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Ecological Changes in Ancient India

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ABSTRACT

A few studies available have focused on the climate change, migration and topographical change in the ancient India, however, topographical changes, history and migration is fully interconnected to each other. Many studies based on literary and archaeology suggested that Aryans migrated to the Ganga Yamuna doab from the northwest, but scholars do not inform what route they followed and what topographical changed were brought by Aryans during the earlier migration? Aryan followed the course of the Yamuna and Ganga because this route was less dense forest. While, north region was surrounded by hilly region and cold, while, south region (modern Rajasthan) was dry zone area, as well as, most of the area was not suitable for agriculture. The studies (Basham, 1967; Romila Thapar, 2002) explained how Aryan settled in the Ganga plain but these did not throw light over the Aryan's migration in the humid zone. However, archaeological evidences suggested that people were already moving from the west to east; even from south to north. But archaeologist failed to explain pattern of migration during 1000-1500 BCE. It seems that environmental conditions were much favourable in the Ganga valley; as well as, the area was suitable for the mixed economy.

Key words : *Migration, Climate Change, Mandal, Janapada, Kautilya,*

Many studies (Sharma, 2005, Upinder Singh, 2008, Basham, 1967, Srimali, 2002 and Thapar Romila, 2002) suggested that early Aaryan's economy based on the pastoral economy in which cattle and horses were very important in Aryan's society and economy. They kept large number of cattle, but they faced problem of limited food production during the winter. Pasture land hardly produced sufficient fodder for their animals because erraticism of rainfall and winter largely affected the pasture lands. They were organised in tribal communities and for the pasture land, they were moving from here and there. They were not engaged still in the large scale of agriculture system; however, they were showing few crops but without irrigation system, they were largely depended on husbandry. However, Rigveda (X. 101.6) mentions *kupa* and *avata*, described as artificial hollow in the earth, which indicates a well, but irrigation system by well (X.25), and canals (X.99, X. 75,) used limited for the agriculture. East zone was the best place for them, flora and fauna were always in surge in the Ganga plain. Perennial rivers Ganga, Yamuna and other not only provided sufficient water but also made a belt of fertile and soft land. The rivers and good monsoon enabled them to take the double-crop. Ganga Yamuna doab was capable to produced surplus and maintained a population density. Surplus supported to strong states and societies such as the Magadha and subsequently Mauryan and Gupta Empire flourished.

Many scholars have given environmental-based explanation of Aryans migration, they held that early Aryan society was based tribal system; always moved from one place to other place for good pas-

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ture land. However, we have no clear idea that what was the role of the climate change in the early Aryan's migration? In the context of Harappan civilization, however, scholars have rejected the environmental explanation linking emergence of Harappa civilization to increased rainfall and declined due to increasing aridity. Climate change must have been a long-term trend towards the increasing aridity and it seems that decline of Harappa civilization as well as early Aryan migration led in the same time. Many studies suggested that Harappan Civilization had experienced of widespread climate fluctuations that had significant impact on Harappan Civilization. It is also suggested that rise and fall of Harappan Civilization were triggered by climate fluctuations that had dominated by seasonal change in the monsoon. Mayank Kumar, however, have focused on monsoon in medieval period of Rajasthan but he pointed out due to fluctuations of monsoon people had developed the arid-adapted techniques. He also pointed that due to fluctuation of monsoon, people directly developed techniques of water management. Mayank Kumar rightly said that monsoon has been an integral part of culture; the folklores, rites and festival are intimately associated with changing season. The climate change certainly had been associate cause to decline and rise of the civilization. Scholars have focus on the climate change in the past, in the context, Shaffer and Lichtenstein focus on climate change in the past and they divided the period from 3000 to 1000 BCE into three climatic sub phases in South Asia.[1] First phase started from 3000 to 1800 BCE seemed rainfall was much higher than present day but to have become drier in the later centuries. Second Phase started from 1800 to 1500 BCE was a short period of decrease rainfall and third phase started from 1500 to 1000 BCE this period had a slight increase in rainfall although arid condition continued (Jha, 2017). Herman Kulke and Dietmar Rothermund summarized the climatic data and point out the pattern of climate change and highlighted shifting of monsoon in ancient South Asia. They further suggested that during third million BCE, rainfall suddenly rise, which reached in peaked by 2500 BCE but by the end of that millennium, rainfall suddenly decreased and again rise and that from around 1800 to 1500 BCE Between 1500 and 1000 BCE rainfall slightly increased and then continued decreased again. Around 500 BCE rainfall increased but around 400 BCE, probably there was driest period. In the following century, Kulke and Rothermund held that, 'the rainfall become more abundant but never reached the level of 2500 BCE. Grewal also said about the region of Punjab that, rainfall has probably decreased during the last two or three thousand years…. when rainfall was heavier, the plant covering was denser and richer.'[4] He further said that when rainfall was heavier, this region was covered with the dense forest and elephants roamed freely. Climate change has been suggested in the connection with the lost river of the desert, the river called Saraswati. [5]

Sir Aurel Stein (1931) and Sir John Marshall (1931) also presented many archaeological evidences of Baluchistan and Sind, and proposed that climate during the Indus Valley Civilization was more wet than at present. However, later on, this theory was questioned on this theory put a different view on the basis of three important facts:

1. 'The evidence for climate change was based on palynological rather than on archaeological data.
2. The climate change consisted of several fluctuations which covered almost entire Holocene in North West India and just the Harappan period.
3. The fluctuation in rainfall was related not only to the growth and decline of the Harappan culture, but also to the origin of agriculture- base life in the eighth millennium BC. And to its expansion in the fourth and third millennia BC. In north- west India.' (Mishra, 2007).

Phadtare reports indicated the climate change, the beginning of aridity ca 4000-3500 cal yrs BP based on pollen data from the Higher Garhwal Himalaya whereas in western peninsular India the reduction in humidity starts ca. 4500 cal yrs BP and intensified at around 3500 yrs BP.' (Gupat *et al.*, 2014). Climate change had been a most important factor in the human occupation and migration. There are many views regarding the increasing aridity in many sites of Harappan Civilization led to the migration towards more conducive areas. While, archaeology evidence explicated, people of many sites of Harappan Civilization led to the arid-adapted life. Harappan Civilization depended largely on rainfall and they were growing more drought-tolerant rain-fed crops such as wheat, barley, peas, lentils etc. However, in the early phase, the rain fall for Harappa civilization was much favourable for their crops and habituated place. In the later phase, Harappa faced a severe problem of increasing of

aridity which was most important role in their migration, however, scholars have still arguments in the matter of increasing aridity around 2000 BCE. Other ecological factors, such as periodic floods, shift in the course of the river and seismic activities, cannot be ignored. For example, Kalibangan, a popular site of Harappa civilization, scholar Robert Raikes suggested that Kalibanga faced severe ecological disaster, Ghagghar river changed their course, result in, decline of Kalibanga around 1800 BCE. D. P. Agrawal was also giving an explanation for the decline of Harappan; he suggested that climate change was vital factor in the Harappan civilization. Archaeological evidences also supported to this hypothesis that in many sites of Harappan but not to all sites. Certainly, aridity was increasing which can be seen in many sites of Harappa. Scholar Ratnagar, 2008 suggested that rainfall per year had been received less than two inches in Sind and Ropar, in Punjab, receives five to six inches of rainfall. However, rainfall zone of both sites was different; they had different causes of declined. For example, the decline of Ropar was directly linked with decline of the lower Indus town. Such as Chattopadhyaya suggested that Ropar was a supply centre for the goods of pastoral economy. (Chattopadhyaya, 2003) and the decline of the lower Indus town also brought decline of Ropar. Inamgaon in Maharashtra, suggested that the onset of an extremely arid phase around 1000 BCE that forces the farmer to desert their homes and take to pastoral nomadism (IBID). Certainly, climate change had to force the mature Harapan people to migrate in towards the higher rainfall zone because these (Ganga valley) areas offered greater security of water. The gradual migration of mature Harappan people was in Haryana, Punjab, Uttar Pradesh and eastern and southern parts of Indi-Ganga plain. However, we have no sufficient climate data which could determine the mature Harappan people migrated due to increasing aridity. Sharma, 2011 rightly said that 'the location and size of settlement were conditioned by environmental factors, with soil and climate condition which determined the selection of site.'[11]

On the other side, Aryans consistently shifting towards the Ganga Yamuna doab and by the end of the Rigvedic period the Aryans had reached the doab. Of the rivers to the east, there was little knowledge but gradually the pace of migration increased, and a pastoral people began to exchange their nomadic life for an economy based on agriculture.[12]Aryan moved towards the semi-arid zone in the Ganga valley such as explanations mostly are not backed by literary and archaeological evidences, but there are evidences of early life of Aryans that may give glimpse idea of ecological changes. Rigveda no mention of famine but first *mandal* of *Rig-Veda* (I,112,11) mention a drought, second *mandal* (Rg. II,15,5) described that due to scarcity a number of people were migrated toward the northward by crossing the *Parusnu*. There are many other stray references of drought found in Vedas, there Indra who was Godof rain, worship was greatly in mode. Gangguli is noted that *Chandogya Upanishad* speaks about a famine and similar '*Agnipurana* ascribed famine to either of the two causes of absolute dearth of excessive rain.'[13] Such as references are not providing much detailed but it is clear that in the Vedic period famine and scarcities was prevailed. However, the Ganga-Yamuna doab was semi-arid zone and famine and scarcity was also in vogue there but rivers, forests and fertile area were enabled them fulfil their needs during any scarcities. Ramayana (*Bala-Khand*) mention that in the reign of Rama, people never faced feared from the famine and scarcities. This area can be accomplishing the requirement of mixed economy; this was more accessible zones where fodder problems got rid. The semi-arid zone assisted them clearing the forest through the fire; they easily burned less dense forest along with riverbanks. Aryans followed the way of Himalayan foothills, as well as, riverbanks of Yamuna and Ganga, simply, they avoid dense forest areas. They reached in more fertile areas; Benoychandra Sen held that 'the *Yajurveda* written when Aryans had reached much further east and South'. Once, Aryans reached in the Ganga-Yamuna doab; they started used artificial water channels for the irrigation. In the *Atherveda* have much references of artificial irrigation system. Gangguli gives example of *Vishnupurva* of the *Harivamsa* in which has mention that the course of the Yamuna was diverted by Balrama in *Brndavana*. In the *Sabhaparva* of Mahabharata mention that Narada advised the king Yudhisthira to dug tanks at proper distance in the kingdom so that agriculture not to depend entirely on rain. Eratosthenes, who came at the time of Alexander's campaign, wrote due to rainfall in the months of summer, plains were overflowed. In general, the region of Ganga-Yamuna was providing a warm climate, which was

largely influenced by the southwest monsoon. The temperature hardly falls away to 0°C during the extreme cold months. Monsoon season gets sultry but carried floods, as well as, abundance flora and fauna.[15] Megasthenes who lived in the court of Chandra Gupta Mourya, praised the fertility, climate and rain system of Ganga-Yamuna doab; he said that the soil produced two crops in a year, and rain and rivers provided enough water to fields. Eratosthenes noted that moisture (rain fall) of this country nourished the fruits and crops. *Arthashastra* (II. IV, 8.2.25) a drought is worse than too much rain, because drought destroy livelihood.[16] Kautilya gives details of rain and season and speaks that many regions of India solely dependent on the rain. R.S. Sharma noted that, 'proceeding from west to east we find the annual rainfall gradually increasing from 25 cm to over 250 cm. The Indus vegetation based on 25 to 37 cm rainfall and possibly the western Gangetic vegetation based on 37 to 60 cm rainfall and possibility the western Gangetic vegetation based on 37 to 60 cm rainfall could be cleared with stone and copper implement and made fit for cultivation.'[17]. The early phase of introduction of iron, as well as copper and bronze, would have help in the clearing of forests. But iron in the large scale had not been used until about 800 BC. This was main reason, initially Vedic society was pastoralists, but some agriculture practised was carried on with cattle-rearing. Since the later Vedic period, migration continued into the Ganga-Yamuna Doab but migration comes in various forms and took long time. Cattle raid was in their culture; they had not abandoned but it had become more common. Certainly, raids would have increased their livestock; they fought consistently over the pasture land and animals. *Rigveda* speaks about the inter-tribal conflicts that Sudas was the chief of the *Bharata* clan; he faced a severe attacked by confederacy of ten clans. The main reason of this dispute was controlling over the grazing grounds and stealing cattle. However, Sudas was victorious but this battle shows that the pasture lands, and livestock was in higher demand. For the new agriculture land, they were consistently clearing the forests. *Sathpath Brahaman* mentions that How Videgha Mathava led to forest clearance in the Ganga plain. Over the controlling vast agriculture and pasture lands in the Ganga plain, many clans were being united into a big confederated, such as *Kuru* and *Panchala* made a powerful confederacy. In fact, Agro-pastoralism still remains the main occupation and number of cattle was a measure of value but agriculture production was become to be more important. Once, they settled in the Ganga-Yamuna Doab agriculture gradually shifts from the wheat, barley etc. cultivation to rice. Rice cultivation enabled to change from *vish*, or clan to *jana* and *janapada* because rice cultivation produced a larger surplus which was necessary for emerging of kingdom.

In brief R.S. Sharma pointed that semi-arid zone was suitable for Aryans because there was a less dense forest area. He further said that 'the thickly forest area, which also had hard soil, could cleared only with the aid of iron implements which become available at a much later stage. It seems that they had climatic knowledge of Ganga-Yamun doab but southwest monsoon was still a secret for them. Aryans had learned here about the classification of soil, plant physiology, seasonable cultivation and developed method of protection of crops, treatment of seeds and several kinds of manure. In brief, the Ganga-Yamuna doab was a good optional for them because, this zone provided main diet of Aryans such as rice, barley, wheat, lentils, peas, etc., in addition cattle, sheep, and goats were the main source of dairy products and meat. Moreover, hunting and fishing must have been supported in their food diet. Makhan Lal has focused on minimum requirement of calories per day for men, and tried to link it with Aryans' diet. He quoted Dhavalikar and Possechi's estimate of diet of an individual. He said reasonably minimum diet for a single person is required about 1,700 calories per day, and for the good health about 600 calories more required. He estimated that the content of one kg grain generates around 3,350 calories, this would feed 2.5 person for one day. He estimates that 'by multiplying this with 2,400 (the estimated population of the settlement) the daily grain requirement comes to 960 kg, which is the daily food requirement. Multiplying this figure by 365 days we get 346,750 kg, which is the early food grain requirement.' In the context of increasing population, Thomas Malthus in 18th century held that population always would grow much greater in comparison to the capacity of food production. He said that population had own nature to increase in geometrical ratio, and subsistence for human in an arithmetical ratio. Makhan Lal estimated that total land requirement for 2,400 people would be 960 acres.[19] He further said that if the land is left for a year vacate, it would be double the areas required which is 1,920

acres, and if the empty period is of two year the land required would be 2,880 acres.[20] In addition, there were many calamities such as drought, flood, and famine had to be reduced the production; in result agriculture land would be require more. Arthashastra, described many dangers which affected the agriculture production such as rats, locusts, birds, insects, and wild animals; he suggests the how protect the field from these dangers.

Romila Thapar quoted 'The gradual clearing of forests over the century has changed the ecology of certain region. The pace of change was not uniform. It was slower in earlier times and more limited in its geographical area, but as the demand for land increased, the clearing of the forest become more faster and the area so cleared, larger.'[21] At this time, the Ganga plain was much wetter than today and covered with dense forest. Megasthenes (Fragm XII) and Strabo (XV,I.37) stated that the largest tigers were found in the dense forest of around the *Prasii* (Pataliputra). E.I. Ropson said that 'in the pre-Mauryan times of early Budhism, most of the Ganga Valley was still jungle.'[22] Kautilya gives details of protective forests in the Ganga valley. However, some part of Punjab was semi-arid that was suitable to cattle rearing. Romila Thapar held that Cultivation in this region, during the Harappan period already have led to some deforestation[23] and in the Vedic period, expansion of agriculture and settlement would have required more clearance of forests. The pastoralism continued to co-exist with the agriculture, although, permanent agriculture had not developed until invented the iron. During the migration, In the Ganga-Yamuna doab, Aryans had developed a complex agro-pastoral economy, permanent settlement and migration was running together. In the course of time, they domesticated several kinds of plants such as rice, but new crops signified modified in the Iron Age. The dry deciduous forests not changed until pre-Buddha period because both iron and fire were using in the clearing the forests convert into cultivation and settlements. However, farming activities had opened woodland but naturally was on forest edge. The good rainfall and humidity would have supported the agriculture but Iron Age was carried significant change in this period because large permanent settlement happened in this period. Along with this change were also associated changes in their diet. The climate and iron might have provided enough support for the summer and winter crops. People had developed method of irrigation system because there was easy to cut soil with the help of Iron. Makhan Lal has drawn attention towards the urbanization in the Gangetic plains around 1000 BCE He stressed that Gangatic plain was covered with dense monsoon forests, and many states like *Kurus* and *Panchalas* were located in the forest's areas. He said that, 'in fact no other parts of India have undergone such a drastic change due to tillage of jungle land in the past two century.'[24] The Kuru's kingdom such as Makahan Lal cited that was surrounded by forest, which extended as far as Kamyaka forest. Apart from the *Kuru* and *Panchala,* other *Janapada* as *Anjanavana* at Saket (Ayodha), the *Mahavana* at *Vaisali* and the *Mahavana* at *Kapilvastu* etc. were surrounded by natural forests, which extended up to lower Himalayas. Pali texts such as *Jatakakatha* in the fragment history described that the *Lumbinivana* of the *Vajji* kingdom, the *Salvana* at *Kusinara*, Bhesakalavana in the *Bharga* Kingdom, the *Simsapavana* at *Kausambii* and *Kosala* were the example of kingdom which were surrounded by forests. Certainly, considerable ecological damaged have happened in the British period. Definitely, until the Mughal period, the forests were undisturbed; however, some parts in the small scale, forests might have been cleared for agriculture purposes and new settlements.

The agronomy, changed the ecology but clearing forest in the Ganga plain was not being very rapidly because: (1) In the Ganga plain, forests were so extensive and dense, (2) cultivation and settlement expansion was limited, (3) the activities of forest burning and shifting cultivation was periodic and limited, (4) forests were sacred places. The literary evidence such *Purans*, *Upanishad* demonstrated concerns of the degradation of ecology like, *Kurma Purana* (1.27. 16-57) says, "Then greed and passion arose again everywhere, inevitably, due to the predestined purpose of the *Treta* [Third] Age. And people seized the rivers, fields, mountains, clumps of trees and herbs, overcoming them by strength."[25] Similarly, Mahabharata in the *Shanti Parva* mention that in *kalyuga* (third Age) "At the end of the Eon the population increase-and odour becomes stench, and flower putrid, women will have too many children…The cows will yield little milk, and the trees, teeming with crows, will yield few flowers and fruits …..there befalls a drought of many years that drives most of the creatures, of dwindling reserves and starving, to their death….The fire of an-

nihilation then invades burns down all that is found on earth……All people will be naturally cruel…Without concern they will destroy parks and trees and lives of living will be ruin in the world. All countries will equally suffer from drought.... It will not rain in season, and the crops will not grow. Buddha and Jain had already demonstrated the ecological views, they considered that nature is supreme than human lives. In fact, despite of non-violence philosophy and concerns for the ecology, the practice of clearance of forests, and new agrarian settlement were continuing running together. Mahabharata marked a story of Arjun, in which echoed of the degradation of ecology. *khandava* forest was protecting by Indra, *Agni* and *Varun* failed to burn it. Request made by *Agni* and *Varuna*, to Krishna and Arjuna for the burn the forest. Arjuna and Krishna made habituated and cultivated area and gave name of *Khandavaprastha*, later on, it become the great city of Indraprastha. The story *khndava* forest shows that how forest was destroyed and described the terrible story of ecological losses. Upinder Singh (Upinder Singh, 2017) mention that all creatures of the forest were hunted down and almost completely eliminated. She also gives terrible sight about the burning of *khandava* forest "*As the khandava was burning, the creatures in their thousands leaped up in all ten directions, screeching their terrifying screamed. Many were burning in one spot, other were scorched-they were shattered mindlessly, their eyes a bursting. Some embraced their sons, other their father and mothers, unable to abandon them, and thus went to their perdition. Still others jumped up by the thousand, faces distorted, and darting hither and thither fell into the fire. All over, the souls were seen writhing on the ground, with burning wings, eyes, and paws, until they perished. As all watery places came to a boil…….The turtles and fish were found dead by the thousands. With their burning bodies the creatures in that forest appeared like living torches until they breath their last. When they jumped out, the Partha (Arjun) cut them to pieces with arrows and, laughing, threw them back into the blazing Fire."*[27] Similarly, a story found in *Satpatha Brahaman* (I.4.1,14-17) tell us how Videgha Mathava and his priest Gotama Rahugana had cleared forest with the help of *Agni* (fire). Both stories tell us process of spread Aryan settlements in the Ganga plain, in which the role of *Agni* (fire) in the burning of forest was prominent. However, *Satpatha Brahaman* is silent to tell how much ecological loss done by fire? The instance of forest clearance in the later Vedic period can be link with the beginning of settled society (*grama/ksetra*). From the early Vedic period, desire of the cultivated land was increasing, however, cattle rearing was more important but agriculture had emerged as a subsidiary occupation. In the hymn of the *Rigveda* desire for the fertile field (*urvara*), and furrows (*sita*) drench by rain, producing rich harvests. From the early Vedic period, agriculture activities had started that's why in some Rigveda hymns prayer Indra beseech him to grant or enrich the fields. The pace of clearing of forests was not fast; it was slower and more limited. The population was certainly consistently increasing; however, we have no idea and evidence, how much population increased but in the later Vedic period but we found many words such as *grama, kshetra, jana, janapada* etc., indicating to settle society. *Manu Smriti* and *Yajnavalkya Smriti* advised to the king for the clear forest and establishment new colonies.

During the middle of the 1000 BCE, ecological changes in the large scale was possible only because of widespread use of advanced iron tools which helped the in clearing the dense monsoon forests of the Gangetic Plains. Scholar Makhan Lal argued that extensive use of iron tools was possible only Bihar ore mines exploited in in the middle of 1000 BCE, however, it was not iron technology alone but powerful states brought great expansion forest lands under the cultivation. The new settlements and agriculture were being along with bank of river, in fertile land and hilly areas, probably, these areas were much easier to clean than dense forest. Initially, iron technology used in only hunting or wars, as well as, for domestic purpose, iron tools were not made for the agriculture. This was happened in pre-Buddhist period; people had started proper rice cultivation and most of the cultivation was on the bank of rivers. However, rice surplus was negligible and rice farming was limited to the hilly regions where shifting cultivation was much popular. It should be remembered that by this time iron was precious metal because for the iron melting required high technology, as well as high temperature, that was why people could not use frequently. But iron weapons were consistently made in pre-Buddha period, S.D. Singh has given an example at the base of excavation at the Garh Kalika mound on the outskirts of Ujjain revealed that iron was known to its ancient dwellers from the earliest period.[30] S.D. Singh explained that the knowledge of iron in India must have come around 1000 BCE but by the second half

of the fourth century BCE was fully used in the society. Upendra Singh said that 'small quantities of iron occur at a few sites in early 2nd millennium BCE. The metal becomes more widely prevalent in c. 1000 -800 BCE.'[31] She further said that 'During c. 800-500 BCE, the use of iron was known in virtually all region of the subcontinent and by this time, most region seem to have entered the iron age.[32] This period was significance because Magadha and Maurya Empire strengthened the iron technology and dominant economic and political institutions, result in, iron technological expansion in Ganga plain gives boost to exploitation of forests. The settlement of this period recklessly increasing beyond the Ganga valley, like, in the South India, especially in Karnataka and Andhra Pradesh had appeared very fast new settlements. It has been suggested that it happened because of iron technology. Certainly, uses of iron consistently increasing, such as B. Prakash pointed out that iron objects found in various excavated sites that is shows fast growth of the technology. He pointed that still growth patten of the use of iron had been in hunting tools and agriculture tools. Emergence of states and second urbanization brought closer to the forests which comes more easily available due to invention of iron.

The Buddhist literatures, particularly, the *Tripitaka* which are relating of Buddha's teaching, these are often provides enough information about the expansion of agriculture with the using of iron tools. early Vedic literatures did not provide us good information of iron because "*ayas*" words, sometimes many scholars identify with the iron but Dilip K. Chakrabarti used this term for both copper-bronze and iron. Dilip k. Chakrabarti mention that in the *BlackYajurveda* positively sound about the iron and used "*syaman*" but *Atharveda* mention specifically *black ayas,* but these references were not of particular historical uses. Dilip K. Chakrabartati wrote that 'Historically, the problem of the beginning of the use of iron in agriculture is a more significant issue than the problem of its very beginning.'[33] On the basis of archaeological evidence, Dilip K. Chakrabarti had identified six early centres of iron in ancient India, each of which may be placed between 800 BCE to 1000 BCE These six sites are associated with early phase of iron such as (1) Baluchistan having popular sites like Moghal Ghundai, Ziwanri etc. (2) Northwest: Gandhara Grave Culture which is locate in the Swat valley, (3) Indo-Gangetic and the Upper Gangetic Valley, which is associated with PGW culture phase, popular sites are jakhera, Atranjikhera, Ahhihchhatra and Hasinapur (4) Middle Gangetic Valley and the adjacent area such as Kausambi, Rajaghat, etc. (5) Central India: Malwa, is Chalcolithic sites in which Ahar and Eran most popular. (6) The South, there are found two culture megalithic and early Iron Age. This area extended from the Berar to Cape Comorin. The scholars had reach at the agreement that in the early phase of iron led to change in the culture life and subsequently, go together with urbanization in the Ganga Valley. This urbanization is popularly known as second urbanization which was associated with NBPW period. Many scholars such as suggested that iron technology was spread in Indian Subcontinent with the migration of Aryans. However, many sites, particularly is south India iron was existed (Dilip. K. Chakrabarti) so iron brought by Aryan in all regions is a myth. Dilip k. Chakrabarti and Lahiri is also provide a list of 1500 iron objects which are found in many Harappan sites, as well as, other Chalcolithic and Copper hoards sites. Around 135 iron items were also found in Atranjikhera, this site is linked with PGW culture.

The sites in Ganga Valley were agro-pastoral economy which was associated with Neolithic-Chalcolithic period. In the Koldihawa site, we found evidence of domestic rice with domestic animals, as well as red ware and grey ware. This site was no single site which produced agro-pastoral life, similarly many sites are closely interlinked with agro-pastoral life, such as, Ahar, Navdatoli, and in South India. Thus, it can be assumed that in initially, iron did not play crucial role in the society because agrarian base culture was already in force in these sites and these sites were contemporary with Harappan culture. Only few sites, likes, Atranjikhera, Jakhera were larger in size; generally, were small in size not exceeding 2-3 hectares. Only sites, a site in Kanpur and second in Kausambi site were in above 5 and 10 hectares, respectively. But Makhanlal said that settlement of Atranjikhera, Kausambi and Jakhera had expanded in the later part of the PGW period. Certainly, PGW people had become usual with the iron and their settlement was consistently increasing, however, they were still using fire for bringing new cultivation land from the forest. We found many iron tools which shows that expansion of the settlement but mostly iron tools were made for domestic and hunting purposes not for agriculture purpose. However, in the Middle Ganga plains'

sites like Lahurdeva, Raja Nal Ka Tila, Dadupaur etc. shows that these sites are closely linked with Black and Red ware phase, but they were also using iron objects and iron tools had limited used in agriculture and other domestic purposes. Another important aspect of early Iron Age is that some sites in the South regions were mostly from Megalithic Culture. Apart from south, The Megalithic Culture can be seen in Jammu and Kashmir, Uttar Pradesh, Bengal, Madhya Pradesh and Chhattishgarh etc. The Megalithic Culture people were mobile pastorals and they had used iron technology but they did not leave past culture which is known from their erected sacred burial for the dead. They offered variety of iron and copper artefacts in the sacred burial places; which shows that they had well developed iron technology. The Megalithic craftsmen were well skilled to made iron tools such as axes, swords, daggers, arrowheads, blades, etc.

In the later phase of Iron Age, the furnaces in northern, central and south India produced massive quantities of cooper, bronze and iron artefacts. Certainly, all kinds of metal objects were making for daily uses and iron technology come from Harapan culture. Lahari and Chakrabarti have demonstrated that around 125 iron objects found in Harappan sites. Archaeological evidence shows that Harappan people had been used various types of metal and they were well skilled in metallurgy. Two references in *Sathpath Brahamana* and *Mahabharata* tell us story, how, in the early Iron Age, Aryan had brought forest land under the settlements. The Megalithic people were migrants had a good agriculturist as it is visualized from archaeological evidences. They made many agricultural tools that were received from various sites, like Veerapuram, Maski, Adichanallur, Kunnatur etc. The *kharif* and *rabi* such as rice, barley, wheat, millet and lentils were common corps. As well as, they maintained a considerable degree of animals; now they had exploited forests and wild animals for subsistence purpose. Despite of it, the highest percentage of domestic animals were followed by sheep and goats; shows that was agro-pastoral life.

Though, the iron technology had started since around 1000 BCE but until the second half of the 4th century B.C its brough full impact on society. This period was witnessed the strengthening of iron technology but it happened initially in Ganga Valley. Once, monarchy system matured, the ruler holds supremacy over the land and natural resources; then employed the general masses in the activities of production. Many new regions in Buddha period had acquired as a status of fully monarchy states, certainly, iron technology was major factor behind of growth monarchy system. Kosambi (1965) points out the location of Magadha; that was very close to mines of iron ore (Chhota Nagpur) and copper (Singhbhumi). The Magdha was surrounded by hills and dense forests; these natural resources exploited by Magadha and also keep control and ownership over the resources. The availability of necessary iron, copper, forests and other raw material contributed to lead a strong powerful Magadha state. In the case of Hastinapura, Sravasti and Kausambi reported several types of iron objects, like, arrowheads, various types of spears, etc. Later on, Taxila Ropar, Sonepur and Sohagaura, these sites were belonging to 3rd and 4th century BCE, shows the expansion of iron technology. By this century, Iron Age in the Ganga Valley had reached at the stage of culmination and conflicts over the iron ore mines had started. Iron technology not only broke hard alluvium soil in middle Ganga plain but also carried big conflict among the states over the control iron fields. The major conflict can be seen between the Magadha and Kosala over the control of natural resources. The powerful states. R.S. Sharma point out that growth of agriculture was major factor causing urban growth; it might be having increasing rice cultivation. In the Buddha literature, we found many references of wood cutter, they were organised in occupational group who were engaged in wood cutting. The community of wood cutters were in high demand in the states because they had great role in the clearing of forests. The *Jatakatha* and *panchtantra* describes many stories which shows that wood cutters go to forest to cut down the trees and wood sell in the cities. There was great demand for wood for the fuel, furniture, and other work. R.S. Sharma points out that use of iron technology not only helped in the creating of surplus but also indicated degradation of ecology. R.S. Sharma highlights the role iron axes in clearing of forests of the Ganga Valley and iron plough in agriculture expansion in this area.[34] A. Ghosh and Niharranjan are not agreeing with the view of R.S. Sharma, he argued that the forests of the Ganga valley could have been cleared through burning.[35] Early phase of iron did not play important role in the cleared forest but later on, around from the 6th century B.C, iron axe was most responsible for the cleared forests. How-

ever, during this period, there was dense forest in the Ganga Valley, result in, there was no significant impact on the forest. Certainly, the expansion of agriculture must have been through the forest clearance but the pace of forest clearance was slow.

From the 6th century BCE, there was common trend growing settlements in the fertile land of Ganga valley. This process placed huge pressure on the forests, Buddhism and Jainism had perceived this situation and respondent to it and by lying emphasis on non-violence and compassion, as well as, conservation of resources. The new settlements were gradually increase; however, all settlement were not urban, remote areas were producing more agriculture production. The Mauryan state adopted coercion policy to generate and take out as much of surplus as possible so as to sustain large army and bureaucracy. In order to, Mauryan state deliberately started policy to control over the natural resources, as well as, encouraged the people brought under the more cultivation land; result in deforestation in the large scale. Moreover, other contemporary states such as Kalinga, emerged because agriculture economy had reached at the level of maturity. Literary andarchaeology resources attested the expansion of agriculture in the remote areas. The radical transformation of the economy and society led, on the one hand to a considerable surplus, and on the other affected man-nature relationship. The Mauryan state was aware to protect the environment and made readjustment relationship with the ecology. On the one side, Mauryan state tried curbed the cutting down of trees and hunting, on the other side, all the forest products were used for the economy. Kautilya realized the importance of metals and mines that's why he appointed several officers such *Akaradhyaksa* (superintendent of mines), *Lohadhyaksa* (superintendent of iron working), *Khanyadhyaksa* (superintendent of digging) and *Laksanadhyaksha* (superintendent of elements). Kautilya believed that mining is a source of all power; he was so conscious state's control over the mines.

Forest exploited much during the Mauryan period because forests were major centre of resources. The state's economy largely depended on the forests because forests were not only providing wood, fuel, hay and other edible and medicine produce as well as were also sources of elephants. The forests were essential for security strategies; however, state encouraged the peasants to brought forest land under the cultivation. *Arthashastra* glimpse about the increasing population and expansion of agriculture which was brought by clearing forests. Vijay Kumar Thakur, pointed that in the beginning of the Maurya period in U.P and Bihar in the NBP phase witnessed a sizeable increase in population."[36] R.C Gaur, who was excavator of Atranjikhera pointed that NBP phase shows that population at this site was more than doubled in comparison with PGW phase.[37] Intensive agriculture closely associated with density of population, despite some approximately estimates, scholars held that population in the Maurya period was 181 million, however Romila Thapar suggested it was far high, but it was based on size of the Mauryan army, calculated from the Greek sources. There large energy was requirements for the fuel for the both domestic and metallurgical purpose, certainly it would have been fulfilling from the dense forest of Ganga plains. I am not focusing on the large energy which was using in metallurgical purpose; however, other materials could have been used fuel energy of forests. Vijay Kumar Thakur said that 'Kautilya was so conscious of the importance of metals and mining that he went to the extent of asserting that mining was the source of all power.'[38] Without energy which received form the forest, no iron industries could have survived, Atranjikhera was a big iron manufactured site, the hill area of this region was in rich in iron but, later on, this place was under the pressure because forest were being cut down. Sir Alexander Cuningham pointed out that 'the quality of Gawalier and Narwar iron and regrets the decline of the industry due to the scarcity of charcoal for smelting as the forests were being cut down.[39] Arthashastra instructed to the state to keep rigorous control over forest activities, Kautiliya recommend to keep a check on the revenue brought in by extending agriculture and possibly to prevent over exploitation of the land.[40]

Forests were often more fast cleared for the new settlements, two methods cutting and burning were frequently had been used in clearing of forests. Kautilya was not favoured of cutting down of forest by indiscriminate and wide spreading burning because it could be burned a pasture land, houses and elephant forests. Similarly, in the Fifth Pillar Edict (Delhi-Topara), Asoka mentions that forest must not be burned because it could be destroying the living being. Both, Kautilya and Asoka were against the indiscriminate burning of forests that was concerns for protection of ecology. On the one side, Kautilya

made special fines for the cutting down of trees; economic motive was behind of it but these measures would be reduced pace of cutting down of trees, he advised the king to established new settlement adjacent the forest and a land which was not suitable for agriculture, forest should be laid down. On the other side, Kautilya was extremely devoted to bring new land under the cultivation, moreover, state had own farms where under the supervision of the *sitadhyaksa* worked labours. Archaeological evidence demonstrated that massive irrigation projects started by state, we found frequently ring-wells which shows that new settlements were being away from the river. Now agrarian activities were being in forests, these forests were far away from the Ganga-Yamuna River. The state was more concerns to protecting and supporting the agriculture system. The Hathigumpha inscription of Kharvela indicates the king's concerns towards the irrigation facilities to the peasants. The forests of the Ganga valley as well as outlying regions had been largely used by Mauryan state. New towns were established into outlying regions such as Amravati, Mysore etc; the demands of timbers consistently increasing, however, Mauryan state efforts were not much serious in distance areas.

From the 3rd century BCE, archaeological evidences demonstrated that cities had expanded in the sizes and urban spread to many new areas that were remote before the Maurya state such as Kashmir, Lower Ganga valley, Punjab plain, Orissa and Brahmaputra valley. However, Upender Singh argue that 'The Maurya impact cannot be ignored, but it should not be exaggerated.' Urban Growth was also accompanied by expansion of agriculture and put pressure on forests for the increasing demand of timber. Megasthenes described that *Patliputra* (Magadh, modern Patna) capital of Mauryan Empire surrounded by wooden wall. Megashtenes described those houses near the bank river were built with mud and wood; it cannot be neglected that *patliputra* had been received timbers from the nearest forests tracts was the greatest in the Ganga valley plain. He also described about the Patliputra; city stretched toward the east around 9 miles and breadth was around 1 $^{1/4}$mile, which was surrounded by a ditch. Mostly houses were built with mud-timbers, although some were of stone, mud-brick. He also indicates towards the abundance of animals and birds; he says that Birds and animals that wander at freedom, however, these were domestic animals. The Greeks and Chinese travellers testified that forests were full from the different wild animals such as tigers, wild buffalo, rhinoceros, wild dogs, and elephants. New urban centre in the Indo-Gangetic plain, like, Ropar demonstrated a transition phase from the village to town, as well as, houses of the mud-timber also presented here.Megasthenes point out in their category of seven people, farmer, herdsmen, hunter and craftsmen were directly or indirectly had relationship with forest. Diodorus also refer to nomadic tribes of herdsmen and shepherds who were engaged in forests forest activities. Megasthenes described about the king's activities of daily life, sometime, king went to the hunts in fence enclosure; king shoot arrows from the platform and sometime, king hunted in the unfenced hunting grounds from an elephant. All the examples show that state had a close relation with the forest and their people. New political and economic consequences brought forest people or tribal under the subordinate of state and forced to accepted new political and economic changes. Tribes always created problems for the expansion of the areas towards the forests that's why Kautilya(2.1.4-6) advised to the king that king should be established new colonies by *Sudra* agriculturists on the virgin land, and the king should be protect the new villagers from the attack of *jungle* tribes.

The Maurya Empire met its end around 187 BCE, but it gives way to the rise of the Gupta Empire. In fact, between BCE 200 and 300 AD., there was time of rise of multiple states in different regions of India, they had own culture. The Shungas, Indo-Greek, Shakas, Parthians and Kushanas respectively ruled in India. In new political conditions began to decline centralized state, and monopoly over the natural resources, however, new states like Kushana empire supported new ecological consciousness. However, new states still claiming ownership on the forests, waste, pastures and landscapes but they had started made land grants with few rights. The decline of Mauryan Empire, carried adversely affected on urban centres, result on religious, scholars, and other nobles who received land grants, in lieu of their services extended their authority over the wells, tanks, forests, waste lands and pasture lands. The declined of urban centre brought massive changes in the ecosystem; it's not only converted forest and virgin land into pasture and agriculture land. However, in the Kushana period again urban centres had started

emerged and migration towards the villages, on the temporary stops. The rapid rate of urbanization continued in the pace of the Satavahana-Kushana period, accelerated the demand skill workers and labours for both purpose of trade and buildings constructions. The land grants made limited by Kushana-Satavahana rulers but, the agrarian expansion in the Ganga Valley had penetrated in the forest's areas. This process was slow and took long time, however, large scale deforestation was not yet. But new urban centres created high demand of wood because large-scale brunt bricks had been used in the construction of houses. It created huge demand of woods fuel for the dry of bricks, as well as domestic purpose. Many stories *Jatakakatha* shows that wood was high demand in cities. Over-grazing was also other problems disturbed of ecosystem. During this period, deforestation and over-grazing not in only happened in Ganga plain but Punjab, Haryana and many parts of South India equally affected. R.S. Sharma point out that many places of Ganga valley such as Kaushambi, Rajghat, Shravasti, Ujjain etc. were under the huge pressure of population, and over-grazing was another problem. Hein-Tsang mentions that there is abundance of animals. Decreasing of forest adjacent the river's banks lead to serious ecological imbalances in these areas and brought under the devastating floods. The archaeological and literary evidences of post Sathvahana-Kushana period illustrated that many cities, such as Kaushambi, Rajghat, Shravasti, were in troublesome by flood. These cities take on many protection devices against the floods (Thakur, 1995) The destructions by the floods recorded in Junagarh Rock inscription of Rudradaman described that Sudarshena Lake Dam become the cause of flood in the reign of Skandagupta, late on, it was repaired by him. *Arthashastra* described the variety of calamities which affected the population of the country. Kautilya (II. IV) said that the people can be affected due to act of God or men, but maximum calamites brought by men. Kautilya (8.2.25) described that, 'a drought is worse than too much rain, because drought destroyed livehood.' D.D. Kosambi point out that Hasitinapur, Atranjikheda, Kaushambi, Patliputra, Shravasti, Chirand, Vaishali, etc., had seriously troubled by the floods. Varahmihira in the Gupta period pointed about losses from the floods, the losses of forests bringing the devastation in the Ganga valley. Jain literature "*Tithogali Paninniya*" has described about the destruction of Pataliputra by flood in the 6th century CE. The man was responsible for the floods and famine; Kautiliya make known that that many ecological problems brought due to man's acts.

Conclusion

Since the ancient India, the Ganga Yamuna Doab is one of the most celebrated spaces in India, it was at the centre of the civilization and emerged many kingdoms. In terms of its capacity to ecology, it has been changed over thousand years, it is equal to or even surpass Mesopotamia, Greece and Maya civilizations. Many kingdoms of India had taken root along the Ganga Yamuna Doab, which continued to sustain till the Medieval period. As the ecological point of view, people in this zone had been improved or changes to some extent, they venture out with their resources such as animals, crops, firewood, etc.

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