CHAPTER 1

GEOGRAPHICAL BACKGROUND

The geographical conditions create barriers and opportunities, based on technological expertise, social, political and economic organisation of the societies. So it is imperative to have general feel of the geographical setting of a region which play an important role in the origins, development and dissemination of cultures. It helps to understand cultural responses to nature through labour. It is true that Marx speaks of labour as a “process between man and nature”\(^1\). But the terms of this interaction are “man, through his own actions, mediates, regulates and controls the metabolism between himself and nature” by working on “objects of labour” that are “spontaneously provided by nature.”

India divided into four major macro regions depending upon the physiographic characteristics namely the Northern Mountains, the Great Plains, the Deccan Plateau and the Coastal Plains and Islands. These are further divided into meso regions, which in turn further divided into micro-regions, and sub-micro region because of differences in their respective natural resources, climatic and geographical conditions.\(^2\) The area of study falls under macro region of ‘the Great Plains’. Because of rainfall, soils and drainage the Great Plains have been divided into seven meso-regions and twenty four micro-regions. The Great Plains include the Punjab plains, the Haryana plains, the Arid Rajasthan plains, the Upper Ganga plains, the Middle Ganga plains and the Lower Ganga plains as meso regions. The OCP culture spread over the Rajasthan plains, the Haryana plains, and the Upper Ganga plains. The Upper Ganga plain has been divided further into two parts, Northern Upper Ganga plains and Southern Upper Ganga plains.\(^3\) Northern Upper Ganga plains consists the districts of Bijnor, Ghaziabad, Meerut, Moradabad, Muzaffarnagar, Rampur and Saharanpur while The districtas of AgraAligarh, Mathura, Bareilly, Badaun, Bulandshahr, Etah, Etawah, Farrukhabad, Kheri, Mainpuri, Pilibhit and Shahjanpur falls in Southern Upper Ganga Plain. The average elevation of Indo-Gangetic plains is ranges from about 150 metre near sea level to about 300 metre in Punjab and upper Ganga plains near the Himalaya foot-hills. These plains have almost uniform topography, though the

nature of the material brought down by the rivers varies significantly, resulting in local geo morphological variations. This region is a broad area of low pressure in the summer monsoon and this low-pressure area helps in heavy rain along this region.  

The Great plains of Indo-Gangetic divide is among the most populated area of world. This region runs parallel to the Himalaya ranges. It stretches from the Jammu and Kashmir in the west to the Assam in the east direction. It covers Punjab plains (including both India and Pakistan), the Haryana plains, upper, middle and lower Ganga plains. These areas have large flood regions of the Indus and the Ganga-Brahamputra river systems. The Indus has the Ravi, the Beas, the Sutlej, the Chenab and the Jhelum as its eastern tributaries. The Ganga has the Yamuna river as its main tributary.

The Indo-Gangetic Divide can be further classified into four categories as Bhabhar belt, Terrain belt, Bangar belt and Khadar belt.

Bhabhar Belt: This belt is a piedmont zone running, parallel from west to east along the Shivalik foot-hills. It comprises of sand, clay, pebbles and even the boulders, which carried downward by the river streams. These streams flow underground in this belt because of the high porosity of the soil deposition. The soil of this belt is unfit for cultivation purposes as it is highly porous and prone to continuous eroding by the torrents.

Terrain Belt: This belt is present next to the bhabhar belt and runs parallel to the the bhabhar belt and have gentle slope. It covers the northern boundary of Indo-Gangetic plain. The streams reappears in this belt and deposit fine silt, sand and clay. It is composed of almost level and fertile soil. This region is rich in new alluvial soil and thickly forested. It is inhabited by different species of wild animals. This region receives good rain fall. Once this belt was about hundred kilometre broad and formed marshy and forested land. This belt is shrinking at alarming rate by forest cutting and now it covers an area of about 7-15 kilometre wide.

---

6 Ibid.
Bangar Belt: The Bangar belt is uplifted area in interfluvial zone above the flood plain. It is composed of older alluvium, which forms the terrace of the flood plains of the rivers. The formation of concretion occurs in the bangar belt.\(^7\)

Khadar Belt: The Khadar belt lies downward to the Bangar belt and comprise deposit of clay, fine silt and sand particles, which is renewed by the recurrent flood in the streams regularly.\(^8\)

To understand the geographical locations of OCP settlements a general framework of the micro physiographical conditions of the area concerned are discussed in the following pages. The area that has been investigated for this archaeological research problem comprises the districts of northeastern Rajasthan, southern Haryana and western Uttar Pradesh. This area is located broadly between 20° 03’ 00” N-30° 12’ 00” N Latitudes and 69° 30’ 00” E-82° 21’ 00” E Longitudes. The archaeological evidences for OCP settlements are mainly found in the districts of Jhunjhunu, Sikar, Jaipur, Nagaur, Bharatpur, Alwar in Rajasthan; district Mahendragarh, Rewari, Gurgaon, Jhajjar, Bhiwani, Sonipat, Rohtak, Ambala, Jind in Haryana and districts of Saharanpur, Meerut, Bulandshahr, Etah, Etawah, Aligarh, Bareilly, Budaun, Moradabad, Shahjanpur and Allahabad in western Uttar Pradesh. This area spreads over different climatic and geographical zones having different array of geology, temperature, rainfall, soil, flora, fauna, water and mineral resources. The OCP culture was different from contemporary neighbouring cultures having been in proximity to copper resources, land locked river system and generally sandy and rugged terrain in northeastern Rajasthan, southern Haryana and western Uttar Pradesh.

The Rajasthan Plains: The geology of the region is highly complicated. It is composed of different rock formations. The rocks system of this area mainly belongs to Pleistocene and Holocene interspersed with Cretaceous, Jurassic and Upper Gondwana systems of rock formations. This territory is broadly sub-divided into two geographical units by the Aravalli Ranges, which runs in the northeast-southwest direction. These ranges run from Palanpur in Gujrat to Delhi and they are broader and higher in southwest than in northeast. In northeast Aravalli ranges are broken into separate hills in Delhi, Dadri and Khetri which is composed of Delhi System of rock formation. This system has

\(^7\) Ibid.  
\(^8\) Ibid.
been divided into two groups namely North Delhi Fold Belt (NDFB) and South Delhi Fold Belt (SDFB) mainly on the basis of contrasting ages of intrusive granite.\textsuperscript{9} The former includes the Khetri basin of main Delhi belt. They are fanned out portion of the main belt in the east, which contains loose contiguous basin separated by faults namely Bayana-Lalsot basin and Alwar basin.\textsuperscript{10} This group is the primary source of copper in India. The main copper deposits are in Khetri, Singhana, Baleshwar, Tejawala, Chiplata in Jhunjhunu district and Kho, Dariba, Bhagoni and Pratapgarh in Alwar district; Khankhera in Bharatpur district also located in North Delhi Fold Belt.\textsuperscript{11} The main non-metallic minerals are gypsum, lignite, fuller earth, asbestos, dolomite, soapstone, talc, mica, etc.\textsuperscript{12} The region on the western side of the Aravalli is an extension of the Great Indian Desert, the western part of which is now in Pakistan. It is mostly an arid, sterile and sandy desert in the west, which grades into a semi-arid steppe in the neighbourhood of the Aravalli Ranges. It is covered by various types of dunes occurring in western and southern parts.\textsuperscript{13} The southeast portion near the Aravalli is drained by Luni and have more rain fall than other parts of the Rajasthan. The north is transitional plain between arid to semi arid climatic conditions. It is dotted with salt lakes such as Didwana, Kuchaman, Degana and Sambhar. The river system is ephemeral.\textsuperscript{14}

The region on the eastern side of Aravalli is semi-arid and it constitutes the northern part of the Deccan Plateau macro region. It consists of the districts of Alwar, Bharatpur, Jaipur, and Ajmer. Aravallis have more or less continuous ranges in Ajmer, Alwar and Jaipur districts. It is endowed with comparatively higher rainfall, and its southeastern parts conform very closely to the patterns of tropical humidity found in central India. The only river of any consequence in this region is the Luni, which rises in the hills near Ajmer and flows west by southwest into Rann of Kutch. The other river of some importance is the Ghaggar (which is being equated with the Saraswati of the Vedic period). It is said to have once flowed through the northern part of Rajasthan and joined the river Indus. These days it flows only during the rainy season, even in rainy season its

\textsuperscript{10} \textit{Ibid.}
\textsuperscript{12} R.L. Singh, 1971, \textit{op.cit.}, p. 60.
\textsuperscript{14} R.L.Singh,1971,\textit{op.cit.},p.54.
water loses itself in sand dunes a mile or two west of the town of Suratgarh in Hanuman Garh district.

The river, which once flowed to the Indus was indeed a very forceful one, having a powerful flow of water. The extinction of such a mighty river purely due to aridity is very unlikely, when the Yamuna and the Ganga, the Nile, the Euphrates and the Tigris river are still flowing. The question of underground flow is unscientific as there is no connection between underground water sample from palaeo-channels in Ganganagar and Jaisalmer districts and Himalaya water source.\textsuperscript{15}

A small rivulet near Kurukshetra was considered as mighty perennial snow fed Rigvedic Saraswati river. It originates from the Shivalik hills in lower Himalayas. It is said to go to the Arabian sea crossing northwestern parts of Rajasthan. Wilhelmy hypothesised that the Yamuna once flowed in the Saraswati river in the pre-Mahabharata era, which however cannot be tested on the basis of available evidences. The permanent imprint of a mighty, snow fed perennial river that are inexhaustible huge reservoir of sweet potable water and thick river sand strata are not available along its bed.\textsuperscript{16} However, the traces of former courses of the comparatively smaller streams like the present day Ghaggar and the Markanda in the area have been recorded by Landsat imagery. It is felt that a major snow-fed stream of the Yamuna's size would leave more distinct traces of its presence if its course had been in this direction during the period when the Saraswati was in flow. The theory that the Yamuna was alternately captured by the Indus and the Ganga systems in past, does not appears very sound.\textsuperscript{17} The Yamuna fault along the west bank of the river should be seen as a deterrent to any such theory of alternate capture hypothesis. Moreover, the presence of numerous ox-bow lakes, abandoned channels, etc, along both banks of the river from Tajewala (where the river comes down on the Gangetic plains) to Agra and beyond, suggests the antiquity of the Yamuna's flow towards the Ganga. Incidentally, the width of the flood plain of the river on its left bank is found to be much greater than that on its right bank in this region.\textsuperscript{18} Moreover, a study of archaeological

\textsuperscript{16} R.C.Thakran personal communication
features in this area, also discounted the possibility of such alternate capture of Yamuna river.19

The rivers of this region are seasonal and centripetal. Their flow depends upon the rainfall. The rainfall is very erratic in the west in comparison to the east in this region. This area is covered by a thick sheet of windblown sand. The main rivers are Kantali, Dohan, Krishnawati, Sahibi, Sota, Banganga, Bandi, Ruparail, Mendha along with their small tributaries with local names. They originate from the central parts of the Aravalli ranges. The Kantali flows towards north and lost into the depression of Rajgarh in Jhunjhuju district. Dohan and Krishnawati flow due northeast and lost in dunes near Dadri in Bhiwani district after passing through the dry tract of Mahendragarh district. The Sahibi and the Sota originating from the hills of Ajitgarh in Sikar district flow towards northeast. They fall in the depression of Najafgarh near Delhi after passing through Rewari, Gurgaon and Jhajjar districts and creat the flood conditions on the border of Delhi. The Najafgarh depression measures about 84.50.square kilometre and it remains water logged till 1839. The construction of a drain in 1837 for draining the water to the Yamuna river by British alleviates this problem.20 The Aravalli ranges from the water divide of north Indian drainage, one towards Bay of Bengal and another towards Arabian sea. The river system of Rajasthan has been divided into three types namely northeast flowing river system, southwestern flowing river system and inland drainage system.21 The northeastern river system comprised of Chambal, Gambhiri and Banas river along with their tributaries. The Kali Sindh, Parbati are the tributary of the Chambal river, While river Khari, Mansi, Berach, Dhund, Kothari and Morel constitute the tributaries of the Banas river. They all fall in the Chambal river.22 The Kothari river rises in the Karauli hills and passing through Sawai Madhopur and Bharatpur districts join the Yamuna river near Utangaon. It brings large quantity of silt along with it and becomes shallow. It causes floods in Bharatpur district, particularly in the plains of Bayana and Rupbas tehsils.23 The southwest flowing river system comprised of the Luni and the Mahi rivers.

The Luni river goes to the Rann of Cutch. Its tributaries comprised Guhiya, Bandi, Khari, Sukri and Jawai river.\(^{24}\) The Mahi river goes to the Gulf of Khambat. The internal drainage system is comprised of the Kantali, Sahibi, Sota, Dohan, Krishnawati, Mendha and Ruparail rivers. The Mendha and Ruparail rivers flow due west and debouches in saline natural depressions and playas of Sambhar. The Banganga river debouches in the natural depression of Ghana Bird Sanctuary near Bharatpur by flowing southeast. The Bandi river flows due southeast and meets Chambal river before finally joining the Yamuna. The Ruparail river rises in Aravalli hills near Thana Gaji in Alwar district. It passes through the Alwar tehsil and terminate at Sukri bund. The Ruparail river used to cause floods in Alwar and Bharatpur districts before the construction of a diversion channel on its channel for water to Ghana Bird Sanctuary near Bharatpur.\(^{25}\) They have the internal drainage patterns and flow according the natural slopes of the land and disappear into sand dunes. All of these river are non-perennial and rain fed.

**Rainfall:** Rainfall is the beginning of the hydrological cycle in environment and controlling factor of hydrological regime of any area. Some of the rain water percolate in the soil, some go waste as runoff in streams, some evaporate, and some transpired by vegetation. The same vapours fall in the form of rain, snow, fog and dew. Rain in arid and semi-arid area are low, sporadic and erratic in time and space. This area is characterized by a progressive fall in the mean annual rainfall towards west, centring on the Thar Desert, with less than 10 centimetre average annual rainfall. One witnesses occurrence of more or less concentrically placed zones of increasing rainfall round the central core of the Thar Desert. These concentric zones are defined according to the average annual rainfall. The arid zone receives 10-25 centimetre average annual rainfall, semi-arid zone receive 25-50 centimetre average, semi-humid zone receive 50-60 centimetre average rainfall while humid regions receive 60-100 centimetre. The climate of this region as a whole has been divided into four seasons namely winter (cool and dry), spring or pre-monsoon (hot and dry), summer or monsoon (hot and wet) and autumn or post-monsoon (warm and dry). Geographically, this area is situated in the normal latitudes of subtropical anticyclones in winter and the deserts are associated with them. In general terms, the aridity in the western region may be ascribed to the rather sharp northwestward boundary to the moist current of the monsoon, as the area lies a little too far west of the

\(^{24}\) *Ibid.*

main monsoonal upper air flow to receive monsoonal rainfall, except some years of higher precipitation. The air circulation in winter characterise by subsiding, low-level anti cyclonic flow. However, in the far northwest the winds are of continental origin and come from the northwest. The winter rainfall resulting from western disturbances is mainly confined to the area north and northwest of Delhi and tends to decrease progressively towards the Thar desert. The Aravalli Range acts as a great divide between the western and eastern climatic provinces of northwest India. The western parts of the Aravallis characterized by extremes of temperature, severe drought, high velocity winds and low relative humidity in comparison to the eastern parts. The region east and south of the Aravallis are characterised by strong periodical rains and more or less uniform temperatures. The northeastern parts of the Aravallis have similar rainfall pattern like western parts but it goes on increasing towards eastern side. The coefficient of rainfall variability is about 80% for the western parts in comparison to 40% for the eastern parts. The 80% rainfall occurs during the monsoon period.²⁶

**Vegetation:** The plants and animals are the mainstay of life for every past society. The plants are the climate indicators also. The vegetation of this area is greatly influenced by the position of the Aravalli Ranges. It divides the plant life into two unequal parts: a smaller one (generally mesophytic) east of the Aravallis, and the larger (mostly xerophytic) to the west of Aravallis.²⁷ The vegetation of the dividing Aravalli range can be considered to resemble much more to the eastern parts than the western parts. In general terms, there are three distinct elements visible in the vegetation stock of this region 1. The Western, Perso-Arabic vegetation along with Indian species of Aravallis ranges themselves in the west 2. The Eastern, Indo-Malayan, east of Aravallis, and third one is a more general element of the Indo-Malayan plant species which are present along the Aravalli Ranges from the gulf of Cambay in the southwest to Delhi in the northeast.²⁸ The 50 centimetre isohyets line also determine the dividing line between these two phytophysiographic regions. Seeing the critical nature of this dividing line between plant cover,

any recognizable shift observed in the past vegetation, in relation to the two floras groups, can be used as a diagnostic index of climate change in the distant past.\textsuperscript{29}

This region tends to be sandy with some areas of older alluvium underneath the aeolian sand. The soil types and rainfall influence the type of vegetation. The trees are stunted and thorny in the northwest covering the district of Nagaur, Sikar and Jhunjhunu. The vegetation consists of the species of Khejri(\textit{Prosopis spicigera}), Kair(\textit{Capparis decidua}), Babul(\textit{Acacia arabica /nilotica}), Peelu(\textit{Salvadora oleoides}), Ber(\textit{Zizyphus numularia}), Ak (\textit{Calatropis procera}), Sagwan(\textit{Tectona grandis}), Mahua(\textit{Bassia latifolia/Madhuca indica}), Dhau/Dhok (\textit{Anogeissus pendula}), Plas/Dhak(\textit{Butea monosperma}), Mango(\textit{Mangifera indica}), Pipal(\textit{Ficus religiosa}), Bar (\textit{Ficus bangalensis}), Gular(\textit{Ficus glomerata}), Jamun(\textit{Eugenia jambolana}), Tamarind (\textit{Tamarindus indica}), Khajur (\textit{Phoenix sylvestris}), Khair (\textit{Acacia catechu}), Runjh (\textit{Acacia leucophleae}) and Siris (\textit{Albizzia lebbeck}), etc.

\textbf{Soil Types:} A particular type of soil is a product of parent rock material, topography, climate and biosphere forces operating through time. The physical and chemical forces determine the characteristics of the soil. These soil formation processes depend upon climate as modified by topography.\textsuperscript{30} The soil of the area can be divided into old and new alluviums depending upon their paedogenesis. The sand dunes are common in western Rajasthan and parts of southwestern Haryana and Punjab. The dunes are generally very thick with fine sand and may or may not be calcareous. The sand of these dunes may be the product of the breaking of light textured plain soils or transported from Sind and Rann of Kutch. The soils of the plain are mostly alluvium. The physical properties of soil are pale brown to brown to yellow brown in colour. It is fine sandy to loamy fine sand and mostly without any structure. Lime concretion zone is encountered at a depth of 60 to 120 centimetre. The striking feature of most of the soils is the presence of alkaline earth carbonate. The percentage of clay content is low and range from 2-8 percentage and soil is susceptible to dispersion. The soil is impermeable due to the presence of sodium carbonate.\textsuperscript{31} The soil contains soluble salts and its Ph value ranges between 8 to 8.8. The desert soil is fertile if adequate moisture is provided.\textsuperscript{32}

\textsuperscript{29} \textit{Ibid.}
\textsuperscript{31} \textit{Ibid.}, p.30.
\textsuperscript{32} \textit{Ibid.}
subgroups of the soil are also interspersed in-between according to the local climatic and topographical variations. The following types of soils are generally found in Rajasthan: 1. Desert soil: It is present in Churu, Jhunjhunu, Bikaner, Barmer, Jodhpur and Jaisalmer districts. It contains high proportion of soluble salt and alkaline in nature. It has inhibitory effect on plant growth. The plants, which can tolerate high salt conditions can withstand in this soil. 2. Red Desertic soil: This soil type is extended over Nagaur, Jodhpur, Pali, parts of Churu and Jhunjhunu districts. It is pale brown to dark brown in colour with high fertility provided water is available. 3. Yellowish brown sandy soil: These soil types are found in Nagaur and Pali districts. They are sandy to sandy loam and sandy clay loam in nature and yellowish brown in colour. Lime concentration is present at a depth of 100-150 centimetre. It is suitable for steppe type cultivation. 4. Alluvial soil: It is present in the southern parts of Ganganagar district and along the dry bed of Ghaggar river. It is of red colour and deficient in essential plant nutrient like lime, phosphorus and humus. It is good for cultivation.\[33\]

**Water Resources:** Water is one of the primary needs of all living being. The water sources of this area are in the form of wells, tubewells and canals depending upon the local conditions of subsurface water. The nature of the surface flow is ephemeral. The water table is high in or near the stream channels, canals and natural depressions. It sinks rapidly away from these sources. Its depth varies from thirty to one hundred twenty metre. In the extreme west it is very deep seated and beyond economic exploitation.

**The Haryana Plains:** The Haryana Plains is a level area except some hillocks of Shivalik system in the north and Aravalli system in the south. This region has been divided into three sub-divisions on the basis of local topography and soil types. These sub-divisions are: Eastern Haryana Plain covering the districts of Ambala, Kurukshetra, Karnal, Jind and Rohtak, Jhajjar and Sonipat. Western Haryana Plain cover the Hisar, Sirsa and Bhiwani districts. Southern Haryana Plain includes the districts of Mahendragarh, Rewari, Gurgaon, Faridabad and Union Territory of Delhi.\[35\] The Eastern Haryana plain is bordered by low Shivalik hills on the northeast. The Shivalik system composed of broad tableland of sand, silt, clay and conglomerate. Its age ranges from

---


Middle Eocene to Lower Pleistocene. It slopes from northeast to southwest direction. A number of rain fed streams or torrents flow down from the Shivalik. The main streams of this plain are the Ghaggar, the Chautang, the Markanda and the Saraswati. These streams are ephemeral and in case of heavy precipitations causes flood in lower reaches.\textsuperscript{36}

Western Haryana plain differ from Eastern plain of Haryana. It consists of sand dunes of varying length, width and height. The water table is deep seated and saline except some lowlying areas where the subsoil water is potable. It is prone to erosion because of wind action as well as due to heavy rain. Geographically it is also known as Bhiwani Bagar. The Ghaggar river flow through its western most parts and its flood plain bifurcate the Sirsa district. This area is contiguous to north Rajasthan and has cultural and climatic affinity with it. The southern Haryana plains differs from the western plains in having Aravalli offshoots. It has undulating character and slopes toward north. This region is dotted with sand dunes particularly in Mahendragarh district. The streams arising from Aravallis hills during rainy season flow towards the north and northeast. These streams watered this region. The main steams are the Sahibi, the Krishnawati, the Indori and the Dohan. They are ephemeral in nature and not of much use either in water table enhancement or in irrigation. The water table is deep seated and the quality of water is generally brackish or saline.\textsuperscript{37}

**Climate:** The climate of Haryana is semiarid in southwest but on the northeast, it resembles with the climate of Gangetic plains. This is due to the continental location of this region on the outer margins of the Monsoon region between the Thar Desert and the Himalaya in the northwest of the Indian subcontinent. Monsoon brings rain during the period of July to September. The period from October to June is generally dry except some shower due to western disturbances, which are significant for rabi crops.\textsuperscript{38}

**Rainfall:** The rainfall in the Haryana plains is low and erratic except in the northeast. The maximum rainfall occurs near the Shivalik foothills, where it measures about 216 centimetre. The minimum rainfall is 25-38 centimetre and it occurs in the southern parts of the plains.\textsuperscript{39} The south and southwestern portion is bound by 50 centimetre isohyets in the northern side. The rainfall occurs mainly during monsoon in the

\textsuperscript{36} Ibid.
\textsuperscript{37} Ibid.
\textsuperscript{38} Ibid.
\textsuperscript{39} D.C.Verma and Sukhbir, Singh, 2001, *Haryana*, 4\textsuperscript{th} ed., National Book Trust, Delhi, p.3.
month of June to September and sometimes in winter during the month of December to February. About 80 percent of rainfall occurs in the Monsoon. The rainfall pattern of Haryana is affected to a large extent by the continental location of this region and nearness to the sub-tropical high pressure of upper air mass of Thar desert. This is the cause of low rainfall and its variation.40

**The Upper Ganga Plains:** The Upper Ganga plain has been divided further into two parts depending upon the topography, soil types, rainfall and vegetation: Northern Upper Ganga plains and Southern Upper Ganga plains.41 It is composed of alluvium brought down from Himalaya by the Ganga, Yamuna and their tributaries. The alluvium is thick near the foothills of Himalaya due to the syncline and thin near its southern parts where it juxtaposed with the Vindhya plateau. The alluvium is deposit over the rocks of Siwaliks and Peninsular India in all probability. The sediments includes sand, silt, clay with occasional gravel beds and lenses of organic marls.42 The older alluvium (*Banger*) is dark in colour. It is generally rich in concretions and nodules of impure calcium carbonate (*Kankar*). These kankar are of all shapes and sizes ranging from few centimetre to the size of human head. Sometimes it occurs in the form of thick sheet. The older alluvium formed slightly elevated terrace from the flood plains. The rivers cut through it at lower levels. It is of middle to upper Pleistocene age.43

**Soil Types:** Geomorphologically there are four major landforms recognised in upper Ganga–Yamuna plains. These landforms are Piedmont, Plains associated with rivers, Interfluvies and Aeolian plains. A number of soil-geomorphic units having individual soil characters differing within ranges are also observed within these landforms.

**Piedmont:** The piedmont is sharply sloping and 10-25 kilometre wide, elongated land form. Piedmont is drained by a number of small and braided, parallel to sub parallel seasonal streams. These streams flow in incised courses for small distance before they cease to exist. Some large streams such as Solani, Ratmau amd Khoh continue their courses further south and joins the Ganga and Ramganga river as their tributaries. The piedmont has been divided into two geomorphic units: (i) younger Piedmont (ii) older

Piedmont. The soils of younger Piedmont are poorly developed and deposited by braided streams passing through the area. The soils of older Piedmont is moderately to well developed. It is a triangular shape soil block bounded by the Yamuna and the Ganga fault lines. Some streams showing dendritic drainage pattern originate from the block, which remove most of the soil exposing coarser sand underneath. About ten percentage of this area has well developed soil.\(^{44}\) At a few locations, south of Roorkee, soil of this nature is buried in small patches below soil of Ganga–Yamuna plains as fossil soil. The shape of the old piedmont is rectangular between Khoh and Ramganga rivers. It is being eroded and sand is spread out as thin sheet of sand further south, which is included in younger piedmont.\(^{45}\)

**River Plains:** The rivers plains have poorly to moderately developed soils. They are associated with rivers as identified by satellite imagery. The main plains are the Yamuna plain, the Ganga plain, the Banganga plain, Ganga–Solani plain and Ganga and the Yamuna plain.

**Yamuna plain:** The channel pattern of the Yamuna changes from braided to meandering, after 35 kilometre on entering into the plain. In this area the river slightly cut the plain and guided by the southern boundary of Yamuna fault. There are two soil geomorphic units: one the old Yamuna plain and the second one is the young Yamuna flood plain. The old Yamuna plain is flat and lies in western parts of this geomorphic unit. The old plain is characterized by weakly developed soil and salt efflorescence at few places. Young flood plain is characterized by newer alluvium and numerous abandon channels.\(^{46}\)

**Ganga Plain:** The Ganga plain has been divided into three soil-geomorphic units: one the old Ganga plain, two the young Ganga plain, three the Ganga flood plain. The first two are elevated and third one is slightly entrenched in nature. The first two are marked by the palaeo-channels of the Ganga. The northwest extension of these palaeo-channels meet the active channel of the Ganga at Haridwar, where Ganga enters into plain. The old Ganga plain has heavy loamy soil whereas the new Ganga plain has sandy soil. Wind action has reworked the alluvial soil of the young Ganga plain into sand

\(^{45}\) Ibid., p.440.
\(^{46}\) Ibid.
mounds upto three metre in height. The Ganga flood plain is characterised by 50 kilometre wide braided channels in the plain. The Ganga has a straight channel for 20 kilometre after entering the plains thereafter its channel adopt meandering character. The Ganga flood plain is bounded by Ganga fault line on the western side by 10-20 metre high bluff, and low cliff on the east side. Ox bow lakes, abandoned old channels and alkalinity in the soil are common features of the Ganga flood plain.⁴⁷

**Ram Ganga flood plain:** The Ram Ganga river flows into a number of straight channels throughout its course. These straight channels take sharp turns before joining the Ganga.⁴⁸

**Ganga-Solani plain:** This plain slopes southwestward with a gradient of .6 metre/km. The soil is sandy to loamy sand. The southern parts of this plain remain water logged due to high water table.⁴⁹

**Ganga-Yamuna plain:** This is the largest soil geomorphic unit in river plains. It covers an area of about 100-120 x 70-80 kilometres. It has gentle slope toward south with a gradient of less than .1 metre/kilometre. It is characterised by number of palaeo-channels of the Ganga and the Yamuna river arranged into anastomosing pattern. The palaeo-channels are of two types one with linear sandy ridges formed by the wind action. These are several kilometres long and their height ranges between 2-5 metre from surrounding surface level. The second type of palaeo-channels are occupied by undrift small streams. These channels appear to have been widened slightly by erosion along their boundaries. These channels are 500-800 metre wide suggesting their origin from large drift of the river. Some of these channels when extended upward combine the Yamuna and the Ganga channel at the point of their entry into the plain. It shows these are the abandoned channel of these rivers.⁵⁰

**Interfluve:** These are the highest point from the flood plain levels in adjoining areas. They are constituted by moderate to strongly developed soils. There are two interfluves in the upper Ganga plain:

---

(i) Ganga–Yamuna interfluve: This geomorphic unit lies in the southern parts of the plains and also known as Ganga upland. This has been divided into two sub geomorphic units: salt affected and non-salt affected. The first sub unit lies in the central parts of the Ganga–Yamuna interfluves. The salt efflorescence in this unit occurs, in small depressions which are patchy in distribution. The soil of this unit is moderate to strong develop with the extensive development of concrete. The non salt effected unit occupied the area near the Ganga and the Yamuna river. The soil is moderate to highly develop but it has no salt efflorescent and calcrete is mildly developed.51

(ii)Ramganga–Ganga interfluves: This unit is rectangular in shape and covers an area of 20-25 kilometre. It is covered by heavy loamy soil. It has undulating topography and 2-4 metre higher than surrounding areas. The relief is about 1.5 metre in its northern parts due to erosion.52

Aeolian Plain: This plain is located on a higher ground than the old Yamuna plain. It is bounded by Aravalli outcrops on the western side. It is characterised by coarse textured soil and absence of natural drainage. It slopes gently towards the east.53

The newer alluvium is fifteen to sixteen metre lower in surface level. It is light in colour and poor in calcareous matter. It is called as khaddar, katri, kachhar and deara in local parlance. It consists of lenticular beds of sand, gravels and peat beds.54 Mineralogically this plain is poor. It consists of mainly sand, marl, saltpetre, brick earth, etc. At some places in older alluvium soil is affected by reh. It is the salt of sodium carbonate and sulphate.

This plain comprises the districts of Muzzafarnagar, Meerut, Ghaziabad, Bulandshahr, Budaun, Moradabad, Shahjanpur, Aligarh, Agra, Mathura, Etah, Etawah, Mainpuri and Farrukhabad. These alluvial plains largely slope towards southeast. It is devoid of stones or rocks near the surface except the presence of some nodular limestone (kankar). The remaining portion of this plain lies on the right bank of the Yamuna. This portion has the network of ravines and some hillocks of red sandstone. It forms the part of eastern boundary of Aravalli ranges.55 The entire area of Muzzafarnagar, Meerut,
Ghaziabad, Bulandshahr, Aligarh, parts of Agra and Mathura, Etah, Mainpuri and Farrukhabad districts lie in Ganga- Yamuna doab. The doab tract consist of central elevated parts flanked on either side by the lowlying land (khadar) of the Ganga and the Yamuna and their tributaries. This elevated portion is traversed by the Krishni and Hindon rivers. These rivers form a considerable khaddar area in their lower reaches.

The Yamuna Khadar touches the border of Muzzafarnagar, Meerut, Ghaziabad, and Bulandshahr. It runs through the Mathura district and the north of the districts of Muzzafarnagar and Meerut. It is swampy and covered by the jungles of Dhak. However, these forests are cleared for agricultural purposes and now are visible in small patches only in its lower parts of the Yamuna khadar in district of Bulandshahr. It is eight to sixteen kilometre wide except the places where the river flows close to its high banks. In Agra, Mathura and Mainpuri districts ravines flank the Yamuna Khadar. These are extended upto three to five kilometre and has left a chain of swamps showing an old channel east of the present course of the Yamuna. The ox-bow Noh jheel, was formed by this old course. This jheel is about eleven kilometre in length and has water year round.\textsuperscript{56}

The elevated land situated between the Yamuna and the Ganga khadar varies in physiographic features due to the rivers and streams flowing through it. The main rivers and stream of this area are the Matha Nala, Krishni, Karushni, Hindon, Kali Nadi east, Kali Nadi west, Singer, Rind or Arind and Isan. At places there are natural depressions, some of which contain water throughout the year. In the northern parts of Muzzafarnagar there are sandy ridges and sand belt. The eastern parts of Meerut district above the Ganga khaddar also have sandy dunes. These sand dunes are scattered in various directions towards east. They form a well defined ridge in the west. A sand ridge is also present on the west side of Kali Nadi in Bulandshahr district.\textsuperscript{57}

The Ganga khadar tract lies between the Ganga and its high banks on either side in Muzzafarnagar, Moradabad, Budaun and Shahjanpur districts. It is an inferior tract with scanty vegetation and is covered by coarse grass, dhak and tamarisk. This part is chiefly useful for grazing. In Buladshahr district it is narrower than the Badaun district and at one or two places river deposited fertile soil which is under cultivation. In Aligarh, Etah and Farrukhabad districts the Ganga khadar is fertile but it is prone to flooding. The

\textsuperscript{56} Ibid.
\textsuperscript{57} Ibid.,p.19.
eastern parts of the Ganga khaddar, comprising of Moradabad, Budaun, Shahjanpur districts, extend from high bank of Ganga to the sub-Himalaya belt and it is somewhat level. This area is drained by the Sot, Ranga, Deoha or Garra and Gomti rivers. Some streams from the tarai also flow through this area. The natural features of this area depend upon the various streams, which cut deep channels in the Ganga Basin.\textsuperscript{58}

**Vegetation:** The major part of the Upper Ganga Plain has lost its natural vegetation cover through the millennia of forest clearing for agriculture. The natural vegetation wherever it exists has varied character depending upon the local climatic conditions. The southwestern parts consist of the flora similar to eastern Rajasthan. The main species are Khejri(Prosopis spicigera), Peelu (Salvadora oleoides), Kair(Capparis deciduas), Phrans(Tamarisk aphylla), Runjh(Acacia leucophloea) Khairi(Dichrostachys cineraria), Babul (Acacia Arabica) Siris(Albizzia lebbec) Sisam(Delbergia sisso), Khejra(Prosopis julifolia), etc., which appears in parts left from cultivation and plantations. The ravine forest south of the Yamuna comprise the open thorn forest. The main plants of these forests are Kikar (Acacia Arabica) and Kair(Capparis decidua). In the northern parts of the plains, near the foot hills, the forest of Sal(Sorea robusta) exists. The pristine forest exists only in high reaches.\textsuperscript{59}

**Climate:** The Upper Ganga Plain falls in sub-tropical monsoon climatic region. It has mild and dry winter and hot summer. The year is divided into four seasons- winter(December to February), summer( March to May), southwest monsoon (June to September) and post monsoon season from (October to November). Monsoon season is pleasant except June when the humidity remains very high.\textsuperscript{60} Day and night temperature remains more or less uniform except the monsoon and winter seasons when temperature increases southeast and decrease northwest respectively. Sometimes this area face extreme of the climate. May is the hottest month with mean maximum temperature hovering around 41C. The highest temperature of 50.4C was recorded at Nazibabad on 28 June 1975. January is the coldest month when the mean minimum temperature hover around 8.5 C. The temperature decreases towards east and north. The lowest temperature of 2.9 recorded at Nazibabad on 29 January1964.\textsuperscript{61}

\textsuperscript{58} Ibid.
\textsuperscript{59} Ibid.,p.92
\textsuperscript{60} Ibid.,p.141.
\textsuperscript{61} Ibid.
Rainfall: The rainfall in the upper Ganga Plain varies a lot. It is about 60 cm. near the border of Rajasthan. It increases towards north and east up to 140 centimetre. The southwest monsoon brings about 87-88 percentage of the total annual rainfall. In winter it is about 4-6 percentage and hot weather and post monsoon season contribute about 3-4 percentage and 4-5 percentage respectively. The mean annual rainfall is 82 percentage. The southwestern region has minimum rainfall and prone to drought. The coefficient of rainfall variability is about 30 percentage on an average. It is higher in southwestern parts and increases upto 40 percentage.  

Palaeoclimate: Climatologically the Indo-Gangetic divide can be divided into four distinct regions depending on the rainfalls and precipitation. It includes arid tracts of Jhunjhunu, Sikar and Nagaur districts, semi-arid tracts of Alwar, Bharatpur, Jaipur, Rewari and Mahaedragarh districts, semi-humid tracts of Gurgaon, Jhajjar, Rohtak, Sonipat, Agra, Mathura and union territory Delhi, humid tracts of Western Uttar Pradesh. The reconstruction of palaeoclimate of this region is problematic in the light of the available data. The scholars are not unanimous in their views, some think it was wetter than today while others believe that there is no major climate change since mid Holocene on the basis of archaeological and palaeo-climatologically studies conducted in this region.

In general, palaeoclimatic research was conducted in the northwestern parts in the context of Harappan civilization demise, which was contemporary to OCP culture. The climate stands accused as has been suggested a shift from wetter to drier climate. A. Stein during his survey of Gedrosia observed the large check dam or gabarband in Baluchistan. He considered them as an evidence for higher rainfall in this area during Harappan times. This view was corroborated by J. Marshall, by discussing the environment of Mohenjodaro. He endorsed his view with the presence of baked bricks in place of sun dried bricks and the presence of picture of damp forest animals like rhinoceros, elephant and tiger on the seals. Wheeler also supported their views but at the same time adds how far that change is for natural causes and how far to sheer human

---

62 Ibid.,p.145.
64 A. Stein,1931, “An Archaeological Tour to Gedrosia”, in *MASI*, No.43, Govt. of India, Central Publication Branch, Culcutta, p.7.
providence is less easy to say. These views were challenged by R.L.Raikes. He proposed that climate is a world-wide phenomenon without any boundary except those inherent in itself. So the changes should be world-wide but the direction and nature of these secular changes may be different at different places. He said that the available evidences for climate change on world-wide scale speak for otherwise. He concluded that the climate change is negligible since last 9000 years or so. He propounded that these Gabarbandh (dam) are of early Islamic times. Moreover, these so called dams do not have any characteristics of being a dam like water tight, impermeable floor, masonry work for strength, capacity for holding large quantity of water, etc. Wheeler also changed his earlier stand for wetter climate during Harappan times. The study of Possehl suggest the shift in settlement pattern, increase in the number of settlements and location of sites on natural depressions and small streams during the shift from Urban to post-Urban phase of Harappan civilization. He elucidate that the effect of the climate change was not so severe to lead for civilization collapse, even if we consider some changes in climate. Moreover, R.C Thakran tells about the absence of permanent signature of a mighty snow fed river, sheet of river sand deposit and huge reservoir of underground sweet, potable water in this part of land point towards the more or less same type of climate in those times as it is today. Most of the study favouring climatic change starts with the study of pollen analysis from lakes beds.

Ramaswamy in 1968 on the basis of meteorological conditions postulated that during 2000-500 B.C., deep trough in the upper westerlies must have extended into Pakistan far more frequently than they are now. This caused the monsoon depression to curve to the north and northeast, leading to the monsoon condition over the entire belt of Indus valley and more precipitation during Harappan period.

The first scientific study of this kind was done by Gurdeep Singh et al. in 1971 and 1972. They attempt to reconstruct the palaeoenvironment of Rajasthan on the basis of

---

68 Ibid., p.157.
71 R.C.Thakran, (personal comm.)
fossilised floral pollen analysis taken from the dry bed of salt lakes at Sambhar, Didwana, Lunkaransar and fresh water lake at Pushkar. Radiocarbon dating was also done of these pollen profiles. They reconstructed the Holocene environment at and around these lakes. They categorise the Holocene climatology in five distinct phases.

Phase-I(upto 10000 year BP) The available evidences suggested extreme aridity and sand dunes formation. The sand dunes encroached upon the river valley and choked them forming the lake basin at Lunkaransar, Didwana and Sambhar.

Phase-II(10000-9500 year BP) during this phase lacustrine period started and facies change from sand to dark grey colour. Laminated clay deposit formed under the submerged conditions. It tells about general increase and westward shift of the rainfall. The freshwater species Typha aquastata found. Open land steppe land with preponderance of grassland occurred.

Phase-III(9500-5000 year BP) The grassy vegetation increased at Lunkaransar, that tells about the further increase and westward shift of rainfall. The cereal-type pollen observed. The evidence of burning of vegetation in the form of charcoal tells about the shifting cultivation.

Phase-IV(5000-3000 year BP) The early stage of the phase show the increase in sedges along with the cereal-type pollens. The occurrence of tree and shrub also increased. The rainfall said to be the highest during this phase, which is estimated 25-50 centimetre higher than today. Toward the end of this phase, between 3800-3400 year BP the sedges decrease and clay stratification broke down and lakes become saline.

Phase-V(3000 BP year upto present) It was observed that aquatic species and tree vegetation were absent during this phase in general\(^3\).

Vishnu, Mittre objected to some of the above observation in the light of information drawn from the mapping of the present day vegetation of Rajasthan by Gaussen et al. He conclude that rainfall isohyte is not the only factor in determining the distribution of plant species in Rajasthan but the bio-climate also depends upon temperature, period of dry months and number of biologically dry days. Moreover, some

identified freshwater species have certain degree of salt tolerance hence they appear in saline environment. He also observed that cereal-type of pollen may be due to the natural mutation in some wild grasses. The charcoal presence may be due the burning of grasses by the pastoralists of that time for enhancing the growth of new vegetation

A.M. Swain et al. 1983 also conducted a pollen profile study from the lake Lunkaransar sediments to estimate past precipitation. According to them the precipitation was 500 mm/yr or 200 mm/yr above the present value between 10500 and 3500 yr B.P. They suggest that with this much increase in rainfall raised the water level of Sambhar lake about 20 metre in present times. But around 3500 B.P. Lunkaransar lake was dry as no pollen was preserved. This study was based upon energy and hydrological budget model of a lake basin and lake Sambhar

In 1992 Gurdeep Singh et al. restudy pollen profile of the Didwana salt lake to trace the history of summer and winter rainfall in the Thar desert since the Last Full Glacial. They divided their pollen profile into zones. They concluded that in zone D4 dated between c. 7500 and 6200 year B.P. The tree savanna developed for the first time in this zone. It includes the desert taxa namely *Aerva, Ephedra, Calligonum, Chenopodiaceae*, trees mainly *Prosopis cineraria*, sub humid zone shrubs mainly *Oldenlandia* and dominated by grasses and *artemisia* in this assemblage. The presence of sedges, *typha* and *Cosmarium desmid* were dominant for most of the time. The presence of this vegetation indicates fresh water lakes. In next Zone D5 dated between c. 6200 and 4200 yr B.P. This zone was characterized by the presence of *Calligonum*, the total disappearance of *Cosmarium* desmids and a decline in the values of *Typha* in the lake basin. It is clear from the data of *Typha* and *Cosmarium* that lake level fell in this zone and it was probably only moderately deep. The shallowing of the lake appears to have promoted an increase in the sedge component in the swamp. Accompanying this change, *Artemisia* and *Oldenlandia* declined about 5000 yr B.P. and grasses and *Prosopis* trees rose from about the same period. *Typha* continued to be represented, and the values of halophytic taxa did not rise. It appears that moderately deep freshwater conditions continued to prevail in the lake between c. 6000 and 4200 yr B.P. In the final Zone D 6 lake sediments dated between c. 4200 and 0 yr B.P. did not yield any preserved pollen.


except for three samples at the base of the zone. Stratigraphically, this period represented by poorly laminated, non-laminated and silty clays under ephemeral lake conditions. The lack of pollen preservation is probably related to degradation of organic matter following seasonal drying of the lake floor. The few samples showing preserved pollen at the base show that both *Oldenlandia* and *Artemisia* had declined to their lowest values by c. 4000 yr B.P. This trend towards dry conditions continued to the present day with the lake remaining ephemeral for the entire period. Further, the surface sample from the site showed that *Aerva* values had returned to high late Pleistocene levels and that *Calligonum* also stayed at a relatively high level. On contrast, however, the *Artemisia* and Chenopodiaceae/Amaranthaceae remained low and *Prosopis* tree pollen continued to occur in low numbers to the present response to the renewed drying during the late Holocene. It was in many ways similar to that prevailing during the late Pleistocene, the change was not by any means as severe. The lake, though ephemeral at the present time, has not yet turned to hypersaline conditions. Further, the semi-arid climate indicator tree savanna-grassland has continued to exist, a feature not found during the late Pleistocene.  

From the above discussion, on the basis of pollen study, it is clear that climate was not continuously arid like today in this part of land. There were alternate phases of dry and wet climate.

Enzel et al., 1999 study the bed of Lunkaransar lake. They divided the section in four zones on the basis of lake deposition. They elucidated the C-14 date for Zone-I 10-8.3 k years as the period of fluctuating shallow lake without any sign of extremes in climate. In the succeeding second zone, which spans from 8.3 to 6.3 k years, the climate was of the same nature. But in the next zone-3 lakes attained maximum stand. The zone was chronologically falls between 6.3 to 5.3 k years. The last zone-4, which started from 4.8 k years BP indicate the starting of dry playa with occasional lakes and the climate was similar as today. This indicates the dry phase was already started 800-1000 years before the early and mature Harappan civilization.

---

Phadtare et al., 2000 conducted a study on Age-constrained pollen data and magnetic susceptibility of an alpine peat profile from the Garhwal Higher Himalaya. It display a continuous record of climate and monsoon trends for the past 7800 year. According to him the dominance of, dominance of evergreen oak (Quercus semecarpifolia), alder (Alnus), and grasses in the pollen record reflect a cold, wet climate with moderate monsoon precipitation around 7800 cal year B.P. From 7800 to 5000 cal year B.P. vegetation was progressively dominated by conifers, indicating ameliorated climate with a stronger monsoon. A warm, humid climate, with highest monsoon intensity, from 6000–4500 cal year B.P. represents the mid-Holocene climatic optimum. Between 4000 and 3500 cal year B.P., the abundance of conifers sharply decreased, with the greatest increase in evergreen oak. This trend suggests progressive cooling, with a decrease in the monsoon to its minimum about 3500 cal year B.P. Two relatively minor cold/dry events at ca. 3000 and 2000 cal year B.P. marked step-wise strengthening of the monsoon until ca. 1000 cal year B.P. After a cold/dry episode that culminated ca. 800 cal year B.P., the monsoon again strengthened and continued until today. A sharp decrease in temperature and rainfall at 4000–3500 cal year B.P. represent the weakest monsoon event of the Holocene record. This cold/dry event correlates with proxy data from other localities of the Indian subcontinent, Arabian Sea, and western Tibet.79

Staubwasser et al., 2003 examined the planktonic oxygen ratios from the Indus delta. It also corroborate the multi-centennial climate changes during the last 6000 year. The most prominent change was around 4200 yr ago. The northern Arabian Sea surface at that time indicates a reduction in Indus river discharge and also suggests that later cycles also reflect variations in the total annual rainfall over South Asia. The late Holocene drought cycles following the 4200 year BP event vary between 200 and 800 years and are coherent with the evolution of cosmogenic C-14 production rates. This suggests that solar variability is one fundamental factor behind Holocene rainfall changes over Asia. They suggested the higher level of solar energy output during the Holocene may have increase inter annual summer monsoon variability, changed winter airflow over South Asia Which affect the annual rainfall over Indus area.80 M. Carrie et al., 2003 studied the previously

published 36 climate records to delineate the temporal and spatial pattern of century scale abrupt changes in Asian Monsoon rainfall since last deglaciation. They concluded that the abrupt changes took place at 11500 cal BP, 5000-4500 cal BP and 1300 AD. The dramatically increase of Monsoon precipitation at the of the starting of Holocene was synchronous with the warming of North Atlantic ocean. Around the middle Holocene(5000-4500 cal BP) there was widespread weakening in Monsoon strength. These changes were not due to gradual drying or a series of abrupt events that occurred in an unorganised fashion across time and space. They suggested this change may be due to the abrupt cooling effect in North Atlantic, as well as a warming and intensification of inter annual variability in the tropical Pacific. They did not found any evidence for change in Asian Monsoon at 8200 cal BP as suggested by several scholars. The precipitation changes at 1300 AD have a heterogeneous pattern than to previous period.81

Prasad and Enzel, 2006 present a comprehensive summary of the available palaeoclimatic records from India and compare the results from different proxies available elsewhere in the world. The results indicate (i) fluctuating levels of the lakes during the early Holocene. The period of relatively higher lake levels from increased precipitation efficiency was reached only approx.7200–6000 cal year B.P., possibly due to the increased contribution from winter rainfall; (ii) onset of aridity in NW India could have begun as early as approx. 5300 cal year B.P. Subsequently, there were multiple wet events but of shorter duration and smaller magnitude than during the mid Holocene (iii) there is evidence of several short term climate events in the proxy record. However, in the absence of a rigorous chronological framework a detailed regional correlation is not possible at this stage. Finally, a comparison between marine and terrestrial records indicates that episodes of strongest and weakest monsoon winds were not always associated with wet and dry episodes respectively in the NW Indian lakes.82

Sarah, J. Ivory et al. study the pollen from the Arabian sea off the Makran coast. They told the weakening of the rainfall between 4700- 4200 BP and end of the humid phase. It also identified two phases of strong summer monsoon between 5400-4200 BP and 2000-1000BP and a contrasting period of winter monsoon between 4200 and 200 BP.

Interestingly it tells about the stability in regional vegetation of low and mid latitude, arid and semi arid areas, since 4500 BP.\(^{83}\)

P.D.Roy et al. studied the playa of Phulera and Pokharan. They suggested two short rainfall vents during ca. 6600-4000 B.C. and persistence higher rainfall regime during 4000-2300 B.C. at Pokharan. It followed the low rainfall conditions between 2300-1400 B.C. These results were corroborated at Phulera.\(^{84}\)

S. Parshant et al., 2010 on the basis of fluvial records of Siwalik succession in the Himalaya foreland elucidate that the peak of the Monsoon was around 10.5, 5.5, 3 Ma after which the strength of monsoon decreased to the modern values with minor fluctuations. Holocene lacustrine evidences from western Rajasthan suggest maximum lake level around 6000 B.C. and complete desiccation between c. 4000-3000 B.C.\(^{85}\) The summery of these contradictory views on the palaeoclimate of northwestern Indis is given in table-1


Table 1.1

The time period and palaeoclimatic conditions of mid-Holocene in India

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>BP Dates</th>
<th>BC Dates</th>
<th>Environmental Conditions</th>
<th>Vegetation</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>-</td>
<td>2000-500</td>
<td>Increase in monsoon precipitation</td>
<td></td>
<td>Ramaswamy, 1968</td>
</tr>
<tr>
<td>2.</td>
<td>3500 uncal.</td>
<td>1900-1800</td>
<td>Lakes dry and aridity continue till today</td>
<td>Singh et.al.,1972; Agrawal and Sood,1982; Swain et.al.,1983; pant and Rupa Kumar,1997</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>4000 uncal.</td>
<td>2550</td>
<td>Ephemeral lakes</td>
<td>Singh et.al.,1990</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>4800-0</td>
<td>c.2800-0</td>
<td>Dry playa and episodic lakes</td>
<td>Enzel et.al.,1999</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>4200-3500 cal.</td>
<td>2150-1750</td>
<td>Weakest summer monsoon event of Holocene</td>
<td>Phadtare,2000</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>4200cal/uncal.</td>
<td>2800 uncal. 2250 cal.</td>
<td>Isotopic records suggest reduction in Indus discharge and dry conditions</td>
<td>Staubwasser,et.al.,2003</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>5300</td>
<td>7150</td>
<td>Aridity set in with phases of minor fluctuation then on</td>
<td>Prasad and Enzel, 2006</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>4700-4200</td>
<td>c.2700-2200</td>
<td>Weakening of summer monsoon precipitation. Stability in low and middle latitude, dry and semidry since 4500 BP</td>
<td>Sarah,J.Ivory et.al., 2009</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Ca 2300-1400</td>
<td>Low rainfall</td>
<td></td>
<td>P. D. Roy, 2009</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>2300-1400</td>
<td>Low precipitation</td>
<td></td>
<td>S. Prasanta and R.Sinha,2010</td>
<td></td>
</tr>
</tbody>
</table>
From the above discussion it is clear that there was climate variability but the uncertainty and controversy about the chronology of the variability of palaeo-climate will remain. For the understanding of palaeoclimate we may take help from the archaeological data, accumulating in the past.

The archaeological material suggests the change in the settlement pattern, subsistence practices, economic activities and material culture. These changes were not possible with the change in climate alone. Other factors including human agencies were also responsible for these changes.

The natural vegetation of India subcontinent is arboreal except the higher reaches and more arid climate of Thar and Baluchistan. However, the continuous unregulated clearing by burning and exploitation by cultivation and over grazing it was gone from plains, lower hills and plateaus. The activities turned them into scrub land.86

McKean’s study of pollen from the Balakot in Las Bela district of Sind provides the fresh insight on the palaeo environment of the Indus Valley. He studied both the past and present vegetation of Las Bela district of Pakistan with the help of the pollen recovered from the archaeological excavations of Balakot and the identification of the vegetations depicted on the pottery. The main plants depicted on the Harappan pottery is Pipal (Ficus religiosa), Date Palm (Phoenix dactylá), Banana (Musa basíalana), Babul (Acacia arabica), Kair (Capparis dactylifera), Khejri (Prosopis spicigera), Phrans (Tamarisk aphylia), Pilu (Salvodora persica), Siasm (Delbergia sisso), Siris (Albizzia lebbeck). The pollens of these plants were also present in a fairly good number in early and mature Harappan levels of Balakot. The arboreal pollens are less than 10 percentage of total recovery of pollens. These arboreal species exist even today in the area of Balakot.87 The cultivated species include squashes, gourd, cotton and barley which were present since the earliest times in Harappan crops repertoire. He concluded that the climate of Indus valley was the same as like that of today. The fall of Balakot was due to the moving away of the Winder river from the site and disturbing the flood plain dominated agriculture.88

88 Ibid.
Moreover, the pollen profile from excavation at the Harappan sites Lothal and Rangpur in Gujrat is similar to the present flora surviving in these areas. The flora excavated from the site of Lothal were Albizzia, Acacia, Soymida, Tamarix, Tectona grandis, Adina cordifolia, Lauraceae and floral profile of Rangpur were Albizzia, Acacia, Soymida, Tamarix, Melia, Pterocarpus santalinus. The pollen profile from the Rajasthan lakes show the presence of non-arboreal dominance and the taxa associated with wet conditions (Artemisia, Chenopodium, Mimosa rubicaulis, Oldenlandia, Typha) are even found today is the existing vegetation of the Thar desert. The Holocene pollen profile from Jaisalmer, Ajmer, Nalsarover and Malvan lakes also suggested grassland and thorn forest vegetation for most of the Rajasthan and Gujrat is not different from what we encountered today in these areas. Even the pollen data from Kalibanga corroborated the idea of similar climatic conditions during Harappan time.

The study conducted by indo-French mission also point towards the same climatic condition as present today during the Harappan times. The mission conducted the explorations in the area of Chautang palaeo-channel and in neighbouring regions. They also visited the already well known sites like Kalibanga, Mitathal, Banawali, Siswal, Agroha, Ganeshwar Jodhpura, Didwana, Paoli and Rakhi Garhi. In 1983 they investigated the Kantali and Dohan river valley. It was a problem oriented expedition. They wanted to know the relationship of archaeological site to their environment, ancient drainage system and ancient canal system if any. They examined 209 sites, 69 bore wells and sections, and took soil samples for further analysis. They elucidated that:

1. The drainage system of the area concerned already dried up in early Holocene.
2. During the following dry phase, dunes were formed and palaeo-channels were filled up with aeolian sand and monsoon flooding deposits.
3. The major alluviation phase was over before the pre-Harappan period: for instance the site no.144 and 197 are located over 8-10 metre sand deposit of palaeo-channel fillings.

90 G.Erdosy,1998,*,op.cit*, p.60.
4. No more alluviation occurs after this period except the local alluviation in Bhadra depression by monsoon floods.

5. The soil of varying fertility was cultivated by the people since the proto historic periods.\textsuperscript{92}

From the above discussion we may assume that the climate of this region is not changed since Harappan times at least until proven otherwise.

\textsuperscript{92} IAR-1983-84, pp. 95-98.