CHAPTER I

Historical Background

Science in its modern outlook and layout was generally regarded as the contribution of seventeenth and eighteenth centuries' transformation of Europe. When the intellectuals began to divert their attention from unknown world of heavenly bodies to the world of nature around them, a momentum was set for a scientific revolution. Unlike the observations made earlier to the concerns of other worldliness, modern studies of science indulged mainly into the investigation of the natural phenomena and ways of its utilisation. As the science improved in the core subjects of astronomy, mathematics and physics, it moved out further to the investigation of less known disciplines of botany, geology, zoology and also agriculture. By nineteenth century, Europe had made transformation from a traditional empirical method to the modern approach of scientific observation and experimentation.

Progress in science had brought great socio-economic changes in Europe. However, its transformation did not occur in one single stage. The transformation to the scientific progress, as Butterfield described was not that "could be completed in a single stage." Scientific progress involved of efforts advanced collectively of the scientists as well as merchants, artisans, and even despotic rulers who reflected in the nature and scope of science and technology. Constructivists attributed major role to the societal conditions in shaping the nature and scope of science and technology. It is also true that science interacts with the society as much as the interaction of society with the science. According to J.D. Bernal science was an output of an organised product of industry and government. The contribution of industrial revolution

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2 Thomas Kuhn and others proposed the view that scientific facts are socially constructed.
3 Bernal, J. D., Science and Industry in the Nineteenth Century, London, Routledge and Kegan Paul Ltd., 1953, pp. 36-38, also see J. D. Bernal, Social Foundation of the Science, London, George Routledge and Sons Ltd., 1939, p. 347, Bernal relates scientific discoveries like electricity and chemistry to growth of the industries such as telegraphy and synthetic dyes.
to science, John Berman describes as an entrepreneurial ideology of science. While explaining the process of science progress, Engles put it “If technique largely depends upon the state of science, science depends far more still on the state and requirements of technique.”

Science also provided tools to create industrial revolution and thereby caused huge increase in manufactured goods and also to the rise of imperialism and colonialism. The very fact of British industrialisation in the early phase involved the application of knowledge also furthered the interdependence of science and imperialism. The association of science with empire commenced from the beginning as imperialists carried their science along with their overseas forays. When the science was in rise, the period also witnessed rapid expansion in the empire.

In recent literature on the history of modern science, the interrelation between imperialism and science was subjected to an intense discussion ranging from cultural origins of science, its epistemological basis, and its role in the progress of industrialisation in Europe to its spread outside Europe. Imperialism and colonialism paved the way for the expansion of science and technology in the colonies. Metropolis represented the core culture and technoscientific superiority. Colonialism came to symbolise ascendancy and predominance. Expansion of colonialism consisted more than a mere political structure, involving complex things of ideology, culture and institutions. Colonialism exhibited therefore, unity and contradiction, direction and ambivalence, power and weakness. It improved a set of structure as well as discourses which when taken together, provide an imbricated view of domination in its myriad forms. It affected every conceivable aspect of human existence of body and mind of both the colonised and coloniser. Like

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colonialism, science also created its institutions forming as a set of structure or organisation of different nature. Although science was universal in character, it was transformed to various formations. The scientific projects that were designed to transfer for the colonies were made subscription to the needs of empire. In a way scientific progress in the colony took the shape as a dependent science. Each scientific project set to transfer into colony embedded a plan and a careful construction. They were not oblivious to the great strides science was then making at home, but sharply perceived the role and importance of science in empire building.

British colonialism made a conscious effort in India to introduce and develop colonial science that was structured specially for the colony. Though the policy pursued by the company later Crown government on science institutionalisation exhibits lacked coherence, but science made progress from time to time in the colonial control, depending on the politico commercial requirements involved. Colonial endeavour of introduction and institutionalisation of science in India was by no means a smooth and uncontested process. In the early phase of colonial rule, policy of science did not form a concrete object. It was the perception of local conditions and circumstances developed by the personal interests of the colonial administrators mainly led to the utilisation of science and technological expertise available among the British servants of the East India Company in India. In fact, in the early phases of the colonial rule, the Court of Directors of the East India Company was reluctant to authorise funds for the scientific projects proposed by British administration in India.

The imperatives for the pursuit of science firstly emanated from the individual interests of the amateur scientists who were employed in the Company. Indian subcontinent appeared to them a vast, unexplored territory that held out the promise of totally new flora and fauna, and the consequence
possibility of developing their career as scientists. In the colonial context, development of science was not an independent process from colonialism; therefore, science cannot be studied meaningfully in isolation from colonialism. Scholars on history of science dealt with the pattern of western scientific transfer to colonies and analysed how imperial exigencies and administrative priorities took precedence over other factors. George Basalla propounded three phases diffusionist model that ascribes civilising role to colonialism as a main agency for spread of science from metropolis areas to what he called non-scientific peripheries. During the phase one of Basalla’s three phased model, the men of the colonial region were involved in simple data gathering activity on natural resources, flora and fauna of the colonies which served as the experimental material for scientific activity in the centre. According to Basalla’s second phase, local members who were trained in western education system, and the settlers or the missionaries helped in the institutionalisation of scientific activity in the periphery and this phase is characterised by colonial science; and in the third phase the local people who prominently trained and educated helped in the professionalisation of modern western science in the colonies. These three phases together forms the completion of the process of diffusion of western science in the colonial regions. But Basalla’s second and third phases found objections from the scholars. Basalla’s homogenised notion of colonial science assumes no distinction between introduction and institutionalisation of science. Basalla’s concept of science not only attracted tremendous currency but at the same time raised considerable amount of debate since 1967, The available evidence in India do not support Basalla’s thesis advocating an equal relationship in scientific and technical pursuits between the metropolis and the colony. Much of the context of the scientific pursuit in the colony was confined to

7 Zaheer Baber, Science of Empire, Albany, State University of New York, 1996, p. 8
9 Scholars like MacLeod attempted to analyse Basalla’s model in the Australia context whereas Deepak Kumar, Satpal Sangwan attempted it in Indian context.
exploration, surveying and application of techniques to aid and promote colonial economic policies.

Metropolitan institutions claimed as centres of knowledge building and knowledge communication. The main goal of science and technological system in India was directed by profit and in some cases to colonial expansion. According to Michael Worboys colonial science was an applied science, which covered economic benefit and disseminated systematic knowledge. He did not discuss 'the results of colonial scientific development efforts and the establishment of regional, later national scientific communities.' For Worboys, science on the constructive side of imperialism ushered three fold responsibilities of exploration and discovery, secondly of solving environmental and disease problems, thirdly, of providing on-going and technical service. Whereas, MacLoed contradicts with Worboys's proposition as he identifies the process of evolution of British imperial science in five distinct phases: (1) metropolitan science, (2) colonial science (3) federative science (4) codified science and (5) commonwealth science. He defined imperial science as a set of structures, an expression of will and a purpose, a mission, a vocation, often inarticulate but enormously powerful. For him the central was no longer as science in imperial history but science as imperial history. Colonial project of science transfer was designed not in a way needed to strengthen the scientific knowledge of the colony. Michael Adas, who refers to several travelogues, writes, "The ultimate outcome of traditional into modern societies was almost unthinkable in the colonial era." He perceives that in its most benevolent manifestations the underlying aim of the civilising mission was to reshape colonial economies in ways that would make them more compatible with metropolitan economies of each imperial system. Through science, coloniser had visualised more profit to them than the colonised. Lucile Brockway’s 'Science and Colonial Expansion' also provide

almost similar argument. He analyses political effects of scientific research as exemplified in the field of economic botany, and in one epoch, the nineteenth century. He focuses particularly on the transfer of scientific plants undertaken by the British botanical garden network to promote the prosperity of the empire.\textsuperscript{11} Daniel R. Headrick’s ‘Tools of Empire’ analyses that technological advancements enabled imperialism to spread at nominal cost where it was otherwise unlikely. In his subsequent volume, ‘Tentacles of Progress’, Headrick extended his argument to implantation of scientific institutions in botanical garden.\textsuperscript{12} Satpal Sangwan’s study from Plassy to the Revolt illustrates more cogently the relationship between application of scientific technology and colonising process in India.\textsuperscript{13} He finds two sets of paradigms of technological applications under colonial rule. The first belong to the stock of technology that helped the British in the imperial and commercial ventures. He includes telegraphy, railways, and shipping in this category. The second set consisted of agricultural and industrial technology that the British introduced to extract maximum out of its natural resources. Sangwan tries to distinguish but ignores the fact that under colonialism colonial scientist was expected to work for the consolidation of the empire. Deepak Kumar’s Science and Raj explores the relationship of science and colonialism during the Victorian period. It discusses several aspects like organisational imperatives, science in education, research in science and response and resistance. It includes several scientific disciplines ranging from geology, botany, meteorology, and medicine to agriculture and looks all of them in an integrated approach. In a way it sets the need for study of each discipline as an independent research. This integrated approach is very useful, but such an approach obviously neglects differences in each individual discipline having separate pattern, character and expansion.

\textsuperscript{13} Satpal Sangwan, Science, Technology and Colonialism: An Indian Experience, New Delhi, Anamika Prakashan, 1990.
Any attempt for evaluation of the nature of science more particularly agricultural science in India during British rule would become an essential to understand the development of scientific agriculture that occurred in England and other countries of Europe. Therefore, it intends to make a brief historical survey of the European agricultural revolution before going to discuss issues of indigenous agricultural science in pre-colonial India.

In Europe, the scientific changes responded when vastly expanded trade looked for scientific schemes and opening up of scientific societies and publications. Science did not arise simply from a creation of demand alone, but promotion of scientific institutions helped “association with like minded persons to hear criticisms of others on their theories and ideas as freely as possible.” The initiatives arose for the organisation of scientific societies, as early as in 1753 when scientists in Britain had started a Royal Society of Arts by one William Shipley, a committed supporter for the promotion of liberal arts and sciences. The Society was interested mainly in the promotion of industrial subjects, but it gave attention for promotion of scientific agriculture too. The Society awarded the prizes for the farmers for cultivation of native crops, production of seeds, improvements of cultivating methods, cattle rearing, and innovation of new implements. The Society circulated scientific information among the cultivators.

At the same time, botanical researches of England improved the knowledge on plants. A more prominent botanical garden was laid out at Kew by Princess Augusta, mother of George III, intending to build a rest house was subsequently raised as important centre for botanical research or economic botany. Since 1840, Kew botanical garden under the directorship of William Hooker, Joseph Hooker and Thiselton Dyer who assumed the office were facilitated researches. Joseph Hooker succeeded William Hooker his father as director in 1865 developed the garden with a well-organised library and

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*Agricultural revolution was ordinarily understood any fundamental practice or technology. The term is commonly applied to the fundamental changes in agriculture that occurred in 18th century Europe.*
herbarium. In 1876, the Jodrell Laboratory was constructed for the research of plant pathology and cytology, which had increased the importance of Kew in improvement of science in English agriculture as well as in colonial agriculture. Under the directorship of Thiselton Dyer between 1885-1905, garden was reorganised to serve as a sort of botanical clearinghouse or imperial institution for exchange of plants. Colonial office made upon the garden from time to time requests for advice on the matters of colonial agriculture, appointment of botanists and agricultural scientists for the colonies. By 1902 colonial office has agreed upon to create a post of botanical advisor and was filled with Thiselton Dyer.

Similarly the organisation named as the British Association for the Advancement of Science (BAAS) has promoted sciences. This association organised annual conferences in different cities of the European countries and in some of the colonies. The Association followed a tradition of organising lectures and publishing reports of the research progress.

Although England had promoted a number of associations, which worked for the promotion, agriculture consisted a part of their broader work of organisation. The lack of an association devoted fully to the promotion of agricultural science was removed in 1837 by establishing a Royal Agricultural Society intending to promote the application of science and technology to the practice of farming. The idea for starting a Royal Agricultural Society gained attention when Earl Spencer, one of the leading agriculturists of the time while speaking at the annual dinner of the Smithfield club proposed the formation of an agricultural society of England. He was induced in his work to promote agriculture mainly by the Highland Societies, which were for a long time doing much useful work among Scotland farmers. In March 1840, the Society received Royal charter and there upon changed its name and became the Royal Agricultural Society of England. The Royal Agricultural Society of England was established with the object of perfecting the system of English agriculture by the union of ‘Practice with the Science’. The last three words ‘practice with
the science' were adopted as the motto of the society and they were inscribed on title page of the society journal. The journal rapidly recognised as the medium for publication of papers on agricultural science. Investigation on agriculture made in England have been published in the journal. The Society had aimed to encourage men of science in their attention to the improved agriculture.15 Through a Journal, Society offered farmers the opportunity to keep in touch with the latest results of scientific work in England and abroad. By 1854, Society’s journal circulated as many as 635 copies. Apart from that Society gave money grants to new discoveries and set standards for good farming.16

Private individuals’ contribution was primary stimulus for the advancement of Agricultural Revolution. In the beginning of the nineteenth century, Humphrey Davy the brilliant chemist summarised the current state of agricultural knowledge particularly agricultural chemistry through a series of lectures and got them published as ‘Elements of Agricultural Chemistry’. Davy’s investigations contributed to the formation of agricultural chemistry.17 Though Davy’s lectures did not create impact on the ordinary farmer, but a few enterprising pioneers were conducted field experiments with new fertilisers.

In 1840, Liebig’s publication on ‘Organic Chemistry in its Relation to Agriculture and Physiology’ set a landmark progress. He discovered and analysed a number of organic compounds. He suggested in his work the necessity of supplying additional sources of ammonia to plant and recommended especially gypsum or powdered charcoal for attracting ammonia from its two abundant sources of urine and the atmosphere. He was exceptionally qualified for the scientific side of his work on the application of chemistry to agriculture. Liebig’s work earned him worldwide reputation as an eminent agricultural chemist among professional circles. His achievement

mainly came from his ability to gather and interpret considerable mass of chemical and related data pertaining to plants and soils that had accumulated up to that time.

Liebig’s tradition was promoted further in the Lawes researches at Rothemsted experimental station started in 1843 at Brad balk. Lawes was educated at oxford but returned without a degree for some obscure reason to set a small estate inherited from his parents. His realisation to get more money led him to improve his lands. Setting himself to find out why liberal doses of farmyard manure and chalk provides higher yields, he worked on a preparation of superphosphate. In 1842 he patented a process for treating phosphate rock to produce superphosphate and thus initiated the synthetic fertiliser industry. In 1843 he opened up a small factory to supply superphosphate and six superphosphate plants were operated in Britain itself by the 1850. And production of superphosphate was increased from 21,000 tons in 1868-71 to 500,000 tons in 1887-91.18 Himself not being fully trained chemist, he appointed Gilbert, a chemist who was trained under Liebig in Germany. In the late nineteenth century, finding the inadequacy of soil chemistry to resolve land problems, researches of Hilgrd and King of America upon physical texture of soil improved a science as a study of soil physics.

Plant Science as a scientific branch of agriculture became prominent at the beginning of the twentieth century when Mendal’s laws of heredity were rediscovered which led to the modern plant breeding. Major advance in the study of diseases of plants and livestock came from Louis Pasteur’s work on bacteria between 1857 and 1881. It improved the soil bacteriology and veterinary science. His investigation of anthrax, for example, relieved one of the greatest scourges affecting sheep.19

In mid nineteenth century, farming was recognised in England on par with any other formal learning. The College of Agriculture established first at Cirencester in 1845 named as the Royal College of Agriculture imparted theory and practical knowledge. The College trained students from land-owning and professional classes and not the common farmers. Some of them were employed at newly instituted agricultural societies and research institutions. The same attitude was conferred to the veterinary science also by raising its status of a new profession through the Royal College of Veterinary Surgeons, established in 1844, only a year before to the Royal College of Agriculture.

The researches at the institutes of the Royal Agricultural Society and Rothamsted Experimental Station contributed through their scientists on fertiliser, soil sciences, silage and plant and animal physiology. Scientific progress gained spirit on the other hand from continuous rising of urban demand for agrarian products. Mushroom growth of population, urbanisation and industrial expansion created wide market opportunities, for the agrarian products.

Scientific agricultural was not simply a superimposition created by urban demands. Rural gentry too obliged itself to the changing demands and the demands of the change. As Christopher Hill commented “... agricultural revolution had come from the desire of landowners and capitalist farmers to make profit by producing for the market.”20 This was conspicuous in the upper class of the rural society. Most entrepreneurs in this sphere were politician landowners and industrialist landowners.21 Through societies and associations, agricultural scenario was led towards scientific and technical innovations. Gradually, by the mid nineteenth century, scientific changes in agriculture affected, “the majority of producers; a fall in agricultural prices tends to lower
the cost of raw materials for the sectors outside agriculture and of food stuffs for wage earners generally.\textsuperscript{22}

In the second half of the nineteenth century, interdependence of industry and agriculture took a reverse turn. Urbanisation and wider industrial growth widened the acreage of cultivation. It gave rise to higher income for both landowners and the tenants. It intern led to the rapid progress in agriculture. It further increased the purchasing power of the people for industrial products. It was rightly presented that home market was a must for large-scale factory production; it is always on the strength of foreign demand.\textsuperscript{23}

Early pioneers set environment to rational approach towards agrarian improvement. Jethro Tull, Townsend, Robert Bakewell, George Cully, Thomas William Coke, Arthur Young, Charles and Robert Colling etc, all of them had amateur innovators. Their vigilance, determination, faith and experience induced them to make innovations in technique. Although they met the strong opposition from conservatives, their advancement added to the vast ocean of knowledge and economy. It received publicity and authenticity through publications.

The advancements towards improvement of agriculture revolution was made when the ‘open field system was disapproved. It prevented the wastage of land, time and labour, especially when it was, incapable of producing enough food for the rapidly growing towns.\textsuperscript{24} In order to expand the cultivable area, British experts approved ‘that to keep with the increasing demand there were being made on it, was to break up the open field farms and to put the commons to profitable commercial use.’\textsuperscript{25} The enclosure system was extended which contributed to the revolution of production of crops, fruits, improvement of breed and living conditions of livestock and other positive changes to its credit. Landowners too gave it an approval, ‘so that the latest farming

\textsuperscript{22} Phyllis Deane, \textit{The First Industrial Revolution}, Cambridge, Cambridge University Press, 1988, p. 49.
\textsuperscript{23} Ibid.
\textsuperscript{25} Phyllis Deane, \textit{The First Industrial Revolution}, Cambridge, Cambridge University Press, 1988, p. 44.
technique could be used without hindrance.\(^{26}\) Agricultural improvement differed in character and role in various regions of Britain. Different improvements of tillage, rotation of crops and stock improvements were practised. The new Horse hoeing Machine of Jethro Tull conveyed the more positive usage of natural resources in the soil than was possible by reliance on traditional methods.\(^{27}\) There was a revolution in the hand-harvesting machines also, which diminished manual labour in farms. Crop rotation and fallow system were replaced by legume rotation and field grass husbandry. Townhend’s introduction of turnips as rotation crop helped in the nitrogen fixation in soil and provided fodder for cattle.\(^{28}\) Bakewell had experimented with sheep and cattle in 1745. He worked with passion to spread the new beasts and techniques of breeding. The observant contemporary, Arthur Young, in his 46 volume annals published the changes in the agricultural techniques. Royal forest was brought under cultivation. The drainage scheme of marshes increased cultivable land by 10 per cent. Extension of potato cultivation prevented famine ravages.

Regional specialisation in crop cultivation and usage of fertilisers added to the quantitative and qualitative growth. Improvement of the breeds of livestock provided good drought, dairy and meat producing animals. At this level “theories of the mechanism of heredity were unknown, experiments to this end were based upon empirical methods.”\(^{29}\)

The agrarian modernisation in Europe was neither an accident nor an output of a single man or cause workmanship. Necessity at various factors, incidents, individuals, environments, separately as well as together, worked into the making of Agrarian Revolution. But it was not an incident that could be studied in isolation. It not only affected European intelligentsia, society, economy and politics, but also impressed societies and economies worldwide.

\(^{26}\) Ibid, pp. 52-53.
\(^{28}\) Nurkse, R., Problems of Capital Formation in Underdeveloped Countries, Delhi, 1973, p. 52.
\(^{29}\) J. Walker, and C.W. Munn, op. cit, p. 30.
In England and other countries in Europe made a transformation from science as a vocation to science as an enterprise.

**Situating the Indigenous Agriculture science:**

Whereas agrarian system evolved by the precolonial India represented dissimilarities to the conditions of Europe, but did evolve a system of agriculture capable of advancing. The precolonial agriculture produced agricultural commodities like cotton for the market. Agriculturists and manufacturers were involved in exchange and money economy. The available evidences of agriculture on precolonial India do not prove it as backward or stagnant but at the same time lagged behind Europe. The evidence on precolonial Indian economy was mostly scattered in different forms and yet to be compiled completely. However, accounts of the European observers, travellers, and administrative servants possess information on agriculture system. They were mainly written to meet administrative requirement, personal curiosity or Home demands. Their accounts reveal two distinct perspectives on Indian agriculture.

The first set of accounts consisted of persons who regarded the Indian agriculture bleak and black. They described Indian agriculture as primitive and unscientific and beyond capable of improvement of its methods and implements. Most of these observers could hardly identify existence of any science in Indian agriculture. According to them number of implements used by the farmer was few and method of construction was crude. They described Indian farmer as ignorant of real farming. Buchanan, Robert Wallace and some collectors of the district subscribed to this opinion. Collector of Tanjore, Harris described agricultural methods as extremely defective, which were based on custom and superstition. The implements of cultivation were considered to be

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31 Letter from Harris, Collector of Tanjore, Board of Revenue Proceedings, 1800, pp. 7106-7.
the last word in crudeness and inefficiency. Cattle were miserable and starving creatures that could hardly draw the plough. The application of the manure was defective and irrigation was insufficient. They also hold the opinion that the principle of rotation was little known and imperfectly practised, while seed selection was seldom or never attempted. Buchanan repeatedly refers the slovenliness of cultivation in the districts that "want of skill is conspicuous in every direction."

Second set of accounts represented the contrary set of opinion. These accounts provided cautious observations. They found Indian agriculture as an advanced art but rejected it to regard as a science. Robert Wight, who was appointed to examine agricultural conditions in the Madras presidency in 1834 refused to agree that agriculture as a backward system and remarked that the "the Indian agricultural system was by no means as defective as it was reported to be, and was indeed decidedly superior to English middle class farming." Again, Lord Ellenborough, the Governor General of India emphatically asserted in the course of a Minute on cotton cultivation in 1840 that "in the details of cultivation the natives of India have little or nothing to learn from agriculture of other quarter of globe. In 1865, J.W.B. Dykes, Collector of Nellore reported that cultivation in certain parts of the district was of a very high standard and compared favourably with the best farming in Belgium and Germany. At a latter period, (1880) Nicholson, collector of Coimbatore, after discussing the backwardness of cultivation of the poorest farmers continues; 'on the other hand, the art is both excellently known and practised by the average and substantial ryots.' He was of the opinion that in garden cultivation particularly, the ryot was master of his art "and that there was little that he did not know. On irrigated lands every requirement of advanced cultivation was fulfilled with regard to ploughing, manuring, care of cattle, etc. There was no

wastage of seed and great attention was bestowed on irrigation, weeding, cleaning.35 And this was no ‘fancy picture’ but generally followed in the better class of gardens. Even dry cultivation, which received less attention, was far from despicable. Dr Voelcker, who was appointed to suggest upon Indian agricultural improvement, stated that, “on the one point there can be no question, viz., that the ideas generally entertained in England, and often given expression to even in India, that Indian agriculture is as a whole primitive and backward, and that has been done to try and remedy it, are altogether erroneous. It is true, as indicated above, that no matter what the statement may be made, as deduced from the agriculture of one part, it may be indirectly contradicted by a reference to the practice of another part, yet the condition has forced itself upon me that, taking everything the conditions under which Indian crops are grown, they are wonderfully good.” To take the ordinary acts of husbandry, “nowhere would one find better instances of keeping land scrupulously clean from weeds, of ingenuity in device of water-raising appliances of knowledge of soils and their capabilities, as well as of the exact time of sow and to reap, as one would in Indian agriculture, and this not at its best alone, but at its ordinary level. It is wonderful, too, how much is known of rotation, the system of mixed crops, and of fallowing.” Voelcker stated further that “while some have erred by calling the agriculture primitive and forgetting that novelty is not necessarily improvement, have thought that all that was needed was a better plough, a reaper, a threshing machine, or else artificial manures, to make the land yield as English soil does, others have equally erred by going to the opposite extreme, and have condemned all attempts at improvements asserting that ryot knows his own business best, and that here is nothing to teach him.”36

The writings of scholars of history and history of science of recent years present a perspective that differs from the earlier two. These works explore science evolution objectively. Irfan Habib, Harbans Mukhia were rejected the decline of agriculture in Mughal period. Harbans Mukhia refers to a medieval work on agriculture, Dhar-Fn Falahat, as a proof of advancement of plant knowledge. According to Mukhia, the work illustrates various methods of grafting, preparation of soil, harvesting techniques, water and manure requirements. More importantly it refers male and female plants. The technique of grafting was discovered and developed was excellent as a result, of which a large number of varieties of fruits were cultivated with excellent sweetness, aroma and flavour. Several tracts were written in Persian on various plants, for example, Amanulla Hussaine, writing in the sixteenth century, recorded the crops of bequila been, baqila-i-misri, or Egyptian bean, imported fertilising qualities to the soil, a fact recognised now as nitrogen fixation by leguminous plants.

Jogi Raju who was appointed as a farm manager in the Pithapuram Zamindar’s estate responding to the offer of a prize for the best essay on agriculture by the Madras Agricultural Students Union wrote in 1920 a history of agriculture in India. He traced out two Sanskrit works, Balaramakrshisasthram and Basava’s Krishisasthram composed in seventeenth century in Madras province secured through a local Brahmin pundit. Neither of the date of composition nor the authorship of these works was known but from the occurrence of the names of crops, such as chillies and tobacco they placed as composition of the sixteenth or seventeenth century works but they were originally written in much earlier period.

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37 Harbans Mukhia, Agricultural Technical in Medieval North India, Paper presented in a Seminar on Traditional Technologies in Indian Agriculture, New Delhi, 6-8 March 1989.
According to the title of the work *Balaramakrishisasthram*, Balarama (brother of Lord Krishna) was said to be an original author. The other work, *Krishisasthram* was authored by Basava who also an author of the famous medical work ‘Basava Rajiyam.’ These two works were subjected to a process of mutilation and interpolation. However, they represented a more systematic attempt and many scientific truths were beautifully expressed.

According to the *Balaramakrishisasthram*, agriculture consisted not only of the production of food grains, sugar etc. through crops but was also of flowers and fruits from trees, of thread and cloth from cotton, of milk and ghee from cattle, of blankets from wool, of silk from the silk worm, and even of salt from the sea and of precious stones from the earth. This definition assigns agriculture a wider scope than the definition of modern agriculture.

Basava’s *Krishisasthram* classifies soils in different ways. According to colour there were black, white, red and yellow soils. Soils were also distinguished based on components of clayey, sandy, stone and low, medium and high lands. Three kinds of saline soils were mentioned, viz. *Usarakshetra, Lavanakhetra and Rajakshetra* decreasing in their salinity from the first to the rest. Ill-drained soils were *dravkshetra*. Vernacular names were formed for different soils on the same basis and show that even very minute difference were recognised.

Paddy, sugar, plantains and opium according to Basava, grow well on low lying lands as also Bengal gram, hemp, green gram, wheat, mustered and gingly. The higher lands were said to suit gingly, castor, black gram, horsgram, redgram, cow gram and cholam, tenai and chillies. Cotton and gogu were said to suit both high and low lands.

The effect of different soils on the same crop was also discussed in the *Balaramakrishisasthram*. In the case of sugarcane black soils were said to produce hard jaggery, while that produced on red and white soils was clean and that on sandy soils granular. Basava dealt with the improvement of soils also in some detail. Sandy and stony soils could be improved by the addition of silt.
and decayed vegetable and animal matter, red and yellow soils by the excreta of animals, and clay soils by the addition of sand. Saline soils, it was stated, could be improved by the addition of sand, ashes of kodu millet, and other straws, neem and other oil cakes and green manure such as indigo, sunn hemp etc. Besides these crops, cholam, lime seed, long pepper, ginger and tobacco were also find mention. Both tobacco and chillies were considered to be introductions by the Portuguese. Maize groundnut, which was later introductions, does not find mention in the works.

The cropping seasons were also fully detailed. The year was divided into 27 periods known as karthis and the crops to be sown in each was also mentioned. Fourteen karthis-Aswani to Hastha were formed the main sowing season, but in the month of Makara (January to February) what were known as Uttarasaaya or subsequent crops, viz., gingly, green gram, short duration paddy, indigo and cotton were sown. Special attention was paid in forecasting of the rain. There were empirical, as well as astronomical methods existed to forecasting of the rain. One work, Sasyanandam in Telugu was devoted entirely to such methods. Besides the methods based on the position of the plants and stars, other signs of prospective rain were studied. The Krshi Parasara is an independent text on agriculture contains 243 verses divided into two parts. The first part relates to the forecast of rainfall and the influence of the planets and stars. The second deals with the practical details of agricultural operations. Some pieces of information about meteorological forecasts were current among cultivators as handed down by tradition, but their practical usefulness has yet to be established. The agricultural methods and implements were quite developed and adapted to the local environmental and topographical conditions.

The implements of agriculture were few and simple. By far the most important, and in some parts practically the only one worth the name, was the

plough. Its construction was much the same in all the districts. It was generally a crooked tree or branch or a piece of wood with a pointed end, to which pair of bullocks was yoked by means of a simple wooden pole and yoke. Much has been said of the shortcoming of this primitive plough, its clumsy construction and inefficiency. But this so-called plough was not without the advantages of its own. The justification of the ryot was that the under existing circumstances, it was the best that could be utilised. The repeated ploughing and cross ploughing of the land, which was taken by the English observers to be a proof of the imperfection of the plough, was in fact practised both to extirpate weeds ... to loosen the soil. The advantage of repeated tillage over deep tillage was clearly shown in the adages held among the ryots for example, if the soil be ploughed to the consistency of butter, the yield will be a mountain heap,” Then again “ploughing can do what manuring can not.” “Land ploughed seven time need no manure and defective tillage can not be made up for by manuring.” Then another saying, “better plough six times in a hundred days than hundred times in six days.” They show existence of idea that “soil ploughed and exposed to the air will be benefited. But ploughing cools the soil and “the coolness produced by tillage is the best coolness, as a mother milk is the best milk.”

One great advantage of the wooden plough to the ryot was its cheapness both with regard to cost and repair. The wood was procured from local sources for nothing, and it was generally constructed and repaired free of particular charge by the village carpenter who was maintained by annual fees. The ryot had only to pay for the iron required. The implements performed wide range of functions with labour saving effect. The price in early nineteenth century varied from 8 annas to 2 rupees the most. Yet another advantage was its

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44 Board of Revenue Proceedings, 1840, p. 6082.
lightness, for the cattle of most of the district were not very strong, and the ryot, besides, was accustomed to carry the plough on his shoulders from field to field. Further, rice and other cereals required only light ploughing. Indeed deeper ploughing would be positively harmful, exploring the land to harsh sun.

Dr. Wight had impressed favourably by the Indian cultivating methods in general and the plough in particular. Of the crooked stick as it was called, he states that for all its unprepossessing appearance, in actual performance it could compare favourably with the latest English plough, the natives one is more properly a cultivator. It performs the functions of a plough, grubber and even a harrow for covering the seed.” He noted with admiration that it constructed on the same principles, as was English grubber or smith steam cultivator.45 The collector of Nellore also stated in 1840 that the local plough was better than the imported English implement.46 These certainly had sufficient opportunity to form an accurate judgement, but they were no doubt carried away by their enthusiasm and made exaggerated statements. The other implements commonly used were the sickle, the hoe and harrow, several kinds of levellers, a manvety (mamotty) the axe, seed drill, rake, a gorruu, harrow or seed drill and guntaka (Grubber and leveller).47

The differences in equipment accounts in some degree, for the superiority of agriculture in some districts over others. For wet and dry grains, the yield and profits were far higher in Vizagapatam and Masulipatam than in the Southern districts. In Coimbatore, where implements were very few, the profit per acre was less than 12 annas.48 Even in the case of cotton the yield was much better in the northern districts, particularly Ganjam and Vizagapatam. In Malabar, where equipment was most imperfect the yield was often as low as three fold and seldom more than sixteen fold of seed sown.49

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46 Board of Revenue Proceedings, 1840, proc. no. 6082. TNA.
47 B. Heyne, Tracts on India with Journals of Tours in the Peninsula and account of Sumatras 1814. p. 74.
49 Thackeray, Report on Malabar, 7 September 1807. TNA.
The most noteworthy feature was that of manure. The quantity was deficient and method of applying it unsatisfactory. There was an adage that given a sufficiency of water and manure, the ryot could raise a crop even from stones. Without manure, even good soils fail to yield any considerable return. Defective manuring was not due to want of knowledge. On the other hand, the ryots were perfectly sensible of the efficacy of manure and the value of the different substances that could be utilised and several proverbs on the subjects, current in the districts seem to prove it. But in spite of all the proverbs manuring was not approached from a scientific viewpoint and both quantity and quality left much to be improved. The use of cattle dung as fuel deprived the land of much of its most valuable requirements. Buchanan observed that it was the most common fuel used in parts of the districts through which he toured. With the dwindling of free forest and waste the poorer ryots were obliged to use dung as fuel to an increasing extent. About 1860, W. R. Robertson calculated that in the Madras city dung cakes were used at the rate of 100 per month per adult in many middle class families and this comprised one-third of the fuel employed. The use of dung as fuel was not however, universal. The best cultivators, particularly in Coimbatore, Cuddapah, Bellary and other places never burnt cattle dung but used twigs, lopping from trees and hedges, stalks, saw dust, etc. If it was burnt it was generally in towns due to necessity as no other fuel was available and not to ignorance or carelessness.

Manure was so much in demand that prices were rising and in some parts even the well being of cattle was sacrificed for the sake of quantity. According to J. O. Minchin, Collector of Kurnool, "no agriculturist in the world are more alive of the value of manure than those of India, and with regard to their high garden cultivation, there is little which under their peculiar circumstances they have to learn from European science." The ryots used every

50 Buchanan, op. cit., Vol. 1, p. 126.
51 Letter from the Collector of Madura to the Board of Revenue, 8 November 1865. Also see Letter from the Collector of Canara to the Board of Revenue, 14 August 1865.
kind of manure available; cattle and sheep dung, house and village sweeping, ashes, green and dry.\textsuperscript{52}

Other substances used as manure were leaves, ashes, house-sweepings, paddy and other husks, fruit skins, bark, tank silt, milk hedge, varagu and other straw, flowers, oil seed refuse and indigo and indigo seed. Fish manure was used to a certain extent near the coast, but bones were not, partly due to prejudice and partly to the demand for export. For betel and other gardens, offal and blood were also applied. In the alluvial tracts, tank and river silt was spread over the fields and soil mixing was practiced throughout the Presidency.

The quantity of manure applied varied considerably. In Canara it was said that for every cubit of land a basket of cow dung was necessary. Usually garden lands received most of the available supply while wet fields came next and dry fields last. In Nellore, garden lands were manured every year and some times even twice. The wetlands had their turn every alternate year and the residue was applied to dry lands once in 3, 4 or 5 years. In North Arcot, it was stated that a cawni (1.3 acres) required 40 to 50 cart loads. If sheep folding was resorted to 300 to 500 sheep were penned on one cawni for three of four nights at the rate of 3 annas per night per 100 sheep.

The principle of rotation of crops seems to have been generally recognised and followed to some extent. Certain crops were known as agili or recuperative and other as peerpu or exhaustive and latter were sown on the same field continuously. Thus tobacco was usually followed by dry grains or gram and cotton was hardly ever raised on the same land consecutively. Sugarcane, which was also very exhaustive, was alternated with some other crop.\textsuperscript{53} Mixed cropping was really a variation of the principle, and it was a practice which further secured the ryot against possible loss due to inclemency of season; for even if one crop was lost the other would remain. In the Telugu districts, in particular mixed cropping was common. Frequently a cereal crop

\textsuperscript{52} MacLeod report on Dindigul, 20 February 1794.
\textsuperscript{53} Baramahal Records, Section IV, p. 2.
and a leguminous one were sown together and the latter continued on the
ground after the former was reaped.

Rotation where it was practised depended on the district, soil, crop and
season. In Nellore, much of the land was cultivated with jonna or millet with a
crop of caster oil or varagu intervening now and then. In certain parts of the
districts a more regular system was evidence.\textsuperscript{54}

The chief rotation appears to have been between varagu and jonna and
occasionally horse gram, korra, indigo or ragi. In Vizagapatam, though the
methods of cultivation were in other respects comparatively advanced; there
was little attempt at rotation except in the case of sugarcane and cotton.\textsuperscript{55} The
ryots of Kurnool regularly alternated exhaustive crops with recuperative ones
while mixed cropping was also common.\textsuperscript{56} In Godavari, green gram, caster oil
and ginglelly were grown in rotation as second crops on wet fields while
tobacco, and cholam were sown mixed.

In North Arcot, sugarcane and betel were always followed by
recuperative crop.\textsuperscript{57} The principle of rotation was understood to a certain extent
in Madurai and Tinnevelly, and Buchanan noted several types of rotation with
regard to dry grains in Coimbatore. In Tanjore and other districts, however,
there was little attempt at any system of rotation. It is a significant fact that
though there are innumerable proverbs in Tamil regarding methods of
cultivation, time of sowing, reaping, etc., there is no mention of rotation and
only a single reference to fallowing.

Fallowing was generally practised in many of the districts, through the
extent to which its utility was understood and availed. The fields of Tanjore
were left fallow every alternative year or once in three or four years according
to necessity. In Nellore the poorer lands were frequently left fallow
immediately after they showed signs of exhaustion. The better soils of Kurnool

\textsuperscript{54} Letter from J. W. B. Dykes, collector of Nellore to the Board, 12 October 1865.
\textsuperscript{55} Letter from D. F. Carmichael, Collector of Vizagapatam to the Board of Revenue, 23 August 1865.
\textsuperscript{56} Letter from J. I. Minchin, Collector of Kurnool to the Board of Revenue, 3 November 1865.
\textsuperscript{57} Letter from J. Fraser to the Board, 19 August 1865.
were continuously cropped, but the poorer ones, after being cultivated for three years were left fallow for three or four years. In Coimbatore fallowing was a general feature, the field being often tilled, and left uncultivated for a season. In Canara, there was neither rotation nor fallowing, but in certain parts there was a system of cultivation known as kumeri where a crop was grown only once in a series of years and not again until field became a jungle when it would be burnt and another crop sown.

It has characterised India for centuries, for agricultural conditions in this country tend to be not static. The state of affairs has often attributed to the ryots ignorance, carelessness and superstition. Robert Wight reported to Government that "the apathy, not to say aversion of the people to all improvements... is proverbial and is dwelt upon in nearly all the reports." It formed "an almost inseparable obstacles to the success of many of the measure proposed for their benefit."

This was largely true, but the point may be over-stressed. It must be remembered that the position of the ryot was such as to preclude the possibility of experiment and speculation. The vast majority of the agriculturists were so poor that they were obliged to borrow money at exorbitant rates to cultivate the coarse grains and even for very subsistence. The slightest mishap to the crop left them destitute of the necessities of life. Further, the agricultural charges, excluding the revenue assessment were usually more than double the profit and the net return rarely exceeded Rs.2 or 3 per acre, constituting interest on capital and insurance against risk as well as return for labour. As Wight himself admitted, it was hardly to be expected that in such circumstances the ryots "would willingly depart from the beaten track and enter on a new untried field of adventure, however promising the speculation. They would require at least some guarantee against loss. Principles of rotation, however much they may be appreciated, had often to give way to the exigencies of the market and where,

\[58\] Robert Wight, Report on Agriculture. 20 May 1836.
as was very frequently the case, each farmer possessed only one or two fields, a system of rotation was out of the question. Such things as improved implements and more and better manure meant capital and was therefore seldom possible. Many of the ryot's deficiencies could be removed by the spread of knowledge and the establishment of Government agencies that would introduce and popularise advanced agriculture, but the chief desideratum was an improvement in his economic position.

The consolidation of the colonial political power over the Madras province by mid nineteenth century offered to encourage intensive cultivation of agricultural products destined to export. From beginning of nineteenth century establishment of stable political conditions in the province led to the concentration on agriculture. The East India Company issued a proclamation announcing to the people the change of the government from the Nawab and desiring the people to return to their villages in order to begin to their usual cultivation which they were compelled to abandon. Such a proclamation was issued in August 1801 in the districts of Madura, Tinnevelly, contained a promise of grain and money to those inhabitants who return to their villages and resume cultivating their lands.

The important feature of the trade in last quarter of the eighteenth century was dominated with the exploration of Indian made textiles. But as the introduction of various policies and measures in the Home Government in England, since early decades of the nineteenth century, reversed the India's trade changed to export of raw cotton to feed the British textile industry and importation manufactures into India. For the production of new market crops, some of British officials thought farming techniques used usually by the ryot for the subsistence production required a change to produce commodities for the market expectations.