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RESEARCH PAPER

Theory of Adaptive Change (TAC): Understanding Origin of Agricultural Lifestyle in North-Western India

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North-western India is now emerging as one of those places where the transition(s) from hunting gathering to farming occurred indigenously, so it is feasible to observe the processual change within the region as a whole. This transformation which represents a profound social change is generally attributed to traditional climate forcing model leading to a collapse of foraging economies. This paper discusses that the origin of agricultural lifestyle in north-western India did not happen only because of the collapse of the foraging economies due to climatic factor but also because of the resilient cultural system they had.

Keywords: TAC; transition; hunting-gathering; Mesolithic; Chalcolithic; resilience; climate; western India

Introduction

Many times it is not enough to just look at facts and artifactual evidences but also to realize the thought process behind it, the choices made by people involved and also to try and analyze the progression of society. A lot of importance has been placed on Climate as being one of the major driving forces behind appearance and disappearance of different cultures or subsistence strategies. While this does hold true and the idea has gained a lot of credence in the academic circles, we must also try and look at socialistic ideas to understand human adaptive cycles.

One of the theory which is being actively used is the Theory of Adaptive Change (TAC) also known as Resilience theory to explain this transition to agricultural lifestyle. TAC grew out of the New Ecology, which has at its foundation in the principle that change is "neither continuous and gradual nor consistently chaotic but is episodic in nature" (Holling and Gunderson 2006: 26). The goal of the theory is to understand change in systems, and the primary unit for doing so is the adaptive cycle. The cycle consists of four phases organized in a figure 8 consisting of: growth, accumulation, restructuring, and renewal (Holling 2001). It is at once a measure of the capacity for change in a system and its degree of connectedness. Traditional ecology only recognized two of these phases, growth and accumulation. As theorized by Charles Redman (2005), this framework can potentially integrate a number of contrasting positions like agency, tradition, landscape, and ecosystem. Besides this possible application of social memory studies which has been implied loosely, but not examined thoroughly, might play a very substantial role in the sociocultural resilience within communities.

As of yet TAC probably has never been used in Indian Archaeology to address appearance or disappearance of any culture or subsistence strategy. Takamune Kawashima has also applied it to study Social change at the end of the Middle Jomon (Kawashima: 2013). Even in Levant it has been applied very successfully to explain Neolithic cultures (Rosen and Rivera-Collazo 2012: 3640–3645). It has also been used to study the adaptive cycle of the coastal hunter along the South Eastern Atlantic coast of Georgia *(ca. 4,200–1,000 B.P.)* (Victor D. Thompson and John A. Turck: *American Allfialliry* 74(2), 2009, pp. 255–278). Nelson et al (2006) applied TAC to understand the collapse and reorganization of the Mimbres agricultural group from eleventh to thirteenth centuries in the desert southwest. But in Indian context it has not yet been applied. The focus has always been on climate as the major cause of rise and collapse. In this paper an attempt has been made to apply the theoretical foundation of TAC to explain origin of agricultural lifestyle in North-western India.

Theory of adaptive change: framework

The principal idea of TAC is the adaptive cycle, which interpret change as linked across multiple geographic and historical scales (Holling and Gunderson 2002; Redman and Kinzig 2003). Often people may not deal with changes in same manner as one adaptive cycles leads to another. Furthermore, adaptive cycles can be specified by its magnitude occurring at household, village, and regional levels (Nelson et al. 2006: 409). however these adaptive cycles are not a "rigid, pre- determined path and trajectory" (Holling and Gunderson 2002: 51).

TAC primarily focuses on the reorganization phase of the adaptive cycle. The stress is on the restructuring of the

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system, which may be similar to, or completely different from the previous adaptive cycle. This stress on restructuring requires consideration to both "destabilizing and stabilizing forces" as these forces impact variety, resiliency, production, and "social memory" within systems (Redman and Kinzig 2003: 1). During the growth and conservation phases, extended periods of growth and cohesion take place. These are tailed by the release and reorganization phases, which "involve an increase in the diversity of social and ecological units (households or plant resources) and of their functions, and increased opportunities for innovations" (Nelson et al. 2006: 409). The four phases are designated as:

- **Growth or exploitation (r):** In this phase the society is colonizing and expanding, and increasing its connectivity and reach. It would also include increase in the exploitation of the available resources. Since there is expansion and growth it may also include political and economic development.
- **Conservation (K):** This is identified as the conservation phase. It focuses on accumulation of resources and wealth. It would also seek to increase stabilization of the society and giving it a fixed framework. It displays the least resiliency and the lowest possibility for change leading to release and rearranging.
- **Release (Ω):** According to Redman "this is a stage in which the tightly bound accumulation of biomass becomes increasingly fragile. This is also identified as the (**Ω**) phase. This is typically represents a phase in which the environment and resources have totally been exploited and to an extent exhausted." This phase generally marks the end of a particular society or culture and paves way again for reorganization.
- **Reorganization (α):** Also represented as the **α** phase, It basically gives us a measure of the flexibility and rigidity of the society. Here we can examine the social response of the society in wake of a change. This phase has the highest possibility for innovation and adaptability deriving both on traditional answers maintained within social memory and as well as invention. The triggering of social memory and the **α** phase reorganization is the key aspect that reasons against the perception of a cultural collapse.

With the help of TAC we can explore social changes within dynamic environmental contexts and relate the results to an understanding of transition from hunting gathering to farming and adaptations associated with it.

Palaeo-environmental background of Western India

The pioneering work was done by Singh et al (1971). However this work is no more considered as consistent as it was done prior to the discovery that C 14 thus leading to dates which are actually off by significant periods of time. The actual evidence for the climatic and environmental changes during the Holocene in western India is derived from the palaeo-botanical materials extracted from saline lakes like Didwana, Sambhar and Lunkaranswar in Rajasthan (Singh et al. 1990) dates given in uncalibrated BP and the calibrated dates in BC. The pollen evidence suggests that during the last glacial period i.e. C 23 ky BP to 13000 years BP there existed hyper-arid conditions with a treeless savannah grassland environment and a weak summer monsoon with increased winter rains. Between 12800 BP and 9380 BP as shown by rising lake levels an temperatures there was more moisture circulating was so interesting leading to the development of shrub savannah grassland biome. During the next period from 9380 BP to 7460 BP the trend continued leading to a tree and savannah biome. However by 6010 BP a declining trend in the precipitation developed and has continued till modern climatic conditions with occasional acacia trees were reached after 4180 BP.

Enzel et al (1999) worked on the Lunkaraneswar of Rajasthan and the result of this work revealed that the early Holocene witnessed many minor climatic fluctuations. The Lake underwent dramatic fluctuations around 6300 BP, when the lake level rose to high and with minor fluctuations continued till 5500 BP when it reduced abruptly and then it dried completely by 4800 BP.

Based on the data from the lake deposits in Rajasthan, Krishnamurty et al (1981) concluded however that:

Before 8000 BC- severe aridity
8000–7500 BC- Relatively wet
7500–3000 BC- Relatively Dry
3000–1700 BC- Sudden increase in wetness
1700–1500 BC- Relatively dry
1500–1000 BC- Relatively wet
1000–500 BC- Arid

Shinde and the team including scientists from the International Centre for Japanese Study, Kyoto, Japan (Shinde et al. 2004: 387) have also worked on the existing climatic problem and the recent work done in the Sambhar lake by them yielded this result.

Cal yrs 6200–4100 BC- Wet phase
Cal yrs 4100–3800 BC- Dry phase
Cal yrs 3800–2200 BC- Wet phase
Cal yrs 2200- till present wet phase begin to decline.

Archaeological background in western India

It is believed that with the onset of Holocene and copious plant and animal food led to an explosion in the population of Mesolithic hunter gatherers. There are some sites in India which gives evidence of transition from upper palaeolithic to Mesolithic. Initially Mesolithic period in India was mostly understood by microlithic industry which is characterized as the first striking feature (typo technological approach). In the more recent time an adaptation based understanding has become more relevant (environmental-economic approach) (Sarkar and Shinde, 2011–12: 297 to 308). Mesolithic sites are found all over India, however it is more concentrated in the plains of Gujarat state and Mewar Plateau in Rajasthan state in western India. Apart from western India Mesolithic is also found in the hilly zone of Central India (mainly northern part of Madhya Pradesh state), Middle Ganga Valley (especially

Allahabad and Pratapgarh districts in Uttar Pradesh state), Indrāvati valley in Orissa state (eastern India), as well as Krishna and Tungabhadra river valleys and Kurnool region of Andhra Pradesh in the south of the subcontinent (Sosnowska, 2011: 99). Post Mesolithic in western India we see the emergence of Chalcolithic cultures who were the first farmers of the region. There is no evidence of Neolithic. This is quite understandable because there is no law which requires every society to pass through all developmental stages (Misra 2007: 154). Development tales place through learning acquired by adaptation and contact with others. Considering the fact that the Aravalli hills in western India have extensive deposits of chalcopyrite ore, the Mesolithic communities could directly jump to Chalcolithic phase by learning agriculture and copper use simultaneously as the latter being easily available in the area. The noteworthy first farming cultures from western Region are Ahar (Sankalia et al. 1969) and Ganeshwar Jodhpura Culture in Rajasthan (GJCC) (Agrawala and Kumar 1993: 125–134); Padri (Shinde 1998: 174–182) and Prabhas Patan (IAR 1955–56: 15) in Saurashtra and Anarta in North Gujarat (Hegde and Sonawane 1986: 23–31). The sites that the authors have used for this study are those sites that have yielded botanical and /or faunal evidences.

Upper palaeolithic to Mesolithic transition- In the Thar especially in the dry zone on its south eastern border it has been possible to demonstrate a continuous indigenous technological and typological development from the upper Palaeolithic industries of the end of the Pleistocene through to the microlithic industries of the Holocene. The process involves a steady reduction in size and series of minor technological modifications (Allchin 1985: 130). Particularly clear sets of examples of this are to be found in the Pushkar locality in Rajasthan and certain groups of site in Central Gujarat. Budha Pushkar which has the largest and still perennial fresh water lake has more upper palaeolithic and Mesolithic sites. Artifact assemblages have been found on sand dunes around fresh water lakes (Misra 2007: 128). A C14 date on pedogonic carbonates from the artifact bearing horizon from 16 R locality near Didwana is 26210 ± 2110–1670 BP. Another C 14 date on pedogonic carbonate close to 16 R is 22760 ± 1220 yrs BP. Thus the upper palaeolithic of the Didwana area can be dated to C 25000 BP. In central Gujarat the upper palaeolithic site of Visadhi and the Mesolithic sites of Pavagarh and Mitli show similar pattern. The sites are generally small.

Aceramic Mesolithic phase- In western India Mesolithic can further be divided into aceramic Mesolithic (without pottery) and ceramic Mesolithic (with pottery). The important excavated sites are Bagor in Rajasthan (Shinde et al. 2004: 383–406) and Loteshwar in Gujarat (IAR 1990–91: 12–16). The lower 23cm of the habitational layer 3 constitutes the Aceramic phase in Bagor. It consists of quartz tools, debitage and bone fragments devoid of ceramics. This phase represents the earliest structure found at the site. It is difficult to discern the shape of the structure but considering the stone alignment it appears to be circular which is represented by hard and compact surface. One post hole was noticed in association with the structure. The faunal remains was studied by Dolly Shah revealed entirely wild species including cattle, hog deer (*Axis porcinus*), wild boar (*Sus scrofa cristatus, Wagner*), barasingha (*Cervus duvauceli*), monitor lizard (*Varanus flavescens, Gray*), jackal (*Canis aureus, Linn*), rat (*Rattus rattus*), and river turtle (*Lissemys punctata, Bonnaterre*) (Misra 1973: 106). However P K thomas's work shows both the presence of wild and domesticated species from the very beginning. The domesticated species include cattle (*Bos indicus*), buffalo (*Bubalus bubalis*), goat (*Capra hircus aegagrus*), sheep (Ovis *aries*), and pig (*Sus scrofa cristatus*) (Misra 2007: 149). Latest starch grain analysis from the site of Bagor (Kashyap 2006: 218) shows that the inhabitants exploited both vegetable and seed crops including roots like ginger (*Zingiber*), sesame (*Sesamum*), beans/pulses like *Macrotyloma*. They also exploited fruits like phoenix (date palm) and Magnifera (Mango). The aceramic phase has been dates to cal yrs 5680 BC (Shinde et al. 2004: 396). Loteshwar, located on the margin of a salty waste depression east of the Little Rann of Kutch, is one of a number of sites in North Gujarat with Mesolithic followed by Chalcolithic deposits The Mesolithic deposit is rich in both geometric and non-geometric microliths, lithic debitage, pallette stones, and faunal remains but devoid of any ceramics and is referred to as Aceramic Microlithic. There is one conventional radiocarbon date of 4730 BC run on charred bone from Period I at Loteshwar (PRL-1567) (Patel 2009: 176). Loteshwar is extremely rich in faunal remains. A preliminary study shows predominance of antelope (*Antelope cervicapra*) and gazelle (*Gazellel dorcus*) (Ajithprasad 2004: 123). A large amount of grinding tools were found probably as part of food processing as well as tool production. At Langhnaj in Gujarat aceramic Mesolithic phase can be equated with aceramic Mesolithic in Bagor based on the comparison of materials has been dated to around 2500 BC which is much later than Bagor, According to Shinde et al (2004: 398) this could have been possible as the Mesolithic assemblage took some time to move down from the Bagor region.

Ceramic Mesolithic phase- This phase has been identified at the site of Bagor confined to layer 2. The evidence from this phase indicates the continuance of the blade industry and structural activity without any radical change except the presence of pottery. The potsherds coarse, red brittle hand made, few has been made on a slow turn table, has grass and sand tempering. They are ill fired and in some cases decorated with incised crisscross designs. Two structural phases have been identified in this phase, the first being represented by well rammed hard floor. One structure in this phase appears to be a domestic cum manufacturing unit as is clear from the contents like couple of core fragments, quartz raw material, debitage and finished tools. The evidence of domestic consists of concentration of animal bones on the northern side and a saddle quern with two grinding stone. The beginning of the ceramic phase is dated to cal. yrs 4490 BC by AMS dates (Shinde et al. 2004: 396). Kashyap's (2006: 218) starch grain analysis shows that new plant were added to the economy of the Ceramic Mesolithic phase possibly that of *Tamarindus* (Tamarind), *Cajanus* (pigeon pea). She has also mentioned about possibly *Eleusine* (finger millets)

and *Sorghum* (Jowar) but with caution. The starch grain possibly *Hordeum* (barley) on the grinder from this phase is also worth noticing. Starch grain studies provide evidence of intensification of plant use during the ceramic phase (Kashyap 2006: 218). Kashyap's study on the metal residue on the microliths from this provided visual evidence of copper on the edges. This is an extremely important find as this indicates that metal in this case copper was introduces in pressure debitage technique to produce microliths. This could be interpreted in the way that probably hunter gatherers learnt the use of copper tools and probably retrieved them (as there is no manufacturing evidence of copper) from the already developed farming chalcolithic communities nearby. In this phase there was a major decline of the animal bones and stone tools suggesting a reduced role for hunting thus implying a greater dependence of food production.

Chalcolithic Farming phase- This phase which is identified by the Ahar and the GJCC in Rajasthan and Padri, Prabhas Patan and Anarta in Gujarat shows the emergence of village life based on farming. This region indicates a local evolution of village society. The excavation at the site of Balathal and Gilund in Rajasthan and Padri in Gujarat has produced evidences of the origin of Chalcolithic culture and a continuing development of the early farming community. The phase has given evidences of copper technology in the form of copper tools like chopper, knives, razors, chisels, celts and arrowhead. Structural evidences show both domestic and public architecture like mud and wattle and daub structures with well made floors and monumental warehouse and boundary wall respectively. Vast amount of pottery has been found from all these sites. They are primarily fast wheel made and can be classified into two main groups of fine and coarse wares. These are further subdivided based on their surface treatment like Red Slipped, Grey ware, white painted black and Red ware, Micaceous ware etc. Studies on palaeobotanical remains are available from Ahar (Vishnu- Mittre 1969: 229–235) and Balathal (Kajale 1996: 98–102) and these include wheat (*Triticum cf aestivum* Linn. and *Triticum* sp.), barley (*Hordeum vulgare* Linn.), panicum millet (*Panicum* sp), indeterminate millet (*Setaria* sp), green gram/black gram (*Vigna* sp), common pea (*Pisum arvense* Linn), Trianthema (*Trianthema* sp), Italian millet (*Setaria italica*), Indian jujube (*Zizyphus jujube* Lamk) and safflower (*Carthamus tinctorius*). Faunal remain studies from Ahar (Shah 1969: 237–245), Balathal (Thomas 2000: 147–151), Gilund (landtt 2014: 227–230). Faunal assemblages consist of 32 species of animals, comprising 19 species of mammals, one reptile, two birds one fish and dog and pig are represented. The wild fauna is represented by elephant (*Elephus maximus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), blackbuck (*Antelope cervicapra*), nilgai (*Boselaphus tragocamelus*), four horned antelope (*Tetracerus quadricornis*), chital (*Axis axis*), boar (*Suf scrofa*), hare (*Lepus nigricollis*), rat (*Rattus rattus*), mongoose (*Herpestes edwardsi*), pea fowl (*Avo cristatus*), fowl (*Gallus gallus*), turtle, fish and mollusks. The other material culture consists of tools, house hold equipments, ornaments and terracotta (TC). TC beads and animal figurines are pretty common in chalcolithic sites. Beads of semi precious stones like carnelian, jasper and agate, steatite, faience, shell and bone are also found. One unique find of the Ahar culture are the stepped cross, stamp seal in the shape of star and seal impressions found on a clay bin associated with the monumental warehouse structure (Shinde and Possehl 2005: 159–163). This chalcolithic phase ranging from c. 3700 BC to c. 1500 BC can be again divided into Early, Mature and Late phase.

TAC model in North-western India

Through TAC the inter-relationships between climate change, cultural change and human decision making about selection of plant and animal resources can be explored which helps us assess evaluate hunter-gatherer resilience during episodes of adverse climate change (Rosen and Rivera Collazo, 2011).

Upper palaeolithic to Mesolithic transition: r phase- During the end phase of the late Pleistocene (Spanning 16 Ka to 12–11 ka) there is evidence of climatic change due to the gradual strengthening of the summer monsoonal winds, Aeolian accretion was rapid for a limited time slice (1000–2000 years) and extensive dune development took place all over the Thar, particularly in the time bracket of 14–12 Ka (Thomas et al. 1999 and Juyal et al. 2000). The Luni river also emerged out of a nearly defunct phase of the LGM and started depositing gravels during episodic strong flood (Tandon et al. 1999). Owing to an overall rise in ground water and the surface flow of water, the playas like Didwana in the eastern margin and the Bap Malar ad Kanod in the western margin possibly turned into shallow fluctuating saline water bodies (Kajale et al. 2004). The pollen analysis of gypsum rich sediments of the Bap Malar and Kanod shows that the vegetation continued to be dominated by *Gramineae, Cyperaceae, Chenopodiaceae/Amranthaceae, Salvadoraceae* etc, not substantially different from what we see today (Deotare et al. 2001). This is the time period of the transition from upper Palaeolithic to Mesolithic in western India and around 10,000 BP there is an upsurge of Mesolithic hunter gatherers population as is evident from the sudden increase in Mesolithic sites in this region. The declining and the fact that hunting pattern indicates no reshuffling suggest increasing dogmatism and connected to the home range. The Mesolithic people chose to settle in restricted but affable environments that offered better resources.

Aceramic Mesolithic Phase: k phase- Social rigidity intensely amplified during the Aceramic Mesolithic phase which is indicated by the earliest circular structures found in sites like Bagor represented by compact hard floor. This rigidity was complemented by the augmentation of resources within the home range. This interpretation is replicated in the substantial increase in hunting diversification as is revealed in Dolly Shahs study of faunal remains (Misra 1973: 106). Small game exploitation like rat (*Rattus rattus*), monitor lizard (*Varanus flavescens, Gray*) and river turtle (*Lissemys punctata, Bonnaterre*) indicates a much higher enabling in hunting strategies near the permanent

base camp. This noticeable utilization of resources close to the home range and rising regionality connected to lowering mobility and becoming almost sedentary are all indications of the rigid K phase of the adaptive cycle.

Ceramic Mesolithic Phase: Ω phase- Increasing attachment to a specific and restricted resource distributiton within the home range made the Mesolithic hunter-gatherers susceptible to the impact of environmental stress. The well investigated playas in Thar reveal a marked change in the interplay of summer and winter monsoon though individual lakes vary in their response due to local factors. It has been noticed that around 6 ka dessication phase started which continued till 3.5 ka (Kajale et al. 2004: 90). Because of the dessication phase probably the climate started shifting and the Ceramic Mesolithic phase entered a release and reformative phase caused by the uncertainty of rearranging habitation within the home ranges. This is indicated by the archaeological finding from the site of Bagor where a major decline of the animal bones and stone tools suggesting a reduced role for hunting and increase in plant cutting has been established (Kashyap 2006). Rather than investing so much on hunting as a subsistence strategy they adopted to broadening of plant collection as their subsistence strategy. Heightened exploitation of plant consumption along with food processing equipments is seen at the site of Bagor. During this reshuffling phase the Mesolithic population were probably also coming in contact with incoming pastoral/farming groups as for example the evidence of Mesolithic habitation from sites like Loteshwar and Langhnaj indicates the presence of human traditions in the region and their interaction with the incoming pastoral groups and probable incorporation of the people within their own cultural group. Kashyap's (2006) study on the copper residue on the microliths may also indicate the interaction between the Bagor Mesolithic group and some copper using group. The ceramic Mesolithic phase especially with respect to the site of Bagor is a transitional phase from hunting gathering to incipient farming people.

Chalcolithic Phase: α phase- The eventual Mesolithic transition to Chalcolithic is not an outcome of the breakdown of the Mesolithic hunting-gathering lifestyle but rather, a persistence of social processes that started before the Mesolithic and climaxed in the intensified association and stringency of social groups at the beginning of Mesolithic. This change should not be associated to the collapse of the hunting gathering lifestyle that could not endure the environmental stress but rather are coherent with the flexible nature of hunter-gatherer economy, which could use "social memory" and longstanding knowledge of the nature to respond to changes. Sites like Balathal and Gilund have produced evidences of the origin of Chalcolithic culture and a gradual development of the early farming community.. The beginning of the Chalcolithic is therefore the phase of innovation and adaptation. Transition to the agricultural way of life involved much more than simple herding and cultivation. Along with agriculture was seen the growth and development of science and technology.

Conclusion

In this paper an attempt has been made for the first time to use the TAC model of adaptive cycles to understand the transition from Mesolithic to chalcolithic in North-western India It has been argued that this change was not due to the subsequent collapse of hunting-gathering lifestyle that led to farming in north-western India. Rather the Mesolithic people relied on long term "social memory" and because of their resilient capacity they initiated a string of sustenance procurement which eventually helped them to begin farming. It has been proposed that these r, k, Ω and α phases are socially prescribed responses to environmental pressure on a temporal micro scale. With increased organizational rigidity in the beginning of Mesolithic led to initiate a change in the later part of Mesolithic by changing the characteristic of traditional hunting-gathering lifestyle to a more thorough food processing system.

Traditionally subsistence change to climate change has always been seen as an outcome of climate forcing, leading to a supposed collapse in a naïve way. But in reality it is a much more complicated interface between man and nature in the context of social behavior. Therefore a simple cause and effect way of looking into the result of climate change on evolution of complex society is not enough. It requires a more comprehensive deliberation of environment, its influence on human behavior, the role of "social memory" and traditional knowledge system that has helped humanity to survive so long.

Competing Interests

The authors have no competing interests to declare.

References

Agrawala, R C and **Kumar, V** 1993 Ganeshwar: Jodhpura culture: New Traits in Indian Archaeology. In: Possehl, G L (ed.). *Harrapan Civilization: A Recent Perspective*. American Institute of Indian Studies and Oxford Publishing co, New Delhi, 125–134.

Ajithprasad, P 2004 Holocene Adaptations of the Mesolithic and Chalcolithic Settlements in North Gujarat. In: Yoshinori, Y and Vasant, S (eds.). *Monsoon and Civilization*. Roli books Pvt. Ltd, New Delhi.

Allchin, B 1985 Some Observations in the Stone Industries of the Early Holocene in Pakistan and Western India. In: Misra, V N and Peter, B (eds.). *Recent advances in Indo Pacific Prehistory: Proceeding of the International Symposium held at Poona*, Dec 19–21, 1978. Oxford and IBH Publishing Co, New Delhi

Deotare, B C, Kajale, M D, Kusumgar, S, Gogte, V D, Ramesh, R, Rajguru, S N, Donahue, J D and **Jull, A J T** 2001 Pliestocene: Holocene Climatic Changes in Arid Core of the Thar Desert: A case Study of the Kanod Playa, District Jaisalmer, Rajasthan. In: Simon, K, Akira, M, Liliana, J and Rowley-conwy, P (eds.). *The Jomon to Star Carr*. Oxford: Hadrian Books, British Archaeological Reports International series.

Enzel, Y, Ely, L L, Misra, S, Ramesh, R, Amit, R, Lazar, B, Rajguru, S N, Baker, V R and **Sandler, A** 1999 High-Resolution Holocene environmental changes in the

Thar Desert, Northwestern India. *Science*, 284: 125–128. DOI: https://doi.org/10.1126/science.284.5411.125

Hedge, K T M and **Sonawane, V H** 1986 Landscape and Settlement Pattern in Rupen Estuary, Man and Environment, 10: 23–30.

Holling, C S 2001 Understanding the Complexity of Economic, Ecological, and Social Systems. *Ecosystems* 4(5): 390–405. DOI: https://doi.org/10.1007/s10021-001-0101-5

Holling, C S and **Lance, H G** 2002 Resilience and Adaptive cycles. In: *Panarchy: Understanding Transformations in Human and Natural System*. Lance, H G and Holling, C S (eds.). 25–62. Washington, DC: Island Press.

IAR 1955 Indian Archaeology A Review, 15.

Juyal, N, Kar, A, Rajguru, S N and **Singhvi, A K** 2000 Chronostratigraphic evidence for episodes of desertification in the southern margin of Thar Desert, India. *International Conference on Desertification*, Dubai, 12–16 Feb. 2000, 195–197.

Kajale, M D 1996 Palaeobotanical Investigations at Balathal: Preliminary Report. *Man and Environment*, 21(1): 98–102.

Kajale, M D, Deotare, B C and **Rajguru, S N** 2004 Paleomonsoons and Paleoclimatic Background to the Prehistoric Cultures of the Western and Central Thar Desert, Rajasthan, Northwestern India. In: Vasant, S and Yoshinori, Y (eds.). *Monsoon and Civilization*, 83–96.

Kashyap, A 2006 Use Wear and starch Grain Analysis: An integrated Approach to Understanding the Transition from Hunting Gathering to Food production at Bagor, Rajasthan, India. Unpublished Ph.D. Thesis. Michigan: Michigan State University.

Krishnamurty, R V, Agrawal, D P, Misra, V N and **Rajaguru, S N** 1981 Palaeoclimatic Influences from the behaviour of Radio-Carbon Dates of Carbonates from sand dunes of Rajasthan. *Proceedings of the Indian Academy of Sciences (Earth Planet Science)*, 90: 155–60.

Landtt, M J 2014 Faunal Remains from Gilund. In: Vasant, S, Teresa, P R and Gregory, L P (eds.). *Excavations at Gilund: The Artifacts and other Studies*. University of Pennsylvania Museum of Archaeology and Anthopology, Philadelphia.

Misra, V N 1973 Bagor- A Late Mesolithic settlement in North–west India. In: *World Archaeology*, (1): 92–100. Taylor and Francis Ltd.

Misra, V N 2007 Rajasthan: Prehistoric and Early Historic Foundations. Aryan Books International, New Delhi.

Nelson, M C, Hegmon, M, Kulow, S and **Schollmeyer, K G** 2006 Archaeological and ecological perspectives on reorganization: A case study from the Mimbres Region of the U.S.

Patel, A K 2009 Occupational Histories, Settlements and Subsistence in Western India: What Bones and Genes and can tell us about the origins and Spread of Pastoralism. *Anthropozoologica*, 44(1): 173–188. Publications Scientifiques du Museum national d"Histoire naturelle, Paris. DOI: https://doi.org/10.5252/az2009n1a8

Redman, L C (Mar. 2005), Resilience Theory in Archaeology Author(s). In: *American Anthropologist*, 107(1): 70–77. DOI: https://doi.org/10.1525/aa.2005.107.1.070

Redman, C L and **Kinzig, A P** 2003 Resilience of past landscapes: Resilience theory, society.

Rosen, M A and **Isabel, R-C** 2012 Climate change, adaptive cycles, and the persistence of foraging economies during the late Pleistocene/Holocene transition in the Levant. *Proceedings of National Academy of Sciences of the United States of America*. DOI: https://doi.org/10.1073/pnas.1113931109

Sankalia, H D, Deo, S B and **Ansari, Z D** 1969 *Excavations at Ahar*. Deccan College Post Graduate and Research Institute, Pune.

Shinde, V S and **Possehl, G L** 2005 A Report on the Excavations At Gilund, 1999–2001. *South Asian Archaeology 2001*, Catherine, J and Vincent, L (eds.). Paris: 1: 293–309.

Shinde, V S, Shweta, S D and **Yasuda, Y** 2004 Human Response to Holocene Climate Changes in Western India between 5th and 3rd Millenniums BC. In: Monsoon and Civilisation. New Delhi: Roli Books, pp. 383–406. Southwest. *American Antiquity*, 71(3): 403–432.

Sosnowska, H 2010 (2011), Outline of Mesolithic and Beginnings of Neolithic in India. *Ana- lecta Archaeologica Ressoviensia*, 5: 95–139.

Tandon,S K, Jain, M and **Singhvi, A K** 1999 Comparitive development of mid to late Quarternary fluvial and fluvioaeolian stratigraphy in the Luni, Sabarmati and Mahi river basins of Western India. *Gondwana Geological* Magazine special, 4: 1–4.

Thompson, V D and **Turck, J A** 2009 Adaptive Cycles of Coastal Hunter-Gatherers. *American Antiquity*, 74(2): 255–278. DOI: https://doi.org/10.1017/S0002731600048599

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