

## ***Interactive comment on “Hydrology and Water Resources Management in Ancient India” by Pushpendra Kumar Singh et al.***

**Pushpendra Kumar Singh et al.**

pradeep@civil.iisc.ernet.in

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### Response to the Reviewer's Comments

We thank the reviewer for the constructive comments and suggestions to improve the manuscript. We provide here our responses to the comments and mention the actions to be taken on the manuscript where relevant.

General Comment: The comments on the paper ‘Hydrology and Water resources Management in Ancient India’ by Pushpendra et al. Authors have made the efforts to bring out the state-of-the art on development of Hydrology and Water Resources in ancient India with reference to mechanism of rainfall and its measurements; Water management Technology and Waste Management Technology. The manuscript is well written

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and very interesting, which highlight the rich inheritance of India in Water resources management.

While going through the entire manuscript, I could observe that authors have brought out clearly the developments which took place in ‘Indus civilization’ during 3000 BC to 1500 BC, Vedic period between 1500 BC -500BC and Mauryan dynasty during 400BC to 184 BC.

Response: Thank you for the positive feedback.

Comment : The following points seem to be missing in the manuscript, though authors have highlighted the limitations in deciphering the literature at: Point No. (6) of the Summary and Conclusions.

Comment 1: In the manuscript, I could see the remains of ‘water resource Technology’ of earliest Harappan/Indus valley civilization are available at present. The description of Vedic period, which came afterwards are given in Vedas (text) only, their physical descriptions are not available at present though they came after Indus civilization. Are such Vedic descriptions pertain to the period much before Indus civilization?

Response 1: It is mentioned in the manuscript [page # 1; Line #12] that the Vedic Period followed the Indus Valley Civilization (IVC) period. More clearly, after the de-urbanization phase [~1900-1500 BC] of the IVC, the Vedic period came into existence and is generally bracketed between [~1500-500 BC] (Kathayat et al., 2017; Witzel, 2014; Sen, 1999).

Therefore, the beginning of the ‘Vedic Period’ in India is assumed at about ~1500 BC and the ‘Rigveda’ (the earliest of the four Vedas) and many other Vedic texts were composed in this period and in later periods (Kathayat et al., 2017; Sen, 1999; Witzel, 1997). With this, the Referee may also take note of the Response 10 C of the comment of Referee 1. [C-10 a] about the periods of the Vedic texts.

Along with this it would be also interesting to quote Kenoyer (2003) : “Our information

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is hampered by the fact that most of the Indus settlements dating to the 'Vedic Period' have either been destroyed by later erosion or brick robbing or are covered by continuous inhabitation, which makes excavation impossible". It needs to be noted that surprisingly, both Harappa and Mohenjo Daro also supported later settlements dating to this time, but these levels have been badly disturbed (Kenoyer, 2003).

Chronologically, followed by the fall of the IVC, the Vedic period can be further classified into two stages as : 'Early Vedic Period [~1500-1100 BC]' and 'Late Vedic Period [~1100-500 BC]' (Kathayat et al., 2017). Worth mentioning Witzel (1987 & 1999) that 'the Early Vedic period (as attested in the Rigveda hymns) was marked by tribal or pastoral societies, centered in the northern Indus Valley'. However, by the end of this period, the Vedic Society shifted from nomadic life to the settled agriculture with movements towards the east into Gangetic Plains. During the 'Late Vedic Period', the agriculture, metal, commodity production, and trade was largely expanded (Kathayat et al., 2017). After the 'Late Vedic Period' the period of 'Mahajanpadas' came into existence and finally converges into the 'Mauryan Empire'.

As for as the physical description of the 'water resources technologies' is concerned, we have elaborately discussed this in our manuscript at many places, e.g., [Page # 8; Lines: 271-300]. However, it would be appropriate to mention at this juncture that much more research is further needed for 'Vedic Period [1500-500 BC]' on various unexplored aspects of the Vedic Texts from Vedas to Puranas and many other Samhitas [see: Conclusion # 6; Page 14; Line # 502].

Comment 2: Also, the description of rainfall is available in Ramayana and Mahabharat. However, the period for which such descriptions are given in these literatures is missing. For example, Ramayana was scripted during 200 BC, but its description belongs to which period? Such description will be of much interest to readers from India.

Response 2: As observed by Goldman (1984), Brockington (1984, 2000) and Murthy (2003), the core of the epic Ramayana is as old as ~800-500 BC. The epic Ramayana

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is based on the ancient 'ballads/tales' handed down by the 'sutas' (hymns) from generations to generations and compiled between ~300 BC-200 AD by 'Valmiki' (Winternitz, 1996). Bhargava (1982) also mention that the original portion of the Ramayana was composed by the poet Vālmiki about a thousand years after the event on the basis of tales handed down by the hymns. The exact composition period is, however, largely differed by many authors (See, Sharma, 1990; Macdonnel, 1919; Keith, 1915). However, this topic is beyond the scope of this study.

Comment 3: Though the period of Indus valley civilization is mentioned in the literature, however, which ruler ruled that period, is not available. Further, what was the major reasons for collapse of Indus valley civilization? Was it water crisis which led to ruin of entire civilization? The description like Maurya dynasty seems to be more appealing.

Response 3: Thank you for this comment, The 'single state' concept was not applicable to the any of the cities of the Indus Valley Civilization, as do we have for the other contemporary civilizations such as Mesopotamia, i.e., the evidence of centralized control such as the palaces, temples and differentiated burials (Kenoyer, 1994; Possehl, 1998, 2003). The Indus society was based on the shared concepts of power and dominance and the military conquest pattern has not been found in the Indus Valley Civilization (Kenoyer, 2003). However, more information will be available to the world once the linguists are able to decipher the Harappan script as 'inscribed' on the seals, amulets and pottery vessels (Kenoyer, 2003).

Major reasons for collapse of Indus valley civilization (IVC):

Many factors - including climatic, economic and political - have been cited in the past as reasons behind decline of IVC. However, no single explanation can be thought of to be the sole descriptor of this decline. These factors perhaps concatenated to eventually led to the fall of IVC.

Climate Change: The dry epoch that lasted for about 900 years due to weakening of Indian Summer monsoon (around 4350 years ago) adversely impacted the agrarian

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society of IVC (Das, 2018; Dixit et al., 2014). The period of long dry spell reduced the snow cover in northwest Himalaya, causing reduced water availability in Indus river (Dutt et al., 2018; Kathayat et al., 2017). The reduction in water availability severely impacted agricultural systems (Sarkar et al., 2016) and production which ultimately lead to the migration of population towards Gangetic plains.

**Infectious Diseases:** The vulnerable state of Harappan society is compounded by concurrent social and economic changes, promoting further disintegration of IVC. The stratified social structure and urbanization facilitated propagation of infectious diseases (leprosy, tuberculosis) within the marginalized population. These factors led to massive migration of population from Indus Valley around 1900 B.C. (Schug et al., 2013).

**Natural Disasters:** The presence of silt deposits, topographic and geological anomalies suggest the occurrence of massive floods was related to the decline of IVC. The tectonic disturbances might have altered the course of Indus river affecting the water availability for agricultural production (Dales, 1966).

#### References:

Bhargava, P.L.: A Fresh Appraisal of the Historicity of Indian Epics. *Annals of the Bhandarkar Oriental Research Institute*, 63(1/4), pp. 15-28, 1982.

Dales, G. F.: THE DECLINE OF THE HARAPPANS, *Scientific American*, 214(5), 92–101 [online] Available from: <https://www.jstor.org/stable/24930939> (Accessed 11 July 2020), 1966.

Das, B.: A prolonged drought destroyed Indus Valley Civilization, new study says, *Nature India* [online] Available from: <https://www.natureasia.com/en/nindia/article/10.1038/nindia.2018.61> (Accessed 11 July 2020), 2018.

Dixit, Y., Hodell, D. A. and Petrie, C. A.: Abrupt weakening of the summer monsoon in northwest India ~4100 yr ago, *Geology*, 42(4), 339–342, doi:10.1130/G35236.1, 2014.

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Dutt, S., Gupta, A. K., Wünnemann, B. and Yan, D.: A long arid interlude in the Indian summer monsoon during 4,350 to 3,450 cal. BP contemporaneous to displacement of the Indus valley civilization, *Quaternary International*, 482, 83–92, doi:10.1016/j.quaint.2018.04.005, 2018.

Kathayat, G., Cheng, H., Sinha, A., Yi, L., Li, X., Zhang, H., Li, H., Ning, Y. and Edwards, R. L.: The Indian monsoon variability and civilization changes in the Indian subcontinent, *Science Advances*, 3(12), e1701296, doi:10.1126/sciadv.1701296, 2017.

Keith, A.B.: The Date of the Ramayana." *Journal of the Royal Asiatic Society*. pp. 318-321., 1915,

Kenoyer, J. M.: *The Harappan state: was it or wasn't it*, Madison, WI: Prehistory Press., 1994.

Kenoyer, J. M.: Uncovering the keys to the lost Indus cities, *Scientific American*, 289(1), 66–75, 2003.

Macdonell, A.A.: Ramayana." *Encyclopedia of Religion and Ethics*, Vol- 10, edited by James Hastings, Edinburgh: T. & T. Clark, pp. 574-578, 1919.

Murthy, S.S.N.: A Note on Ramayana. *Electronic Journal of Vedic Studies*, 10(6), pp. pp. 1-18. © ISSN 1084 -7561, 2003.

Possehl, G. L.: Sociocultural complexity without the State. *The Indus Civilization, in Archaic states*, vol. School of American Research advanced seminar series, edited by G. M. Feinman and J. Marcus, pp. 261–291, School of American Research Press, Santa Fe, N.M., 1998.

Possehl, G. L.: The Indus Civilization: an introduction to environment, subsistence, and cultural history, in *Indus ethnobiology*, edited by S. Weber and W. Belcher, pp. 1–20., 2003.

Sarkar, A., Mukherjee, A. D., Bera, M. K., Das, B., Juyal, N., Morthekai, P., Deshpande,

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R. D., Shinde, V. S. and Rao, L. S.: Oxygen isotope in archaeological bioapatites from India: Implications to climate change and decline of Bronze Age Harappan civilization, *Scientific Reports*, 6(1), 26555, doi:10.1038/srep26555, 2016.

Schug, G. R., Blevins, K. E., Cox, B., Gray, K. and Mushrif-Tripathy, V.: Infection, Disease, and Biosocial Processes at the End of the Indus Civilization, *PLOS ONE*, 8(12), e84814, doi:10.1371/journal.pone.0084814, 2013.

Sen, S. N.: *Ancient Indian history and civilization*, New Age International., 1999.

Winternitz, M. A.: *History of Indian Literature*, Motilal Banarsidas, Delhi 1996 (reprint).

Witzel, M.: Central Asian roots and acculturation in South Asia: linguistic and archaeological evidence from Western Central Asia, the Hindukush and northwestern South Asia for early Indo-Aryan language and religion, in *Linguistics, archaeology and the human past*, edited by T. Osada, pp. 87–211., 2005.

Witzel, M.: *The Development of the Vedic Canon and its Schools : The Social and Political Milieu*", Harvard University. pp. 261–264, 1997.

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Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, <https://doi.org/10.5194/hess-2020-213>, 2020.