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Intensive Agriculture

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Editorial

Intensive agriculture has emerged as primary subsistence need for feeding growing population of the world. In India, intensification of agriculture initiated during 1960s, with adoption of improved varieties of wheat, rice and maize for cultivation. This was achieved through the pioneering work by agriculture scientists and the efforts of farmers, helping India attain a breakthrough in the agriculture sector. This period of agriculture boom is termed as *'Green Revolution'.* Green Revolution nearly quadrupled the production of wheat and rice, transforming India's fertile areas into granaries. In India, the Green Revolution began in Punjab, Haryana and western Uttar Pradesh with the use of High Yielding Varieties (HYV). By 1983 it also included rice cultivation and extended its domain to Bihar, Andhra Pradesh and Tamil Nadu. During Green Revolution era, remarkable production of wheat and rice was witnessed. Production of wheat increased from 12.5 million tones (1964-65) to 80.8 million tones (2009-2010), Similarly production of rice increased from 25.0 million tones in 1960s to 85.7 million tones in 2011. This was mainly due to phenomenal increase in per hectare yield of these crops during this period. Similarly production of other crops has also increased multifold in past 40 years. Intensification of agriculture has however, brought an array of agrarian problems along with environmental consequences, which need to be tackled properly to ensure sustainable growth in agriculture sector, which is a major Gross Domestic Product (GDP) contributor.

Punjab is the most stunning example of Green Revolution in India. The innovative and hard working farmers of the state adopted new practices coupled with necessary investments to make it a great success. The rapid adoption of the new technologies and inputs has also led to a sharp increase in farm mechanization. The State's agriculture has, however, now reached a plateau under the available technologies and natural resource base and has become cost intensive and less remunerative particularly in the case of marginal farmers. Over intensification of agriculture over the years has imposed pressure on fragile agro ecosystem of the State, thereby diminishing economic returns affecting the socioeconomic condition of farmers.

Present issue of this newsletter looks into the intensification of agriculture in India and Punjab, in achieving food security of the Nation. Further this issue also touches upon the impact and future concerns of intensive agriculture.

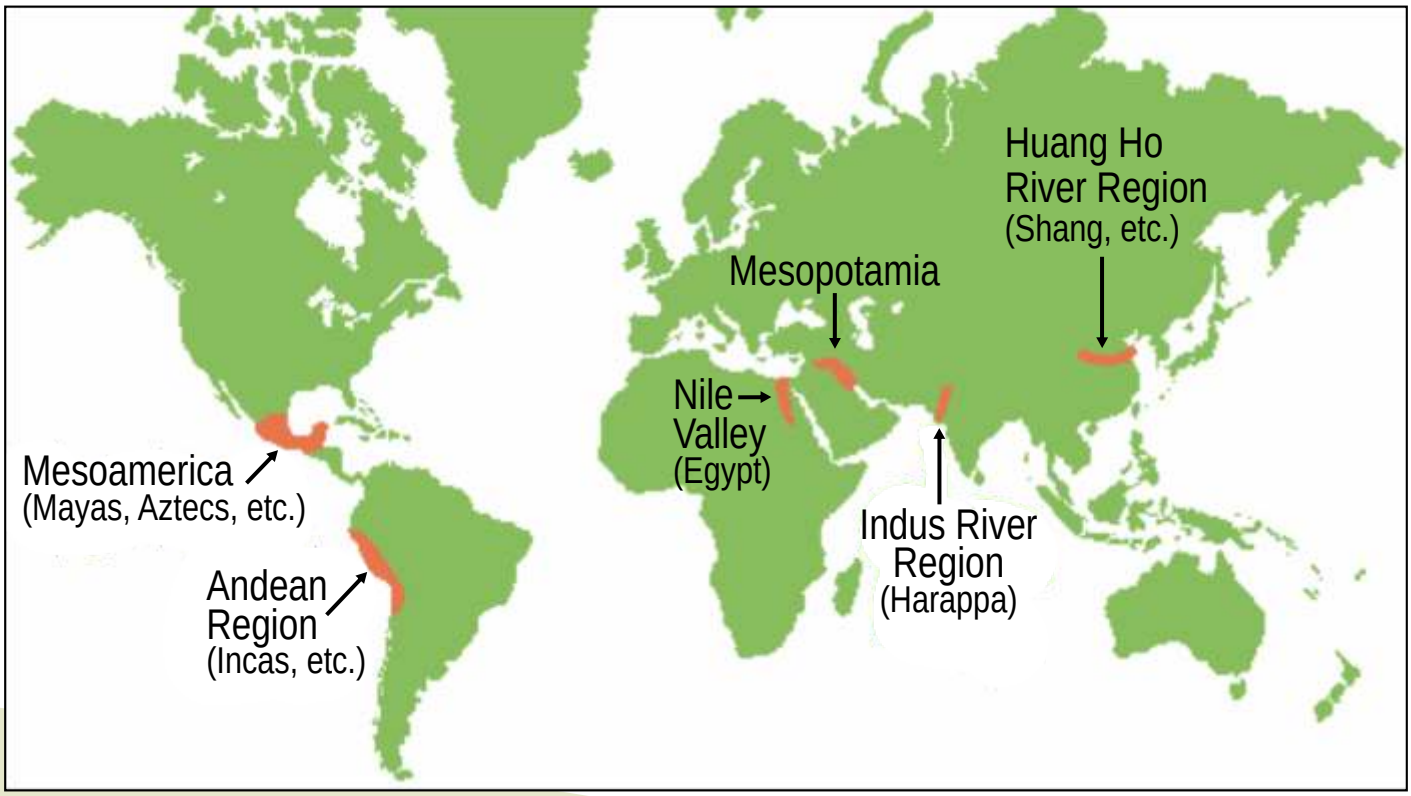
Editors

INTENSIVE AGRICULTURE

Intensive agriculture is the primary subsistence pattern of large-scale, populous societies as it results in production of more food per acre of agriculture land as compared to other subsistence patterns. With the settlement of human civilizations around some major river valleys, need for intensive farming methods became necessary as the human population was increasing, forcing our ancestors to shift from hunting to crop cultivation somewhat about 5,000 years ago. This transition from hunting to agriculture and then to intensive agriculture was originally made possible by water management systems and the domestication of large animals for pulling plows. Agriculture historians based on their excavation studies, suggests that the first intensive agricultural societies were the ancient civilizations in Egypt, Mesopotamia (now Iraq and eastern Syria), India and Pakistan, North China, meso-America, and Western South America (Fig.1).

Now with world population reaching 7 billion mark (UN, Census-2011), intensive agriculture has emerged as the primary food production pattern in all developed and most of the developing nations, except, those that are too arid or too cold for any form of farming outside of greenhouses. Agricultural production has witnessed dramatic rise in the last 5 decades or so in the countries all over the world due to the innovation of large-scale agricultural techniques, option of high yielding varieties of crops and the availability of commercially produced fertilizers, pesticides, and herbicides. Global food requirements will continue to increase in coming years, as populations rise and as growing incomes promote both an increasing volume and a changing pattern of

Fig.1. Centres of Ancient Intensive Agriculture



Source: O'Neil, 2006

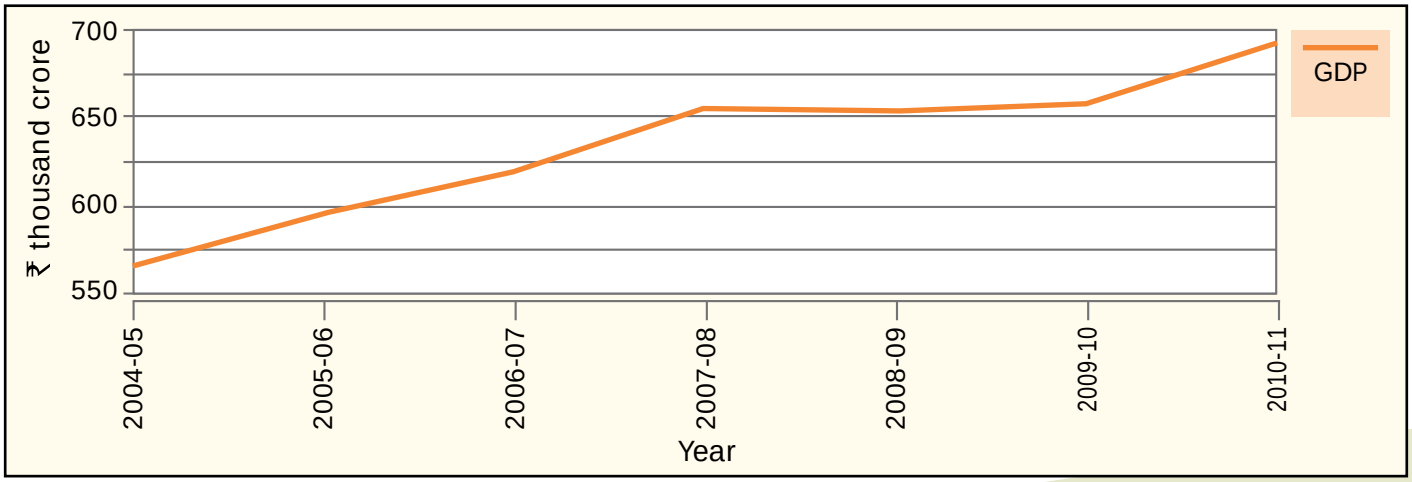
food consumption. With populations and incomes growing, agricultural production will need to continue to increase, if future demand for food is to continue to be met at current price levels. In 2009, World Bank reported that strong productivity growth with intensification of agriculture and the utilization of hitherto unused cropping should ensure the continuing adequacy of food supplies. Developed nations have already pushed their agriculture into intensive mode to meet their food supply along with of developing nations.

INTENSIVE AGRICULTURE : INDIAN SCENARIO

Agriculture in India has a long history dating back to ten thousand years. Today, India ranks second worldwide in farm output. Agriculture and allied sectors like forestry and logging accounted for 14.2 % of the GDP in 2010-11 (*Economic Survey of India, 2010-11*), employed 60% of the total workforce and despite a steady decline of its share in the GDP, is still the largest economic sector and plays a significant role in the overall socio-economic development of India (Fig.2).

Pioneering work by agriculture scientists and the efforts of farmers had helped India achieve a breakthrough in the agriculture sector in the 1960s, popularly known as the 'Green Revolution', term, coined by William Gaud, Director, United States Agency for International Development (USAID) in 1968, is applied to the period from 1967 to 1978. High agricultural production and productivity achieved in subsequent years by India has been the main reason for attaining food security to a large extent. The total food grain production increased from a mere 50.8 million tonnes during 1950-51 to 218 million tonnes in 2009-10 (*Economic Survey of India, 2010-11*), and productivity increased from 522 kg/ha to more than 1,798 kg/ha (Table 1). The increase in production of food grains was possible as a result of adoption of quality seeds, higher dose of fertilizer and plant protection chemicals. Irrigation played a major role in increasing the productivity. Increased cropping intensity and higher quantity of inputs including adoption of good seeds, tractors, irrigation pumps, harvesters and power threshers extensively (Table 2).

Fig.2. GDP for Agriculture and Allied Sectors



Source: Department of Agriculture & Co-operation, Ministry of Agriculture as cited in Economic Survey of India, 2010-11.

Table 1. Post Green Revolution Agricultural Production (1970-2010)

(Base : Triennium ending 1981-82 = 100)

	Weight	1970-71	1980-81	1990-91	2000-01	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10[a]
1	2	3	4	5	6	7	8	9	10	11	12
A. Foodgrains	62.9	87.9	104.9	143.7	158.4	159.9	169.2	175.9	186.8	189.8	176.6
(a) Cereals	55.0	84.1	105.0	144.2	165.5	164.4	174.7	181.2	192.7	196.2	181.6
Rice	29.7	84.4	107.8	149.4	170.9	167.2	184.6	187.7	194.4	199.4	179.2
Wheat	14.5	67.7	103.2	156.6	198.0	195.0	197.0	215.4	223.2	229.2	229.3
Coarse Cereals	10.8	105.4	99.8	113.1	107.2	115.6	117.7	117.3	140.9	138.4	116.8
(b) Pulses	7.9	113.6	104.1	140.5	109.3	128.9	131.1	139.1	144.6	142.7	143.0
Gram	3.1	126.3	105.4	130.2	93.7	133.0	135.6	154.0	139.8	171.7	178.7
B. Non-foodgrains	37.1	82.6	97.1	156.3	178.2	206.7	230.3	242.9	247.3	220.7	206.2
(a) Oilseeds Total[b]	12.6	97.1	95.1	179.5	176.5	231.0	262.9	238.7	266.7	226.8	240.8
Groundnut	5.6	101.8	83.4	125.3	106.8	112.9	133.3	91.1	153.1	119.5	91.9
Rapessd and Mustard	2.4	97.2	113.0	256.3	205.2	372.1	398.5	364.5	285.5	352.9	314.3
(b) Fibres	5.1	65.6	94.2	128.2	126.6	204.9	229.5	277.4	303.4	267.0	288.1
Cotton	4.4	63.4	93.2	130.9	126.6	218.4	246.0	300.9	344.1	296.2	318.2
Jute	0.6	76.5	100.8	122.6	144.2	145.5	154.3	159.7	158.2	149.1	165.6
Mesta	0.1	77.3	96.7	76.7	72.5	51.1	50.9	55.9	58.0	42.8	34.6
(c) Plantation Crops	2.3	73.2	76.0	144.9	209.0	225.4	236.3	243.3	238.9	238.9	238.9
Tea	1.5	74.7	101.6	132.3	151.3	159.2	168.7	175.1	168.4	168.4	168.4
Coffee	0.4	79.0	85.1	121.8	216.8	206.2	200.8	186.2	186.2	186.2	186.2
Rubber	0.4	60.8	101.1	217.2	416.1	494.8	529.8	563.0	563.0	563.0	563.0
(d) Others											
Sugarcane	8.1	81.2	98.8	154.3	189.4	151.7	179.9	227.5	222.8	182.4	177.8
Tobaco	1.1	75.5	100.2	115.8	71.8	114.4	115.0	108.2	102.7	129.4	129.4
Potato	2.1	50.2	103.9	163.3	241.5	253.8	256.7	238.2	305.8	369.8	238.7
C. ALL COMMODITIES	100.0	85.9	102.1	148.4	165.7	177.3	191.9	200.7	207.1	192.8	179.9

[a] On the basis of Fourth Advance Estimates as on 19.07.2010.

[b] Includes groundnut, rapeseed & mustard, sesamum, linseed, nigerseed, castorseed, safflower, sunflower and soyabean.

Source: Department of Agriculture & Co-operation, Ministry of Agriculture as cited in Economic Survey of India, 2010-11.

Table 2. Production of Major Crops in India (1960-2010)

(Million tonnes)

Group/Commodity	Unit	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10[a]
1	2	3	4	5	6	7	8	9	10	11	12
Foodgrains	Tonnes	82.0	108.4	129.6	176.4	196.8	208.6	217.3	230.8	234.4	218.2
Kharif	Tonnes	NA	68.9	77.7	99.4	102.1	109.9	110.6	121.0	110.1	103.0
Rabi	Tonnes	NA	39.5	51.9	77.0	94.7	98.7	106.7	109.8	116.3	114.4
Cereals	Tonnes	69.3	96.6	119.0	162.1	185.7	195.2	203.1	216.0	219.9	203.6
Kharif	Tonnes	NA	65.0	73.9	94.0	97.6	105.0	105.8	114.6	113.5	99.5
Rabi	Tonnes	NA	31.6	45.1	68.1	88.1	90.2	97.3	101.5	106.4	104.1
Pulses	Tonnes	12.7	11.8	10.6	14.3	11.0	13.4	14.2	14.8	14.6	14.6
Kharif	Tonnes	NA	3.9	3.8	5.4	4.4	4.9	4.8	6.4	4.7	4.3
Rabi	Tonnes	NA	7.9	6.8	8.9	6.6	8.5	9.4	8.4	9.9	10.3
Rice	Tonnes	34.6	42.2	53.6	74.3	85.0	91.8	93.4	96.7	99.2	89.1
Kharif	Tonnes	NA	39.5	50.1	66.3	72.8	78.3	80.2	82.7	84.9	75.9
Rabi	Tonnes	NA	2.7	3.5	8.0	12.2	13.5	13.2	14.0	14.3	13.2
Wheat	Tonnes	11.0	23.8	36.3	55.1	69.7	69.4	75.8	78.6	80.7	80.7
Jowar	Tonnes	9.8	8.1	10.4	11.7	7.5	7.6	7.2	7.9	7.2	7.0
Kharif	Tonnes	NA	5.8	7.5	8.3	4.5	4.1	3.7	4.1	3.1	2.8
Rabi	Tonnes	NA	2.3	2.9	3.4	3.0	3.6	3.4	3.8	4.1	4.2
Maize	Tonnes	4.1	7.5	7.0	9.0	12.0	14.7	15.1	19.0	19.7	16.7
Bajra	Tonnes	3.3	8.0	5.3	6.9	6.8	7.7	8.4	10.0	8.9	6.5
Gram	Tonnes	6.3	5.2	4.3	5.4	3.9	5.6	6.3	5.8	7.1	7.3
Tur	Tonnes	2.1	1.9	2.0	2.4	2.2	2.7	2.3	3.1	2.3	2.6
Oilseeds [b]	Tonnes	7.0	9.6	9.4	18.6	18.4	28.0	24.3	29.8	27.7	24.9
Kharif	Tonnes	NA	7.0	5.0	9.8	11.9	16.8	14.0	20.7	17.8	15.7
Rabi	Tonnes	NA	2.6	4.4	8.8	6.5	11.2	10.3	9.0	9.9	9.2
Groundnut	Tonnes	4.8	6.1	5.0	7.5	6.4	8.0	4.9	9.2	7.2	5.5
Kharif	Tonnes	NA	NA	3.7	5.1	4.9	6.3	3.3	7.4	5.6	3.7
Rabi	Tonnes	NA	NA	1.3	2.4	1.5	1.7	1.6	1.8	1.6	1.8
Rapeseed & Mustard	Tonnes	1.4	2.0	2.3	5.2	4.2	8.1	7.4	5.8	7.2	6.4
Sugarcane	Tonnes	110.0	126.4	154.2	241.0	296.0	281.2	355.5	348.2	285.0	277.7
Cotton	Bales [c]	5.6	4.8	7.0	9.8	9.5	18.5	22.6	25.9	22.3	23.9
Jute and Mesta	Bales [d]	5.3	6.2	8.2	9.2	10.5	10.8	11.3	11.2	10.3	11.3
Jute	Bales [d]	4.1	4.9	6.5	7.9	9.3	10.0	10.3	10.2	9.6	10.7
Mesta	Bales [d]	1.1	1.3	1.7	1.3	1.2	0.9	1.0	1.0	0.7	0.6
Plantation Crops											
Tea [e]	Tonnes	0.3	0.4	0.6	0.7	0.8	0.9	1.0	0.9	0.9	1.0
Coffee	Tonnes	....	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Rubber	Tonnes	....	0.1	0.2	0.3	0.6	0.8	0.9	0.9	0.9	0.8
Potato	Tonnes	2.7	4.8	9.7	15.2	22.5	23.9	22.2	28.5	34.4	NA

NA : Not Available
a Fourth Advance Estimates as on 19.07.2010.
b Includes groundnut, rapeseed & mustard, sesamum, linseed, castorseed, nigerseed, safflower, sunflower and soyabean.
c Bale of 170 Kgs.
d Bale of 180 Kgs.
e Calender Year.

Source: Department of Agriculture & Co-operation, Ministry of Agriculture as cited in Economic Survey of India, 2010-11.

With the induction of mechanized inputs the face of Indian agriculture started changing quickly and farmer community of early sixties welcomed the introduction of high yielding varieties of wheat and other crops which needed irrigation facilities. The progressive farmers and policy makers of India soon realized that the traditional water lifts, which were driven by draught animals or operated manually, could not meet the water requirement of the high yielding varieties of different crops. Lift irrigation was, therefore, quickly mechanized through the use of electric motor or diesel engine powered pumps, simultaneously mechanized threshers replaced the traditional practices of threshing, and this was beginning of an era of extensive use of tractors for primary tillage, transport and the use of tractor powered or self-propelled harvesting equipment. Intensive agriculture has also led to extension of area under irrigation. In India, area irrigated has doubled over four decades, from 19% to 38% of the net sown area.

The important event in the history of intensification of Indian agriculture during Green Revolution was revamping of the 'The Indian Council for Agricultural Research (ICAR)', a scientific body established by the British in 1929, re-organized in 1965 and then again in 1973. It developed new strains of high yield variety (HYV) seeds, mainly of wheat, rice millet and corn. The most noteworthy HYV seed was the K68 variety for wheat.

Intensification of Indian agriculture post-Independence can be broadly explained under the following:

- Improvement and Intensification of Wheat Cultivation : The three species of wheat namely, *Triticum aestivum* (bread wheat), *Triticum durum* (macaroni wheat) and *Triticum dicoccum* (Emmer or Khapli) grown on commercial basis in the Indian subcontinent from pre-historic times are of spring type. Another wheat species *T. sphaerococcum* that was cultivated in the ancient past during the Indus Valley civilization period has now almost vanished. Systematic wheat improvement in India started during 1905 and since then has undergone many developmental changes after pioneering works of imperial botanists Howard and Howard at Pusa, Bihar in the beginning of twentieth century. The beginning of growing dwarf wheat cultivars was made by introducing the seeds of four varieties, Sonora 63, Sonora 64, Mayo 64 and Lerma Rojo 64 along with 613 segregating lines from International Maize and Wheat Improvement Centre (CIMMYT), Mexico. This provided the base material for development and commercial release of another five important varieties namely PV 18, Kalyan Sona, Sonalika, Chhoti Lerma and Safed Lerma thereby ushering in the Green Revolution in India. These dwarf wheats were highly responsive to inputs, were non-lodging types and possessed desired level of disease resistance. Due to these qualities, the dwarf wheat varieties could yield exceptionally high under best management production conditions especially in Indo-Gangetic Plains (IGP). Later in 1970-75, it was realized that semi-dwarf, high yielding and input responsive lines should be crossed with local wheat to combine attributes from both the groups.

In the year 1965, All India Coordinated Wheat Improvement Project (AICWIP) was established, this was an important milestone that brought about systematic developments in wheat research and had resulted in the real breakthrough in wheat productivity.

Since the initiation of the Green Revolution in the mid sixties, India achieved remarkable increase in production and productivity of wheat. This is indicative from the fact that the area, productivity and production of wheat to the tune of 123%, 226% and 630% respectively by the year 2006-07 as compared to 1965-66. This achievement in India's wheat production has been perhaps the most important and unparallel in the history of developing world as stated by the Nobel Laureate Dr. N.E. Borlaug.

The launch of the Green Revolution and rise in production coincided with productivity growth in the magnitude of 2-3% at national level saving crores of rupees to Indian treasury for importing wheat from other countries. Few land mark wheat varieties like Sonalika, Kalyan Sona, HD 2009, WL 711, WH 147, UP 262, Lok 1, HUW 234, HD 2285, HD 2329 and PBW 343 dominated wheat areas for reasons of wider adaptability, high yield potential, disease resistance, grain quality, maturity duration, plant height and other desirable agronomic traits (Table 3). India became second largest wheat producing country during 1997-98. In 2010, India was second major producer of Wheat after China (Fig.3).

The wheat programme since its inception (1965) has released 344 wheat varieties (291 bread, 46 durum, 4 *dicoccum* & 3 triticale) for cultivation under different production conditions in all the six wheat growing zones (Table 4). The varieties have been released after very strict evaluation for yield advantage, disease resistance and the minimum required quality traits in order to provide the opportunity for varietal

Table 3. Landmark Varieties & Yield Potential of Wheat in India

Variety	Year of release	Yield potential (Q/ha)
S 227	1965	33.7
C 306	1965	36.0
Sonalika	1967	45.5
Kalyan Sona	1970	46.0
WL 711	1975	46.8
UP 262	1977	44.0
WH 147	1977	45.1
HD 2189	1979	45.7
HD 2009	1980	45.8
Lok 1	1981	45.4
HUW 234	1984	35.3
HD 2285	1985	42.5
HD 2329	1985	47.1
UP 2338	1990	51.3
WH 542	1992	61.5
Raj 3765	1995	48.9
PBW 343	1995	63.0
HD 2687	1999	62.9
HD 2733	2001	61.5
GW 322	2002	61.0
DBW 17	2006	64.1

Source: http://www.dwr.in

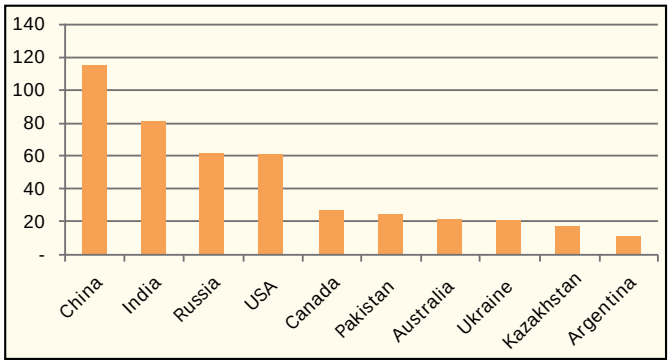
Table 4. Wheat & Triticale Varieties in India (1965-2007)

Species	Released by		Total
	CVRC*	SVRC*	
Bread wheat	199	92	291
Durum wheat	27	19	46
Dicoccum wheat	04	-	04
Triticale	02	01	03
Total	232	112	344

*(*CVRC –Central variety release committee, SVRC – State variety release committee)*

Source: http://www.dwr.in

Fig.3. Top Ten Wheat Producing Countries



Source: Food Outlook: Global Market Analysis, 2009

diversification to combat the threat of diseases and nutritional disorders.

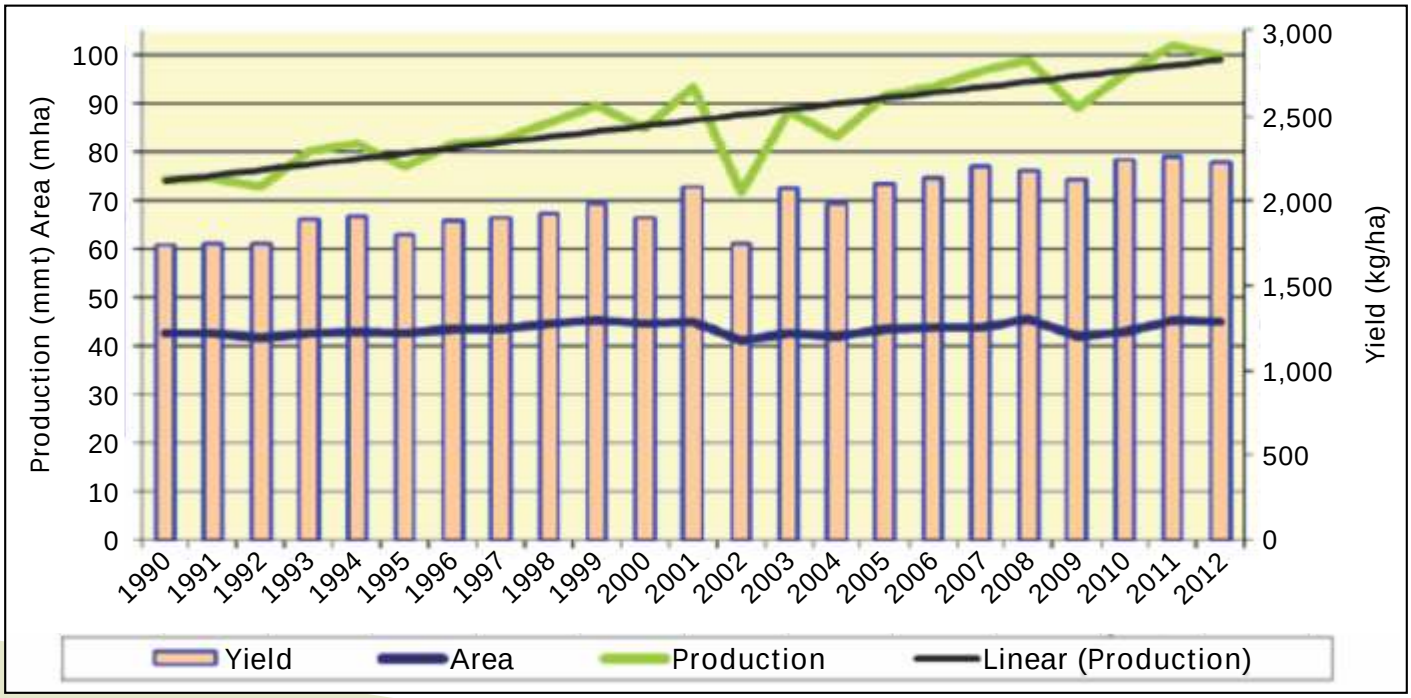
- Rice Intensification in India : During Indus Valley civilization, rice farming began as a small but important part of Indian culture. In early Sanskrit texts, references to rice have also been made. Those from the first millenium B.C. show that the god of weather, Indra, was asked for good monsoon rains and a bountiful harvest. It is believed that the scientific name of rice, *Oryza*, was derived from 'arisi', the Tamil word for rice. India is considered to be one of the original centers of rice cultivation covering 44 million hectares. It contributes 21.5 percent of global rice production. Its rice harvesting area (44.0 million ha) is the largest in the world. Around 65% of the total population in India eats rice and it accounts for 40% of their food production (Table 5 & Fig.4).

Table 5. Area, Productivity & Production of Rice in India

Year	Area (million hectare)	Productivity (kg/ha)	Production (million tonnes)
1950-51	30.8	668	20.6
2006-07	43.8	2131	93.3
2007-08	43.9	2202	96.7
2008-09	45.5	2178	99.2
2009-10	41.9	2130	89.1
2010-11	37.0	2177	80.4

Source: Directorate of Economics and Statistics, 2008

Fig.4. Area, Production & Yield of Rice in India (1990-2012)



Source: GAIN Report, 2010

However, productivity of rice is only 2.1 tonnes/ha (milled rice) which is lower than worlds average productivity of 2.9 tonnes/ha. Intensive cultivation of rice in India began in 1966, when India adopted IR8 - a semi-dwarf rice variety developed by the International Rice Research Institute (IRRI); IR8 was a success throughout Asia, and dubbed as the "Miracle Rice". Later scientists at IRRI began crossing IR8 with at least 13 other varieties from six nations. Eventually, they developed IR36, a semi-dwarf variety that proved highly resistant to a variety of pests and diseases and produced the slender rice grain preferred in many countries. In addition, IR36 matured rapidly - in 105 days instead of the 130 days of IR8 and 170 days for traditional varieties. That meant that many regions could finally grow two crops a year, instead of one. By the 1980s, at least 11 million hectares were planted with IR36 around the world.

Rice research in the country is being carried out by various organizations and Institutes under the Indian Council of Agricultural Research (ICAR), State Agricultural Universities, Department of Agriculture of the states, traditional universities and other public and private sector national, multinational and international research organizations. Directorate of Rice Research (DRR), Hyderabad and Central Rice Research Institute (CRRI), Cuttack are the two ICAR institutes exclusively engaged in rice research for irrigated and rainfed ecologies, respectively.

DRR also coordinates rice research across the country under All India Coordinated Research Project on Rice, known as AICRIP. This network, the largest in the world, has 47 exclusively funded research stations affiliated to state Agricultural Universities and Departments of Agriculture with over 350 scientific manpower. Besides, more than 60 centres participate in AICRIP as voluntary centers. Over the past four and half decades DRR has been instrumental in development and release of over 946 rice varieties for all the rice ecologies. Impact of these varieties is reflected in doubling of rice production and tripling of productivity during the same period. DRR itself has developed over 39 rice varieties and three hybrids. Of the varieties released under AICRIP, 19 are being cultivated in 25 other rice growing countries worldwide. These high yielding varieties and hybrids cover over 80% of the rice area. The national hybrid rice network coordinated by DRR helped in release of over 46 hybrids both from public sector and private sector. Area under hybrids is now about 1.25 million ha and with a minimum of 1 tonne yield advantage, hybrids alone are contributing to production of an additional 1 million tonnes per year.

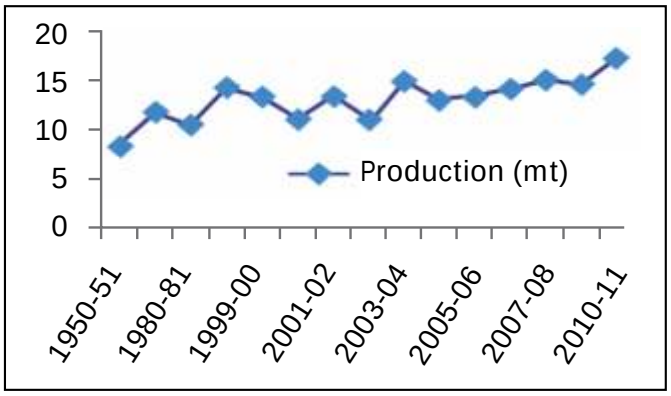
System of Rice Intensification (SRI) emerged in the 1980's as a synthesis of locally advantageous rice production practices encountered in Madagascar by Fr Henri de Laulanie, a Jesuit Priest who had been working there since 1961. But, it is Dr. Norman Uphoff from Cornell International Institute for Food and Agriculture, Ithaca, USA, who had brought this method to the notice of outside world in the late 1990s. Today SRI is being adopted in many states in India and the response from farmers has been overwhelming seeing the benefits of the method, notwithstanding the constraints. SRI is a combination of several practices those include changes in nursery management, time of transplanting, water and weed management. Its different way of

cultivating rice crop though the fundamental practices remain more or less same like in the conventional method; it just emphasizes altering of certain agronomic practices of the conventional way of rice cultivation. All these new practices are together known as System of Rice Intensification (SRI). SRI is not a fixed package of technical specifications, but a system of production with four main components, *viz*., soil fertility management, planting method, weed control and water (irrigation) management.

- Production of Pulses : Pulses are one of the important segments of Indian agriculture after cereals and oilseeds. These pulses constitute chickpea, pigeonpea, lentil, mungbean, urdbean and fieldpea. Food and Agriculture Organization of United Nation (FAO) has estimated that in 2009 about 90% of the global pigeon pea, 75% of chickpea and 37% of lentil area falls in India. The net availability of pulses has come down from 60 gm/day/person in 1951 to 31 gm/day/person in 2008 and their production has stagnated (Fig.5). As India is lacking behind as far as intensive cultivation of pulses is concerned but still, India is the largest producer and consumer of pulses in the world contributing around 25-28% of the total global production (www.faostat.fao.org)

  India grows a variety of pulse crops such as chickpea, pigeonpea, green gram (mung beans), black gram (urd bean), dry peas and lentils under a wide range of agro-climate conditions. The production of total pulses in India is presently about 15 million tonnes covering an area of about 22-23 million hectare majority of which falling under rainfed, resource poor and harsh environments frequently prone to drought and other abiotic stress condition. The total pulses production in 2010-11 was 17.29 million tonnes from 25.51 million ha area which was all times high. Pulses are least preferred by farmers because of high risk and less remunerative than cereals; consequently, the production of the pulses is sufficiently low. To meet the demand of pulses, India is at present importing about 3 million tonnes. Chickpea continues to be the largest consumed pulse, comprising of 45-50% of the total pulses production of India.

Fig.5. Trends in Total Production of Pulses in India (1951-2011)

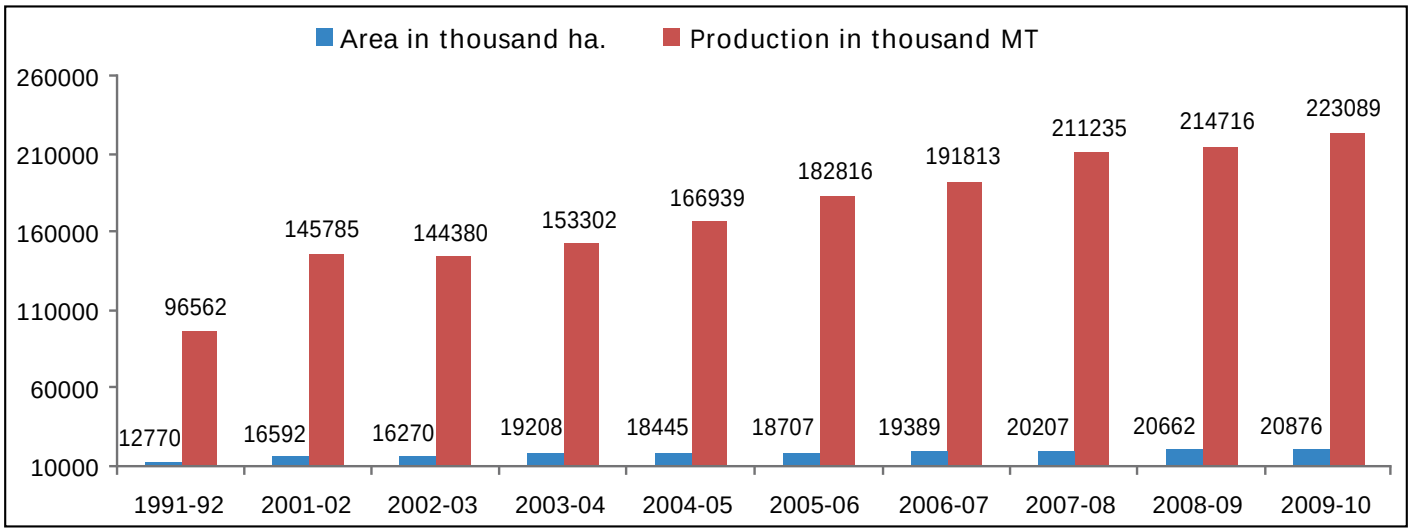


Source: www.iipr.res.in

- Vegetables and Fruits Production : In last one decade, there has been considerable progress in enhancing the productivity of vegetables which is presently 16.7 tonnes per hectare.

  Presently vegetable cultivation occupies 7.98 million hectare area with the annual production of 133.74 million tonnes (Fig.6). Potato ranks first (26.6%) in total production of vegetables followed by other important solanaceous vegetables like tomato (8.6%) and brinjal (8.0%). Onion, one of the most important vegetables, occupies significant share (10.5%) in vegetable production. Cauliflower and cabbage are most preferred winter vegetables and their total share in the country's vegetable production is 5.1 and 5.3%, respectively (Fig.7). Other important

Fig.6. Area and Production Growth Trends for Vegetables Crops (1991-2010)

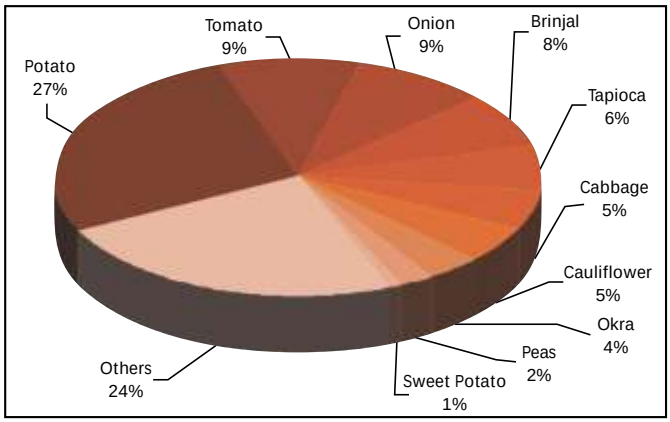


Source: Kumar et al., 2011

vegetables which are primarily grown in the country are okra, vegetable peas and a good range of cucurbits.

India is the second largest producer of fruits after China, with a production of 71.52 million tonnes of fruits from an area of 6.3 million hectares (Fig-13). A large variety of fruits are grown in India, of which mango, banana, citrus, guava, grape, pineapple and apple are the major ones. Apart of these, fruits like papaya, sapota,annona, phalsa, jackfruit, ber, pomegranate in tropical and sub tropical group and peach,pear, almond, walnut, apricot and strawberry in the temperate group are also grown in a sizeable area (Fig.8 & Fig.9).

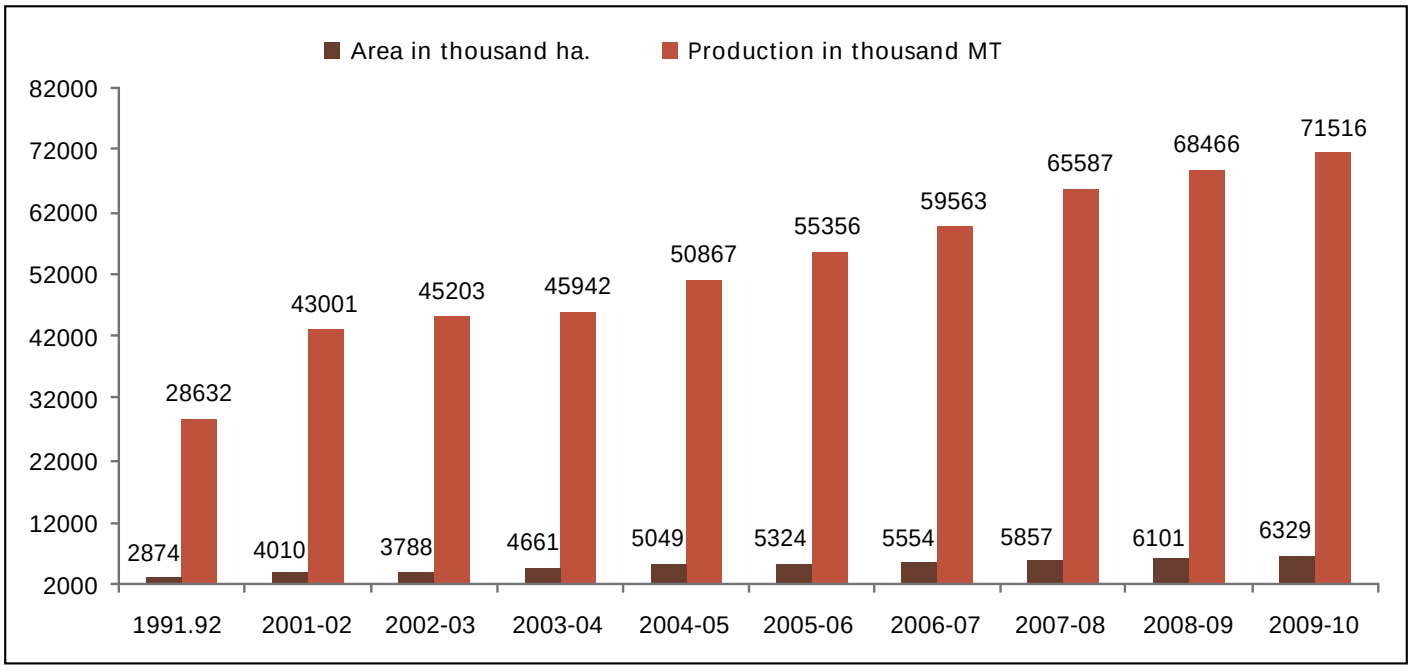
Fig.7. Production Share of Major Vegetables Crops in India (2009-10)



Source: Kumar et al., 2011

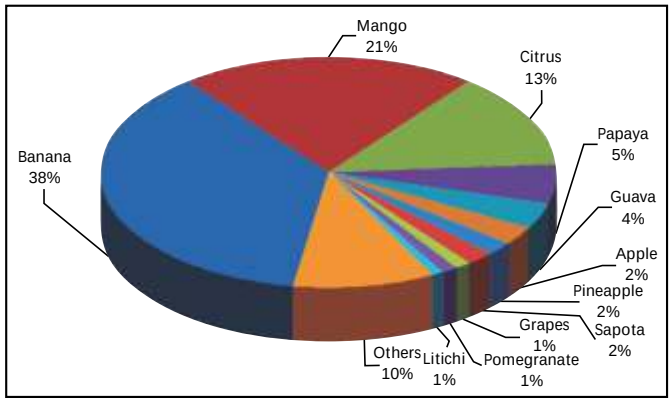
Scientific research was given impetus through establishment of All India Coordinated Research Project (AICRP) on vegetable crops during 1971 at IARI, New Delhi with the responsibilities of coordinating and monitoring of vegetable research programmes of the country. To give a fillip to the vegetable research and to meet the challenges of nutritional security, the status of AICRP on vegetable crops was elevated to the level of Project Directorate of Vegetable Research (PDVR) during 1986. During 1992 the head quarter of AICRP on vegetables was shifted to Varanasi from IARI New Delhi. During the year 1999, ICAR approved the establishment of an independent research institute on vegetables named as Indian Institute of Vegetable Research (IIVR). Whereas for intensification of fruits cultivation in India, National Horticulture Board (NHB) was set up by Government of India in April 1984 on the basis of recommendations of the "Group on Perishable Agricultural Commodities", headed by Dr M.S. Swaminathan, the then Member (Agriculture), Planning Commission, Government of India. The main objectives of the NHB are to improve integrated

Fig.8. Area and Production Growth Trends for Fruit Crops



Source: Kumar et al., 2011

Fig.9. Production Share of Major Fruit Crops in India (2009-10)



Source: Kumar et al., 2011

development of Horticulture industry and to help in coordinating, sustaining the production and processing of fruits and vegetables.

- Allied Sector (Dairy, Livestock and Fisheries) Animal Husbandry, Dairy Development and Fisheries sectors play an important role in the national economy and in the socio-economic development of the country. These sectors also play a significant role in supplementing family incomes and generating gainful employment in the rural sector. India, has strengthened position in these areas. Data of Department of Animal Husbandary, Dairying & Fisheries reveals that last three decades has been intensive in dairy, livestock and fish production (Table 6).

India ranks first in respect of buffaloes, second in cattle & goats, third in sheep, fifth in ducks & chickens and tenth in camel population in the world. India continues to be the largest producer of milk in world. Several measures have been initiated by the Government to increase the productivity of livestock, which has resulted in increasing the milk production significantly to the level of 121.8 million tonnes at the end of 2010-11 as compared to 53.9 million tonnes in 1990-91.Now per capita availability of milk is 281gms (Table 7).

Table 6. Production of Major Livestock Products & Fish (1950-2010)

Year	Milk (Million tonnes)	Eggs (Million Nos.)	Fish (Thousand tonnes)
1	2	3	4
1950-51	17.0	1832	752
1960-61	20.0	2881	1160
1970-71	22.0	6172	1756
1980-81	31.6	11060	2442
1981-82	34.3	10876	2444
1982-83	35.8	11454	2367
1983-84	38.8	12792	2506
1984-85	41.5	14252	2801
1985-86	44.0	16128	2876
1986-87	46.1	17310	2942
1987-88	46.7	17795	2959
1988-89	48.4	18980	3152
1989-90	51.4	20204	3677
1990-91	53.9	21101	2836
1991-92	55.7	21983	4157
1992-93	58.0	22929	4365
1993-94	60.6	24167	4644
1994-95	63.8	25975	4789
1995-96	66.2	27198	4949
1996-97	69.1	27496	5348
1997-98	72.1	28689	5388
1998-99	75.4	29476	5298
1999-00	78.3	30447	5675
2000-01	80.6	36632	5656
2001-02	84.4	38729	5956
2002-03	86.2	39823	6200
2003-04	88.1	40403	6399
2004-05	90.7	45201	6304
2005-06	97.1	46231	6572
2006-07	100.9	50653	6869
2007-08	104.8	53532	7127
2008-09	108.5	55638	7620
2009-10P	112.5	59800	7850P

P=Provisional

Source: Department of Animal Husbandary, Dairying & Fisheries, 2011

Table 7. Rise in Milk Production in India (1991-2011)

Milk Production in India		
Year	Production (Million Tonnes)	Per Capita Availibilty (gms/day)
1991-92	55.7	178
1995-96	66.2	197
1999-2000	78.3	217
2008-09	112.2	258
2009-10	116.4	273*
2010-11	121.8	281

Source: Department of Animal Husbandary, Dairying & Fisheries, 2011

Poultry in India, since last four decades began to witness remarkable growth from backyard to poultry industry. Egg production at the end of the Tenth Plan (2006-07) was 50.7 billion numbers as compared to 21 billion during 1990-91. India with 59.84 billion eggs production in 2009- 10, ranks third in egg production in the world as per Food and Agriculture Organization data for the year 2009 (www.faostat.fao.org)

India is the third largest producer of fish and the second largest producer of fresh water fish in the world. Fish production has

Table 8. Rise in Fish Production and Export (1990-2010)

Year	Fish production (million tonnes)			Export of marine products	
	Marine	Island	Total	Qty. ('000 tonnes)	Value (` crore)
1990-91	2.3	1.5	3.8	140	893
2000-01	2.8	2.8	5.6	503	6288
2005-06	2.8	3.8	6.6	551	7019
2006-07	3.0	3.0	6.8	612	8363
2007-08	2.9	4.2	7.1	541	7620
2008-09	3.0	4.6	7.6	602	8608
2009-10	2.98	4.87	7.85	664	9921

Source: Economic Survey of India, 2010-11

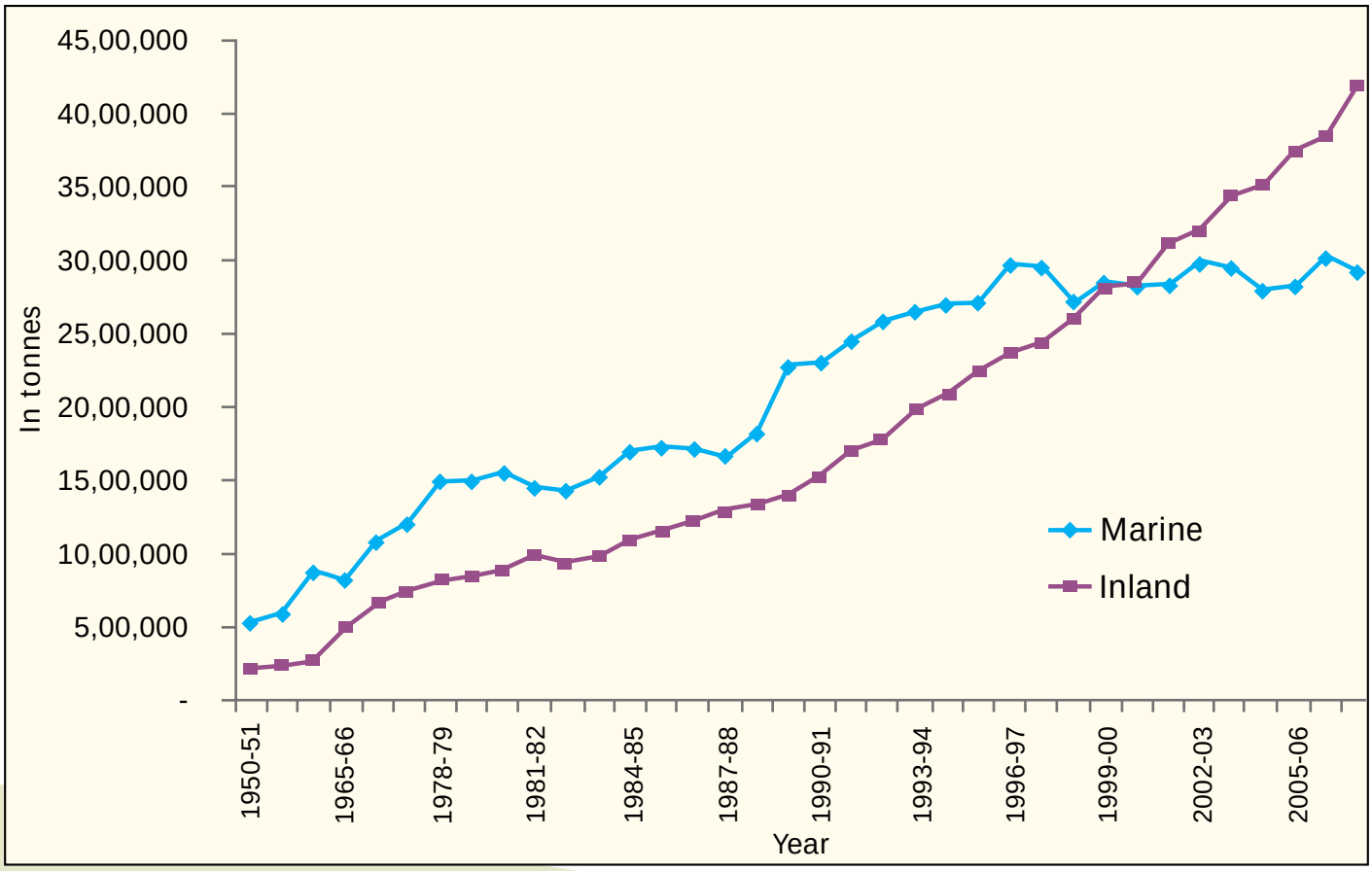
increased from 41.57 lakh tonnes (24.47 lakh tonnes for marine and 17.10 lakh tonnes for inland fisheries) in 1991-92 to 78.51 lakh tonnes (29.89 lakh tonnes for marine and 48.62 lakh tonnes for inland fisheries) in 2009-10 (Fig.10 & Table 8).

FOOD SECURITY & INTENSIFICATION OF AGRICULTURE

Since independence, there has been considerable increase in production and productivity of foodgrain and other crops. However in many states of India, a major area under food crops is still rainfed, therefore production and productivity of food crops continue to depend largely on amount and distribution of rainfall. Although there has been a spectacular increase in foodgrain production, yet there are large year to year variations.

Ministry of Agriculture, Govt. of India, formulated National Food Security Mission (NFSM) in 2007 which envisages an increase in rice, wheat and pulses production of 10, 8, 2 million tonnes, respectively by the end of the Eleventh Five Year Plan.

Fig.10. Marine & Inland Fish Production in India (1950-2008)



Source: www.fao.org

Table 9. National Food Security Mission

S.No.	State	Total number of Districts covered under				
		NFSM	NFSM-Rice	NFSM-Wheat	NFSM-Pulses till March 31, 2009	NFSM-Pulses As on 1.4.2011
1.	A.P.	22	11	NC*	14	22
2.	Assam	18	13	NC*	NC*	10
3.	Bihar	38	18	25	13	38
4.	Chhattisgarh	18	10	NC*	8	18
5.	Gujarat	26	2	4	11	26
6.	Haryana	21	NC*	7	5	21
7.	Jammu and Kashmir	3	3	NC*	NC*	NC*
8.	Jharkhand	17	7	NC*	NC*	17
9.	Karnataka	30	7	NC*	13	30
10.	Kerala	1	1	NC*		NC*
11.	M.P.	50	9	30	20	50
12.	Maharashtra	33	6	8	18	33
13.	Orissa	30	15	NC*	10	30
14.	Punjab	20	NC*	10	7	20
15.	Rajasthan	33	NC*	15	16	33
16.	Tamil Nadu	30	5	NC*	12	30
17.	Uttar Pradesh	71	26	38	19	71
18.	West Bengal	18	8	4	5	18
	Total	480	142	142	171	468

NC* = Not covered

Source: NFSM, 2011

NFSM covers 480 districts of 18 states (Table 9). The Mission covers about 13 and 20 million hectares area under wheat and rice respectively. However, under pulses there is additional thrust on area expansion through intercropping, utilization of rice-fallow lands, promotion of summer moong in rice-wheat farming system and replacement of low yielding and non-remunerative crops. Considering the strategic importance of pulses crops, efforts to improve productivity have been stepped up with the merger of pulses component of Intergrated scheme of Oilseeds, Pulses, Oilpalm and Maize (ISOPOM) with the NFSM Pulses.

FUTURE OF INTENSIVE AGRICULTURE AND CONSTRAINTS

NFSM, aims at more intensification of Indian agriculture for achieving additional production of 20 million tonnes of foodgrains by addressing major technological and socio-economic constraints impeding exploitation of available crop productivity and production potential. The production constraints given in '*National Food Security Mission Retrospect and Prospect, 2011'* are briefly discussed below.

1. Predominantly rainfed nature of Indian agriculture : Area under foodgrain crops is close to 124 million hectares, of which almost 55% continues to be dependent on

rainfall. Besides, area covered by minor irrigation projects and well irrigation,also vagaries of monsoon. Rainy season crops, in general and pulses in particular suffer due to temporary water logging and floods, whereas post rainy season crops such as wheat and rabi pulses face moderate to severe moisture stress. This eventually leads to seasonal fluctuations in yield and therefore production of foodgrain.

2. Soil related constraints : Pulses in particular, are highly sensitive to acidic, saline and alkaline soil conditions. North Western States have extensive area with high soil pH whereas eastern and North Eastern States possess major land mass suffering from chronic soil acidity. The problem is compounded by the ever increasing deficiency of micro nutrients and some secondary nutrients. Sulphur deficiency has extended to more than 40 % cropped area, whereas zinc, boron, molybdenum, iron and manganese deficiency has spread to 49,33,13,12 and 5% of cultivated area, respectively, in the country.
3. Input quality and availability related constraints : Availability of quality seed of improved varieties remains inadequate. As a consequence, seed replacement rates (SRR) have remained low, particularly in pulses.
4. Weeds and diseases : Wild oat and *Phalaris minor* are most common obnoxious weeds of wheat which have become tolerant to commonly used herbicides in Punjab, Haryana and western Uttar Pradesh. They are now making inroads to western and central regions of the country. Direct seeded rice and pulses also suffer heavy losses due to weed infestation.
5. Inadequate and irregular supply of power : Energy consumption in agriculture has witnessed exponential increase over the last two decades in view of inadequate availability of labour and animal power for agricultural operations, increase in cropping intensity, facilitated by development of irrigation infrastructure and diversification of agriculture in favour of input and energy intensive crops.
6. Infrastructural constraints : Manual harvesting and processing of harvested produce are still very common especially in Eastern India. Lack of threshing floors, paddy dryers, unscientific storage of produce, under developed warehousing, transport and marketing facilities not only lead to avoidable quantitative and qualitative losses but also add to the cost of production and marketing.
7. Credit availability : Small and marginal farmers often lack credits worthiness, this impedes adoption of scientific practice inspite of farmers' willingness to adopt the same.
8. Policy related constraints : Lack of dedicated procurement agencies in many states, especially for pulses, inadequate system of input, credit and service delivery to farmers, non coverage of many areas and crops under crop insurance scheme, vast and rising gap between farm-gate and market prices of foodgrain etc are other constraints limiting the production of foodgrain.

EFFECTS OF INTENSIFICATION OF AGRICULTURE

In India, the success in increasing agricultural productivity has, however, brought with it substantial environmental challenges. Agriculture is the most important user of environmental resources, including water, forests, pastures & nutrients and its sustainability depends upon their availability. Five key environmental challenges that

threaten the future viability of intensive agricultural systems, particularly at regional and local levels are namely land degradation, limits to water availability, loss of biodiversity, declining agricultural genetic diversity & climate change. These challenges have been due to changed agricultural practices as discussed in the following texts.

- Increased Chemical Inputs : Intensive farming practices, particularly with wheat and rice in India, have virtually mined nutrients from the soil. Due to heavy use of fertilizers, excess nitrates have leached into groundwater and contamination of groundwater with nitrates has increased dramatically. As such, the cultivable lands have become sick by over-application of chemicals. Apart from over use of chemicals, equally important issue is imbalance in the application of fertilizers and pesticides. After independence the use of fertilizers in India in the last 50 years has grown nearly 170 times. In 1950 use of fertilizer per hectare in India was 0.55 Kg but by 2001-02 this figure has increased to around 90.12 Kg per hectare, 105.5 kg in 2005-06 to 128.6 kg in 2008-09 and 135.25 Kg per hectare in 2009-10. However, improving the marginal productivity of soil still remains a challenge. Fertilizer consumption in India has been increasing over the years and today India is one of the largest producers and consumers of fertilizers in the world (Table 10).

  Other major input for Indian agriculture is use of various pesticides, like insecticides, weedicides, fungicides, rodenticides, etc. As the cropping pattern is becoming more intensive use of these pesticides is also increasing. Consumption of insecticide in

Table 10. Trends in Production, Imports and Consumption of Fertilizers in India

(Thousand tonnes of nutrients)

	1970-71	1980-81	1990-91	2000-01	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11[a]
1	2	3	4	5	6	7	8	9	10	11	12
A. Nitrogenous fertilizers											
Production	830	2164	6993	11004	11338	11354	11578	10900	10870	11900	12175
Imports	477	1510	414	154	411	1385	1689	3677	3844	3447	3448
Consumption	1487	3678	7997	10920	11714	12723	13773	14419	15090	15580	NA
B. Phosphatic fertilizers											
Production	229	842	2052	3748	4067	4221	4517	3807	3464	4321	4532
Imports	32	452	1311	396	296	1122	1322	1391	2927	2756	3515
Consumption	462	1214	3221	4215	4624	5204	5543	5515	6506	7274	NA
C. Potassic fertilizers											
Imports	120	797	1328	1541	2045	2747	2069	2653	3380	2945	3022
Consumption	228	624	1328	1567	2060	2413	2335	2636	3313	3632	NA
D. All fertilizers (NPK)											
Production	1059	3006	9045	14752	15405	15575	16095	14707	14334	16221	16707
Imports	629	2759	2758	2090	2752	5254	6080	7721	10151	9148	9985
Consumption	2177	5516	12546	19702	18398	20340	21651	22570	24909	26486	NA

[a] Estimated (Production figures are considered actual for April-November 2010 and estimated for Dec. 2010-March 2011

Note : Import figures are from April - November 2010; Figures may not add up to total

The entire demand of Potassic fertilizers is met through import.

Source: Department of Fertilizers, Ministry of Chemical & Fertilizers as cited in.

agriculture has increased more than 100% from 1971 to 1994-95. For instance, insecticide consumption in India, which was to the tune of 22,013 tonnes has increased to 51755 tonnes by 1994-95. Consumption of all of these pesticides in same duration has increased more than two times, that is from 24,305 tonnes to 61,357 tonnes.

The dramatic increase in the number of humans during the twentieth century in India and rest of Asia has instigated a concomitant growth in agriculture, and has led to conversion of wildlands to croplands, massive diversions of water from lakes, rivers and underground aquifers, and, at the same time, has polluted water and land resources with pesticides, fertilizers, and animal wastes. The introduction of monocropping and the use of relatively few plants for food and other uses – at the expense of the wide variety of plants and animals utilized by earlier people and indigenous people – is responsible for a loss of diversity and genetic variability. The native plants and animals adapted to the local conditions are now being replaced with exotic species which require special inputs of fodder and nutrients, large quantities of water. Such exotic species frequently drive out native species.

Agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security. ICAR, started a Network on Climate Change and agriculture launched in 2004 for studies on impact assessment, adaptation and mitigation options.

- Farm Mechanization : Presently, India is the largest manufacturer of tractors in the world, accounting for about one-third of the global production. Power tillers are becoming popular in lowland flooded rice fields and hilly terrains. Steady growth was observed in manually operated tools, animal operated implements, and equipments operated by mechanical and electrical power sources. In manually operated equipment, the number of sprayers has almost doubled since 1992. After liberalization and with development of prototypes of machines, manufacturing got a big boost particularly in Haryana, Punjab, Rajasthan, Madhya Pradesh and Uttar Pradesh. About 700-800 combines are sold annually. Tractor operated combine harvester, costing only 25-30 percent of the self propelled combine, has been a good innovation by manufacturers of Punjab; and this machine can be owned individually by farmers. The self propelled combines are largely owned by custom-hiring contractors. Standardization and quality of implement manufacturing is ensured mainly by BIS and over 500 standards on agricultural machinery are prescribed. Since the early seventies, the composition of the relative share of different sources of power for farming operations has undergone significant change as can be seen from Table 3.6. According to a study (Singh *et al.*), the share of agricultural workers and draught animals have come down from 63.5 percent in 1971-72 to 13.67 percent in 2009-10 whereas that of tractors, power tillers and diesel engines and electric motors has gone up from 36.51 percent to 86.33 percent during the same period (Table 11 and Fig.11 & 12).

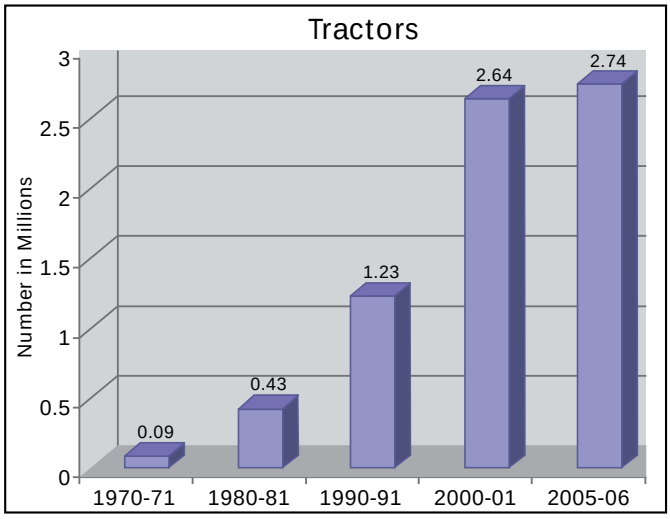
Table 11. Percentage share of different Farm Power Sources in Indian agriculture

Year	Agricultural workers	Draught animals	Tractors	Power tillers	Diesel engines	Electric motors	Power kW/ha
1971-72	10.64	52.86	8.45	0.11	17.16	10.79	0.424
1981-82	9.20	33.55	18.46	0.11	22.85	15.82	0.592
1991-92	7.22	20.50	26.14	0.16	21.14	24.84	0.907
2001-02	5.70	11.76	36.77	0.36	19.10	26.31	1.352
2005-06	5.39	9.97	38.45	0.44	20.09	25.66	1.498
2009-10	5.12	8.55	41.67	0.52	19.01	25.13	1.658

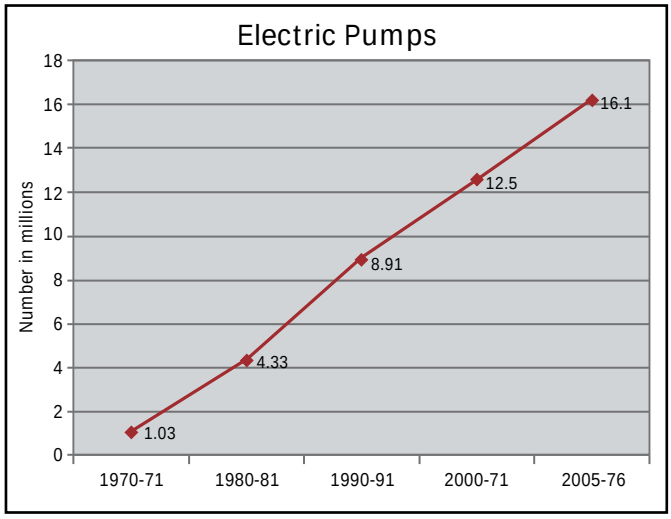
Source : *Singh et al.,2011*

Fig.11(A-D). Trends in Farm Mechnization in India

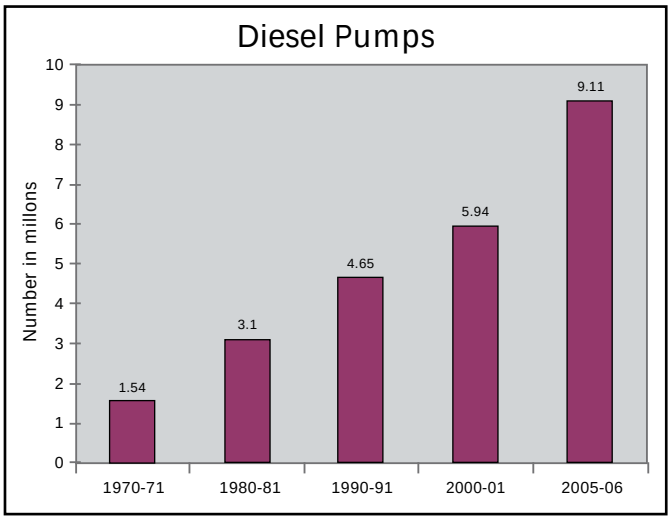
(A)



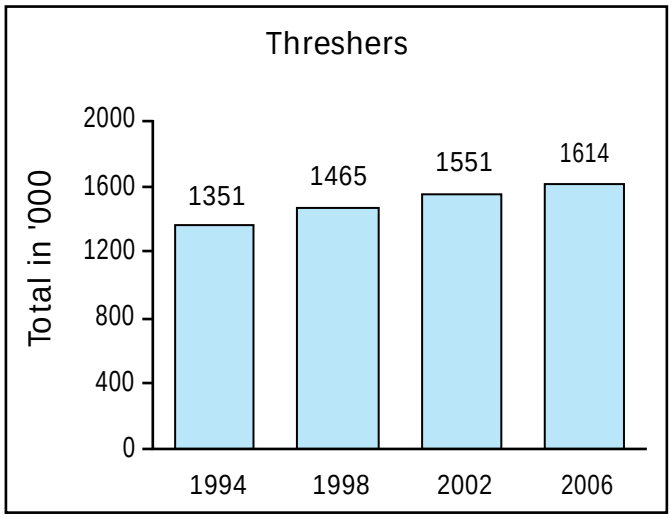
(B)



(C)

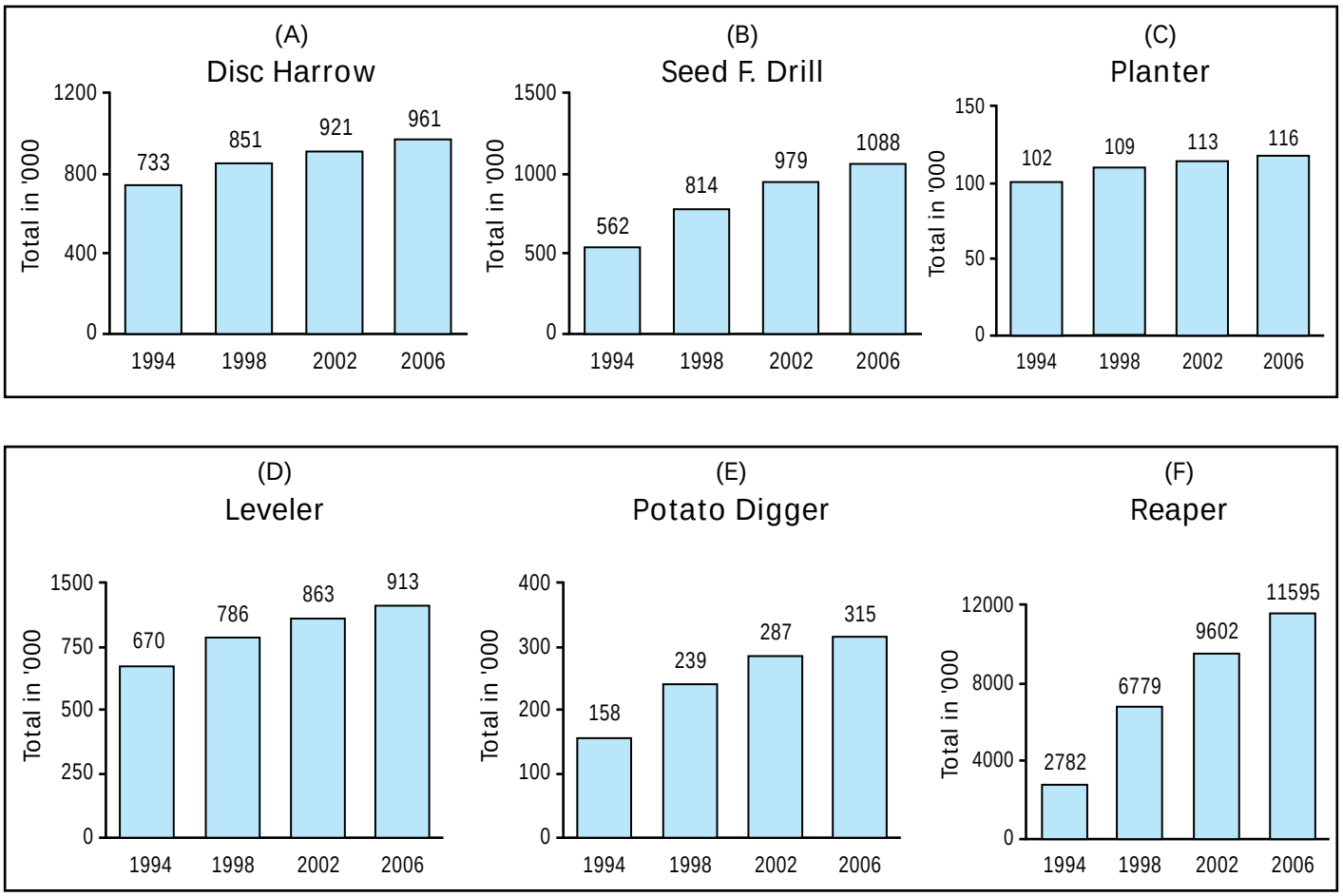


(D)



Source: FICCI, 2007

Fig.12(A-F). Trends in Farm Mechnization in India



Source: FICCI, 2007

The growth in the electro- mechanical power in India is evident from the sale of tractors and power tillers, taken as an indicator of the adoption of the mechanized means of farming, during the last eight years as shown in Table 12.

As mentioned, India is largest manufacturer of tractors with an estimated 2,75,000 units being produced in the last financial year. Different sizes of tractors are manufactured in India ranging from less than 25 HP to more than 45 HP but most popular range is 31- 35 HP. The Tractor sales show that their demand is region specific. Punjab, Haryana & Western Uttar Pradesh constituted the major Tractor market. The share of eastern states, namely Bihar, Orissa, West Bengal and Assam had been consistently low at 7- 9% due to various socio- economic, agro-climatic and other reasons.

Table 12. Sales of Tractors and Power Tillers in India

Year	Tractors Sale (in Nos)	Power Tillers Sale (in Nos)
2004-05	2,47,531	17,481
2005-06	2,96,080	22,303
2006-07	3,52,835	24,791
2007-08	3,46,501	26,135
2008-09	3,42,836	35,294
2009-10	3,93,836	38,794
2010-11	5,45,109	55,000
2011-12 (Upto December 2011)	4,19,270	39,900

Source: Department of Agriculture & Cooperation, 2011

The credit availability to the farmers in this area has been another major reason for the slow growth in the eastern States. About 700- 800 *combines* are sold annually in India.

INTENSIVE AGRICULTURE : PUNJAB SCENERIO

Agriculture is the dominant economy in the state of Punjab, with the state having become the breadbasket of India. In 20010-11, agriculture & allied sector accounted for almost 35.25 percent of the gross state domestic product (GSDP). The state of Punjab which occupies only 1.5 per cent (5. 04 m ha) of the geographical area of the country, has been one of the world's most remarkable examples of agricultural growth in the last three decades. Agricultural growth in Punjab has been closely associated with the well-known 'Green Revolution', which saw the development and adoption of new, high yielding varieties (HYV's) of wheat, rice and other food crops. The astounding agricultural growth in Punjab is exemplified by the increase in wheat production from 1.9 to 5.6 million

tonnes during the years 1965 through 1972. Growth in rice production has been equally impressive.

During eighties, Punjab experienced the highest annual growth rate of food grain output among all the states of India. In fact, Punjab's annual growth rate of food grain output of 6.4 per cent was almost two and a half times that recorded at the all-India level. Punjab's contribution to central pool in terms of wheat and rice is overwhelmingly impressive, though it has reduced over the years (Table 13).

Table.13. Contribution of Wheat and Rice by Punjab to central pool (1980-81 to 2009-10)

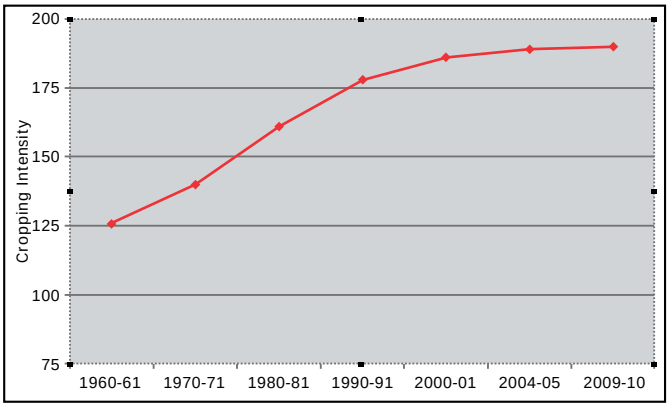
Year	Rice		Wheat	
	Contribution to the Central Pool (lakh tonnes)	Percentage share to contribution	Contribution to the central pool (lakh tonnes)	Percentage share to contribution
1980-81	25.2	45.3	42.8	73.0
1985-86	41.8	42.8	61.5	59.4
1990-91	48.2	41.0	67.5	61.0
1995-96	34.6	34.8	73.0	59.2
2000-01	69.4	33.3	94.2	57.6
2004-05	91.1	36.2	92.4	55.0
2005-06 (R)	88.6	32.0	90.1	60.9
2006-07 (P)	78.3	31.2	69.5	75.3
2007-08 (R)	79.8	27.8	67.8	60.9
2008-09 (P)	85.5	25.1	99.4	43.8
2009-10 (P)	92.8	29.5	107.3	42.2

Source: Statistical Abstracts of Punjab:1989,1993,2003,2009 & 2010 as cited on www.punenvis.nic.in

Cropping intensity in Punjab is 190% which is well above the national average of 135% (Fig.13). Over the last four decades state has been through lot of changes in cropping pattern as shown in Fig.14.

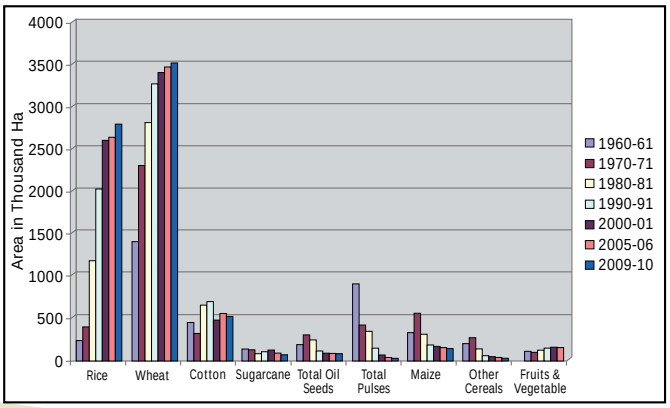
Post Green Revolution, Punjab emerged as a leading state in terms of wheat and rice production. Punjab leads in irrigation with 97.4% of its net sown area under irrigation, out of this 70% (2.93 m ha) of irrigation is achieved with the use of 13.5 lakh tubewells of state, rest of 27% (1.10 m ha) of area uses canal water for irrigation. (Fig.15).

Fig.13. Increase in Cropping Intensity (%) in Punjab (1960-2010)



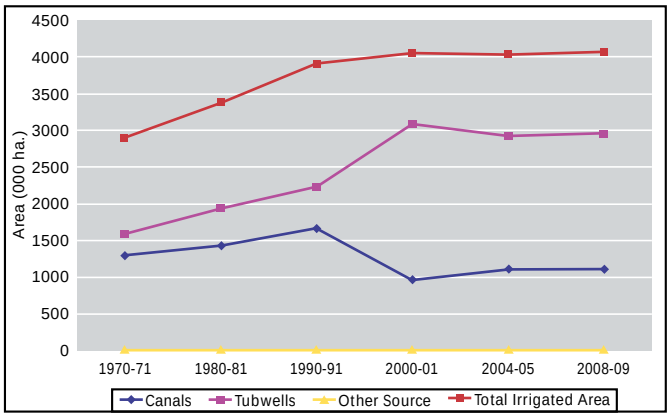
Source: Statistical Abstracts of Punjab as cited on www.punenvis.nic.in

Fig.14. Changes in Cropping Pattern of Punjab (1960-2010)



Source: Statistical Abstracts of Punjab as cited on www.punenvis.nic.in

Fig.15. Net irrigated area by different sources in Punjab (1980-2010)



Source: Statistical Abstracts of Punjab as cited on www.punenvis.nic.in

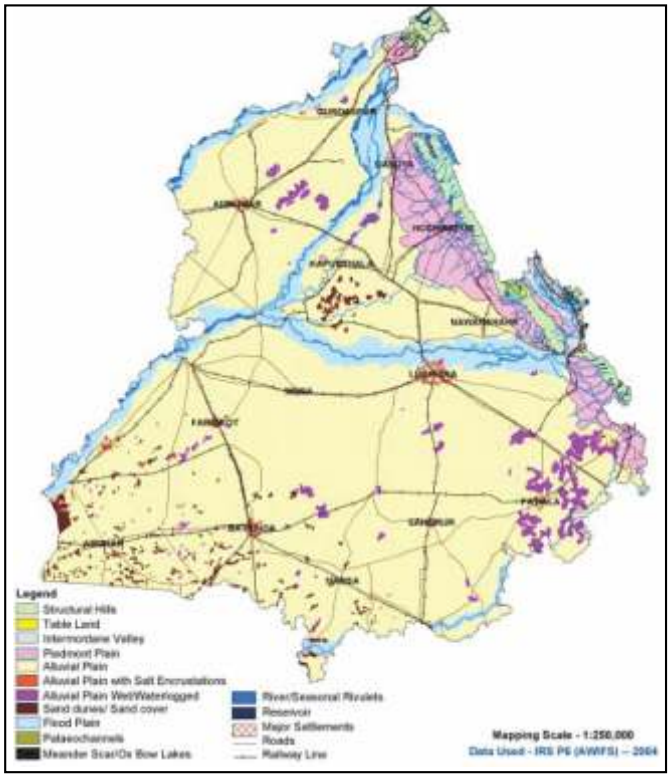
Agro-ecologically, the state can be divided into three regions (Fig.16):

Zone-I : The sub-mountainous region, known as the Kandi area, has undulating topography and includes the districts of Gurdaspur, Pathankot, Hoshiarpur, Nawanshahr,Mohali and Ropar. The cropping pattern of the area is more diverse because of heterogeneity in agro-climatic conditions, with the area producing crops such as wheat, rice, basmati rice, maize, oilseeds, fruits and vegetables.

Zone II: The central region includes the districts of Amritsar, Tarn Taran, Kapurthala, Jalandhar, Ludhiana, Patiala, Fatehgarh, and Sangrur. The falling water table and declining soil fertility pose a threat to the sustainability of the production environment of this region.

Zone III: The south-western region is popularly known as the cotton belt and includes Bathinda, Faridkot, Mansa, Moga, Muktsar, Fazilka and Ferozepur districts. This region is endowed with sandy soil and is much drier than the other two zones. In contrast with Zone II, the water table has been continuously rising during the past two decades at the due to a higher inflow of canal water (Hira *et al*. 1998).

Fig.16. Agro-ecological zones of Punjab



Source: PRSC, 2004 as cited in Tiwana et al., 2007

Fig.17. Geomorphology of Punjab

Source: PRSC, 2004 as cited in Tiwana et al., 2007

Geo-morphologically, the area in Punjab has been divided into eight geomorphic units *viz*. hills, table land, intermontane valley, piedmount plains, alluvial plains, sand dunes, palaeochannels and flood plains. Seven dominant soil types exist in the state (i.e. Fine Loamy Udic/Typic Haplustalfs, Coarse Loamy/ Typic Ustrochrepts, Fine Loamy/Typic Ustrochrepts, Coarse Loamy/Ustic Haplocambids, Fine Loamy/ Ustic Haplocabids, Ustic Torripsamments & Typic Ustipsamments) (Fig.17).

Growth and Intensification of agriculture in Punjab can be explained under following headings:

- Intensive Cultivation of Cereals : Before the onset of famed 'Green Revolution', farmers in Punjab would grow an array of cereals like jowar, bajra and barley besides rice, wheat and maize. But with high yielding varieties of wheat and rice clubbed with subsidies and Minimum Support Price (MSP) offered by government during sixties and seventies, impetus shifted for intensive cultivation of rice and wheat in the State.

Table 14 & Table 15 shows the trend of decrease both in terms of area and production for cereals like jowar, bajra, barley and maize. The impact of Green Revolution was spectacular that between 1965-66 and 1970-71 the per hectare yield of wheat doubled, from 1104 kg/ha in 1965-66 to 2238 kg/ha in 1970-71. After wheat, paddy provided a major push to agricultural prosperity in the state, with the introduction of dwarf varieties developed by International Rice Research Institute (IRRI), Manila. By the mid 1980s, except for the southern parts of Punjab, the State began to follow a wheat-paddy rotation

Table 14. Area under different Crops in Punjab (1970-2010)

Year	Kharif Cereals				Rabi Cereals			
	Rice	Jowar	Barja	Maize	Wheat	Barley	Other Cereals	Total Cereals
1970-71	390	5	207	555	2299	57	1	3514
1980-81	1183	1	69	382	2812	65	1	4513
1990-91	2015	(a)	12	188	3273	37	(a)	5525
2000-01	2612	(a)	6	165	3408	32	-	6223
2005-06(R)	2647	4	6	149	3464	20	-	6290
2006-07(R)	2621	-	7	154	3467	19	-	6268
2007-08(R)	2609	-	5	154	3487	16	-	6271
2008-09(P)	2735	0.1	5	151	3526	16	-	6433
2009-10	2802	0.1	3	139	3522	14	-	6480.1

(Area 000 ha) , (a) Below 500 ha, (R) Revised, (P) Provisional

Source: Statistical Abstract of Punjab, 2010

Table 15. Production of Major Crops in Punjab (1970-2010)

Year	Kharif Cereals				Rabi Cereals			
	Rice	Jowar	Barja	Maize	Wheat	Barley	Other Cereals	Total Cereals
1970-71	688	3	243	861	5145	57	(a)	6997
1980-81	3233	1	86	612	7677	108	(a)	11717
1990-91	6506	1	13	333	12159	101	(a)	19113
2000-01	9157	-	5	461	15551	109	-	25283
2005-06(R)	10207	-	6	407	14476	66	-	25162
2006-07(R)	10138	-	7	481	14596	64	-	25286
2007-08(R)	10486	-	5	525	15716	57	-	26789
2008-09(P)	11000	0.1	5	514	15733	55	-	27307
2009-10	11236	0.1	4	475	15169	47	-	26931

Production (000 MT), (a) Below 500 MT, (R) Revised, (P) Provisional

Source: Statistical Abstract of Punjab, 2010

pattern in cultivation, and, as a consequence Punjab became the food bowl of the country. Between 1970-71 and 2000-01 production of wheat has gone up more than three times from nearly five million tonnes to more than 15.5 million tonnes. Similarly, production of rice, the other major crop of the state after green revolution, has gone up more than thirteen times between 1970-71 and 2000-01.

Pioneering work of various agriculture scientists along with path-breaking researches conducted in Institutes and Universities like Punjab Agriculture University, helped in transforming a food-deficient India into a food self-sufficient nation. Revolutionary role of Punjab Agricultural University (PAU) for this dramatic transformation is always acknowledged.

Contribution of Dr.M.S.Randhawa is remarkable, as Vice-President of Indian Council for Agricultural Research; he guided all the research that later on was to bloom into the Green Revolution in Punjab.

- Production of Pulses : Punjab had fairly diversified cropping pattern before the green revolution. Production of pulses in the state however got worse with rising income of farmers due to rice-wheat cultivation during seventies and eighties and the situation nearly decimated during 2009-10.Gram which used to be an important pulse crop during sixties, declined from a level of nearly 360,000 hectares in 1970-71 to less than 5,000 hectares in 2010. Story of production of other pulses crops like arhar, moong, mash, massar is similar to that of gram (Table 16).
- Production of Oilseeds : Again no intensive cultivation of oildseeds crops is going on in the state of Punjab. Both area under cultivation and total production under oilseeds like groundnut, rapeseed, mustard, sunflower, sesamum and linseed have declined over the years in the state. (Table 17).
- Horticulture Crops : Out of the total net sown area of 42.01 lakh ha, horticulture crops are currently grown over an area of

Table 16. Area and Production under Major Pulses Crops in Punjab (1980-2010)

Year	Gram		Mash		Arhar		Moong		Massar	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
1980-81	258	150	21.5	8.6	21.3	22.5	15.1	11.1	19.76	8.8
1990-91	60	45	8.5	3.6	14.5	12.7	50	37.3	9.67	6.3
2000-01	8	8	3.5	1.7	8.7	7.6	29.5	18.4	4.7	3.1
2006-07(R)	3.9	4.0	3.4	1.4	7.3	6.8	12.4	10.8	2.3	0.9
2007-08(R)	2.0	2.1	3.6	1.6	6.3	5.6	14	10.0	1.4	0.7
2008-09(P)	3.0	3.5	2.9	1.5	5.9	5.7	8.9	7.9	1.2	1.0
2009-10(P)	3.0	3.4	2.8	1.3	4.6	4.4	7.0	6.4	1.1	0.7

Area (000 ha); Production (000 MT), (a) Below 500 MT, (R) Revised, (P) Provisional

Source: Statistical Abstract of Punjab, 2010

Table 17. Area and Production under Major Oilseed Crops in Punjab (1980-2010)

Year	Groundnut		Rapeseed & Mustrad		Sunflower		Sesamum		Linseed	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
1980-81	83	104	136	77	-	-	16.9	5.3	1.9	0.8
1990-91	11	9	69	69	5	7	18.2	6.7	0.8	0.7
2000-01	4	4	55	67	7	8	19.2	7.6	0.6	0.6
2006-07	4.4	3.8	41	46	15.3	25.1	9.6	3.2	0.2	0.1
2007-08	3.2	2.8	30	35	20	38	6.8	2.2	0.1	0.1
2008-09(P)	3.1	3.0	29	34	19.4	33.1	8.1	2.7	0.1	0.1
2009-10(P)	2.5	3.1	30	39	21.9	38.6	7.3	2.6	-	-

Area (000 ha); Production (000 MT), (P) Provisional

Source: Statistical Abstract of Punjab, 2010

2.05 lakh ha which accounts for 4.8 % of the net sown area. The area under fruit crops is 0.47 lakh ha. The major fruit crops of Punjab are citrus, mango, litchi, guava, ber, and pear. Among the citrus group most of the processable varieties are grown in the state. In Punjab mandarin, kinnow is the most prevalent variety covering an area of 20,000 ha with a production of 3.00 lakh tonnes. There is further scope to double the production in the next 5 years. Punjab is a leading state in terms of production of vegetables. The total area under vegetable crop is 1.58 lakh ha with the production of 27 lakh tonnes, which accounts for 2.5% of the total vegetable production in the country. The annual productivity of the state is 16.8 MT/ha as compared to the average national productivity of 14 MT/ha. The major vegetables grown in the state are cauliflower, peas, potato, onion, chilies, tomato, brinjal. (NHM, 2006). Flowers are grown over an area of 0.006 lakh ha.

- Livestock : Livestock plays an important role in the rural economy of the state. It has contributed 8.46 % to the Gross State Domestic Product (GSDP) in 2009-10 (Q). As per the 17th livestock census, 2003, the state of Punjab had 1.10% of cattle, 6.12% of buffaloes, 0.36% of sheep, 0.22% of goats and 0.22% of pig population of the country. The poultry population is 2.2% of the country's total poultry population. In numerical terms, total livestock population amounts 8.6 million and total poultry population including ducks stand out as 10.78 million. The milk, eggs and wool production in state was 8,391 thousand tonnes (second in rank among the states), 3.06 billion numbers and 554 thousand kgs, respectively during the year 2003-04 (Source: Department of Animal Husbandry, Punjab).
- Fisheries : Punjab has achieved first position in the country with regard to average fish production of 6 ton per ha which is 3 times more than the national average. According to Department of Animal Husbandry, Dairy Development and Fisheries, Govt. of Punjab, area under fish cultivation has been progressively increasing. The major fish species which are being promoted for pisiculture in the state are *Labeo rohita* (Rohu), *Catla catla* (Katla), *Cyprinus carpio* (Common carp), *Ctenopharyngodon idella* (Grass carp) and *Hypophthalmichthys molitrix* (Silver carp).

INTENSIVE AGRICULTURE AND ITS IMPLICATIONS

- *Ground water depletion*: The dominance of rice-wheat system has caused reduction in area under low water requiring crops, which led to over exploitation of groundwater resource, as the surface water is not adequate to meet the irrigation needs of the state. The number of tube wells has increased from 0.19 million in 1971 to 1.3 million. The average annual rainfall is 580 mm and is ill distributed in time and space. The total water supply of 3.13 m ham falls short by 1.27 m ham of the total water demand of 4.40 m ham (Table 18).

Table 18. Status of Water Resources in Punjab

Annual canal water available at Head Works	14.54 m ham
Annual canal water available at outlets	1.45 m ham
Annual ground water available	1.68 m ham
Total annual available water resources	3.13 m ham
Annual water demand	4.40 m ham
Annual water deficit	1.27 m ham

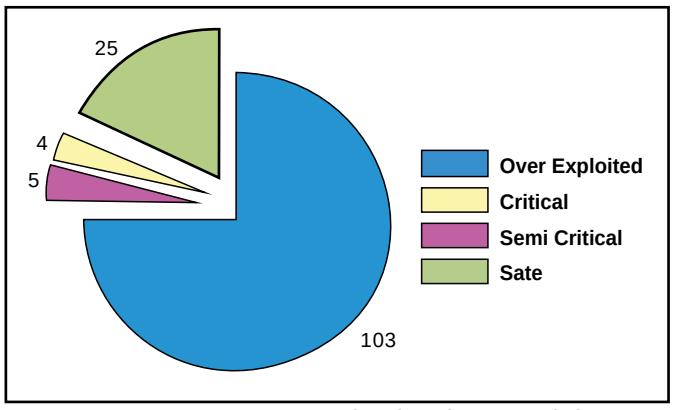
Source: CGWB & Deptt. of Irrigation, Punjab, 2005 as cited in Tiwana et al., 2007

As per the guidelines of Ground Water Resources Estimation Committee (GEC), the present ground water development (ratio of gross ground water draft for all uses to net ground water availability) in the state is 145% as on March 2004 as per data provided by Central Ground Water Board (CGWB) and Department of Irrigation, Punjab.

Out of 137 blocks of the state, 103 blocks are overexploited, 5 blocks are critical, 4 blocks are semi critical and only 25 blocks are in safe category (Fig.18). The gravity of the situation can be gauged from the fact that ground water in 75% of total geographical area of the state is over exploited in terms of stage of ground water development, as exploitation is more than 100 percent, 7% area of the state is under the category of critical and semi critical category and only 18 % area of the state is safe for ground water development. However, only a part of this is in Kandi area zone. The rest is in south western Punjab and is saline and unfit for use. All the blocks of various districts like Amritsar(16 blocks), Jalandhar (10 blocks), Moga (5 blocks), Kapurthala (5 blocks), Sangrur (12 blocks), Fathegarh Sahib (5 blocks), Patiala (8 out of 9 blocks) and Ludhiana (9 out of 10 blocks) have been found to be over-exploited leading to sharp depletion of the water table in these districts. Data indicates that the number of dark/ overexploited blocks have sharply escalated during the period 1992 to 2004 (Fig.19).

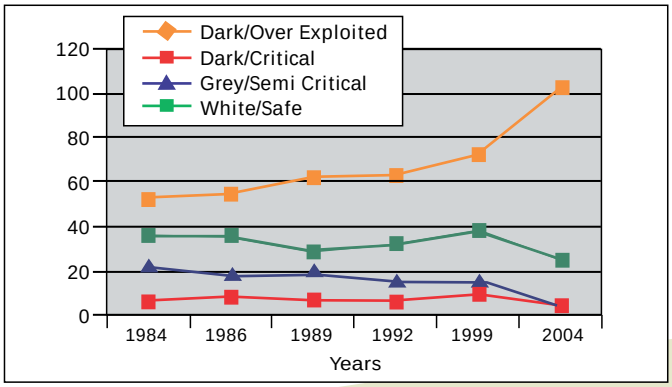
- Soil Degradation : Maintenance of soil fertility is essential to sustain agricultural production. The soils of Punjab are generally low in N content, low to medium in P and medium to high in K except in Kandi belt which has low to medium K content (Department of Agriculture, Punjab) (Fig.20, Fig.21 & Fig.22). Most of the soils of Punjab are alluvial and deep, varying from sandy to silty clay.

Fig.18. Categorization of Blocks in Punjab based on Ground Water Development



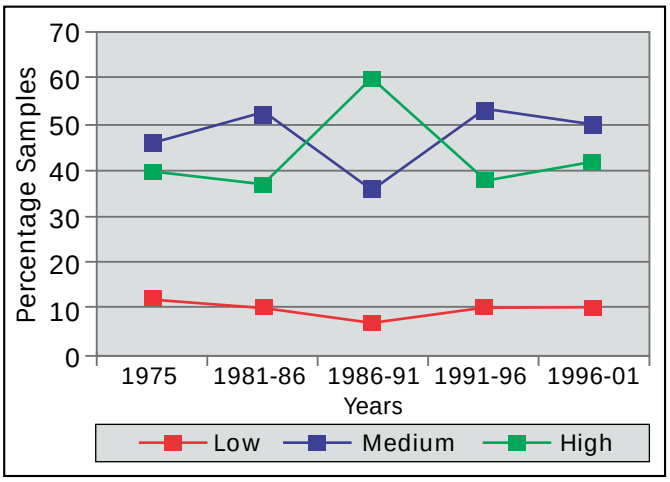
Source: CGWB & Deptt. of Irrigation, Punjab, 2005 as cited in Tiwana et al., 2007

Fig.19. Increase/decrease in number of various categories of blocks : Punjab (1984-2004)



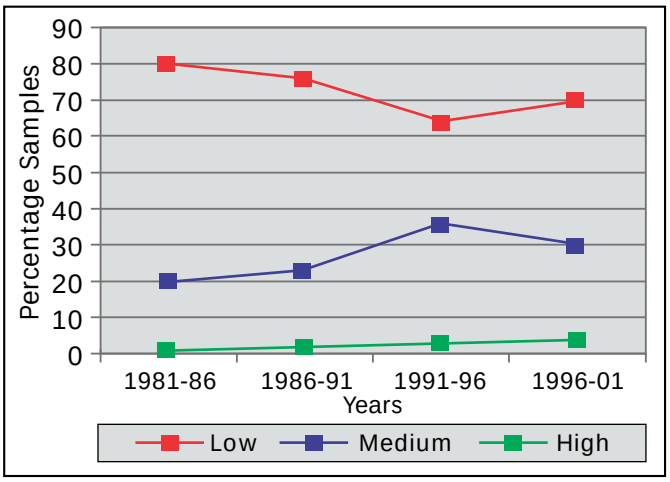
Source: CGWB & Deptt. of Irrigation, Punjab, 2005 as cited in Tiwana et al., 2007

Fig.20. Trends in available Organic Carbon Content in Soils in Punjab



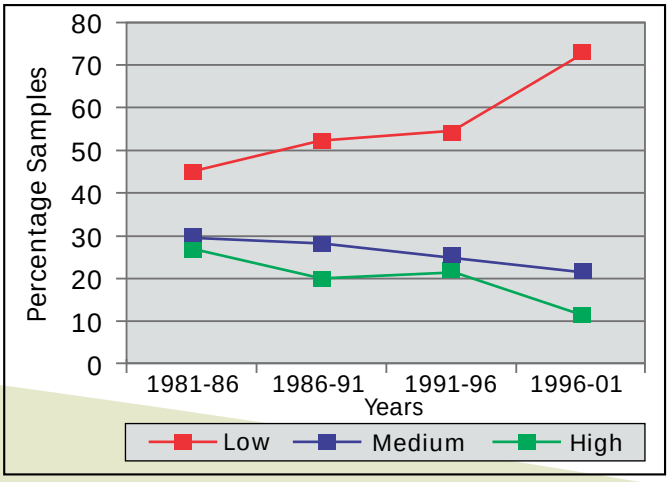
Source: Tiwana et al., 2007

Fig.21. Trends in available Potassium Content in Soils in Punjab



Source: Tiwana et al., 2007

Fig.22. Trends in available Phosphorus Content in Soils in Punjab



Source: Tiwana et al., 2007

In the past two to three decades, intensive agricultural practices have put a tremendous pressure on the soils and resulted in steady decline in its fertility (nutrient availability), both w.r.t. macro & micro-nutrients (Table 19). Both rice & wheat have high nutritional requirements and the double cropping of this system has been heavily depleting the nutrient contents of soil e.g. rice – wheat sequence that yields 7 tonnes/hectare of rice and 5 tonnes/hectare of wheat removes more than 300 kg N, 30 kg P and 300 kg of K/hectare from the soil. Even with recommended rate of fertilization in this cropping pattern, a negative balance of primary nutrients still exists (Benbi *et.al*., 2006).

Table 19. Changes in Micronutrient Status in various Districts of Punjab

District	Year	Percent Samples deficient			
		Zinc	Copper	Iron	Manganese
Ludhiana	1970	56	-	-	2
	1988	12	2	1	5
	2004	7	2	7	22
Jalandhar	1977	45	6	0	0
	1998	14	0	13	39
Sangrur	1977	71	4	7	0
	2000	14	0	18	35
Patiala	1980	23	1	4	2
	2004	12	1	5	5
Gurdaspur	1982	52	2	2	1
	2000	42	1	1	5
Kapurthala	1983	45	1	4	0
	1992	15	0	8	3
Kapurthala	1984	47	0	0	0
	2004	36	0.5	4	5
Hoshiarpur	1985	59	1	13	6
	2004	31	6	24	25
Mukastsar	1992	70	2	61	7
	2004	37	5	31	8

Source: Tiwana et al., 2007

Hence, farmers in the State have been applying higher and higher doses of major nutrients, especially nitrogen for sustaining adequate production levels. Due to intensive cultivation, the organic carbon of the soil has come down from 0.5 per cent in 1960 to 0.2 per cent in 1990.

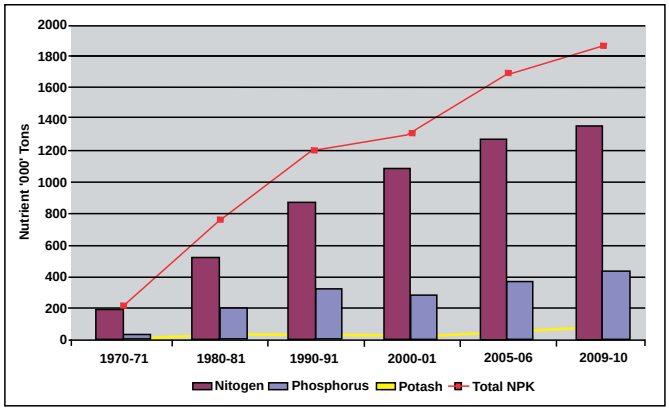
- Menace of Straw Burning : Burning of wheat and rice straw has also contributed to loss of soil fertility apart from causing air pollution. Punjab produces around 23 million tonnes of rice straw and 17 million tonnes of wheat straw, annually. This straw is rich in Nitrogen, Phosphorus and Potassium contents. However, instead of its recycling into the soil by mulching, it is burnt in the fields. This raises the temperature of the soil in the top 3 inches to such a high degree that Carbon: Nitrogen equilibrium in soil changes rapidly. The carbon as CO_2 is lost to atmosphere, while nitrogen is converted to nitrate.

  Recently, Honorable Punjab and Haryana High Court in response to civil petition filed by Captain Sarabjit Singh Vs state (CWP No. 10138/2006) ordered that straw burning is an issue where promulgation of a law banning such activity possibly may not yield the desired result.

  Further honorable court stated that the issue needs to be seen from the perspective where the society and the government, who are beneficiaries of the industrious activity of a farmer, take proactive measures by providing solutions to a farmer which are affordable and readily available and thus save both the farming community as also the general public from the hazards ensuing the polluting activity of burning straw. Court further suggested that Govt. should promote and take steps for easy availability of Resource Conservation Technology (RCT)/ machines like rotavator, zero-till drill and happy seeder which provide viable options to the farming community for not burning left over straw in the field.

- Over use of Fertilizer & Pesticides : Fertilizers are an important component of agricultural technology. Whereas initially organic fertilizers were mainly used in the fields, however, chemical fertilizers have played a very important role in enhancing the agricultural production in the state. Since the introduction of high yielding varieties, the consumption of chemical fertilizers has been increasing steadily. It has increased more than 8 times in the past 35 years from 213 nutrients thousand tonnes in 1970-71 to 1694 nutrient thousand tonnes in 2005-06 (Fig. 23).

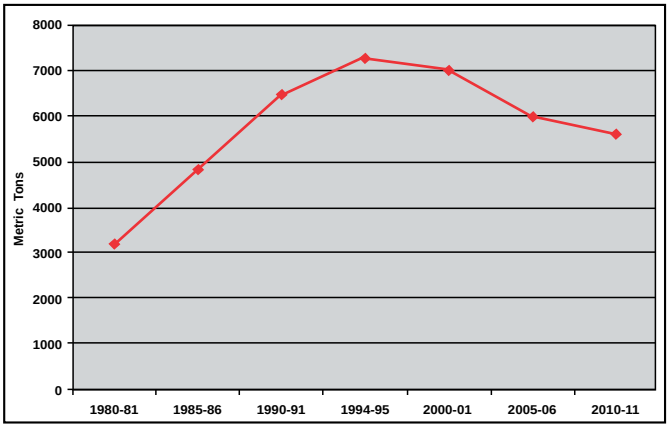
Fig.23. Consumption Trend of Chemical Fertilizers in Punjab (1970-2010)



Source: Directorate of Plant Protection & Quarantine, GoI and Central Insecticide Board & Registration Committee, as cited on www.punenvis.nic.in

The state of Punjab is one of the highest users of chemical pesticides especially after the ushering in of green revolution. Pesticide consumption in India has increased from 2353 MT in 1955 to 40672 MT in 2005. In Punjab this has increased from 3200 Metric tonnes (MT) in 1980-81 to 7300 MT in 1994-95 but came down to 5970 MT in the year 2005-06 (Fig.24).

Fig.24. Consumption Trend of Technical Grade Pesticides in Punjab (1980-2010)



Source: Directorate of Plant Protection & Quarantine, GoI and Central Insecticide Board & Registration Committee, as cited on www.punenvis.nic.in

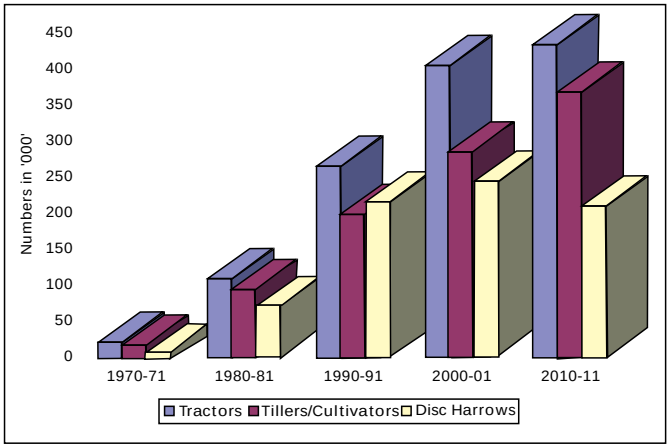
Currently, the state consumes about 17 percent of total pesticides used in India. Out of these, more than 90 per cent of the pesticide is being used in the cultivation of cotton, rice and .The Malwa region (cotton belt) accounts for nearly 75 percent of pesticides used in the state. The decrease in pesticide consumption since 2003-04, can be attributed to the introduction of Bt cotton in the state (which requires lesser number of sprays) as well as, better awareness among farmers as state government is now promoting biopesticides *(Department of Agriculture, Government of Punjab).*

- Increased Farm Mechanization : Intensive agriculture requires farm mechanization, besides modern inputs of seeds, water and such chemicals as fertilizers and pesticides. The rapid adoption of the green revolution technology in Punjab has led to a sharp increase in farm mechanization. Farm mechanization, no doubt, has been beneficial for the intensive use of land and has helped considerably in overcoming the risk of unfavorable effects of weather on maturing crops. But this has also directly or

indirectly affected the natural environment due to increasing use of fossil fuels, gaseous emissions and direct impact on soil.

Tractors : In 1960-61, there were seven tractors per thousand hectare of land, which shot up to 96 in 1998-99. On an average, there is now one tractor for every eight hectare of net cultivated land, and in some districts the area operated by a tractor is even lower. In contrast, at the all-India level, the area operated by a tractor is above 66 hectare. So over the years availability of tractor per ha of area has increased tremendously and currently it is twice the number of tractors required with respect to area. Another way of looking at it is, about 16% of total tractor of India are operating in the state of Punjab (Fig.25 & Table 20).

Fig.25. Trends in usages of Tractors, Tillers/Cultivators, Disc Harrows in last five decades



Source: Department of Agriculture, 2011

Table 20. Agricultural Machinery in Punjab (in numbers)

Agricultural Machinery	2007-08	2008-09	2009-10	2010-11
Tractors	4,20,000	4,25,200	4,25,200	4,34,000
Disc-Harrow	2,20,000	2,24,000	2,24,300	2,10,000
Seed-cum-Fertilizer Drills	1,78,000	1,83,000	1,83,000	1,66,489
Spray Pumps (Knapsack)	6,55,000	6,65,000	6,55,000	6,00,000
Vertical Conveyor Reaper	5,518	5,522	-	-
Combine Harvester (Self Propelled)	7,600	8,400	8,400	8,130
Combines (Tractor Driven)	6,570	6,670	6,270	6,056
Threshers	9,10,400	8,22,000	8,02,000	7,40,000
Straw Reaper	21,848	32,666	32,900	33,678
Maize Sheller	1,890	1,893	1,850	1,832
Potato Planters	5,160	5,330	5,250	5,228
Tube wells(Electric)	9,71,000	10,05,200	11,05,517	11,41,606
Tube wells(Diesel)	2,75,000	2,71,000	2,70,000	2,40,000
Sugarcane Cutter Planter	340	290	-	-
Strip-till -Drill	215	195	-	-
Zero-till-Drill	9,883	10,141	10,300	10,465
Rotavator	2,243	6,419	6,720	8,691
Aero Blast Sprayings	70	70	70	-
Laser Land Leveller	-	-	-	4,500

Source: Department of Agriculture,2011

Excessive use of tractors also causes damage to physico-chemical characteristics of soils, particularly where puddling is done for rice cultivation. With the loss of soil characteristics, biological activities are also impaired and in the long run, such soils are likely to become unproductive. Soil compaction by agricultural machinery is also recognized as being a significant contribution to decreased soil fertility and increased erodability. Soil compaction increases resistance of soil to penetration by roots and emerging seedlings, limits gaseous exchange between roots and atmosphere and reduces water infiltration, altering soil moisture and accelerating runoff and erosion.

Powers Tillers : The production of power tillers started in 1961 with license to manufacture 12 models. Farmers of Punjab adopted them openly during the green revolution and now approximately there are 350,000 units in use in farms of Punjab.

Disc Harrow : Sale of Disc Harrow implement has reduced in recent decade in Punjab owing to improvement of other alternatives.

Seed-cum-fertilizer drills : The land levelers, seed-cum-fertilizer drills have also been accepted by the farmers but trend in their growth show saturation.

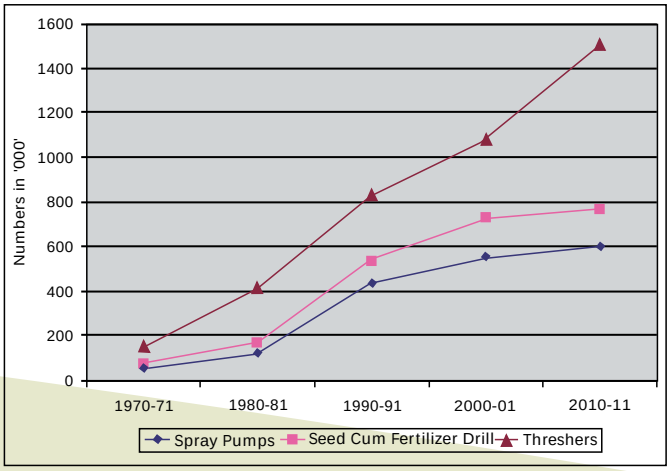
Combines and harvesters : With the introduction of combine both self propelled/ tractor operated there was a massive displacement of both agricultural and migrant labourers in Punjab.

Today nearly 40 percent of the wheat crop and 70 percent of the paddy crop is harvested through combines. It is estimated that currently more than 14 thousands combines are operating in state, though number of threshers has decreased from 300 thousand in 1995 to 92 thousand in 2005. Similarly trends in use of other mechanised farm input has gone spiral over the years in the state. (Fig.26 & 27).

High Speed Diesel : The agriculture sector consumes around 30% of total High Speed Diesel (HSD) consumed in the state and it has increased from 626 Thousand Metric Tons (TMT) of HSD in the year 2002 to 685 TMT HSD in the year ending 2005. More mechanization means more demand of HSD in farm sector.

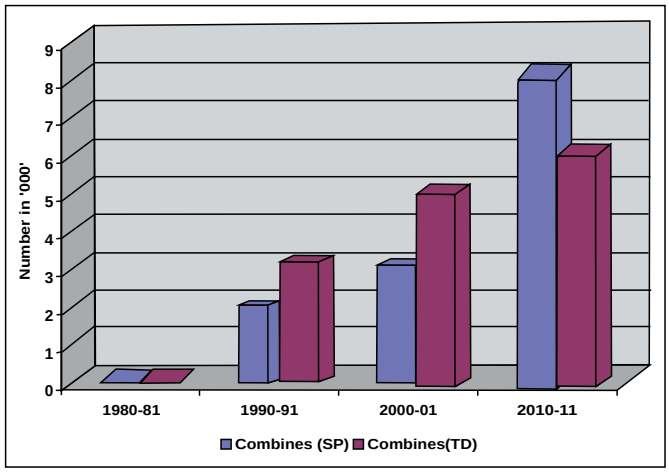
Tubewells : It is important to take cognizance of the fact that central Punjab has 72% area under paddy cultivation, out of which only 21% area has canal water irrigation facility. The tubewells in the central districts of the state constitute around 70% of total tubewells in Punjab (over 6% of the total tube wells of India are in Punjab), which have increased from 1.92 lacs (0.91 electric and 1.01 diesel operated) in 1970-71 to 12.76 lacs (9.96 electric and 2.80 diesel operated) in 2008-09 and during

Fig.26. Trends in usage of Spray Pumps, Seed cum Fertilizer Drills and Threshers in last five decades



Source: Department of Agriculture,2011

Fig.27. Trends in Combines usages in last four decades (Self propelled and Tractor Driven)



Source: Department of Agriculture, 2011

2009-10 number of tubewells has reached 13.15 lacs (10.65 electric and 2.50 diesel operated) as shown in Table 21.

During a short span of a decade between 1997 and 2007, there has been a four-fold increase in cumulative fall in water table in the central districts of Punjab. Accordingly, the traditional centrifugal water lifting technology is becoming redundant and being replaced by the costlier submersible technology in the state. As per 2008 estimates, there were 45,680 submersible in the state, which was 45% of the total electric driven tubewells (9,68,007) in the state 9,68,007 (Singh, 2011).

Table 21. No. of Tubewells in Punjab (Lakh)

Year	Diesel operated	Electric operated	Total
1970-71	1.01	0.91	1.92
1980-81	3.20	2.80	6.00
1990-91	2.00	6.00	8.00
2000-01	2.85	7.88	10.73
2003-04	2.88	8.56	11.44
2004-05	2.88	8.80	11.68
2005-06	2.88	9.05	11.93
2006-07	2.80	9.52	12.32
2007-08	2.75	9.71	12.46
2008-09	2.80	9.96	12.76
2009-10 (P)	2.50	10.65	13.15

P= Provisional

Source: Statistical Abstract of Punjab,2010

- Loss of Agricultural Bio-diversity : The strategy for increasing agricultural production followed in Punjab was based on putting large cultivated areas under wheat and rice; use of high yielding seeds, water and fertilizers; and efforts to improve input-use efficiency for reducing the cost of production. Over time, the wheat-rice rotation, now covering over 60 per cent gross of sown area, has created problems of serious consequences. Mono culture of wheat and rice has resulted in the loss of domesticated floral biodiversity of the state. Prior to the green revolution, 41 varieties of wheat, 37 varieties of rice, four varieties of maize, three varieties of bajra, 16 varieties of sugarcane, 19 varieties of pulses, nine varieties of oil seeds and 10 varieties of cotton were reported to be in use in Punjab. Data indicates that out of 47 post green revolution varieties of wheat released by PAU, only 5 are widely used. Similarly, out of 19 varieties of rice released, only eight are currently in use (Table 22).

Table 22. Domesticated Plant Diversity Pre and Post Green Revolution

Crops	Pre-green revolution varieties	Post-green revolution varieties	No. of varieties in use
Wheat	41	49	13 (3 main)
Rice	31	27	9 (4 basmati)
Cotton	17	32	12 (included 4 varities of BT Cotton)
Maize	4	24	11
Sugarcane	11	16	6
Bajra	3	11	5
Pulses	18	47	24
Oil Seeds	8	35	19
Vegetables	35 spp.	148 var.	-
Fruits	16 spp.	67 var.	

Source: Tiwana et al., 2007

Desi maize is however, still favored by farmers. The domesticated agricultural faunal diversity includes three breeds each of cows, buffaloes and sheep and two breeds each of goats and poultry. Out of these, Murrah & Nili Ravi breeds of buffaloes, Hariana & Sahiwal breeds of cattle, Lohi, Nali, & Desi breeds of sheep and Beetal breed of goat are indigenous. Out of these, Sahiwal breed of cattle, Nilli Ravi of buffaloes, Lohi of sheep and Beetal breed of goat are threatened.

WAY FORWARD AND FUTURE ALTERNATIVES

Punjab's agriculture has reached a point where it must make significant changes if the state is to move forward. Conversely, if it does not rationalize incentives, reinvigorate old institutions and create new institutions, and increase investments significantly, it will suffer declining income and employment and irreversible environmental degradation. In 2006, International Food Policy Research Institute (IFPRI) New Delhi, in its report suggested following major recommendations required in future for reviving the agriculture of Punjab:

- Diversification : Diversification toward high-value commodities—basmati and fine long-grained rice, durum wheat, fruits and vegetables, milk, poultry, fish and their processing—has already begun in Punjab. In order to revitalize agriculture, the Government of Punjab (GOP) constituted a number of expert committees (e.g., the Johl Committee, 2002, and the Alagh Committee, 2005) to explore alternatives to the rice–wheat system. The problem has also been addressed by other groups. These expert committees and groups have recommended the diversification of agriculture towards high-value commodities(HVCs) and a broader mix of traditional commodities and agro-processed products that augment farm income, promote exports, and conserve soil and water resources. There is an urgent need in Punjab to diversify into new areas like vegetables and fruits, oil seeds, pulses and allied fields such as dairy farming, poultry, piggery, etc. The Government of Punjab had launched a multi crop multi year contract farming scheme to give boost to crop diversification in 2002. The programme is being implemented by Punjab Agro Foods Corporation (PAFC). So far more than 0.186 million ha acres is covered under crops other than wheat and paddy like hoyla, winter maize, sunflower, drum wheat, moong etc. involving 0.1 million farmers under this program.
- Reform Marketing and Public Foodgrains Management : Reforms needed to promote agricultural diversification include changes in the grain management system to properly align price and production incentives. The presence of MSPs at current levels works against agricultural diversification by assuring very high floor prices for wheat and rice production, while the prices of HVCs are market-driven and more variable within and across seasons. Agricultural diversification would benefit greatly from reforms that adjust the MSP to align resource decisions with proper price incentives.
- Reform Input Subsidies : Input subsidies pose a constraint to diversification. Subsidies have accomplished the objectives for which they were originally intended. Fertilizers, irrigation, and electric power are now being provided at low, sometimes

zero, costs. Subsidies are promoting input-intensive agriculture, specifically wheat and rice. The distribution of benefits is increasing inequalities in incomes and between regions. Because of landholding distribution, the largest amount of subsidies goes to medium and large farmers despite the fact that the subsidies have been justified, in part, to benefit the smallholder. The subsidy on fertilizer is huge. In addition, fertilizer is being applied on wheat and rice at or above the recommended levels, and fertilizer components are out of balance (too much nitrogen relative to phosphorus and potash). The marginal responses to fertilizer are low, if not negative, and wheat and (especially) rice yields are stagnating.

FICCI, 2007

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Department of Animal Husbandry, Dairying & Fisheries

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Directorate of Rice Research

http://www.dwr.in
Directorate of Wheat Research

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Food & Agriculture Organization of United Nations

http://faostat.fao.org/
Statistics Division of the Food & Agriculture Organization of United Nations

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Indian Institute of Pulses Research

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International Rice Research Institute

http://www.nfsm.gov.in
National Food Security Mission

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National Horticulture Board

http://www.punenvis.nic.in
Punjab ENVIS Centre

http://www.punjabgovt.nic.in
Government of Punjab-Portal

http://www.sri-india.net
System of Rice Intensification

www.ficci.com
Federation of Indian Chambers of Commerce

News

Farmers make it big with Protected Cultivation

At time when mounting debts are leading to suicides among farmers, 'protected cultivation' has made agriculture a remunerative vocation for some of the progressive farmers.

Eager to break away from the wheat-paddy cropping pattern, Patiala-based Meharban Singh and Ludhiana-based Davinder Singh decided to experiment with vegetable cultivation. Unlike most farmers who follow the herd mentality that often leads to a glut in the market, they first studied the possible pitfalls and the ways to overcome them. “We had a clear idea that our venture should be economically viable,” says Davinder.

Both, Meharban and Davinder conducted a preliminary research before contacting the experts at Punjab Agricultural University (PAU). To get the required know-how and learn about the latest techniques in vegetable cultivation, they visited countries like Spain and Italy.

In 2002, Meharban and Davinder started their ventures at their fields in Saholi (Patiala district) and Mushkabad (Ludhiana district), respectively.

At every stage, it was their willingness to take a calculated risk that helped.

They found that drip irrigation increased the profitability by more than 30 per cent. In 2008, they decided to adopt the poly-house technique. Instead of going for that technique in a big way, they adopted it on an experimental

basis on small patches of land. "Only when the experiment proved successful did I opt for the poly-house technique on five acres of my land," says Meharban, who has successfully cultivated tomato, coloured capsicum, and bitter gourd through this technique.

The protected cultivation technique entails a one-time investment of Rs 37 lakh per acre. The investment excludes the recurring labour and seed costs. Both the farmers have received about 50 per cent financial assistance through a scheme of the National Horticulture Mission.

The annual income from one acre of land under protected cultivation was around Rs 6-7 lakh, says Meharban.

Director, horticulture department, Punjab, Dr L.S. Brar, said protected farming was the best technique to increase per unit yield as well as the income from the land.

"In protected cultivation, there was a better control of light, temperature and humidity, and consequently, a better growth of crops. There was also a restricted use of pesticides. Besides, the window period of the crops is increased," adds director, research, PAU, Dr SS Gosal. However, the protected cultivation requires intensive crop care that can only be provided by skilled labour under expert guidance.

Source: The Tribune: Mar. 28, 2012

Useful Weblinks

http://www.warda.cgiar.org/
Africa Rice Center

http://www.bioversityinternational.org/
Biodiversity International

http://www.cifor.cgiar.org/
Center for International Forestry Research

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Indian Council of Agricultural Research

http://www.icrisat.org/
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

http://www.ifpri.org/
International Food Policy Research Institute

http://www.iita.org/
International Institute of Tropical Agriculture

http://www.ilri.org/
International Livestock Research Institute

http://www.irri.org/
International Rice Research Institute

http://www.nabard.org
National Bank for Agriculture and Rural Development - NABARD

http://ncdc.nic.in/
National Cooperative Development Corporation(NCDC)

http://nhb.gov.in/
National Horticulture Board (NHB)

http://www.novodboard.com/
National Oilseeds and Vegetable Oils Development Board

http://www.indiaseeds.com/
National Seeds Corporation limited

http://www.worldagroforestrycentre.org/
World Agro forestry Centre (ICRAF)

Punjab ENVIS Centre Participation in Round Table Meeting on Sustainable Agricultural Mechanization through by FAO & UNAPCAEM

Based on the good work done by ENVIS Centre, Punjab on its website regarding State of Environment Issues especially agriculture, United Nations Asian & Pacific Centre for Agricultural Engineering & Machinery (UNAPCAEM) and Food & Agriculture Organization (FAO) invited two scientists from PSCST for Round Table Conference on "Sustainable Agricultural Mechanization (SAM) in Asia" at Bangkok, Thailand on 8th-9th December, 2011 .

The objectives of the roundtable were to discuss status of agricultural mechanization in Asia and identify constraints as well as best options for achieving environmentally sound sustainable agricultural mechanization in the region. Two experts, namely Dr. Neelima Jerath, Executive Director and Mr. Gurharminder Singh, Senior Scientific Officer (Env)/ Coordinator ENVIS Centre attended the roundtable meeting and presented the following papers :

1. "Intensive Agriculture in Punjab: An Environmental Appraisal" by Dr. Neelima Jerath.
2. "Farm Mechanization in Punjab and its Social, Economic and Environmental Implications" by Mr. Gurharminder Singh

The visit was sponsored by UNAPCAEM. The meeting was attended by representatives of 14 Asia-Pacific region countries including India, Asian Development Bank and John Dhree (Tractor Manufacture). The roundtable brought together key country stakeholders and experts on agricultural mechanization to discuss the modalities in developing Sustainable Agricultural Mechanization Strategies (SAMS) as well as gauge country interest in conducting SAMS in individual countries. A draft regional framework for SAMS was also developed after various country presentations, discussions and group work.

Dr. Neelima Jerath, Executive Director, PSCST Presenting Paper on 'Intensive Agriculture in Round Table Conference'.

Dr. Neelima Jerath, Executive Director, and Mr. Gurharminder Singh, Senior Scientific Officer /ENVIS Co-ordinator with other participants during deliberations in Round Table Conference

FAO & UNAPCAEM Round Table Meeting had been a major source in the development of the article in this newsletter.

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