SCIENTIFIC AND TECHNOLOGICAL BASE TO THE AGRARIAN ACTIVITY IN BRITISH GUJARAT

'Then comes a gentleman *Hakim,*
to teach us to plough and to weed,
I sowed the cotton, he gave me,
but first I boiled the seed.
He like us humble farmers,
and speaks so gracious and were
As he asks for our manners and customs,
I tell him a pack of lies'.[1]

Above stated couplet embarks upon the attitude of the natives and the inherent limitation imposed on the Britishers to rule over British Gujarat territories. Colonisers single handed could not spread their tentacles over the Gujarat region. They were in great need to understand the knowledge and skills employed by the natives in the agrarian sector. Their recording of the information with the help of the locals was a difficult task. The produced literature during the colonisation process on the agricultural discourse was bound to be superficial. But at the same time, they should also be credited with publication of number of reports, pamphlets and; forms of information which are used by the scholars to understand the agricultural dynamism in pre-Independence epoch.

Discussion carried out in the second section of Chapter Two fairly establishes that the territories occupied by the British from 1750 onwards in Gujarat sub-regions were brought under cultivation thoroughly.[2] At the same time, the traditional knowledge and agricultural practices remained in vogue uninterruptedly. However, British decided to bring in the changes as per their industrial needs. This chapter offers a survey of the mode of production of food and cash crops; experiments carried out for the enhancement of crops yield and seed quality, description of tools and implements; irrigation methods; horticulture activities and animal husbandry. *Revised Revenue and Survey Settlement Reports* (*RRSSR*) published under *Selections from the Record of the Bombay Government* (*SRBG*) of the various *talukas* of British Gujarat inform us about the extent of cultivation; crop-pattern; yield; and generated

[1] Satpal Sangwan (1991), *Science, Technology and Colonisation: An Indian Experience, 1757-1857*, 130-31.
[2] Brahama Nand (2004), *Fields and Farmers in Western India, 1850-1950*, 77.

income at length and other miscellaneous information related to agrarian activity, settles and the transformation the locality and sub-regions had undergone.[3]

Food and Cash Crops Cultivation

Food Crops

English and Dutch Factory Records amply provide the description of food crops in British Gujarat territories. These also document the appreciation which the Britishers had for the peasants and their knowledge on cultivation. For them, the region was vibrant in terms of both quality and quantity.[4] They allowed less changes as the traditional methods were sufficient to fulfill the local needs and had generated enough surplus for uneven period. A survey of *Agricultural Reports*[5] and *RRSSR* do bear testimony for the decades of the second half of the 19th century that there were attempts to enhance the production of food crops. It is noteworthy to mention that the following food crops: rice, wheat, *jowari*, *bajri*, *kodra*, *ragi*, *bavto*, *vari*, *chaenna*, maize were grown under grain crops category; *math*, *mag*, *guvar*, *adad*, *kulthi*, *tuver*, *val*, *chola* under pulses category; *tal*, *sarsav*, *rai* remained under oil producing crops and variety of fruits continued to be cultivated.[6]

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[3] "*SSR* of *Purgunnas* of Puranteej, Hursol, Morassa, Bayur and Veeramgam of Ahmedabad Collectorate" (1853), *SRBG*, No. 10, Bombay; "Report on the Portions of Dholka *Purgunna* Situated in Ahmedabad and Kaira Collectorate" (1853), *SRBG*, No. 11, Bombay; "*RRSSR* of Broach *Taluka* of Broach Collectorate" (1902), *SRBG*, No. 407, Bombay; "*RRSSR* of Jambusar *Taluka* of Broach Collectorate" (1903), *SRBG*, No. 412, Bombay; "*RRSSR* of Ankleshwar *Taluka* of Broach Collectorate" (1902), *SRBG*, No. 529, Bombay; "*RRSSR* of Dohad *Taluka* of Panch Mahals Collectorate" (1927), *SRBG*, No.612, Bombay; "*RRSSR* of Halol *Taluka* of Panch Mahals Collectorate" (1927), *SRBG*, No. 616, Bombay; "*RRSSR* of Bardoli *Taluka* of Surat Collectorate" (1897), *SRBG*, No. 360, Bombay; "*RRSSR* of Chorasi *Taluka* of Surat Collectorate" (1897), *SRBG*, No. 359, Bombay; "*RRSSR* of Olpad *Taluka* of Surat Collectorate" (1897), *SRBG*, No. 361, Bombay; "*RRSSR* of Chikhli *Taluka* of Surat Collectorate" (1899), *SRBG*, No. 381, Bombay; "*RRSSR* of Bulsar *Taluka* of Surat Collectorate" (1900), *SRBG*, No. 303, Bombay; "*RRSSR* of Jalalpur *Taluka* of Surat Collectorate" (1900), *SRBG*, No. 305, Bombay; "*RRSSR* of Pradi *Taluka* of Surat Collectorate" (1904), *SRBG*, No. 425, Bombay; "*RRSSR* of Mandavi *Taluka* of Surat Collectorate" (1904), *SRBG*, No. 426, Bombay.

[4] William Foster (1906-23), *The English Factories in India*, 13 Vols., Oxford; Ghulam Ahmad Nadri (2007), "Eighteenth Century Gujarat: The Dynamics of Its Political Economy, 1750-1800", Unpublished Ph. D. Thesis, Leiden.

[5] *Annual Reports of the Department of Agriculture of the Bombay Presidency* (1894-1945); *Annual Reports on the Experimental Work of the Dohad Agriculture Station* (1910-12) and *Annual Reports on the Experimental Work of the Surat Agriculture* Station (1906-10).

[6] Brahama Nand (2004), *Fields and Farmers in Western India, 1850-1950*, 244; *GBP* (1879), *Ahmedabad*, 53-54 and *GBP* (1879), *Kaira and Panch Mahals*, 45.

Cash Crops

Cotton, indigo, sugarcane, tobacco, opium, etc., were the cash crops cultivated in various pockets of British Gujarat. These crops received maximum attention of the colonial authorities in comparison to the food crops. In the following sections, various experiments were carried out to increase the yield of above mentioned crops. This chapter contains description of these efforts at length.

Cotton

Cotton alias *kapas*, raw form is cultivated in black soil. Broach District during the reign of British is reported to be the richest growing sub-region of Gujarat.[7] However, entire Gujarat region produced superior quality cotton. It was sown after rain in the month of June and its picking was done in March.[8] Regarding the chief strain of cotton, Dholera and Broach staples used to be the two chief strains. All the varieties of cotton staples grown in Gujarat were the progeny either of Dholera or Broach categories. The different cotton plants cultivated in Ahmedabad and Kaira Districts was progeny of Dholera cotton and varieties of cotton staples in areas of south Gujarat belonged to Broach one. Two varieties of cotton were grown in Broach region, the annual black soils *laria* and the triennial of light soil *jaria.* In addition to these, there were two others, *roji* and *narma*. The *roji* was inferior in quality and grown in Baroda to be mixed with the regular Broach cotton as an adulterant. *Narma* or d*ev kapas* (*Gopssipium reloigiosm*) was a perennial plant lasting for five or more years. It was used for the sacred thread preparation and was grown in small quantities near temples or dwellings of ascetics.[9]

The industrial and commercial needs of the British promoted for planned organisation of cultivation of cotton crop. The measures included the enhancement of the extent of cultivation, improvisation of seed quality, harvesting and storage.

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[7] K. L. Tuteja (1990-91), "Agricultural Technology in Gujarat: A Study of Exotic Seeds and Saw Gins, 1800-50", 139.
[8] *Ibid*.
[9] Shantha Hariharan (2002), *Cotton Textiles and Corporate Buyers in Cottonopolis: A Study of Purchases in Gujarat, 1600-1800*, 206-07.

Sowing of Cotton

Method reported for sowing the cotton seeds is as follows:

Gazetteer of the Bombay Presidency, Surat and Broach Districts[10] reports that the cotton seeds were rubbed on the frame. This frame was created with the help of wood and was covered by coconut fibre cords which were tightly stretched over the frame. The seeds were wetted with muddy water and afterwards plunged into wood ashes. The ashes separated the seeds from each other so that it could be easily dropped one by one on the field. Manure was not generally used as local farmers believed that it would not increase the yield.[11] When the land was ready, the seed was sown with the help of a drill plough furnished with three tubes or feeders. Irrigation of cotton plant was not done frequently as plant did not require much water for its growth. Within ten months, plant grew into maturity with white flower. The white flowers were then collected from the field.

The cotton at Surat was sown annually with the help of drills at the commencement of first rain. Accordingly, the ground was ploughed and well cleaned from weeds and unwanted plants. The best technique to grow cotton was to use a field which had been kept fallow for one year. This land would always produce crops more abundantly. After sowing and irrigation, the plant reached mature stage. There were three gatherings of raw cotton in one season. The first picking of cotton commenced from the middle of the end of February month and yielded the finest wool. The pods were taken from the top of the shrubs. The second picking of cotton was followed after fifteen days. Cotton collected in this stage was found to be inferior.[12] The last one was not considered good and it was picked from the lower part of the bush of the plant.[13]

Increase in demand of raw cotton in England further pressed the British to carry out experiments for its improvement as the cotton staples of Gujarat were short in length. In contrast, the manufacturing houses in England worked on long staples

[10] *GBP* (1877), *Surat and Broach*, 392.
[11] *Ibid*.
[12] R. D. Choksey (1968), *Economic Life in the Bombay Gujarat, 1800-1939*, 135.
[13] *Ibid*.

of cotton for production of fabric. In the above circumstances, colonial government in Gujarat and pressure from the textile lobby of England led to the introduction of a number of new cotton seeds. These seeds were probably transmitted from the other colonies in the USA, Africa and Australia.

Kaira became the first British district for the trial of new exotic cotton seed.[14] For the said purpose, 4,750 *bighas* of land were planted with Bourbon cotton seed under the supervision of Assistant Surgeon Gilders. But the very first initiative of the colonial government met with failure. Bourbon cotton reached maturity in eighteen months instead of one year.[15] The moisture in soil was adequate to produce blossoms, but insufficient for complete growth. The immature cotton buds collected were tested with newly send cotton gins for its utility as a long staple plant. In this respect, in 1816, Court of Directors sent two Whitney saw gins, but it injured the cotton fibre during the cleaning process as fibre were not strong and often led to its damage. The end result was its failure.[16] The first phase shows that the British authorities introduced exotic seeds in haste without a well-planned approach and lack of managerial skills.

Cotton Improvement in Broach

The experience at Kaira for the trial of Bourbon seed forced the government to look into the matter with seriousness and effective set of experts were hired for its successful result.[17] In 1812, Bourbon seed was sent to Bombay from England and in place of Kaira, this consignment was forwarded to Broach and Surat. Both these sub-regions in south Gujarat was well known for the black soil and good quality of local cotton staples. This step met the same fate as in the case of Kaira trails for Bourbon seed.[18]

[14] K. L. Tuteja (1990-91), "Agricultural Technology in Gujarat: A Study of Exotic Seeds and Saw Gins, 1800-50", 145.
[15] W. R. Cassels (1862), *Cotton*: *An Account of Its Culture in Bombay Presidency*, Bombay, 12.
[16] *Ibid.*, 12-15. Also see K. L. Tuteja (1990-91), "Agricultural Technology in Gujarat: A Study of Exotic Seeds and Saw Gins, 1800-50", 145.
[17] *GBP* (1877), *Surat and Broach*, 395.
[18] *Ibid*.

According to K. L. Tuteja:[19]

> With experience in these experiments, it was decided to open experimental farms for exotic cotton seeds trials in British Gujarat. In 1831, the Bombay government established an experimental farm in Broach under Mr. Finnay, an indigo expert who worked in Bengal. Under his supervision, cotton flowers obtained from the cultivated exotic seeds were compared with the locally grown cotton plants. He went for a comparative analysis in terms of output between the exotic cotton and indigenous staples with the help of the native instrument called *charkha* and imported cotton gin. Native cleaned cotton from foot roller (*charkha*) and saw gin. He found that the *charkha* yield was better in comparison to the imported instrument. It was observed that gin was not appropriate for Gujarat cotton because it damaged the staples. In the same year, Mr. Martin was appointed as cotton supervisor for cotton experiment at Danda Farm in Broach. **He was firm believer in the skills and ability of the local peasants for the cultivation of cotton staples**. If these were properly guided and supported in terms of expertise and financial help, there was greater chance of adoption and cultivation of exotic cotton seeds on a wider scale. For this purpose, he distributed exotic seeds to the farmers. But still his noble efforts were discarded by the cultivators as they found that the exotic seeds did not grow well in the soil. During 1840s, under the pressure from the Manchester Chambers of Commerce and the Glasgow East India Association, Company hired twelve American planters and three of them were sent to Gujarat under the supervision of Dr. Pearl and later under Dr. Burn. **This was one of the serious efforts from the colonial government for the success of exotic seeds; and therefore, experts were called from abroad who were known for remarkable achievements in their respective fields**. These experts were asked to work with different lands of different soil composition. In this venture, they were provided with 350 *bighas* of land for experimental farming. About two hundred and fifty *bighas* situated at village Ulderwa and Ussooria had light coloured soil; while the other one hundred *bighas* consisted of the best and most productive soil at Kokurwarra near Broach were further made available to them. All these farms were sown with New Orleans seeds. These high level efforts also ended in failure as crops failed to mature. One of the important factors for the immaturity of the exotic seeds was availability of sufficient moisture in the soil which was not favourable to the seeds. American cotton had shallow roots which were well suited in the American soil. In Gujarat with moisture in the soil and long dry season, the exotic plants were bound to wither. In contrast Broach-Surat cotton had long tap roots and grew well in the black soil. American planter Mr. Hawley was deputed to Broach Farm but he also met with same fate. **One of the important reasons for the failure of exotic seeds was that these foreign planters were not scientist and their knowledge was based on their observation without any technical knowledge on their native environment**. When they tried to implement the same experience in Gujarat, they failed because Gujarat had different ecological set-up in comparison to America.

All the above examples do not mean that all the initiatives for the introduction of exotic seeds were taken by the British government only. Cultivators in Gujarat were not at all hesitant about the cultivation of the foreign seeds. There were numerous examples about the cultivation of exotic seeds by the peasantry. For

[19] K. L. Tuteja (1990-91), "Agricultural Technology in Gujarat: A Study of Exotic Seeds and Saw Gins, 1800-50", 146-49.

one such example, a large house and Amjad *Bag* (garden) near Broach was granted rent free to Merwanji Hormasji (a native agent for the Company to provide it with provision for China trade and also a cotton investor) in 1834.[20] Various trails were executed in the Garden with exotic seeds. Besides its cultivation, he also established screws and warehouses for the purpose of packing and storing of cotton. Unfortunately, his effort also ended in failure.[21]

Situation in Ahmedabad and Surat

Experiment for long staple cotton was also tried in Ahmedabad District. In the very first attempt in 1833, Mr. Martin selected two spots namely in Dhandhuka and Ranpur for growing Egyptian and Pernambuco cotton.[22] In 1852, Mr. Price started the cultivation of New Orleans seeds. He supplied seeds to the natives and even he was ready to bear all the losses if farmers failed in the cultivation. Owing to heavy rain the staples failed.[23] Unfortunately, Price was replaced by Mr. Daly on the pretext of mismanagement.[24] But this does not mean that no positive experience was gained from these trails. Egyptian and Hinganghat showed some sign of hope. Further, thinning was tried but it also failed as plants did not throw side roots.[25]

Mr. Daley at Surat was made the supervisor of exotic cotton seeds trials. He met with same destiny as of Mr. Price at Ahmedabad. Experiments in Surat had uniformly failed.[26] Mr. Daley was removed. In the next desperate effort, Mr. Hope, Collector of Surat was provided with financial aid from the government for cotton trials. He was also assisted by Mr. Carrel, an Inspector in the cotton frauds with the understanding to supervise the experiments.[27] By 1861-62, the period of experiments had ceased altogether. Mr. Stormont arrival from England to Broach in 1868 led to the conclusion that **local varieties were superior in comparison to the exotic one**.[28]

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[20] *GBP* (1877), *Surat and Broach*, 396.
[21] *Ibid*.
[22] *GBP* (1879), *Ahmedabad*, 56.
[23] *Ibid*.
[24] *Ibid*., 57.
[25] *Ibid*.
[26] *GBP* (1877), *Surat and Broach*, 399.
[27] *Ibid*., 399-400.
[28] R. D. Choksey (1968), *Economic Life in the Bombay Gujarat, 1800-1939*, 133-34.

Majority of the planters were convinced with the superiority of the local varieties of cotton in comparison to the foreign staples. Local cotton plants were suitable in the black soil of Gujarat. The existing indigenous varieties were the outcome of long process of trails and errors practised by the peasantry since antiquity. Ten to twenty years of half-hearted experiments without proper understanding of the local environment, geography and soil chemistry would definitely led to the failure or at least limited success. This seriousness came only when Dr. Voelcker urged the government to establish experimental farms with adequate staff and funding with a team of experts. Absence of research was very important factors for the failure of cotton experiments in Gujarat. Mere use of short cut to fulfill the demands of the government by amateur planters did not come with miracle. A series of research activities on an organisational structure was mandatory for the success of cotton staples. It became possible only when the Imperial Agricultural Research Institute (popularly known as Pusa) was established in Bihar in the first half of the 20^{th} century.

The question arises that why the Britishers were still going with long staple cotton experiments. One possible reason which was already stated was that textile mills in England worked on long staple cotton. But in Gujarat, cleaning of cotton from its seeds became another factor. The native instrument *charkha* though cleaned excellent quality of cotton from the indigenous cotton plants, the quantity obtained was limited and cleaning process was time consuming. To increase the output of cleaned cotton, saw gins were introduced to speed up the cotton cleaning process. The instrument was opposed by the natives for a number of factors. The working on gins was tedious task and required hard labour from the workers. Further, native cotton when cleaned by the American saw gin generally injured the cotton. Seeds which were collected after the cleaning with the help of *charkha* were used for oil extraction. It was also used as fodder for animals and manure for agricultural activity. Gin machine damaged the seeds during the cleaning process. Further, merchants and middle men were also not interested in its use because the quantity obtained was less in weight in comparison to the *charkha* cleaned cotton. Gradually, it was accepted but not on a large scale in the rising cities and urban centres. In

villages *charkha* was still popular. At Dharwar in Maharashtra, the government initiatives and seriousness led to its gradual acceptance. With the same hope by the government in Gujarat, it was further tried in Broach, but results were not encouraging. These examples gave an insight to the authorities. Improvements were introduced with a number of adjustments to the gin to fulfill the local demands. Platt Macarthy roller-gin introduced in 1864 was generally accepted by the peasants; but its adoption took a long period of time.[29]

Cleaning of indigenous cotton became next important task of the government for its export to England. The price of Indian cotton in England market was affected because of its unclean condition. One suggestion was to clean cotton and a variety of experiments were restored. In one such attempt, cotton was given to *bhukaries* whose duty was to clean cotton with indigenous instrument and deliver the cleaned cotton directly to the government.[30] A vast number of interested men and women rushed there in the hope of earning. Government through this scheme received cleaned cotton which was obtained with the use of the *charkhas.* The practice became so popular that the government felt that any other mechanical device if introduced, the people would not accept these instruments against *charkha*.[31]

Long staple cotton was used in mills of England is a well-known fact. But this does not mean that Indian cotton did not find markets of Manchester, Liverpool and others in England. It was still in demand and still cheap in comparison to the long one. It was used for manufacture of coarse cloth. This was well addressed by Mr. J. A. Turner, Chairman of the Manchester Commercial Association.[32] According to him, if best Surat cotton was sent in a clean state unmixed with leaf and not cut by saw gins; it would be cheaper in Liverpool than the common American one.[33]

There were number of factors both natural and men made which led to the mixing of dust and unwanted materials in the cotton. Roads were not good and

[29] *GBP* (1877), *Surat and Broach*, 397-401.
[30] R. D. Choksey (1968), *Economic Life in the Bombay Gujarat, 1800-1939*, 135-36.
[31] *Ibid*.
[32] *Ibid.*, 135.
[33] *Ibid*.

cotton was conveyed entirely on carts which invited the deposition of dust over the cotton. Cotton was exposed to every species of depreciation during its transit to Bombay and the dew and the dust did their worst to it. Further, peasants, merchants and middlemen occasionally deliberately mixed unwanted materials and exposed it to moisture to increase the weight of the cotton bales.[34]

By the end of the 20th century, after a series of long trial and error methods / experiments led to the cultivation of long staple cottons. Previous experiences in Gujarat and expertise help from the research institutes were successfully applied in the experimental farms in the various districts of British Gujarat. Fusion of indigenous and exotic varieties led to the development of number of long staple cotton. Gins were also accepted along with *charkha* which was still used in rural areas. One can verify this in *RRSSR* of individual *talukas* in British Gujarat. Increasing demand created during the world wars decade forced the Bombay government to make every possible effort in Gujarat. In this regard, they tried to encourage the cultivation of American, Cambodia and improved Broach cotton plants. Seed farms were established in all the cotton growing regions. Efforts were also initiated to stop the adulteration of cotton.[35] Improvement in indigenous cotton remained in progress and works were in continuation to isolate and maintain purer types of cotton staples to improve their quality and outturn. It was found that the experiments had already yielded encouraging results. Care was also taken for the marketing of cotton in a cleaner condition. Simultaneously, in all the cotton growing districts of Gujarat, efforts were also carried out to cultivate the superior long stapled exotics. Besides, ready acceptance of long staples in England's markets; developed improved hybrid Indian cotton was also in demand because of the improvement in the quality of cotton.[36]

[34] *Ibid.*, 136.
[35] *Ibid.*, 142.
[36] *Ibid.*, 142-43.

Measures Taken to Control Spotted Boll Worm

Besides all the above discussed issues, the control over insects and pests was the dire need of time as it had several times affected the cotton crop. Their attacks often led to the severe loss of cotton production. In one such attempt, the British government had to combat a very serious problem of severe damage done by the pest called Spotted Boll Worm. In 1905, their attack led to the failure of cotton crops in Punjab. Authorities needed an urgent demand for its immediate solutions and efforts were made in this direction. In 1922, the Indian Central Cotton Committee completed an investigation into the nature and extent of the problems and as a result of their conclusion, work was started at Surat in September 1932.[37] Further, trails in connection with clearing of the pests were conducted.[38] Description is as follows:

Spotted Boll Worm worked well in the night. Following steps were taken to control it:[39] (**see Illustration Nos. I and II**)

- Cotton plants were covered with mosquito nets in the night. The remedy suggested was not feasible, and therefore, was not followed by the farmers.
- Small round thin trenches with a circular opening were made at the base of the plants with a quantity of water with a thin film of oil (sesamum or castor oil).

But both these methods were not encouraging.

Other attempts to control it were also tried which are mentioned below:

- Removal of attacked shoots
- Trap crop *bhindi* (lady's finger) was grown along with the cotton plant to control the pest as its affinity to *bhindi*. But the step was not good as it increased the growth of the worm instead of its control.

At Surat seven different types of insect enemies of the Boll Worm were noticed and one of these *Microbracon lefroyi* was made the subjects of study.[40] But again, the ongoing experiment's results were not very encouraging.

[37] B. P. Deshpande and N. T. Nadkarny (1936), "Spotted Boll-Worms of Cotton in South Gujarat, 1923-31", *Scientific Monograph No. 10*, ICAR, Calcutta, 1.
[38] *Ibid*.
[39] *Ibid.*, 8-9.
[40] *Ibid.*, 13.

Baits

Bait is a kind of food used to trap insects, pests and rodents. A large number of aromatic substances such as amyl acetate, methyl butyrate, clove oil, vinegar, rum, country liquor, turpentine and a few others of similar nature emitting different kinds of smell were exposed in the cotton fields.[41] These baits were used with the hope to attract the boll worm in order to trap them. But none of these were successful. Other substances such as cotton seed cake and sesamum cake mixed with large quantities of water did, however, attract some of them. But it had also limited result.

Soil Milch

A thin surface layer of pulverised soil in the fields is called soil milch.[42] Soil milch method was also tried but the result was same.

Insecticides

Lead arsenate and Paris green which were often used as poison for the insects were tried in the form of dust and spray, but of no avail. Calcium arsenate and sodium silico flouride were also tried and were found to be effective in reducing the number of the large of the Spotted Boll Worms, but in consequence of their use serious aphis infestation developed and nullified their beneficial effects. As the same time, it attracted the Wings Aphis which flourished on the dusted plants by reason of immunity they secured from some of their insect enemies.[43] When the insecticides were blackened by mixture with powdered charcoal before dusting, Aphis infestation decreased but did not disappear altogether.

[41] *Ibid*.
[42] *Ibid.*, 13-14.
[43] *Ibid.*, 15.

Clean up Measure (see Illustration Nos. III and IV)

It was a common practice that immediately after *kapas* was harvested the cotton plants should be uprooted, malicious weeds destroyed and the cultivation of *bhindi* to be stopped.[44] Native implements used were unable to uproot the cotton plants from the soil. An implement called Plant Puller was manufactured for uprooting the plants.[45] It was effective and economical. The government decided to manufacture this tool for its distribution to the cultivators to control the pests.

The plant puller scheme was introduced in Surat and Broach.[46] Arrangements were made to get it manufactured on a mass scale at Baroda with an understanding that it should be supplied to the cultivators at a low price of Re. ½ per puller. It was essential for the success of this scheme that all the cultivators from the surrounding areas should adopt the method of uprooting the cotton plants with plant pullers instead of hacking them with *kudalis* as they used to do before.[47] A strong bias against the idea of uprooting cotton from the soil existed in some of the villages. To overcome this problem, extensive educational propaganda was undertaken for explaining the damage caused by this pest.[48] Following control measures were executed like personal discussions with large number of cultivators with magic lantern lectures; by demonstrating the actual working of the pullers; holding of competitions and awarding medals and prizes.[49] The Publicity Officer of the Indian Central Cotton Committee[50] rendered valuable service by issuing illustrated hand bills and leaflets about the advantages of the measures taken. For its wider publicity in leading newspaper, he even personally visited the tract where such propaganda was going on. The result was encouraging.

[44] *Ibid.*, 16.
[45] *Ibid.*, 18.
[46] *Ibid.*, 19.
[47] *Ibid.*, 20.
[48] *Ibid*.
[49] *Ibid*.
[50] *Ibid.*, 20-21.

Silk

Pre-British Gujarat period do not report about silk production and its products manufacturing. It was imported largely from Kashmir and Bengal. In Gujarat, however, it was collected from silk worm from the forests.[51] But the quality and output were pronounced not fit for the purpose. In 1803, Captain Miles mentioned that citadel of Champaner-Pavagarh City Complex was inhabited by silk weavers who manufactured *kinkhabs*. He also reported that the water of Champaner was held durable as it maintained the colour of the silk.[52]

A number of experiments for the production of silk were carried out in Ahmedabad, Kaira and Broach sub-regions. In Kaira, Dr. Burnes, a Civil Surgeon was entrusted with the duty to engage himself in experiments relating to the culture of silk worms in 1837. A government garden was established at Kaira.[53] Experiments were made in the growth of mulberry trees and the rearing of silk worms. In 1838, the government plantation on the banks of Shedhi, near Kaira Bridge was planted with 800 trees of St. Helena species.[54] It was reported that all of these thrivied well. St. Helena species stood in rows twelve feet apart with straight stems three to four feet high. These were manured with dry cow dung, and in the hot season watered two to three times a week. In 1840, Dr. Burn reported that his plantation was in a flourishing state. About 60,000 worms were fed and some silk had been reeled.[55] Further, three *Gujaratis* youth were given allowances to learn reeling under Signor Mutti, then employed by government in the Deccan in silk culture. Kaira experiments were continued for some years. In 1844, Dr. Thatcher who was next in charge of the garden reported that these worms suffered from heat. Natives were not responding for the reeling of silk.[56] Local people did not like the killing of the worms, and therefore, not adopted it on wider scale. The garden was then closed in 1847.[57]

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[51] M. S. Commissariat (1938), *A History of Gujarat*, Vol. I, 200.
[52] *Ibid*.
[53] *GBP* (1879), *Kaira and Panch Mahals*, 54.
[54] *Ibid*.
[55] *Ibid*., 55.
[56] *Ibid*.
[57] *Ibid*.

In Broach, a Parsi named Shapurji Pestonji planted some mulberry trees on an experimental basis.[58] His idea of successful culture of silk from the worm did not materialise. He suffered loss and under debt pressure left the experiment. Variety of incentives was tried from the governmental side to induce people to attempt the culture of silk.[59]

Indigo

Indigo production in Gujarat was an important industry to assist the colouring of the cotton and silk fabrics manufactured by the artisans. Sarkhej in Ahmedabad was very important centre for its production.[60] Borsad in Kaira and Jambusar in Broach were the other important regions known for indigo cultivation, but were inferior to Sarkhej.[61] A number of European travellers like Finch, Pelsaert and Tavernier had written about the indigo preparation in Ahmedabad.[62]

Tavernier (French traveller) describes the procedure for indigo preparation in Gujarat: "After the Indian have cut the plant, they throw it into tanks made of lime which become so hard that one would say that they are made of a single piece of marble. The tanks are gradually from 80 to 100 paces in circuit and when full water or a little more, they are filled with the cut plant. The Indians mix it and stir it up every day until the leaf-for the stem is of no account becomes reduced into slime or greasy earth".[63]

Pelsaert (Dutch traveller) discusses another aspect of the manufacturing process largely employed in Bayana near Agra. According to him: "Two or three men in standing position put the indigo back and forward with their arms and owing to the continuous motion, the water absorbs the dark-blue colour. They allow it to rest for some days and when they see that the entire indigo sink to the bottom and

[58] J. Geoghegan (1872), *Some Account of Silk in India*, 40.
[59] *Ibid*. Also see R. D. Choksey (1968), *Economic Life in the Bombay Gujarat, 1800-1939*, 220.
[60] Surendra Gopal (1975), *Commerce and Crafts of the Gujarat in the Sixteenth and Seventeenth Century*, 223.
[61] *Ibid*.
[62] *Ibid*.
[63] Jean-Baptiste Tavernier, *Travels in India*, (tr.) by V. Ball (1977), Vol. II, New Delhi, 8-9. Also see Surendra Gopal (1975), *Commerce and Crafts of the Gujarat in the Sixteenth and Seventeenth Century*, 223-24.

that water is clear above, they open the holes made round the tank to allow the water to escape. The water having been drawn off, they fill baskets, take the paste in their fingers and mould it into pieces of the shape of a hen's egg, cut into two. But indigo of Ahmedabad is flattened and made into the shape of a small cake".[64]

Indigo during the process of manufacture was unfortunately mixed with dirt and unwanted materials. The colonial authority in Gujarat dissatisfied with the quality of the local produce tried to organise the production under their supervision.[65] For this, they purchased leaves directly from the peasants and engaged hired labourers to prepare the indigo in Ahmedabad. They adopted the methods prevalent in the north India. Soon, they abandoned the attempt because it was pronounced costly.[66] They turned their attention to the other indigo producing regions like Bengal province for fulfill its demand for textile colouring.[67]

The following information about indigo cultivation in Kaira District is documented in *The Dictionary of Economic Products of India*[68]*:* In Kaira, indigo was cultivated in *gorat* soil at the time of monsoon. The field was thoroughly ploughed and manured. The seed was sown with the judicious use of drill-plough. Constant weeding was necessary for the growth of the plants it was reported that by the month of September, crop was matured. Its leaves were carefully gathered in order to avoid the wetting of the leaves.

Attitude of the natives were very important factors for the success of a particular crop and its finished products. In Borsad[69], indigo was not considered fit to be cultivated for the following reason. The destruction of animal in the preparation of indigo dye was looked as a sin and it was a general understanding among *Patidars*

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[64] W. H. Moreland and P. Geyl (tr.) (1925), *Jahangir's India: The Remonstrantie of Francisco Pelsaert*, Cambridge, 10. Also see Surendra Gopal (1975), *Commerce and Crafts of the Gujarat in the Sixteenth and Seventeenth Century*, 224.
[65] Surendra Gopal (1975), *Commerce and Crafts of the Gujarat in the Sixteenth and Seventeenth Century*, 224.
[66] *Ibid*.
[67] Prakash Kumar (2001), "Scientific Experiments in British India: Scientists, Indigo Planters and the State, 1890-1930", *IESHR*, 38 (3), 253.
[68] George Watt (1897), *A Dictionary of the Economic Products of India*, Vol. IV, Calcutta, 412.
[69] "Papers Relating to the *RRSS* of Borsad *taluka* of Kaira Collectorate" (1895), *SRBG*, No. 337, NS, 4.

not to grow it.[70] The unpleasant smell produced in the process of manufacture was a deterrent fact which discouraged its cultivation by the peasants.[71]

A number of factors were responsible for the decline of indigo industry in Gujarat which enjoyed reputation in pre-colonial period. Indigo manufactured in Bayana near Agra was considered the best one and it was the chief target of the European merchants. Later on, Bengal region became popular in terms of its cultivation and production. A number of British planters established farming culture in indigo cultivation region of Bihar area on a plantation basis. Government pumped huge resources and number of experts were hired. Indian Imperial Institute at Pusa was established in indigo producing zone under the pressure from the indigo lobby.[72] Indian government agreed to sanction the grant requested by the Bihar Indigo Planters Association and Indigo Improvement Syndicate.[73] Bihar area under such governmental patronage emerged as an indigo hub. But the most serious threat came with the introduction of artificial dye Alizarin from Germany which proved very dangerous to the indigo industry in India.[74] Its impact was also felt in Gujarat and gradually Sarkhej became an abandoned region in terms of indigo cultivation and its manufacture.

Sugarcane

Sugarcane was cultivated extensively in south Gujarat. Most of these tracts were under the control of Baroda State. Gandevi in Navsari under Baroda State was best known for its cultivation and manufacture of variety of products. Surat was another such centre.

[70] *Ibid*.
[71] *Ibid*.
[72] Prakash Kumar (2001), "Scientific Experiments in British India: Scientists, Indigo Planters and the State, 1890-1930", 259.
[73] *Ibid.*, 259-60.
[74] *Ibid.*, 260.

Sugarcane Cultivation in Baroda State

Sugarcane (*Saccharum officinarum*) was chiefly grown in majority of the *talukas* of Baroda State. Sugarcane was cultivated in *bagayat* land (garden land with irrigation facility) and it thrived well in black and medium deep soils. Its cultivation was scattered in all the districts of the Gujarat State besides Baroda State. Gandevi and Vyara *talukas* of Navsari District in Baroda State were reported to be the largest supplier of sugarcane.[75] It was also cultivated in Dhari, Damnagar and Kodinar *talukas* of Amreli District in the same State.[76] It is well known fact that the sugarcane crop requires copious irrigation facility with adequate manuring. It was reported that in State, the land was frequently manured and sometimes supplemented with castor cake. According to Irfan Habib, fish was used as manure in the sugarcane cultivation in south Gujarat[77] and in Konkan with coconut palms.[78] Most probably the coastal areas of the western India used fish manure as it was available in plenty. Farmers at Surat planted sugarcane with small fish called '*Gudgeons'* as they believed that without the fish, the canes would not produce good harvest.[79] After a through cultivation, planting of sugarcane was done either in the month of December or in March–April.[80] It was also grown as a dry crop in low–lying areas in Visnagar and Mehsana *talukas* in Kadi District of Baroda State.[81]

The second largest princely state of India was fortunate to have enlightened Diwan named T. Madhavrao (1875-83) and dynamic Maharaja Sayajirao Gaekwad III (1881-1939). A number of initiatives were taken by diwan and later on these were carried further during the rule of Maharaja when he came to power. He not only encouraged the cultivation of sugarcane on extensive scale in State territories but also patronised its manufacture of finished products by hiring experts. In the same direction, iron cane crusher instruments were introduced which was an improvement

[75] *Gazetteer of Baroda State (*1923), Vol. I, 294.
[76] *Ibid.*
[77] Irfan Habib (2008), *A People History of India: Technology in Medieval India, c. 650-1750,* 5.
[78] *Ibid.*, 26.
[79] Cf. V. A. Janaki (1974), *Some Aspects of the Historical Geography of Surat*, 13.
[80] *Gazetteer of Baroda State (*1923), 294.
[81] *Ibid.*

over the old wooden ones.[82] It was also reported that significant improvement had also been made in the furnaces to economise the fuel.[83]

The State further took effective measures to control the crops against the possible attacks from the pests. Stem Borers[84] and Aphides were most troublesome for damaging the cane crops. To increase the yield of canes, the State purchased ammonium sulphate, artificial chemical manure, etc. It was reported that the artificial manure was used by the farmer in Vayra *taluka*.[85] Pumpkins, cucumber, onions and other vegetables were grown along with cane to provide shelter and as manure to sugarcane. Even maize, *guvar*, *val*, *bhindi* were cultivated in the cane field.[86]

Experiments for Sugar Manufacture in Baroda State

Maharaja Sayajirao Gaekwad III took various measures to improve the manufacture of sugar by establishing sugar mills in his territory. Mr. P. S. Melbill, Resident to Baroda State was consulted on this matter. Raoji Vittal was Sayajirao agent and he was entrusted with the task of supervising the whole process of manufacture of sugar. Mr. Melbill was requested to suggest necessary steps regarding sugar production and financial assistance was provided for the experiments. T. Madhavrao even abolished sugar monopoly in the State to encourage private participation in this field.[87]

Mr. Mebill discussed that the Bengal method of sugar manufacture process was different from the northern India method. The cane juice instead of being boiled to the consistency of *gool* was only boiled to tenacious syrup and this syrup was clarified by the action of regrettable heat. This process was not used in Baroda and

[82] *Ibid*.
[83] *Ibid.*
[84] The use of maize as trap plant between sugarcane was believed to control the attack of sugarcane borer. But latest researches at Imperial Agricultural Institute, Pusa in the first quarter of the 20th century identified that sugarcane borer was distinct and only attack sugarcane. The use of maize as trap crop would act as food to further increase their numbers. So it should be discarded. The remedy given was to plant the cane one or two months early as chances of borer breeding will be disturbed or minimize and the cane could escape the attack. See Ramrao S. Kasargode (1920), "The Sugarcane Borer and Its Control", *Bulletin No. 94 of 1919*, Department of Agriculture, Bombay, 1, 10.
[85] *Gazetteer of Baroda State (*1923), Vol. I, 294.
[86] George Watt (1897), *A Dictionary of the Economic Products of India*, Vol. VI, Pt. II, 217.
[87] "Correspondences Regarding the Manufacture of Sugar" (1876-88), *Huzur* Political Office, Baroda Record Office, Baroda, 49.

hence it was ruled out. Mr. Mebill suggested that the adoption of the northern Indian practice for sugar manufacture could be of great help. He also gave many valuable suggestions regarding the manufacture of sugar.[88] After much deliberation, it was decided to employ three parties from the north India who were known for their skills in sugar making.

Three parties were expert in this field and these were thus consulted:[89]

- Bishan Singh, Rup Singh and Jivan Singh of 22nd Regiment from Punjab
- Durga and Bhagwan Halwai from Benaras (present Varanasi)
- Govind Singh and Nashan Singh from Jalandhar

A sugarcane field in Makarpura, a place in central Baroda was provided to Bishan Singh's party to conduct experiments. They observed that *gool* made by the people was watery and pronounced not suitable to use.[90] They were provided with another field on 20th March, 1876. Here, the cultivators prepared good quality of *gool* and all the cane sugar juice extracted from the sugarcane was handed over to Bishan Singh's party who in turn converted it into *rab* at the mill. Sayajirao's agent Raoji Vittal proposed to set a mill at government sugarcane field at Makarpura in order to enable Bishan Singh's party to further conduct experiments. They prepared *rab* but owing to inferior quality of sugarcane, *rab* was pronounced not good for the making of sugar. In this regard, another field was purchased in Masana village and they commenced with their work. They observed that sugarcane juice prepared was of best quality. It was ascertained that the owner of the field prepared two *maund* of *gool* at each operation. *Gool* prepared was of good quality and it was converted into syrup and was put into *khanchee* (sugar pit).The clarifying operation commenced. But they failed to convert it into refined sugar. They made sugar like but were not able to refine it into proper order. Unfortunately, they were called back as their leave duty expired. The half-finished task was handed over to Jalandhar's party.[91] Jalandhar's party reported on 24th March, 1876 and came with many valuable

[88] *Ibid.*, 37-38.
[89] *Ibid.*, 21-24.
[90] *Ibid.*, 83-85.
[91] *Ibid.*, 105-19.

specimens from Punjab.[92] Owing to upcoming monsoon, they proposed to postpone the experiments.[93] By the end of monsoon, they commenced with their work. They prepared excellent quality of *rab* at the field near the limits of village Suma. This *rab* was put into the *khanchee* and good quality of sugar was made, but the quantity obtained was very less. The reason given by them was that large quantity of syrup escaped and the ground in the *khanchee* absorbed syrup. The Jalandhar's party prepared *boora*, *khand*, sugar candy, *butassa* from the syrup.

The Benaras's party knew refining sugar from *rab* but they had never made *rab* directly from the sugarcane. They were also not well acquainted with the making of *rab* as observed later. So, they were provided with *gool*. They converted it into *rab* but complained that *rab* prepared was pronounced not good for making sugar. They prepared very less quantity of sugar in comparison to the other parties. They proposed to make sugar candy from the syrup.[94]

Diwan Sir T. Madhavrao requested these parties to furnish with detailed account regarding experiments so that price could be determined of refined sugar. Bishan Singh's party made twenty five *maunds* and seven *seers* of sugar; Jalandhar's party made twenty two *maunds* and nine *seers* and Benaras's party made only six *maunds* and thirty five *seers* from the given quantity of sugarcane juice.[95] A comparison was made with the local price of *rab*.[96] After a through observation and calculation, it was noticed that these experiments could be successful if prices of refined sugar would be cheaper than the existing prices. In these experiments, about 10 % of sugar was obtained from one *maund* of *rab*. By calculation, it was estimated that if 20% of sugar could be manufactured from one *maund* of *rab*, it would be economical.

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[92] *Ibid.*, 13.
[93] Sugar refining process depends on the prevailing weather condition which can affect both the cane and the manufacturing process. Excessive rains would damage the crop and dampen the sugar produced. A deficient rainfall, apart from affecting the crop, would also create a serious shortage of the aquatic weed called *siwar*, an important accessory in the manufacturing process. See Shahid Amin (1984), *Sugarcane and Sugar in Gorakhpur: An Industry into Peasant Production for Capitalist Enterprises in Colonial India*, New Delhi: OUP, 17.
[94] "Correspondences Regarding the Manufacture of Sugar" (1876-88), 55-61.
[95] *Ibid.*, 116.
[96] *Ibid.*, 93.

Raoji Vittal observed that majority of these experiments was conducted on red sugarcane. He suggested for conducting further experiments in Navsari would be beneficial as peasants' cultivated white sugarcane in large quantities.[97]

To promote sugar manufacture, three sugarcane-pressing mills were purchased by Baroda State. Mills were placed at Gandevi[98], Baroda and Amreli. Detailed reports with samples of sugar manufactured were sent to Prof. E. Kinch, Royal Agriculture College, Cirencester, England and to Dr. Brandes, Gottingen, Germany for analysis and suggestions.[99] A detailed summary of process used in the manufacture of sugar was also prepared. (**see Appendix No. II**)

Exotic Sugarcane Plants Introduced in Gujarat: Partial Success

Exotic sugarcanes were introduced in British Gujarat from Mauritius, Java, Cuba, Havana and other parts of the world. Some of these gradually accepted by the cultivators. For example, Mauritius strain over the period of time was accepted by the farmers.[100] In Surat, Mauritius canes were planted.[101] Initially, when Mauritius sugarcane was introduced in Gujarat, its yield was low. It was ascertained that after about three to four years of its cultivation, the yield would improve.[102]

The various varieties of canes which were tried at Amalsad Farm, Surat, *Bandya* cane was found most suitable in terms of its yield. Unfortunately, it was not accepted by the cultivators because it was considered hard for extracting juice.[103]

Castor seed oil was used for lighting lamp and its refuse was used as manure for sugarcane.[104] The white or Mauritius cane was introduced in 1834-35 required

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[97] *Ibid.*, 116-18.
[98] In the Bombay Presidency, sugar factories were opened at Poona and Gandevi of Baroda (March, 1887). The latter was established in a sugar growing tract of about 1,200 acres. The construction cost was about 2½ lakhs of rupees. It failed owing to short working season and high price fetched by jaggery as compared to sugar. The average out-turn of jaggery per acre in Gandevi was two tons per acre, which the yield of sugar was 3/5 to 4/5 only. See George Watt (1897), *A Dictionary of the Economic Products of India*, Vol. VI, Pt. II, 214.
[99] "Correspondences Regarding the Manufacture of Sugar" (1876-88), 263, 289-91.
[100] P. R. Mehta (1905), *The Elements of Agriculture of the Bombay Presidency*, Bombay: DPI, 80.
[101] *Ibid*.
[102] *Ibid*.
[103] *Annual Report of Department of Agriculture of the Bombay Presidency* (1919-20), 39.

more water and it was prone to attack from jackals.[105] But its greater quality and quantity made it popular.[106] Colonel Sleeman was known for the introduction of foreign canes into the western India. Framjee Oowsjee Esq., Mr. Sundt and Hurrybhai Omerashankur, *Mamlatdar* of Chowrasee *taluka* of Surat were leading spirits in Gujarat for Mauritius cane cultivation.[107] The edible cane of soft pulpy stem of high percentage of crystallisable sugar was delicate and liable to be attacked by white ants, easily injured by winds and prey to the pilfering proclivities of the people and not good for *gur* making. Therefore, natives preferred small staples with hard bark which could withstand white ants, jackals, winds, severe drought, inundation, swampy soils and high temperature.[108] *Suran* and groundnuts crops were cultivated along with canes to discourage the attacks of animals, but these were not able to solve the problem. Shooting of pigs and jackals in Surat for sugarcane was not enough. Mr. T. N. Jhaveri, Entomological Assistant adopted poisoning method and convinced the villages who gradually started using it. In the process, pigs were killed when they consumed the poison.[109]

Like cotton, sugarcane was also attacked by pests. The use of maize crop as a trap crop to minimise the attack on sugarcane bears evidence to the belief that the borer in maize, sugarcane and *jowar* were identical and that maize was preferred to other's among the food plants.[110] Latest researches in the first half of the 20th century at Pusa identified that the borer of sugarcane was not common and was different.[111] One of the probable remedy suggested was early planting of sugarcane decreased the amount of attack from the very beginning; and once the tilling period was over the cane could be considered free from any chance of attack. Canes planted in January or early in December were more likely to escape attack then cane planted in March or April. Secondly, maize or *jowar* could be used in rotation with cane. But it could not

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[104] *GBP* (1883), *Baroda*, 91.
[105] *GBP* (1877), *Surat and Broach*, 66.
[106] *Ibid.*, 66.
[107] George Watt (1897), *A Dictionary of the Economic Products of India*, Vol. VI, Pt. II, 42, 82-83.
[108] *Ibid*.
[109] *Annual Report of Department of Agriculture of the Bombay Presidency* (1920-21), 63-64.
[110] Ramrao S. Kasargode (1920), "The Sugarcane Borer and Its Control, 2.
[111] *Ibid*.

be considered as an effective measure to control the infection of cane from borer as it was different from borer of maize or *jowar*.[112]

Dr. Voelcker Suggestions about the Improvement of Sugarcane and Its Manufacture

Dr. Voelcker who was expert in agriculture in England was appointed by the Government of India (GOI) to suggest about the improvement of Indian agriculture with suggestions. In the process, he arrived in India in 10th December, 1899 and he toured number of regions. In the western India, he visited Ahmedabad, Nadiad, Baroda, Mahim, Bombay, Poona, etc.[113]

Voelcker suggested: "Mauritius system of cane cultivation to be used to increase its yield. The Mauritius system is to place the cutting in holes about nine inch deep, placed away rowed 3½-4 feet apart or else to lay the cane along channels or furrows in the bottom of which the manure is put and the about it. The 'Hole System' is mostly used on undulating ground, but the 'Furrow System' is one of the best wherever irrigation was required. Thus, the furrow system is best suited to India. If the plan of sowing the seed-cane in furrows is to entirely replace that of simply leveling the ground and sowing the cane broadcast over the field, a very much increased yield of sugar will be the result. About precaution taken at the time of cutting of canes, he warns about the harm of early cane cutting; the saccharine juices will be less; some sugar will be transformed into fibre and other constituents. In some parts of India, the cane, instead of being freshly planted each year is allowed to stand over for a second, third or even later season and is called 'Ratoon' cane".[114]

Voelcker also commented about the utensils used for sugar manufacture. According to him: "Tin vessel shall be used in place of earthen vessels. It can be purified by burning sulphur to keep it clean and sweet. The porous earthenware pots soakes juice and made it sour. Washing will not remove this and the vessel is never

[112] *Ibid.,* 10.
[113] *Voelcker Report on Indian Agriculture* (1897), 2nd Edn, 432.
[114] *Ibid*., 243, 249.

sweet, the consequence is that, when the juice is put into the vessel, the acidifying process is quickly set up and a certain amount of crystallisable sugar is lost".[115]

Sugar factory was established at Baroda (present Vadodara) and Poona (present Pune) in the last quarter of the 20th century. Both of these did not bear the desired results.[116] For the limited success of factory system in Poona and Baroda, he enumerated the following reasons: "Cane does not receive adequate manure; uneven rainfall; virtual absence of canals and even if it exists its water distribution was not proper; it is cultivated on small patches; its transport to factory is a troublesome task; working season in India is only seventy five days, only few of the factories are allowed to make rum from the molasses; and the prohibition when exercises, destroys the profit of refining. In 1889-90, nine million rupees of sugar is imported from Mauritius while nine million rupees worth unrefined sugar is exported chiefly from Madras. The western region is getting maximum import of sugar. The data clearly establishes that the Bombay Presidency in general and Gujarat in particular is lagging behind the other two Presidencies in terms of its production and export".[117]

R. G. Padhye who was expert in sugar was sent to various countries to study the manufacture process of sugar by the Government of India with suggestions. He made a critical appraisal about the failure of factory system for its manufacture in India. In Java, Cuba, Mauritius, canes were raised on plantation basis. In India, cane was cultivated individually and not on plantation basis. Therefore, sugar factories depended on the supply of cane from farmers, and many of these farmers refused to sell it because they could still make profit by selling *gur* in the market. *Gur* was cheaper and required less fuel. It was not market oriented, and therefore, its price was stable. On the other hand, sugar price was fluctuated according to the world market.[118]

[115] *Ibid*., 250.
[116] *Ibid*., 251.
[117] *Ibid*., 251-52.
[118] R. G. Padhye (1924), "Sugar Industry in Western India and Methods of Sugar Manufacture", *Bulletin No. 116*, Department of Agriculture, Bombay, 13, 15.

According to him: "The chief cause of low efficiency of Indian factories is absence of chemical control. Under this system, it is included the account of every pound of sucrose that entered the factory in the form of cane, and it predicts how much of it is lost in bagasse, filter press in evaporation, crystallisation and so on".[119] He further observes: "It is a general misconception that Excise Department policy regarding the manufacture of rum in the sugar industry is hampering its growth. For making rum, one needs molasses rich in sucrose and in turn; the sugar production will increase. The best thing is to extract as much sugar out of molasses. Most of the sugar refineries of the world who manufactured rum are closed".[120]

Sugar beets were tried as an alternative of canes in the first half of the 20th century. Beet industry was known for sugar production in the European countries. But in India, it did not receive the attention of the cultivators. Different varieties of sugar beets namely French Vilmorine A&B, American and refined Sutton were tried.[121] The results obtained could not draw the attention of the cultivators.[122]

Tobacco

Tobacco was prominently grown in *Charotar* tract of Kaira District.[123] The two chief varieties were *talabdi* or local strain and *khandeshi* from Khandesh region. Former grew even in poor soil and it required less manure; latter demanded more manure and good soil but one advantage was that it needed less water.[124]

Charotar region in Kaira District was known as garden of the western India because of its fertility of soil and abundant supply of water from the wells. But decreasing water level during the first half of the 20th century led to the abandonment of many crops. Tobacco had gained supremacy in this situation, as it needed little irrigation and had a high market value.[125] Further, wells in the region contained

[119] *Ibid.*, 29.
[120] *Ibid.*, 201-02, 208-09.
[121] *Annual Report of Department of Agriculture of the Bombay Presidency* (1920-21), 58.
[122] *Ibid*.
[123] *GBP* (1879), *Kaira and Panch Mahals*, 48.
[124] *Ibid*.
[125] Harold H. Mann, M. L. Patel and V. M. Majmudar (1926), "The Improvement of Tobacco in Northern Gujarat", *Bulletin No. 132 of 1926*, Department of Agriculture, Bombay, 1.

essential nutrient necessary for the better yield of tobacco plant.[126] Earlier, it was grown only in 3% of the cropped area; but its cultivation gradually increased in the region because it fulfilled twin demands.[127] Being a cash crop, it enabled the farmers to pay high land revenue; and secondly, Britishers were eager for its cultivation for international demands.[128] It was chiefly grown in Anand, Borsad, Matar[129] and Nadiad[130] *talukas* of Kaira District. From the table given below one can compute that roughly two fold increase of the tobacco yield in the below mentioned areas.

Increase in Tobacco Yield in Kaira District:

Name of *Taluka*	**1876-77**	**1886-87**
Nadiad *Taluka*	3,620 acres	8,880 acres
Borsad *Taluka*	4,260 acres	7,400 acres
Matar *Taluka*	600 acres	1,160 acres (up to 1892)

Source: Crispan Bates (1981), "The Nature of Social Change in Rural Gujarat: The Kheda District, 1818-1918", *MAS*, 15 (4), 789-90.

Soil and Method of Tobacco Cultivation

Tobacco was cultivated on *goradu* soil (alluvial soil) above flood level or near riverbeds. The soil in *Charotar* villages contained large percentages of potash, phosphoric acid with little proportion of nitrogen which was very important for the tobacco plant yield and its good taste.[131]

Following information is available in Harold H. Mann, M. L. Patel and V. M. Majmudar (1926), "The Improvement of Tobacco in Northern Gujarat", *Bulletin No. 132 of 1926*, Department of Agriculture, Bombay about the methods to prepare

[126] *Ibid.*, 2.
[127] *Ibid.*, 1.
[128] *Ibid.*, 1-2.
[129] Crispan Bates (1981), "The Nature of Social Change in Rural Gujarat: The Kheda District, 1818-1918", *MAS*, 15 (4),790-91.
[130] In Nadiad, trials for tobacco cultivation began as early as 1862. Attempts were made to produce crops suitable to the European market. Planters and curers from Madras were employed as well as specialists from Germany. The experiments undertaken in the 1880s alone cost Rs.1,20,000. See Cathy Chua (1986), "Development of Capitalism in Indian Agriculture: Gujarat, 1800-1900", *EPW*, 21 (48), 2098.
[131] Harold H. Mann, M. L. Patel and V. M. Majmudar (1926), "The Improvement of Tobacco in Northern Gujarat", 2.

seedbeds, methods used in the cultivation and some of the varieties of tobacco plants in Kaira District. According to the Report:[132]

> The seedbeds were made on high-level ground and under tree shade to protect the young seedlings from direct sunlight. These beds were constantly manured. Great care was taken if beds were irrigated with artificial means to avoid the decay of the seedlings. The matured seedlings were sown in the next field which was ploughed and manured. It was reported that a tool known as *samer* (flat plank) was employed to compress the soil to ensure a firm bed. The first two hoeing were done by hand at intervals of a week followed by the bullock blade-hoe. Irrigation was done through the wells. It was also reported that some of the wells contained considerable amount of nitrates in water which was considered boon for the tobacco plants. When the flowering shoot appeared, it was nipped off and at the same time, all plants were nipped off leaving about sixteen leaves. Suckers which begun to form after this time were removed once every week. The plants were ready by the months of January and March. Before the leaves were removed, the colour of the leaf should be golden brownish spots, while the leaf tips show the signs of drying. *Gandiu* and *piliu* were the most important variety of tobacco crop. It was reported that *gandiu* was local staple and *piliu* was of *Khandeshi* origin. As per the estimate, *gandiu* occupied at least 50% of the area under the crop. It had a large, broad, coarse, thick leaf giving strong tobacco. *Piliu* was grown in Petlad *taluka* (Baroda State) and parts of the Borsad *taluka*. It had narrow and short leaf in comparison to *gandiu*. *Kaliu*, *movadiu* and *shengui* were the other tobacco crops. The soil in *Charotar* villages contained large percentages of potash, phosphoric acid with little proportion of nitrogen which was considered as the main reason for the good yield and taste of the tobacco plants.

Experiments Regarding the Improvement of Tobacco

Steps regarding the improvement of tobacco were carried out according to the European demands for cigarettes manufacture. The local varieties grown in Kaira were unsuitable to the western demands because of it being very strong, thick, coarse and the leaves were objectionable because of the large amount of stalk in the leaves. Therefore, it had no markets in the European countries. However, these indigenous cultivated tobacco varieties were used by the natives for *bidi* and *hookah* smoking, and as snuff for chewing. It was much in demand in the local markets. Therefore, it cannot be justified to conclude that local varieties were useless from the western market point of view.

Early attempts to improve the quality of tobacco grown in *Charotar* were taken in view to suit the foreign demands for cigarette manufacture. The methods used for this purpose was to cultivate imported exotic seeds of desirable quality and modification of the curing process of tobacco leaves. Experiments were started from

[132] *Ibid.*, 2-6.

1865 when Shiraz and Madras seeds were introduced for cultivation. Shiraz seed was pronounced superior with fine flavour. Madras seed was discarded because it was brittle and unsuited to the European markets. The natives were also instrumental in the improvement of tobacco and it was reported that required resources were collected on their own effort. Government was also aware about the importance of the natives and every support was assured to them. Though assistance was provided from the government, lead for tobacco improvement was taken by late Rao Bahadur Sardar Bechardas Desai of Nadiad. An association of natives in the sub-region was established. It was reported that they were indulged in the introduction and use of different kinds of foreign tobacco. An improved method of curing was also executed for the improvement of tobacco plants. The money received for this association was totally a local effort. Rao Bahadur Sardar Bechardas Desai opened an experimental station and curing sheds were erected. He also sought the service of foreign experts. It was further reported that these experts were appointed and maintained for a series of years, a factory for cigarettes and smoking mixtures were also opened.[133]

During this period, Havana, Sumatra, American, Madras, etc., varieties were tried. Most of these plants grew well and cured with the assistance of expert curers. Unfortunately, the cured tobacco did not meet the approval of the foreign market because of ignorance of principles of scientific curing. In 1920-26, a new government farm was established at Nadiad for tobacco study and a large curing house was erected. However, the farm did some work on manure and methods of cultivation of tobacco; nothing was done regarding the production and curing of better tobacco than that locally grown. However, the increasing demand of tobacco forced the government to take some serious steps. It was decided to continue with experiments on indigenous tobacco staples. The trials of foreign seeds were placed in a secondary position.[134]

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[133] *Ibid.*, 7-8. Bechardas Veharidas Desai had applied for 500 acres in *Mal* area (excluding *Charotar* tract) but the government provided him with special conditions under which he was asked to take over 1,200 acres for tobacco cultivation and agricultural experiments. See Vinayak Chaturvedi (2007), *Peasant Pasts: History and Memory in Western India*, New Delhi: Permanent Black, 37.

[134] Harold H. Mann, M. L. Patel and V. M. Majmudar (1926), "The Improvement of Tobacco in Northern Gujarat", 8.

Experiments on Local Types of Tobacco

The limited results received from the trials with exotic seeds, it was decided to experiment on the local staples. Different staples of local varieties were collected. Only those tobacco plants were selected which had the most desirable characters. These were propagated under condition of strict self-fertilisation in each generation. The process was hazardous and time consuming as they tried to obtain the purest local strain of tobacco. After three years of continued process, government was able to obtain purer strains of local varieties with desirable characters. Improved variety of *gandiu* was named 'No. 6 *gandiu'*. Very shortly, it was reported that it gained wide acceptance among the people and was in great demand.[135] The advantages which established it as a favourite crop was its high yield with quality, indifference to frost and the lower cost of growing owing to the small numbers of suckers.

Improvement in Growing the Tobacco Crop

Regarding the improvement of tobacco crop cultivation, it was decided to improve the seed quality. The results showed that seed from the suitable plant was 23½% lower in germination in comparison to those plants which were specially kept for production.[136] In America and Europe, it was common practice to separate the heavy seeds from lighter ones and used the former. *Charotar* tobacco cultivators did not practice this activity.[137]

Tobacco was an exhausting crop and it needed heavy manure.[138] Use of *sun* hemp and castor cake in partial replacement of farmyard manure gave better results and there was no fear of lowering of its quality, a common belief among the peasants.[139]

The high quality *kalia* tobacco was sent by rail to the markets of Ahmedabad, Borsad, Broach, Surat and Bombay and the lower quality *jurdo* was collected by

[135] *Ibid.*, 9-11.
[136] *Ibid.*, 14.
[137] *Ibid*.
[138] *Ibid.*, 19.
[139] *Ibid*.

dealers for transmission to Malwa and Marwar via the town of Kapadvanj.[140] Furthermore, the opening of the branch line to Ratlam meant that large quantities of cheap tobacco began to be consumed by *Bhils*, *Naikas* and the other poorer sections of Panch Mahals.[141] It was even exported from Cambay port to countries as distant as Arabia and Turkey.[142] Kaira also benefited as it was joined by railway with Ahmedabad, Delhi route and Cambay.[143]

Baroda State also experimented in the improvement of tobacco. It was reported that Petlad in Baroda State was noted for producing superior quality of tobacco. But insufficient knowledge about the curing and dressing of the tobacco leaf, the output was not very promosing. Rao Bahadur Vinayakrav Janardhan Kirtane, *Naib Diwan* was entrusted with the task to introduce improvement about tocacco cultivation.[144] However, details are not provided in the available archival records.

Curing and Manufacture of Tobacco

According to Voelcker: "Curing of tobacco as conducted by the natives is done in a very primitive way. The leaves are not removed one by one when ready for picking, but after a few spots have begun to appear on the lower leaves, the entire plant is cut off close to the ground, and is left exposed to the night dew. Next day, the plants are arranged in small circular heaps, about two feet high, with the stalks outwards. At the close of the day, the heaps are opened, and the leaves are spread out for the night. The next day, these are heaped again, and after about five days they begun to turn yellow. The plants are hung upon horizontal poles for fifteen to twenty days, the stalks being pressed close to each other. After this, the leaves are again packed in square heaps, and these heaps are opened are re-packed every two or three days. The leaves finally become blackish. This blackening is a sign of fermentation being finished, and the leaves are then stripped off the stalk and are tied up in

[140] Crispin Bates (1981), "The Nature of Social Change in Rural Gujarat: The Kheda District, 1818-1918", 790-91.
[141] *Ibid*., 791.
[142] *Ibid.*
[143] *Ibid*.
[144] *GBP* (1883), *Baroda*, 90.

bundles and baled. Often, crude molasses (jaggery) and water are sprinkled on the leaves after fermentation is over".[145]

Tobacco was prepared in two ways for the purpose of smoking and chewing. *Kalio* was chiefly used for smoking. The stem of *kalio* was cut from the base and it was then dried in the sun. The thick stalks were cut from the middle for drying. Dried plants were sent to the curing shed. In the shed, leaves were sorted. The lower and the small upper leaves were placed in one heap and middle leaves in another. Next, the leaves of each heap were kept in small bundles called *padas*. The bundles were piled up and left for three days to ferment. Fermenting was repeated from four to six times.[146] Great care and attention were required at the time of fermentation to obtain good quality of tobacco.

To manufacture *jardo* tobacco, the leaves were taken off along with stems by means of a crooked knife called *kariyu*. Leaves were then exposed to sun and these were sorted into better and poorer kinds and made into *padas*. Fermentation was the next step. The bundles were ready for sale as *jardo*. *Jardo* was used for smoking as well as for chewing. *Kalio* was another variety used for chewing. *Jardo* tobacco was also used for smoking in cigarettes, *bidi* and in small pipes. Snuff was also prepared from *jardo*.[147]

Tobacco Pests Control Measures

The tobacco plant had a great enemy in *Orobanche nitotiana* or '*Bodu*' a vegetable parasite which grew out from the root-stock of the plant.[148] It attacked weak plants and propagated on poor rather than on rich soil. The only way to effectually remove it was to detach the tobacco plant before the seeding of the parasite had begun. Through hoeing of the land and careful cultivation was said to keep it's germination under control.[149] Another such insect was caterpillar. These were searched every night and morning to control their damage to the leaves. One

[145] *Voelcker Report on Indian Agriculture* (1897), 271.
[146] *GBP* (1879), *Kaira and Panch Mahals*, 49-50.
[147] *Ibid.*, 50.
[148] *Voelcker Report on Indian Agriculture* (1897), 272.
[149] *Ibid*.

worm attacked the root and withers the plant, bringing on the disease called *chith*; another worm, eating into the stem and joints, stopped the growth and brings on the disease called *ganthor*.[150] Prolonged dry season led to another disease called *chanhdi* with spots on the leaves. Damp climate caused white coating called *charu*. Frost could cause blight to whole crop.[151]

Nadiad Agricultural Farm was established in 1878 under the supervision of the Agriculture Association.[152] For the said purpose, an agriculture class was attached to the Nadiad High School. Manorial experiments were conducted to increase the yield of tobacco.[153]

Tobacco stimulated two other industries namely metal ware and pottery. The two principal means of smoking tobacco were the *hookah* and the *chilam*. The *hookah* is an elaborate contraption in three parts. One is the metal bowl which acts as the tobacco burner and parches atop the steam connecting it with parts, a metal bowl filled with water. Finally, there is stiff or flexible tubing, surmounted with a mouth piece through which the smoke is drawn from the top bowl and through the water container. The aristocrats fancied highly-worked and decorated metal bowls and water-containers which provided employment for the hundreds of metal workers. The aristocracy also sported decorated metal boxes which held the tobacco plugs in satisfactory moisture. These became additional items for the metal and jewelry workers to manufacture.[154] The poorer folk used burners and water-bowls of clay from which the more plebian *chilimo* was also made. The *chilim* was a short pipe with a tapering cylindrical body with a narrow mouth piece which was covered with a cloth while smoking. Thousands of such *chilims* provided an additional business to the potters.[155]

[150] *GBP* (1879), *Kaira and Panch Mahals*, 49.
[151] *Ibid*.
[152] *Voelcker Report on Indian Agriculture* (1897), 368.
[153] *Ibid*.
[154] B. G. Gokhale (1974), "Tobacco in 17th Century India", 491-92.
[155] *Ibid*.

Opium

Opium was prepared from *Papaver somniferum*.[156] According to the observations of Nathan Allen, some tracts of India were known for opium cultivation on an extensive scale in alluvial plains in the Ganga River and rich plain of the central India. The mild climate, rich soil, plentiful irrigation and hardworking peasants were added advantage for its cultivation in India. Men and women were employed for poppy farming. The process was very simple. Field should be finely ploughed and made completely free of weeds. The fields were fenced and divided into squares by the means of small dikes. The requisite amount of water should be made available. The field required frequent removal of weeds. The seed of poppy was sown in November; and during a period of about six weeks in February and March, the juice was then collected. He further mentions the method of obtaining juice.[157]

The falling of the flowers from the plant was signal for making incisions, which was done by the farmers with hooked knives in a circular manner around the capsules. From these incisions a white milky juice was exuded, which was concentrated into a dark brown mass by the heat of the sun; and this being scraped off every evening as the plant continued to exude. This was crude opium. To prepare opium for China market, watery extract obtained during incision were dried. It was considered best in terms of purity and strength of flavour.

Opium Plant Cultivation in Baroda State

Gazetteer of the Bombay Presidency, *Baroda*[158] provides the following information about the cultivation of opium. *Bajri* was cultivated before opium on the land which enabled the land with enrichment of essential nutrients. The opium seed was sown with broadcast method and earth turned down by an implement called *khandi*. Care should be taken regarding seeds. It should be a year old and not damp. Frequent irrigation was needed at least seven times. The poppy heals were considered ready for scarification when they presented a coating of a light brown

[156] Nathan Allen (1853), *The Opium Trade Including a Sketch of Its History, Extent, Effect, Etc., as Carried on in India and China*, 6.
[157] *Ibid*., 6-8.
[158] *GBP* (1883), *Baroda*, 97-98.

colour and did not yield easily to the touch. The process of scarification commenced in February and March. *Nareni* was an iron instrument consisting of three blades, each somewhat similar to a straight pointed lancet, tied together in a line, 1/8th of an inch apart, and wrapped up so as to have only the points; protruding was used to made incisions. Incisions were made from the bottom to the top, each incision took shape in three lines. The another instrument called *kharpo,* for scrapping the juice was a two-inch square iron tray with three sides turned up and one left open to act as a blade and was fixed to a wooden handle. The blade was oiled before it was applied to the capsule. The juice was removed from the *kharpo* into a brass basin already oiled. Everyday's collection was stored in pots.

Opium Manufacture

Gazetteer of the Bombay Presidency, Baroda provides us information of market ready opium, labour involved and skills required.[159] The collected juice was ready for opium manufacture. This method involved the collection of juice. A copper vessel (*parat*) was required in which fine bags of juice were empties and the whole was kneaded into one mass by a man who treaded on it. Following steps were taken to manufacture finished opium: "Close by the vessel and in a line with it, were three copper sheets, on opposite sides of each of which sit two men. As the process of kneading went on, the first couple took a small quantity of juice from *parat*, mix it well on the sheet, and then pass it on to the next sheet, to be mixed by the second set, and so to the third for the same purpose. From the third sheet, it was removed into a copper dish. When the dish hold 30-40 lbs., it was replaced by an empty one, and the juice was taken about seven or eight minutes; but when the *hamals* as these were called; warm to their work only half that time was consumed. Most of these eat *mahjam* and under its effect the work was exciting. The room in which the opium was caked and left to dry was spread with a layer of poppy leaves, six inches deep. During caking time, three to five men work in this room, first one to make up the opium into cakes, second one to give them a coating of *rabba*, and the last to place the finished cakes on the layer. All the caking was done manually. A good caker would manufacture six to eight hundred cakes a day. Three *champnis* or pressing were gone through with an object to give the cake a complete spherical form and to

[159] *Ibid.*, 99-100.

make the outer coating firm and smooth. The first *champni* was done twenty days after the caking and the other two follow at intervals of twenty five days. The finished cakes were ready for export. The same process was executed in manufacturing opium for local use".[160]

A Rajput from Rahuri from Sidhpur in Gujarat obtained seeds from Malwa and tried for its successful cultivation.[161] But his experiment was not very successful. Another person named Brahmanveda (*Kunbi*) successfully spread the cultivation of opium in Baroda.[162]

Poppy seeds were exported to Belgium, France and Britain to be used as oil and as an article of food.[163] It had also medicinal value and was used as a prophylactic against malarial fever. Many of the Fishermen swallowed opium pills before entering into water which enabled them to work hard in water.[164]

Various Processes to Maintain the Soil Fertility

Skills of *Gujarati* farmers were appreciated by number of colonial authorities like Alexander Walker, Voelcker, etc. They were impressed by various technique employed by these cultivators to maintain the fertility of the soil.

The agricultural productivity in Gujarat was not uniform and it differed from area to area. Colonel Walker mentions that the agricultural productivity of Gujarat was in a prosperous state in comparison to that of Bengal.[165] He called the farmers hard working and appreciated the knowledge of various methods of crops cultivation; seed germination; growth in yield by maintaining fertility through leaving arable lands fallow periodically and brought rotation of crops in use. Another step in the

[160] *Ibid.*
[161] *Ibid.*, 100.
[162] *Ibid*.
[163] G. Graham Dixon (1922), *The Truth About Indian Opium*, 5.
[164] *Ibid.*, 1.
[165] Alexander Walker, "Indian Agriculture", in Dharampal (1971), *Indian Science and Technology in the Eighteenth Century:* S*ome Contemporary European Accounts*, 190.

process involved the fencing of the field. While fencing the square shape was preferred and these were kept neat, tidy and frequently maintained.[166]

Colonel Walker refers to the following observations about the superior skills of the cultivators of Gujarat. According to him, "peasants of Gujarat learnt careful and skilful agriculture through constant practice since antiquity".[167] Peasant of Gujarat was in no way lagging behind the European agriculturist in terms of skills. It may be possible that Europeans had the impression that the methods employed by Gujarat's counterpart were primitive and non-scientific. But it should not be ignored that the farmers of the Gujarat region were efficient because they acquired skills through experience. Colonel Walker observes: "A native cultivator is often condemned for practising shallow ploughing. The native, however, knows from the experience that the soil at the surface which is well heated by the exposure to the sun requires light ploughing which yields the best return".[168]

He further observed that, "…the practice of keeping a portion of land as fallow to retain its fertility. Most soils in north Gujarat, lands are producing when kept continually from year to year under cultivation than when allowed to lie fallows, such soils however as improve by a year or two's respite, always receives it. This is not uncommon in Surat and even in Broach District..."[169] One should remember that even during the reign of Sher Shah Suri and Akbar, the practice of leaving the land uncultivated was in vogue. This was done for retaining the fertility and increasing the yield of crop.

In his report, Colonel Walker brings to our notice that agriculturists in Europe and America had different set of practice. For instance, in Britain farmers had command over manure, but the regular rotation did not improve the productivity of the lands, whereas in America, virgin or new lands were continuously cultivated for many years together to produce the same crop, without the assistance of

[166] *Ibid*.
[167] *Ibid.*, 198.
[168] *Ibid*.
[169] *Ibid.*, 199.

manure.[170] Similarly, in Lithuania there was a regular succession of the same crops and in West Indies cultivators constantly produced sugarcane on the same land.[171]

Rotation of Crops

Gujarati peasants were also known for their knowledge about crop rotation and advantages of mixed cropping of different plants. Say for example, cotton was followed by *jowar. Jowar* with fibrous roots and shallow feeder could survive on the top surface of the soil whilst cotton having long tap roots could penetrate deeper into the subsoil. By alternating deep rooted and shallow rooted plants, cultivation in the same field, the soil would contribute to the nourishment for both the plants. In the next step, wheat crop replaced *jowar* cultivation. It was a system of rotation based on two years of wheat and cotton. Wheat was also used as a cleaning crop for the third year on the same field which followed the cotton-*jowar* rotation process.[172] Further, if the land became foul, the usual two year cotton-*jawar* rotation was extended with *tal* and *tur* as a three year crop.[173] *Tur* was considered as a renovating crop.[174] It was a leguminous crop well known for nitrogen fixation in the soil.[175] Usage of its leaves as manure is also reported.[176]

The *Gujarati* cultivator was also aware of the nature of soil and could predict about where and when the rotation of crop was not fesible.. This is illustrated through the following information. The suitability of soil, climatic condition and irrigation facilities were the essential parameters which were required in the process of the rotation of crops. For instance, the tracts of retentive black soil in Gujarat which were subject to water logging grew only *rabi* crops or *jowar* or wheat. Rotation on such land was difficult. Similarly, on the light sandy soil adjoining the coastal regions, *bajri* was raised on the same fields in successive years as the soil could not grow cotton or *jowar*. *Kyaris* or rice beds were another instance in point. This produced only rice, for none of the other farm crops, if grown in rich beds,

[170] *Ibid.*, 191.
[171] *Ibid*.
[172] J. B. Shukla (1937), *Life and Labour in A Gujarat Taluka*, Bombay, 179.
[173] *Ibid.*, 180.
[174] *Ibid*.
[175] *Ibid*.
[176] *Ibid*.

would pay so well. *Val* was taken as a second crop in the *kyaris* to be assisted for the purpose of rotation. Another crop was used to control the salinity in the soil. *Val* was cultivated in rotation to bring salt to the surface so that rice could be cultivated in the same beds in the succeeding year.[177]

Different kinds of seeds were sown in the same field were kept separate by the judicious use of seed-drill, or they were mixed together and sown by the broadcast method. A plant called *sota gowar* was often sown broadcast with sugarcane in order to provide shelter to the sugarcane from the violent heat of the sun. Farmers also planted rye-grass and clover, with wheat, barley or oats, tares with rye, beans and peas, vetches, corn, etc. *Jowar* and *badgery* were cultivated together in the same field to be used as fodder for the animals. *Soondea*, *darrya joar*, *rateeja* and *goograjoar* were other crops grown in rotation.[178]

Advantages of the Mixed Cropping:[179]

- The practice would at least act as a safeguard to control the total failure of the produce.
- A sprinkling of pulses enabled the cultivator to have a variety of fresh vegetables for his household.
- It empowered the farmer to make a more economic use of his time, for all the crops did not ripen and became ready for harvest at the same time.
- Cereals were improved by the subordinate pulses. The latter, being leguminous crops, fixed nitrogen in the soil which were used for cereals crop.

Manures

Colonel Walker was also impressed by the skills used for the manufacture of manure which was made on a very simple basis. He refers to the following details about judicious use of manure:[180] "Cattle are provided with straw in order to increase the quality of the manure. Peasants collect leaves, putrescent substances, old grass and branches of trees and set these on fire. The ashes are then spread on the ground. It is also reported that the saline and bottoms of the tanks are dug up which are

[177] *Ibid.*, 180-81.
[178] *Ibid.*, 179-81; Alexander Walker, "Indian Agriculture", in Dharampal (1971), *Indian Science and Technology in the Eighteenth Century: Some Contemporary European Accounts*, 185, 187-88.
[179] J. B. Shukla (1937), *Life and Labour in A Gujarat Taluka*, 181.
[180] Alexander Walker, "Indian Agriculture", in Dharampal (1971), *Indian Science and Technology in the Eighteenth Century: Some Contemporary European Accounts*, 192-94.

considered valuable manure. The heat of the sun, natural and artificial moisture and the inundations of rivers keep the soil in India in a state of perpetual fecundity and renderes it fruitful year after year. The animals dung on the road and other places are collected by boys and girls to make cakes and are dried in the sun". He also reports about the usage of same practice in north England as well.

The following observation of Colonel Walker, therefore, shows the validity of the traditional mode of collection of plant and animal refuse for the making of natural manures. It can be apprehended that more or less the process used for manure making which was practiced by the peasants in India since antiquity was also applicable to Europe and Egypt.

Interesting Case of Nadiad Pit

At Nadiad, Mr. Becherdas Viharidas Desai, a *Patidar,* had a large masonry pit which was used for the manure manufacture from the animal refuse. The following arrangement made by him was opposed by the sanitary officers.[181] Voelcker during his tour in Gujarat was impressed by the skill employed by Becherdas Viharidas Desai for manure making through the natural process. Voelcker defended Becherdas Viharidas Desai case and was in favour of continuation of the urine pit. Animal urine from the adjoining areas flowed through channels to the pit. When it became dry it was used as excellent manure. It is notable that it was without foul odour. However, the sanitary authorities stopped this practice. Reasons are unknown. Collector of Kaira introduced a pass system to be renewed annually. But the permission to acquire this pass and complicated rules led to the decline of locally invented manure making through pits. Voelcker who was in favour of the natives was supported by T. R. Fernandez, Deputy Superintendent, Gujarat Revenue Survey to revoke the pass system. According to the 'Clause 5' under the pass system, it was mandatory that pit must be covered with coating of pure things. The word 'pure things' were confusing to be understood by the people. This jeopardy was often used by the municipality to harass the farmers. Further, according to the 'Clause 4', dust would be mixed with urine, but they should not dig the earth of pit areas. Owing to this rule, farmers had to carry dust from the far off areas. Cultivators were also

[181] *Voelcker Report on Indian Agriculture* (1897), 128-29.

experiencing difficulty as the mixing of dust prevented the process of fermentation. The case of Nadiad pit was important because it shows the inter-contradiction among the British authorities and highlights the innovativeness of the indigenous lot.[182]

Besides using pits for manure making, the dried out tanks could also be used for cultivation. The bottoms of tanks were converted into the rice fields. These dry bottoms still retained moisture; and enriched with the alluvial deposits would definitely led to production of abundant crop.[183] In Nadiad, the fields were surrounded by hedges growing on embankments. The following arrangement enabled the soil to soak rain water thoroughly. When in turn, the field required to be manured, the soil was thrown back from the hedge-side on to the field and soil was spread over it.[184]

Voelcker requested to the GOI to stop the export of oilseeds outside India.[185] These oilseeds residual cakes retained the fertility of soil as manure used by the peasants.[186] *The Royal Commission on Agriculture* (1928) refused to make any firm recommendation on this issue.[187]

Natural occurring lime was used as manure. It worked beneficially as a plant food, enabled clay land permeable to moisture and helped soil to absorb potash, ammonia and other salts. It was also required in the process of nitrification, by which nitrogenous components in the soil were made available for the plants use.[188]

The benefits of the natural made manure were based on harmonious relations established with the agricultural productivity with its ecology. It was procured locally from the dung of the animals, dropping of birds, refuse of plants, etc. It was cheap and its excessive use did not decrease the productivity of the land.

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[182] "Papers Relating to the *RRSS* of Nadiad *Taluka* of Kaira Collectorate" (1895), *SRBG*, No. 295, NS, 5-6; *Voelcker Report on Indian Agriculture* (1897), 128-29.
[183] Alexander Walker, "Indian Agriculture", in Dharampal (1971), *Indian Science and Technology in the Eighteenth Century: Some Contemporary European Accounts*, 195.
[184] *Voelcker Report on Indian Agriculture* (1897), 110-11.
[185] *Ibid*., 106.
[186] Irfan Habib (2010), *A People's History of India: Man and Environment, The Ecological History of India*, Vol. 20, AHS, New Delhi: Tulika Books, 27.
[187] *Ibid*.
[188] *Voelcker Report on Indian Agriculture* (1897), 49.

Chemical Manures

Chemicals manures made artificially were also tried by the farmers as the availability of the natural manure was limited.[189] It could be made in factories on a mass scale and proved cheaper in terms of its purchase. But it required a good deal of water for its proper functionality through artificial irrigation because of erratic nature of rainfall.[190]

Artificial manure could not be applied for cotton cultivation in the western India because of its affinity to great deal of water requirement. Black soil needed moderate requirement of rainfall otherwise soil would become cohesive and would damage the cotton roots. There should be perfect timing between rainfall and artificial manure applied. Delay in rain would do harm as plants were grown up and in need of water.[191]

The British government was in favour of manufacture of artificial manures to increase the crops yield in quick succession. Experiments to improve the yield of crops with the application of artificial manure were being by the agricultural stations established in Gujarat. But the exercise at these farms proved a daily routine work and no serious attempts were made to combat its harmful effects.[192]

Well known Messer. Croft and Welts & Co. were manufacturing bone manure at Mazagon Dock, Bombay. Some Hindu and Parsi merchants restored to mixing of bone-meal with shell, lime and other cheap materials.[193] Manure made from animal bone did not attract wider response from the farmers because of their prejudices.

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[189] J. B. Shukla (1937), *Life and Labour in A Gujarat Taluka*, 184.
[190] *Ibid.*
[191] Harold H. Mann and S. R. Paranjpe (1919), "Artificial Manures: Experiments on Their Value for Crops in Western India", *Bulletin No. 89 of 1918*, No. 2, Department of Agriculture, Bombay, 8.
[192] *Ibid.*, 2.
[193] *Voelcker Report on Indian Agriculture* (1897), 118.

But chemical manures were slowly and gradually infiltered into the villages because it could increase the productivity of the crops. However, its damage was well known.

Land Reclamation

Increasing salinity over the prolonged period decreased the soil fertility. Steps were taken by the government to bring these lands under cultivation.

Government authorised Surat Collector to give land affected by increasing salinity on contract to make it cultivable.[194]

Four methods were tried then[195]:

- Flooding the field with sweet water
- Encouraging the growth of those plants which could subsists on salt
- Application of lime and other chemical substances
- Working with the application of manure

The village of Pinjarat in Olpad *taluka* had evidenced two interesting attempts for the reclamation of the salt lands.[196] Mr. Dhirajlal Umedram, a former district Deputy Collector had undertaken 328 acres of salt lands for reclaiming of which 17 acres became fit for cultivation. In 1888, 164 acres of salt lands were granted jointly to Mr. Lallubhai Kunverji of Rander and Mr. Khandubhai Khusalbhai of Pinjarat for the same purpose.[197] Results were not encouraging.

Water-Logging

On account of waterlogging in some villages, cultivation was a risk. The usual remedy for this would be under-drainage. Under-drainage proved to be a difficult task in the black soil. The soil completely dried up during the year and the cracking of the soil tore apart the ties which then ceased to act as a drain.[198] As regards open drains, it was difficult to keep them uncovered owing to the sticky character of the black soil. Further, owing to the great retentive power of this soil, it

[194] *GBP* (1877), *Surat and Broach*, 61.
[195] *Ibid*.
[196] J. B. Shukla (1937), *Life and Labour in A Gujarat Taluka*, 178.
[197] *Ibid*.
[198] *Ibid.*, 188.

required usually large number of drains. The result was that cultivation without drains was still continued.

It was found on Surat Government Farm that the limitations imposed by water-logging were the dominant factor in the yield of cotton and *jowar,* the staple crops of this area. With a view to increase the yield of these crops, various methods like deeper and more perfect cultivation; introduction of leguminous crops like *tur* and groundnut; and judicious use of cattle manure and artificial manures were tried between 1902 and 1920.[199] Results were not very encouraging. The limitation factor imposed by water-logging was found out in 1920-21. Since then, yield of crops obtained by adopting the universal method of growing them on the flat land followed by the agriculturists in this part were compared with results obtained on plots on which cultivation on high ridges was undertaken. After a series of experiments carried out by the farm, the superiority of what was known as 'Ridge Cultivation' had been firmly established.[200] Not only did the adoption of this method prevent the land from being partially waterlogged but also the yield of crops could also be raised.

Shifting Cultivation

Shifting cultivation was practiced by the farmers who inhabited the mountainous terrain surrounded with dense forest. In Dangs, cultivators practiced shifting agriculture by clearing trees and burning the grasses. It was an annual practice. After the cultivation and harvesting of crops, cultivators chose to migrate in the new tract. The practice was eco-friendly and it did not disturb the forest balance.

Shifting cultivation[201] did not usually destroy trees and in the process small size plants were growing with soft timber to be used by the *Dangis*. This practice was of great significance as Dangs had little use for large timber. But it did not matter to forest officials, since large and straight stems were the most valued commercially. After the leases, they made repeated efforts to curb and reshape the *Dangi* use of teak and timber, but met with little success. By the late 1870s, it was

[199] *Ibid*.
[200] *Ibid.,* 188-89.
[201] Ajay Skaria (1996), "Writing, Orality and Power in the Dangs, Western India, 1800-1920s", in Shahid Amin and Dipesh Chakrabarty (eds), *Subaltern Studies*, Vol. IX, New Delhi: OUP, 36.

felt that the only way of success was to completely revamp forest rules. Officials proposed forest demarcation dividing the Dangs into research and protected forests. But the colonisation of forest definitely had an adverse impact on the shifting cultivation in Dangs.[202]

Rab Cultivation

Debris from the forest was piled on a small plot of land and was then burnt. Seeds normally of *nagli* (a grain) or rice were sown. Once the monsoon rain appeared, the area around this plot was either ploughed or worked with hoes. It appeared that *Konkanis* largely of *Kunbis* group used bullock-drawn ploughs to practice this style of cultivation. When the seeds had sprouted, they were transplanted to the prepared land. Weeding had to be carried out periodically and the crop was harvested soon after the monsoon. The *rab* of burnt forest waste was particularly good medium for seed growth and yields tended to be high. Dangs, with its abundant supply of such waste, was well suited for such agriculture. As a rule, an area was cultivated only for two or three years. After this the soil tended to become exhausted and a fresh patch of land was sought.[203]

They *Dangis* also went for *kumri* or *dalhi* cultivation which required no ploughing or weeding in the field. In this method, a portion of the forest tract was selected usually on the top of a plateau or higher side of a valley. The selected forest land was cleared of scrub. It was then dried out and further it was burnt. *Nagli* seeds were sown in the ashes. The seeds sprouted with the arrival of rain and harvesting was complete by the end of the monsoon. But crop yield were low as the soil on these plateaus and slopes was not fertile as compared to the flat lands. Both these methods complemented each other.[204]

The use of fire by the *Dangis* was based on sound knowledge about the ecology of the region. Cleaning the underground dried leaves and by reducing the density of trees, the fire maintained an ecological balance between the forests and

[202] *Ibid*.
[203] David Hardiman (1996), "Power in the Forests: The Dangs, 1820-1900", in David Arnold and David Hardiman (eds), *Subaltern Studies*, 95.
[204] *Ibid.*, 95-96.

grassland. The burnt zones were reported to have quick growth of grass after rain. This was the ideal habitat for many herbivores such as *sambhar*, antelope or even hare, which could not have flourished as well in dense forest. The following arrangement also maintained the 'Food Chain' and balanced environment which could support wildlife in the region.[205]

The practice of annual fire in the forest by the natives encouraged the growth of fresh and sweet grass. In the prevention of use of fire with the colonial reservation policy, the grass in the reserves and the protected areas were no longer traversed by fire. It was also observed that grass became coarse and less suitable for grazing by the animals. Fire also played an important role in the germination of teak trees. Gradual decrease of this fire culture was even noticed by the officers placed in Dangs. Surat Forest Officials from 1910 onwards send number of complaints about the stoppage of annual fire in Dangs. They were surprised by the skills long practiced by the *Dangis* regarding the way in which teak was reproduced in poor natural conditions. Large scale cutting of timber for its sully for railways and navigation often caused denudation. Nurseries were set up on a large scale to supply seedlings of valuable timber trees especially of teak, for filling blanks left by old feelings or circulation.[206] But the colonial policy of forest reservation disturbed the natural balance of the forest. It also shattered the traditional techniques employed by the forest inhabitants to maintain the ecological balance.

[205] Ajay Skaria (1999), *Hybrid Histories: Forest, Frontiers and Wildness in Western India*, New Delhi: OUP, 50.
[206] *Ibid.*, 205-06.

Agricultural Tools and Implements

Cultivators employed a number of tools and implements for the agricultural activities. These tools were largely designed as per the demands of the crops and nature of the land. Most of these tools and implements were discovered, modified and adjusted since antiquity.

Alexander Walker's Account on the Tools used by the Cultivators

Walker was a civil servant who worked in Gujarat and came in constant touch with the natives to know about the agrarian practices of the cultivators. According to him: "Gujarat plough is light and neat instrument. It has no coulter. The native instrument has a shield of iron which enables to make deep furrows as straight as a line. Its use can enable a peasant to cultivate and produce sufficient crops. The plough is largely used and establishes the natives as skilled agriculturist".[207]

Further, he informs that natives used a variety of implements for husbandry purpose as well. They cleaned their fields by hoeing, hand weeding and weeding plough. They also used mallets for breaking clods, which was usually done with harrows and rakes.

Indian farmers used simple agricultural tools for its simplicity to work. These were light in weight which facilitated to work in the field without any fatigue to him and cattle during ploughing the fields. The numerous ploughing by the cultivators helped to remove weeds from the field. It also loosened the soil which often became hard and dry under a tropical sun. Frequent tilling of lands was necessary to open the earth through constant ploughing for air, dew and rain. These advantages could only be achieved by exposing top surface from time to time to the atmosphere.[208]

[207] Alexander Walker, "Indian Agriculture", in Dharampal (1971), *Indian Science and Technology in the Eighteenth Century:* S*ome Contemporary European Accounts*, 181.
[208] *Ibid.*, 185, 186-87.

The top surface soil in Europe was not productive because the essential nutrients required by the plants were found deeper. Therefore, in England plough was heavy and made of iron so that it could penetrate deeper into the soil to bring nutrients on the surface. The use of chalk and lime prevailed in places where it was accessible and could be used. The plough, the harrow and the roller were pulled by oxen or horses. Hand tools were used for digging drains, cutting hay, reaping the harvest and threshing.[209]

Native Plough (see Illustration Nos. V and VI)

In Ahmedabad, plough, *kodalee*, *danturda* (sickle), *wansee*, *khurpee*, *punjetee* (rake), *phawra* (spade for digging), *kowaree* (axe) are reported to remain in use for agricultural.

Following are the parts of a plough:

Vernacular name (*Gujarati*)	**English Equivalent**
Chowra	----
Churah	----
Dandee or *Cher*	The shaft
Hatha	The handle
Hull	The coulter
Joosra	The yoke
Jotur	Neck straps made of cotton thread and some times of leather
Kose	An iron share
Kuswala	A wooden wedge to hold fast the *kose* and *chowra*
Naree	A rope of about half an inch thick made of tanned leather for tying the yoke to the shaft
Nyah	An iron nail which served to bind the yoke to the shaft
Somul	Four pegs on the yoke to which the neck straps are tied

Source: Renu Saxena (1989), "Ahmedabad from *circa* 1750-1850: A Review of It's Society, Economy and Institutions", 15-16.

In plough, iron point consisted of a slightly curved bar, about three inch in diameter and two feet long. It was pointed at one end and put through a hole in the

[209] Fussell (1969), "Science and Practice in 18th Century British Agriculture", *Agriculture History*, 43 (1), 10.

hull called *chowra*. This was the common structure, but certain modifications were allowed to suit with different soils.[210]

Size of plough differed as per the varieties of soil. The *charda* (lower part of plough) in which the share was fixed was made broader and larger, while the share itself was pointed at the end and was a little longer then was the case with most ploughs. For hard soil, size and shape of plough differed. The lower part of it was longer and less broad.[211]

Land was frequently infested with weeds such as *kunda* (*Saccharum ciliare*) which, if buried would readily shoring up. The native plough, with its digging action, tore the weed out and brought it to the surface; a furrow-turning plough would cover it over and controlled its propagation. For breaking up new land, the native plough had advantage and somewhat resembled the tearing action of the steam-diggers.[212]

Introduction of the British Plough: **A Story of Ignorance about Ecology and Local Practices**

In the middle of the 19th century with the growth of steel industry, variety of agricultural implements was manufactured in England. Agricultural enthusiasts, without examining the conditions prevalent in India, imported agricultural implements from England for the experimental farms in India. The result was that large dumps of agricultural implements and machinery got accumulated at these farms and were not used.[213]

The iron coulter in plough introduced by the British was rejected to prevent the erosion of the substances present in the surface soil like alkaline substances and minerals that were beneficial for the crops.[214]

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[210] Renu Saxena (1989), "Ahmedabad from *circa* 1750-1850: A Review of It's Society, Economy and Institutions", 15-16.
[211] *GBP* (1883), *Baroda*, 85-86.
[212] M. S. Randhawa (1983), *Agriculture in India*, Vol. III, New Delhi: ICAR, 251-52.
[213] Deepak Kumar (1984), "Science in Agriculture: A Study in Victorian India", in A. Rahaman (ed.), *Science and Technology in Indian Culture*: *A Historical Perspective*, New Delhi: NISTADS, 215.
[214] Vijaya Ramaswamy (2011), "Craft Technologies and Craft Communities in Peninsular India: An Overview of 16th to 18th Centuries", in Rattan Lal Hangloo (ed.), *History of Science and Technology: Exploring New Themes*, Jaipur: Rawat Pub., 93.

The black soil was well known for its power of contraction during the hot weather. With the first advent of the rains, the loose crumbled surface soil was washed into the crack. The soil expanded and became capable of being worked into fine filth by the local harrow. As fresh layer was being brought to the surface, the soil was thus renovated every year. It was for this reason, the black soil was said to plough itself. Moreover, the western implements, being made of iron, could not be put into the fields during the rains as the wet earth stuck to iron more tenaciously then to wood.[215]

In Salsette near Bassein, husbandmen objected to the imported plough being too heavy for him and his cattle. The cost of these imported ploughs was beyond the purchasing capacity of a cultivator. Being made of iron, it required frequent repairing. The repair task was difficult because of limited iron smiths. The Indian plough could easily repaired by the village carpenter at low cost. There was, thus, no chance for the replacement of the native wooden plough by the iron plough until the difficulties as the initial cost and repair could be met.[216]

The main objection of the British technicians to the Indian wooden plough was that its wooden share did not insert the soil and went to a depth of only three or four inches. They considered the re-ploughing and cross-ploughing by the Indian plough as a proof of its inability to go deep enough and to invert the soil once for all. The Indian cultivators was, however, well aware of the nature of soil which when heated at the surface by exposure to the sun, yielded the best return. He had known from experience that in a climate where the productive powers were great, it was only necessary to put the seed a little way into the ground. If it was buried deeper, it would rot and decay before it could germinate, or it would remain dormant in the earth. Later scientific observations have disapproved the idea of deep ploughing in India.[217] Conserving moisture, exposure of weeds and slices to the sun, availability of lime stone and *kankar* into the depth of the soil and the uncertainty of rainfall, all

[215] J. B. Shukla (1937), *Life and Labour in A Gujarat Taluka*, 173-74.
[216] Satpal Sangwan (1991), *Science, Technology and Colonisation: An Indian Experience, 1757-1857*, 130.
[217] *Ibid.*

these factors affirmed the preference of Indian husbandmen and his wooden-shared plough against deep ploughing.[218]

In Olpad *taluka* of Surat, the local artisans had devised an ingenious adjustment to the wooden plough, in which a broad and sharp-edged blade made of iron was fitted on to the shoe and the plough was used for lifting up the cotton stalks. The implement worked efficiently and was found much useful in the locality owing to the fact that labour was very clear and scarce.[219]

Two other ploughs exclusive of the common plough and the drill plough were employed. One of these had a horizontal part and immediately followed the drill plough at work. It was set into earth about depth of seven inch or eight inch and passed under three drills at once. It was operated by agitating the earth so as to make the sides of the drills fall in and cover the side grain, which it performed very efficiently and left little trace of a soil. The other plough alluded to was used after the corn grew about eight inch to ten inch high. It cut the weeds between three drills at once and earthen up the roots of the corn at the same time. The weeding plough bore some resemblance to the English horse shoe. But the more common implement was the ordinary hoe, which resembled the English one shape, though its handle being short, the hoers in using it must take a sitting pasture.[220]

Sowing Machine (Seed-Drill)

According to Edward Gorden Fawcett, the description of the sowing machine during the 18th and 19th centuries is as follow: "It has a bonnet at the top into which the grain is placed from which four hollows bamboos conducted the grain, each through one of the prongs of the harrow or rakes. One person uses to drive and another one attempts with a bag of grain tied round his waist and fed the machine. The prongs of the fork are about a foot apart and the outlet for the grain is in the back part of the prong, so that it is not liable to get blocked up by the earth in its

[218] *Ibid*.
[219] *Annual Report of Department of Agriculture the Bombay Presidency* (1915-16), 31.
[220] Satpal Sangwan (2007), "Level of Agricultural Technology in India, 1757-1857", *Asia Agri-History*, 11 (1), 6.

progress. The yoke is made rather wider than usual so that the oxen are kept clear of the furrows".[221]

The same author also refers to different parts of a sowing machine:

Vernacular Name	Description
Ankra	Two hooks fixed behind the body
Dandwa	Four hallow bamboos
Danta	Four prongs of the harrow
Falwa	Iron shares at the end of the prongs
Hutwa	Two handles at each of the above
Joosra	Yoke
Loreea	The body of the harrow
Naree	Leather thong for binding the yoke
Oarenee	The wooden bawl
Somal	A wooden peg for fixing the bands
Sumra	The shaft

Source: Edward Gorden Fawcett (1849), "Report on the Collectorate of Ahmedabad", *SRBG*, No. 5, N. S., Bombay, 7.

With the development of time we do find reference to other sowing implements in the south Gujarat region. These are *nangar* (a seed drill for planting sugarcane) and *champon* (clod crusher), *karpi* (hoe) and *fadka* (three coultered seed drill).[222]

A summary of variety of primary sources like reports on agricultural activity; Correspondences, *Gazetteers*, *Manuals* refer to the following agricultural tools which has been very meticulously complied by G. C. Mukhtyar.[223]

[221] Edward Gorden Fawcett (1849), "Report on the Collectorate of Ahmedabad", *SRBG*, No. 5, N. S., Bombay, 7.

[222] *GBP* (1883), *Baroda*, 79 and G. C. Mukhtyar (1930), *Life and Labour in A South Gujarat Village*, 143. Seed is sometimes sown through a drill or hallow bamboo pierced with holes and fixed behind the plough in which *kharpi* is substantially passed over the surface is soften the intervening spaces left by the furrows. Rice is threshed. *Jowar*, *bajri* and wheat were further crushed by bullocks and carts to separate the left out seed.

[223] G. C. Mukhtyar (1930), *Life and Labour in A South Gujarat Village*, 144-46.

Vernacular names and their uses of some of the tools and implements:[224]

Gujarati Name	**Usage**
Datarder (sickle)	Cutting of ripe crops
Dharui (scythe)	Cutting branches of *babul*, removing thorny plants
Ediu (yoke)	Yoking bullocks to the sugarcane press, or assist to *kosh* for fetching water
Galli (big cart)	Transportation purpose
Jotar, Nandi	Tying bullock to the yoke
Kadha (small pan)	Cooling *gul* (or *gool*)
Karpi (hoe)	Interculturing cotton
Kolu (sugarcane press)	To extract juice
Kosh (leather bag)	To carry water
Kuhadi (axe)	Cutting purpose
Kundi	Retaining juice when sugarcane sets are squeezed between rollers
Orni (seed drill)	Sowing seeds
Paniu (harrow)	Leveling the ground
Panjethi	Gathering leaves or taking dung from manure pit
Pat	A long wooden rod for moving the three rollers
Pavdo (hoe)	For digging soil
Sarak (rope)	Binding heaps of grass or bags of corn loaded in carts
Supdu	Winnowing
Thalu	Supporting rollers from below
Toplo	Carrying grain on head
Vartu (rope for hanging *kosh*)	Suspending the *kosh*

With the use of ploughs, cultivators were able to loosen the soil, bring out the moisture and essential nutrients and weeds were removed from the field. Seed-drills were used to sow the seeds in the same land in a harmonious way so that seeds could get enough space in equal distribution to receive water and minerals for its judicious growth. These two important tools were used all over British Gujarat with few modifications as per the nature of the soil of the particular area. Besides these two tools, peasants also employed number of tools and instruments for the cultivation of crops.

[224] *Ibid*.

Other Tools and Implements

Satpal Sangwan provides following description about the tools and implements used in agriculture: "Harrows consisted of a brand pierced with rough pegs or more frequently of the bought of a tree on which one or two children themselves to give it necessary pressure. It was not used in all soils. By the beginning of the 19th century, a four cultured seed drill had come in use for the purpose of harrowing with the seed and seed tubes removed. Two types of levellers were used by the Indian peasants to pulverise the tenacious textured surface and also to conserve the moisture. One of these was the *moyi*, an implement made of two pieces of bamboo about six feet in length and joined together by some crow-bars like a ladder. When in operation, the ladder to which a pair of oxen was yoked was drawn transversely across the field, while the driver stood upon it to give it weight. The other, a still cruder contrivance was merely a thick narrow plank. The Indian cultivator tilled his fields both by hoeing and hand-weeding. In the eastern parts of India, the implement to clear the fields was made of iron and was known as *pason.* Millets were used for breaking clods, with the usual assortment of hoes, harrows and racks. In Madras, heavy soils were dug with a crowbar called *khank.* With the soil cracked in the hot season, the crowbar was inserted adroitly into the cracks and huge clods were levered out. In Bombay and coastal India, the *vaddors* (professional diggers) used a strong blade of steel fifteen inch to eighteen inch long, about three inch wide at the point. The blade was fitted like a hoe to a powerful hardwood handle three feet long. This implement was used with great effect on black soil when it cracked".[225]

Satpal Sangwan further refers to the other instruments used: "*Kodali* (for digging) consists of a blade of an iron blade of varying width fitted to a wooden handle with which it makes an acute angle. It is worked by the arms with the blade pointing towards the workman. It penetrats about four inches and brought up the soil in large blocks which are left to weather down. Voelcker was specially struck with the effectiveness of a small hand-pick in common use for digging holes to put seedlings. The original pick is made from the forked branch of a hard-wood tree and picks of this character are extensively used in forest tracts. The indigenous iron pick

[225] Satpal Sangwan (2007), "Level of Agricultural Technology in India, 1757-1857", 6.

is very much of the same shape, while its size depends on the use it was put to. A small pick is used for lifting potatoes, turmeric, onions and crops of that class. Sickles used for reaping grain crops or for grass-cutting are generally of two types, the *harqsuua*, which has no teeth and is the larger of the two and the *kachiya* which has teeth and is small in size. In some parts the farmers use a large sickle called *jhapau* to cut grass. Sieves of bamboo or grass and riddles of various patters are used on threshing floor to handle the threshed chaff and grain and to separate grain from chaff when the wind is not strong enough for winnowing in the usual way. The winnowing scoop or *sup* is used in every parts of India. The corn trodden out under the feet of the bullocks mixed with the broken chaff (*bhusa*) is poured from a height when the wind is strong enough to carry away chaff and light grains. The good grain is further cleaned of earth particles and other impurities by means of the *sup.* Grains are grounded into flour in the quantity for daily use by means of the pestle and mortal".[226]

The above mentioned tools and implements enabled the cultivators to produce varieties of food and cash crops. The crops yield produced with the judicious use of these apparatus led to the growth of crops which could not only allow the peasants to look after his family but also surplus produce facilitated the rise of the urban centres and supported the other non-agrarian activities.

Sugarcane Crushing Instruments

As we are well informed that the Northern Division of the Bombay Presidency, i.e., British Gujarat had witnessed the increase in sugarcane production. The cultivation of sugarcane also initiated the demand for its finished products / manufacture like sugar, *gur*, &c**.** We are also aware that sugarcane products were in high demand within and outside Gujarat.[227] To increase the extraction of juice, crushing instruments were used by the peasants which were based on simple mechanism. The descriptions of the crushing instruments are provided here.

[226] *Ibid*., 9.
[227] Surendra Gopal (1975), *Commerce and Crafts of the Gujarat in the Sixteenth and Seventeenth Century*, 62, 68 & 138.

The first sugarcane mills had two manually powered horizontal rollers. They were scaled-up versions of the cotton gin and were probably developed in India around 1500 A.D.[228] Joseph Needham has pointed out that the cotton gin and the sugar-cane roller mill use the same technology and were the ancestors of all steel-rolling mills, paper and textile machinery.[229] He places the cotton gin as primary and their joint origin tentatively in India. In the 19th century, there were examples of ungeared cotton gins and sugarcane roller mills from India.[230] Two types of the crushing cane instruments were employed namely 'Mortal' and 'Pestle' similar to oil-press and secondly wooden roller mill. 'Mortal' and 'Pestle' mill were good if made of stone, but in most areas this was found to be very expensive and hollowed wood was used instead. This was prevalent in Gangetic plains, Orissa and central India.[231] But it was ill suited to milling cane when the cane was dropped into 'Mortal'. The second device, the wooden roller mill, involved the motion in opposite direction of two mounted wooden rollers, one of which was rotated by oxen driven around it. The main roller moved the other through ridges on its upper part fitting into grooves of the other. The canes were crushed by thrust between the rollers. This mill was employed in Gujarat, Maharashtra, Andhra Pradesh, Chhattisgarh and even in Punjab also.[232] The wooden crushers used manually can still be seen in Vadodara city along with the iron roller machine which runs on electricity.

During the last quarter of the 19th century, iron roller mills were manufactured in India by Messers Mylne Thompson of Bihia of Bhojpur District in Bihar, an improvement of the indigenous mill (**see Illustration No. VII**).[233] By the end of the century, thousands of the roller mills were being manufactured by the Indian artisans which was verified by *Voelcker's Report* and the *Administration*

[228] Cotton saw gin could be originated in 6th century A. D. as attested from one of the paintings of Ajanta Cave. For description of cotton gin tool, refer Section 'Cotton Textile Manufacture' in Chapter Three of this thesis. Also see Irfan Habib (2000), "Joseph Needham and the History of Indian Technology", *IJHS*, 35 (3), 259-60.
[229] *Ibid*., 260.
[230] John Daniels and Christian Daniels (1988), "The Origin of the Sugarcane Roller Mill", 504-6.
[231] Satpal Sangwan (2007), "Level of Agricultural Technology in India, 1757-1857", 15.
[232] *Ibid*., 18.
[233] *Ibid*.

Report of Punjab (1989) which reports that it was widely accepted and replaced the local crusher instrument.[234]

Though the wooden roller mills were hard to work with and did the pressing ineffectively (canes having to passed through the rollers several times three or four or sometimes as many as eight); yet they were preferred by the Indian peasants on various grounds. It could be made locally and the canes had not to be chopped up or cut into short pieces. Moreover, a wooden roller mill for crushing sugarcane could be easily maintained by an Indian farmer. The whole expanse of the sugar mill in the 1830s was about Rs. 31 and the machinery required to be renewed once in five years.[235]

Continuing the discourse on the efficiency of the indigenous varieties of crushing machine, P. R. Mehta has opined out that though iron mills was gradually accepted in the northern India, it was far cry and not used in Gujarat owing to its high price. According to his estimate, it was priced at Rs. 110 at Poona. Iron mill expressed 73% of juice and wooden mill excreted 50% to 60% from the sugarcane. A wooden mill would cost Rs. 35 to 50 and required constant repairs while crushing was continued. On the other hand, an iron mill required fewer repairs. A common belief prevailed among the people that iron mill would spoil the quality of *gool* by turning it darker.[236] From the paragraph, it can be assumed that iron mills had certain advantages, but still people continued with traditional instrument to extract juice from the sugarcane.

In 1873-74, an improved iron-sugar mill 'Bihia mill' was manufactured by Messers Thompson and Mylne. When it was first manufactured, it had two rollers. Later on, three roller mills were introduced. Prof. Robert Wallace of Agriculture Department in the University of Edinburgh, who came to India about 1880, noted that about 70,000 iron sugar mills were in use in India. The machine was simple and the manufacturing company established depots in the districts, where worn out mills

[234] *Ibid*.
[235] *Ibid.*, 19.
[236] P. R. Mehta (1905), *The Elements of Agriculture of the Bombay Presidency,* 198-99.

would be replaced by new ones. It extracted juice up to 50% to 60% of the cane weight.

The general acceptance of the Bihia mill was that it was originated under the light of the requirements of the locality. It was an improvement of the native crushing mill. In Gujarat with little exception, the wooden mills were still used.[237]

Shallow Iron Evaporation

In the same manner, shallow iron pans were used to boil the juice, but in Gujarat, cultivators used pans which were not shallow. Also, a peculiar method regarding the use of fuel for boiling the juice was that in place of dry leaves of sugarcane, *babul* tree as a fuel was preferred.[238]

Another improvement which Voelcker recommended was the popularisation of the shallow iron evaporating pan for boiling the cane juice. The more rapid evaporation effected by the broad shallow pan as against that with the narrow and deeper pen generally used would give less opportunity for secondary fermentations setting up. Shallow pans also controlled the entry of impurities finding their way into the juice during the operation.[239]

Introduction of New Tools and Implements in the First Half of the 20th Century

Tools used for separation of cotton from seeds also find detail description in *Annual Report on the Experimental Work of the Surat Agriculture Station* (1906-07). For example, two iron hand gins were received from the Inspector General of Agriculture in India in the first decade of the 20th century.[240] These were based on the principle of McCarthy gins without movable knives.[241] Its roller was studded with small pins. Every effort was made to encourage the peasants to work on it, but the cotton always stuck to the roller and was gradually chopped into the pieces. Of the two iron mots, one was received from Nasik and another one from Belgaum. The

[237] M. S. Randhawa (1983), *Agriculture in India*, 253-56.
[238] P. R. Mehta (1905), *The Elements of Agriculture of the Bombay Presidency*, 193-94.
[239] M. S. Randhawa (1983), *Agriculture in India*, 257.
[240] *Annual Report on the Experimental Work of the Surat Agriculture Station* (1906-07), 29-30.
[241] *Ibid*.

first worked like the *Sundhia* leather *kos* with only defect that it took a very long time to fill. The second from Belgaum weighted 50 lbs., i.e., double the weight of an ordinary *kos.* It was circular in shape. Though, it worked well if cautiously used; but it had some drawbacks, viz., "that when the bullocks went a little further than the stopping point, the whole adjustment of the frame with the lower pulley was upset".[242] The price of this '*kos*' was Rs. 15, i.e., the same as that of the leather one.[243]

The other instrument mentioned in the *Annual Report of Department of Agriculture* (1922-23), Bombay Presidency was Mansfield Water Finder. It was used to locate underground supplies of water. Kaira District Local Board purchased several of these machines.[244]

Beside this, we also find mention of Musto Power Machine and Calyx Hand Machine had been lent to the Kaira District Local Board. A proposal was made to hire Case Tractor belonging to Messers Polson Manufacturing Company of Anand.[245] It was hired by the Agriculture Department. This implement was repaired by Mr. Vaidya in order to try it in Broach and Surat.[246]

Owing to the hardness of the soil in Panch Mahals, BT2 iron plough was tried to remove the underground weeds which was not possible with the native plough.[247] It was very heavy, and therefore, it could be drawn with the help of a gang of children.[248]

Along with the purchase and its introduction, other activities were encouraged by the agricultural departments like organising demonstrations to popularise the usefulness of these instruments. In one such effort during 1911-12, the

[242] *Ibid*.
[243] *Ibid*.
[244] *Annual Report of Department of Agriculture of the Bombay Presidency* (1922-23), 25.
[245] *Ibid.*, 84-85.
[246] *Ibid.*
[247] *Annual Reports on the Experimental Work of the Dohad Agriculture Station* (1910-11), 21.
[248] *Ibid*.

Dohad Farm organised a demonstration by inviting 338 farmers. 189 of these invitees remained present on the occasion.

The objectives of their visits were:[249]

- To see the system of ploughing in *san* in green manure and
- The working of the *Hindustani* and other iron plough

Irrigation

In India for irrigation purpose, chiefly two methods were employed namely lift irrigation and gravity flow of water. Wells and tanks came under the former category and rivers under the latter one.[250] Availability of adequate water table[251] during pre-British Gujarat made the use of wells and tanks most suitable for irrigation utility. Monsoon enhanced the irrigation potential. These water structures were eco-friendly. Numerous tanks, reservoirs, artificial lakes, dams of solid masonry in rivers, &c were constructed for the purpose of irrigating the field. The judicious use of these water works showed the people understanding of nature and significance of its ecological balance. These works were executed by government, wealthy individuals and sometimes even by the women. The other community say for example, Muslims were also active in constructing many magnificent reservoirs for water.[252]

These water works were greatly suffered during the colonial phase. For instance, construction of canals decreased the efficiency of wells owing to diversion of water channel, lowering of water table and increasing silt. In the same way, erection of embankments to channelise the rivers for the purpose of canals and

[249] *Ibid*., 23.
[250] R. P. Kulkarni (1982), "Irrigation Engineering in India", *IJHS*, 17 (1), 28.
[251] Earlier methods of harvesting rainfall could involve building of check dams or rivers or channeling rainwater into reservoirs so that water had time to soak into the ground and thus fill the wells. Allowing river to flood could ensure the same result. It can be argued that it was the decay of arrangements of these sorts which caused a decline in groundwater levels in many areas and thus, a drop in water levels in wells and even their drying up. See David Hardiman (2006), *Histories for the Subordinated*, New Delhi: Permanent Black, 326.
[252] Alexander Walker, "Indian Agriculture", in Dharampal (1971), *Indian Science and Technology in the Eighteenth Century:* S*ome Contemporary European Accounts*, 195.

railways; or for the prevention of floods had considerably reduced the extent of land cultivation formerly enriched by shifting river course.[253]

Water-Lifting Devices

M. S. Randhawa refers the following methods generally employed in the different parts of India to draw water from the wells, tanks and reservoirs.[254] As per his information, the indigenous methods of lifting water from wells were of three types: if the left was small, the water was raised by palmyra leaf or bamboo baskets attached to ropes which were swing by two persons. For greater depths, the picotah or yetham was used. It was drawn by men. The picotah was consisted of vertical past to support a long inclined beam. A bucket was attached at one of its end. The bucket was lifted to carry out water and it was emptied into the irrigation channel. The last lift consisted of a large hemispherical leather or iron bucket with a long tail open at the end. A rope supported the top of the bucket and another was attached to the tail. The farmer passed over a wheel working between two pasts fixed at an angle and the latter over a roller on a level with the channel. As soon as the bucket was filled, it was hoisted by a pair of bullocks. The operation was repeated to take out more water.

Anton Hove who was travelling in Gujarat in 1787 has penned down his observation about the methods and devices used for lift irrigation.[255] According to him: "Water is lifted from a well by means of a large leather bag (*kos*) pulled by a pair of bullocks. *Kos* is emptied into a channel which is connected to the field. He also refers to manually operated water raising machine. It consists of a wheel five metres in diameter and it is suspended vertically on four poles with a role ladder around the rim. Over the rim, earthen pots are tied. The motion in the wheel set by human power who sat on the cross-beams and turns the wheel. Pots are emptied into a trough which is connected to the fields. He also reports that these devices are also used on the banks of the rivers. In some cases, channels are dug in the river bed to

[253] Irfan Habib (1999), *The Agrarian System of Mughal India, 1556-1707*, 28-30, 31.
[254] M. S. Randhawa (1983), *Agriculture in India*, 246-47.
[255] Anton Hove (1855), "Tours for Scientific and Economic Research Made in Guzerat, Katthiawar, and the Conkuns in 1787-88", *SRBG*, No. 16, NS, Bombay, 36-37. Also see David Hardiman (2006), *Histories for the Subordinated*, 329-30.

bring water beneath a suitable vertical bank or a pit (*oria* or *dhekudi*) is dug in the river bed below a suitable bank, into which water percolats. It is also reported that these arrangement are temporary in nature because of shifting nature of the rivers and its banks are not stable".[256]

Noria was a vertical wheel that had water containers on its rim. Set up over a sheet of water, its rim-containers picked up water as these went down into the water and then came up with a rotation of the wheel. When these passed the top of the wheel and descend, these emptied, pouring their water into channels prepared alongside.[257] *Saqiya* (Persian wheel) was another device. It could be used for milling grain and smoothening gun barrel. There was an attempt to improve the apparatus of the Persian wheel so as to enable it to lift water to reach a height much above the level of the oxen. This was done by making the drawbar rotate a long vertical axle, at the top of which was put horizontal wheel, whose pegs meshed with the ways of a vertical wheel, which by set on the same axle, in turn rotated the well-wheel carrying the chain of pots.

By the late 19th century these began to be replaced by the metallic wheel and chain, with the cumbersome lantern gearing being replaced by toothed wheels. The counter weighted scoop being a lever, with the unweight arm worked usually by the feet. This is practicable whenever as in streams and canals; the water is close to the ground level.[258]

Ramia kos[259], *dhekudis, sundhia kos* and fixed pulleys were used to carry water from wells and tanks. The *supde* and *charaidu* deserve mention. The first was an oblong-shaped vessel with a rope on each side of it fixed to hooks and requiring two men to work it. The *charaidu* was a vessel with a length greater than its breadth. One of its ends was purposely made broader than the other, and the whole was fixed

[256] Anton Hove (1855), "Tours for Scientific and Economic Research Made in Guzerat, Katthiawar, and the Conkuns in 1787-88", 36-37.
[257] Irfan Habib (2008), *A People History of India: Technology in Medieval India, c. 650-1750*, 8-9.
[258] *Ibid.*, 12-14.
[259] *Ramia Kos* is used for irrigation. It consists of a large leather bag containing sixteen gallons of water which is drawn by a pair of bullocks are allowed a steep descent to pass along while water is being pulled up. See *GBP* (1883), *Baroda*, 78.

in a wooden frame with a sort of screw to it at its middle point. It was so contrived that when the broader end of it was pressed down the narrower end risked, and subsequently, the water which had been taken in by dipping its broader end, it was thrown out from the narrow end. These two contrivances were used when the water was not very deep. It was used in *Charotar* area.[260]

Wells and Reservoirs

Two British officers namely J. Cruikshank and P. M. Melville from Ahmedabad District in 1825 and 1827 respectively provide following details of the wells found in Gujarat region: "When majority of the wells are dug close to the water level which lasted only for a season. For the construction of a deep well, it shall be made either of rock or brick. This sort of well can be built by peasants without the assistance of professionals. Brick well built by professional are of great depth. When such a well is built, earth is dug up to twelve metres. A large wooden wheel of the circumference of the inland well is then taken to the bottom of the pit to serve as a base for the bricks. The bricks ire built up using clay and is covered with *chuno* (lime plaster). It is reported that it can last for many years".[261]

Wells in Gujarat were dug on the thin layer of soil over rocky substratum. Owing to this these shallow wells, reaching down to the rock, could not provide a year round supply of water. It became necessary to dig through the rock to tap deep-down springs. Sites were chosen with care and skill by hiring *panikals* (traditional water diviners to locate the underground water). Their method used was acknowledged by the British officers. They could also indicate that at what depth the spring would be tapped. In some cases, the residents of a village themselves undertook such work. It was a time consuming long term project as hewing out the rock with a chisel would definitely took time. In some cases, blasting logs were used to split the rock. This technique was reported in Saurashtra where wells were constructed by blasting rocks with gunpowder and lined these with stone.[262]

[260] *Ibid.*, 85.
[261] David Hardiman (2006), *Histories for the Subordinated*, 327-28.
[262] *Ibid.*, 328-29.

Next, in importance to wells were reservoirs because these could be used for irrigation and allowed water to percolate into the soil and top up surrounding wells.

James Forbes who resided at Dabhoi near Baroda in 1777-78 stated that there was generally a tank in each village.[263] These were enclosed with strong masonry and their banks were adorned by banyan, mango and tamarind trees. In Dholka *taluka* reservoirs were used on a large scale for irrigation. The countryside sloped gradually from north to south; the reservoirs were constructed to take advent of this feature. Their northern sides were hardly built up at all, while on the south there were large strong embankments. The overflow from one reservoir thus filled one below it.[264]

Hove observed the technique used to bring water into the reservoir from the rivers.[265] Reservoirs were filled either by rain or flood inundation. The inundation was made using the river creeks with a bank behind built to close them off from the river, but most had been dug out with great labour. Their banks were planted with trees to strengthen them. A sliding sluice was constructed in the bank adjoining the river which was left open when the water level was on its height. As per the requirement, the sluices were opened for the flow of water into the channels which was further connected with the fields. It was reported that strips of land were left between the fields. It was done to allow subsidiary channels on temporary basis for the charge of into the village lands. In 1825, such arrangement was built across the Khari River in Ahmedabad District.[266]

The colonial rulers did not value the traditional water systems in use since antiquity. Consequently, these structures which were in urgent need of restoration failed to get the attention of the colonial authorities. For example, Karna Sagar near Ahmedabad washed away in monsoon (1814) was not repaired by the British

[263] J. Forbes (1834), *Oriental Memoirs: A Narrative of Seventeen Years Residence in India*, Vol. II, 40. Also see David Hardiman (2006), *Histories for the Subordinated*, 331-32.
[264] David Hardiman (2006), *Histories for the Subordinated*, 331-32.
[265] Anton Hove (1855), "Tours for Scientific and Economic Research Made in Guzerat, Katthiawar, and the Conkuns in 1787-88", 109.also see David Hardiman (2006), *Histories for the Subordinated*, 332-33.
[266] David Hardiman (2006), *Histories for the Subordinated*, 332-33.

government.[267] Same was the fate with number of existing water bodies which were largely neglected. The apology offered by the government was that repair works demanded huge expenditure which was beyond their capacity.[268]

Natives were also responsible for its desertion. These water bodies needed frequent repair, but their general neglect led to their abandonment. The nature of the black soil which was generally found in Gujarat, further, chocked up the well. Therefore, it became necessary that the sides of the wells to be strengthened either with stones or bricks. In coastal regions, the depletion of groundwater led to ingress by seawater and wells filled with salty water decreased the crop yield.[269]

Rivers and Canals: Natural Limitations

The Famine Commission (1880) estimated that the total irrigated area in the Bombay Presidency was barely a half million acres compared with over eleven million acres in the United Provinces and other five million acres each in Punjab and Madras.[270] *The Indian Irrigation Commission* (1901-03) recommended the construction of large canals on Sabarmati, Mahi, Narmada and Tapti Rivers.[271] Schemes were submitted to the Bombay Government in 1919 and in 1921 for the Sabarmati Canal Project. But these proposals were rejected by the government for financial crunch.[272] According to R. C. Dutt, up to 1880, 125 million had been invested in railways, but only 12 million in irrigation.[273] Even, *Royal Commission on Indian Agriculture* (1928) stated that Gujarat was even worse in irrigation expenditure compared to Sind and Deccan.[274]

In 1856, Captain Trever (Bombay Engineer) first proposed the irrigation from Tapti River. Captain Chambers who had worked on Madras Rivers was given

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[267] *Ibid.*, 342.
[268] *Ibid*.
[269] *GBP* (1883), *Baroda*, 85.
[270] Neil Charlesworth (1985), *Peasants and Imperial Rule: Agriculture and Agrarian Society in the Bombay Presidency, 1850-1935*, Cambridge: CUP, 141.
[271] G. C. Mukhtyar (1930), *Life and Labour in A South Gujarat Village*, 5.
Ibid.
[273] Daniel R. Headrick (1988), *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940*, New York: OUP, 194.
[274] R. D. Choksey (1968), *Economic Life in the Bombay Gujarat, 1800-1939*, 91.

the task to survey the region.[275] He suggested the construction of a canal fifty miles running to the south west to Auranga River near Valsad. It was also expected to make it fit for navigation along with irrigation. Captain Trever in 1867 was asked to report on Chambers's proposal.[276] Finally, masonry weir across the Tapti River at Kamlapor, thirty five miles above the city of Surat was made for the irrigation of the nearby areas.[277]

The Allidhar Vellar *bund* near Harmadia, Natilia *bund* near Dhari in Amreli taluka and the Chikli and Bandharpada in Navsari taluka were some of the examples which were in use.[278]

The British experts could not solve the problems of canal construction because of natural barriers and topography of the region.

Rivers in Ahmedabad flew along deep narrow channels were not suited for direct river irrigation. The Irrigation Branch of Public Works Department (PWD) started in 1867-68, surveyed water levels in Dholka, Sanand, Daskrio and Parantij *talukas.*[279] To increase the flow of the water in the Khari and also for irrigation, the Hathmati Canal was opened in 1873.[280] It received water from Hathmati River near the fort of Idar State. This was the classic example where the British government used the native structure to build a canal (**my emphasis**). At this point, water was raised by a rubble masonry made of sandstone and limestone. Absence in the bed of the river of any solid foundation made the task difficult of canal construction. Looseness of soil created loss of water by soakage and finally river flow in deep narrow channels with sandy beds were the natural barriers for the construction of canals not only in Ahmedabad but also in other districts of British Gujarat.[281]

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[275] *GBP* (1877), *Surat and Broach*, 15.
[276] *Ibid.*, 16.
[277] *Ibid.*, 17.
[278] J. M. Mehta (1930), *A Study of Rural Economy of Gujarat Containing Possibilities of Reconstruction*, Baroda: Baroda State Press, 20.
[279] *GBP* (1879), *Ahmedabad*, 50.
[280] *Ibid*.
[281] *Ibid.*, 50-51.

Black soil used for cotton did not require irrigation owing to its absorbent nature for water and introduction of irrigation canal in the black soil would do more harm than good. Rivers of Gujarat were very deep below thirty feet of the natural surface of the country, subject to violent floods. Many of the sites were in princely states, and therefore, cooperation was needed between these states and British Gujarat.[282] Canals could not be used as river beds laid at a great depth below the surface of soft alluvial soil deep into which these had cut their tortuous course. These rivers annually overflowed their banks and made ravages upon the banks and widen the river bank. This difficulty had prevented many cultivators from digging wells on the river banks.[283]

In canal technology, British engineers in India started systematic establishments of metrological departments to study the nature of Indian rivers, especially, for silting of rivers over the period of time and breakthrough achievements were brought about. Indus River was selected for study. Unfortunately, no such attempt was reported for the rivers of Gujarat[284] Indians abandoned number of canals constructed by traditional methods because of silting of the rivers.

Introduction of Water Pumps: Limited Success

The British experts were aware of the limitation imposed by the nature for the construction of canals in British Gujarat. They were forced to acknowledge the utility of the wells and the tanks used by the natives.

In the next step, the government introduced water pumps to draw water from these water bodies. This initiatives had little acceptance among the people. The limited financial and the small irrigable lands at the disposal of the bulk of farmers were some of the hurdles in the popularising mechanised irrigation.[285]

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[282] J. M. Mehta (1930), *A Study of Rural Economy of Gujarat Containing Possibilities of Reconstruction*, 19.
[283] *GBP* (1883), *Baroda*, 84.
[284] R. P. Kulkarni (1982), "Irrigation Engineering in India", *IJHS*, 17 (1), 40-41.
[285] J. M. Mehta (1930), *A Study of Rural Economy of Gujarat Containing Possibilities of Reconstruction*, 71.

An instance can be drawn from native who put up a first class pumping plant on the Sabarmati River. However, he found that the cultivation was a challenging task; in due course of time he decided to abandon the plant.[286]

Charotar tract became the leading example in setting large number of tube wells and pumps.[287] There were thirty nine pumps used in Borsad *taluka* which increased to one hundred and forty three within the decade.[288] It was also estimated that in the same *taluka* 11% of the villages accounted for 41% of the pumps. Even, pipes were laid down to take water from wells. For example, at Navli in *Charator* in 1920 had pipes running for one a half kilometres.[289] In Matar *taluka* of Kaira, pumps run by oil engines were tried near river was pronounced of no avail owing to its remoteness from the city. Further, it was not accepted because for its repair work the service of skilled engineers was difficult to procure.[290]

By 1911, fourteen boring machines were in operation in Kaira District.[291] This instrument was installed in those areas where farmers were in a position to do so as in case of *Patidars* of *Charotar*. But it was very expensive, and therefore, the ordinary peasants could not afford it.[292]

Tube-well and pump installation were very expansive. Those who tried with its introduction taking financial support often found themselves in debts. In order to pay off loan, the owners had to sell as much water as they could sell it to their neighbours. This practice led to excessive use of water and it was reported that the water level decreased rapidly.[293]

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[286] *Annual Report of Department of Agriculture of the Bombay Presidency* (1917-18), 8.
[287] David Hardiman (2006), *Histories for the Subordinated*, 348.
[288] *Ibid*.
[289] *Ibid*.
[290] "Papers Relating to the Second *RRSS* of Matar *Taluka* of Kaira Collectorate" (1900), *SRBG*, No. 579, NS, 4.
[291] David Hardiman (2006), *Histories for the Subordinated*, 346-47.
[292] *Annual Report of the Department of Agriculture of the Bombay Presidency* (1910-11), 13. Also see David Hardiman (2006), *Histories for the Subordinated*, 346-47.
[293] David Hardiman (2006), *Histories for the Subordinated*, 347.

The government expertise was also not available. There was general lack of trained engineers who could advice on these machines working on water resources. Even, the government never judiciously utilised their technical skills. Authority looked upon them for the construction of roads, railways, canals and survey works. The Corps of Engineers, the only agency at the disposal of the government was insufficient to meet the requirements not only of the Government but also for the natives.[294]

From the above discussion, it is well assumed that natives tried to practice traditional water harvesting system. They even did not hesitate to employ machines introduced in Gujarat for water requirement. Owing to its high cost, technical issues and expertise help made the acceptance of pumps difficult.

Animal Husbandry

Peasants were able to produce varieties of crops with enabled cultivators to maintain cattle stocks which could be used for tilling lands, providing manure for the fields, besides milk and *ghee* used for domestic purpose. As in case of high applause for agricultural practices of *Gujarati* peasants by the Britishers; the cattle received the same treatment.

Cattle

Reports of the Agriculture Department of the Bombay Presidency, *Gazetteers*, Correspondences, etc., do provide information about the cattle stock of Gujarat. Following description is furnished by J. B. Shukla: "In Olpad *taluka* in Broach, two cattle breeds are *talabda* and *sindhia*. Famous *kankerji* cattle of north Gujarat is admixture of foreign blood. People purchase bullocks from wandering *Sindhis* and *Rabaris*. *Sindhis* are basically broker and their breed are *mulvi* or cross *mulvi* from Rajputana. *Talabda* cattle are preferred as they are tall, strong and active compared to latter".[295]

[294] Satpal Sangwan (1991), *Science, Technology and Colonisation: An Indian Experience, 1757-1857*, 59.
[295] J. B. Shukla (1937), *Life and Labour in A Gujarat Taluka*, 145-46.

Rabaris were associated with cattle breeding and moved from place to place in search of pasture and grass for their cattle. They bred unconsciously by selection and by survival of the fittest with their understanding developed since generation. Best selected bull was used for mating purpose. Only healthy remained in the herd, sick and unfit were abandoned. Owing to religious objection, castration of bulls was forbidden among high castes.[296]

Upper castes did not practice castrating owing to their religious bias. Lower castes had no religious bias in castrating their animals, and therefore, cattle breeding were rendered by them. In one interesting case, two *Koli* villages of Karanj and Ichhapore in Olpas *taluka* approached the Athwa Agricultural Farm, Surat for the issue of breeding bulls developed in the farm. It was also reported that general neglect of cow was an important factor for its decline of good quality breed.[297]

There was some change in attitude among the high caste regarding the bias against castrating the cattle. *Patidars* of Gujarat had modified their caste rules so as to permit the castration of bulls.[298] The same community was also praised to excellent upkeep of the buffalo in *Charotar* and they were experts in feeding milch animals.[299]

Following were the causes for cattle disease in Gujarat:[300]

- Religious prejudice to slaughter of diseased cattle
- No attempt to isolate undesirable cattle from herd or castrate them
- Starvation of female stock and general neglect of bulls
- Little importance to selection of the sire
- Famines and shortage of fodder

Cattle disease was common phenomenon in British Gujarat. Subjects employed traditional remedies to control the various diseases.

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[296] J. M. Mehta (1930), *A Study of Rural Economy of Gujarat Containing Possibilities of Reconstruction*, 195-96.
[297] J. B. Shukla (1937), *Life and Labour in A Gujarat Taluka*, 150.
[298] G. Keatinge (1921), *Agricultural Progress in Western India*, London, 121-22.
[299] *Ibid.*
[300] J. B. Shukla (1937), *Life and Labour in A Gujarat Taluka*, 147-51.

Following were some of the traditional methods used in this regard:

English Name	***Gujarati* Term**	**Remedy**
Choking		Thrusting a strip of a palm leaf into the mouth
Cough	*Khamsi*	Giving paddy or leaves of bamboo or rubbing salt on the tongue
Diarrhoea	*Atisar*	Giving ash mixed with sour milk or plantains
Foot disease	*Kharva*	Pressing the foot of the animal in hot dust or tying a bandage of crushed tobacco leaves of pineapple plants round the feet
Hemorrhagic septicemia	*Galsuna*	Application of juice of *agpan* or *dormora*- kinds of trees
Infection of the Stomach	*Fugvu*	Giving liquor or eggs
Memities		Application of the juice of leaves of mango tree or rubbing that portion with silver or iron
Mouth disease	*Mova*	Giving boiled *tur* or rubbing the tongue with the bark of a babul tree or with the pulverized leaves of *chanothi*-a kind of vegetation
Skin disease	*Khujali*	Application of castor oil or sesamum oil
Tick fever		Giving toddy or alum water to drink
Timpanists	*Afro*	Rubbing salt on the back of the animal or giving salt water or cucumber water or juice of white onion or eggs
Verruca	*Mata*	Taking oath of the goddess supported to control the disease and giving boiled *tur* or *ghee*

Source: G. C. Mukhtyar (1930), *Life and Labour in A South Gujarat Village,* 146.

Fodder

Agricultural practices which were founded on good principals showed the best practice of farming and the care of the Indian husbandman to provide food for his laboring cattle. In Gujarat, hay was a regular crop, stacked and preserved and cut by reapers hook.[301]

In Nadiad, the cultivators did not use the village common land for their cattle. Every one of their fields was enclosed with a hedge and a headland of grass from fifteen to twenty feet wide all-round the field for producing capital grass. There were double object in this practice, for as the fields were hedged and had trees around

[301] Alexander Walker, "Indian Agriculture", in Dharampal (1971), *Indian Science and Technology in the Eighteenth Century:* S*ome Contemporary European Accounts*, 188.

them for supplying firewood and wood for implements, the people know quite well that crops would not grow when shaded, but grass would nurture. They obtained four or five cuttings of grass in the year as food for their cattle, and when the fields were empty the cattle were let in to graze on them. Same plan was adopted in Baroda.[302]

In dry season, fodder for animals was very difficult to obtain. That's why farmers also practiced mixed cropping for this, growing heterogeneous substances that were within his reach. Hay was made in stack and covered and protected by a movable roof. Sometimes, animals were fed with green grass like fiorin (used in England), pulse, carrot, etc.[303]

An indigenous gentleman, named Bappoo Mehta had sown clove with great success in Kaira. The seed was obtained from Bussara, Ahmedabad and produced abundant crop. It fed an entire cavalry regiment and kept it in an excellent condition.[304]

The cultivators of south Gujarat where *jowar* had overgrown in height cut the tops of *jowar* plants of convenient length and allowed the stubbles varying in length from four to six feet to remain in the field. These stubbles were first purchased, chaffed and fed to Amalsad and Surat Farms bullocks for several days.[305] When it was found that these well-fed cattle live on this stuff, the matter was brought to the notice of the Director of Agriculture who consulted the Commissioner in the matter and being assured by him as regards the supply of wagons, ordered the operations on a large scale for supplying the stuff to the famine-stricken districts. Accordingly, several power chaff-cutters were put at different stations on the BB&CI Railways and a total quantity of 1,754,189 lbs. of chopped stuff were supplied to famine-stricken parts in Gujarat north of the Narmada River.[306]

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[302] *Voelcker Report on Indian Agriculture* (1897), 174.
[303] Alexander Walker, "Indian Agriculture", in Dharampal (1971), *Indian Science and Technology in the Eighteenth Century: Some Contemporary European Accounts*, 188
[304] Satpal Sangwan (1991), *Science, Technology and Colonisation: An Indian Experience, 1757-1857*, 188-89.
[305] *Annual Report of Department of Agriculture of the Bombay Presidency* (1918-19), 34.
[306] *Ibid*.

The government were satisfied with the knowledge of fodder and its management during the time of scarcity by the natives. In the cases discussed above, the natives provided information to the government about the variety of fodder to be provided to the animals.

Dairy

It is reported that in Nadiad and Borsad *talukas* of Kaira District, there were ten and eleven creameries respectively during the first half of the 20th century, while the number of *bhathis* for the preparation of *mawa* in both these sub-divisions came to thirteen and six respectively. Polson and two dairies were in Anand.[307] In Anand, about fifty cream producing machines manufactured butter to Bombay and Ahmedabad. The Mission Hospitals and Dispensaries at Anand and Nadiad were large consumers of milk. In Anand, there were about thirty eight casein factories to manufacture casein.[308] The success secret of these creameries was good quality milk yielding cattle breeds. This was even attested by Voelcker.[309] He considered milk of Indian buffalo rich in yield and protein and fat compared to England's one. In Gujarat, milk cattle were much valued.[310] A cow would milk for seven months, giving 5 to 10 lbs. (2.27 to 4.53 litres) of milk a day and cost from Rs. 20 to Rs. 50. The buffalo was praised and being fed with oilcake, cotton seed and *jowar* fodders to keep in milk for eight months, giving for the first three months 20 lbs. (9.07 litres), the next 3/12 lbs. (5.4 litre) and the last two 6 lbs. (2.7 litre) of milk daily. Its value was from Rs. 30 to Rs.100.[311]

Mr. H. A. Howman, a well-known dairy farmer from Warwickshire, England visited India in 1889, who came out on behalf of the Dairy Supply Company Limited of London for the purpose of introducing the mechanical cream separators.[312] These

[307] J. M. Mehta (1930), *A Study of Rural Economy of Gujarat Containing Possibilities of Reconstruction*, 277.
[308] *Ibid*.
[309] *Voelcker Report on Indian Agriculture* (1897), 207-08.
[310] *Ibid*., 207.
[311] M. S. Randhawa (1983), *Agriculture in India*, 239-40.
[312] *Ibid.*, 241.

separators were of Swedish origin; the invention of Dr. Howman also took over with him a number of other applications for making butter.[313]

The following information is available about the method used in the preparation of *ghee* by the natives.[314] The milk of the cow was boiled and left to cool. A little sown milk was added and left for twelve to twenty hours in a brass vessel narrowed towards the top. After standing, the milk was by a stick with the constant action of the hands.[315] The butter came in about a quarter of an hour and was drained off on to a cloth. The butter was put into another brass vessel and kept over fire. With the action of heat, the water was evaporated. The residue obtained was *ghee* or native butter. It was largely used in cooking. It could be kept in good condition for a long time.

He showed that he could not only make *ghee* from the butter produced but that from the separated milk sweetmeats and curds could be made a perfectly well. The separation also gave in the form of freshly separated milk, a perfectly sweet and wholesale article of drink.[316] In England, the main difficulty with the cream-separators had been the utilisation of the milk and this was likely to prove the same in India. If the natives showed a readiness to take it, either for drinking or for manufacture into sweetmeats, thus obstacle might be overcome, but not otherwise. It was however; when Mr. Howman put himself into competition with the skilled *ghee* makers, he failed in showing that he could produce more *ghee* than the native manipulator. He could always get more butter, but in turning it into *ghee*, the native's excelled.[317]

It was one of the important subsidiary industries. By 1926, there was one milk buffalo per 7.3 acres of cultivated land in Kaira and 11 acres of cultivated land in Ahmedabad and Surat. These centers compared quite favourably even with

[313] *Ibid*.
[314] *Ibid.*
[315] *Ibid.*
[316] *Ibid.*
[317] *Ibid.*

Denmark which had one cow for six acres. Kaira had the greatest possibilities for the development of a dairy industry.

The success of this industry (milk, butter and *ghee*) depended on co-operative organisation. In many villages in *Charotar*, these were cream separators and the cream after separation was exported to Bombay and Ahmedabad where it was made into butter. Before Australian competition stepped in India, butter was exported to Ceylon, Japan and Strait Settlements. Gujarat was known for its *ghee.* Quite some portion of it was locally disposed of by the farmer. Mehmadabad in Kaira District exported *ghee* valued at Rs. 2,00,000.[318] Nadiad produced *ghee* worth Rs. 16,000 every year.[319] It was one of Gujarat richest industries with great possibility of future development. In Borsad *taluka* in Kaira, more than 70% of the subsidiary income came from cattle and the farmers were enabled to carry on agricultural despite its un-remunerative character.[320] The following prediction comes true after the Independence of the country. Anand now itself emerged as a District is well known for the production and supply of milk all over India and abroad. Anand Milk Union Limited popularly known as AMUL and monitered by National Dairy Development Board, a Central Government Agency is doing remarkable business in the production of milk and its ancillary products. The success of Anand is because of the co-operative initiatives of the milkmen, entrepreneurs and the government body. Dr. Vergise Kurien, noted scientist was well known for his valuable effort for making Anand as the leading supplier of milk products in India.

Mava was another important product chiefly made from milk, which was milk boiled down and condensed and used in the manufacture of native sweets.[321] The manufacture of cream far export was a new industry introduced since 1890, at local exhibition; the Swedish cream-separator was exhibited. In Nadiad, there were two large separates, which used up daily 3,200 lbs. of milk. The cream was sent to Deesa and Bombay and the separators milk to Ahmedabad and Baroda. Beside, the

[318] R. D. Choksey (1968), *Economic Life in the Bombay Gujarat, 1800-1939*, 225.
[319] *Ibid*.
[320] *Ibid*.
[321] "Papers Relating to the *RRSS* of Nadiad *Taluka* of Kaira Collectorate" (1895), *SRBG*, No. 295, NS, 8.

Nadiad town separators, there were two machines at Utarsanda and one in Chaklasi. They supplied milk and cheese to the Prince of Wales Dairy Company in Bombay.[322]

British Government and Animal Husbandry

In 1902, the Indian Civil Veterinary Department was established by the permanent transfer of seventeen officers from the Army Veterinary Department to the Civil Department; and the appointment by the Secretary of State for India of four civil officers recruited in England.[323] This method of recruitment by the Secretary of State for India or by local appointment remained in force till trend of the British rule in India. In spite of these additions to the staff, complaints were still being made that, owing to a shortage of officers insufficient attention was paid to cattle breeding. The Inspector General in his Report of 1902, pointed out that the demand for balls could not possibly be met from the only two farms under his control, namely that at Hissar in the Punjab; and that of Chharodi in Gujarat, latter was established to save the famous Kankrej breed in verge of extinction owing to famine.[324]

British government was not seriously interested in the development and growth of animal husbandry. Such great handicap clearly shows the seriousness of the government regarding the improvement of animal stocks in India. In a half-hearted effort, a cattle farm was established at Northcote Cattle Farm at Chharodi in Ahmedabad. (**see Map IV**)

Government was not happy with the cattle breeds in Gujarat. It decided and instructions to various District Local Boards were sent by the Government of Bombay since 1861 to propagate '*Bahamni* bull' among the people. It was an ancient practice of natives in Gujarat of dedicating a bull to the God and it was publically feed. Unfortunately, it was on the verge of decline and even the efforts of the government for its revival failed in their attempt. The establishment of Veterinary Department and expertise help, number of cattle was crossed to suit the specific purpose. It was decided to distribute these stocks to the natives. In 1907, the Civil

[322] *Ibid*
[323] M. S. Randhawa (1983), *Agriculture in India*, 244.
[324] *Ibid*.

Veterinary Department started giving crossed bulls to the natives for breeding purpose. In 1918, a new section for cattle breeding was started under the Agricultural Department and a Special Deputy Director of Agriculture for animal breeding was appointed. The Northcote Cattle Farm at Chharodi was put under his supervision. It was originally started as a preservation society in the famine of 1899-1900.[325] In 1907, it was put under the government management.[326] In 1918, it was transferred from the veterinary department to agriculture department.[327] In 1921, forty nine of the best cows were taken in hand and attempts were made to improve their milking qualities.[328] *Panjrapoles* and *gaurakshaks* were being used for the improvement of breed. The veterinary department started inoculation to prevent diseases.[329]

The government farm at Chharodi, Swaraj *Ashram* at Sabarmati in Ahmedabad and farm in Surat had achieved valuable results to this end and continued vigorous efforts not in this direction alone but also towards popularising the stock.[330]

Voelcker was in favour of crossing Indian cattle with English bulls. The objective was to produce cattle suited for work, and not, as in England to produce either meat or milk. At the Bhadgaon Farm (Bombay Presidency), he saw a bullock crossed between Mysore cow and a Shorthorn bull, a big and beefy animal, ate great deal, but was not adopted for ploughing.[331] He requested officers of the Military Department who attained knowledge in animal breeding at cattle farm should not be transferred; only those officers would be appointed to this skill who had sound knowledge of animal breeding.[332]

He was impressed by the breeds of Gujarat and suggested for cross-breeding. Gujarat, Sind and Nellore cows were noted for their milking properties. Gujarat cows

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[325] J. M. Mehta (1930), *A Study of Rural Economy of Gujarat Containing Possibilities of Reconstruction*, 198.
[326] *Ibid*.
[327] *Ibid*.
[328] *Ibid*.
[329] *Ibid.*, 199.
[330] *Ibid.*, 226.
[331] *Voelcker Report on Indian Agriculture* (1897), 200-01.
[332] *Ibid*., 204.

were used for crossing at Hissar Cattle Farm, Haryana and at Poona investigation was carried out about its milk producing properties.[333]

Cattle in India and Gujarat in particular were not used as meat because of the bias prevailing among the natives. Large part of the Indian population consisted of vegetarians and for the rest; the consumption of meat was minimal per head. The production of cattle and even of sheep for meat was extremely limited. Ignoring the use of cattle as meat, animal husbandry in Gujarat concentrated on use of animals in agricultural work, obtaining milk, etc. Sheep and goats were often domesticated to obtain wool, skins and sometimes for meat consumption.[334]

In 1882, the *Quarterly Journal of Veterinary Science and Animal Management in India* was started.[335] This journal was the first veterinary periodical to appear in India and it also claimed to be the first veterinary journal in the world to deal with the Military Science.[336]

Organisation of Agriculture on Colonial Pattern

Early Initiatives: Botanical Gardens

Introduction of Western / European science in India was not uniform, well planned and implemented with serious efforts. It is well known fact that they needed raw material for its industries in England. Therefore, in a systematic way, Indian agriculture was commercialised to fulfill the colonial demands. In India, various agricultural policies; establishment of institutions; educational structures; etc., were mainly guided by the commercial motives of the Britishers.

European science in India was not introduced on uniform scale. Only those branches were introduced which help them to rule the country. Botanical, Geological

[333] *Ibid*., 206-07.
[334] H. H. Mann, *The Social Framework of Agriculture: India, Middle East and England*, ed. by Daniel Thorner (1967), 290.
[335] M. S. Randhawa (1983), *Agriculture in India*, 191.
[336] *Ibid*.

and Geographical Sciences were given top priority. On contrast, Agriculture, Physics, Chemistry and Zoology remained less attended.

The Great Trigonometrical Survey of India was established in 1818 to tap colony resources.[337] Unfortunately, it was turned into a Revenue Survey Department which changed its basic functioning. Many of its officers were transferred to different departments. One of its dynamic directors, Medlicott was made inspector of schools. Next in line, T. Oldham tried very hard to maintain its originality, but he completely failed to do so.[338] He proposed to offer scholarship to the students of Calcutta University to join the Department as apprentices. His proposal was vetoed by the Finance Department and the initiative did not materialise. Even his idea of sending his officers to foreign for higher learning met with same providence.[339] Botanical Survey lost its original task. Its officers were attached to Revenue, Agriculture and Forestry Departments. Brandis and Gamble who were botanists were assigned with the task to manage the forests.[340] Botanical Garden maintenance and its upkeep remained under the provincial control, but botanical research was under the imperial control. In the same fashion, the Principal of Poona College of Science who belonged to the Education Department was entrusted with the task of supervising whole of the Bombay Presidency including Sind. He was not able to discharge his duties properly under the administrative burden and his expertise to introduce initiatives remained in bud.[341]

The first noticeable episode in the development and introduction of plants within and outside India was the establishment of botanical gardens in Calcutta. Later on, it was followed by Bombay and other Presidencies. Nathanial Wallich (a Danish) was appointed at Botanical Garden, Sibpur near Calcutta. He had worked as per the requirements of the government and was never given free hand to go beyond the scope of the EEIC.[342] His task was merely to collect new flora and sent the

[337] Deepak Kumar (2006), *Science and the Raj*: *A Study of British India*, 74. Also see Manosi Lahiri (2012), *Mapping India*, Delhi, Niyogi Books, 29-32, 157-62 & 301-02.
[338] Deepak Kumar (2006), *Science and the Raj*: *A Study of British India*, 77.
[339] *Ibid*.
[340] *Ibid.*, 79.
[341] *Ibid.*, 83-84.
[342] *Ibid.*, 38.

results to the Royal Botanic Garden, Kew. Deepak Kumar opined: "The Indian produced knowledge was transformed unilaterally to England without acknowledging the colony".[343] For the Calcutta Botanical Garden, Robert Kyd imported sage tree, Persian date tree. Dr. Roxburgh introduced Cape wheat from the Cape of Good Hope. Seeds of some improved food grains like wheat, rye, maize and cork were tried.[344] The Bombay Botanical Garden was established in 1791 with the aim of conducting experiments in the cultivation of sugar, indigo, tobacco, coffee etc. [345]

William Moorcraft introduced the cultivation of oats into India for the first time in 1816. Nutmeg was introduced in the Calcutta Botanical Garden. Cinnamon was introduced in the Garden from Ceylon, camphor tree from Cape of Good Hope, Benzoin tree from Sumatra, etc. Flax, hemp, rhea, tobacco, henbane, vanilla, coffee, Indian rubber, Japanese mulberry, cardamoms, tapioca and cocoa were introduced.[346] The sketches of Indian flora and fauna were drawn by the Indian artists and many learned *pandits* were employed for the compilation of books which were later published in Britain. Colony proved to be a vast store house for the Britishers.

Besides government, the name of William Carey, a missionary in Bengal is very important. Being an amateur, he tried individually of agricultural improvement and his effort led to the establishment of the *Agri-Horticutural Society* (*AHS*) *of the Eastern India* in 1820. He started his Botanical Garden at Madnavati near Malda, Calcutta. He suggested all kinds of information about Indian agriculture; improvement of agriculture by the use of better manure; rotation of crops; irrigation; drainage and scientific agricultural implements; improvements of cattle and bringing uncultivated land under cultivation. In his herculean efforts, he was helped by the government and various agricultural fairs were organised. His efforts led to the introduction of science subjects in Serampore College of Bengal. He also opened a printing press which published books. But he did not encourage the study of science

[343] *Ibid.*, 37-39.
[344] Satpal Sangwan (1984), "Science Policy of the East India Company in India", in A. Rahaman (ed.), *Science and Technology in Indian Culture*: *A Historical Perspective*, 173.
[345] Zaheer Baber (1998), The *Science of Empire: Scientific Knowledge, Civilisation and Colonial Rule in India*, New Delhi: OUP, 165-68.
[346] M. S. Randhawa (1983), *Agriculture in India*, 40-47.

from the native point of view. Even he criticised Indians for lacking understanding about the agriculture. It shows his limited understanding of the potential of the Indian farmers which they inherited since antiquity; were known for production of a variety of crops which sustained directly or indirectly some of the great civilisations of the world.[347]

From Mayo to Curzon: Dream of Integrated Agriculture Department

Agriculture was the most disorganised sector compared to the other departments under the British government. It received less priority and financial resources, and therefore, did not attract talent. But government derived maximum revenue from agriculture without its upgrading and improving, and left in the hands of private agriculturist's societies. The government responded only when criticised by the *Famine Commission* of 1866, 1880 and 1901.[348] On the recommendation of the *Famine Commission* (1880), Provincial Agricultural Departments were established with limited budget. In the absence of sufficient staff and specialists in agricultural and its allied sciences, these departments became ineffective for agricultural progress and innovation. The government preferred to depend on traditional agencies like the Agricultural and Horticultural Society of India rather than to introduce novelty.[349]

The following information is provided by M. S. Randhawa[350] about the story of the establishment of the agriculture departments in India:

The Earl of Mayo (Governor General of India, 1869-72) had an agricultural background and was a practicing farmer in Ireland.[351] He must be considered as the first authority who was serious about the development of a systematic agriculture department with adequate staff, sufficient fund and team of experts. He encouraged the digging of canals and organised a Department of Knowledge and Statistics, Animal Husbandry, Fisheries and Forests in the GOI. In his vigorous effort, he was

[347] Chittabarta Palit (2006), *Scientific Bengal: Science, Technology, Medicine and Environment Under the Raj*, Delhi, 43-47.
[348] Deepak Kumar (2006), *Science and the Raj*: *A Study of British India*, 96.
[349] *Ibid.*, 96-97.
[350] M. S. Randhawa (1983), *Agriculture in India*, 175-82.
[351] *Ibid.*, v.

assisted by civil servant A. O. Hume. Hume is best known as the founder of Indian National Congress (INC) in 1885, but he was more inclined towards agriculture improvement and his love for Ornithology.[352] Their joint efforts proved vital for the future of Indian agriculture. They failed to organise a Department of Agriculture in GOI owing to opposition from the conservative colleagues; but their effort led to organisation of agriculture at the center and in the provinces in due course of time, but with limitation and burden to extract maximum revenue. The American Civil War forced the Manchester lobby to put pressure on the Secretary of State for India to improve cotton staples of India to fulfill their demand for scarcity of cotton.[353] Secretary of State for India asked Governor General Mayo to start cotton improvement plan. Mayo sought opinion of his officers to open an Agriculture Department. He was not supported by the higher authority. He was adamant and proposed to open Agriculture Department at center and provinces under the Director General of Agriculture. Secretary of State for India objected and called to put it under Revenue Department including a Director General and seven directors and their staff offices, forty model farms with schools or colleges.[354] The scheme did not materialise as funds were not sanctioned. It was handed to Additional Secretary and put under the control of Revenue Department. No scientific officers were employed either by the GOI or by the provinces; and it became merely a collection of statistics. After Mayo assassination by a *Pathan* criminal, Hume who was in charge of the office of Revenue, Agriculture and Commerce was transferred to Allahabad and hence, the great idea of Mayo and Hume could not take shape.[355] But their dream never vanished. With the arrival of Lord Curzon in 1898, he decided to introduce some remarkable administrative decisions for the improvement of agriculture departments. With the monetary help from an American philanthropist, Henry Phipps, Curzon decided to establish a laboratory for agricultural research at Push in Bihar.[356] The spirit shown at Pusa led Curzon to make more ambitious plans. In 1905, he proposed to establish in each important province an agricultural college and research station, adequately equipped with laboratories and staff consisting of an

[352] *Ibid*.
[353] *Ibid.*, 175-76.
[354] *Ibid.*, 182.
[355] *Ibid.*, 184.
[356] Deepak Kumar (2006), *Science and the Raj*: *A Study of British India*, 90.

expert agriculturist, economic botanist, etc.; but the idea was vetoed by Morely, Secretary of State for India. In the first quarter of the 20th century, leadership in agricultural research was provided by the British scientists at the Imperial Agriculture Research Institute, Pusa.[357] The most prominent among them were persons namely Sir Albert Howard who worked on wheat. Joh Walter Leather who developed soil science, Harold Maxwell-Lefroy and Thomas Bainbridge Flutcher worked on Indian insects and pests and Sir Edwin John Buther work on fungi. There findings are still considered as classic studies.[358] Later on, Indian scientists were trained under the guidance of British scientists. Sir T. S. Venkataraman worked with Dr. C. F. Barber and at Coimbatore they involved hybrid canes which made India self-sufficient in sugar. Ram Dhan Singh and Dr. B. P. Pal, who had worked with Sir Albert Howard at Pusa, made a distinguished contribution in wheat-breeding.[359]

With the establishment of Pusa Institute a new atmosphere was created for serious research to improve the Indian agriculture. It started five sections namely Chemistry, Agriculture, Cattle Breeding, Economic Botany, Entomology and Mycology. The institute attracted five British scientists, viz., Albert Howard, Edwin John Bulter, Harold Maxwell Lefroy, Thomas Bainbrigge Fletcher and John Walter Leather.[360] In 1905, Howard was appointed Imperial Economic Botanist at Pusa. He made outstanding contribution to the selection of wheat strains, known as Pusa wheat, to soil studies in relation to the root systems of crop plants and he pointed out the importance of organic manures, composites and green manure.[361] In 1914, he took a leading part in founding the Indian Science Congress (ISC) for which he was elected President in 1926. **Howard greatly admired Indian peasants' skill for mixed cropping**. He noticed that leguminous crops, such as chickpea and pulse were often grown mixed with wheat. The wheat crop benefited from the nitrogen fixed by the bacteria in the nodules by the leguminous crops. He arranged an experiment in 1915 to test this observation.[362] A field wheat was sown, three lines of wheat separated by one line of chickpea, a pulse, the superior growth of the two outside

[357] *Ibid.*, 91.
[358] *Ibid*.
[359] *Ibid*, 90-91.
[360] M. S. Randhawa (1983), *Agriculture in India*, 303.
[361] *Ibid*.
[362] *Ibid.*, 308.

lines of wheat which were next to the lines of gram was so marked that weighting of grain were made when harvest came round; the result showed that the outer lines of wheat gave a harvest 34% higher than the inner lines.[363]

T. B. Fletcher (Imperial Entomologist since 1913) mentioned how exotic pests and diseases were carried along with different materials. It was due to his efforts that the Destructive Insects & Pests Act, 1914 was passed as a measure against the introduction of noxious insects into India.[364] Most of these scientists received their higher degree in Germany and not in England.[365]

Establishment of Agriculture Department in the Bombay Presidency: Poona as Focal Point

Agriculture research was done by the Agri-Horticulture Departments under limitations. Death cry of Mayo-Hume and urgent need for agriculture improvement by the *Famine Commission* (1880) forced the GOI to introduce a number of initiatives for its progress to control famines. In a disorganised way, agricultural departments were opened in the various presidencies with limited staff. In terms of the western India, an agricultural unit was opened at Poona in 1879 which made important experiments in cotton and plough technology. Agricultural classes were opened at Sibpur (Madras) and Kanpur. But these half-hearted attempts had neither an all India perspective nor sufficient research orientation.[366]

In the Bombay Presidency, a Director of Agriculture was appointed in 1883. J. M. Mollison, a Canadian became the first of its Directors and carried out major efforts for improvisation in agriculture. Next important figure was well known Dr.

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[363] *Ibid*.
[364] *Ibid.*, 323.
[365] *Ibid.*, 330.
[366] In 1865, Madras Government established an experimental farm at Saidpet to afford facilities for testing the merits of life known machines, implements, manures, crops, systems of culture, livestock, etc. Due to the effort of R. Temple, an agricultural class was opened in Poona Civil Engineering College (1879) and such classes were also opened at six of the principal *zilla* schools. Temple had faith in the native people regarding agriculture. He even proposed to conduct a degree course in agriculture but Bombay University only agreed to give diploma. *Famine Commission* (1880) proposed to train ICS probationers in Agriculture College which was strongly refused by GOI and Secretary of State for India equally. See Deepak Kumar (2006), *Science and the Raj*: *A Study of British India*, 90, 125-126.

Harold H. Mann. Dr. Mann got his B. Sc. Degree from Victoria University of Manchester in 1892. He was Chemical Assistant for research under Voelcker and organised the laboratory and 'Pot Culture' station at Woburn in 1898. He came to India as the first Scientific Officer of the Tea Association in April 1900. In 1907, he was appointed Principal of the College of Agriculture at Poona.[367] In 1921, he became the Director of Agriculture, Bombay Presidency.[368] Experimental stations were opened in Gujarat in the five districts at Viramgam in Ahmedabad, Nadiad in Kaira, Dohad in Panch Mahals, Broach and Surat (**see Map IV**) under his instruction and guidance.

Dr. Voelcker a Miracle Man: British Government Found an Agriculture Magician?

Dr. Voelcker, expert in agriculture science, was sent to India in 1890 to report on the state of Indian agriculture. He pointed out the absence of technical expertise in agriculture departments. He recommended the separation of agriculture from Land Records; and that it's Director and Assistant should have expertise. He also recommended that they should not be civilian on the pattern of Geological, Botanical and Metrological Departments. As a result of recommendation, Curzon initiated an Indian Agricultural Service in 1906 with technical knowledge in agriculture as a mandatory measure.[369]

Dr. Voelcker criticised the government's attitude towards Indian agriculture. He was convinced with the "agricultural skills of the natives" best suited with the environment.[370] He attacked Madras Government for deteriorating the Saidpet Agriculture College. He was dissatisfied with the syllabus taught there which was modelled on the European system and not on Indian experiences.[371] For example, pairing, burning and warping of land were mentioned; manures such as sulphate of ammonia, dried blood-soot and artificial manures were the part of books. Surprisingly, none of which had any place in Indian agriculture. In another example,

[367] M. S. Randhawa (1983), *Agriculture in India*, 190.
[368] *Ibid*.
[369] Deepak Kumar (2006), *Science and the Raj*: *A Study of British India*, 101-02.
[370] *Ibid.*, 128.
[371] *Ibid*.

fattening of animals was not practiced in India, but these were taught. On the other hand, Indian expertise in agriculture was omitted, such as canal and well irrigation, oilcake refuse, *ghee*, etc.

In order to take advantage of Dr. Voelcker's advice, in 1890, a conference of Directors of Agriculture was called upon and it was decided that higher agricultural education should be developed from the knowledge acquired from the local farmers to be incorporated into agriculture departments.[372] In general, agriculture became an optional subject. Agriculture classes were began in some *zilla* schools but they collapsed as it was not included in the syllabus for the university entrance examination. Calcutta University was not in favour of affiliation of agricultural colleges as they thought that natives who would twin the training received to profit in private farming or estate management. Shimla Conference (1901) on agricultural education recommended vernaculars as the medium for agricultural education.[373]

Following estimate was predicted by A. W. Thomson that Manchester used to spend £ 300,000 on one school and this was about twice the annual provincial grant of education in the whole of the Bombay presidency. Introduction of agriculture in educational structure was mere a wish. There were no serious efforts made in this regard for its systematic dessesimation into the thought process. Like Indian nationalism against the British rule, agricultural education was an unwanted and neglected child.[374]

Colonial Agricultural Education

Between 1835 and 1856, English medium schools were opened in British Gujarat. School at Surat and Ahmedabad offered higher education up to the college entrance standard.[375] Poona College and Elphinstone College in Bombay were two centres for collegiate education. The London Missionary Society established and

[372] *Ibid.*, 129.
[373] *Ibid.*, 129-31.
[374] A. W. Thomson (1901), *Report on Technical Education in Primary and Secondary Schools*, 2. Also see Deepak Kumar (2006), *Science and the Raj*: *A Study of British India*, 128, 149.
[375] S. N. Sen (1991), *Scientific and Technical Education in India, 1781-1900*, New Delhi: INSA, 166.

patronised a private school at Borsad.[376] Irish Presbyterian schools in Gujarat and Saurashtra were established for giving vernacular education. The general subjects of study in the high schools included Indian and English History, Geography, Grammar, Geometry, Algebra, Trigonometry and Astronomy.[377] Chemistry, Botany and Geology were occasionally taught in the Elphinstone College. In 1854-55, Herbert Girand was Professor of Chemistry, Botany and Geology. Dadabhai Naoroji taught Mathematics and Natural Philosophy at the same college.[378]

Agricultural education did not appear to have received sufficient attention in the beginning of the 19th century as it was attached with institute as subsidiary wing. The engineering college at Poona (Kirkee) had an agricultural wing (1879). In 1877, the government accorded the rightful place to agricultural education as it did for the other subjects.[379] The importance of agricultural education was stressed by the Agricultural Conference (1888). The Bombay University was the first to recognise agriculture as a separate subject for award of degree examination. Even so, it was only in 1905 that steps were taken for starting an agriculture college at Poona.[380]

Poona College offered three year diploma course in agriculture.[381] The course on agriculture proper comprised soils; manures; implements and machines; crops; irrigation; cattle physiology and anatomy of farm animals; management of farm animals and parasites. It had a veterinary hospital and bacteriological laboratory for the study of cattle diseases.[382] Voelcker visited the College and found that the course was drawn on English model. He suggested that the students should concentrate more on the practical side of agriculture by one of the three ways:[383]

- Working on a farm
- Having a portion of land attached to each student which he could cultivate
- Spending a certain part of their time at large farm at Bhadgaon

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[376] *Ibid.*, 167.
[377] *Ibid*.
[378] *Ibid.*, 176.
[379] B. V. Subbarayappa (1971), "Western Science in India up to the End of the 19th Century", in D. M. Bose, et. al. (eds), *A Concise History of Science in India*, New Delhi: INSA, 554.
[380] *Ibid*.
[381] S. N. Sen (1991), *Scientific and Technical Education in India*, *1781-1900,* 449.
[382] *Ibid*.
[383] *Ibid.*, 450-51.

The Baroda College also introduced an agricultural branch of collegiate education in agriculture headed by T. H. Meddleton, a qualified agriculturist specialised who had studied at the Edinburg University and had a professorship in agriculture. The Bombay University recognised the college for training students for diploma in agriculture.[384]

Surat and Nadiad High Schools established 'Model Farms' and ran agricultural classes. The subjects included Chemistry, Botany, Physical Geography, Geology, Agriculture and Surveying. Voelcker visited Nadiad School and reported as follows: "At Nadiad the Agricultural class is attached to the high school, agriculture being an optional subject in the school. The farm of the Nadiad Agricultural Association is utilised for the instruction of the class".[385]

According to Volecker, agricultural education was theoretical and students did not practice on lands. Even qualified students who received degree in agriculture chose government jobs and seldom showed their willingness for agriculture service. He requested that various universities should go for degree course in place of diploma. Each college should be provided with a demonstration farm where the students could see and cultivate of different crops. For the agriculture schools, he recommended that each one had an illustration farm and text books should be component of agricultural knowledge largely drawn from Indian environment. Regarding the text books he was not happy with the text books used (Wrightson's *Principles of Agricultural Practice*, Warrington's *Chemistry of the Farm,* Johnston and Cameron's *Agricultural Chemistry and Geology*) as these were based on the European agriculture system lacking Indian component and often misleading the students. He recommended J. B. Fuller's *Agricultural Primer* book for study which was later translated in vernacular language for the benefit of the students.[386]

[384] *Ibid.,* 451.
[385] *Ibid.,* 452-53.
[386] *Ibid.,* 465-68.

Edward Buck, Secretary to the GOI suggested taking landowners on tours to visit agricultural farms, horse breeding establishment, dairy farms, forests, irrigation works, etc., would improve the practical knowledge of the students[387]

The District Agriculture Overseer, Godhra remarked that despite inferior caliber of the *Bhil* and *Patelia* boys, they had shown their aptitude for the agricultural subjects.[388]

Vernacular Agriculture School in the limits of Ambali village in Godhra with 30 acres donated from Mr. Rustomji Dalal (Parsi), the school began working from 1st June, 1920 with 20 students and curriculum was based on those of Loni School in Poona. It received Rs. 500 from the Trustees of the Sir Sassoon David Trust for boarding expenses and Rs. 120 from Rustomji Dalal.[389]

A batch of farmers were transferred to Nagpur and their skills and openness against prejudice led to the increase of yield and gradually local farmers started adopting their industry and even Brahmins took to learn the art from them.[390]

Agriculture Department in British Gujarat: Experiential Stations

The constitution of the Famine Commission (1880) recommended the opening of agricultural departments in the provinces on urgent basis. The GOI appointed noted agriculture scientist Voelcker to suggest various suggestions to improve the state of Indian agriculture. Following his publication of report, experimental stations were opened in Gujarat at Surat, Broach, Viramgam, Nadiad and Dohad under the control of Poona Agriculture College. Technical experts along with staffs were appointed with adequate land and resources. In the ongoing study, it will be clear that under limitations still these farms did valuable jobs in the introduction and development of hybrid varieties crossed with local strains. All of these farms were managed by the Superintendents who were mostly Indian.

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[387] *Ibid.*, 473.
[388] *Annual Report of Department of Agriculture of the Bombay Presidency* (1919-20), 45.
[389] *Ibid.*, 59-60.
[390] *Voelcker Report on Indian Agriculture* (1897), 22.

Following were the agricultural farms established in Gujarat:[391]

- Broach Farm: Breeding pure strains of cotton and *jowar*; study of *jowar* borer, experiment on Kankrej cattle for milk property
- Nadiad Farm: Developing pure strains of tobacco
- Viramgam Farm: Propagation of improved cotton
- Dohad Farm: Wheat experiments and crops suitable for irrigation
- Amalsad Farm at Surat: Study of Red Rot of Sugarcane and introduction of varieties of sugarcane

The establishment of these farms in the beginning of the 20th century opened a new era of serious research. More number of seeds and plants were introduced from outside. The farms became operational to discharge its initiatives for systematic activities for propagation of plants, introduction of tools and implements, disease control, demonstrations and other propaganda. The appointment of experts and skilled staffs with financial aid created an atmosphere for judicious use of the farms. In the decades after their establishments, following seeds were tried and hybrids were developed.

The important cash crops like cotton, tobacco got the top priority compared to other crops as per the demands of the government. Surat, Broach and Viramgam experimental stations developed cotton staples of *vijaya*, *suwag*, B. D. 8, B. D. 4, B. 9, 1027 ALF and IA varieties to replace indigenous *wagad*, *kamani*, *rozi*, *goghari*, etc. These were diseases resistant with long staple but yield was low. Experiments Farm at Nadiad worked on improving upon the indigenous varieties of tobacco such as *gandiu*, *movadiu*, *piliu* and *khakhari* for *bidi* making. Virginia tobacco was tried on experimental basis in Bajwa, Baroda and Nadiad for cigarettes and cigars. Sugarcane and groundnut were generally neglected. A disease resistant high yielding *jowar* propagated from Surat Farm did find the support of the farmers.[392]

Surat

Surat Agriculture Station was established in 1896. Night soil was tried and proved good yield when tried for cotton and *juwar*. Rotted cactus manure was also tried. It was made from fresh cactus cut and buried in a pit a full year. But it was

[391] *Annual Report of Department of Agriculture of the Bombay Presidency* (1922-23), 16.
[392] J. M. Mehta (1930), *A Study of Rural Economy of Gujarat Containing Possibilities of Reconstruction*, 77-78.

costly compared to farmyard manure. Ammonium sulphate was tried on Broach *desi* cotton and Perrio *jowar*.[393]

At Amalsad Plot in Surat which was especially reserved for sugarcane experiments, nine varieties of canes namely *malbari*, *pundya*, stripped Mauritius, *baungdya*, Bassein Red, J. 247, *manjar*, Red Mauritius and *khadya* were tried.[394]

Broach *desi* cotton was tried over the years on Broach farm and *surti-deshi* (cotton) at Surat Agriculture Station.[395]

The station observed that cotton was deeply sown it yield decreased owing to high moisture content. Therefore, shallow cultivation was promoted for cotton cultivation. In case of *jowar* the case was opposite.

Various oil yielding plants were introduced and trials were made. Virginia, Japanese big and Pondicherry yielded more oil, ripe early and seed in comparison to husk to the local varieties. Senegal and Mozambique were introduced. Application of lime to *chick tikka* disease was not effective.[396]

Eight new varieties of groundnuts-Java, East Africa, Egyptian, Brazil, Barbados, Mauritius, Mozambique and Senegal were tried and last two results were positive. Seventeen varieties of *tuver* were tried: Bilaspur No. 1, 2 and 3; Sambalpur No. 4,5,8,9 and 10; Bangalore, Variegated, Bellari No. 35, 40, 43; Arhar, Nadiad Red and White and Khandesh early. Best were Bilaspur 1, Sambalpur, Bangalore and local proved positive and tried for cross breeding.[397]

Others varieties tried were *tali*, *saidi* beans, *chavli*, lucrane seed-Turkish *alfalfa* (imported) and from Montana, Texas and Etah were tried. Out of 279 *jowar*

[393] *Annual Report on the Experimental Work of the Surat Agriculture Station* (1906-07), 8-9.
[394] *Ibid.* (1918-19), 29.
[395] *Ibid*.
[396] *Ibid*. (1906-07), 21-22.
[397] *Ibid.*, 24.

varieties only 4-Lalu, Egyptian White and Red were positive and tried for cross breeding.[398]

At Surat Station, cotton was attacked by locally known '*Dahido-amite*'. Stem borer was found in *chavli*. *Tal* was attacked by caterpillar and young *jowar* were attacked by beetles.[399]

Mr. Bhiambhai Morarji Desai, an Indian was Surat Agriculture Station Superintendent. On 8th November, 1908, a large demonstration was organised by him at Surat to show the cultivators important activities of the farm, implements, machinery and management of dairy. He also assisted the department for agricultural shows at Nadiad, Dharwar, Ahmedabad, Godhra and acted as judge for Ahmedabad Horse and Cattle Show. He was asked to advise to open a farm at Balasinor State in Gujarat.[400] Owing to his extra work, a post of Divisional Inspector of Agriculture was created to coordinate with all Agricultural Associations.[401] Mr. Kulkarni was cotton supervisor and in charge for cotton experiments at Farms at Nadiad, Dohad and Dhulia and a new experimental plot at Navsari. Mr. Kulkarni made cotton experiments at Eru village in Navsari.[402]

Nadiad

It can be speculated that cured leaf of tobacco from Nadiad farm was demanded by cigarette manufacturers in Bombay. Samples were also sent to Indian Leaf Tobacco Development Company, Chirala, Madras; Messers Cox & Kings, London and the Bureau of Agricultural Economics, Department of Agriculture, USA.[403] All these institutions reported very favourably and the Bureau of Agriculture Economics appreciated samples of White Burley to be the best, and recommended its cultivation in Nadiad. The Bombay merchants were willing to enter into a contract for purchasing up to eight lakhs lbs. of this sort of leaf. The cultivators were showing interest for its cultivation it. Tobacco leaf was liked by

[398] *Ibid.*, 25.
[399] *Ibid.*, 26.
[400] *Ibid.* (1908-09), 1-2.
[401] *Ibid*., 3.
[402] *Ibid*., 16.
[403] *Ibid*. (1937-38), 176.

cigarette industries but Nadiad still required some improvements in flavor and sweetness.[404]

Dohad

Dohad Agriculture Station was established in October, 1906 and was situated at a distance of three miles to the south of Dohad Railway Station of the Godhra-Ratlam Railway.[405]

Mr. Gulabbhai N. Desai was the Superintendent-in-Charge of the farm in 1910-11.[406] He gave advice to neighbouring cultivators and assisted in carrying out demonstration at Ahmedabad and Dohad.[407]

Following exotic seeds of wheat were introduced, viz., Indo-Australian wheat, Australian 27, Macaroni, etc. Latter proved superior to local wheat *wagia*, *pissi*, *dhola katha*, etc. Famous Federation Wheat of Australia was also tried, but with limited success. The next step was selection. Best seeds were collected from the selected wheat plants (propagation[408]). Seeds were also collected from rust free plants. Cross wheat method was also applied and only two of these survived.

Following were crossed:[409]

a) *khapli* × *dhola khata*
b) *lal katha* × *khapli*

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[404] *Ibid*.
[405] *Annual Reports on the Experimental Work of the Dohad Agriculture Station* (1910-11), 1.
[406] *Ibid*., 2.
[407] *Ibid.*
[408] Propagation means selecting best seeds, plants or samples from the planted ones. In modern times this has been replaced by micro propagation. In this process, the best seeds are treated in test tube in a laboratory with chemicals and other important nutrients required. The technology used is known as tissue culture where the cells are extracted from the healthy seeds or plants and treated with essentials nutrients. The technology is good as it increases the production. But it has increased commercial greed. The plants produced through this process are seedless. Farmers have to purchase the seedlings from the companies who are making these samples. A time will come when farmers will be controlled not by the nature but by these multi-national companies. Many a times, this technology can prove harmful as it changes the genetic structure to increase the yield but at the cost of the harmful effect mitted to consumers. To increase the profit MNCs are producing seedless samples which are deficient in vital vitamins, minerals. This is a serious situation in the modern world because we are eating food with fewer nutrients whose effects everyone are witnessing. Research in the field of genetics is praiseworthy, but its misuse will prove disastrous to the coming generation.
[409] *Annual Reports on the Experimental Work of the Dohad Agriculture Station* (1910-11), 4-12.

One of the original objectives for starting the Dohad Farm was to teach the *Bhils* about utilisation of irrigation facilities provided by the new Muvalia Canal for rice cultivation. It was questionable whether the cultivation of rice would prove more profitable than the local system of double cropping with maize and wheat especially where the irrigation water was lift. Bhils used broadcast method for rice.[410]

Khandesh cotton, Pure *neglectum*, *karkeli*, *mathio* (local variety) and Bourbon were tried but result was not encouraging. Others crops like groundnut, castor, *til*, gram were experimented on the Farm.[411]

Fresh Italian Potatoes seeds were obtained from Bombay and the crop was sown according to the ridges and furrows system, the tubers being planted at the bottom of the ridges and not in furrows as in common in this Presidency. The irrigation water was lifted by a chain pump.

Sarsav, tobacco, *mug*, *math*, *udid*, *choli*, *guvar*, *kulthi*, tapioca and indigo were also tried.[412]

Selected maize plants were selected for the experiments. As a common knowledge, maize cross fertilised very rapidly in the field and it had, therefore, been decided after considering the methods of maize selection evolved in the USA, to detassel half of each row to facilitate half the maize produced in each row being self-fertilized and half cross-fertilized.[413]

Groundnuts, Spanish peanuts, Japanese large, Chinese No. II and Senegal were next introduced and experimented plants.[414]

[410] *Ibid.*, 13-14.
[411] *Ibid.*, 14-16.
[412] *Ibid.*, 16-17.
[413] *Ibid.* (1911-12), 2.
[414] *Ibid*., 5.

There has been little agricultural improvement during the last decade except Halol *taluka* owing to the introduction of cotton cultivation; the condition of the people had improved.[415]

Baroda

Baroda State also responded with the establishment of agriculture department with models farms, expert appointments and creating infrastructure for its functioning. Mr. Middleton, distinguished agricultural student of the UK, was hired by Baroda State. Voelcker visited the Baroda Farm managed by Mr. Kacherao Jadav, an ex-student of the Royal Agriculture College, Cirencester. Voelcker was impressed with the practical lessons were conducted at the Farm. Attached to the Farm was a wonderful collection of implements: a huge wagon from Germany, used for bringing brewers grains and beet root pulp and distilleries and required six horse to draw it, huge iron seed-drills, heavy iron plough, manure distributers and seed-barrows for sowing rye grasses, among barley. There was also a chemical laboratory in the city with equipment.[416]

Agriculture Education

In Dohad Farm, Government Primary Vernacular Bhil School was opened in 1919. Class VI and VII standards were given one lecture and two practical per week.[417] Godhra had an Agriculture School.[418] Later on, Surat also got such educational institute.[419]

Some novelties were worked out for dissemination of agriculture knowledge at large. Five teachers from five districts of British Gujarat was chosen to get training in agriculture from Vernacular Agriculture School, Godhra so that they would be transferred to respective area to promote agriculture education.[420]

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[415] *Ibid.*, 14.
[416] *Voelcker Report on Indian Agriculture* (1897), 368-69.
[417] *Annual Report of Department of Agriculture of the Bombay Presidency* (1918-19), 29.
[418] *Ibid*. (1922-23), 27.
[419] *Ibid*., 27.
[420] *Ibid*., 89.

These were the places for the said initiative:

Place	***Taluka***	**District**
Waghchhipa	Pardi	Surat
Shukaltirth	Broach	Broach
Uttarsanda	Nadiad	Kaira
Kanbha	South Daskroi	Ahmedabad
Nadisar	Godhra	Panch Mahals

Source: *Annual Report of Department of Agriculture of the Bombay Presidency* (1922-23), 89.

Gujarati monthly magazine "*Khedut, Kheti* and *Sahakar*" was published in 1935-36 for general benefit and government had planned to purchase 500 copies for free distribution.[421]

Chorasi (Surat) Association was active in agriculture progress. Broach Agriculture and Industrial Association published quarterly named *Gujarat Agricultural and Industrial Quarterly* in *Gujarati* language.[422]

Seed-Depots

Side by side seed depots were opened in British Gujarat on co-operative basis.[423] These centres sold good seeds developed in various farms. Navsari Tata Gin, Bardoli Depot, Madhi Depot, Sayan Depot, Kim Depot, Sachin-Pardi Depot, Sania Depot, Surat Farm Depot, Vedchha and Ankleshwar were opened to improve cotton seed distribution. People of Miyagam-Dabhoi of Baroda State were so keen to secure over improved seed that when they failed to secure it from the department; they purchased it from these gin-owners and merchants who had purchased farms improved *kapas* from the cultivators who had grown it last year.[424]

Local activists were also reported as participants for enhancement of agrarian environment. *Sheth* Bamanshaw Jamasji purchased 1027 ALF seeds of improved cotton from Broach Station and distributed it to the cultivators of Ankleshwar, Hansot *mahal* and Nandod State. Messers Dahyabhai Sundarji, Ghelabhai Paragji, J.

[421] *Ibid*. (1935-36), 166.
[422] *Ibid.* (1922-23), 22.
[423] *Ibid*. (1920-21), 46.
[424] *Ibid*.

N. Kapadia and others of Messers Narandas Rajaram and Co. helped in the distribution of improved cotton seed to the farmers.[425]

Breakthrough in agriculture productivity is a difficult task. It cannot be achieved in decades. But at least, a start was made from the various farms in British Gujarat. Technical progress in agriculture was, therefore, not an easy process. Use of exotic seeds, manuring system, artificial manures on the pattern of England and America did not give desirable results. Further, they convinced of the importance of local strains. For the remarkable change in agriculture huge financial expenditure is essential requirement. The British government tried to transform the structure of the Indian agriculture with limited financial inputs and half-hearted initiatives led to the failure for change. Beginning of the 20th century, they were convinced and serious policy was introduced. Hierarchies of research stations, expertise help, pumping of money led to the gradual change in agriculture. New seeds and plants were tried along with local ones led to the emergence of hybrid identity which was symbiosis of British-Gujarat agricultural set-up. The natives also showed active participation in the adoption of new knowledge and these were successfully assimilated in agrarian society of Gujarat.

[425] *Ibid*.