Irrigational Development in Northern India during Early Medieval Period (c. A.D.700-1200)

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ABSTRACT
The present paper aims to study the advancement of agricultural technology during early medieval period with special focus on irrigational techniques employed to facilitate the agricultural expansion during the selected period. The Whole Study is based upon the primary source of information. Primary source of information which is used is mainly in the form of literary and inscriptive evidences. Secondary source of information is also used to supplement the study. From the study it is clear that multiple crops were cultivated. Irrigational advancement made it possible to cultivate the cash crop like sugarcane in the arid regions of Rajasthan too. Great attention was paid to improve the irrigational facility as the use of Araghatta and Vapi was prevalent for irrigation in that period. Thus it can be safely said that agricultural advancement and development was taking place in that period.

INTRODUCTION
The etymological meaning of the term ‘agriculture’ is culture of the soil (Latin, agricultura). The science or art of cultivating soil, growing and harvesting of crops, domestication of animals and raising of livestock is simply known as agriculture. But, today this would be too narrow interpretation of the term as the growing of crops and the cattle rearing are as much part of agriculture as the original cultivation of the soil. In its broadest sense the simple definition of agriculture is the service and practice of farming. The Vedic synonym for agriculture is the Sanskrit term krsi, literally the act of ploughing. According to Patanjali the term krsi includes not only ploughing, but also the feeding of ploughman, managing the seeds and bullocks and also doing subsidiary agricultural activities (like digging of land, sowing and reaping of crops, winnowing etc.). Historically, agriculture has been the chief occupation of primitive people. It has shifted hunters and gatherers from nomadic life to sedentary life consequently the problem of irregular and lesser supply of food of the early man had been solved. Although the agricultural techniques at that time were very primitive but the food supply through this planned and systematic activity has increased the food production many folds. The story of Indian agriculture began by 9000 BCE as a result of early cultivation of plants, and domestication of crops and animals. Settled life soon followed with implements and techniques being developed for agriculture. It has increased the food production many folds. A agricultural practices have played such a pivotal role in our society that its importance can’t be denied in maintaining the continuity of Indian civilization. It seems that the principal distinction or division of land was made on the basis of land being cultivated and uncultivated, irrigated by wells, tanks, rivers or rains and seasonal crops grown on it. Early Indian agriculture rested on irrigation and natural rain. In fact, agriculture to a great extent depends on irrigation. It is no wonder that among all agricultural technologies maximum focus is given to the adequate usage of the hydraulic endowments.

Thus, in the present paper a humble attempt is made to focus upon the irrigational facilities used in early medieval period taking northern India as a unit of study.

OBJECTIVES
Present paper is meant to fulfill the following specific objective.

1. The term ‘agriculture’ is derived from Latin ‘Agricultura’. ‘Agri’ meaning the land and ‘cultura’ meaning to cultivate. The word culture is Middle French and again comes from the Latin Cultura which is borrowed from the Latin word colere meaning to till or cherish. (Barnhart et.al 1977) (www.healthyag.com/def_agri.html)
To discuss the agricultural techniques used in that period with special reference to hydraulic resources and irrigational facilities during the selected period.

**METHODOLOGY**

Historical and analytical method is used in the present study. The entire study is mainly based on primary source of information. Secondary data is also used to supplement the primary information.

**DISCUSSION:**

Hydraulic Resources and Irrigational Techniques:

True it is that the study of any agricultural system is incomplete without proper understanding of irrigational system of its time. Irrigation is the artificial application of water to soil, to cultivate land for the regular and consistent production of crops, which may broadly be categorized into two i.e. natural irrigation and artificial irrigation. Natural irrigation is through monsoon rains, which feed river bodies and become a good source of irrigation. Even otherwise, sprinkling of water over agricultural fields during rain is great irrigational tool. Artificial irrigation is through human efforts like digging up of wells, canals, hydraulic engineering efforts etc. Digging of wells and tanks has been propagated in India as a charitable work of merit.

Due to unpredictable natural means of irrigation, agricultural expansion and the consequent evolution of human civilization has been critically related to the availability of sufficient hydraulic resources. Hence, it is not surprising that during the period under review maximum attention was paid towards the adequate usage of the hydraulic endowments.

The Aparajitapraccha, a twelfth century work, seems to be the earliest text to devote a full chapter to the discussion of step wells, wells, ponds etc. The early medieval text Brihakalpasutrabhashya shows a remarkable awareness of the variability of hydraulic endowments and hence we find the multiplicity of storage systems and irrigation mechanisms in disparate regions. It shows us the dependence of Lata (southern Gujarat) entirely on rain, of Sindhu (lower Indus valley and the Indus delta) on rivers, of the Dravida country (far south India) on reservoirs, and of Uttarapatha (generally north India) on wells. Kamandaka also emphasizes the importance of irrigation for agricultural expansion. He advises the king to pay proper attention for providing irrigational facilities in case of failure of rainfall for the fertility of land leading to great agricultural production.

In large part of northern India rainfall pattern was not equal and regular so the only option left with Indian peasants was to supplement the rainfall by digging wells and censer it by tanks and storage reservoirs. The variation in rainfall pattern is also attested by Alberuni.

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6 Puspa Niyogi, Agrarian and Fiscal Economy of Eastern India (from the 4th to the 12th century A.D.), p.145.

7 Ibid.


10 Ranbir Chakravarti, ‘Agricultural Technology in Early Medieval India’, p.238.

11 Ibid.

12 Nitisara is a didactic work in metrical form written by K amandaka. It is like a guide book for kings, dealing mainly with statecraft and polity. Regarding date of the treatise there is a controversy. Though it is generally believed to have been written around Gupta period, yet few references regarding polity and economy led to decide it a work of post Gupta period. Nitisara is generally regarded as an abridgement of K autiliya’s Arthashastra and acknowledges that ‘he has drawn the nectar of his work from the great ocean of Arthashastra’. (Rashmi Upadhyaya, ‘A Processual Model of State Economy in Nitisara of K amandaka’, p.03).

13 The Rigveda contains references to the well being used for watering the field. The word avata means a well. Later V edic literature and Buddhist texts show that water was powered into channel and set to different part of the field. The archaeological evidences presents a testimony to a channel and dockyard with embankment walls, built out of burnt bricks unearthed at Lothal dated 1500 B.C. to 1000 B.C. In Arthashastra irrigation is discussed in detail and lays down that irrigation tax should be given to the state by the peasants. Manu states that the boundary of the fields should be determined by tanks, ponds, channels and other reservoirs of water. (C.F.G.C.Chauhan, op.cit., p.90 fn.41, 42, 43, 44.)

14 “India has the tropical rains in summer, which is called varshakala, and these rains are the more copious and last the longer the more northward the situation of a province of India is, and the less it is intersected by ranges of mountains. The people of Multan used to tell me that they had no varshakala, but the more northern provinces nearer the mountains have the varshakala......Kashmir had no varshakala, but continual snowfall during two and a half months...” (E.C. Sachau (ed.), Alberuni’s India, Atlantic Publishers and Distributors, New Delhi, Reprinted in 1989, vol. I, chapter XVIII, pp.211-212).
As India's material culture is rooted in agriculture, the agrarian sector in turn is inseparably linked with irrigational devices and technology. Consequently, great magnitude was shown towards the improvement of the resources of irrigation. Aparajitapraccha presented a picture of havoc and distress caused by famines and suggested to improve the means of irrigation to escape their horrible consequences. 16 Tanks, canals, river, wells etc. were the usual means of irrigation. 17 Medhatithi stressed on irrigated agriculture to save the crops from the vagaries of monsoon. 18

Source under study pays significant attention to the interrelationship between rainfall and agriculture. Parashara proposes to ascertain the amount of rainfall with the help of rain gauge which could give idea about the necessity of artificial means of irrigation. 19 He also directs the people by stating that “All agriculture has rainfall at its roots, life too has rainfall as its source. Therefore, at the outset, acquire knowledge of rainfall very carefully.” 20 Rain water was the only dependable source of irrigation. 21 Knowledge of rainfall is therefore a primary need of agriculture. 22 This is clearly a step ahead of sacrifices and prayers on which the Vedic people depended for ensuring proper rainfall. 23 Rainfall which was earlier viewed as a phenomenon of fight between good and evil forces of nature, as a divine grace, was for the first time viewed as a subject of systematic study. 24 In this context, excavation of wells (kupa), tanks (tadaga) and step wells (vapi) was considered meritorious and this too must have helped to ensure the easy supply of water for irrigation purposes. 25 A Lekhapaddhati document also mentions kupa (well), tadaga (tank) and nadi (river) as usual means of irrigation. 26 The reference to damming of water 27, reservoir bound with stones 28 having resemblance to the ocean 29 and the cultivation of sugarcane in the arid zone of Rajasthan 30 also suggest harnessing of water for irrigation. 31 The Aparajitapraccha 32 provides an elaborate description of wells which are classified under the following ten categories: (i) srimukhah (caturhastah), (2) vijayah (panchahastakah), (3) prantah (sadabhihostah), (4) dundubhih (saptahastakah), (5) manoharah (astahastakah), (6) cudamanih (saptahastakah), (7) digbhada (dasahastakah), (8) jayah (ekadasakarah), (9) nandah (dvadasakarah), (10) sankarah (trayodasakarah). Kupikas or wells, are divided into two classes. 33 Similarly, there is a reference of four types of kundas and six types of tanks. 34 The reference of tanks, wells, canals and rivers is also found in Sukraniti. 35 Such references lead to the inevitable conclusion that farmers of the time used varied means of irrigation to cope up with the sporadic nature of monsoon.

Since early times the primary responsibility to develop artificial means of irrigation was upon the king. 36 Medhatithi states that it is the nature of rainy season that there should be rain, and yet, on account of the faulty action, either of the king or of the kingdom itself, there is sometimes drought. 37 It was as a result of this notion that the kings undertook the excavations of wells, tanks and canals. 38 The Aparajitapraccha advises that crops should be protected for maintaining the kingdom and that water reservoirs should be excavated for the irrigation of crops. 39 It was the recognition of the practical importance of irrigational works which led Lakshmishadara, the Gahavadala minister, to defy conventional notions and

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15 Ranbir Chakravarti, op.cit., p.237.
16 B.N.S.Y adava, Society and Culture in Northern India in the Twelfth Century, p.258.
17 Ibid., p.257.
19 Ranbir Chakravarti, ‘Agricultural Technology in Early medieval India (c. A.D. 500-1800)’, op.cit., p.238.
20 Krshiparashara, v.10.
22 Ibid.
23 Ibid.
24 Ibid., p.418.
26 Lekhapaddhati, op.cit., p.19.
27 S.R.Sharma, op.cit., p.201, fn.28.
28 Ibid., fn.29.
29 Ibid., fn.30.
30 R.S.Sharma writes that the construction of vapi became very popular in Gujarat and Rajasthan. According to him the word vapi is derived from the Sanskrit root vap which means ‘to sow’ and therefore it is clear that step-wells were meant for irrigating the fields. (R.S.Sharma, ‘How Feudal was Indian Feudalism’, p. 37).
31 S.R.Sharma also discusses about the government’s hydraulic projects for the welfare of people and religious merit during the period (S.R.Sharma, op.cit., p.201-202).
32 Aparajitapraccha, p. 183.C.Y adava, Society and Culture in Northern India in the Twelfth Century,p.258.
33 Ibid.
34 Ibid.
35 Ibid.
36 Lallanji Gopal Economic Life of Northern India, p.283.
38 Ibid.
39 Ibid.
class such works of public utility separately under dana (charity) and ascribe them a high spiritual efficacy.\textsuperscript{40} It was a change of real significance and the lead has been followed by subsequent writers on the subject.\textsuperscript{41} The Naradasmrti states that the erection of dyke in the middle of another man’s field is not prohibited in view of the fact that it would be advantageous for irrigation purposes, while the loss is trifling.\textsuperscript{42} It also states that with owner’s permission one can restore the decayed dyke.\textsuperscript{43}

It is not easy to assess the regional trends of water management of the period. Evidences make it a well established fact that due recognition was given to irrigation, both natural and artificial. The former channeled the water of the rivers and the monsoons in the northern and north-eastern parts of India respectively and the latter utilized the stored water in tanks, pools, and wells was adopted in central, north-western and southern parts of India.\textsuperscript{44} At first the agricultural and hydraulic situation of northeast is to be studied. North-eastern India is plenteously watered by monsoons. Eastern India is also blessed with great rivers, such as the Ganges, the Brahmaputra and their tributaries.\textsuperscript{45} Settlement patterns in general were also based on irrigational activities and the available resources for it. One inscription from Bangladesh portrays the largest known brahmanical colonization program in north-India, planned and designed by a political authority consisting of an extensive settlement created in the tenth century in Srihatta (Sylhet area).\textsuperscript{46} It was a settlement of an impressive size, involving the merging of three districts, probably created out of virgin tracts (bhumi-chidranyayena), as it had an extensive forest and marshy lands in descriptions on copper plates from seventh and eighth centuries.\textsuperscript{47} This assorted arrangement was certainly sustained by agricultural resources obtained by bringing uncultivated tracts under the plough, possibly utilizing irrational resources.\textsuperscript{48} Varendri region corresponding to Rajasahi, Bogra and Dinajpur areas in modern Bangladesh, the very heartland of Pala dynasty (c. A.D. 750-1200) had been a flourishing, settled area for centuries.\textsuperscript{49} The royal patronage to irrigational works is also attested in north-east. Thus, Ramapala (1072-1127), the last great ruler of the dynasty and the champion of the eminent Sanskrit text, the Ramacharitam of Sandhyakaranandini is being endorsed not only for his conquests but also because of the public works of great utility in the form of the construction of large lakes with tall palm trees and lines of hillocks on their border, so as to make them look like veritable seas.\textsuperscript{50} These artificial water bodies built under the patronage of the king and his ministers were larger and more impressive than ordinary tanks (tadaga) and ponds (puskarini) and represent an augmentation of hydraulic resources.\textsuperscript{51} No less significant is the text’s account of the levy of only mild taxes, obviously to ensure that the local human resources did not desert the war-torn territory.\textsuperscript{52} The eleventh-century charters from Bengal and Bihar contain regular references to rivers, streams (srotosvin), rivulets (ganginika), dikes (khata/kulya) and embankments (ali/brihadali).\textsuperscript{53} Besides Ramapala’s efforts, there is little indication of the construction of large, supra-local hydraulic projects by political authorities in this region.\textsuperscript{54} However, it is evident that to ensure proper irrigation and drinking water facilities, Palas and Senas constructed large tanks throughout Bengal.\textsuperscript{55} Considering the region of Kashmir, the uppermost and an important region of Northern India, the most outstanding irrigational project entailing inventive engineering skill belongs to King Avantivarman of Kashmir. Under his rule the minister Suyya dammed the river Vitasta (Jhelum) to save Kashmir from devastating floods of the Mahapadma Lake. Suyya deepened the bed of the Vitasta at its two ends, cleaned the river bed at its bottom after constructing a temporary stone dam at all threatened points and built protective stone inscription. This record mentions the cultivation of paddy and sesamum, a royal granary and well-planned, prosperous city of Pundranagara (Mahaasthan in Bangladesh), the earliest known urban centre of Bengal and still an impressive archaeological site. The region’s prosperity continued in the Gupta age (fourth to sixth centuries) and during the reign of Sasanka (c. A.D. 600 to A.D. 619 if not up to A.D. 637). Varendra or Varendi, in the heartland of north Bengal, was described as the ancestral home (janakabhu) of the Pala kings. (Ranbir Chakravarti, op.cit., p.244 and fn .40).

\textsuperscript{40} Ibid.
\textsuperscript{41} Ibid.
\textsuperscript{42} S.P.Raychaudhuri et.al., ‘Agricultural’, op.cit. p.360.
\textsuperscript{43} Ibid.
\textsuperscript{44} Ibid.
\textsuperscript{45} Puspa Niyogi Agrarian and Fiscal Economy, op.cit., p.145.
\textsuperscript{46} Ranbir Chakravarti, op.cit., p. 243.
\textsuperscript{47} Ibid.
\textsuperscript{48} Ibid., pp. 243-44.
\textsuperscript{49} Northern Bengal had a complex and developed economy with a strong agricultural foundation as early as third century B.C., as illustrated by the fragmentary Mahasthangarh stone plaque inscription. This record mentions the cultivation of paddy and sesamum, a royal granary and well-planned, prosperous city of Pundranagara (Mahaasthan in Bangladesh), the earliest known urban centre of Bengal and still an impressive archaeological site. The region’s prosperity continued in the Gupta age (fourth to sixth centuries) and during the reign of Sasanka (c. A.D. 600 to A.D. 619 if not up to A.D. 637). Varendra or Varendi, in the heartland of north Bengal, was described as the ancestral home (janakabhu) of the Pala kings. (Ranbir Chakravarti, op.cit., p.244 and fn .40).
\textsuperscript{50} Ibid.
\textsuperscript{51} Ibid.
\textsuperscript{52} Ibid.
\textsuperscript{53} Ibid.
\textsuperscript{54} The only exception to this general pattern is the unique practice of levying a water cess (jalakara) in the twelfth century in Gahadavala realm around Kanyakubja. (Ibid., p.245).
embankments for seven yojanas along the river bank.\textsuperscript{56} Thus, he was able to shift the junction of the Vitasta and the Sindhu from old to its existing position.\textsuperscript{57} On the land raised from water he founded many villages protected by circular dykes and constructed extensive projects.\textsuperscript{58} Kalhana notices the prosperity resulting from the work and wrote verses in praise of the engineer.\textsuperscript{59} A brother of Kashmir, Lalitaditya Muktapida reclaimed many hitherto water-logged areas by making an arrangement at Laksadhara for conducting the water of Vitasta and by constructing a series of water-wheels, distributing it to various villages.\textsuperscript{60} Besides, King Harsha is credited for the excavation of the big Pampa Lake, identified by Stein with the modern Pampasar.\textsuperscript{61}

The greater part of Ganga River valley and the Ganga delta was watered by perennial rivers of glacial origin and well nourished by rains.\textsuperscript{62} Rock inscription at Ajayagarh fort situated between the entrances to the Patal Ganga and Patal Jumna records the construction of a well by Kalyandevi, the chief queen of Virarvarman, a ruler of the Chandelas dynasty.\textsuperscript{63} The region belonging to Bengal belonged to the category of devamatrika (area with profuse rainfall) and nadimatrika (riverine) tracts.\textsuperscript{64} Within this environment hydraulic resources and facilities were important landmarks of rural space.\textsuperscript{65}

The more arid western India, especially Rajasthan and Gujarat, famous for its agrarian economy featuring cereals and cash crops like cotton, oilseeds, indigo and sugarcane, is also very significant for the study of irrigational works.\textsuperscript{66} In Rajasthan, an area with less rainfall than Gujarat, inscriptions from the eleventh century onwards refer that the introduction of irrigational technologies resulted in the production of diverse crops even in arid environment.\textsuperscript{67} The Chalukyas of Gujarat had many important irrigational works to their credit.\textsuperscript{68} It seems that even the first king of the dynasty, Mularaja I (A.D. 941-996) paid due attention to the system of irrigation.\textsuperscript{69} Sridhara in his prashasti claims that one of his ancestors was appointed by Mularaja I (A.D. 941-996) to dig vapis, wells and tanks.\textsuperscript{70} A long list of efforts on the part of rulers to enhance the hydraulic resources can be prepared on the basis of available evidences.\textsuperscript{71} According to Merutunga, Durlabhara (A.D. 1010-24) excavated a tank called Durlabh tank at Anahilavada.\textsuperscript{72} The queen of Bhima Chalukya (A.D. 1023-65) named Udayamati caused the construction of a new reservoir at Pattana which was better than even the Sahasralinga lake excavated by Siddharaja. She is also credited for the excavation of a well at Anahillapataka, which is now known as rani ki vav.\textsuperscript{73} The construction of two big reservoirs has been ascribed to Karnadeva (A.D.1066-94).\textsuperscript{74} The stepwell at Davad (near Idar) was probably built during his reign.\textsuperscript{75} Ayanalladevi, the mother of Jayasimha Siddharja (A.D. 1099-1144) is credited for the construction of a large number of tanks and vapis.\textsuperscript{76} Besides the usual local level irrigational projects like tanks and wells, vapis were also meant as irrigational resources. Vapis began to figure prominently since the early medieval times.\textsuperscript{77} It has also wide distribution in the dry regions of Gujarat and Rajasthan and is the same as baoli of modern times.\textsuperscript{78} A more correct term for step well could be a staircase well or stepped well.\textsuperscript{79} In Gujarat, the terms vav or vavdi and in Rajasthan as well as other regions of northern India around Delhi and Ajgra the terms baoli or bauli were in common use.\textsuperscript{80} It is supposed that tanks at Viramgam and Dholka and stepwell at Nadiad and Virpur were built under the patronage of the mother of king Siddharja.\textsuperscript{81} A water pond at Dhadak and the step wells found along the major military and trade route from Anahilavada to Somnathapattana via Munipura, Jhinjhuvada, Wadhwan, Dhandhalpura, Chobari, Gondal and Junagadh were built along the river bank.
by Siddharaja.\textsuperscript{82} He also constructed a large reservoir called Sahasralinga Lake at his capital.\textsuperscript{83} Archaeology confirms the high engineering skill employed in this irrigational project. The lake received water from the river Saraswatī with which it was connected by a 300 ft. long channel.\textsuperscript{84} Excavations have brought to light the stone sluices through which water was conducted to the lake.\textsuperscript{85} Further, during the reign of Bhimadeva II (A.D. 1178-1242) an effort seems to have been made to extend irrigational facilities to north-west Saurashtra and Kutch.\textsuperscript{86} Not only kings but also feudal lords and merchants showed great concern towards constructing vapis and providing other irrigational facilities.

Prabandhacintamani acknowledges Tejapala, the minister of king Viradhavala as the constructor of many tanks.\textsuperscript{87} The records of the period clearly point towards the digging of tanks and wells by many feudatories and ministers under the auspices of Kalachuris.\textsuperscript{88} Malayasingha, a feudatory is reported to have dug a tank in A.D. 1192.\textsuperscript{89} Rauta Vallaludevaka, another feudatory, dug out a water channel.\textsuperscript{90} Similarly, in the region of Rajpur-Bilaspur area there are references of the excavation of tanks and wells by the Tummana Kalachuri feudatory Brahamdeva and ministers Purusottama and Gangadhara.\textsuperscript{91} Likewise, the Mangalana (Jodhpur) stone inscription (A.D 1215), praises the Mahamandalesvara Jayasimha for building a vapi in the land of water scarcity (daumara bhumi).\textsuperscript{92} An inscription found at Sunak, 14 miles southeast of Anahilavada, mentions the construction of a vapi by Thakkura Mahadeva.\textsuperscript{93} The Ladol Copper plate inscription also (A.D. 1099) mentions that Siddharaja donated a piece of land for the maintenance of a vapi, constructed by Vilahala, the son of a mahamaya (minister) at Takaodhi, near Gambhu in north Gujarat.\textsuperscript{94} In the Gaya district of Bihar Gangadhara, a minister of King Rudramana is said to have constructed a tank.\textsuperscript{95} Wells (kupa), step wells (vapis), tanks (tadaga), reservoirs (sar); and watering troughs (prapa) have been constructed by Vastupala, a merchant minister at a number of places in Gujarat.\textsuperscript{96} There are several other references where kings and merchants, ministers and feudal lords took keen interest in providing the irrigational facilities in north India during early medieval period. The state evinced keen interest in the upkeep of the irrigational works and even framed rules for their proper functioning.\textsuperscript{97} While recently scholars are realizing that the existing sources mostly indicate the preponderance of small scale local level irrigational projects.\textsuperscript{98} However, there are also some instances of large scale or supra local irrigation projects.\textsuperscript{99} Lekhapaddati documents also mention the varigriha karana (official in charge of irrigation).\textsuperscript{100} It suggests that there was a department of irrigation and state took interest in irrigation work.

Besides the above mentioned irrigational works which owed their existence to the state, there must have been many others built by private individuals. It may be regarded that the individual and group initiatives in launching and maintaining irrigational projects far outnumber those of royal or administrative efforts.\textsuperscript{101} As regards the technical devices used to raise water from wells our evidences are also not lacking. Desinamamala refers to such terms as agatti, unkaddi and dhenka which according to the editor of text, mean a contrivance for drawing water from deep wells.\textsuperscript{102} However, the whole technique of drawing out the water has not been described by him. According to the editor of text, mean a contrivance for raising water from deep wells.\textsuperscript{103} The empty buckets became full and the full buckets empty.”\textsuperscript{104} Merutunga also notices the use of water-wheel for irrigating the fields. By describing the rotation of water-wheel, he states “the empty buckets became full and the full buckets empty.”\textsuperscript{105} However, the whole technique of drawing out the water has not been described by him. It is apparent from one metaphorical reference that araghatta or water-wheel in the region of Gujarat was used to draw out the water from deep wells.\textsuperscript{106} The

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\textsuperscript{82} Ibid., pp.30-32. \\
\textsuperscript{83} Dvyasrayakavya of Hemachandra, XV.114-15; Prabandhacintamani of Merutunga, p. 92.CF. V.K.Jain ibid., p.32. \\
\textsuperscript{84} Lallanj Gopal, op.cit., p.285. \\
\textsuperscript{85} Ibid. \\
\textsuperscript{86} V.K.Jain, op.cit., p.32. \\
\textsuperscript{87} Lallanji Gopal, op.cit., p.285. \\
\textsuperscript{88} Ibid. \\
\textsuperscript{89} Ibid., fn.4. \\
\textsuperscript{90} Ibid., fn. 05. \\
\textsuperscript{91} Ibid. \\
\textsuperscript{92} V.K.Jain, op.cit., p.32. \\
\textsuperscript{93} E I, II, p. 316 ff. CF. Ibid. \\
\textsuperscript{94} Ibid., pp.32-33. \\
\textsuperscript{95} E I, p.292.
\end{flushright}
inscriptions of southern Rajasthan especially from the regions of Jodhpur, Udaipur, Banswara, Sanchor and Sirohi repeatedly refer to irrigation with the help of arahatta or araghatta and dhimada or dhihu.107 The Pattanarayana inscription from Sirohi (AD 1287), specifying a levy on the produce of irrigated fields, enjoins that two seers should be paid from the field irrigated by dhimada and eight seers should be paid from that irrigated by an arahatta.108 This difference with regard to the levy of produce between dhimada and arahatta in terms of the methods of operation and their relative capacity to irrigate.109 The technical nature of arahatta, generally translated as a Persian wheel, is a matter of controversy.110 The device araghatta demands close scrutiny,111. The essential part of the araghatta was the ghatiyantra or the device with pitchers, usually mounted on the wheel, but not attached to its rim.112 The ghatiyantra as an irrigational device is therefore often held as a pot-garland.113 The Upamitibhavaprapanchakatha of Siddharshi (A.D.906) presents the most elaborate account of the device.114 The arahatta, according to the text, seems to have drawn water from a reservoir which in turn received its water from irrigation well.115 The text highlights the spokes (arakas) of wheel which was a revolving apparatus though it does not refer to any gearing mechanism enabling the conversion of the horizontal rotary motion into a vertical rotary motion.116 The latter feature which became visible from the fourteenth century onwards as suggested by Irfan Habib, represented the typical Persian wheel or the saqia.117 The prevalence of araghatta as a hydraulic machine is best demonstrated by an eleventh century panel from Mandsor (Pali district, Rajasthan).118 In a very few studies of the history of water lifting devices in India, such as Ananda K. Coomaraswamy’s pioneering note on Persian wheel, there has been lack of differentiation between various kinds of water wheels and all references of a water wheel were understood in terms of geared saqia.119 Lallanji Gopal claims an Indian origin for the saqia while Needham suggests that Indians can be credited only with the discovery of noire, which stood the test of subsequent research fairly well.120 Whatever may have been the technical nature of araghatta it can be safely said that it was much in use in early medieval northern India especially in arid regions of Gujarat and Rajasthan.121 R.S.Sharma attests it by stating that the cultivation of sugarcane not only in central India but also in arid zone of Rajasthan makes the use of araghatta but obvious.122

Vapis and araghattas appear more frequently as important landmarks in the rural space in Rajasthani inscriptions of the eleventh century than in those of the ninth and tenth centuries.123 Here B.D.Chattopadhayaya’s fabulous paper must be quoted.124 He has listed the regions of early medieval Rajasthan irrigated by araghattas, vapis, wells etc.125 Two things are evident from the table, one is the use of araghatta appear more frequently from twelfth century onwards, secondly they were in use, mostly, in west Rajasthan a relatively more arid region.126 There is little doubt that the introduction of the araghatta and vapi considerably benefited agricultural production especially because these were mostly in use in the relatively arid western India, although there are references confirming the fact that the machine wills called araghattas were also owned by private individuals.127 But, the new devices

107 B.D.Chattopadhayaya has provided a complete table of irrigational devices, the regions covered by the them, with date( B.D.Chattopadhayaya, ‘Irrigation in Early Medieval Rajasthan’, op.cit., pp.47-48). See also V.K.Jain, op.cit., p.28.
108 Ibid.
109 Ibid.
110 Ibid. p.29.
111 Ranbir Chakravarti op.cit., p.246.
112 Ibid.
113 Ibid.
114 CF.Ibid.
115 Ibid.
116 Ibid.
117 Ibid.
118 Ibid.
119 Irfan Habib, ‘Joseph Needham and the History of Indian Technology’, p.256, Indian Journal of

History of Science, 35.3 (2000), pp. 245-274. A chronological three stage development as suggested by Irfan Habib is as follows:

I. Noria alone, fourth century BC to fourth century AD.
II. The pots previously attached to the spokes and rim now transferred to the chain (pot garland) (sixth-seventh century); the use of ungeared saqia attested, twelfth century.
III. Introduction of gearing mechanism, and thereby the full-fledged saqia or Persian-wheel, making possible the use of animal power, some time before 1500 AD. (Irfan Habib, ibid., p.257)

120 Prof. Habib also agrees with Needham’s suggestion that probably noria had an Indian origin as there have been no traces of it found before 350 BC in any other civilization except India.(Irfan Habib, ibid., p.257).
121 Ranbir Chakravarti, op. cit., pp.245-49.
122 R.S.Sharma, Indian Feudalism, 2nd ed., p. 204.
123 Ranbir Chakravarti, op. cit., p.249.
125 Ibid.
126 Ibid., p.48.
127 Ranbir Chakravarti, op.cit., p. Besides Dabok record of 644, an inscription of 1143 from Kekind
were unlikely to have been easily affordable for the common peasants. It is only the rich peasants and landlords who had adequate means and resources to invest in these hydraulic technologies and devices.128

**CONCLUSION**

Indian economy has always been agriculture centric, it was inseparably linked with irrigational devices and techniques. Literary as well as epigraphic sources of the period indicate that great magnitude was shown towards the improvement of the resources of irrigation. The most outstanding irrigational project entailing inventive engineering skill was undertaken in Kashmir. The river Vitasta (Jhelum) was dammed to save Kashmir from devastating floods of the Mahapadma Lake.

New irrigation resources like araghatta/arahata and vapi which were particularly suitable for lifting water from great depths; began to appear in the texts describing irrigational developments of the period. Araghatta, generally translated as a Persian wheel was much in use in early medieval northern India especially in arid regions of Gujarat and Rajasthan. There is little doubt that the introduction of araghatta and vapi considerably benefited agricultural production especially because these were mostly in use in the relatively arid western India. Above all it may not be denied that all efforts to pump up irrigational techniques going on in the country could not diminish the ultimate dependence of Indian agriculture on rains.129 However, it seems quite probable that state’s initiative as well as public efforts in providing and maintaining irrigational facilities led to profusion of multiple crops. Agricultural scientists are of the view that traditional water harvesting systems, being simple and sustainable, need to be respected, encouraged and maintained. They carry a great deal of historical significance as they can provide a safe back up plan.

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[12] Niyogi Pusa, Agrarian and Fiscal Economy of Eastern India (From the 4th to the 12th Century A.D.), Kolkata, 201


