Development of Agriculture Technology in the United Provinces (U.P.) during the Colonial Rule and Its Impact on Demography

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***Abstract* - Agriculture which forms the mainstay of millions in India was primitive in nature and insufficient to cope up with the requirements. When British consolidated its position in India following suppression of the 1858 Mutiny introduced a few reforms in this sector. Introduction of the American plough, new variety of seeds and fertilizers together with canal irrigation system somehow improved the production. But the real motive behind introduction of these reforms was not general public welfare. Preference was given for the production of cash crops to cereals and faulty distribution system led to recurrent famines resulting in high crude death rate. Low potential supply of irrigated water especially to eastern and the southern parts of the province kept the people starved till the Independence of India in 1947.**

***Key Words* - Geographical diversity, Cash Crops, Famines, Irrigation Commissions, Canal Irrigation.**

I. INTRODUCTION

The kingdom of Oudh was annexed to the British Empire on 13th February, 1856 and with it the combined Province of Agra the total area reached to the extent of 107,494 square miles. The above statistics are about the British part of the provinces and area of the native states is not included. (1) The total area in terms of acreage was 6.64 crore acres and the cultivable land in it was more than 4.74 crore acres. The ratio of the rural-urban population was 8:1. It is clear from the above data that half of the total land of the province was used as agriculture land and 80% of the population depended on agriculture as their livelihood. (2). Thus agriculture formed the main occupation of the population of our study area during period under study.

The province had a great diversity in its geographical and meteorological conditions. The Irrigation Commission 1901-03 in its report has grouped the entire province into 4 district zones.

A. The Sub-Montane Tract

A narrow strip of land 30-50 miles in breadth. It extended from Dehradun to Gorakhpur. Population in the area was minimal. Agriculture conditions of the area were not very good and produced only rice and wheat as the main crops. In this tract rainfall varied between 50-70 inches annually. During 1873 rain failed in Gorakhpur and Basti districts and severe draught occurred in Bijnor and Bareilly in 1877.

B. The Central Tract

Spread between the Sub Montane Tract and the river Ganga. Being the largest of the 4 tracts it included Rohilkhand, Oudh, and Gorakhpur division with 1/3 of the total cropped area. The main produce of the tract included rice, wheat, and barley, sugarcane, poppy and indigo. Average rainfall in the tract was 35-40 inches. It was deficient of monsoon rain fall. The tract suffered severe draught and famines during 1837, 1860, 1869, and 1877. District badly affected were Hardoi, Moradabad, Badaun , Lucknow, RaeBareilly, Barabanki, and Azamgarh. Hardoi , Sitapur, Lucknow, Baranki , Unnao, and RaeBareilly again suffered the turmoil of famine during 1896-97.

C. *The Doab of the Ganges and Yamuna*

Extended from the foothills of the Shivaliks to the Sangam at Allahabad. This tract included 13 districts. The whole tract had numerous distributaries of Upper and Lower Ganga and Yamuna Canals. Average rainfall in this tract was around 30 inches. The tract suffered famines during 1837 and 1860-61.

D. The Southern Tract

Consisted the area south of the river Yamuna. This tract was altogether different in geographical formation and agriculture from 3 other tracts. The western part of the tract consisted of the Districts of Jhansi, Hamirpur, Banda and Jaloun. The eastern part of the tract included Mirzapur, Banaras and Gazipur. The tract is known as Bundelkhand and being dry suffered ravages of famines during 1837, 1869, and 1896-97. Though the eastern part formed the Ganga alluvial soil and produced excellent crops also suffered a less severe famine during 1896.

II. DEVELOPMENT OF CANAL SYSTEM IN INDIA

Failure of monsoon with no major irrigation facilities made the province prone to recurrent famines. The pattern of agriculture was traditional with use of bullock carts and wooden ploughs for tiling soil. No advanced technology was available which could augment agriculture productions. In the initial years of their rule the British Indian Government was

indifferent towards the improvement of agriculture in India. While making a comparative statement on canals and railways R.C Dutta commented, "Preference was given to railways which facilitated British trade with India, and not canals which would have benefitted Indian agriculture." (3)

Recurrent famines compelled the British rulers to import technologies to improve agriculture which included introduction of new trends of crops, new agriculture tools and appliances and scientifically constructed means of irrigation. The American Ploughs were introduced in the province but evoked less response from the cultivators due to socio economic considerations. These ploughs were expensive, made of iron and unlike wooden ploughs not repairable. Other equipment's introduced were threshing machines and water pumps. Introduction of tractors, power mills for sugarcane were obviously beyond the reach of the small cultivators. Thus till 1928 the general agriculture practices in the United Provinces remained largely traditional, indigenous and inefficient. New inventions thus became the need of the hour. The Agriculture Department of the province distributed American and the European ploughs among the cultivators at a low price.(4) The department also distributed a large quantity of manures and fertilizers beside traditional manures to facilitate the cultivators to get benefit from the new products.

Nevertheless, the British rulers had a utilitarian motive behind introduction of new agricultural technology in India. They preferred production of cash crops to cereals. Hence they encouraged sericulture in Dehradun, tobacco in Gazipur, and fruits in Kumaons. But this change in pattern of agriculture caused shortage of basic food needs of the larger population which resulted in food shortage and consequent famines.

The famines of the 19th century specially that of 1937-38 in Northern India compelled the British Government to pay attention towards improving irrigation works.(5). Artificial Irrigation became the need of the hour. Hence the Director of canals was entrusted with the task of irrigation works and supervise improvements of two canals, one in Hissar which crossed Agra and Western and Eastern Yamuna canals. Northern India again suffered a terrible draught during 1859-60. This goad the Government to construct canals. By this time Public Works Department also came into existence and the Director of Canals was brought under the Public Works Department. Construction of canals begun in a planned way and grouped under two categories: 1. Productive and 2.Protective.

The Productive canals were remunerative and financed by the government from the Loan Funds while Protective canals were considered valuable to fight against the famines. (6) and funded from the Famine Relief Fund. Minor works included repairs of old canals systems and expenditure met from the Revenue Fund.

The Indian Irrigation Commission Report of 1903 gives details of the projects as below:

In the United Provinces state irrigation works comprised five large, eleven small canals and twelve small storage works. Unlike inundation types these canals were perennial in nature and supplies taken from the rivers with permanent or temporary dams built on them. Of the five numbers of the Ganga Canals four belonged to the Upper and Lower Ganga Canals and Agra Eastern Yamuna canals. These canals were grouped under the Productive canals while Betwa Canal was grouped into protective head. Rest of the works was grouped under minor works. Storage works were completed in Dun, Bijnor, Rohilkhand, Jhansi and Hamirpur. A good number of works of minor canals were also constructed in Nainital district and came to be known as Terai Bhawar Canal. Here it is worth to mention that 75% of the provinces irrigation requirements were fulfilled by the private works which included kutcha and pucca wells and open pits from where earth was removed for construction of mud houses. Surprisingly we do not find any man made water tank for irrigation in the province. But efforts of the State Public Works Department and irrigation engineers together with the local support groups in the year 1901-02 total irrigated area touched 26,16,105 acres. Out of this, the area irrigated by the Productive canal was 2452743 acres, Protective canals covered 48767 acres and Minor irrigation works covered 114595 acres. (7)

Details about the crude death-rate for the population is available from Kingsley Davis's publication: The population of India and Pakistan (1951). The foregoing table will amply show how rampant was the crude death rate of the Indian population following 1880 until 1920. There was a high death-rate of 40-50 per 1000 inhabitants, whereas a clear decrease took place after 1920.
This is indicative of the measures taken against and the prevention of famines especially the irrigation projects

TABLE I
CRUDE DEATH-RATE OF THE POPULATION OF INDIA 1881 – 1941 IN RELATION TO FAMINES AND EPIDEMICS

Decade	Average annual crude death rate	Annual natural increase	Famines and epidemics
1881-1891	41.30%	7.60%	
1891-1901	44.40%	1.40%	Terrible acute famine in 1885-1900, Plague Epidemic 1896; Cholera Epidemics in 1891-1892; 1894-1897 and 1900
1901-1911	42.60%	6.60%	Cholera Epidemic 1905-1908; Plague Epidemic 1907
1911-1921	48.60%	0.90%	Influenza Epidemic in 1918 with plus minus 20 million deaths; Cholera Epidemic 1918-1921
1921-31	36.30%	10.10%	
1931-41	31.20%	14.00%	

Source: Kingsley Davis's: The population of India and Pakistan (1951).

A. Research Work in this Field

A number of research works were carried out by some dedicated engineers and men engaged in the field of irrigation whose contributions made it possible to work on the development of a network of canals in North and north western India.

1) **Sir Proby Thomas Coutley, KCB**, an English Engineer and a paleontologist, was instrumental in constructing the Ganga Canals. Appointed as a Superintendant General of Canals in 1836 Sir Proby was responsible for remodeling of Eastern Yamuna Canal (1824-1840). He was also responsible for the construction of Upper Ganga Canal (1839-1854) and creating dams over the Ganga. His actions brought him opposition from the Hindu Priests of Hardwar who agitated again the arrest of Mother Ganga by Sir Proby. He had to pacify them by leaving a portion of the Ganga for direct flow and started the work of digging after offering puja to Lord Ganesha, the God of good blessings. He also suffered resistance from Lord Ellenborough but his persuasiveness led to the final opening of 348 miles (540 kms) long Ganga Canal on the 8th of April, 1854. The canal had 306 miles of branches and 3000 miles of distributaries and irrigated an area of 767,000 acres of land of 5000 villages. Sir Proby was also instrumental in founding the Roorkee Engineering College (now IIT Roorkee) and one of the 12 hostels of IIT Roorkee is named after him.

2) The next pioneering name in this series was of **Thomas Login.** During 1864 Login initiated research on fundamental ideas of causes of silting and scouring on scientific basis.

3) In between 1874 and 1879 **Cunningham** made valuable contributions in the development of the technique of measurement of discharges and determination of velocity. His work was contained in 3 volumes of the" Roorkee Hydraulic Enterprises". Printed by Thomas College Press in 1881. Cunningham also investigated into the stability and strength of the masonry wall foundations in quick sand.

4) **Colonel J. Clibborn** and **J.S Beresford** worked on the percolation of water through sands. They made, at different times, a series of experiments on sand enclosed pipes. The Government of India published their notes in 1902 which explained how water flows through under weirs and the other masonry works built on sand and the question of upward pressure on the bases of such structures. (8). According to them the lines of flow through sand below the foundation on sandy beds were clearly traceable equip-potential curve following the lines of best resistance. Beresford also made another useful contribution in determining the loss due to absorptions in canals.

5) **Major H. Helsham Jones** carried out a very important experiment on the taming of rivers in the alluvial stages. The experiment was conducted at the head works of the Lower Ganga Canal.

6) **Kennedy**, during 1881-82 made an important estimation of the losses due to evaporation and absorption in the Bari Doab Canal.

7) **Colonel Clibborn** , the author of „Irrigation Works in India" carried out historic experiments during (1895-97) with khanki sand to investigate the laws of flow of water through sand in relation to weir design. His other contribution included investigation on the replenishment and velocity of flow of ground water in Gangetic plains. (9). Colonel Clibborn‟s experiments helped in construction of masonry wells in a practical way and gave us the idea of up thrust experienced in the D.S floors. Of the weirs on sandy foundations, varied with hydraulic gradient.

Hence with the onset of the 19th century the British Government took certain initiatives to introduce new technology in the field of agriculture and irrigation. It was thought unwise to depend fully on monsoon rains. The alluvial part of the Doab flushed with humus of the Ganges and Yamuna every year was fertile enough to produce excellent crops but vastness of the area often experienced paucity of water. The southern part of the state especially the Bundelkhand area, was not as lucky as that of the North. Hence need of artificial irrigation was direly felt to combat famines and draught.

To set the home right the administration of the department was revamped with the appointment of Sir John Strachey, Lieutenant Governor, as the Director of Agriculture and Commerce. (10).With the appointment of Sir Edward Buck the post of the Director became permanent. The Royal Commission Report explained the role of the Director was to establish and prove to Indian agriculturists advantages of small improvements which they can afford and improve their already existing systems.

The second phase of the research work focused on various ways and means of the construction of irrigation channels and reservoirs. From the summary study of the Public Works Department „C‟ File No. 124 W/1947 we find the references of the related research works done in the field of Irrigation and waterways. This period extended from 1900-1946.

1) Credit goes to **G. Barlow**, the first Chief Engineer of the Hydro Electric Survey of India (1915) for the study of determination of the volume of total annual run off from a catchment.

2) **G. Laccy**, the Executive Engineer and the Research Officer, produced a practical equation for the same.

He did an important task in designing the channels in alluvium. His concept of channel losses as a factor of Distributary Design was applied during the construction of Sharda Canal which led to the development of Silt Theory. He developed a new method of observing discharges in canals by using rods of 0.4" depth and 0.8" depth.

3) **William Maurice Griffith** developed a useful silt excluding device which allowed only surface water to enter the distributaries. He also designed Kolaba Meters.

4) **R. B. Edgecombe** further carried out the research of G. Laccy in 1934. He confirmed the flow equation advanced by Laccy and made experiments on various types of linings. He installed automatic gauge meters in different channels to determine the losses. He authored the book entitled " Silting of Reservoirs and Measures Taken or Projected for its Prevention and Control ". Book was printed by Government Press in Allahabad in 1934.

Works were done further on calibration of flumer and falls, use of tar for painting steel works, lining of Gul (drains) with Sodium Carbonate and Usar (arid) soils, water consumption by different crops and silt sampling at different ponds of channels. Innovations were made in the study of fluming structures and development of hyperbolic exponents.

5) L. Y. Baker collected sample data from the Himalayas to the Bundelkhand and studied run off volumes in catchment areas to make predictions on catchment run off.

6) F. H. Hutchinson, the Chief Engineer, further expanded the research work and in 1946 established a Hydraulic Laboratory at Bhadrabad and proposed field stations for soils and tube wells in Roorkee.

B. Appointment of Irrigation Commission

Severe famines of 1896 and 1901 in almost every provinces of British India drew attention of the Government which culminated into the appointment of the Indian Irrigation Commission in 1901 by Lord Curzon, Viceroy of India, under the chairmanship of Sir Colin Campbell Scot Moncrieff. The Commission submitted its report in 1903 in which it recommended measures for the Irrigation of an additional 10,200 square miles beyond roughly 30,000 square miles already irrigated. The acceptance of this proposals by Lord Curzon's Government in 1905 became a landmark in the Government of India's Irrigation Policy. The Commission besides recommending projects for increased areas paid special attention to the Bundelkhand region in Uttar Pradesh which was worst sufferer of famines. Bundelkhand had many rivers like Pahuj, Betwa and the Ken which during rainy season overflowed the region but water leans during the summer. Hence storage of the rain water was the main problem

C. Canal System in India

1) *Betwa Canal:* On the recommendation of the Indian Irrigation Commission 1903 the only work undertaken in Uttar Pradesh was the Betwa Canal Project to cater the needs of the districts of Jhansi, Hamirpur, Jalaun and few native states. The project was undertaken as a Protective Canal Project to combat the menaces of recurrent famines. River Betwa forms the central part of the canal near Prichha, 17 miles from Jhansi (11). The main canal is 19 miles long bifurcated into two branches- Hamirpur branch and Kathakund branch. The Hamirpur branch ran a short distance from the Betwa River and the Kathakund branch near Pahuj. As there was no work of engineering interest, so the Commission suggested the additional storage and remodeling of channels which could increase the financial value of these channels so that they carry larger supplies to cater the main canals. the task of remodeling of Kathakund branch begun during 1904-05 under the Public Works Department to enhance the targeted capacity to 600 cubic feet than existing 350 cubic feet per second. It led to the raising of intake capacity of Parichha dam which catered 16 ,300 acres during 1905-06. But lean supply of the water during the winter season necessitated the construction of another dam at Dhukwan, 25 miles above Parichha which was completed in 1910. On the Hamirpur side canal was widened to carry targeted 1300 cubic feet a second against existing 7000 cubic feet a second. Several distributaries were also remodeled to cater more areas.

Commission also recommended construction of a canal from the Ken river to protect Banda district. The main canal extended to 37 miles with 2 branches and attached distributaries. The project which was sanctioned in 1903 was completed in 1906. The canal was managed by the Public Works Department up to 1908. Need of a larger reservoir was felt for supplementary storage. Hence dam was constructed at Gangao on Ken river, 30 miles above the headwork. The construction of the dam started in 1911 and completed in 1917. By 1946-47 canal extended to 86 miles with 334 miles of distributaries. It catered an area of 1, 40,592 acres (12).

Dhasen ,a tributary of Betwa was a seasonal river bringing maximum supply of 5,10,000 cubic feet water per second during monsoon butreduced to nil during summer. A project for building a canal with 3 branches of Islampur, Jabalpore, and Mohoba was sanctioned in 1905 to facilitate irrigation in the Diistricts of Hamirpur, and Jhansi and a small part on native Indian states. Two dams were built on it at Pahari and Lachaura at 7 miles interval. The inferior lining used in Pahari dam created a breach which swept the dam in 1918. The lining was immediately repaired and the dam became operational.

In addition to these Pahuj- Garhmau canal was sanctioned in 1909 to serve the watershed areas between river Pahuj ,Betwa, Burma and the Ken.

It was designed to protect northern Jhansi district from draught and famine. The masonry dam was built across river Pahuj with a short canal of 15 mile to join with an escape at Birgwan nala and a second tank was built near Garhmau to take its feed. 5 earthen embankments and a small masonry dam was built to feed the gaps of the low rise hills in Garhmau. Pahu-Garhmau Link Canal included a number of existing close by small tanks with a storage capacity of 300 million cubic feet of water.

Another tank was built at Majhewan over Gunchi Nadi to to cater the second watershed areas between rivers Ken and Burma. The purpose of the tank was to recharge the neighbouring wells. But soon breach developed in this tank because of the faulty foundation. Later in 1912 a project was sanctioned which led to the construction of two small canals, rising of the embankments and a masonry escape. These two canals were extended to 30 miles and built at at the cost of Rs. 4 lacs.

In addition to the larger systems, a large number of small storage schemes were also undertaken to provide irrigation facilities in Bundelkhand. These tanks , 12 in numbers, were scattered. Hence the Commission recommended formation of a separate subdivision under an assistant or subordinate engineer who can have better supervision over these tanks. It resulted in formation of a new Tank Division in 1905 to deal with the construction of new and systematic restoration of the old tanks in Jhansi and Hamirpur districts. It led to the restoration of several tanks in Bundelkhand region during this period.

The eastern districts of Bundelkhand constitute Mirzapur, Banaras, and Gazipur which were not as bad as Jhansi or Hamirpur. The Commission recommended works on 4 projects of Ghagar, Ganai, Garai and Sukhra which were suitable for the eastern Vindhyas district of Mirzapur.

2) *Ghagar Canal:* Situated at the high central Indian platue Ghagar Canal was the most important project in Mirzapur district. The work started here in 1912 and completed in 1918 with a cost of Rs. 43 lacs (13). The region suffered as many as 8 famines between 1875 and 1910. The project, however, did not match the expenditure incurred. Revenue generation was less than the expenditure incurred on relief and construction costs.

3) *Ganai Canal:* Second important canal project in the Mirzapur district was the Ganai Canal Project. Situated at the foot of the Ganga valley, unlike other, this project was only productive project in this region. It irrigated the area between the Vindhya Mountains and the Ganga river. The reservoir at Ganai with a feed area of 12 miles down the canal on every side together with fertile soil and good climatic conditions the area became the high productive zone with good crops.

4) *Garai Canal***:** Sanctioned in 1909 the Ganai Project was completed in 1915. It included construcin of an earthen dam about 1 mile long and 56 feet high with a storage capacity of 480 million cubic feet of water. It was connected to a small 11 miles long canal which fed an area of 8000 acres during draught years.

5) *Sukhra Dam***:** The Sukhra Dam was constructed in Mirzapur district in 1909. It was an earthen dam constructed for the purpose of irrigation with a length of .7 miles (1158 meters) and height of 34 feet with a storage capacity of 260 million cubic feet. Dam was connected with a 7 miles long canal which primarily fed 2500 acres of Ganga Basin Area. The construction cost was Rs. 2 lacs.

6) *The Ganga Canals:* The Doab region between the Ganga and Yamuna had good irrigation facilities through the Upper and Lower Ganga Canals and Eastern Yamuna Canals. But due to faulty distribution facilities the region was not fully protected against famines. Hence the Irrigation Commission in 1903 recommended improvement in the methods of distribution and extension of the existing canals. The work of extension was then looked after by the Public Works Department. The Ganga Canal project was primarily an irrigation project though some navigation channels were also provided with lock gates to negotiate falls. The canal was administratively divided into Upper Ganga Canal from Hardwar to Aligarh with some branches and the Lower Ganga Canal which constituted several branches down stream Aligarh.

The Upper Ganga Canal: The Upper Ganga Canal (UGC) was the original Ganga Canal. It started from Bhimgoda Barrage near Har-ki-pauri at Hardwar and crosses through Meerut and Bulandshar and continued till Nanu in Aligarh district where it was bifurcated – one towards Kanpur and another towards Etawah. It is the largest perennial and oldest irrigation system of India. The planning of this system started as early as 1838 and feasibility report was approved by a C Committee of Engineers in 1848. After approval of Lord Harding, then Governor General of India the construction started and the project was completed in 1854 in a record time of 6 years. The canal was commissioned on 8th April, 1854 after a trial run and necessary improvements. (14)

George Walter Mac George in his book entitled," Ways and Works in India" gave an account of public works in carried out in India from the earliest times, mentioned Ganga Canal Project which was undertaken during the famine of 1837 was the first major irrigation work done by the British India Government in Uttar Pradesh.. Sir William Warner Lee, the author of the book entitled, "The Life of Marquis of Dalhousie" referred to the high

appreciation made by Lord Dalhousie on completion of this project.

The project was carried out under the supervision of eminent British Engineer Sir Probey Cautley. The main canal was 290 kilometer long and covered a gross command area of 393000 ha.

Originally canal was designed with a head discharge of 6750 cusecs capacity which in 1938 was increased to 8500 cusecs. In 1951-52 it was again raised to 10500 cusecs. In the beginning the water from the river was diverted to a canal by erecting temporary bund every year after monsoon. By 1920 a Pucca weir was constructed at Bhimgoda and the weir was replaced by a barrage in 1986 to regulate discharge. The current details of the main canal, branches, distributaries, minors and escapes of the system are as follows

TABLE II

UPPER GANGA CANAL SYSTEM AND ITS LENGTH (IN KM)

Sr No	Details	Length (Km)
1	Main Canal	291.96
2	Branches	562.36
3	Distributaries	3299.95
4	Minors	2427.95
	Total	6582.22

Source: Department of Irrigation, Government of Uttar Pradesh

The canal which was built 154 years ago is still catering needs of the population of the command area which has increased in magnitudes than the year when became operative. The Upper Ganga Canal irrigates the fields of the cultivators of Uttarakhand and Uttar Pradesh.

The Lower Ganga Canal: The weir constructed at Narora intersects the canal system 48 kms. downstream from Nanu. Further it touched Sengar River and Sersa River near Etawah and crossed Sikohabad in Mainpuri district which became Bhoginipur branch of the canal. Bhoginipur branch became operational in 1880. This branch started from village jeera of Mainpuri district and runs towards Kanpur traversing 166 kms. At a distance of 48 kms an escape was made at Batrai where from a channel 6.4 km carried the excess water to finally meet with the river Yamuna crossing the ravines. This branch included 386 kms of distributaries.

The Bhoginipur branch together with Kanpur and Etawah branch came to be known as Lower Ganga Canal. The old channels of the old Kanpur and Etawah between Nanu and the point of intersection at Narora were known as “Stumps” and were brought into the use only when the supply of water in the Lower Ganga system leaned. The main branch of the river passed through Kalyanpur in the backyard of IIT Kanpur before breaking in to several branches.

A branch harbored Kanpur water supply near J.K Temple.

Initial capacity of the system was 5000 cusecs. Farukhabad branch was widened in 1906 and an aqueduct was constructed near Nadrai 33 kms. down Farukhabad. The district which got benefit from this system were Aligarh, Manpuri, Etawah, Kanpur and Allahabad. In 1947 the total length of this canal was 640 miles (1029.98 kms) and distributaries 3277 miles (5273.82 km). Total area under irrigation was 1,185,731 acres. Total expenditure incurred was Rs. 4, 39, 52,713.

7) *The Eastern Yamuna Canal:* The Yamuna canal Commenced at the Dakhpathar barrage in present Uttarakhand. If feeds a stopover at Asan in Doon valley which is 7 miles away from Dakhpathar.

Here Easter Yamuna canal formed confluencewith Asan River which emerged from Doon valley. Iffurther made a stopover at Hathikhand barrage in Nagar district of Haryana. But originally it was Tajewala Barrage, 2 miles to the Hathikhand barrage, which was constructed in 1873 that diverted water into the Western and Eastern Yamuna canals. But Tajewala Barrage is now out of service and now new Hathikhand barrage was mode operational in October 1996. The Western Yamuna canal served the districts of Yamunanagar, Karnal and Panipat in Haryana and further down provided municipal water supply of Delhi. But Eastern Yamuna canal served Uttar Pradesh.This perennial source of supply to the canal is the river Yamuna. The Eastern Yamuna canal entered Uttar Pradesh from the district of Saharnpur and flows to Muzffarnagar and Meerut and finally meet Yamuna River at Delhi. The flood of 1924 caused immense damage to the canal and hence large repairing of the canal was undertaken during 1925-26. The canal stretched to 100 miles during 1946-47 was 904 miles of distributaries. It irrigated 382, 045 acres of lands. The total cost of the canal stood at Rs, 64,02,529 during 1947.

8) *The Agra Canal:* Agra canal began from Okhla ,10 km south of Delhi is another important irrigation Canal. It became operational in 1874. The perennial source of water to the canal was the river Yamuna. The weir constructed at Okhla was first of its type in North India which based on the foundation of fine sand. It was about 0.45 miles (.731 km) in length and 7 feet in height above the summer level of the river. The canal flows through the highland between Khari Nadi and the Yamuna. It finally touched Banganga River about 20 miles downstream Agra. The canal irrigated above 306104 acres of land in 1944-45. The main canal was 129 miles long and with distributaries stretched to 837 miles in 1946-47. The total expenditure incurred in the project was Rs. 1, 25,43,0585.

9) *The Sardah Canal 1930:* The Sardah canal was the last major British colonial project in the United Provinces of India. Sardah Canal begins from Sardah Barrage dam near Banbasa in Champawat District of Uttrakhand. It was one of the longest irrigation Canal Project in Northern India. The Canal become operational in the year 1930. From the beginning the Canal raised huge Public resistance. Hence the Irrigation Commission in its report observed: "There is probably no scheme for the introduction of the Canal irrigation into any part of India which has formed the subject of so much discussion as that for a Canal from the Sardah river for the irrigation of Oudh ------numerous objections which have been raised against the scheme are sufficient to prevent the utilizationin the Ganga, Gogra (Ghagra) Doab, of the volume of water which now runs in the Sardah river" (15)

In 1970 Col. J.G. Forbes, RE, officiating as Superintendent Engineer Sardah canal, Oudh, prepared report on the Sardah Canal Project. In its introductory Col. Forbes defined the area where this Canal will irrigate. "The tract of the country to be provided with irrigation contains an area of upwards of 20,000 square miles , extending from Burm Deo, at the foot of the Himalayas to Beyreah, at the junction of the rivers Gurha and Ganges. It is bounded on one side by the river Gurha, Deoha and the Ganges, and on the other site by the Gogra" (16)

The Taluqdars of Oudh were opposed to the report and Irrigation Commission also did not show courage at the face of the public opposition. Hence commission worked on an alternate proposal of d Sardah water in to the Ganges. Thus Providing additional supply to the Ganga and Agra system by using separate feeders from the Ganga canal to the Eastern and the Western Yamuna canals also. Hence Sardah, Ganga, Yamuna feeder Project was prepared.

But the shortfall of rain brought the season almost on the brink of famines. Tube well irrigation was no longer sufficient and led to crop failure inferior quality of crops. This changed the mindset of the Talukdars who become ready for canal irrigation is Oudh. Hence as comprehensive canal irrigation project in Oudh was taken in hand and Sardah, Ganga, Yamuna feeder proposal was dropped.

Sardah canal project had two parts:

a. Proper Sardah Canal
b. Kichha Feeder

Sardah Proper canal project was designed to irrigate North Western district of Oudh, white kichha feeder would revitalize existing Rohilkhand Canals in westward direction across the Tarai in the foothill of the Himalayas. Secretary of State for India sanctioned the Project in 1919-20.

Sardah being are intentional river, the Nepalese part of it is known as Mahakali river. Hence the Project had to be supported with an agreement between British India and Nepal. The Sardah Agreement Letters of Exchange dated 23rd August and 12th October of 1920 Provided Payment of Rs.50,000 to Nepal in exchange of 4000 acres of land in the eastern flank of West Nepal. The Sardah of Agreement 1920 transferred the ownership of Part of the left bank area (close to the barrage) from Nepal to India. This way the upper Sardah barrage though in the Nepalese site belongs India. This treaty was subsumed in 1996. Prime Minister of both the countries signed a Treaty in February, 1996 for integrated development of the Mahakali. River (Sardah India) including existing Sardah barrage, existing Tanakpur barrage and the Pancheswara Project (in Nepal Mahakali).

That treaty invited high applauds from the United Nations Environment Project (UNEP). It observed that, "the signing of the Mahakali Treaty has Provided India and Nepal with opportunity for meaningful Cooperation to benefit the millions of People in two countries whose livelihood depends on the waters of the Mahakali River". (17) Mahakali flows for a length of 138.26 miles length in Nepal and 200 miles in Indian Side. In its upper tract Sardah Right Bank Canal with a capacity of about 396 cubic meter per second for irrigation in India. Nepal started utilising her share of water after computation of Mahakali Irrigation Project there in 1975. Besides irrigation Sardah upper barrage in India generates hydropower with an installed Capacity of 41 MW from the Canal head Power Station. From the study of irrigation department of Uttar Pradesh website 5 main branches of the Sardah canal system in Put up in a chart form as below :-

TABLE III
MAIN BRANCH OF SARDAH CANAL SYSTEM (18) AND ITS COVERAGE AREA

Sr No	Name of Canal	Discharger Cu.mts	Irrigation (acres)
1	Sardah Main Canal	325.8	22,00,000
2	Hardoi Branch	124.60	
3	Kheri Branch	79.29	
4	Old SS Feeder	99.11	
5	Bisalpur Branch	9.91	
6	Negohi Branch	94.07	

The length of the Canal along with distributaries is 7668 miles (12368 kms) and irrigated area about 8 Lakh hectares of land in the districts of Saharanpur, Barabanki, Pilibhit, Sitapur, Kheri, Hardoi, Luckhnow, Unnao, Raibareily, Pratapgarh, Shultanpur and Allahabad.

Another Canal Sardah Sahayak canal began from Sardarsagar about 12 miles below the Sardah Canal head works near Indio-

Nepalese border which augmented the supply of the main canal. It irrigated about 7.5 hector of land in Jaunpur, and Ballia districts in Eastern Uttar Pradesh. The canal was finalised during the Third Five Year Plan period.

10) *Other Smaller Canal:* Indian Irrigation Commission which was entrusted with the task of studying the irrigation conditions in India and suggest measure for improvement. The commission did not recommend any new works in the Sub Montane tract as whole water supply was being already in utilisation in the western district of Dehradoon, Bijnor and Bareilly. Among these minor canals Ramganga canal emerged from the dam of Kalagarh on the Ramganga River in Pauri Garwal district of Uttrakhand. This Project was multipurpose in nature. It was designed as an irrigation and hydro electricity Project. Besides giving 198 MW Power, the Canal also irrigated 142086 acres of land. Project was completed in 1974. Two other smaller canals which were undertaken were Bijnor canal and Rohilkhand canal which supported irrigation in Dehradun, Bijnor, Moradabad, Nainital and Bareilly districts of Uttar Pradesh and Uttara Khand.

III. TUBE WELL IRRIGATION

Despite the fact large of Uttar Pradesh had canal irrigation or shallow wells, need was felt during 1930 for additional source of water. There were many lands in the higher elevation and out of reach of gravity irrigation and canal water was not available round the year. Hence many farmers developed their own shallow tube wells as Supplementary means of irrigation. But these initiatives were unsatisfactory being too small. On the other hand the natural water reservoirs in the foothills of the mountains were not beneficial due to quick silting. Hence the possibility of obtaining additional supplies of irrigation water by means of tube wells was first considered seriously way back in 1931. This change of Policy got impetus due to availability of electric Power generated at the falls of the Ganga Canal.

During 1931-34 experimental tube wells were installed and some were run successfully on commercial basis in Western Uttar Pradesh. Initial success led to the boring of many energised tubewells of 1- ½ cusec capacity. Depth, capacity, Spacing, operation etc. were being specified scientifically.

During 1936, the Chief Engineer of the State put forward the Ganges Valley State Tube well Irrigation Scheme. This involved the installation of 1500 slandered 1-½ cusec tubewell in 7 districts of Bijnor, Moradabad, Badaun, Muzaffarnagar, Meerut, Bulandsaher and Aligarh. These wells command 1,462,000 acres of cultivable land; where no other effective irrigation facility was available. It irrigated 182,750 acres of sugarcane, 350,850 acres of wheat and 87,720 acres of Kharif Crops. By 1943-44 under Grow More Food Scheme 200 more new state tube wells were installed. From the study of the PWD. C.file no. 62w/1-1943 gives us following trends in the installation of Tube well

TABLE IV
MINOR IRRIGATION- INCREASE IN THE NUMBER OF TUBE WELLS

Year	No. of Tube wells
1935-36	743
1936-37	1348
1937-38	1454
1938-39	1474
1939-40	1478
1940-41	1555
1941-42	1619
1942-43	1641
1943-44	1649
1944-45	1687
1945-46	1847
1946-47	2009
1947-48	2062

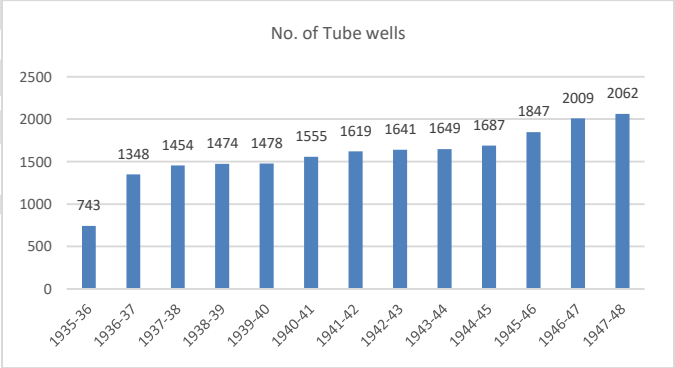

Fig. 1 Graphical representation of No. of Tube Wells over the years

IV. CONCLUSION

To sum up, Indian agrarian society since times immemorial was economically self-sufficient. It was a type of self-sufficient village economy where most of the things of daily necessities were produced in the village itself, except salt and kerosene etc. The articles and implements might have been obsolete in nature comparing to today's standards. But those wooden plow, carts and artisan wells. (Rehr) were appropriate in those days. Those were locally available, repairable and less expensive. But opening of the market with the advent of the British changed the situation drastically. The British come to India with their commercial motives. Hence, they after consolidating their position politically introduced new agricultural methods and policies. Introduction of cash crops like Jute, Cotton, indigo and plantation Products like Tea, Coffee, and Rubber etc. were given preference. For this the

colonial rulers introduced European techniques and imported implements like European iron plow, crushers, showers, seeds and manures which were not welcome by the native cultivators. But recurrent famines and draught rather forced the British to introduced new methods of irrigation. New techniques were imported and research made which culminated into the development of a network of canals. Though there was initial resistance from within, in the end the benefit of the new irrigation system was reaped well. But it created a complex problem. Dependence increased on land. Too much pressure on land created serious distortions in Indian economy. The disproportionate dependence on agriculture destructed the delicate balance of Industry and agriculture. After a thorough study of d the Census reports from 1891 to 1931, Rajni Palme Dutt, the rightist thinker and scholar had calculated the rise of dependence in agriculture and Comparative decline on Industry. (19)

TABLE V
AGRICULTURE –INDISUTRY DICHOTOMY

Year	Percentage of Population Dependent on Agriculture	Percentage of Population Dependent on Industry
1891	61.1	
1901	66.5	5.5
1911	72.2	4.9
1921	73	4.3

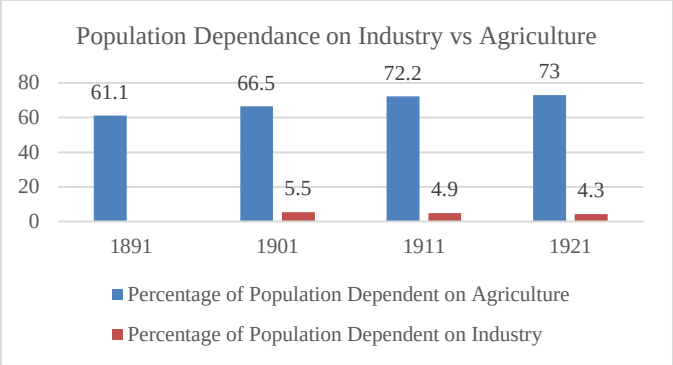

Fig. 2 Graphical representation of Population Dependence on Industry vs Agriculture

Hence rise in population together will new agricultural development created some flutters in so long tranquil India society which were socio-economic and historical in nature.

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