

A Study of Palaeo-channels and Lost Rivers of Desert Areas in Gujarat and Rajasthan Using Remote Sensing and GIS

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ABSTRACT

In this paper we have prepared the maps of Palaeo-channels of rivers of Kachchh region of Gujarat. One can easily detect Palaeo channels in the Kachchh region of Gujarat as many rivers from Punjab, Rajasthan and J&K were flowing in this region. There are literature evidences and local stories that the people travelled using boats in these rivers and there were tax collection centers on the banks of these rivers. Kachchh was the entry gate to Sindh. Sindh was one of the most prosperous regions once upon a time as there were riverine ports which had enormous import and export activities. But, due to tectonic activities the rivers of western India shifted their courses westwards. Hence many rivers originating from Himalayas flow from Punjab to present day Pakistan. There were mighty rivers like Saraswati flowing in this region. It is also said that the culture flourished on the banks of Indus and Saraswati was known as Sapt-Sindhu Civilization. In this paper, we have tried to map the route of the Palaeo channels that flows through the desert areas of Rajasthan and Gujarat.

Keywords: Kachchh, Palaeo Channels, Sapt-Sindhu Civilization, Saraswati, Sindhu, Thar Desert.

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INTRODUCTION

Palaeo-channels are deposits of unconsolidated sediments or semi-consolidated sedimentary rocks deposited in ancient, currently inactive river and stream channel systems. These are typical riverine geomorphic features in a location representing drainage streams, rivers, rivulets which were flowing either ephemeral or perennial during the past time and now stands either buried or shifted due to tectonic, geomorphologic, anthropogenic process/activities, as well as climatic changes. When a channel ceases to be part of an active river system, it becomes a Palaeo-channel. (Singh *et al.*, 2011).

According to Agarwal and Singh (2007) and Tripathi *et al.*, (2004) There are many ancient rivers in India that can be considered as holy in ancient times but now they are disappeared due to reasons for the rapid growth and urbanization. Rivers like Saraswati, Ghaggar-Hakra, Markanda, Dongri, Luni, Saragmati, etc. these rivers flow between the Gujarat and the Rajasthan state which are now considered as the lost rivers or the dried-up part of it, even though Ghaggar and Hakra and become small seasonal rivers before Vedic times.

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A Palaeo-channel is distinct from the overbank deposits of currently active river channels, including ephemeral water courses which do not regularly flow. A Palaeo-channel is distinct from such watercourses because the riverbed is filled with sedimentary deposits which are unrelated to the normal bed load of the current drainage pattern. Many Palaeo-channels are arranged on old drainage patterns which are distinct from the current drainage system of a catchment. Palaeo-channels can be most easily identified as broad erosional channels into a basement which underlies a system of depositional sequences which may contain several episodes of deposition

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and represent meandering peneplains. Thereafter, a Palaeo-channel may form part of the regolith of a region and, although it is unconsolidated or partly consolidated, is currently part of the erosional surface. Palaeo-channels form due to an equilibration of a river with its erosional level, whereupon the net transport of sediment balances erosion. Palaeo-channels are not necessarily permanent; it is possible for them to become eroded via reactivation of erosional activity or reactivation of the original river system. They form due to an equilibration of a river with its erosional level, whereupon the net transport of sediment balances erosion. Palaeo-channels form by palaeo-valleys and erosional channels in basement becoming filled with sediment. For longer preservation, Palaeo-channels must have the source of river flows removed, either via a river changing course, climate change strangling inflows into the catchment, or perhaps faulting or tectonic movements altering the dynamics of a river system and/or its flow direction ("Palaeo-channels").

The main objectives of this study are to identify the lost rivers that were present in ancient Vedic times and has been mentioned in many literatures. The main source of study is remote sensing technology by which it become possible to

identify palaeo channels through image analysis via satellite-based programmes.

Map 1 depicts that the course of Paddhar River which was flowing near Radhanpur of present day in Patan district, was coming from Jodhpur Rajasthan to the Gulf of Kachchh and passing through the present-day area of Little Rann of Kachchh (Map published in 1794).

Map 2 displays that the Saraswati River was coming to Great Rann of Kachchh and taking turn towards south-east direction and through the Little Rann of Kachchh it was meeting Arabian sea via the Gulf of Khambhat.

As per historical evidence, Saurashtra was an island in the 2nd millennium BC. Kachchh also was an island up to 18th century AD and ships were playing in the present Rann area. It is found from literature that Thirpur Nagar, the present Tharad of Banaskantha district, was a prominent Hindu and Jain centre from the Rajput period onwards. A picture in one of the manuscripts written by Kalyansekav Dhanya kumar shows Tharad as a port. There are some scattered references to navigational activities during the Solanki period also. Here map 3 depicts that Siddharaj Jaysinh



Map 1: The Green color indicates the course of Paddhar river flowing from Rajasthan and Gujarat state (*Source: antiquemaps.com)



Map: 2 Course of Saraswati (*Source: S.P. Das Gupta 2003)

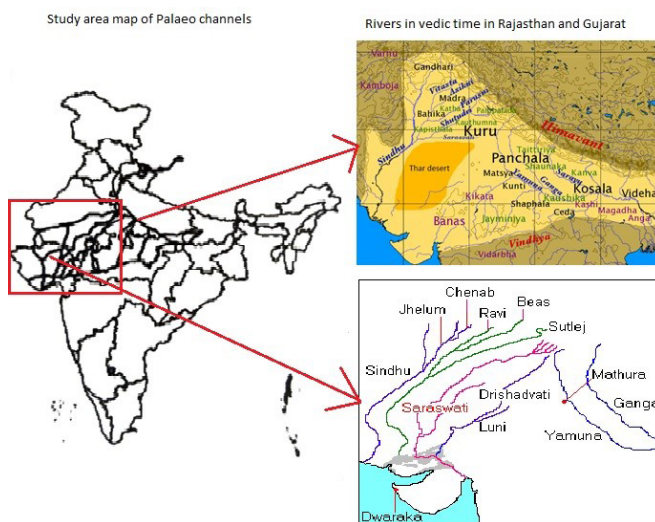
visited Varahi of Santalpur taluka, Banaskantha district in a chariot and handed over the chariot to the mahajana of Varahi town to take care and went to Sanchor by ship and boat from Varahi (Prabandh Chintamani). It is said that the old name of Varahi was Fabava or Fabavah (port). There was a flourishing wooden shipbuilding industry in Gujarat at Mandavi, which played a significant role in shaping the destiny of nations, which ventured across the seas to extend their influence. Historical evidences show that the Rann of Kachchh was once a Gulf and was suitable for shipping and up to the seventh century ships were plying in this area.

STUDY AREA

The area of study is northern and North western parts of Gujarat and some deserted areas of Rajasthan in which the flow of the Palaeo channels can be detected easily from Rajasthan to Gujarat state. In Gujarat, Kachchh region is used for mapping because it covers the whole desert region of Gujarat state. The rivers that previously flown from this region or are currently flowing through this region or is completely lost Palaeo channels are taken into consideration in the present study. The maps of palaeo channels of Brahmini, Khodasar, Banas, Rupen,



Map 3: Historical travel of King Siddharaj Jaysinh across the river Paddhar whose course is visible in the satellite image (*Source: - Vedic Saraswati River pg no. 178)



Map 4: Flow of the river Saraswati from Tibet to Gujarat (Vedic Saraswati River pg no. 194)

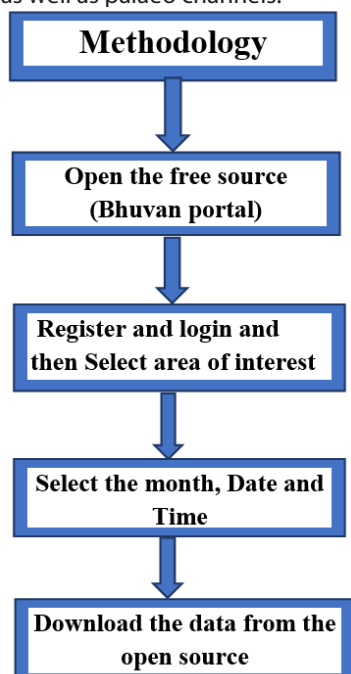
Saraswati, Karaswaai, Malan, Kankavati, Phulkaand and Godra were prepared using Q-GIS.

According to Thakker (2013), map 4 shows that the Saraswati River originated in Tibet from Ganglanring Tso lake through Gaumukh following from Tibet, then it flows through Uttaranchal, Uttar Pradesh, Madhya Pradesh and Rajasthan and merge into Narmada River and also one channel enters in Gujarat into Bhadar river and moves towards Saurashtra Girnarin Sonrek river and may be again one channel enters into Prabhas region and flows in the Arabian sea. Another channel might meet Sabarmati River and must flow to the Gulf of Cambay in Gujarat. Apart from this one flow might enter in Pakistan region as Nabisar and entered in the Great Rann of Kachchh to Khadir Bet near Dholavira and passed through Great and Little Rann of Kachchh and entered Tarnetar as Nyankumati river and from there it might be entering in Ghaantvad and meet Gupt Prayag and finally entered the Arabian sea.

METHODOLOGY

It is a well-known fact that western rivers are shifting westwards and eastern rivers are shifting eastwards. It is also said that the rivers from 'Punjab and Kashmir' flowed via Rajasthan to Gujarat and emptied themselves in Gulf of Kachchh or Gulf of Cambay. There are literature evidences that Gurunanak Saheb travelled from Punjab to Kachchh using a riverine Boat/Ship and stayed in Lakhpat, Kachchh on his way to Mecca. There is evidence that once upon a time the area of Thar desert had big rivers like Indus and Saraswati. Then eventually due to tectonic activities, the rivers shifted westwards.

LISS-III and LISS-IV images were used to study and map the palaeo channels observed by visual interpretation on Q-GIS software. Remote Sensing images were interpreted on Q-GIS in the lab which is open-source GIS software. One-by-one subsets were created by providing the coordinates of rivers. Literature review was done to prepare the lists of rivers to study which has new channels as well as palaeo channels.



After downloading the data from the open-source file, layer stack the image by setting the spectral bands of the LISS 3 and LISS 4 images. Then start doing the interpretation on the area also by using the various snap tools and plugins we can easily identify the course of the rivers flowing through the various respective areas and at last we can easily map the course of the dried, lost or identify the present river in the desert areas of Gujarat and Rajasthan states.

RESULTS

The blue lines show the present-day rivers and dark blue color lines shows the Palaeo-channels observed in the study area. From the figure, it can be observed that the flow of the direction of present day river and the direction of the Palaeo-channel are different. It is also observed that at some places Palaeo-channels are diverted from the original path of the river which might have resulted in the formation of present-day rivers.

As seen in the above Figures 1.1 to 1.10 depicts the flow of the rivers that are flowing from Gujarat to Rajasthan state here these are the major lost rivers that are identify by using the R.S and GIS technology, they have now lost their course and further dried up by flowing. Figure 1.3 depicts the Banas river flowing from the Aravalli hills in the Rajasthan state found reaching to the Gujarat state.

As seen in the above figures there are ample sources of freshwater around and across Little Rann of Kachchh. It can also be seen that many of the rivers within or around Little Rann of Kachchh have either stunted flow or have changed their courses. The closest possibility for the changing of their courses can be directed towards geological reasons earthquakes/tsunamis or subsidence which might have taken place in the past. Such events might have altered the courses of these rivers and with passage of time some of these rivers might also have dried up due to changing of climatic conditions. One of the most important palaeo-channel being the one going right across the Rann into which once Saraswati and Rupen poured their waters into; Whose flow has been restricted at the periphery around the core of the Rann. Saraswati is believed to have 5 tributaries out of which one was named Nanda, which could be the reason for the naming of Nanda Bet.

DISCUSSION

Shukla Z., *et al.* in 2014 investigated that the Palaeo-channels are remnants of stream channels cut in older sediments and filled by younger overlying sediments representing the distribution of valley systems as these existed at given geological time in the past. Reconstruction of Palaeo-drainage network in Mainland Gujarat using remote sensing techniques has a societal relevance as the information is utilized as groundwater prospective zones and suitable sites for artificial recharge. River Saraswati originated in Himalayas and dried up during 2500-1500 BC, due to tectonic and palaeo-climatic changes. River is described as 'Ambitame, Naditame, Devitame' that is the best of mothers, best of rivers and the best of goddess and was the largest of the 7 rivers of their country. Thar desert region today does not show presence of any perennial river system or even of a major seasonal stream, except river Luni which mark the eastern limit of Thar desert and flows parallel

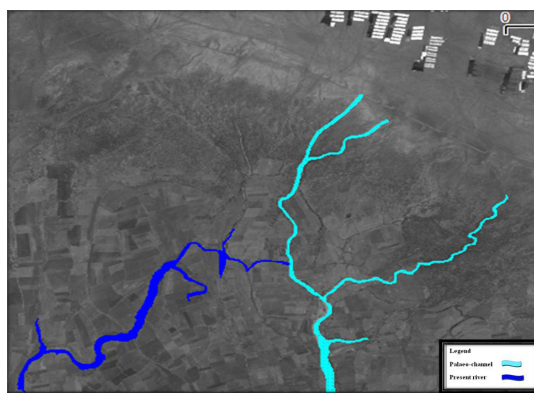


Figure 1.1: Brahmini and its palaeo-channels (Kachchh, Gujarat)

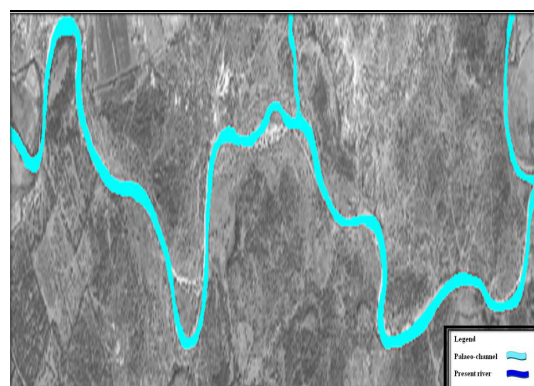


Figure 1.2: Khodasar and its palaeo-channels (Kachchh, Gujarat)

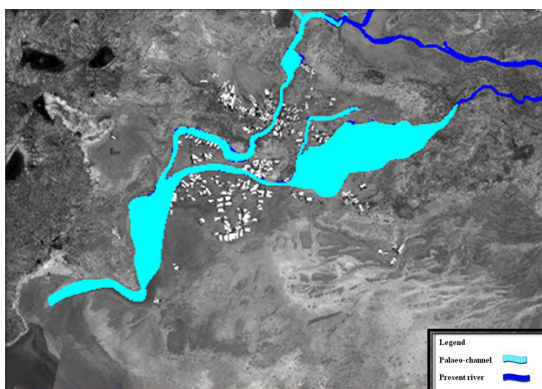


Figure 1.3: Banas and its palaeo channel/plain (Aravalli range, Rajasthan)

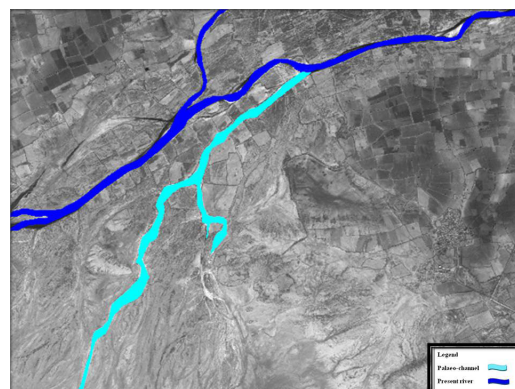


Figure 1.4: Rupen and its palaeo-channels (Taranga, Gujarat)

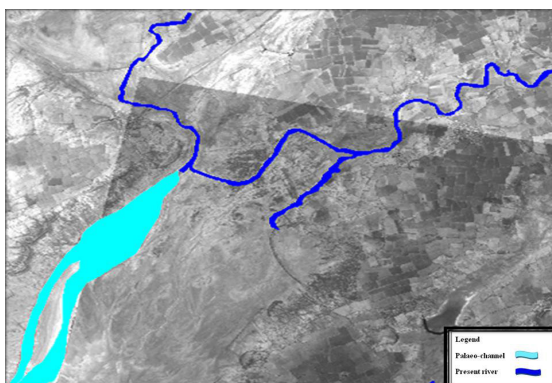


Figure 1.5: Saraswati and its palaeo-channel (Aravalli hill, Gujarat)

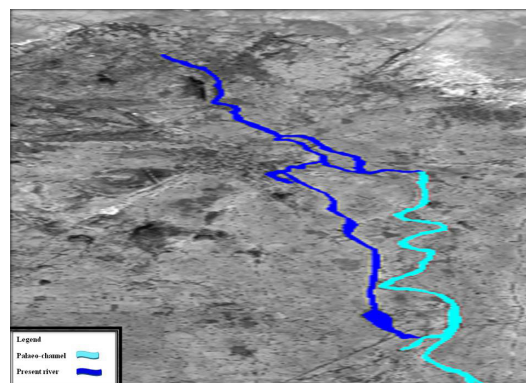


Figure 1.6: Karaswaai and its palaeo-channels (Known as Saraswati river, Aravalli hill, Gujarat)

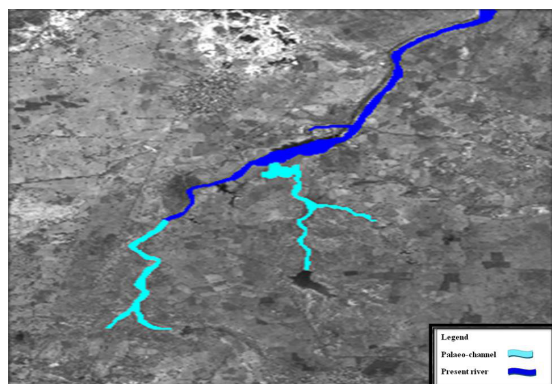


Figure 1.7: Malan and its palaeo-channels (Mordhara hills, Gujarat)

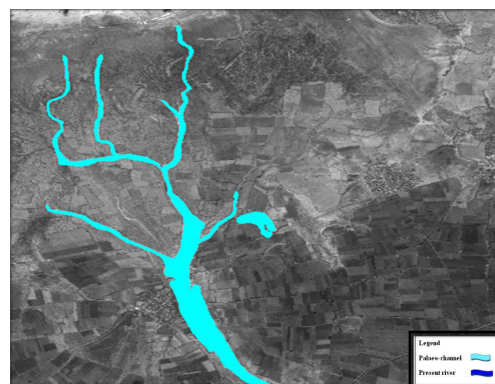


Figure 1.8: Kankavati its palaeo-channel (Bhilpur village, Gujarat)

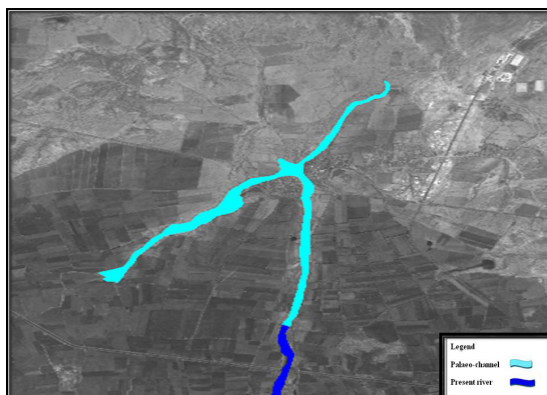


Figure 1.9: Godra its palaeo-channel
(Tributary of Saraswati River, Gujarat)

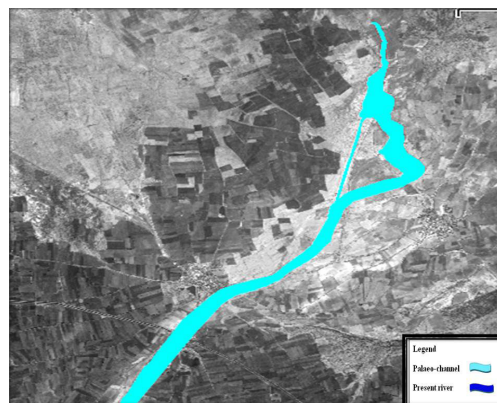


Figure 1.10: Palaeo-channel of Phulka
(Surendranagar, Gujarat)

to Aravali mountains. On the banks of this mighty river, once upon a time thrived a well-known major ancient civilization of the world “The Harappan civilization”, that occupied an area over 1 million square kilometers, more than 1200 settlements archeological sites of Harappan and other ages are discovered along the dried channels of River Saraswati. Study area forms the part of Thar Desert terrain that include parts of Rajasthan, Gujarat (Kachchh region), Haryana and Punjab states in NW India and part of Sindh and Bahawalpur Provinces in Pakistan (eastern part of the Indus River Basin).

Bajpai, *et al.*, in 2004 reviewed that the Luni River basin has been evolved because of typical hydro-geomorphic processes of arid zone, operating under the influence of active tectonic lineaments. A detailed analysis of stream morphology in relation to geology and lineaments conducted on selected windows indicated the morphological control of the streams while flowing over the lineaments from the eastern to the western part of the basin.

H.S Saini *et al.*, in 2020 studied that the buried course of the desiccated river Saraswati Ghagghar-Hakra from Himalayan front to Arabian Sea through the plains of NW India has been in discussion and scientific investigations since ~140 years due to its importance in societal evolution and drainage disorganization. Its plains were inhabited by the Harappan/Indus civilization (7000–1200BC) which collapsed around 4-3 ka BP. Views, both, in favor and against a relation between collapse of civilization and drying up of the Saraswati river exist. The palaeo course of this river, causes and timing of its drying and reasons of civilization collapse still elude consensus.

Sinha *et al.*, in 2013 studied that a major palaeo-river channel course, the Ghaggar-Hakra, flowed in the interfluvium between the modern Yamuna and Sutlej rivers in the western Ganges basin during the Late Quaternary. This Palaeo-channel course has been associated with extensive Bronze-age Harappan civilization archaeological sites that are located with the channel. A major problem with earlier interpretations has been that little information exists on the geology of the Palaeo-channel system. Electrical resistivity soundings were used to map the large-scale geometry and architecture of the Palaeo-channel system. A thick and extensive sand body is present in the subsurface in parts of north-western Rajasthan, Haryana, and Punjab. The dimensions of the Palaeo-channel bodies imply that these are the deposits of a large river system, though detailed sedimentological analysis

is necessary to validate this. Nevertheless, this study reports the first geophysical evidence for the subsurface geometry of the palaeo-Ghaggar-Hakra river system.

Tripathi *et al.*, in 2004 identified that the river along which the famous Harappan Civilization developed and the causes of the demise of this culture are topics of considerable debate. Many of the Harappan sites are located along the ephemeral Ghaggar river within the Thar desert in the northwestern India and adjacent Pakistan. The Ghaggar was also thought to be the mythical river Saraswati, which was described as glacial-fed river. Sr and Nd isotopic composition of the Ghaggar alluvium as well as Thar Desert sediments suggests a Sub-Himalayan sediment source, with no contribution from the glaciated regions. The development of extensive Harappan Civilization all along the Ghaggar suggests a catchment with high monsoon rainfall. It is likely that with the changes in the monsoon scenario after 3500 BC could have gradually dried up the Ghaggar river and resulted in the migration and/or extinction of the Harappan Civilization on this river.

Roy and Jakhar in 2001 studied that the several lines of geological evidence confirm the existence of a high-energy fluvial regime in western Rajasthan during the Late Quaternary period. Geomorphic description of the extinct river system matches well with the Saraswati River described so vividly in the Rig Veda. The vedic river which presumably flowed parallel to the Aravalli mountains during its initial stages, migrated westward during neotectonic uplift of the Aravalli mountains. The neotectonic movements, which brought about the down-sagging of the northern part of Aravalli mountains also forced the Yamuna River to swap its original course to flow across the flattened ‘mountain’. The river presumably pirated the Saraswati waters while it drifted eastward to join the Ganges.

Rajani and Rajawat in 2011 studied that a large number of remote sensing-based studies have shown evidence of a prominent river system, which has become buried under sand cover of Thar desert sometime during late Holocene. This major river has been identified as Saraswati, a legendary river mentioned in ancient Indian texts. Pattern of Palaeo-channels indicate westward migration of the Saraswati river in parts of Indus alluvial plain. Through this study it was found that there is a large spread of mature Harappan (2200–1700 BC) sites along the Palaeo-channel of the Saraswati and its tributaries in north-west India, but late Harappan (1700–1500 BC) sites are limited

to further west in adjoining regions of Pakistan indicating that the shift of cluster of settlements have followed the pattern of river migration towards west.

Singh *et al.*, in 1972 investigated that a series of radiocarbon determinations have been carried out of lacustrine deposits contained in three playa basins, namely at Sambhar, Didwana and Lunkaransar, in Rajasthan, in conjunction with stratigraphical and palynological investigations. It is revealed that the lake deposits, which overlie thick beds of sand at each site, date back from early Holocene times (ca. 10,000 B.P).

Singh and Sinha in 2019 studied that in the Indo-Gangetic plains (IGP), the inter-basinal area between the Ganga in east and the Indus in west is currently devoid of any major drainage. A wide Palaeo-channel belt, the Ghaggar-Hakra channel, has been mapped in this region. Their previous studies along with others established that a large Himalayan River flowed through this Palaeo-channel, and a large-scale drainage reorganization occurred during the last 10 ka.

Gupta *et al.*, in 2004 reviewed that the numerous studies have been carried out during last 20–25 years by different agencies to trace the courses of palaeo river Sarasvati. Varying number of courses of river Sarasvati have been suggested by the different workers in the north-western region. Taking advantage of the developments in satellite/ sensor and digital image processing technologies an attempt has been made to rediscover the course of river Sarasvati and solve the controversy regarding its exact course, in the sand covered Thar desert region. The findings raise the doubt that 'Rise along Delhi-Hardwar ridge' as suggested by earlier workers was the main cause for west-ward shift of Sarasvati River and ultimate drainage desiccation in the northwestern region. The analysis indicates towards rise in Himalayas/ Siwaliks and consequent displacements in the Siwaliks and its foothills region (in the form of Yamuna and Satlej tear faults) as the main cause for drainage desiccation and disappearance of river Sarasvati.

CONCLUSION

The development of civilization happened on the banks of rivers in India. We have pilgrimages on the banks of rivers. We worshipped rivers. In India, it is important to study palaeo channels if we want to understand the past of culture and civilization. In the present paper, we have detected 10 palaeo channels of 10 present-day rivers flowing in the desert region. River-geologists say that there is always water flowing underground a Palaeo channel. That is, Palaeo channels are always a good source of fresh water and never get vanished though the river gets vanished or change its course on the ground. The study of Palaeo channels can resolve the issue

of water in the study region. Many archeological sites might get detected if the Palaeo channels are studied using remote sensing. If dredging is done on a large scale in these palaeo channels, and these rivers get inter-linked then the farmers will not have to depend on the monsoon for cultivation and also the excess or lack of water can be overcome during flood or drought.

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