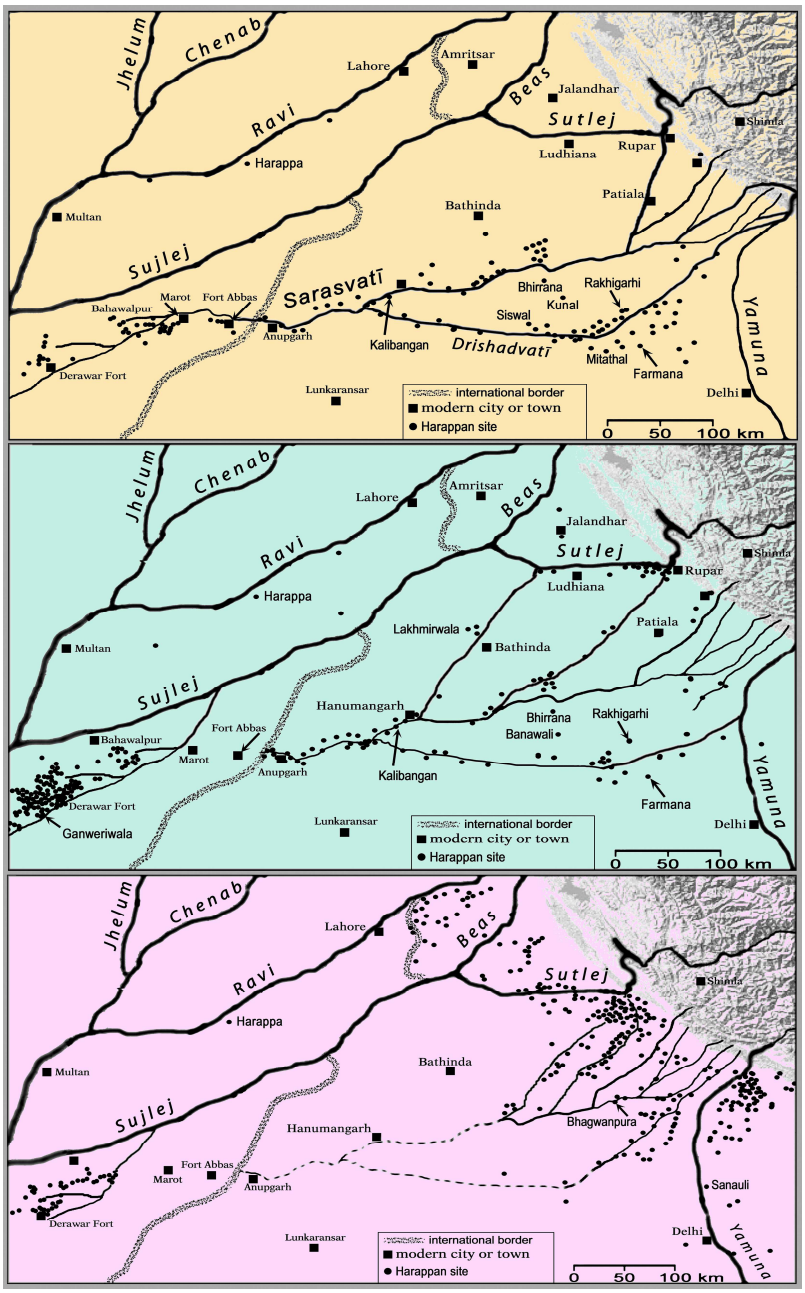

Fig. 8.5. Distribution of Early, Mature and Late Harappan sites (from top to bottom) in the Sarasvati basin and tentative reconstruction of the river's evolution (see last section for a closer discussion). Note the desertion in the central basin from 1900 BCE. (map by Michel Danino).

How then could the Indus or Harappan Civilization be "pre-Vedic," since it thrived as long as the "Vedic" Sarasvati flowed? And how could supposed Aryans, arriving four or five centuries after the river's "loss," praise in their Vedic hymns what was now a defunct river, or at most a seasonal stream, as a "mighty" river flowing "from the mountain to the sea"? The contradiction was glaring: as Max Müller put it, "the loss of the Sarasvati is later than the Vedic age" (1869: 60), which is what the texts unambiguously tell us, and that loss (or a major phase of it) was now datable to about 1900 BCE. The logical conclusion seemed inescapable: the early Vedic age had to be earlier than that date and now seemed to coincide with Mature phase of the Indus Civilization (2600–1900 BCE), if it was not earlier.

Of course, such a date for the Vedic age collided head-on with the mainstream theory of an Aryan invasion or migration (AI/MT) around 1500 BCE, with the Rigveda's composition generally assumed to take place some two or three centuries later.

On various grounds, especially textual ones, several eminent Indian figures (including, chronologically, Swami Dayananda Saraswati, Swami Vivekananda, Sri Aurobindo, P.T. Srinivasa Iyengar, B.R. Ambedkar, A.D. Pusalker) had already rejected AI/MT and the chronology attached to it. We might have expected the findings of the Sarasvati river to be regarded as corroborating their reasoned views. The opposite happened: a few scholars, such as Romila Thapar, Irfan Habib, Shereen Ratnagar, Suraj Bhan or the late R.S. Sharma, started in the 1980s questioning the identification between Ghaggar and Sarasvati. These scholars were poorly read in the Vedic literature, but they were influential with the media and in academic circles. Ironically, most of them (references in Danino 2010, Ch. 11) had initially accepted the said identification of the Sarasvati, but now that the chronological implications emerged, they chose to reject it rather than call into question the sacrosanct AI/MT. In so doing, they concealed from the larger public the acceptance that the very same identification had received from dozens of European scholars for over a century; indeed, several of these "negationists" were responsible for the media propaganda attributing the Sarasvati's identification to Hindutva ideology, with terms such as "chauvinism," "jingoism," "false patriotism" or worse generously thrown at the proponents of that identification or of possible parallels between Harappan and Vedic cultures.

Did this school of scholars propose alternative theories to identify the Sarasvati, if it was not (anymore) the Ghaggar–Hakra river? Most of them simply ignored the question, but two at least did try to take up the challenge. Irfan Habib (2000–01) decided that the Sarasvati was not a particular river, but "the river in the abstract, the River Goddess"— in other words, a "mythical" river. But this, as we saw, made nonsense of the Rigveda's realistic details on the river, and the equally realistic and internally coherent descriptions, in the subsequent literature, of the river's decline and ultimate disappearance in the sands of the desert in several stages. On the other hand, Rajesh Kochhar (2000) relocated the Vedic Aryans to Afghanistan and the Sarasvati along with them; as we saw above, the theory of an "Afghan Sarasvati," proposed in the late Nineteenth Century by Thomas and Hillebrandt, had not gained acceptance. In this refurbished thesis, the Sarasvati mentioned in the Rigveda is a "later" Sarasvati, so named by the Aryans in order to remember the erstwhile one left behind in Afghanistan (Kochhar, 2000: 132). There are many problems with this theory (Danino, 2010: 260–265); I will only mention three here:

(1) There is in the Rigveda no mention of Afghanistan, except for the western tributaries of the Indus, nor also any indication of a migration and the conquest or occupation of a new territory, unless one tortures the text into yielding an Afghan terrain and a homeland outside the subcontinent (Danino, forthcoming-b).

(2) Part of the thesis depends on circular evidence (quite common in the Aryan debate): thus, "We have argued that the Ghaggar system was already defunct in the Ṛvedic times" (Kochhar, 2000: 129); the date of the Rigveda is imposed as 1500 BCE or later, so that the impossibility of identifying the Vedic Sarasvati with a "defunct" Ghaggar follows — the conclusion is built in the premise.

(3) Assuming that the Aryans nevertheless migrated into the Indus plains from Afghanistan at some point, would they have been foolish enough to wait until they reached a defunct river to name it "Sarasvati," when they could have so renamed instead the Indus itself or any of its five tributaries encountered in their eastward migration? If they wanted to honour the memory of a Sarasvati left behind, would they have chosen a respectable flowing river or a "defunct" one? Or were they perhaps victims of a mirage in the Thar Desert? We get no answers to these questions (and a few more), which expose the internal contradictions in the "Afghan Sarasvati" thesis.

Recent Research on the Sarasvati

Leaving aside the controversy, several scientific disciplines have had their say in recent decades. Since the 1970s, satellite imagery has proved to be a useful tool in delineating the numerous palaeochannels of the Ghaggar–Hakra system, with the limitation that it cannot supply dates for their desiccation. Nevertheless, it can contribute much to our understanding of the region's hydrology. A recent case is a recent remote sensing study (Orengo and Petrie, 2017): processing 1711 multi-spectral images taken by Landsat 5 satellites over 28 years, it brings to light "an unsuspectedly complex palaeo-river network comprising more than 8000 km of palaeo-channels." The study's conclusions included a series of cautionary statements:

> Given the complexity of the hydrological system, the variety in the climatic and weather system of this region, and the diversity of ways that ancient populations are likely to have obtained water, it is unwise to use the date of occupation at specific settlements to date when specific channels carried water. ... The factors influencing water availability along the Ghaggar–Hakra basin are much more complex than previously thought. The traces of palaeo-rivers that have been identified cover the entirety of the landscape in the northern sector forming an almost continuous parallel pattern, which points to the changing nature of these channels and the likelihood that floods and river avulsions have been a relative common occurrence. The waters feeding the various palaeo-rivers originated from glacier-fed sources, such as water supplying the various palaeo-rivers related to the Sutlej, which appear to include the main Ghaggar–Hakra channel, as well as monsoonal rain which is likely to have contributed to both perennial and ephemeral rivers. ... All these factors join to create an extremely complex picture in which water availability and location is dependent upon a multiplicity of factors and difficult to predict in the long term. (Orengo and Petrie, 2017: 16, 17)

This insistence on the complexity of the Sarasvati river system and its decline is welcome; nor is it really new: a few earlier studies, including some based on satellite imagery, had highlighted it too (e.g., Danino, 2010: 72, 282). However, Orengo and Petrie added a degree of precision as well as a stimulating discussion on the system's interaction with the Harappan Civilization.

In the last decade or so, a number of geology and river studies have thrown new light on the

system's evolution and collapse, though at times with contradictory findings, which is unsurprising given the contributions the Ghaggar system received from four possible sources at different epochs: the Sutlej or a branch of it in the west; the Yamuna or a branch of it in the east; glacial sources from the higher Himalayas (as maintained by a few early studies: Puri, 2001, 2008; Valdiya, 2013, 2017); and a number of smaller rivers, perennial or not, flowing down from the Shivaliks in the Yamuna-Sutlej interfluves, such as the Dangri and the Markanda.

Without going into a full discussion here, let us look at the chief results of a dozen studies published in the last decade, following a chronological order and limiting ourselves (with one exception) to the upper and central course of the Ghaggar; a few recent studies of the Rann of Kachchh, where the Hakra once upon a time debouched, are therefore not included here.

- Saini et al. (2009) found "channel activity during the mid-Holocene ... in a part of the Haryana plains" and a "second fluvial phase ... represented by a palaeochannel segment whose signatures are dated between ~ 6.0 and ~ 2.9 Ka," i.e., between 4000 and 900 BCE ("Ka" or "ka" refers to "kilo-annum" or a thousand years; for the benefit of general readers, I have often converted this date format into "BCE" years, which stands for Before Common Era. The other common scientific abbreviation is "BP", or Before Present). Since the said palaeochannel runs very close to the current Ghaggar, its window of activity, which brackets the Indus Civilization, suggests that the Ghaggar had partly revived or was somehow persisting in that period. Two of the authors (Saini and Mujtaba, 2010) confirmed these findings in a study of the same palaeochannel published the next year, which concluded that "the channel received enough water supply between 5.9 and 4.3 ka ago, and even before," i.e., between 3900 and 2300 BCE, after which date "the river got starved of regular water supply, became sluggish and finally dried up." These dates would still cover the Early Harappan as well as much of the Mature Harappan phases.
- Kshetrimayum and Bajpai (2011) conducted a geoelectrical resistivity survey of the area between the Markanda, a major tributary to the Ghaggar system, and the Sarsuti. Their study revealed extensive water-bearing "buried sand channels" composed of coarse sand with gravel (at a depth between 10 and 100 m) and fine sand (beyond a depth of about 45 m), extending laterally over some 12 km and connecting the Markanda river with the Sarsuti (which the authors identified with the Vedic Sarasvati).
- Clift et al. (2012) dated zircon sand grains from trenches and drilled cores at four sites in Cholistan. By comparing the zircon grains with those from other regions, the geologists concluded that the Yamuna once flowed into the Ghaggar-Hakra, but switched eastward tens of thousands of years ago; the Sutlej also contributed to the Ghaggar system but abandoned it 10,000 years ago or earlier. As a result, any drainage capture affecting the Ghaggar system "appears to have occurred prior to human settlement and not to have directly caused the Harappan collapse." This broad conclusion will be confirmed by several of the subsequent studies, as we will see.
- Giosan et al. (2012) led a more comprehensive study, which rejected the possibility that "large glacier-fed Himalayan river watered the Harappan heartland on the interfluve between the Indus and Ganges basins"; instead, it proposed that "only monsoonal-fed rivers were active there during the Holocene." In particular, "rivers were undoubtedly active in this region during the Urban Harappan Phase." Indeed, the study found "sandy fluvial deposits approximately 5,400 [years] old at Fort Abbas in Pakistan [in Cholistan], and recent work on the upper Ghaggar–

Hakra interfluve in India also documented Holocene channel sands that are approximately 4,300 [years] old," that is, during the Harappan urban phase. In a later comment, the lead authors clarified, "Our research points to a perennial monsoonal-fed Sarasvati river system with benign floods along its course" (Giosan et al., 2013). The Ghaggar–Hakra was thus active during the urban Harappan period, although, according to the study, no longer fed by glacial sources: "Reliable monsoon rains were able to sustain perennial rivers earlier during the Holocene, [which] explains why Harappan settlements flourished along the entire Ghaggar–Hakra system without access to a glacier-fed river" (Giosan et al., 2012).

- The next year, a geoelectric resistivity study (Sinha et al., 2013) offered "stratigraphic evidence that a palaeochannel exists in the sub-surface alluvium in the Ghaggar valley. The fact that the major urban sites of Kalibangan and Kunal lie adjacent to the newly discovered subsurface fluvial channel body ... suggests that there may be a spatial relationship between the Ghaggar–Hakra palaeochannel and Harappan site distribution." Although a reliable dating of this buried water-bearing sand body was beyond the study's scope, its importance lay in firmly establishing the presence of such subsurface water-saturated sand bodies (detected earlier, though much less precisely, through surface surveys, open wells, tubewells, satellite imagery, etc.). This was independently confirmed by a careful isotopic study of sediments, which found them to represent "buried channel sand bodies ... deposited in the Ghaggar Plains through a large river system possibly originating in the Higher Himalaya ... [and] overlain in recent times by the finer sediments deposited by the present-day Ghaggar river" (Singh et al., 2016: 95, 98).
- In one of the most data-rich studies, Singh et al. (2017) investigated a palaeochannel of the Sutlej, which connected it with the Ghaggar system, and the main Ghaggar palaeochannel itself. Dating sand grains through optically stimulated luminescence (OSL), the study showed that the "flow of the Sutlej in this course terminated considerably earlier than Indus occupation, with diversion to its present course complete shortly after ~8 ka," i.e., 6000 BCE. Afterwards, "the Sutlej has remained trapped in an incised valley and has not revisited its former Ghaggar–Hakra course." This statement is however problematic, as there is some historical evidence of occasional connections between the Sutlej and the Ghaggar even in medieval times (Danino, 2010: 46). Be that as it may, the authors observe that "the persistence of fine-grained fluvial sedimentation in the Ghaggar–Hakra incised valley during the mid-Holocene demonstrates that Indus urban settlements in the region were likely sustained by monsoon-fed fluvial activity," but consider it unlikely that such a monsoon-fed river flow could have been perennial in Mature Harappan times, as proposed by Giosan et al. (2012). The picture they propose is therefore one of a much reduced, at best seasonal Ghaggar system, which, though "counter-intuitive," would have in fact been more conducive to the establishment of Harappan settlements, in their opinion. They boldly conclude, "It was the departure of the river, rather than its arrival, that triggered the growth of Indus urban settlements here," and opine that Harappan urban settlements in the region were not "necessarily co-located with the Ghaggar–Hakra palaeochannel," citing the case of Rakhigarhi, a large Harappan city in Hisar District of Haryana. I will discuss this last point as well as the question of perenniality of the Ghaggar when we come to the last study discussed here (Dave et al., 2019).
- Another 2017 study, going by the date of its preprint (Durcan et al., 2019), sampled eleven locations in the lower Ghaggar basin, mostly in Rajasthan, and dated their sediments through OSL. It found "fluvial deposition which mostly pre-dates 5 ka, although fluvial deposits are

detected in the Ghaggar palaeochannel at 3.8 ka and 3.0 ka [1800 and 1000 BCE, post-dating the decline of urbanism." This points to occasional revivals of the Ghaggar, though probably weak ones (some are described as "low energy, possibly ephemeral flooding or ponding"). This was confirmed by samples from the channel adjacent to Kalibangan and further downstream, which evidenced some fluvial activity around 1000 BCE (earlier periods are not available for these samples). However, three locations sampled from "the tributary to the south of the main Ghaggar–Hakra palaeochannel and to the east of Kalibangan" came up with dates of fluvial activity about 6500, 4300 and 4500 BCE, the last two dates ushering in the Early Harappan phase; this palaeochannel, interestingly, is not the main Ghaggar channel but probably a branch of the Chautang river (commonly identified with the Drishadvati of Vedic literature), which, when the whole system was active, flowed south of the Ghaggar (the Sarasvati), joining it just upstream of Suratgarh (Fig. 8.4). This study, too, emphasized the complexity of the region's hydrology, observing for instance that "thicker units of fluvial sediment are deposited in the early Holocene, although in the sediments sampled, there is no statistically significant change in particle size which can be used to infer a weakening of fluvial transport energies with time."

- Chatterjee (2017: Chapter 3 of his PhD thesis) sampled sub-surface sand bodies present beneath the modern Ghaggar alluvium along a 250-km stretch down to Anupgarh, encountering "layers of sub-surface grey micaceous sand body all along the Ghaggar flood-plain." This grey micaceous sand has long been identified as originating in the Higher Himalayas, as it is not present in the Shivaliks; it thus points to glacial sources, which several studies consider must have stopped by 6000 BCE at the latest, if not much earlier (Clift et al., 2012; Giosan et al., 2012; Singh et al., 2017; Dave et al., 2019). Chatterjee got the following OSL dates for this "sand horizon" (rounding off and omitting margins of error): about 36,000 years ago between Hanumangarh and Kalibangan; about 19,000 years ago just north of Kalibangan; however, a sample at Hanumangarh returned much more recent dates of about 3400, 4000 and 6500 BCE. "And at Anupgarh a colony of fresh-water bivalve shells was encountered embedded *in situ* within this micaceous grey sand layer"; since shells contain carbon, they are a good proxy for C14 dating, and yielded dates of about 4000 BCE, which "can be considered as the depositional age of the fluvial sand horizon." This is in tune with the Hanumangarh sample. Chatterjee conducted an isotope study of sand samples of different ages and concluded that "the white micas of the Ghaggar alluvium were derived from the Higher Himalaya." Aware that such late dates for Higher Himalayan contributions clash with the results of other studies, he "hypothesise[s] that some distributaries of the Sutlej could have been flowing into the paleo-Ghaggar during the mid-Holocene (>6 ka [before 4000 BCE]), which later migrated away making the Ghaggar an ephemeral river."

- In this study, Chatterjee and Ray (2018) analyzed not only sediment samples from the Ghaggar, but also, probably for the first time, material used in the manufacture of Mature Harappan pottery from Kalibangan, going by the reasonable assumption (corroborated in the study) that clay and sand used in this pottery originated locally. Both proxies were dated through OSL. The sediment samples' chronological horizon showed that "the Ghaggar had changed from a glacier fed strong fluvial system to a rain fed alluvial river during the Holocene," while there was "a clear absence of any grey micaceous sand component within the pottery, which ... implies that by the time the Mature Harappans settled in Kalibangan, the glacial connection to the Ghaggar was significantly reduced and little sediment originating from glaciated terrains was depositing in the channels."

The study's overall conclusion was that "the Ghaggar had already transitioned from being a glacier-fed river to a rain-fed river during the Mature Harappan period."

- In an extension further east of Sinha et al.'s earlier study (2013), Khan and Sinha (2019) conducted a geophysical survey of the upper Ghaggar, studying palaeochannels that connect the Yamuna with the Ghaggar system through resistivity soundings as well as well logs. Those "palaeo-Yamuna" channels had long been traced through remote sensing and are part of the Chautang system. In a fine confirmation, the study evidenced wide subsurface sand bodies at a low depth (10 to 20 m) and typically 30 to 50 m thick. These huge sand bodies saturated with fresh water are best explained as "deposits of a large river system" which once connected the Yamuna with the Ghaggar system. Khan and Sinha noted, "A dense concentration of Harappan sites has been documented in the Jind and Hisar districts of Haryana and further west in the Ganganagar district of Rajasthan, and this can only be explained if the Yamuna once flowed through these southwesterly flowing palaeochannels. ... The palaeo-Yamuna does represent the courses of a major feeder to the Ghaggar–Hakra system (Sarasvati) as suggested by thick sand bodies." This might be taken to mean that these palaeochannels were active, at least partly so, in the Harappan period, but the authors note further on: "The avulsion/abandonment of the Yamuna to the east and the Sutlej to the west were nearly contemporaneous," both phenomena occurring at least 5,000 years before the Mature Harappan phase. So were the new study's palaeochannels active, partially active, or dry during that Mature phase? Khan and Sinha suggest that this issue will be clinched once they publish "chronological data from the palaeo-Yamuna cores," which is under preparation. In any case, "the channel was nearly contemporary with the Ghaggar-Hakra channel flowing to its west and they together formed a large river system that was abandoned more than ~ 8–10 ka ago." Interestingly, earlier studies have suggested that the Yamuna was flowing eastward into the Gangetic plains much earlier, possibly 30 to 50,000 years ago (Srivastava et al., 2006: 128; Tandon et al., 2006: 21; Clift et al., 2012: 213); if so, a westward contribution of the Yamuna to the Ghaggar system prior to 6000 BCE would imply a bifurcation of the river after it reaches the plains. In this context, the author's observation, "It is even possible that such 'flipping' [of the Yamuna from its old westward course to its new eastward course] may have happened episodically" takes on a special significance, as our understanding of the Chautang's fluvial history would largely depend on a more precise documentation of those "episodes."
- One of the latest and data-rich studies in the field (Dave et al., 2019) concludes that "all the major rivers of Himalayan origin ceased to flow through this region before the Holocene, and certainly well before the Harappan culture." While this statement may well be correct—although not all of the above studies agree with it, as we saw—the next statement that "The landscape since then [the Harappan period] has remained largely unchanged" is problematic for two reasons:

  (1) There is considerable palaeoclimatic evidence from many studies to the effect that the Northwest's climate in the Mature Harappan phase was wetter and its environment more congenial than they are today. This is independently established by the presence of rhinoceros bones at many Harappan and Chalcolithic sites in Gujarat and at a site in Rajasthan (Karanpura), today located on the edge of the desert (for references and a discussion, see Danino, 2016; Danino forthcoming-a). The "landscape" has certainly

changed; if this study finds that it has not, either there is a flaw somewhere in its data or methods, or its results have not been properly interpreted.

(2) Much like Singh et al. (2017) discussed above, the authors assert that most Harappan sites thrived without proximity to a "major perennial river," but do not offer reliable data to this effect—nor could they, as only a fraction of all Harappan sites have been properly surveyed and inventoried (hundreds of them are currently disappearing in Haryana and Punjab before having even been documented, owing to rapid urbanization and mechanization of agriculture). It is sobering to recall that "the locations of large numbers of sites that appear in many of the site registers are incorrect, and this makes it impossible to discuss past settlement and/or landscape dynamics on the plains of northwest India with any substantiation. It is also clear that many modern villages appear to overlie ancient sites, and that many sites have not previously been recorded" (Singh et al., 2010: 47). While it has long been known that many sites were indeed located away from major rivers, especially in the eastern region of the Harappan world, I suggest that this is mostly the case with smaller settlements; the larger urban centres, dependent as they were on trade in raw and finished goods, and therefore on river communication, did choose the proximity of sizeable river bodies. Indeed, the paper fails to mention the glaring cases of Mohenjo-daro, Lakhan-Jo-daro, Chanhu-daro, established on the Indus (with Mohenjo-daro enduring several floods as a result) or Harappa on the Ravi. In the Ghaggar basin, Rakhigarhi in southern Haryana, was located between what are today two palaeobeds of the Chautang river, close to their confluence; it is true that those channels' fluvial condition in Harappan times is unknown; however, a survey of Rakhigarhi's hinterland "potentially indicate[d] the existence of a large water course or canal that ran on an alignment close to Rakhigarhi" (Singh et al., 2010: 47), which a recent remote sensing study appears to confirm (Mehdi et al., 2016: 32 and Fig. 8.5). Some 50 kilometres away, Farmana, the second largest urban centre in Haryana after Rakhigarhi, reported no wells (Shinde et al., 2008: 5) or reservoirs; however, reports of palaeochannels in its vicinity remain too vague to be of any use. Proximity to the Ghaggar proper was certainly the case of Kalibangan, Banawali and Bhirrana, at least, all of which were on the banks of the river or its channels. The authors of the study only discuss the case of Kalibangan, and observe: "... it is still unclear how the sites between 73° and 75° E, like Kalibangan, survived and flourished without a perennial water source. It seems reasonable that the large urban centres utilized groundwater, as evident from the presence of wells at Kalibangan, and that people in these settlements practised water harvesting ..." But Kalibangan does not appear to have had enough wells to supply water to a population of a few thousands (recall Mohenjo-daro's 700 wells for comparison), and there is no evidence of water-harvesting on an adequate scale, since no reservoirs have been found. In other words, the study asks us to believe that the Harappans, invariably praised for their pragmatism, their planning and construction skills, were foolish enough (a trait they shared with the Aryans, apparently, see above) to build cities on the banks of defunct rivers, with entrances into fortified areas facing a dry riverbed, as would be the case at Kalibangan and Banawali at least. This architectural feature alone is enough to establish that there was a flowing river in Mature Harappan times; otherwise, those cities would have been unsustainable as trading centres—yet Kalibangan saw a continuous occupation during the Mature phase, for "over half a millennium" (Lal et al., 2003: 3).

Meandering thoughts

Nevertheless, accepting that that river had lost its glacial sources by then, as most studies surveyed above argue, it follows that the Ghaggar was seriously diminished in Harappan times. Let us note, however, that this was actually advanced way back in 1993 not by geological studies but by Rafique Mughal's observations during his archaeological survey of Cholistan. Noticing the absence of Mature Harappan sites in a stretch of almost 100 kilometres close to the international border, where however Early Harappan sites were present, Mughal concluded, "Archaeological evidence now available overwhelmingly affirms that the Hakra was a perennial river through all its course in Bahawalpur during the fourth millennium B.C. (Hakra Period) and the early third millennium B.C. (Early Harappan Period)" (Mughal, 1993: 94). According to him, two events must have occurred shortly before the start of the Mature phase: the capture of the Chautang by the Yamuna, depleting the Ghaggar upstream, and the drying up of a channel of the Sutlej feeding the Hakra close to the international border.

Mughal's view of a still vigorous Ghaggar prior to c. 3000 BCE is not too far from Chatterjee's findings (2017) of Higher Himalayan contributions up to c. 4000 BCE. And of course, his inference of a weakened Ghaggar–Hakra in Mature Harappan times is compatible with most of the above recent studies (e.g., Saini and Mujtaba, 2010; Giosan et al., 2012; Chatterjee; 2017), except those (e.g., Singh et al., 2017; Dave et al., 2019) that insist that the river was either dry or, at best, seasonal. As we saw, not all studies tell the same story, and even those proposing a defunct Ghaggar disagree on the dates when the Yamuna's contributions ceased. The reason for such divergences lies, again, in the complexity of the phenomenons involved: avulsing rivers may or may not leave their old beds overnight, and even if they do, the deserted beds may occasionally be reactivated in feeble ways that are not easily detectable; so too, sediment records cannot easily distinguish between a seasonal and a modest but perennial river.

Proposed Main Stages for the Sarasvati River

The picture I propose has five main stages for the Sarasvati, which are as follows.

(1) A mega-river before 10000 or 15000 BCE, with major contributions from the Sutlej or the Yamuna, which does not mean that those two rivers fully flowed into the Sarasvati system (it would certainly not be the case with the Yamuna, at least).

(2) A river receiving Higher Himalayan contributions up to 4000 BCE (Chatterjee, 2017), though those contributions, whether from the Yamuna or the Sutlej, need not have stopped all at the same time: some of them may have done so much earlier, as suggested by several studies. It is also important to realize that depending on the region's tectonics, such contributions may have stopped in one channel but continued in another for a while, which would explain discrepancies between different studies, depending on which channels or locations they tested.

(3) After glacial sources were cut off, the river turned monsoon-fed but, thanks to a more vigorous monsoon and densely forested Shivalik slopes, was still of decent size during the Early Harappan phase (roughly, the fourth millennium BCE), allowing it to flow into Cholistan at least, as noted by Mughal (1993).

(4) The river's decline continued in Mature Harappan times (roughly, the third millennium BCE), a period of increasing aridity. Though diminished, it remained perennial in its upper and central reaches and flowed down to Anupgarh (close to today's international border), but rarely

beyond. It could also have received occasional contributions from the Sutlej and Yamuna through intermittent revivals of palaeochannels connecting those rivers with the Sarasvati system (see above, Durcan et al., 2019), while the main Sutlej and Yamuna were well established in their present courses. In particular, if, as seems to be the case, the Yamuna bifurcated while entering the plains, it could have continued contributing a small portion of its waters to the Chautang system.

(5) About 1900 BCE, at which time Mature Harappan sites are abandoned in the central basin of the Ghaggar, its retreat continues, leaving it as no more than a seasonal foothill river. Whether this new stage was caused by a sudden event (seismic or tectonic) or two centuries of drier climate—or possibly a combination of several such factors—cannot be firmly answered for the moment.

The above picture, admittedly hazy in its details, receives some support from the following argument: if the contention in a few studies above that the Ghaggar's decay was basically complete long before the urban Harappan phase, and therefore could not have caused its decline about 1900 BCE, were correct, it would be very difficult to account for the absence of Late Harappan sites from the Ghaggar's central basin, when many hundreds of them are found hugging the Shivalik's piedmonts (Fig. 8.5). Several studies have documented this absence (Joshi et al., 1984; Danino, 2010: 148–152; Gangal et al., 2010; Rajani and Rajawat, 2011; Giosan et al., 2012: E1690– E1692). A severe reduction of water resources — and therefore of the Ghaggar's course — seems the best explanation for this phenomenon, while the piedmonts would still have a number of minor streams flowing down, if seasonally, from the Shivaliks, which would be adequate to sustain the Late Harappans' rural lifestyle. In contrast, in the Punjab, Sindh and Gujarat regions, which did not experience such a hydrological collapse, Late Harappans often continued to live at the same locations as their urban predecessors.

Even once the Ghaggar–Hakra's hydrological history is well established in its main stages (which will require more multidisciplinary studies of its basin), a comprehensive correlation with the region's palaeoclimate and environment will remain to be done. A first promising step in that direction was made recently (Petrie et al., 2017); this study stressed again the failure of "simple" answers (i.e., the drying up of a river, or a severe drought) to account for the long tussle between resilience and adversity that the Harappans must have experienced. As always, the accumulation of data alone will ultimately paint the full picture.

As regards the "controversy" surrounding the Vedic river, allowing for some metaphorical inflation in the Vedic hymns, nothing in the recent research contradicts the river's break-up and gradual extinction as recorded in India's ancient literature. We are thus back to the original problem: If we accept the Vedic hymns' description of a river flowing from the mountain to the sea and located between the Yamuna and the Sutlej, the Ghaggar remains the sole candidate; but as we now know, this description can only apply to the early 3rd millennium BCE or earlier, an epoch that does not fit with the conventional scenario of a 2nd-millennium Aryan migration into India.

More importantly, perhaps, it is now clear that climatic, environmental and hydrological disruptions played a major part in the break-up of the Indus Civilization, among other possible factors. This holds a critical lesson for us today, when we have interfered with climate and environment—and, in India, our rivers—in a way the planet had never experienced earlier.

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