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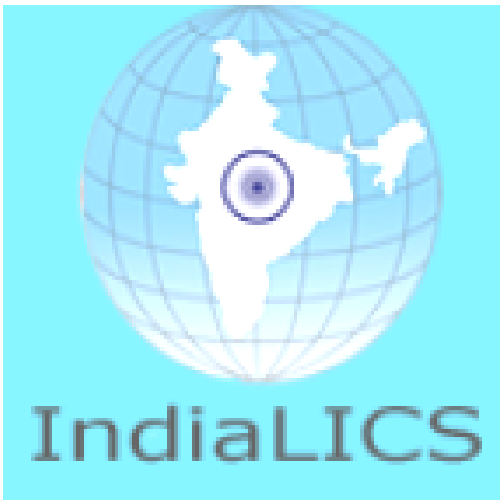

Technological innovation and agrarian transition: impact on small and marginal farmers

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HYV (High Yielding Variety) seeds resulted in Green revolution in the 1960s and Genetically Modified crops in the form of Bt cotton was introduced after the 1990s in India. These scientific innovations are widely debated and discussed over the claims of increasing productivity and reducing poverty among the economically impoverished groups of farmers. However, these innovations have not been successful to bring about structural change in the agrarian economy. Social and economic inequality in the rural farming community still persists. The paper seeks to analyse the impact of introduction of these scientific innovations on small and marginal farmers. These scientific innovations have been conceived as 'paradigms' which have brought about technological revolution in Indian agriculture but have failed to bring about structural change. The problem of caste and class inequality found among different groups of farmers has not been solved with the introduction of such scientific innovations. With the help of several case studies and secondary evidences collected during specific time periods from 1960s to 1990s and after 1990s from different states, the paper shows that these two innovations have brought about 'paradigmatic' change in agriculture science and development but have not been successful to bring about any structural change in the rural community.

Keywords: scientific innovation; agrarian social structure; caste and class groups; social and economic inequality.

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1. Introduction

India accounts for 2.4 % of world's geographical area and has to support about 17 % of the world's population and 15 % of the total livestock. With the limited resources it has become an increasing challenge for Indian agriculture to keep pace with the world agriculture. Agriculture is an important sector which accounts to a total of 14% of the country's GDP and about 11% of the exports. About half of its population relies on agriculture for consumption and production purpose. Agriculture serves as the only means of livelihood for most of the economically deprived group of peasants who constitute the farming community in the rural areas. In order to keep a constant rise in the country's growth scenario it is necessary for this industry to perform well so as to meet the rising demand for food and also to increase income of those who are dependent on agriculture for their livelihood.

Social scientists have pointed out that such technological innovation has increased impoverishment and has helped some selected groups of farming community to grow. This paper is focussed on two such technological innovations which have been considered as important innovation for their claim to reduce poverty by decreasing social inequality between different groups of farmers. Social scientists like Ronald Herring, David Zilberman, Matin Qaim and others have claimed that introduction of HYV (High Yielding Variety) seeds which resulted in leading Green revolution in India and the Genetically Modified (GM) crops introduced in the form of Bt Cotton will help in reducing poverty by increasing yield and thereby income of the small and marginal farmers. Based on this hypothesis, that technological innovation can reduce poverty and social inequality, this paper tries to locate several instances with the help of case studies from different states the impact of introduction of these technological development in rural community. Precisely, the research questions which the paper aims to answer are:

1. What is the nature of social structure in rural community in which these technological innovations have been introduced?
2. To what extent the technological innovations like Bt cotton seeds and the introduction of the HYV seeds has helped in reduction of social inequality by reducing poverty?
3. Which are the groups of farmers who have been benefitted with the help of these technological innovations and to what extent these innovations have helped the small and marginal farmers?

The objective of the paper is to analyse and understand the nature of 'diffusion' of technology among different groups of farmers in the set institutional framework which is defined by caste and class inequality in the rural economy. In order to achieve an understanding of the complex process it is a necessary to analyse the social structure and the place of innovations in this structural set-up.

What are scientific innovations?

Innovation in simple terms can be defined as new product that caters to people for better services. In agriculture, technological innovation is considered as those products or services which will help in increasing agricultural production. Such technological innovation will help in increasing production of crops both in terms of quality and quantity. J. Cassilato's work on 'Innovation Systems and Development', emphasises that the 'capacity to create', 'immitate', 'use' and 'modify' innovations are considered as important determinants for successful development of firms which are engaged in the process of innovation. His work also points out that the innovation system does not function outside the social system or the social context. This paper takes up the discussion on such social context in which two such

technological innovations have been introduced in the farming community and to what extent they have been successful to cater to different groups of farmers.

The term innovation has been used in the paper in congruence with the idea of 'paradigms' propounded by Thomas Kuhn. These innovations can be defined as scientific developments whose achievements are 'sufficiently unprecedented to attract an enduring group of adherents' and these are mostly 'open-ended' in nature which leave all sorts of problems for the practitioners in the same field to resolve them (Kuhn 1996). The transformation of one 'paradigm' to another has necessarily led to the development of most advanced form of scientific innovation. In other words, technological innovation can be termed as the product of science which is a 'constellation of facts, theories and methods' and an 'ever growing stockpiling' of such 'facts', 'theories' and 'methods' has resulted in newer scientific achievement or that which has resulted in 'paradigms' or innovations.

Agricultural occupation in India has been through the process of several such innovations which have defined and re-defined newer methods of increasing production and improving quality of the produce. These innovations have left newer questions to be resolved and have resulted in further scientific development in agricultural production. However, scientific innovations or 'paradigms' as propounded by Kuhn comes from a *positivist* tradition[1] which emphasises on narrowing down scientific knowledge into merely a process of understanding cause and effect relation. There is a necessity of scientific innovation which will take into account the 'whole' formed of several 'parts' (Oberoi 1978). In other words, technological innovation in agriculture cannot be judged only by the extent to which it increases or decreases profit for the farmers. The success of technological innovation should also take into account the extent to which it has helped as many farmers from all classes and caste groups in the rural community.

The 'whole' as perceived in the paper is the social context in which the innovations are made and the 'parts' are its constituents like the different groups of farmers belonging to several caste and class affiliation. The objective of the paper is to understand the nature of 'diffusion' of technological innovation to these constituent parts. The paper analyses the varying impact of introduction of technology on the group of big and middle farmers or the big landlords to the small and marginal farmers and the landless and agricultural labourers. The group of big and middle farmers have formed the powerful social, economic and political class of cultivators traditionally. The small and marginal farmers, agricultural and landless labourers are completely deprived of any form of social, economic or political affluence (Desai 1948; Habib 1982).

Science and technology are aimed at bringing about economic growth. However, when we talk about sustainable development or development that will take into account the growth of all sections of society the challenge of science is to bring about such innovation which will be accessible to the most economically deprived groups of people. This paper focuses on how technology has resulted in bringing about different kinds of agricultural development at different points of time in history and if at all these innovations have helped to remove inequality between the small and marginal farmers with those of the big and medium farmers who have always benefitted from all forms of development in agriculture.

The paper is divided in four sections starting with the conceptual framework, where a discussion is made on understanding of the nature of 'peasantisation' and caste and class difference found in Indian agrarian social structure. The following section is based on a detailed analysis of introduction of the High Yielding Variety (HYV) seeds and the introduction of the Genetically Modified (GM) crops in the form of Bt cotton. This section also shows the debate that has arisen from these innovations, that to what extent these have

been beneficial to the section of the small and the marginal farmers. Finally, the paper ends with a section on Conclusion. This paper is based completely on secondary sources of field evidence carried out by several sociologists, anthropologists and economists at different points of time on understanding the impact of technology at a very micro-level study on agrarian structure and agrarian relations in different states. NSS survey reports, agricultural census reports, ethnographic studies and secondary field evidences have been taken up as important sources of data on landholdings of different class of farmers, incidence of indebtedness, caste and class groups and their condition as a result of introduction of agricultural innovation.

2. Conceptual Framework

The social situation in Indian agrarian economy has been much more complex. The complexity has arisen because of the existence of the caste and class groups. In Indian agrarian economy those who constituted the upper caste have also been traditionally the big landowners and landlords. The agricultural labourers, tenants, sharecroppers, and the small and marginal farmers mainly came from the low castes. The Kings, the *zamindars* or the *jagirdars* have been traditionally the landowners in the Northern region of country. Similarly, in the South the agrarian economy constituted of the *Nayar* and *Nambudri* Brahmins at the apex of the social structure with the agricultural labourers and sharecroppers and tenants coming from the lowest caste groups of the *Parayas* and *Pallas* (Beteille 1974).

Indian agriculture has developed by introduction of several technologies like the use of canal and well irrigation, seed restoring and seed producing technologies, different forms of ploughs, multiple-cropping system and many others which have been equivalent to and sometimes not even heard of in Western scientific discourse. Technological innovation resulted in the process of intensification of agriculture where the agricultural labourers worked merely as labourers with no right on the produce. With the introduction of technological innovations peasant differentiation has increased to a point where the big or the 'capitalist' farmers are able to usurp large sums of surplus and use it to invest for further increase in production purpose. The agricultural labourers, tenants and sharecroppers are left with meagre proprietorship where they do not have the capacity to invest for better agricultural production and usually fall in a debt-trap.

In all of these, the small and marginal farmers and the agricultural and landless labourers lose out chance to own the surplus which rests in the hands of the big capitalist farmers. This paper aims at analysing two such technological developments in Indian agriculture whose impacts have been much debated by social scientists in different spheres. The two technologies have been used in two different contexts. The process of developing the two technologies has been widely disparate. However, the purpose of introduction of two technologies was to increase production. In both the contexts, it is shown how the two technological innovations have impacted on the group of the small and marginal farmers who are traditionally termed as the 'impoverished' or the 'ruined' group of workers in agrarian economy.

3. Agricultural Development and Agrarian Transition

Development of new technologies played an important role in economic development of nations. The aim of the introduction of agricultural technologies has been to provide affordable means to different groups of farmers in order to increase productivity of either food grains or cash crops or horticultural items. The technologies claim to reduce economic inequality by increasing profit-making avenues for all groups of farmers. These competing claims have been negated by many social scientists, who, emphasise that these technologies

have increased economic and social disparity between different caste and class of farmers and also regional disparity between states with better facilities for implementing the newer technologies than those which lack in using these technologies. There are again other groups of social scientists who have essentially followed a pro-technological understanding stating that introduction of these technologies can lead to poverty reduction in the rural areas.

In the following few sections the paper shows the two new technologies which have been widely used in post-colonial Indian agricultural development. It analyses the change rural social structure is undergoing. It examines to what extent the small and marginal farmers constituting the low caste and lower class groups are being affected by the introduction of these technologies. Case studies and field evidences from different states have been used to illustrate the national scenario on agricultural development that has mainly taken place in India from 1960s-1990s and from 1990s till the present time period.

3.1. Green Revolution and Small and Marginal Farmers

a) Historical Background

With the end of colonial period, the task was set for the political leaders to employ certain regulations that will increase agricultural productivity so that it can yield good returns for the farmers. The nationalist leaders and politicians were divided on the view of how to bring about development in the country. During the second plan period agricultural production fell by 10 per cent between 1956-57 and 1957-58, food prices increased phenomenally by 50 per cent and the government was forced to import six million tons of food grains in these two years. At this juncture, introduction of scientific technologies, remunerative prices, greater investment in seeds, pesticides and fertilizers and not merely organizational change were focused at for growth in agricultural output (Gupta 1998).

Green Revolution started with an invitation extended by the Mexican government to the Rockfeller Foundation in 1941 to provide with technical assistance to the developing countries to increase the yields of the food grains. This was aimed at the transfer of the idea of fertilizer-responsive grain varieties and the capacity to develop them from temperate countries to the countries of South and South-east Asia, the Middle East and the Latin America. The transfer of this technology was spearheaded by the public-research institutes in the less developed countries (LDCs), the International Agricultural Research Centers, the Ford and Rockfeller Foundation and the United States Agency for International Development (USAID) (Pray 1981).

The success of the "New Variety" depended on the use of excessive fertilisers and pesticides, application of the package of modern inputs and availability of controlled irrigation water. With the introduction of High Yielding Variety seeds, production of wheat went up to 16.6 million tons in 1967-68 which was a one-third increase from its previous yield of 12.3 million tons in 1964-65. By 1971-72 the yield from the "miracle seeds" started tapering off. India started facing problems of low production in other crops where new variety seeds were used since late 1970s with crop failures and famines which affected nearly 33,000,000 people (Metress 1976).

Introduction of HYVs increased social tension in the rural areas because there was seemingly large inequality between the earnings of the large farmers compared to the small and the marginal groups of farmers. There were regional disparities and in the targeted districts there were intra-regional differences between different groups of farmers. Wheat production in the new programme was successful mostly in the north-western India which

constitutes of agriculturally developed regions with ample supply of irrigated water and large tracts of cultivable land (Chakravarty 1973).

b) HYV and Agrarian Transition: Case Studies

Amit Bhaduri (1995), writing on the agrarian relations in West Bengal in 1970, emphasized that the introduction of the new technology has not changed the existing "semi-feudal" relation of production in the State. It is marked by the 'master-serf' type relations of production with prominent features like existence of sharecropping, perpetual indebtedness of the small tenants, usury and landownership in the hands of same economic class and lack of accessibility for the small tenant to the market. The landowner leases out his land for at least one full production-cycle and the net harvest is shared between the tenant and the landowner. Of the various sharecroppers the least privileged is the group of *kishans*, who virtually do not own any land. The agricultural labourers and the *kishans* together formed 55 per cent of the peasantry in the villages surveyed. The *kishan* is almost always heavily indebted. Immediately after the harvest in order for repayment of previous debt, the *kishan* has to give over a substantial portion of the produce. The *kishan* usually borrows from the *jotedars*, who are the landowners-cum-lender of paddy. These landowners take advantage of the fact that the *kishans* are mostly not credit-worthy and are also not able to access the commodity market. They are unaware of advantage of the price fluctuations. The *kishans* always borrow paddy at a time when the price of the paddy is too high and have to repay the loan immediately after a good harvest when the price plummets deeply, thus repaying the debt at a very high rate of interest that is set by the *jotedars*.

A similar class difference is found in the field study of agrarian change in Gujarat by Jan Breman (1989). In 1960, about 10 to 15 per cent of rich peasants commanded roughly half of the available cultivable land and this land belonged to the dominant *Patidar* caste group. The *hali* system has declined with the increasing commercialization of agriculture. The condition of the *Halpatis* or the agricultural labourers has not improved from what it was in the colonial period. This is because the larger landowners constituting the *Patidars* preferred migrant workers from other states to those of the *Halpatis* from the same region to work as agricultural labourers.

In Punjab, G.S. Bhalla and G.K. Chaddha (1983) have analysed in detail the farm size holdings of different groups of agriculturists and how their social and economic condition was impacted after the green revolution. Self-cultivation of farmers was used for adopting new initiatives to employ newer technology for better agricultural productivity. During the period 1966-72 the number of tractors, electric pumps and oil engines increased four, nine and three and half times respectively in the state against a much lower expansion at the national level. According to the NSS data of 1953-54 and 1971-72, there were wide inequalities in the distribution of operational area in rural areas of Punjab.

The study emphasizes that the small and marginal farmers, though have a limited farm size, fall under market compulsions to produce as much as those of the large farmers. In comparison to the large farmers, due to small size holding, the small farmers have to invest more in fertilisers and scientific farming techniques so that their produce can match the optimum level of production by the large farmers. This increases financial constraints over the small farmers. Compared to the farm investments the value of crop output from the small farmers is much less than the value of crop output from the big farmers.

From Table 1 it can be seen that the total value of output of food grains; wheat, rice, maize and *bajra*, from category VI group of farmers is incredibly higher than that of the

output from category I and II farmers. The study points out that the output from category I and II farmers is possible at the expense of excessive expenditure in form of intensive inputs to equalize or at least match the production from the big farmers belonging to category V and VI. Such an imbalance in expenditure and profit for the small farmers increases the destitution level and makes income distribution highly unequal between the small and the large farmers. In the Table, category I refers to the marginal peasants, category II denoting the small peasants, category III the lower middle peasants, category IV the upper middle peasants, category V the big peasants and category VI the very big peasants:

Table 1: Value of crop output from different farm size groups

Crop	I (0-2.49 acres)	II (2.5-4.77 acres)	III (5 -7.49 acres)	IV (7.5-12.49 acres)	V (12.5-24.99 acres)	VI (25+ acres)
Wheat	1246.10	2562.34	4207.63	6556.44	10658.26	19058.59
Rice	280.35	756.25	1156.12	1810.84	2679.17	6781.40
Maize	445.97	638.64	948.69	1310.44	1857.89	1880.80
Bajra	12.41	50.60	111.86	197.15	548.90	789.87
Total	1984.83	4007.83	6424.3	9874.87	15744.22	28510.66

Source: Chadha, G.K. and G.S. Bhalla. 1983. *Green Revolution and the Small Peasant: A Study of Income Distribution among Punjab Cultivators*, 50.

Table 2: Household income and savings

Item	I	II	III	IV	V	VI
Total farm output	2647.14	5744.87	9287.54	15061.52	24861.00	45131.59
Household Income (per family)	3502.55	4077.64	5241.45	10208.51	16229.85	27859.11
Annual Consumption expenditure	4201.88	4872.41	5766.06	7212.67	9030.00	12887.19
Household savings (per family)	-699.24	-794.78	175.39	2995.83	7196.85	14971.92

Source: Chadha, G.K. and G.S. Bhalla. 1983. *Green Revolution and the Small Peasant: A Study of Income Distribution among Punjab Cultivators*, 78-79.

Table 2 shows the household consumption, total output and household savings of the households surveyed under the six categories of agriculturalists. The income of the marginal and small farmers falls short of their consumption expenditure. On the other hand, the middle and large farmers experience huge surpluses in their farm output and their household savings far exceed those of the marginal and small farmers. The high cost/high yield cereal technology of the green revolution called for substantial investment which is beyond the means of the small and the marginal farmers. In Punjab, the marginal farmers are working harder to supplement their income from non-farm sources like dairying, poultry farming and others (Dhanagare 1987).

The small and the marginal farmers with very small size holding are often under a financial constraint and face deficits even after green revolution. The financial constraints increase because these groups of farmers have to invest more in agricultural inputs. These farmers are under constant market pressure to match the production level of middle and large farmers. Social scientists like Pranab Bardhan and Prabhat Patnaik have have emphasised on higher productivity from small farm size. However, the present field evidences show that this productivity comes at the cost of increase in expenditure and comparatively lower outcome. This is evident from the following Table 3 which compares income of different groups of farmers in the States of Punjab and Uttar Pradesh where 'new variety' seeds were widely acclaimed.

Table 3: Farm Business Income in Different Size Classes of Farms

Size Group	Punjab			Uttar Pradesh		
(acres)	1955-57	1967-69	Increase %	1955-57	1967-69	Increase %
0-5	482.67	-	-	333.4	3450.59	934.23
5-10	590.71	2956.32	400.47	1019.39	9015.39	784.45
10-15	1105.03	4968.77	349.65	1102.92	13796.33	1150.89
15-20	1465.21	5977.76	307.98	2225.21	20394.16	816.50

Source: Saini, G.R. 1976. "Green Revolution and the Distribution of Farm Incomes." *Economic and Political Weekly* 11 (13): 17.

Field studies on credit sources to the small and marginal farmers in the Green Revolution prone state of Haryana shows that the small and marginal farmers mostly avail loans from informal sources like the local moneylenders or the larger landowners. These groups of moneylenders give loans at very high rates of interest from the normal institutional sources of credit. In this process the small and marginal farmers end up in indebtedness which they are unable to pay off at a later stage. Agricultural labourers like the small and marginal farmers take loans from the informal sources. The interest usually paid to repay loans from the informal sources ranged from 24 to 60 per cent annually, which is much higher than the interest charged from the institutional sources. This increases 'indebtedness' and 'dependence' of agricultural labourers and small and marginal farmers over the bigger cultivators and other local moneylenders (Jodhka 1995).

Table 5: Credit Sources from different agents

SIZE CLASSES (land in ha)	**Total Households (%)**	**Institutional Agents (%)**	**Non- Institutional Agents (%)**
<0.01	1.4	22.6	77.4
0.01-0.4	32.8	43.3	56.7
0.41-1.00	31.7	52.8	47.1
1.01-2.00	18	57.6	42.3
Up to 2	83.9	51.3	49.7
2.01-4.00	10.5	65.1	35
4.01-10.00	4.8	68.8	31.1
10.00<	0.9	67.6	32.4
All sizes	100	57.7	42.4

Source: *Agricultural Credit in India: Changing Profile and Regional Imbalances*. EPW Research Foundation, Mumbai-2007-08.

The above compilation of data on credit sources taken from NSSO, Situation Assessment Survey of Farmers 2003 also supports the field level data shown on the credit sources. 77 per cent of the farmers owning negligible land of less than 0.01 hectare take loans from non-institutional agents followed by the farmers owning 0.01 to 0.4 hectares of land. Lowest percentage of farmers taking loan from non-institutional agents is seen in the size holding of 4.01 to 10 hectares of land. Literature on traditional caste and class has shown that the lower class of farmers were those who also belonged to the lowest castes. It can be inferred from this table that the low class of farmers or the farmers with lowest farm size are those from the lowest caste groups. In other words, farmers from the lowest caste and class groups are the ones who get entrapped in the 'debt-trap' because they have to repay the loans at very high rates of interest than the institutional sources.

Caste structure in Haryana villages is mostly based on occupations in land than their position in the ritual hierarchical structure. *Jats*, *Rors*, *Punjabi Aroras* and *Gujjars* are mainly the dominant castes and held large tracts of land. Along with these caste groups the Brahmins who were locally called as the *Pandits* also held some amount of land in the villages. The *Banias* are mainly the traders and the moneylenders who later settled in the cities for business purposes (Beteille 1978; Jodhka 1995). The *Sainis* or *Malis* also owned land but not as big as those of the *Jats* and *Rors*. Mostly the big and very big farmers belonged to the caste groups of *Jats*, *Rors*, *Gujjars* and *Punjabi Aroras*. Some of the members of these caste groups were also small and marginal farmers. All the farmers who owned more than fifty acres are from these caste groups and members of these groups do not work as agricultural labourers even if they do not have a large holding. Majority of the small and marginal farmers belonged to the caste groups of the *Sainis* or *Malis* and *Pandits*. The agricultural wage labourers who did not own any land came from the backward caste groups of *Jhimmars*, *Dhobis*, *Nais*, *Kumhars*, *Jogis* and others and from the scheduled caste groups of *Chamars*, *Churahs*, *Dhanaks*, *Dakots* and others (Jodhka 1995).

During this period mechanization in the farms was intensified. Mechanization spread from the big and the very big farmers to the middle and small farmers. The small and the marginal farmers worked as attached labourers. According to the study, unequal economic and social position of different groups of farmers existed and was more reinstated with the introduction of the new techniques. The middle and big farmers were mainly favoured to take loans and invest in agricultural works from the commercial banks. The small and marginal farmers and the agricultural and landless labourers were usually not preferred for their inability to repay the loans at the fixed time period (Jodhka 1995).

Green revolution has led to 'agricultural proletarianisation' (Harriss-White 1979). Writing on the impact of the introduction of the new technique in South India, she pointed out that, there has been a 50 per cent increase in impoverishment of the small and marginal farmers and the agricultural and landless labourers. Field study by John Harriss (1982) further elaborates this point. He emphasised that 'commoditisation' or deepening of commodity relations in farmer households has taken place with the introduction of green revolution in the villages of North Arcot, Tamil Nadu. The *Agamudaiyans* or the class of big landlords who own 60 per cent of the total landholdings and form 34 per cent of the total population reap maximum profit from the introduction of the new technologies. The *Yadhavas* or the class of middle peasants owned rest of the landholdings and the *Harijans* and the *Chakkaliyans* who formed the lowest community mostly worked as agricultural labourers and many have been displaced from agriculture itself to work in the cotton textile mills as casual or wage labourers.

Green revolution was brought about with the help of a scientific technology, which according to Kuhn, can be called as a 'paradigmatic shift' in Indian agricultural development since independence. The 'new variety' seeds can be called as an innovation and also a 'paradigmatic shift' because it increased productivity both in terms of quantity and quality of food grains mainly wheat. This innovation has taken place as a result of years of questioning the normal processes of agricultural and scientific technology. It has brought about a stage of paramount importance which emphasises that by improving technology there is a possibility of increasing production and not merely relying on rainfall or soil quality or depending on irrigation and increasing labour. This revolution has negated most other technological innovations before. It has left the platform open for introduction of a better technology to increase productivity further. This, according to Kuhn, needs to be resolved by other groups of scientists at a later stage of agricultural development. A similar technological innovation which was introduced in Indian agriculture was the Bt technology or the Genetically modified crops. Almost 40 years after green revolution this technology was introduced in Indian agricultural scenario.

3.2. Genetically Modified crops and advent of Bt Cotton

a) Historical Background

Discoveries in physics in the Newtonian era led to industrial revolution, discoveries in chemistry laid the foundation for Green Revolution with the help of *Mendelian* genetics and the recent developments in genome sciences in biotechnology has helped in further development of agriculture which can bring about significant changes in due course of time (Rao 2010). These new technologies hope to reduce poverty, to increase income and also provide better livelihood by raising levels of nutrition among the small and marginal farmers.

Biotechnology came up with hopes of improving social and economic condition of farmers hit by low and poor levels of productivity. Modern agricultural biotechnology is employed by scientists to understand and manipulate the genetic make-up of organisms for use in the production or processing of crops, livestock, fisheries and forestry (Rao 2010). Transgenic cotton is one such instance of biotechnology which has been successful with the help of genetic modification. There are many facets of biotechnology other than genetic modification, namely, genomics, bioinformatics, tissue culture and others (Rao 2010). To put it simply, genetic modification is the science of transfer of genes between different organisms.

Genetically Modified (GM) crops have been introduced in the form of canola, cotton, soybean and maize. In India, these crops have been introduced in the form of Bt (*Bacillus thuringiensis*) cotton. In Bt cotton, insect resistance is via a gene taken from the soil bacterium *Bacillus thuringiensis*, which produces insecticide that does not allow the pests to attack the plant (Stone 2010). Thus the pests die when they attack such plants injected with the Bt gene. However, in due course of time these pests also become resistant to such insecticides and thus the Bt gene stops protecting the plant. Reports from biotechnologists and agricultural scientists point out that lack of awareness and weak flow of information about proper pest management has resulted in the failure of the scientific innovation. There has been a debate that introduction of Genetically Modified (GM) crops can increase agricultural production in India.

In 1995, Indian government authorized MAHYCO (Maharashtra Hybrid Seed Company) to sell Monsanto seeds in India. Monsanto acquired 26 per cent of the share. However, the central government emphasized on elaborate testing of the imported Bt cotton

seeds before they could be commercialized. After elaborate testing the central government did not approve of commercialization of the imported Bt cotton seeds. By the time the field trials ended almost hundreds of acres of land were cultivated with the newly modified cotton seeds. The initial good returns from the seeds were a sign of hope in Indian agriculture. The problem arose with increase in the price of Bt cotton seeds sold by Monsanto than the local seed variety. The Bt cotton seeds also lacked the vigour to remain productive for long. Farmers have to buy new stocks after a short time which was again expensive. The small and the poor farmers could not procure the seeds and were left over in the competition to increase production (Roy 2013).

Table 6: Bt Cotton adoption in India

Year	Area Under Bt cotton (ha)	Per cent of total cotton area	No. of farmers
2002-03	44,500	0.58	54,000
2003-04	1,00,000	1.31	-
2004-05	5,00,000	5.57	3,00,000
2005-06	13,00,000	14.38	10,00,000
2006-07	38,00,000	41.27	23,00,000
2007-08	62,00,000	68.88	38,00,000
2008-09	76,00,000	82.00	50,00,000

Source: Rao, Chandrashekhar N. and S. Mahendra Dev. 2010. *Biotechnology in Indian Agriculture: Potential, Performance and Concerns*, 62.

There has been an increasing trend towards adoption of Bt cotton which is also evident from the case studies and field studies. The anti-GMO activists and anti-globalisation activists stated that genetically modified crops are not bio-safe (Shiva 2013). The anti-biotechnology campaign attacked the notion of genetic democracy propounded by the pro-biotechnology groups. The arguments in favour of introduction of biotechnology state that India's food crisis problem can be solved with the help of genetic modification of the crops. These groups also emphasised that the problem does not lie in the introduction or use of bio-technology for agricultural development. Pro-biotechnologists emphasise that with proper dissemination of knowledge, technical skill and regulation of the seed market biotechnology can help to eradicate problems of hunger and food sovereignty in the country (Roy 2013).

b) Bt cotton and the farming community

It is difficult to understand the impact of Bt cotton on agrarian structure. There are very few studies which focus on analysing the place of caste and class in understanding the impact of Bt cotton adoption in India. There are various studies on economic efficiency of adoption of Bt and non-Bt cotton. Widely, looking through an extensive review of literature it can be seen that there are two world-wide recognised competing claims led by different social scientists in different regions. On one hand, there are the pro-biotechnology group of social scientists who have showed with their area studies that Bt cotton has helped in increasing production and agricultural efficiency. On the other hand, there have been works of several anti-GMO social scientists who have denied the overpowering notion of genetic modification being helpful for the group of small and marginal farmers in developing countries like India.

From the data at the national level it can be seen that adoption rate of Bt cotton from the non-Bt variety is very high. India has been an important platform for using the Bt seeds in agricultural production. The table shows that the cost of pesticides has significantly reduced. However, the cost of the Bt seeds from the conventional seed varieties has increased to a large extent. Economists and social scientists emphasise on the net income of the Bt adopters

which has also significantly increased with the use of the Bt seeds. The matter of concern is that this net income is incurred by only few sections of farmers who can afford to pay off the seed costs and other costs including fertilisers and irrigation facilities.

Table 7: Adoption of Bt cotton in India and other countries

Item	China	India	Mexico
Commercialised since	1997	2002	1996
Adoption rate (%)	66	7	50
Change in pesticide cost (%)	-65	-41	-77
Change in Yield (%)	24	34	9
Change in seed cost (US$/ha)	32	56	58
Change in net income (US $/ha)	470	111	295

Table 8: Farm size of Bt adopters

Item	2002-03	2003-04	2004-05	2005-06
Average farm size of Bt adopters (in ha)	6.6	5.7	6.2	5.6
Average farm size of Non-Bt adopters (in ha)	4.9	5.3	4.8	5.0

Source: Qaim, Matin. 2005. "Agricultural Biotechnology Adoption in Developing Countries." *American Journal of Agricultural Economics* 87 (5): 1317-1324.

The study by Qaim (2005) has taken a sample size of 375 farmers from the states of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. Though the agro-ecological zone from where the samples have been taken for the survey is not mentioned in the study. Qaim shows that an increase of 56 per cent in cost of seeds, 34 per cent in yield and 111 per cent in net income is recorded. There is a significant decrease in use of pesticides. A study from three districts of Punjab shows a very contrasting result from this field study. The study shows that the cost of cultivating Bt cotton is much higher than the cost incurred to cultivate other hybrid and non-Bt varieties. It also shows that the average size of operational holding where mostly Bt cotton has been cultivated is 9.75 hectares in contrast to the field study done in the four states of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. Net income from Bt cotton is not very high than the income incurred from other varieties. However, in this study too, the agro-ecological condition of the regions has not been mentioned. But the study has emphasised that continuous irrigation plays an important role in successful Bt yield.

In contrast to both the studies, a field study in four districts of Nalgonda, Kurnool, Warangal and Guntur of Andhra Pradesh shows that the yield of Bt cotton for different groups of farmers varies in different years because of the differential rainfall in two years of 2004 and 2006 (Rao 2010). In this study, Bt cotton production has varied from one district to the other depending on whether it has had good rainfall or not and whether the small, marginal and large farmers have irrigated or un-irrigated land. Interestingly, the study shows that in the districts of Nalgonda and Kurnool in 2004, the small and marginal farmers had a very low yield, which, the author predicts, is a consequence of low rainfall. The yield for the same group of farmers in the same districts in 2006 is significantly high as a result of increasing rainfall. Again the author also predicts that the overall low yield of Bt cotton in these two districts is less than Warangal and Guntur due to lack of irrigation facilities.

Table 9: Bt adoption in Punjab in the districts of Bathinda, Ferozepur and Mansa

Item	**Overall (n=210)**
Average size of operational holding (ha)	9.75
Productivity (q/ha) (Average seed cotton yield)	
Bt cotton	24.17
Other hybrids	23.39
Cost of seed (Rs/ha)	
Bt cotton	4,621
Hybrid cotton	1,914
Other varieties	484
Chemical Fertilisers	
Bt cotton	2,494
Hybrid cotton	2,051
Other varieties	1,764
Net Income	
Bt cotton	21,558
Hybrid cotton	18,311
Other variety	11,975

Source: Singh, K. et al. 2008. "Attributes and Socio-Economic Dynamics of Adopting Bt Cotton." *Economic and Political Weekly* 42 (52): 73-80.

Results from the contrasting field studies emphasise on the fact that the impact of Bt cotton cannot be understood by a uniform scale for all groups of farmers in different regions. Some of the important points of convergence found in all the field studies are:

- mostly the middle and large farmers with large farm size have received help from the use of Bt variety
- the cost of Bt seeds is much higher than that of the non- Bt seeds
- the use of fertilisers has varied from one region to the other and some field studies also point out that the use of fertilisers also depend on the level of education and awareness among the different groups of farmers
- the success of Bt seeds is possible with the help of better irrigation and mostly takes place in the rain-fed areas
- finally, there have been different claims about yield of Bt variety. This has varied from region to region and also from different groups of farmers. However, most of the studies point out that there is not much significant difference in the yield between the Bt and the non-Bt variety (Shiva 2013).

It can be pointed out from these varied studies that understanding Bt variety as a breakthrough scientific innovation in Indian agriculture is subjected to many social, economic and agro-ecological factors. The innovation has not helped all groups of farmers uniformly. Works of Suman Sahai, Sudhir Mishra, Vandana Shiva have pointed out greater concerns over bio-safety of the genetically modified crops and losing of indigenous knowledge to produce and restore seeds to the multinational corporations other than the mere debate on high and low yield of Bt cotton. There are no such field studies to assess the impact of introduction of Bt technology over the agrarian structure in the rural economy. There are several studies which explain the nature and culture of production introduced in Indian agricultural system. From these field studies, the unequal social relations between the

caste and class group of farmers since 1990s have been taken up to analyse the impact of technology and innovation on the agrarian economy.

Joan P. Mencher (2013) in his field study in South India emphasized that the private corporations and the US food systems are trying to encroach on the local and the global food systems. The upper caste agricultural farmers were encouraged by the agriculture extension workers to keep 'hybrid' cows while the lower caste farmers mainly kept the '*desi*' or the local cows. The 'hybrid' cows produced more amount of milk than did the local cows. The hybrid cows were more susceptible to diseases. The poorest farmers belonging to the groups of scheduled castes (SCs) and the scheduled tribes (STs) lose out to the global food system dominated by the notion of input-intensive production. A similar situation is also found in Sahel zone of West Africa, where the idea of 'seed exchange' with the neighbours has changed to a demand driven need to buy seeds that would give better yield. Kristal Jones (2013) states that traditionally seeds were available in exchange with other seeds or other farm inputs.

The field studies emphasise that the small and marginal farmers get affected by the multinational companies encroaching the seed market and not allowing the indigenous practice of exchange of seeds. In order to buy the expensive seeds these farmers often fall into the 'debt-trap'. The NSSO 70th round report of 2013 shows that there is high incidence of rural indebtedness among the group of 'cultivators' (having operated land of 0.002 hectares or more) than those of the 'non-cultivators' (remaining households). This incidence of indebtedness and consequently farmers committing suicides have been reported after the failure of Bt cotton crops in many agriculturally productive states.

Farmer suicides in India reached almost to an epidemic proportion in some of the pockets of the country and were first reported during the late 1990s (Nagaraj 2008). From 1997 to 2006 an approximate number of 166,304 farmers committed suicides and most of these suicides have been reported as farm-based suicides. In 2012, 13,754 farmer suicides were recorded which was 10.2 per cent of all suicides (Mishra 2014). An intriguing fact is that the high risk zones or the regions where maximum number of farmer suicides took place belonged to some of the most agriculturally productive states like West Bengal, Maharashtra, Andhra Pradesh and Tamil Nadu and accounted for 57 per cent of total farmer suicides in the country.

Farmer suicides in Maharashtra and Andhra Pradesh took place in the cotton producing areas. Decline in cotton profitability, prices of cotton in the world market, reduction in the crop area for cotton production, lower cotton production compared to the US and other world producers like China were some important factors that led to increase in indebtedness of the cotton farmers. Cotton yield of Maharashtra was lowest in 2004-05 and 2005-06 among other states. Poor irrigation facilities in the state increased the cost of production. The negative surplus and the increase in cost of production resulted in an increase in indebtedness of the cotton growing farmers (Mitra 2007). Most of the field studies on farmer suicides in the state have pointed out that introduction of the Bt variety of cotton is responsible for such an upsurge in farmer suicides. In Vidarbha, crop area under Bt cotton increased from 0.4 per cent to 15 per cent in 2005-06 (Mitra 2007). The cotton growing regions mainly Vidarbha recorded highest number of farm suicides because of the introduction of the newer Bt cotton.

Pro-biotechnology reports and groups emphasise that introduction of Bt cotton has not been the sole reason for farmer suicides. There are other reasons like increase in the crop loans, indebtedness to the moneylenders and erratic rainfall. But the point where different views converge is that the procurement of Bt cotton seeds sold by Monsanto through Mahyco

were more expensive than the local seeds. This often incurred huge amount of expenditure for the farmers who had to take loans in order to procure the seeds. The condition of mainly the small and poor farmers was worsened when the Bt cotton could not be protected from the local pests.

The 'Seed Tribunal' which took place to record the testimonies of some of the farmers on farmer suicides revealed certain important facts about the seed trade in the rural economy. In the present condition the multinational seed industries have taken control of the seed exchange in the rural economy. One of the testimonies in the report pointed out:

> Today under US patent law, it is illegal for farmers to save patented seeds and re-use it. Monsanto requires farmers-its customers- to sign a gene licensing agreement before they buy the company's patented, genetically engineered seeds. If farmers are caught infringing the patent, Monsanto would 'vigorously prosecute' them in court. In some areas the company has hired Pinkerton investigators-private police- to root out farmers who are saving Monsanto's patented seed. In other words, farmers are turned into criminals and rural communities are becoming corporate police states (Assadi 2000).

In the cotton producing districts of Bhatinda and Sangrur in Punjab, small and marginal farmers owning less than 2.5 acres of land committed suicide. The average debt to be repaid in these households was Rs 3.79 lakh, while their total annual income was only Rs 63,000 (Singh 2011). The shift in agricultural production from staple food to other market-oriented crops, inefficiency in dissemination of knowledge on how to use proper technology, lack of communication between the 'agricultural assistants' and finally, low credit availability to the small and the marginal farmers are some of the important causes of farmer suicides (Vasavi 1999).

The situation has been made worse with the introduction of the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001. According to the Act the farmers can save, exchange and use the seeds in the form of farm produce for further agricultural production. However, the Act does not provide with the right to sell the seeds. This prohibition is a big blow to the farmers. Taking away such a right results in complete dependence of the farmers over the multi-national seed companies for the seeds. 60 lakh tones of seeds are produced in India every year (Sahai 2000). The National Seed Corporation and the State seed corporation produce only 15 per cent of the total and the rest 85 per cent of the seeds amounting to 52 lakh tones are produced by the farming community. If the right of the farmers to sell seeds is taken away then this gap of 52 lakh tones will be filled by the multi-national seed companies, thus, taking away seed production completely under their control.

The draft Seeds Bill was passed in 2004 to replace the Seeds Act of 1966. This bill created a regulatory environment conducive to the growth of the seed industry. The Seeds Bill makes the registration of all varieties of seeds mandatory. It emphasizes on registration of all varieties of seeds before it is sold in the market and that no producer shall grow or organize the production of seed unless he or she is registered by the State to do so. On one hand, it aimed at helping the illegal sale of seeds but this restricted many groups of farmers. This is because the registration process is an expensive affair which in most cases is not affordable to all groups of farmers. According to both Shiva (2013) and Stone (2010), this increase in shift towards the use of the genetically engineered seeds has not only resulted in a process of agricultural 'deskilling', but has also led to a reduction of biodiversity in agricultural production which was the mainstay of primitive agriculture in the country. By

taking away the right to produce seeds, the private corporations will encroach on the rural agricultural market and can ruin the rural economy, mainly, the small and marginal farmers.

4. Conclusion

The two technologies, namely, the high yielding variety (HYV) seed technology and the Bt technology can be called as important breakthroughs in the history of agricultural development in India. From where the paper has started, these can be termed as 'paradigms' or 'paradigmatic shifts' in the world of agriculture. From the HYV seeds to the Bt cotton seeds, there has been a scientific revolution. Scientific endeavour has been successful to delve into changing genetic structure in order to increase productivity and quality of produce.

To answer the research questions, firstly, it can be pointed out from the study that the nature of social structure in the rural community has not changed. The traditional caste and class disparity continues to persist among the farming community. Case studies from West Bengal, Gujarat, Haryana, Punjab, Andhar Pradesh, Tamil Nadu show that small and marginal farmers are tied in the complex politics of social and economic condition of the rural economy in the country. The condition of the small and marginal farmers has not changed much from what it was in the colonial period. The nature of 'sub-infeudation' and exploitation of the lowest caste and class of cultivators has intensified with the increase in commercialisation and introduction of 'profit-making' agricultural production. *Santhals* in West Bengal, *Pallas* and *Parayas* in Tamil Nadu, *Dublas* in Gujarat, *Dhobis*, *Chamars*, *Chandals* and other low caste and tribal groups have suffered mostly in existing social structure.

Green revolution and Bt technology has helped only some groups of farmers who have been able to implement the technology. In green revolution, there was no involvement of multinational seed corporations taking over the indigenous right of the farmers to re-sell the seeds. With the introduction of patenting policies and implementing tough regulations to follow international treaties, Bt technology has become more of a menace for the small and marginal farmers. These two technological innovations have not been successful to reduce poverty and thereby reducing social inequality between groups of farmers. Studies from states of Punjab, Haryana, Uttar Pradesh show that instead of reducing inequality these innovations have increased income inequality. Indebtedness has increased among the small and marginal farmers because they compete with the big farmers to be at par with them.

Undoubtedly, it can be pointed out from the study that the group of small and marginal farmers and those of the agricultural and landless labourers have not been benefitted much from these technological innovations. These innovations have helped the big and medium farmers who have the economic capacity to afford to invest such technological innovations which can increase productivity of crops in term of quantity and quality. The complexity with the introduction of GM seeds has taken place with the introduction and regularisation of patenting policies. For most of the small and marginal farmers it is difficult to get the patented seeds as they are more expensive than the indigenous cotton seeds. These forms of regulation reduce the process of 'diffusion' of technology to all groups of farmers. Even farmer suicides are greater among the small and marginal farmers due to increasing 'indebtedness'.

J. Cassilotao and M. Lastress's definition of innovation system is defined as a process of interaction of various agents which innovate and those who benefit from these innovations. The present study shows that the process of 'diffusion' of technological innovation is hindered by the fact that the powerful agents, the multinational private corporations which produce the new products, the class of big and medium farmers and groups of 'middlemen'

control the process of interaction in the rural community. These innovations fit the definition provided by Thomas Kuhn but do not take into consideration of the 'whole' social structure and its constituent 'parts' formed of different groups of caste and class categories of farmers. Thus, the traditionally lower caste and class groups of small and marginal farmers and agricultural and landless labourers have always been left out in the process of agricultural development with the help of technological innovation and this finding contradicts the hypothesis which the paper is initiated.

Notes:

1. Positivist tradition refers to the tradition of Western scientific understanding. This has come from August Comte's philosophy which emphasises that social sciences are *positive* sciences and can be understood through cause and effect relation. This tradition ignores the fact that social sciences can take into account the human aspirations like 'well-being' and 'happiness'. This tradition was later critiqued by the Frankfurt school scholars who emphasised that social sciences cannot be devoid of human aspirations. See Theodore Adorno and Max Horkheimer (1989): *Towards a New Manifesto*, New York, Verso.

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