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Impact of Technology Transfer on Economic and Socio-cultural Life of Rural Poor in India

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Introduction

Agriculture continues to be the most crucial sector of the Indian economy in spite of the fact that its contribution to Gross Domestic Product (GDP) has declined to 26 % by 2000-01 (at 1993-94 prices) from 59 % in the year 1950-51 (Table 1). However, it provides employment to around 58 % of the workforce which is keeping it at the centre stage of the Indian economy. Any change in the sector in terms of policy, technological or institutional, have a multiplier effect on the entire economy and its population. Agricultural sector besides providing labour to the industry which is slowly progressing in India also provide food to the population and workers at affordable prices to keep the prices under control in the economy. Agriculture also provides raw materials to the industry like textile, jute, food, sugar, food processing and so on. Besides this, the agricultural sector is the biggest market for low price and middle price consumer good, including durable goods as well as capital goods like agricultural implements produced in the industrial sector thus helping in the growth of industrial sector. Agriculture has also contributed towards exports; it has helped to substantially cut down on imports of foodgrains, thus improving the foreign reserves of the country.

On the eve of independence the state of Indian agriculture can be summed up as stagnant with deficient infrastructure, traditional technology and exploitative institutions. Nevertheless, the growth of agricultural production in India since independence has several distinguishing features. In terms of growth rates, there is a clear break with the colonial period trends in production and yields. Second, the post independence growth has two distinct phases generally termed as pre-green revolution period and post-green revolution period. Post green revolution period is marked by the adoption of new technology in few crops especially wheat and rice operating along with increased use of inputs like fertilizers and irrigation. The post green revolution period can be divided into three phases namely:

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First phase (1967-68 to 1980-81), the early green revolution phase and Second phase (1980-81 to 1990-91), the late green revolution phase, and Third phase (1991-92 to 2001-02), stagnant period.

Table 1. Share of gross domestic product and workers in the agricultural sector in India (at 1993-94 prices)

Year	Percentage share of agri. to GDP	Percentage share of agri. workers**
1950-51	59.2	69.4
1960-61	54.8	69.5
1970-71	48.1	69.7
1980-81	41.8	60.5
1990-91	34.9	59.0
2000-01*	26.2	58.4

Source: National Accounts Statistics, 2002, New Delhi, Central Statistical Organization, Ministry of Planning and Statistics. Govt. of India.

** Source: Various Population Censuses, Registrar General of India

* Provisional

Agriculture in Pre- and Post Independence Period

Colonial agriculture was characterized as stagnant using primitive technology with exploitative institutions. The Table 2 presents the growth rates of Indian agriculture in the pre-independence period from 1891 to 1946. The period of around half a century prior to independence suggests a pro longed agriculture stagnation.

Table 2. Growth performance of major crop groups in pre-independence and post independence period

Sl. no.	Major crop groups	Pre-independence period (1891-1946)			Post -independence period (1949-50 to 2001-02)		
		Area	Output	Yield	Area	Output	Yield
1.	Foodgrains	0.31	0.11	-0.18	0.35	2.48	1.78
2.	Nonfood grains	0.42	1.31	0.86	1.26	2.96	1.36
3.	All crops	0.40	0.37	0.01	0.57	2.66	1.68

The growth rate of output of all agricultural crops put together for about half century preceding independence was only 0.4 % per annum. Almost all the growth in the agricultural output was contributed by growth in area under the crops with very little or negligible

contribution by the yield per hectare. A break-up of the total agriculture output into food grains and non food grains shows diverse trends. The rate of growth for the foodgrains output was very low at 0.1 % per annum as compared to 1.31 % per annum for the non-foodgrains output. The increase in foodgrains output was very low despite some increase in the area under foodgrain crops. Obviously yield rates in this crop group were falling during this period. However, relatively higher growth rate of non-food grains crops were largely due to greater support to commercial crops from the British rulers. This was due to their major concern for the supply of agro-based raw materials to British industries. Later this was aimed at supporting the indigenous industries.

Thus on the eve of Independence the agriculture sector of India could be characterised as one which was stagnating what ever growth was there, was due to the deliberate policy of Commercialization pursued by the British. Given the fact that more than half of the domestic product was contributed by agriculture sector, lack of growth in this sector became a major obstacle to the overall economic growth of the country.

In the post independence period agriculture growth received primacy. This objective was achieved by implementing policies and programmes having bearing on agricultural production. The basic thrust of these policies was to expand and improve the irrigation input base and improve the technology. The production performance of agriculture in the post independence period was quite impressive. Over the period 1949-50 to 2001-02 the aggregate output increased at an annual growth rate of 2.48 % per annum with yield increases being the major source of growth. Food grains have an output growth not only noticeably higher than the pre-independence period but also higher than the population growth rate registered in the recent decades. It can be noted (Table 2) that the post independence record of Indian agriculture has been remarkable in comparison with the experience of many developed and developing countries in the initial stages of economic development.

Growth in the Pre- and Post Green Revolution Period

The agriculture sector's impressive growth rate in the post independence period was primarily due to the higher priority accorded to this sector by the Indian planners. The policy makers adopted a two fold strategy to rejuvenate agriculture. The first element of this strategy was to implement land reforms in order to remove the institutional bottlenecks and the second was to undertake massive investment in irrigation and other infrastructure in order to update agricultural technology.

Although the land reforms undertaken during the mid fifties did succeed to a large extent in abolishing intermediaries, however they failed to bring about an equitable distribution in land ownership as depicted in the Table 3. Nevertheless, large investments in irrigation and other infrastructure including extension and community development programmes, resulted in substantial increases in both net area sown and gross cropped area, thus increasing crop output. However the growth process of Indian agriculture was not smooth. Inspite of positive agriculture policy pursued by the state one finds the Indian economy reaching a critical stage in relation to food production towards the end of fifties. It however became increasingly clear that there being obvious limits to the extension of area, steps were needed to increase land yields. Therefore the subsequent decade witnessed the emergence of new production oriented strategy for agriculture. This strategy sought in the first instance, to achieve quick break through in production in selected favourably endowed areas especially having assured irrigation. By concentrated efforts in the form of intensive use of better methods of production these areas were expected to show higher production. This program was known as Intensive Agricultural District Programmes (IADP). New institutions were set up to extend support to developmental activities in different fields. To begin with the new strategy failed to make much impact and agricultural situation deteriorated considerably during the early sixties. Consequently country had to resort to large scale imports of food grains.

Table 3. Distribution of operational holdings - All India

Categories	No. of holdings (000' No)			Area (000' hectare)			Average size holding (ha)		
	1976-77	1980-81	1990 - 91	1976-77	1980-81	1990-91	1976-77	1980-81	1990-91
Marginal (<1 ha)	44523 (4.6)	50579 (6.6)	63389 (59.4)	17510 (10.7)	19727 (12.0)	24894 (15.0)	0.39	0.39	0.39
Small (1-2 ha)	14728 (18.1)	16102 (18.0)	20092 (18.8)	20904 (12.8)	23010 (14.0)	28827 (17.4)	1.42	1.43	1.43
Semi-medium (2-4 ha)	11666 (14.3)	12476 (14.0)	13923 (13.1)	32428 (19.8)	34533 (21.2)	38375 (23.2)	2.78	2.77	2.76
Medium (4-10 ha)	8213 (10.1)	8078 (9.0)	7580 (7.1)	49628 (30.4)	48324 (30.0)	44752 (27.1)	6.04	5.98	5.9
Large 10 & above	2439 (2.9)	2157 (2.4)	1654 (1.6)	42874 (26.2)	37174 (22.8)	28659 (17.3)	17.58	17.24	17.33
All holdings	81569 (100)	89392 (100)	106637 (100)	163344 (100)	162758 (100)	165507 (100)	2.0	1.58	1.57

Source: Agricultural Statistics at a Glance (various issues), Ministry of Agriculture, Govt. of India.

High Yielding Varieties (HYV) Seeds

The food situation in India on the eve of the introduction of new high yielding varieties was alarming. Poverty, malnutrition and starvation was quite widespread. Unemployment has increased out of proportion because of stagnation in the industrial sector. There was serious risk of breaking down of the socio-political order incase the situation did not improve. The food imports were continuously rising. The possibility of importing further was declining due to the uncertainty in world supply of foodgrains in the face of increasing demand from the food deficit regions of the world. Moreover, food prices in the world market were high and increasing, where as the economy's capacity to import was limited. The possibility of increasing production by bringing more land under cultivation through land reclamation measures and cultivation of culturable waste land's was almost exhausted. An overwhelming part of the increased production in future had to come by way of increased land productivity. Therefore in 1965 a "new strategy" for agriculture for the fourth plan was outlined. Independent of the new HYV of seeds and would have been put in operation if the former would not been available.

However it was a sheer coincidence that, by this time, after years of international research and experimentation, the new high yielding varieties of wheat and rice of short duration, short stem, fertilizer responsive became available for commercial cultivation in India. Extensive trials were undertaken in 1964-65 and 1965-66 and it was proved that these were adaptable to Indian conditions. With this agricultural development strategy went under a dramatic change. The change was from traditional to modern agriculture based on the use of non-form purchased inputs like fertilizers, pesticides, electric and diesel pumpsets, tractors and later on harvester combines.

The new technology (also known as bio-chemical technology) was introduced in India in the mid sixties for stepping up the crop output growth rates. The growth rates for the two periods i.e. 1949-50 to 1964-65, the pre-green revolution period and 1967-68 to 2001-02, post green revolution period are presented in Table 4. Agricultural growth during 1949-50 to 1964-65 was as high as 3.15 % per annum with food grains growing at 2.82 % per annum which was much below the growth rate of 3.74 % per annum registered by the non-food grains. Another noticeable feature of these very high growth rates were that wheat, registered higher growth rates due to increase in area rather than yield. On the contrary, in case of paddy growth of yields was substantially higher than that of area growth rate. Even in the case of coarse cereals as a group growth rate of yield rate were higher than the area growth. Inverse was the case of total pulses as group which grew as a consequence of area expansion only. In fact there was deceleration in the yield growth in their case.

Therefore one finds that growth in food grains production were equally shared by growth of area and yield rates. However it is clear from the Table 4 that in overall agricultural growth major contribution was made by the growth of area as compared to growth of yield. This was more glaring in case of non-foodgrain crops. The table clearly reveals that except for wheat growth rates attained in the pre-green revolution period could not be maintained in the post green revolution period despite the adoption of new technology, in some cases growth rates were considerably lower than the earlier period i.e. pre-green revolution period. This is in spite of the fact that the two drought years 65-66 and 66-67 have been dropped from the data.

The impact of the new technology on wheat production is clearly visible. Wheat production growth rate has increased from nearly 4 % per annum in the pre-green revolution period to 4.34 % per annum in the post green revolution period. However, growth rate of rice production which was around 3.5 % in the pre-green revolution period fell to around 2.8 % in the; post-green revolution period. For coarse cereals the decline in the growth rate was quite significant. The output growth rate of coarse cereals declined from 2.25 % per annum in the pre-green revolution period to a bare minimum rate of 0.54 %. Pulses also registered decline in growth rates from 1.41 to 0.81 % in the same period. The perceptible decline in the coarse cereal and pulses production is due to the drastic decline in growth of area experienced by these crops in spite of the some gains in their yield growth rates. In spite of the fall in growth rates of coarse cereal's production, foodgrains as a whole maintained a growth rate of 2.5 % in the post-green revolution period which was slightly lower as compared to 2.8 % in the pre green revolution period. Although the major source of increase in agricultural output in the pre-green revolution period was the expansion in area under the crop. Whereas, in the post-green revolution period one finds a significant contribution made by the yield rates towards the increase in the production of agricultural output which has increased from 1.36 to 2.12 % per annum. Whereas, the growth of area under foodgrains have declined from 1.35 % per annum in the pre-green revolution period to a bare 0.01 % in the post-green revolution period. It may be pointed out that the possibility of expansion of net sown area had almost exhausted by the late sixties i.e towards the beginning of green revolution. Nevertheless because of irrigation expansion and adoption of HYV seeds of short duration, there has been an increase in the gross cropped area due to increase in intensify of cropping. In fact, when one compares the early green revolution period and the later green revolution period one finds that agricultural growth has been made possible by the increasing irrigation levels in case of foodgrains as well as non-foodgrains.

Table 4. Growth performance of major crop groups in pre and post green revolution (% per annum)

Particulars	Rice	Wheat	Coarse Cereals	Cereals	Pulses	Foodgrains	Oilseeds	Fibers	Non-Foodgrains	All crops
					1949-50 to 1964-65					
Area	1.21	2.69	0.9	1.25	1.12	1.35	2.67	2.71	2.44	1.55
Production	3.5	3.98	2.25	3.21	1.41	2.82	3.2	4.56	3.74	3.15
Yield	2.25	1.27	1.23	1.77	-0.18	1.36	0.3	1.88	0.89	1.21
					1967-68 to 1980-81					
Area	0.76	2.94	-0.03	0.39	0.45	0.38	0.24	0.21	0.98	0.54
Production	2.22	5.64	0.62	2.7	-0.39	2.39	1.04	2.45	2.36	2.38
Yield	1.46	2.61	1.57	1.78	-0.66	1.54	0.77	2.06	1.2	1.43
					1980-81 to 1989-90					
Area	0.41	0.46	-1.34	-0.26	-0.09	-0.23	1.51	-1.5	1.42	0.1
Production	3.62	3.57	0.4	3.03	1.52	2.85	5.2	2.44	3.77	3.19
Yield	3.19	3.1	1.62	2.9	1.62	2.74	2.43	3.98	2.31	2.56
					1990-91 to 1999-2000					
Area	0.62	1.67	-0.54	-0.08	-0.61	-0.17	1.14	2.13	1.37	0.25
Production	1.9	3.81	1.48	2.1	0.61	1.94	2.13	1.74	2.78	2.28
Yield	1.27	2.11	-0.08	1.58	0.96	1.52	1.25	-0.48	1.04	1.31
					1967-68 to 2001-02					
Area	0.62	1.38	-1.44	-0.02	0.3	0.01	1.31	0.24	1.36	0.34
Production	2.78	4.34	0.54	2.77	0.81	2.51	3.32	2.44	3.2	2.78
Yield	2.2	2.92	1.9	2.32	0.74	2.12	1.6	2.15	1.68	1.9

Source: Agricultural Statistics at a Glance, Ministry of Agriculture, Govt. of India.

That is the growth rates for the post green revolution period were lower than the pre-green revolution period in spite of the adoption of improved technology. Even this rate became possible due to impressive growth rate of wheat which due to its high weight in the overall foodgrain production could compensate the fall experienced by other cereal and pulses crops. In fact some scholars have gone to the extent of describing green revolution as wheat revolution.

Agricultural Growth in Various Phases of Green Revolution Period

It is usual to compare the performance in the pre-green revolution period with that in the post green revolution period as a whole to gauze the impact of new technology. The beginning of eighties made a definite departure from the trends observed in the early phase of the green revolution period in several respects. There seems to be an acceleration in the growth rate of foodgrains as well as non-foodgrains output during the period 1980-81 to 1989-90 as compared to the early green revolution period that is from 1967-68 to 1980-81. Crops such as paddy, cereals as a whole, pulses and oilseeds whose growth rates in the first decade in the green revolution period had fallen much below those recorded in the pre-green revolution period have shown higher growth rates. It gives clear indications that the major inter crop imbalances in growth witnessed in the early years of the green revolution period are getting redressed to some extent in the recent period.

The comparisons of these two periods suggest that there is an increase in the growth of output of the foodgrain crops. Rice have grown at a rate of 3.62 % in the second phase of the green revolution period as compared 2.22 in the early green revolution period. However there is a perceptible decline in the growth of wheat output from 5.64 % in the early green revolution period to 3.57 %. The reason was quite simple as growth rate of area has steeply declined from 2.94 % in 1967-68 to 1980-81 only 0.46 % during the period 1980-81 to 1989-90. Nevertheless, it is noticeable that growth of yield has further increased from 2.61 to 3.10 % in the respective periods. Among the coarse cereals there is acceleration in the growth rates of Bajra, Maize and millets. On the whole one finds increase in growth rates for the total cereals from 2.61 to 3.60 %. Growth in case of total pulses as well as total foodgrains have also accelerated in the post green revolution period of 1980-81 to 1989-90.

During the nineties i.e, stagnant green revolution period (1991-92 to 2001-02) growth rate of production for both foodgrains and non-foodgrains crops taken together as declined to 2.3 % per annum from 3.19 % per annum achieved during 1980's. The decline in the growth rate of foodgrains was sharper from 2.85 to 1.94 % pre annum. Production growth rate of paddy has declined because of perceptible decline in growth rate of productivity,

though there have been some increase in area. However, the performance of wheat was somewhat better but there was a decline in productivity growth rates. Plateauing of yield of paddy and wheat in higher productivity areas under paddy wheat system and low yield levels in central, eastern and north eastern part of the country have affected the growth of production. The decline in productivity in the nineties has been ascribed to fall in public investment in agriculture because of ever increasing subsidies. Coarse cereals productions recorded a negative growth rate mainly due to diversion of area to more remunerative crops and productivity of coarse cereals remains stagnant.

Generally a major technological improvement in a crop would be accompanied by an upward trend in both its area and yield. An analysis of area and yield for the post-green revolution periods suggests that only rice and wheat the two crops using HYV technology have positive rates of growth of area due to shift from other low productivity crops. To sum up productivity increases is the major source of impressive growth of output in the later green revolution period.

Factors Influencing Productivity

The gains in foodgrains output in the post-green revolution period have come essentially from the improved utilization of the available infrastructure and from the resulting increase in yield per hectare. Growth of foodgrains output in particular and total agricultural output in general is predominantly dependent on increasing yields rather than area. This underscores the growing importance of yield increasing technology. Clearly, current inputs like fertilizer and irrigation have become more important as a source of growth in the recent period. Although the spread of fertilizer to the new areas where the existing level of application was relatively low would have contributed to the rise in productivity per unit of fertilizer.

A major feature of the HYV technology was its package approach. New high yielding varieties seeds, fertilizers, pesticides, controlled water supply and mechanical equipment from seed drills to tractors and combine harvesters – all these agricultural inputs together formed a package. The core of this package was the miracle seed which was developed through selective breeding to be highly responsive to fertilizer input coupled with use of pesticides and herbicides, while without a controlled supply of water the full potential of the new varieties could not develop. A major feature of the new seeds is their shorter maturing period, thus leading to increase in cropping intensity. Therefore increased yield rates coupled with higher cropping intensity led to higher growth of agricultural production in the post green revolution period. The adoption of the HYV technology yielded such spectacular results that it was termed as “green revolution”. Inspite of the fact that it was limited to some

cereal crops only and that too in the regions with good irrigation potential. As such its success depended on the availability of assured irrigation use of fertilizers and the HYV seeds.

Progress of HYV is indicated in the Table 5. The area under High yielding varieties of paddy and wheat increased from 0.88 and 0.54 million hectares in 1966-67 to 32.2 and 23 million hectares respectively by 1997-98. The total area under HYV crops increased from 1.88 million hectares to 76 million hectare over the same period. In 1966-67, it constituted only 2.5 % and 4.2 % to the total are under the respective crops. However in 1997-98 share of HYV area to total area under these respective crops was 67.5 % and 88 %. Total HYV area as a proportion of total foodgrains area has increased from 1.63 % in 1966-67 to 54.3 % in the year 1997-98.

Table 5. Progress in Use of Agricultural Inputs

Area under HYV (Mha)	1960-61	1970-71	1980-81	1990-91	1994-95	1997-98	2001-02
Paddy	0.89@	5.59	18.23	27.39	31.02	32.20	
Wheat	0.54@	6.48	16.10	20.97	23.25	23.00	
Total:	1.89@	15.38	43.08	64.98	71.27	76.00	
Consumption of chemical fertilizers (Lakhs tones)							
Total (N+P+K)	2.92	21.77	55.16	125.46	135.64		193.06
Per hectare (kg)	1.9	13.10	331.83	67.49	75.68		101.21

@ relates to 1966-67.

Source: Agricultural Statistics at a Glance DE&S, Ministry of Agriculture, Govt. of India (various issues)

Impressive success of this programme has resulted in phenomenal increases in the production of these cereals as well as total foodgrains during this period. Productivity of rice increased from mere 863 kgs per hectare in 1966-67 to 2,066 kgs by 2001-02 i.e. more than doubled, wheat productivity from mere 887 kgs per hectare to 2,863 kgs per hectare ie. by around 2.7 times in the same period. However the overall production of rice and wheat has risen much faster by 2.6 and 5.3 times respectively during this period because of increases in area under these crops due to relatively higher yield rates. That is to say the success story of HYV programme is limited to the two major foodgrain crops i.e. rice and wheat. Besides this it was also localized to the few states of the Indian Union and it was more true about wheat than rice. HYV was a spectacular success in case of wheat in Punjab, Haryana and

UP to be precise western U.P. where water was available in plenty. To an extent incentive price support policy of the government also played a crucial role in the increased use of new seeds.

In fact the increase in wheat output has become an important stabilizing factor in foodgrains production in the country of late wheat cultivation is spreading in the non-traditional areas such as West Bengal, Maharashtra, Assam, eastern Bihar and Orissa. In case of cultivation of HYVs of paddy there is a visible significant progress made although the pace of development is not as fast as in the case of wheat. This is due to the fact that the bulk of the crop is grown in the Kharif season which suffers from the vagaries of the monsoon, characterized by drought or floods and its vulnerability to attack by pests and diseases is very high. However in the rabi season (or winter) when rainfall is low and water management is easier the HYVs of paddy have shown much better results. As a result of the introduction of HYVs, paddy production has increased at a faster rate in the non-traditional rice growing states like Punjab, Haryana and Western Uttar Pradesh which are therefore contributing a significant proportion of the total procurement for the central pool because of limited local consumption.

Irrigation and Water Use

Water is a crucial input for plant growth. Annual precipitation is a major source of water in India. Average annual rainfall is about 1,200 mm but it is seasonal and highly uneven in its geographical distribution over the country. In some areas of the country e.g. West Rajasthan, the annual rainfall is less than 200 mm; in others e.g. Southwest India and parts of Assam it is as high as 4,000 mm. As much as 34 % of the net sown area lies in low rainfall regions i.e. with annual precipitation of less than 750 mm. Another 36 % of the area receives 750 mm to 1,150 mm. Only the remaining 30 % of the net sown area enjoy benefit of more than 1,150 mm i.e. high rainfall. In view of uncertainties in rainfall irrigation is a critical requirement not only in low and medium rainfall regions but is necessary even in high rainfall regions as a supplementary source of water in the Kharif season.

The importance of irrigation to India's agriculture cannot be over stated. Apart from its vital importance for healthy crop growth, irrigation has attained crucial significance in view of the country's expanding needs of food production. The availability of water all the year round through irrigation networks facilitates double cropping as well as reduces the impact of vagaries of nature. Given the limited opportunities for bringing the additional acreage under cultivation in future, irrigation is capable of playing a useful land augmenting role in India. Increase in agricultural production in general and foodgrains production in particular for the

growing population have to come largely through higher intensity of cropping and increased productivity per unit of land.

Irrigation is a pre-condition for the successful introduction of the new varieties even in areas known for heavy rainfall, such as the rice producing deltas of south India. The dwarf sized new varieties could not be cultivated in flooded low lying areas which have traditionally been planted with taller varieties adapted to growing with water in the fields. Therefore successful attempts were made to breed high yielding varieties which can cope with deep water conditions.

One finds that the net irrigated area as a proportion of net sown area and gross irrigated area as a proportion of gross cropped area increased from 17.56 and 17.11 % to 19.34 % and 19.90 % respectively during the period 1950-51 to 1965-66 i.e. pre-green revolution period, which further increased to 40.0 and 39.2 %, respectively, in post green revolution period. This is also reflected in the increase in the cropping intensity which have increased from 111.1 in 1950-51 to 135.1 in 1998-99 (Table 6). In the initial stages increase in net irrigated area were brought about mainly through canals and wells. According to Table 7, the percentage area irrigated by these two sources of irrigation in 1950-51 was 68.5 % which increased to 71.1 % by 1960-61. However after the mid sixties a much faster growth was registered by tube well irrigation, which is assured irrigation a prerequisite for the successful adoption of HYV technology. Over and above the quality of irrigation has improved that is it has become more assured as compared to pre-green resolution period.

Table 6. Selected categories of land use classification (million hectares)

Year	Net area sown	Net irrigated area	Percentage of NAS irrigated	Gross cropped area	Gross irrigated area	Percentage of GCA irrigated	Cropping intensity
1950-51	118.75	20.85	17.56	131.89	22.56	17.11	111.10
1955-56	129.96	22.76	17.62	147.31	25.64	17.41	114.10
1960-61	133.20	24.66	18.51	152.77	27.98	18.32	114.70
1965-66	136.20	26.34	19.34	155.28	30.90	19.90	114.00
1970-71	140.27	31.10	22.17	165.79	38.12	23.04	118.20
1980-81	140.00	38.72	27.66	172.63	49.78	28.84	123.30
1990-91	142.25	47.78	33.59	185.91	62.47	33.60	129.90
1998-99	142.60	57.03	40.00	192.62	75.56	39.20	135.10

Source: Agricultural Statistics at a Glance DE&S, Ministry of Agriculture, Govt. of India (various issues).

Table 7. Area irrigated by sources (area in thousand hectares)

Year	1950-51	1960-61	1970-71	1980-81	1990-91	1996-97
Canals	8,295	10,370	12,838	15,292	16,900	17352
	(39.8)	(42.1)	(41.3)	(39.5)	(35.7)	(31.46)
Tanks	3,613	4,561	4,112	3,182	3,245	3343
	(17.3)	(18.5)	(13.2)	(8.2)	(6.2)	(6.06)
Tube wells	(a)	135	4,461	9,531	14,211	30825
		(0.6)	(14.3)	(24.6)	(29.9)	(55.9)
Other wells	5,978	7,155	7,426	8,164	9,999	(b)
	(28.7)	(29)	(23.9)	(21.1)	(21.1)	
Other sources	2,967	2,440	2,266	2,551	3,079	3623
	(14.2)	(9.8)	(7.3)	(6.6)	(6.5)	(6.57)
Total net irrigated area	20,853	24,661	31,103	38,720	47,434	55143
	(100)	(100)	(100)	(100)	(100)	(100)

(Figures in the brackets are percentages)

(a) Included under "other wells" as separate figures were not collected during this year

(b) Other wells included in 1996-97

Source: Agricultural Statistics at a Glance DE&S, Ministry of Agriculture, Govt. of India (various issues).

Fertilizers Consumption

Rapid population increases coupled with increasing demand for land for non-agricultural purposes has lead to increasing pressure on land. Therefore the major emphasis has to be on raising the yield per acre of cropped land and on increasing cropping intensity of land used for cultivation. The net sown area is inelastic and has not increased much since 1970-71 to 1998-99. It was 140.27 million hectares in 1970-71 and increased to only 142.6 million hectares by 1998-99 i.e. has remained almost stagnant for twenty-eight years. It has already been pointed out that the new varieties are responsive to fertilizer input. Therefore with increasing dosages of fertilizer, the output from traditional varieties has grown only to a limited extent, whereas the new varieties show increasing yields up to a very high level of fertilizer input. The adequacy of the fertilizer supply is for this reason, considered by many as a major pre-condition for the success of the technology associated with the new varieties.

Traditionally the level of consumption of fertilizer in India has been very low at less than a kg per hectare. Before the green revolution period i.e., 1960-61, the consumption of fertilizer was only 0.3 million tones. However it increased to 1.90 kgs per hectare of cropped area by 1960-61 and increased to 9.40 at the time of introduction of HYVs in India. It rose to

around 32 kgs per hectare of cropped are and touched an all time high figure of around 101 kgs per hectare in the year 1998-99 (Table 8). However, consumption in India is very low in comparison other Asian countries like Rep. Korea and Japan, where the application of fertilizers per hectare is as high as 453 kg and 289 kgs respectively. Fertilizer consumption rapidly increased with the introduction of HYV's. The domestic production of fertilizer increased from 98 thousand tones in 1960-61 to 14,704 thousand tones by 2000-01. Dependence on imports has declined over the year s and they are only 2,196 thousand tones i.e. around 13.1 % of the total consumption.

Table 8. Economics of application of fertilizers on paddy and wheat in India

Particulars	1971-72	1981-82	19991-92	2001-02
Qty of paddy required to buy				
(a) 1kg of N	3.79	4.44	2.89	1.89
(b) 1kg P205-ASSP	5.45 - 6.67	4.24 - 5.31	3.37	2.95 - 3.54
DAP	3.51	5.07	3.29	2.91
Complex	4.64 - 5.60	5.84 - 7.17	3.82 - 4.67	3.08 - 5.30
(c) k20	1.68	1.89	1.23	1.34
Qty of wheat required to buy				
(a) 1kg of N	2.64	3.93	2.96	1.64
(b) 1kg of 205-ASSP	3.80 - 4.64	3.75 - 4.70	3.44	2.56 - 3.07
DAP	2.45	4.48	3.36	2.53
Complex	3.24 - 3.91	5.17 - 6.35	3.90 - 4.77	2.67 - 4.60
(c) 1kg of k20	1.17	1.67	1.26	1.16

Source: Agriculture at a Glance, 2002, Ministry of Agriculture, New Delhi

The phenomenal increase in production and productivity in agriculture since the mid sixties have been achieved through exploitation of the potential of HYVs with the help of increased use of fertilizers and assured irrigation. The pace of growth slowed down considerably during the period 1972-74 culminating in 1974-75. That was the period of energy crisis; the availability of fertilizers in the world market had shrunk; the prices had skyrocketed; ocean freight costs had galloped and profitability of fertilizer use had reached a low point. The steep rise in the price of chemical fertilizers had a dampening effect on the use of fertilizers. In northern India where selling fertilizers was never a problem, sales met with resistant from the peasants. The situation changed due to corrective action taken by the government, and supported by the industry and facilitated by the distinct improvement in the world situation. The Table 8 clearly shows that the fertilizer prices have continuously declined since 1980s in terms of rice and wheat output prices.

Massive increase in fertilizer consumption would require a matching effort to strengthen the production and marketing infrastructure so as to make the right type of fertilizer available to the farmer at right place, at the right time and at the right price. It would also need a matching effort in providing strong extension support and making available other inputs such as irrigation water, credit and quality seeds to the farmers.

Investment in Agricultural Sector

Investment in the economy in the agricultural sector picked up with the introduction of new technology. Table 9 shows that during the pre green revolution period i.e. 1960-61 to 1969-70 growth of capital formation in the agricultural sector was 3.65 % per annum. The public sector investment was growing at 2 % per annum and the private sector at a rate of 5 % per annum. It may be mentioned that the share of private sector was higher in the capital formation in the agricultural sector as compared to public sector. However, in the post-green revolution period the growth of capital formation picked up and grew at 5.38 % per annum due to public sector participating more rigorously and growing at a higher rate of 6.41 % per annum and even higher than private sector. Then, there is a steep decline in the following periods as far as public sector investments are concerned. This has a bearing on the productivity in the agricultural sector which has started stagnating or declining. On the contrary growth rate of private sector picked up in the following periods i.e., 80 and 90. This happened because of wide spread mechanization.

Table 9. Growth in gross capital formation in agriculture: 1960-61 to 2001-02

Period	Public sector GCF	Private sector GCF	Total GCF
1960-61 to 1969-70	2.54	9.81	6.67
1970-71 to 1979-80	9.60	7.90	8.61
1980-81 to 1989-90	-4.38	2.08	-0.86
1990-91 to 2001-02	-0.66	3.70	2.86
1960-61 to 2001-02	1.47	3.55	2.85

Mechanization is induced by the secular tendency for the biological sources of energy to become costlier as compared to mechanical sources. This is due in part to the labor saving bias of the technological change as well as increasing ease with which capital can be substituted for labor in agriculture. Further with the rise in incomes of farmers, the desires to reduce the drudgery of manual work assert itself. It may even raise the participation rate among those who could afford to abstain from the drudgery of manual work. Further, as Hanumantha Rao has argued labor in the sense of effective energy or efficiency units can't

be abundant when food is in short supply and the cost of labor can rise despite the growth of population. Besides economic compulsions, the presence of mechanical sources of energy particularly tractors adds to the prestige (status) of farmers.

The accompanying Table 10 shows the degree of mechanization of Indian agriculture since 1966. The table shows a very low degree of mechanization in the year 1966 i.e. at the time of adoption of new technology. Since then the pace of mechanization gathered momentum as is evident from the increase in the number of oil engines with pumping sets and electric pumping sets for irrigation, four wheeled tractors and threshers for wheat, paddy and other crops etc. The number of electrical pump sets has increased from 415 thousand in 1966 to 4,518 thousand by 1987 i.e. increased ten times (Table 10).

Table 10. No. of selected agricultural implements and machinery (in thousands)

Items	1966	1987	1992
1. Ploughs (wooden & iron)	43,446	51,888	395,815
2. Diesal engine (pump sets)	471	116,666	45,774
3. Electric pump used for irrigation	415	4,518	64,035
4. Tractors used for agriculture	54	738	12,218
5. Threshers	349	515	
6. Sugarcane crushers	695	718	5,861
7. Animal carts	12,697	14,350	133,860

Source: Livestock Census 1966, 1987, and 1992

Many factors have contributed to the growth of tractor use in the country with the introduction of the new varieties. On the supply side, the HYV seeds have been launched with an accompanying generous credit policy which has made the purchase of agricultural machinery easier. However, easy financing can't by itself explain the shift to tractor ownership, since according to available estimates, until 1970 only 10 % of the tractors were purchased with the institutional loans.

Most of the money for their purchase came from private sources, part of it from the increased profits accruing to the large farmers from the cultivation of new varieties. The food situation in India on the eve of introduction of HYV was alarming. Even the possibility of importing foodgrains had exhausted due to the uncertainty in word supply of foodgrains especially in the face of increasing demand from food deficit regions of the world. On the other end possibility of increasing production by expansion of area had exhausted and the only option left was to increase productivity. Exactly at that time newly developed improved

varieties of seeds of wheat and rice which were more responsive to fertilizer and irrigation became available.

This led to impressive growth of production of wheat and rice output due to spectacular increase in the productivities of these crops. Expansion of area under high yielding varieties of seeds was matched by the increasing application of technical inputs. The adequacy of the fertilizer supply was a major pre-condition for the success of this technology. Another crucial input was the assured irrigation. The availability of water all the year round through the irrigation networks initially and tube well irrigation later on not only helped in increasing the productivities of the HYV crops but also resulted in increasing cropping intensity to increase the per unit productivity of land. Although mechanization especially tractors and combine harvesters were instrumental in replacing both bullock power and human labor nevertheless they had an advantage in saving time by enabling certain agricultural operations to be completed within given time, thus leading to higher intensity of cropping on the one hand and increasing productivity by minimizing losses on the other.

Impact of Technology

A technical change of such a magnitude has for reaching implications for the economy and the people and institutions governing them. Some of these issues have been discussed here. The most hotly debated issue about green revolution is the growing income inequalities between different regions and different classes of farmers. Since the success of new technology depended greatly on the adequate provision of water, its beneficial effects were mainly concentrated in the irrigated regions of the country. Therefore in the early phase of green revolution regional disparities were high. It was because of the inability of the poorly endowed regions to adopt new technology on large scale. Regions poorly endowed with suitable Soil, climatic and irrigation facilities of these have failed to achieve the same level of output and income as that of better-endowed regions.

However experience in the later period reveals trends, which were typical of a diffusion process. These trends were: the spread of green revolution to new areas, the increasing adoption of new technology by small, farmers, the decline in relative prices of food grains, and, rise in the real wages in agriculture in the less developed regions where technology is spreading.

Although it is a general understanding that any land saving technological charges would displace labor did not come true. The land saving technological charges in labor abundant economy like India has resulted in greater absorption in agriculture. Many studies showed that green revolution did increase labor absorption in the farm sector. In fact the

demand for labor increased in the green revolution regions prominent among them Punjab followed by Haryana. The rise in demand for labor in Punjab was so much that about a million workers use to migrate each year from the agriculturally backward regions of eastern up and Bhihar for rice transplanting and harvesting of paddy and wheat in the state.

The short-duration HYVs of seeds coupled with increase in irrigation facilities resulted in increase in cropping intensity and led to increase in labor use. In practice, however, Because of the profitability of intensive farming involving the use of a large quantity of water and fertilizers per unit of land, there was an incentive for increasing cropping intensity, leading to increase in output per unit of land. However, until recently the impact of new technology and the expansion of tube well irrigation was not significant in the regions where labor was plentiful. A major proportion of area continues to be rained and may explain why the rise in cropping intensity at macro-level has fallen short of the plan expectations in the post-green revolution period.

Growth of agriculture has been uneven because of heterogeneity of soil and climatic conditions not only across the regions but in a region as well. There fore the absorption of labor has to be guided by these conditions and the nature of crops grown and input as well as availability of institutional credit for the less developed regions. Some scholars have mentioned that uneven regional growth was mainly responsible for the low absorption of labor within agriculture. In a large number of states, especially in those regions where there was an abundant availability of labor, the growth of output was too slow to generate adequate employment opportunities. In high-growth regions labor was not plentiful and wage rates were high. Which led to movement of labor from low growth backward regions to high growth developed regions. The sudden rise in the demand for labor in these areas also induced mechanization and labor-saving practices in general. The improved performance of the eastern states in respect of food grains output, particularly rice, during the eighties, might lead one to think that these regional disparities have stared narrowing down in the recent years.

However, the inter-state disparities in agricultural wages started declining since the mid-seventies (Jose, 1988). The decline in disparities in real wages is even more significant. This is because the decline in the relative prices of food grains had a greater impact on the purchasing power of wage-earners in low-wage areas. For example, the disparities in real wages in agriculture between the Punjab on the one hand, and Bihar on the other, started declining from eighties. The real wages in the Punjab having risen significantly in the early phase of the green revolution virtually stagnated after the mid-seventies for some years and have continuously increased up 1993-94 and then moderately declined.

Whereas the real wages in Bihar started rising slowly and then remained almost stagnant but were higher than Karnataka, where the impact of technology was almost missing. Nevertheless in eighties and nineties the inter-regional variations were almost constant as is depicted by the coefficient of variation (CV) in Table 11. The causes for the constancy of inter-state disparities in real wages are: due to the out migration of labor form the less developed low wage regions to the high-wage areas the mechanization of agricultural operations in the developed regions having a depressing effect on rising wages, the decline in the relative prices of food grains; the increase in employment generated in the less developed regions under the poverty alleviation programs; and the recent decline in agricultural growth in these regions. An encouraging consequence of these developments is that the disparity between the male-female wage rates has also, started decline in several states. The use of new technology may have improved the bargaining power of female labor for operations such as transplanting and interculturing on account of the rise in seasonal demand for such labor.

In the initial stages of technological change, large farmers, owing to their better access to knowledge and resources and because of their capacity to bear risks, took the lead in the use of high-yielding varieties of seeds coupled with fertilizers thus increasing output on their farms faster than on small farms. This resulted; in weakening or in some places even the disappearance of the traditionally-observed inverse relationship between farm size and output per hectare, which prompted some analysts to assert that in the context of new technology large farmers are as efficient as, and even more efficient than, small farmers However this fact could no be substantiated by not be an studies conducted even in the late eighties. In fact, authors own study based on 1974-75 data of Haryana and Orissa study based on 1989-90 data clearly shows the inverse relationship between farm size & Productivity. (see Table 12 & 13).

However, such observations and studies reflected that higher output per acre of net sown area among small farms was achieved not only through higher cropping intensities involving the greater use of labor as well as by stepping up significantly the yield per hectare, of certain individual crops such as rice and wheat, due to intensification of inputs like fertilizer and irrigation. In so far as cropping intensity among small farms continued to be higher than among the large farms.

Table 11. Real wage rates (Rs.) of male agricultural laborers (field man, field labor and/ploughman) across different states for the period 1980-81 to 1996-97

Year	AP	Bihar	Gujarat	Haryana	Karnataka	Kerala	MP	Maharastra	Orissa	Punjab	Rajasthan	Tamil Nadu	UP	WB	CV
1980-81	1.69	1.36	1.49	2.87	1.51	2.90	1.10	1.29	1.08	2.69	2.02	1.44	1.44	1.74	35.56
1981-82	1.66	1.53	1.98	3.12	1.41	3.08	1.17	1.26	1.06	2.66	2.24	1.53	1.82	1.66	35.91
1982-83	1.91	1.51	2.64	3.38	1.46	3.04	1.41	1.43	1.00	2.83	3.05	1.45	1.74	1.58	38.48
1983-84	2.11	1.57	2.75	3.59	1.32	2.62	1.55	1.53	1.18	3.06	3.00	1.53	1.79	1.60	36.83
1984-85	2.26	1.81	2.90	3.51	1.33	3.01	1.66	2.05	1.39	3.30	2.09	1.68	1.92	1.92	31.79
1985-86	2.39	1.90	2.73	3.43	1.74	3.32	1.64	2.09	1.40	3.31	2.43	1.72	1.98	2.25	28.82
1986-87	2.52	2.04	2.78	3.75	1.63	3.44	1.82	1.89	1.46	3.56	2.96	1.73	2.18	3 .007	32.14
1987-88	2.48	1.94	2.36	3.47	1.59	3.53	1.76	1.89	1.40	3.60	3.51	1.66	2.00	2.95	33.46
1988-89	2.37	2.12	2.67	3.50	1.82	3.49	1.73	1.90	1.46	3.61	3.00	1.73	2.96	3.36	30.14
1989-90	2.78	2.16	2.69	3.88	1.98	3.47	1.90	2.35	1.59	3.85	2.83	1.92	2.31	3.27	28.13
1990-91	2.80	2.24	2.57	3.78	1.92	3.65	2.03	2.51	1.75	3.99	2.85	1.97	2.22	3.07	27.30
1991-92	2.48	2.14	2.46	4.00	1.67	3.80	1.95	2.14	1.68	4.13	3.02	1.87	2.25	2.88	32.39
1992-93	2.52	2.01	2.65	4.49	1.43	4.17	2.19	2.16	1.86	4.31	2.91	2.12	2.42	3.58	35.39
1993-94	2.74	2.10	2.73	4.26	2.02	4.05	2.11	2.71	1.86	4.38	2.69	2.37	2.25	3.35	30.15
1994-95	2.82	2.19	2.76	4.28	1.70	4.27	2.14	2.69	1.79	4.33	2.72	2.39	2.20	3.17	31.70
1995-96	2.76	2.25	2.71	4.41	1.55	5.23	2.25	2.31	1.75	4.22	3.42	2.51	2.51	3.14	36.05
1996-97	2.81	2.08	2.99	4.47	1.88	5.53	2.28	2.68	1.80	4.03	3.53	2.67	2.36	3.52	35.11
Growth. Rate(%)	2.97	2.67	1.77	2.40	1.50	3.66	4.03	4.35	3.82	3.16	1.93	3.71	2.53	5.23	-

Note: The real wage rate for a state in a specific year has been calculated by deflating the state's nominal wage rate by the corresponding CPIAL of that state in that specific year

Many studies discovered that although the rate of adoption was higher among the large farmers but the intensity of adoption was higher on the smaller farmers as well as proportion of area irrigated which kept the inverse relationship intact (Sharma, 1992). There may be a few studies talking about the mechanical device displacing labor. However their use was necessitated due to shortage and uncertain supply of labor. Therefore it did not have of an adverse effect on the employment and income of hired labor whose absorption has been increasing. However, it did have a depressing effect on the rising wage-rates which almost stagnated. Since such a technology is size-neutral, though not resource-neutral, there was no basis for the emergence of the phenomenon of increasing returns to scale, in the strict sense of the term.

The nationalization of major commercial banks in the mid-seventies and the development of other formal institutions for the supply of rural credit, made the credit available to small and marginal farmers at lower rates of interest, improved the small farmers' access to modern inputs significantly (Desai, 1988). The use of new seed-fertilizer technology among small farms caught up with that of large farms. Small farmers have advantage in respect of cropping intensity, the inverse relationship between farm size and output per net operated area did not disappear, labor input per acre continued to decline sharply with the increase in size of holding which was one of the causes for the inverse relationship. Nevertheless their dependence on the informal institutions for credit continues to be substantially greater than large farmers putting them at a disadvantage.

A comprehensive field study conducted in Haryana, for the year 1974-75 with a large sample of 3,412 households spreading over the whole state which was one of the early adopter of the green revolution clearly brings out that the impact of green revolution was higher among the small farmers as for as output per acre is concerned. Although there was a direct relationship between the rate of adoption and farm size, nevertheless intensity of adoption is higher among the small farmers as compared to large farms i.e. having an inverse relationship. A major proportion of the area under HYV was initially claimed by wheat follower by paddy by the adopter households. However Paddy is localized in a region of the state mainly because of adequate and assured supply of water. Wheat is quite wide spread over, as it requires less intensive irrigation. Study further finds that output of adopter households was significantly higher than the non-adopter households and inversely related with the farm size (Table 12). However, in absolute terms the gaps between the lowest and highest farm size groups have been induced mainly by the skewed land distribution. Study further shows that share of gross irrigated area as well as intensity of cropping are higher for the adopters as compared to non-adopters and is inversely related to farm size. Similarly per acre fertilizer input is also higher for the adopters and is inversely related to farm size.

It is interesting, however that small farms use their cropped area relatively more intensively than large farms. However, the advantages of large farms to the rate of use of inputs including tube well irrigation is outweighed by the advantage that small farms have by way of higher cropping intensity. The study brings out the relationship between farm size and cropping intensity to be negative and statistically significant. The authors have, therefore, studied the relationship between farm size and value of output per acre of net operated area and found this to be negative and statistically significant. It is thus clear that the slight edge that large farmers had in regard to the use of modern inputs was more than counter balanced by the small farmers' advantage due to availability of family labor.

The same findings were reconfirmed by the 1989-90 data of Orissa which again showed that small and marginal farmers not only have a higher intensity of cultivation involving a greater use of labor, irrigation, cropping intensity, and use of organic manures but also show a higher rate of input use involving cash outlays such as for chemical fertilizers. In fact, the per acre use of bio-chemical inputs in HYV is more than double of that in traditional rice for all categories of farm household in the state. It is also observed that all the farmers use more labor per unit of land in HYV than in traditional varieties. The demand for hired labor increases substantially under the new variety. It is because of the agriculture in general and new technology in particular has time bound agricultural operations which increase the demand per labor at that point of time. Even the small farmers are compelled to depend on hired labor to complete the specific agricultural operations in time, though they have surplus labor during other times of the year. Further shows that the availability of 'cheap' family labor and the managerial and supervisory advantages of small size may account for their better performance, particularly because there are some complementarities between the use of biochemical inputs and human labor (Sharma and Swain, 1995).

To sum up the above analysis shows those small and marginal farms, though still lagging behind large farms in the adoption of new technology, have been able to bridge this gap significantly over the last two decades. Their advantages in regard to "cheap" labor and managerial efficiency still persist, resulting in higher levels of irrigation and cropping intensity. On balance, therefore, the inverse relationship between farm size and productivity per unit of net operated area persists even now. Further, since labor input per acre has declined among the large farms, due to the use of tractors and harvest combines had a depressing impact on the employment and income of the wage labor.

Table 12. Input and output per acre according to farm size in Haryana, 1974-75.

Particulars	Marginal (0-2.49)	Small (2.50-4.99)	L-middle (5.00-7.49)	U-middle (7.50-12.49)	Big (12.50-24.99)	Very big (25 & above)	All
Adopeters							
Sample size	191	377	449	494	306	90	1907
Net operated area (acres)	1.63	3.52	5.94	9.66	16.7	32.85	8.99
% Irrigated area	89.23	81.45	73.75	72.08	68.35	65.9	75.21
Cropping intensity	1.87	1.76	1.63	1.59	1.51	1.47	1.66
Family size	6.38	6.54	7.42	7.87	9.11	9.69	7.71
Per acre gross output (Rs.)	1,508.47	1,471.43	1,376.53	1,303.76	1,196.07	1,186.26	1,280.95
Per acre cost (Rs.)	613.14	585.03	492.71	429.77	374.21	383.21	430.32
Per acre fertilizers manure (Rs.)	99.96	97.13	75.01	73.42	66.91	72.73	73.93
Non-adopeters							
Sample size	223	30	381	341	164	36	1505
Net operated area (acres)	1.6	3.5	5.9	9.7	16.4	29.8	7.2
% Irrigated area	53.0	53.1	57.3	50.2	45.0	44.7	52.4
Cropping intensity	1.6	1.6	1.5	1.5	1.3	1.3	1.5
Family size	6.3	6.6	7.3	7.9	9.1	9.1	7.4
Per acre gross output (Rs.)	979.6	446.9	957.5	900.6	788.8	791.5	884.0
Per acre cost (Rs.)	413.4	394.9	348.6	302.5	221.5	204.6	296.6
Per acre fertilizers manure (Rs.)	31.6	31.4	30.0	25.5	20.4	19.3	25.4
Adoption gains (1974-75)							
Percentage gains	62.15	55.41	42.23	44.75	51.62	49.88	44.9
Rate of adoption	46.14	51.15	54.1	59.16	65.11	71.43	55
Intensity of adoption	63.58	53.5	45.62	42.73	40.16	42.22	43.77

Source: Sharma, R.K. (1992).

Despite severe hardships for the migrant labor and their exploitation, social tensions are not acute and, by and large, there is an outward appearance of peaceful transformation in the areas of the green revolution. Apart from the availability of unorganized and dependent migrant labor this apparent harmony is also explained by the prevailing land-tenure systems. The initial conditions in the areas of the green revolution were generally favorable as they were characterized by the Ryotwari system of tenure and not the Zamindari or other semi-feudal systems. However, the major reason for the absence of these tensions were the quantum of work generated in the rural areas which could not been handled by the local labor. Due to enormous increase in output in the states like Punjab lots of high wage jobs were created in the new Mandi towns which absorbed the local labor. Even in the rural areas local labor was offered higher wage jobs in their own states. Also, despite the hardships and exploitation, the income of the migrant labor was much higher than what they would have been able to earn in their own states.

It is interesting to observe that despite the existence of such a large reservoir of labor force, the rate of mechanization was higher in the process of the green revolution. As already mentioned this was due to the fact that agricultural operations are to be competed with in a short span of time and to be on safer side farmers made use of the machines without creating any unemployment among the local labor. It might have slowed down the speed of migration to these areas. However, it does have a depressing effect on the wage rates to the extent that they did not rise further at the same rate.

The small farmers' capacity to survive and even to use technology successfully is reflected in the social relations in rural areas. The conflict of interest one witnesses, on account of the green revolution, is not much between the sharecropper and the landlord or between the small and the large farmers. Although the transformation appears, by and large, peaceful despite being painful in the green-revolution areas, it has repercussions in the backward areas, particularly those characterized by semi-feudal relations. In the process of migration, the labor has become more skilful, enterprising, and has considerably improved its staying power on account of the rise in its income. The Proportion of migration-prone labor is quite high in certain backward areas. As a result of the rise in staying power and supply price of labor, the real wages have started rising in such areas between the early seventies and the late eighties, so that the wage disparity between the developed and the less developed areas has not been increasing further (Table 13). The male-female disparity in wage rate is also coming down.

Table13. Per acre output, employment and expenditure on bio-chemical inputs in Orissa farm size (in acre)

Particulars	Marginal (up to 2.5)	Small (2.5-5.0)	Medium (5.0-10.0)	Large (10 & above)	All
Yield rate per acre of cropped area					
Desi	7.10	6.21	6.91	6.18	6.63
HYV	14.90	16.18	14.56	13.98	15.07
% change	109.85	160.54	110.70	126.21	127.30
Per acre use of human labor days					
Desi	59.11	50.02	45.51	33.32	50.37
HYV	89.90	81.82	74.22	73.05	86.44
% change	52.08	63.57	63.08	119.23	71.61
Per acre expenditure on bio-chemical					
Desi	373.73	338.97	317.91	313.63	344.29
HYV	746.48	723.40	748.49	703.83	732.63
% change	99.73	113.41	135.44	129.41	112.79

There are certain other features of the green revolution, apart from the rise in wages, which have directly benefited the poor. Despite mechanization, agriculture is still more labor-intensive than many of the industrial activities and, what is more, it provides employment to the poorest of poor. Because of competition and also because there is an early limit to the demand for essential commodities like foodgrains, the green revolution has brought about a decline in the relative prices of foodgrains such as wheat and rice. This is how the benefits from the rise in productivity on account of the green revolution have been passed on to the consumers. This is also reflected in the declining poverty ratios (Table 14). The Poorer sections, who spend a large proportion of their budget on foodgrains, have been benefited relatively more than the well-to-do from the decline in the relative prices.

In so far as large farmers have resumed self-cultivation from sharecroppers because of the profitably of new technology, it has led to lower labor absorption and reduced incomes of erstwhile tenants. However, in quite a few places, cost sharing on new input s between the landowners and sharecroppers has become popular resulting in the sharing of benefits from new technology by the landowners as well as the tenants (Srivastava, 2001). Though share crop tenancy is predominant in the state of Orissa, there is a marked shift from share crop tenancy to fixed rent tenancy in the developed villages. One also observers that fixed rent tenancy is positively related to farm size showing that bigger size farms prefer to operate under fixed rent arrangements. There are three important factors which determine the crop

shares between the tenants and the landlords. The quality of the soil, pattern of cost sharing between the lesser and the lessee and the adoption of HYV rice. Impact of the new technology on the inter-locking of the land-lease market has also been studied in Orissa. It is found that more tenants in the underdeveloped villages are operating in the inter-locked market as compared to developed villages where inter-locking is substantially less. Underdeveloped villages, the land credit inter-locking is quite common while in the developed villages, land-labor inter-locking is relatively higher. Technological progress seems to have made a perceptible-dent on rural poverty. The proportion of population below the poverty line is lower in developed areas using HYV technology as compared to in underdeveloped areas. However the most important limitation of new technology is that it tends to accentuate regional disparities. Therefore, in the near future, the new technology should be extended, with effective policy measures, to those areas which were deprived of it in the past.

Table 14. Rural poverty ratio at the state level (Percentage)

STATES	1973-74	1993-94	1999-00
Andhra Pradesh	48.41	15.92	11.05
Assam	52.67	45.01	40.04
Bihar	62.99	58.21	44.30
Gujarat	46.35	22.18	13.17
Haryana	34.23	28.02	8.27
Himachal	27.42	30.34	7.94
J & K	45.51	30.34	3.97
Karnataka	55.14	29.88	17.38
Kerala	59.19	25.76	9.38
M.P.	62.66	40.64	37.06
Maharastra	57.71	37.93	23.72
Orissa	67.28	49.72	48.01
Punjab	28.21	11.95	6.35
Rajasthan	44.76	26.46	13.74
Tamil Nadu	57.43	32.48	20.55
U.P.	56.33	42.28	31.22
West Bengal	73.16	40.8	31.85
All India	56.44	37.27	27.09

Source: Economic Survey 2001-2002

A technology that is essentially natural to scale has been introduces in an environment in which the economic, Social and political institutions have varied widely with respect to their regularity. One can sum up the debate with "Wolf ladejinsky's view" when all is said and done, it is not the fault of the new technology that the credit service doesn't serve those for whom it was originally intended; that the extension service is not living up to expectations; that the panchayats are essentially political rather than development bodies; that security of tenure is a luxury of the few; that rental, are exorbitant; that ceilings on land are merely notational; that for a grater part tenure 12, legislation is deliberately miscarried or wage are hardly sufficiently to keep soul and body together (Binswanger and Rutton, 1978).

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