Agricultural Machinery Industry in India (Manufacturing, marketing and mechanization promotion)

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ABSTRACT

Farm mechanization helps in effective utilization of inputs to increase the productivity of land and labour. Besides it helps in reducing the drudgery in farm operations. The early agricultural mechanization in India was greatly influenced by the technological development in England. Irrigation pumps, tillage equipment, chaff cutters, tractors and threshers were gradually introduced for farm mechanization. The high yielding varieties with assured irrigation and higher rate of application of fertilizers gave higher returns that enabled farmers to adopt mechanization inputs, especially after Green revolution in 1960s. The development of power thresher in 1960, with integrated Bhusa making attachment and aspirator blower and mechanical sieves for grain and straw separation, was the major achievement of Indian engineers. These threshers were widely adopted by the farmers. Gradually demand for other farm machinery such as reapers and combine harvesters also increased. Equipment for tillage, sowing, irrigation, plant protection and threshing have been widely accepted by the farmers. Even farmers with small holdings utilize many improved farm equipment through custom hiring to ensure timeliness of farming operations. The present trend in agricultural mechanization is for high capacity machines through custom hiring and for contractual field operations. However, mechanization of horticulture, plantation crops and commercial agriculture is yet to be introduced in the country. The pace of farm mechanization in the country accelerated with the manufacture of agricultural equipment by the local industries. With the modest beginning of manufacture of tractors in 1960s with foreign collaboration, to-day the Indian farm machinery industries meet the bulk of the requirement of mechanization inputs and also export. The manufacture of agricultural machinery in India is quite complex comprising of village artisans, tiny units, small-scale industries, State Agro-Industrial Development Corporations and organized tractor, engine and processing equipment industries. Traditional hand tools and bullock drawn implements are largely fabricated by village craftsmen (blacksmith and carpenters) and small-scale industries. The small-scale industries depend upon public institutions for technological support. These industries, however, upgrade these designs and production processes with experience. Organized sectors confine to the manufacture of machines like tractors, engines, milling and dairying equipment.

These industries have adopted sophisticated production technologies, and some of them match international standards. The enhanced scope of import of technology (product designs and manufacturing process) by organized sector and entry of foreign investors is likely to accelerate exports. Since cost of production of farm machinery in India is more competitive due to lower labour wages, the importers from various Countries will find Indian farm equipment more attractive. Indian products, however, shall need improvements in quality for gaining major export growth. For this, mass production of critical and fast wearing components and their standardization would greatly help.

This paper reviews the status of agricultural mechanization in India, including the aspects of production of implements and equipment, after- sales- services, level of their adoption and the role of different public and private Institutions in supporting and promoting this critical input for making Indian agriculture to meet the international challenges of productivity and cost of production.

1. INTRODUCTION

The country witnessed unprecedented growth in agriculture which has helped India to graduate from hunger to self sufficiency in food grains by increasing the food grain production from 51 million tonnes to 208 million tonnes, with surplus for export. The technology back-up by agricultural scientists, in the form of "*Green Revolution*" combined with industrial growth, positive policy support, liberal public funding for agricultural research and development and dedicated work of farmers contributed to the phenomenal increase in agricultural, animal and fish production. Application of engineering in agriculture was equally appreciated by the farmers and to-day they feel proud to have improved machinery from *Bakhars* to rotavators, *Persian wheel* to drip and micro-sprinkler systems, cone-dibblers to pneumatic planters, sickles to combine harvesters, sieve to colour sorters, and, *kolhus* to solvent extraction plants, and hand mills to roller flour mills, etc. The farmers are not afraid of hot/cold desert and vagaries of weather as they have green houses and low tunnel plastic houses technology to grow crops in any place at any time of the year.

The growth in adoption of agricultural machinery in the country has been possible due to their local manufacture. The manufacture of agricultural machinery in India is under taken by village artisans, tiny units, small scale industries, organized medium and large scale sector. Organized sectors manufacture sophisticated machinery such as tractors, engines, milling and dairying equipment. Traditional hand tools and bullock drawn implements are largely fabricated by village craftsmen (blacksmith and carpenters) and power operated machinery by small-scale industries.

An analysis has been made in this paper to review the status of manufacture of agricultural machinery, after sale services, level of adoption of mechanization inputs by the farmers so as to plan for future mechanization.

2. HISTORICAL PERSPECTIVE OF MANUFACTURING OF AGRICULTURAL MACHINERY

Blacksmiths and carpenters have been the traditional fabricators of agricultural equipment in India. The early agricultural mechanization in India was greatly influenced by the technological development in England. In 1889, Watts and Kaisar introduced ploughs, corn grinders and chaff cutters Cawnpore (now Kanpur) Experimental Farm in Uttar Pradesh. Sardar Joginder Singh (1897-1946), who was the Agriculture Minister in the Punjab Government (1926-37), introduced the steam tractors in India in 1914 for reclamation of waste land and eradication of '*Kans*'. Horse drawn and steam tractor operated implements were imported during the latter part of the 19th century. The horse drawn equipment imported from England were not suitable for bullocks and he-buffaloes used in India and thus, were suitably modified by small scale manufacturers to suit Indian draught animals. With the establishment of Allahabad Agricultural Institute, Allahabad in 1942, the development activities in agricultural machinery accelerated and as a result bullock drawn Meston, Shabash and Wah-Wah ploughs were introduced in Uttar Pradesh, manufactured by the Agricultural Development Society, Naini in early forties.

The Indian farmers gradually responded to farm mechanization technology especially after Green revolution in 1960s. High yielding varieties with assured irrigation and higher rate of application of fertilizer gave higher yields and better economic returns. This enabled the farmers to start adopting mechanization. The development of power thresher with integrated Bhusa making attachment and aspirator blower and mechanical sieves for grain and straw separation in 1960s was the major achievement of Indian engineers which was widely adopted by our farmers. Gradually demand for other farm machinery such as reaper and combine harvester also increased. Demand of tractors in the country was met through importation until 1961 when Eicher Tractors Ltd. and Tractors and Farm Equipment Ltd started manufacturing tractors with foreign collaborations. To meet the additional demand, importation continued up to 1977. Meanwhile many other industries started manufacturing tractors with foreign know how such as Gujarat Tractors Ltd (1963), Escorts Ltd (1966), International Tractors (India) Ltd. (1966), and Hindustan Machine Tools Ltd (1977). Punjab Tractors Ltd. started their production with indigenous technology in 1974. Many more industries started manufacturing tractors since then with indigenous and foreign know how.

3. FARM POWER IN AGRICULTURE

3.1 Unit farm power

During early sixties, a concept of farm power availability per hectare basis was used to indicate level of farm mechanization. The potential power availability was used as the measure and could not reflect critical constraint of farm power availability during peak requirements or the actual level of use. The total farm power availability from animate and mechanical sources in 1951-52 was 0.20 kW/ha which increased to 1 kW/ha in 1996-97. Animate power contributed 60% of the total farm power in 1971-72 and mechanical and electrical together contributed only 40%. In 1996-97 the contribution from animate power reduced to 21% and from mechanical and electrical power it increased to 79%. The farm power input per unit cultivated land in India is still very low compared to South Korea of 7 kW/ha, Japan 14 kW/ha and United State of America of 6 kW/ha. It is evident that mechanical contributed about 78% to the total farm power but for tractive power it is only less than 30% and thus major use of mechanical power has been for stationary farm operations only. The growth in the ratio of availability of mechanical power to total power availability (per ha basis) and mechanical tractive power to total power availability in Indian agriculture indicates that although 78 per cent of farm power was available from mechanical power sources in 1996, only 29.6 per cent of mechanical tractive power offering higher level of technology was available to Indian farms (Table 1).

3.2 Energy ratio for mechanization indicator

A major defect in considering power in quantifying mechanization is that it does not reflect the dimension of time and thus does not bring in the actual scenario in focus. Energy, from this point of view, is a better measure as it can define the actual quantity under use or, in other words, the potentiality of use of available power sources in real terms.

Based on use pattern of diesel, electricity, human and animal power in Indian agriculture, the trend in use of operational direct energy and its projection for the year 2000 is presented in Table 2. It may be seen that the total animate energy availability is decreasing over the years from 2937 MJ/ha in 1971 to 2505 MJ/ha in 1996-97 due to decrease in availability of animal energy. Human energy use increased from 1,331 to 1,525 MJ/ha between 1996-97 and 1971. The animal energy use, however, decreased from 1,606 to 980 MJ/ha, indicating a negative annual growth of 1.9 per cent. Increased cost of maintenance of draught animal has been a main cause

Table 1. Farm power availability per unit net cropped area

Power	1951-52	1961-62	1971-72	1981-82	1991-92	1996-97
Total farm power, MkW	23.54	29.29	44.65	70.26	114.08	138.65
Unit farm power, kW/ha	0.2	0.22	0.32	0.5	0.8	0.97
Mechanical over total power,%	3.6	8.9	36.9	63.7	76.9	78.0
Tractive over total power,%	0.82	2.38	7.73	17.61	26.75	29.6

Note: Human power-0.5 kW, Animal power-0.25 kW per animal, Tractor-22.5 kW, Diesel engine-5.2 kW, Electric motor-3.73 kW.

Table 2. Operational energy use pattern in agriculture

Energy source	1970-71	1975-76	1980-81	1985-86	1990-91	1996-97	2000-01
Diesel energy, MJ/ha	23	78	148	190	288	480	550
Electrical energy, MJ/ha	322	668	1002	1563	3233	5308	7720
Total mechanical energy, MJ/ha	345	746	1150	1753	3521	5788	8270
Animal energy, MJ/ha	1606	1485	1404	1293	1101	980	907
Human energy, MJ/ha	1331	1363	1401	1348	1409	1525	1607
Total energy in agriculture, MJ/ha	3282	3594	3955	4394	6031	8773	10784
Mechanical over total energy, %	11	21	29	40	58	71	76

Note : 40% of the total diesel used in rural sector assumed for crop production and remaining for transport and other agro-industrial activities.

Capacity: Diesel-63.27 MJ/kg; Electricity-11.93 MJ/kWh; Bullocks pair-10.10 MJ; Human-1.84 MJ (male-70% and female-30%).

of this trend. Energy derived from electrical and diesel fuel used by mechanical power sources continued to increase with growth rate of 10.7 and 11.1 per cent respectively to supplement the additional energy need for increased land productivity. The total energy use for crop production increased from 3,282 to 8,773 MJ/ha (annual growth rate of 3.6 per cent) during the period. The share of mechanical energy over total energy used in crop production has increased from 11 per cent to 76 per cent during the same period. In order to meet the operational energy needs, the contribution of mechanical energy has to be increased substantially. To encourage use of tractors in agriculture, more diesel is required for the purpose. In order to achieve the production targets of food grains from 125 million hectare land, and assuming that the available energy is used for its production, the average specific energy availability on all India basis with present growth rate would be of the order of 5860 MJ/ tonne of food grain as compared to 5480 MJ/ tonne in 1996-97.

4. FARM POWER SOURCES IN AGRICULTURE

The use of farm machinery depends upon the farm power sources available in the country for various tractive and stationary operations. Human and animal power, the two 'renewable energy' or ' bio-energy' sources, have traditionally been used for various farm operations. The crops are protected from pests, diseases and from weeds, through the application of chemicals. The application of these inputs is achieved through 'human power' in traditional agriculture. Animate power contributed 60.37% of the total farm power in 1971-72 and mechanical and electrical together contributed only 39.63%. In 2001- 02 the contribution from animate power has reduced to 16.38% and mechanical and electrical power, it increased to 83.62% (Table 3).

Table 3. Percentage contribution of different power sources to total power Availability in India

Power source, million kW	1971- 72	1981- 82	1991- 92	2001- 02
Agriculture Workers	15.11	10.92	8.62	6.49
Draught Animals	45.26	27.23	16.55	9.89
Total Animate Power	60.37	38.15	25.17	16.38
Tractors	7.49	19.95	30.21	41.96
Power Tillers	0.26	0.33	0.40	0.54
Diesel Engines	18.11	23.79	23.32	19.86
Electric Motors	13.77	17.78	20.90	21.26
Total Mechanical & Electric Power	39.63	61.85	74.83	83.62
Total Power kW/ha	0.295	0.471	0.759	1.231

Source: 1. Power availability in Indian Agriculture, 2000, CIAE, Bhopal.
2. Agricultural Research Data Book 2003, Indian Agricultural Statistics Research Institute, New Delhi.

This change in the relative contributions of the animate and nonanimate power sources has been due to the requirements of modern agriculture where timely application of crop production inputs is an important factor to maximize return on input investments. The nonanimate power equipment (like tractors, power tillers, self-propelled planting and harvesting machines, diesel engines and electric motors, etc) also helps farmers to increase cropping intensities through faster turnaround time between successive crops. In addition, the mechanical/Electric machines reduce the drudgery involved in the traditional methods of farming.

4.1 Trends in use of farm power

4.1.1 Human power

Digging, clod breaking, sowing, interculture, harvesting, threshing, cleaning, and grading are performed by human power using traditional tools and implements. Improved tools have also been developed and commercialized. The agricultural worker population in India increased from 97.2 million in 1951 to 235.1 million in 2001 (Table 4). The agricultural workers comprise of small cultivators and agricultural labourers. Of the total agricultural workers, in 1991, 57.86 million (31%) is comprised of women agricultural workers.

Table 4. Human power in Indian agriculture

Agricultural workers	1951	1961	1971	1981	1991*	2001
Cultivators (millions)		99.6	78.3	92.5	110.7	127.6
Agricultural Labourers (millions)		31.5	47.5	55.5	74.6	107.5
Total Human power (million)	97.2	131.1	125.8	148.0	185.3	235.1
Intensity (worker/ha)	0.82	0.98	0.90	1.06	1.30	1.64
Power (Million kW)	4.86	6.55	6.29	7.40	9.26	11.75

Sources: 1. Indian Agricultural in Brief, 27th edition, 2000, Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India.
2. Agricultural Statistics at a Glance, 2002, Directorate of Economics and Statistics, Ministry of Agricultural, Govt. of India.

The human power available (kW/ ha) has increased from 0.045 in 1971- 72 to 0.079 in 2000-01 (Table 5) and the worker intensity has increased from 0.90 to 1.64 worker/ha in the same period. The farm sector therefore, has to absorb more agricultural workers whose work output can be improved by utilizing, ergonomically designed tools.

Table 5. Population of Power Sources and their power availability in India

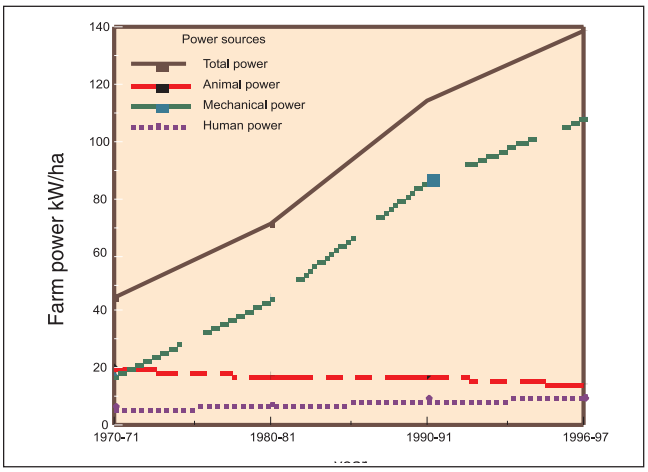
Year	Agriculture Workers		Draught Animals		Tractors		Power Tillers		Diesel Engines		Electric Motors	
	Million	Power (kW/ha)	Million	Power (kW/ha)	Million	Power (kW/ha)	Million	Power (W/ha)	Million	Power (kW/ha)	Million	Power (kW/ha)
71-72	125.67	0.045	78.42	0.133	0.119	0.02	0.016	0.759	1.443	0.053	1.535	0.041
75-76	133.75	0.048	77.52	0.135	0.207	0.04	0.023	1.110	2.075	0.078	2.064	0.056
81-82	146.77	0.051	76.21	0.128	0.513	0.09	0.032	1.562	3.061	0.112	3.203	0.084
85-86	161.09	0.057	75.36	0.129	0.746	0.14	0.040	1.971	3.742	0.139	4.192	0.111
91-92	185.24	0.065	74.11	0.126	1.244	0.23	0.060	3.020	4.800	0.177	6.019	0.159
95-96	200.98	0.071	73.30	0.124	1.734	0.32	0.082	4.098	5.528	0.203	7.464	0.196
00-01	222.55	0.079	72.31	0.122	2.599	0.48	0.122	6.112	6.466	0.238	9.525	0.250
05-06	246.44	0.087	71.34	0.120	3.819	0.70	0.181	9.035	7.432	0.273	11.866	0.311

Source: 1. Power Availability in Indian Agriculture, 2000, CIAE, Bhopal, India
2. Agricultural Research Data Book 2003, IASRI, New Delhi

4.1.2 Draught animal power

Traditionally, draught animals have been used in India for field operations, transport and agro-processing. There are about 79 percent small and marginal farmers who have limited land holdings and resources. These farmers rely on draught animals and human power for farm operations. Even to day, taking 2.5 ha as command area per animal pair, over 57% of the farming area is being commanded by draught animals. Field operations in hill regions and some difficult terrains are being performed by human and animal power.

The population of draught animals, which was 78.42 million in 1971-72, has been showing a decline with the estimated population of 72.31 million in 2000-01 (Table 5). The decrease in the draught animal power is largely due to the increasing use of electro-mechanical power, as can be seen from the following figure.



The usage of draught power in seed-bed preparation, threshing and water-lifting has been reducing in direct proportion to the adoption of tractors and power tillers, mechanical threshers and harvesters, and motorized irrigation pumps. Animals are still the main source of power in hilly areas, for the marginal farmers, and in short distance transport work.

4.1.3 Electro-mechanical power

With increased cropping intensity, farmers have

Table 6. Population growth trends in mechanical farm Power Sources in India

(in million)

Year	51-52	61-62	71-72	81-82	85-86	91-92	95-96*	00-01*
Tractive Power								
Tractors	0.008	0.031	0.119	0.513	0.746	1.244	1.734	2.599
Power Tillers	-	-	0.016	0.032	0.040	0.060	0.082	0.122
Combines	-	-	-	-	0.002	0.003	0.005	NA
Stationary Power								
Electric Pumps	0.020	0.100	1.535	3.203	4.192	6.019	7.464	9.525
Diesel Pumps	0.083	2.230	1.443	3.061	3.742	4.800	5.528	6.466
Others								
Power Sprayers/ Dusters	-	-	0.045	0.124	0.185	0.200	0.250	NA

Note: *Estimated
Source: 1. Power Availability in Indian Agriculture, 2000, CIAE, Bhopal, India
2. Agricultural Research Data Book 2003, IASRI, New Delhi

supplemented or largely replaced animate power with tractors, power tillers, diesel engines and electric motors. The growth in the electro-mechanical power is reported to be as follows.

4.1.3.1 Tractive power

The tractors in India were introduced through importation. There were only 8,635 imported tractors in use in 1951. The local tractor production started in 1961-62 with 880 numbers.

Similarly, the manufacture of power tillers started in 1961 with Japanese collaborations. At one time 12 models of power tillers were licensed to be manufactured. However, many of these units closed down or did not even start because of lack of their suitability to Indian farming conditions, poor after-sales-service network, etc. presently only two manufacturers are producing power tillers.

Since the pace of production was slow, the Government of India continued to allow limited import of tractors to meet the demand of the farmers till 1974. While approving foreign collaborations, Government of India made it mandatory that tractors to be allowed for manufacturing in India shall be tested under laboratory and field conditions to ensure that they were suitable for Indian farming conditions.

The Central Farm Machinery Training and Testing Institute was mandated to test tractors, power tillers and other farm machinery for the benefit of manufacturers and users. A *batch testing scheme* was later introduced to enable manufacturers to continuously upgrade the technology and to safeguard user interests. For this purpose, the Government of India fixed norms of specific fuel consumption, noise, vibration, exhaust emission levels, ergonomics and safety measures, and other performance norms.

Since then growth in production, quality and performance of tractors and other agricultural equipment has greatly improved.

AGRICULTURAL TRACTORS

The sale of Agricultural tractors and other farm equipment has increased. To-day more than 250,000 tractors are manufactured every year by 13 manufacturers. These tractors are available in different horsepower ranges of less than 25 to more than 55 horse power. The share of various HP tractors in the recent years has been as follows.

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 (Table 7).

Table 7. % Share of different HP tractors of total sales

HP Size	97-98	98-99	99-00	00-01
<25	7	7	6	4
25-30	12	15	20	20
31-35	51	51	46	45
36-40	9	8	9	10
41-45	5	4	7	8
>45	15	15	12	14

Source: TMA data

Table 8. Tractor power range manufactured in India

PTO Power kW	No. of Models
Less than 15	3
15-22.5	10
22.5-30.0	12
30.0-37.5	9
Above 37.5	2

Table 9. Year-wise Production and Sale of Tractors and Power Tillers

(in numbers)

YEAR	Production		Sale	
	Tractors	Power Tillers	Tractors	Power Tillers
1986-87	80369	3325	80164	3209
1987-88	92092	3005	93157	3097
1988-89	109987	4798	110323	4678
1989-90	121624	5334	122098	5442
1990-91	139233	6228	139831	6316
1991-92	151759	7580	150582	7528
1992-93	147016	3648	144330	8642
1993-94	137352	9034	138796	9446
1994-95	164029	8334	164841	8376
1995-96	191329	10147	191329	10147
1996-97	222769	11000	222769	11000
1997-98	260815	12200	254279	12200
1998-99	261609	18840	262351	14880
1999-00	278556	16891	173181	16891
2000-01	255690	16018	254825	16018
2001-02 *	214000	16000	221000	16000
2002-03 *	168000	16000	170000	16000

Note :*Data for 2001-02 & 2002-03 are estimated figures.

Sources: 1. Tractors Manufacturers Association, Lodhi Road, New Delhi.
2. Indian agriculture in Brief, 27 edition, Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India.
3. Agricultural Research Data Book 2003, IASRI, New Delhi.

The year-wise production and sale of tractors had shown a healthy trend upto 1999-2000 when it reached a production level of 278556. However, because of drop in sales from 1999-00 due to droughts and floods, and cash flow problems of farmers, the production of tractors

dropped in 2001-02 and 2002-03. The production in 2002-03 is reported to have dropped to 168000 (Table 9). Tractor Manufacturers Association (TMA) sources believes that the growth trend shall revive with good monsoon across the country.

The Tractor sales show that their demand is region-specific. Punjab, Haryana and western UP constituted the major Tractor market in 1980's with 55-57% share of total All India sales. With increased Tractor population in these areas and good successive rains in 1990's, coupled with changes in cropping patterns like adoption of more profitable cash crops (Oilseeds, Pulses, etc.), and better prices, the sales in Gujarat, MP and Rajasthan have been seeing good growth. The contribution of these states improved from 20-22% in early 1990's to 30-32% by the close of the decade.

The share of eastern states, namely Bihar, Orissa, West Bengal and Assam had been consistently low at 3-5% due to various socio- economic, agro-climatic and other reasons. The credit availability to the farmers in this area has been another major reason for the slow growth in the eastern states. The tractor sales, since mid 1990's, have increased to about 10-12% of All India Sales.

Tractor sales in Maharashtra, Tamil Nadu, Karnataka and Andhra Pradesh have been showing consistent growth since mid 1980's. Their share in the Indian Tractor industry, which was about 14-15% in 1990, had increased to around 25% in 1997 when the farmers suffered on account of uneven monsoons, poor cotton crops, etc. This region is expected to contribute more than 30% to the tractor industry in this decade. This expectation is based on the fact that the farmers in this southern region have been adopting high value case crops and latest crop production/ management practices.

POWER TILLERS

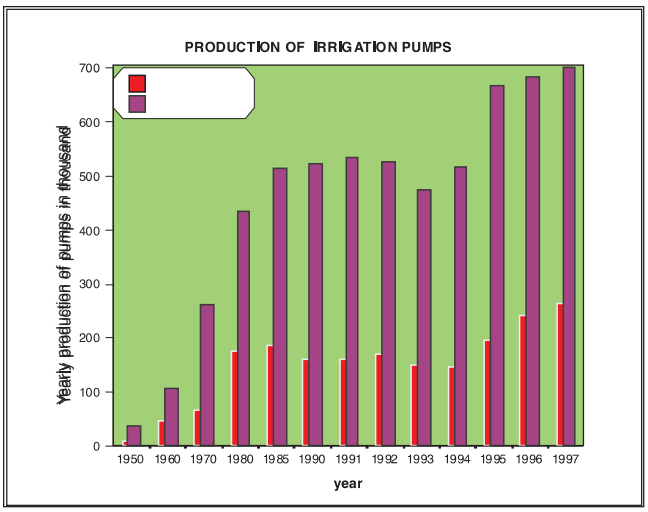
As mentioned earlier, the production of power tillers started in 1961 with license to manufacture 12 models. The manufacturers started offering these to framers in various states covering upland and wetland farming conditions. Their introduction coincided with that of agricultural tractors which were more suitable for upland work and provided more comfortable work environment to the operators. The walk-behind power tillers, on the other hand, created dusty environment for the operator. Secondly, the power tillers in dryland conditions were tiresome which resulted in longer rest periods, and consequently affected the work output. These were also difficult to manage in the hilly situations.

The power tiller models being manufactured, and also those being imported from China, etc, and being marketed for wetland, stationary and haulage work are being well received by the farmers. The 7 available models have a Drawbar power between 5.3 kW to 10.7 kW.

Their production and sale has also increased to about 16000 units annually. Their population has reached 122000 in 2000-01, which is expected to cross 180000 in 2005-06 (Table 5).

4.1.3.2 Stationary Power

Electric Motors and Diesel Engines are the primary sources of stationary power for irrigation, threshing and various post-harvest agro-processing operations.



Diesel Engine population, which was 1.443 million in 1971-72 increased to 5.528 in 1995-96, and, is expected to cross 7.4 million in 2005-06. (Table 5)

Electric Motor population has increased from 1.535 million in 1971-72 to 7.464 million in 1995-96, and, is projected to be around 12 million by 2005-06. (Table 5)

The above shows a substantially faster growth of electric motors which is due to their higher efficiency, lower maintenance hassles and spread of rural electrification coupled with preferential power tariffs to farmers. The studies on operational efficiency of irrigation pumps have shown the efficiency of electric motor operated pumps to be 31.1% against only 12.7% of diesel engine operated pumps.

4.2 Adoption of improved machinery

4.2.1 Seed bed preparation

Deshi ploughs *bakhar* and *patela* were the most popular traditional implements for seed bed preparation prior to 1960's. Cultivator, disc harrow, mould board plough, puddler, disc harrow-cum-puddler, peg tooth harrow, spring tine harrow, rotavator and patela harrow

operated by animal and tractor are the improved implements which have been adopted by farmers (Tables 10 & 11). The growth in use of tractor drawn machinery has been in the range of 9-17%. Different sizes of cultivators and disc harrows are used but due to farm road and terrain constraints, cultivators of more than 15 tines and disc harrows of more than 18 discs are not much in use. The power from higher horse power tractors, therefore, is not fully utilized.

4.2.2 Sowing and planting equipment

The line sowing not only saves seed but also facilitates regulated application of fertilizer near root zone. Besides, it helps control of weeds through use of mechanical weeders. The animal drawn *Dufan* (two row), *Tifan* (three row), *Enatigoru* and *FESPO* plough (all local sowing devices) are used by the farmers as these cover more area and cost less. For precise application of seed and fertilizer, mechanically metered seed drills and seed-cum- fertilizer drills operated by animals and tractors have been developed and are being manufactured to suit specific crops and regions (Tables 10&11).

Table 10. Trends in growth of population of bullock drawn implements

(in million)

Implements	1966-67	1971-72	1981-82	1991-92	2000-01*
Steel plough	3.52	5.36	6.69	9.60	11.70
Cultivator	-	-	4.26	5.79	6.54
Puddler	2.72	1.69	2.32	2.37	2.81
Sowing devices	1.14	4.09	5.62	6.74	8.26
Cane Crusher	0.65	0.68	0.69	0.75	0.73
Sprayer & Duster	0.21	0.44	1.55	1.79	1.86

Source: Singh G. (2000). Agricultural Situation in India, January 2000.

Table 11. Trends in Growth of Power Operated Agricultural Machinery

(in hundred)

Power source	1971-72	1976-77	1981-82	1986-87	1991-92	2000-01
Power						
Sprayer/Duster	448	851	1239	1853	2771	3110
M.B. & Disc Plough	573	925	1429	2392	4989	12431
Disc harrow	556	1292	1892	3574	5456	28814
Cultivator	815	1766	3150*	5956	11558	28115
Seed drill/seed fert.						
Drill	246	640	1606	2777	7301	27405
Planter	85	244	305	443	643	1090
Thresher	2058	4841	10250	13638	13793	30900

Source: Singh G. (2000). Agricultural Situation in India, January 2000

4.2.3 Interculture & plant protection equipment

Weed control in irrigated and rain-fed agriculture during *Kharif* is a serious problem and the yield is affected to the extent of 20-60%, if not controlled. *Khurpi* is the most popular tool used for removal of weeds but it takes 300-700 man-hours to cover one hectare. Use of long handle wheel hoe and peg type weeders, reduce weeding time to 25-110 hours. Bullock operated weeder and cultivator are also used for control of weeds. Different designs of low cost hand operated sprayers and dusters are available for plant protection. Spraying in cotton, paddy, sugarcanes, fruits and vegetables, oilseeds and pulses has become popular.

4.2.4 Harvesting & threshing

The technology for development of harvesting and threshing equipment is motivated by following factors:

1. Economic considerations-reduction in cost of production and reduction in harvest and post harvest losses and quality of produce,
2. Social realities- non-availability of labour during the harvesting period and to ensure timeliness, and
3. Ergonomic considerations -reducing drudgery in the operations.

The harvesting systems prevalent in the country include (Table 12):

(a) Harvesting with sickle followed by threshing with animal trampling.
(b) Harvesting with sickle and manual threshing.
(c) Harvesting with sickle/reaper and threshing with stationary power threshers. Use of reaper harvester is limited due to collection, bundling and transport cost of material and by-products.
(d) Stationary power threshers varying from 5 to 15 hp, operated by diesel engines and electric motors, and tractor pto power. The present trend is to use high capacity machines on custom basis.
(e) Combine harvesting.

Sickles are widely used for harvesting. These are easily available at low cost in the villages but their output

Table 12. Trends in growth of harvesting and threshing machinery

(in hundred)

Power source	1971-72	1991-92
Tractor Powered Combine Harvesters	3.5	61.5
Self Propelled Combine Harvesters	4.5	35.0
Stationary Threshers	2058	13793
Wheat	1825	10757
Paddy	136	1353
Others	97	1683

is low. Self-sharpening serrated sickles of better material and design have been developed. Sickles would continue to be used for various crops by small and marginal farmers, and in hilly regions.

Reapers powered by engines, power tillers and tractors have been developed and introduced for harvesting wheat, paddy, soybean, ragi and mustard. However, because of labour and cost involved in the

Table 13. Technical specification of combines manufactured in India

Combine	Year of Test	Maximum power kW	SFC g/kWh	Cutter bar width, m	Threshing drum type		Weight, kg
					Wheat	Rice	
1. Swaraj 8100	1983	73.3	283	4.28	R	P	8455
2. ESPI 614	1982	57.8	298	4.28	R	P	8720
3. IC 616 Deluxe	1987	72.5	295	4.28	R	P	9140
4. Standard S-8300	1989	75.3	271	4.85	R	P	9395
5. Bharat 730 Deluxe	1989	71.1	264	4.28	R	P	7420
6. Axia 6-514	1989	75.3	258	4.24	R	P	7880
7. Deshmesh 9100	1996	63.6	239	4.28	R	P	10180
8. Preet 987	1996	62.5	240	4.28	R	P	10460
9. Standard C514	1992	71.7	258	4.28	R	P	9495
10. Standard C 412	1992	52.5	256	3.63	R	P	7785
11. Kartar 4000	1989	55.0	318	3.92	R	P	7200
12. Kartar 3500	1986	28.7	329	3.26	R	P	5790
13. Claas Crop Tiger*	NA	45.0	235	2.08	R	P	3900

Note : R = Rasp bar, P = Peg tooth
Source : FMTTI, Budni (MP)

Table 14. Performance of Indigenous combines

Combines		Rate of work (ha/h)	Fuel Consumption (l/h)	Throughput	
				Grain (kg/h)	Crop (t/h)
1. Claas Crop Tiger	W	0.38-0.60	6.35-7.33	1333-2762	2.07-5.70
	P	0.26-0.41	6.25-7.74	1855-2691	4.76-91.2
2. Swaraj 8100	W	0.91-2.62	9.16-11.29	1864-3849	3.81-7.68
	P	0.32-0.61	8.61-10.45	2662-5624	5.49-11.34
3. ESPI 61L1	W	0.92-1.90	7.6-10.83	2704-7723	5.26-13.00
	P	0.51-1.00	6.8-9.50	3504-5432	10.07-17.75
4. IC 616	W	0.58-1.40	9.68-12.57	1929-6177	4.48-16.57
	P	0.56-0.82	10.23-12.26	2829-7156	5.55-17.13
5. Standard S8300	W	0.67-1.55	7.6-9.67	3503-4215	6.20-13.39
	P	0.61-0.87	6.8-9.10	2257-9610	4.58-22.43
6. Bharat 730	W	0.81-1.50	7.08-8.26	2824-6250	5.96-11.98
	P	0.44-0.83	5.88-7.71	1256-5677	5.00-9.95
7. Axia S-574	W	0.56-1.43	7.57-11.73	1124-7785	2.29-14.22
	P	0.54-0.93	6.70-8.96	2226-6021	7.04-14.97
8. Deshmesh 9100	W	0.89-1.27	7.08-8.00	2764-4967	5.27-9.31
	P	0.60-1.06	5.73-6.93	3265-9255	8.42-24.66
9. Preet 987	W	0.76-1.23	6.75-8.28	2059-5418	5.01-11.95
	P	0.60-1.00	5.18-7.37	2583-9114	7.72-22.90
10. Standard C514	W	0.63-1.36	6.55-10.59	2356-10348	4.64-15.73
	P	0.34-1.12	6.33-8.33	2846-10154	9.49-23.27
11. Standard C412	W	0.49-1.00	5.47-9.14	2462-6006	4.21-10.70
	P	0.20-0.65	4.81-7.39	2075-6649	5.65-17.18
12. Kartar 4000	W	0.58-0.98	6.76-10.20	2747-7520	4.29-11.49
	P	0.40-0.80	7.31‘-9.23	1630-6347	3.93-17.85
13. Kartar 3500	W	0.70-1.00	5.28-7.07	1461-3989	2.56-7.38
	P	0.19-0.67	4.88-6.56	2156-4238	3.46-8.23

Note : W- wheat, P- paddy
Source : FMTTI, Budni (MP)

Table 15. Grain losses in Indian combine harvesters

Combines		Threshing efficiency,%	Cleaning efficiency %	Grain breakage %	Total non-collectable grain loss,%
1. Claas Crop Tiger	W	98.17-99.74	97.1-99.87	0.547-4.55	0.254-1.84
	P	96.93-99.82	96.37-99.73	0.299-1.377	0.578-3.15
2. Swaraj 8100	W	96.89-99.92	94.45-99.97	1.78-5.85	0.409-2.74
	P	94.45-99.97	94.82-99.4	1.23-4.14	0.82-3.32
3. ESPI 61L1	W	98.84-100	95.03-99.78	2.16-9.65	0.247-1.83
	P	95.72-99.26	84.37-99.42	1.27-4.11	0.73-5.56
4. IC 616	W	97.53-99.83	96.7-99.94	2.74-9.8	0.616-15.779
	P	88.23-99.37	90.4-98-67	1.21-7.97	0.436-1.84
5. Standard S8300	W	95.07-99.65	88.67-100	3.13-10.09	0.248-2.265
	P	91.65-99.4	90.56-97.95	0.46-9.89	0.162-4.84
6. Bharat 730	W	98.9-99.9	96.0-99.9	0.54-3.29	0.19-2.05
	P	96.4-99.3	95.0-99.2	0.16-2.00	0.076-1.826
7. Axia S-574	W	94.1-99.6	97.3-99.6	1.60-10.47	1.12-6.24
	P	96.0-99.6	84.1-97.0	0.86-2.19	0.643-3.37
8. Deshmesh 9100	W	97.75-99.45	93.67-98.83	1.997-7.27	0.12-2.0
	P	97.26-99.63	89.27-97.26	0.362-3.88	0.362-1.86
9. Preet 987	W	96.83-98.89	93.14-99.23	1.921-7.46	0.131-2.65
	P	97.16-99.71	93.13-98.73	0.706-4.83	0.157-1.34
10. Standard C514	W	95.21-99.3	89.0-99.2	1.79-6.74	0.511-2.72
	P	96.92-99.89	92.3-97.67	0.556-2.22	0.337-1.03
11. Standard C412	W	97.79-99.87	95.93-99.73	2.06-5.38	0.446-5.14
	P	96.06-99.96	90.93-96.87	0.35-4.03	0.292-2.73
12. Kartar 4000	W	98.8-99.9	96.8-99.5	0.74-6.19	0.38-5.07
	P	83.59-98.67	90.96-98.06	0.8-3.94	0.523-8.6
13. Kartar 3500	W	95.8-99.7	94.1-99.6	1.57-5.69	0.612-5.82
	P	97.81-99.59	89.6-98.73	0.275-1.50	1.08-2.40

Note : W- wheat, P – paddy
Source : FMTTI, Budni (MP)

Table 16. Performance of indigenous combine harvesters on soybean and gram

Combines		Rate of work ha/h	Fuel consum-ption l/h	Throughput		Threshing efficiency %	Cleaning efficiency %	Grain breakage	Total grain loss
				Grain kg/h	Crop t/h				
Claas Crop Tiger	Soybean	0.25-0.254	5.82-7.24	341-798	1.11-2.20	97.40-99.96	92.23-97.45	1.56-4.43	3.58-10.92
	Gram	0.24-0.32	6.03-6.67	839-1484	1.56-2.45	98.71-99.83	94.82-99.4	2.28-4.91	2.19-3.99
Kartar K 3500	Soybean	0.538-0.86	6.94-8.04	2153-1663	0.74-4.0	99.08 -100	92-96	4.57-13.12	2.55-9.22
	Gram	0.86-1.26	4.72-5.81	1847-2592	2.47-4.96	97.37-98.64	93.02-98.71	1.01-5.19	4.02-5.83

Source: FMTTI, Budni (MP)

collection, bundling and transport, their adoption is expected to be limited.

Traditionally, threshing of wheat and barley was being done by bullock trampling which is arduous and time consuming. The mechanical threshers of varying power range (5-15 hp) are commercially being manufactured which not only thresh the grain but also provide good quality *Bhusa.* Farmers use self-owned threshers or on custom hiring basis. More than 70-80% wheat, barley, gram, soybean, sorghum and pearl millet crops are estimated to be threshed by mechanical power threshers. Paddy crop is easy to thresh by beating but losses are quite high. Pedal operated paddy threshers reduce drudgery. These have become popular in Eastern India. Raspbar type paddy threshers cause less breakage to paddy stem and, thus, straw can be put to better use. These threshers have become popular in Andhra Pradesh, Tamil Nadu, Karnataka and Kerala.

In regions where work force availability is inadequate, harvesting with combine harvesters is in vogue. Combine harvesters are being preferred as they reduce the turn-around time to facilitate increased cropping intensity.

Tractor-powered and self-propelled combine

harvesters are being manufactured in India. About 700-800 combines are sold annually. Track-type Combine harvesters, especially suitable for paddy crop, are also being manufactured locally. The combine harvesting of wheat, paddy and soybean has been well accepted by farmers. Apart from the work force availability problems, the usage of combined harvesters has helped in timely harvesting of grains avoiding losses due to adverse weather conditions.

The Tractor Powered Combine Harvesters, costing only 25-30% of the self-propelled combines, may be owned by individual farmers. The self-propelled combines are largely owned by custom-hiring contractors.

The demand of combine harvesters for harvesting wheat crop in Punjab, Haryana and Uttar Pradesh encouraged the local manufacturers to develop local combines. More than 48 manufacturers, mainly in Punjab, produce self-propelled and tractor operated combines for harvesting wheat, paddy, soybean and gram.

The entrepreneurs from Rajasthan and Punjab provide combine harvesting services to the farmers in the states of Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh and Tamil Nadu.

Most of the combines are suitable for harvesting wheat and paddy. Farmers also use them for gram and soybean. Claas Crop Tiger and Kartar K3500 are the only combines which have been tested by FMTTI, Budni for gram and soybean.

The technical specifications and Performance data of combines manufactured in India are given in Tables 13, 14, 15 and 16.

4.3 Adoption of post harvest equipment

Agro-processing includes farm-level processing to improve quality of produce and technology for loss prevention in storage, handling and transport. Major equipment which have been developed and adapted for farm level processing include cleaners, graders, dryers, shellers, decorticators, storage structures milling equipment etc. Cottage and industrial level secondary processing includes, rice mills, grain mills, dal mills, oil mills, preservation and processing of animals, fruits and vegetables etc. to increase shelf life and their quality. The growth of these machines is given in Table 17. Today more than 73% of paddy, 55% maize, 24% pulses and 45% oilseeds and 45% sugarcanes are processed by modern machinery besides other commercial crops. The total turn over of food market is approximately Rs. 250000 crores as estimated by Ministry of Food Processing of which value added products comprised of Rs 80000 crores. The total export is estimated at about Rs 11000 crores with rice contributing 29% and marine products 42%. The agriculture processing sector has immense employment potential for rural people, provided these activities are under taken largely in rural areas.

Table 17. Status of post harvest equipment

Equipment	Number in 1991	Projection for 2000
Cleaners and graders	110,000	290,000
Dryers	7,000	25,000
Flour units	266,000	350,000
Dal mills	10,000	25,000
Rice mills	130,000	150,000
Oil expellers	222,000	450,000
Maize shellers	65,000	115,000

4.4 Adoption of machinery by size of holdings

It is generally believed that only farmers having large acreage have adopted mechanization inputs. However, (Table 18), based on data from Input Survey 1981-82, 1986-87 and 1992 of Department of Agriculture and Cooperation, Ministry of Agriculture Government of India, reveals that farmers of all farm holding sizes have adopted implements and equipment from bullock-drawn implements to pump sets, threshers and tractors. Infact, the data shows that the percentage growth of tractors, pump sets and threshers has been higher in the marginal and small farm holding categories.

5. FARM MACHINERY INDUSTRIES IN INDIA

The adoption of mechanization technology depends upon the local manufacture and after-sales-services besides credit and financial incentive provided by the Government. The manufacture of agricultural machinery in India is quite complex comprising from village artisans, tiny units, small scale industries to State Agro-Industrial Development Corporations and organized tractor, engine and processing equipment industries. Traditional hand tools and bullock drawn implements are largely fabricated by village craftsmen and small scale industries. Organized sectors manufacture sophisticated machinery such as tractors, engines, mills and dairying equipment. The small-scale industries seldom have R&D facilities and they depend upon public institutions for technological support. They require not only drawings but also prototypes and technical guidance to manufacture the equipment. These industries however, upgrade the technology with experience.

5.1 Classification of Industries

The classification of industries in India is based on total capital investment (plant and machinery) rather

Table 18. Mechanization inputs adoption as per size of operational farm holdings

Years	Farm holdings (ha)					
	Marginal (< 1)	Small (1-2)	Semi-medium (2-4)	Medium (4-10)	Large (10 & above)	All Sizes
			Bullock drawn steel ploughs (million)			
1982	5.163	2.798	2527	2.186	0.669	13.344
1987	7.180	4.685	3.991	3.137	0.841	19.842
1992	12.527	5.565	4.605	4.107	1.295	28.098
Growth,%	9.27	7.10	6.18	6.50	6.83	7.73
			Bullock drawn disc harrows & cultivators (million)			
1982	4.569	5.198	5.083	4.669	1.402	20.921
1987	4.667	5.968	5.368	5.251	1.380	20.64
1992	5.473	5.881	5.369	3.897	0.997	21.617
Growth,%	1.82	1.24	0.55	-1.79	-3.35	0.33
			Tractors (million)			
1982	0.033	0.042	0.105	0.199	0.108	0.489
1987	0.264	0.231	0.387	0.486	0.209	1.580
1991	0.387	0.764	0.633	0.625	0.356	2.765
Growth,%	27.91	33.65	19.68	12.12	12.67	18.91
			Pump sets (million)			
1982	1.273	1.580	1.975	1.875	0.627	7.330
1987	3.033	2.755	3.029	2.665	0.819	12.317
1991	4.911	4.181	3.469	2.788	0.866	16.216
Growth,%	14.45	10.22	5.79	4.04	3.28	8.26
			Threshers (million)			
1982	0.139	0.113	0.203	0.235	0.078	0.768
1987	0.353	0.357	0.472	0.513	0.224	1.917
1991	18.83	13.50	7.64	6.64	5.64	11.03
Growth, %	18.83	13.50	7.64	6.64	5.64	11.03

Note : Difference in population of agricultural machinery is due to secondary data quoted from two separate sources i.e. Input Survey and Livestock Census data.

Source : Input Survey 1981-82, 1986-87and 1991-92, Ministry of Agriculture, Government of India.

number of workers employed. These are (i) village craftsmen, (ii) cottage industries, (iii) tiny industries, (iv) small scale industries, (v) medium scale industries and (vi) large scale industries. This classification was done to help the small-scale units through incentives and marketing support. The limit of investment is given in Table 19.

Table 19. Classification of industries in India

Category	Maximum capital investment
Village artisans and cottage industries	Unorganized in rural areas
Tiny industries	Rs. 15 lakhs
Small scale industries	Rs. 1 crore
Medium scale industries	Rs. 5 crores

5.1.1 Village craftsmen

Village artisans are the main source of supply and repair and maintenance of hand tools and traditional implements are made by village craftsmen. These include implements and tools like khurpi, spade, sickle, local ploughs, bakhar, sowing devices, yokes, patela, leveller, oil ghanis, grinding wheels, hand mills, hand-operated milk churning tools, winnowing devices, sieves, wooden storage structures, bullock carts, manual water lifting devices etc. If village artisans are properly trained they will accelerate the adoption of mechanization inputs due to their proximity with farmers.

5.1.2 Tiny and small-scale industries

The tiny and small scale units fabricate bulk of improved agricultural machinery such as ploughs, cultivators, disc ploughs and harrows, seed drills, planters, plant protection equipment, reaper harvesters, combine harvesters, threshers, cleaners, graders, mills, crushers, oil expellers, diesel engines, irrigation pumps, dairy machinery etc.

Agricultural machines are reserved for small-scale units. There are more than 18000 such units scattered all over the country but have concentration in selected regions (Table 20).

Table 20. Regions having concentration of agricultural machinery

Northern region
Ludhiana, Moga, Jalandhar, Goraya, Batala, Hoshiyarpur, Karnal, Panipat, Faridabad, Delhi, Agra, Ghaziabad, Meerut, Rudrapur, Muzaffarnagar, Lucknow, Kanpur, Fatehpur and Allahabad.
Western region
Bombay, Pune, Nagpur, Ahmed Nagar, Sangli, Kolhapur, Sholapur, Ahmedabad, Baroda, Anand, Junagarh, Bhopal, Indore, Dewas, Bina, Khurai, Raipur, Vidisha and Gwalior.
Southern region
Hyderabad, Guntur, Anantpur, Kakinada, Coimbatore, Madurai, Chennai, Salem, Palghat, Ernakulam, Kochin and Bangalore.
Eastern region
Calcutta, Vardhaman, Durgapur, Bhubaneswar, Sambhalpur, Patna, Ranchi, Dhanbad and Muzaffarpur.

Some of these units also fabricate implements and equipment for tractor and power tiller manufacturers. They may lack good machine tools and heat treatment facilities. Some of them are more organized and have better fabrication toolings and thus are able to manufacture better quality machinery.

The bulk of the farm machinery is made by the small-scale industries. They use materials from mild steel to medium carbon steel. Heat treatment practices are generally inadequate except in few industries manufacturing knife & tillage tools. Equipment manufactured by the SSI units includes Soil working tools, seeding & planting equipment, hand hoes, sprayers & dusters, harvesting & threshing equipment, like reapers, threshers, combines, maize shellers, decorticators, cleaners, graders, mills, oil expellers etc.

5.1.3 Organized farm machinery industries

The medium scale and large scale industries manufacture diesel engines, electric motors, irrigation pumps, sprayers and dusters, land development machinery, tractors, power tillers, post harvest and processing machinery and dairy equipment. There are 13 tractor, 2 power tiller, 200 diesel engine, 600 irrigation pump, 48 combine and 188 earthmoving machinery manufacturers (Table 21). The marketing of agricultural machinery by these industries is through their network of dealerships and, therefore, these manufacturers are able to provide effective after-sales-service. These industries upgrade their product and process technologies through their own R&D efforts, in addition to technological support from external agencies.

Today, India is recognized as a leading country in the world for the development and manufacture of agricultural implements and equipment. The range of equipment includes, tractors, harvesting and threshing equipment, plant protection machines, irrigation and drainage pumps, sprinkler systems, land development machinery, dairy and agro-processing equipment, etc. India is the exporting increasing volumes of these to various countries including USA, Africa, Asia, etc.

Table 21. Status of farm machinery industries in India

Equipment manufacturers	No. of units
1. Agricultural tractors	13
2. Power tillers	2
3. Earth movers	3
4. Pumps	600
5. Sprinkler set	35
6. Drip irrigation system	35
7. Plant protection equipment	300
8. Combines	48
9. Reapers	60
10. Threshers	6000
11. Seed drills	2500
12. Ploughs, cultivator and harrows	5000
13. Tractors parts and accessories	546
14. Earth moving machinery and parts	188
15. Diesel oil engines	200
16. Rice processing machinery	300
17. Sugarcane crusher	50
18. Chaff cutter	50
19. Dairy and food industries	500
20. Village craftsmen	1 million

Source : Data Book on mechanization and Agro- Processing since Independence, 1997, CIAE, Bhopal.

5.2 Standardization and quality

The Bureau of Indian Standards (BIS) with its network of centers and laboratories in the country is mandated to ensure quality manufacture and marketing of agricultural and industrial products in the country. The BIS formulates specifications of agricultural machinery and other appliances and prescribes test codes. The Bureau also issues ISI quality certificate marks to the products which meet technical specification as per BIS standards. The list of standards released by BIS is given in Table 22.

The Government of India has established Farm Machinery Training & Testing Centres for promotion of quality farm machinery. In case of agricultural machinery, requirement of quality certification is limited to the sale of agricultural machinery financed under Government Schemes. On certain items connected with safety and health hazards, it is mandatory to have minimum safety standards built into the design or in the installation of machinery during operation. Threshers, chaff cutters, sugarcane crushers etc. fall under this category. The agricultural machines manufactured by the organized sector like tractors, earth moving machinery, irrigation equipment, plant protection, dairy

Table 22. List of standards on agricultural machinery

Type of machinery	Standards Nos.
1. Tractors and power tillers and engines	160
2. Soil working equipment	47
3. Sowing and fertilizer application	28
4. Irrigation & drainage equipment and system	30
5. Crop protection	27
6. Harvesting and threshing	24
7. Horticulture and plantation	55
8. Processing machinery	25
9. Milling equipment	18
10. Dairy and animal husbandry equipment	58
11. Farm transport	14
12. Storage structures	53

Source: BIS-1995.

equipment, processing machinery etc. are certified for their quality by BIS.

5.3 Testing and evaluation

The adoption of agricultural machinery is greatly influenced by the quality and after sales available to the farmers. Since manufacture of agricultural machinery is reserved for small-scale industries, the quality is affected by the manufacturing technology adopted by them. Testing and evaluation helps in up-gradation and quality production of machinery. R&D institutions and quality certification agencies conduct the T&E. Testing and evaluation is conducted on newly developed equipment and during its serial production, to facilitate and ensure quality, reliability, durability, functional ease, comfort in operation and cost of operation. Testing is conducted with well defined standard parameters, defined in BIS, ISO, or OECD standards, and where as evaluation is done to measure the performance under simulated or field conditions for the parameters for which the equipment has been designed.

5.3.1 Institutions involved in testing and evaluation

5.3.1.1 Bureau of Indian Standards

The Bureau of Indian Standards has the statutory authority to inspect the quality of products manufactured and marketed in India. The agricultural machines manufactured by the organized sector like tractors, earth moving machinery, irrigation equipment, plant protection, dairy equipment, processing machinery etc. are certified for their quality by BIS. The BIS has established their Regional Testing Laboratories to facilitate testing and evaluation, including that of agricultural machinery. The BIS has also authorized other Government and Semi-Government testing laboratories to conduct testing on their behalf as per BIS Test Codes or ISO Test Codes.

5.3.1.2 Farm Machinery Training and Testing Institute

The Ministry of Agriculture, Government of India has established 6 Regional Testing Centres located at Budni, Madhya Pradesh (Central Region), Hissar, Haryana (Northern Region), Ganganagar, Rajasthan (Northern), Assam (Eastern Region), Anantpur, Andhra Pradesh (Southern Region), Tamil Nadu (Southern Region). CFMT&TI, Budni is equipped to undertake testing of tractors, combines and other agricultural machinery. Other Centres, test agricultural machinery and irrigation equipment. These Centres conduct testing and evaluation as per BIS Test Codes.

5.3.1.3 Regional Research Laboratories under CSIR

The Regional Research Laboratories (RRL) under CSIR have established microprocessor based modern testing facilities especially for metallographic and material testing. These laboratories have memorandum of understanding (MOU) for sharing research and testing facilities for quality assessment of products, including agricultural machinery.

5.3.1.4 Independent testing and evaluation laboratories

Few NGOs, institutions/association have established independent institutions for undertaking testing and evaluation and these have been authorized by Govt. Deptts./BIS/other consumer organizations (Bank Consumers Protection Forum, etc.) to undertake quality performance testing on their behalf. Few Universities, including Agricultural Universities and Institutes under Indian Council of Agricultural Research conduct quality certification evaluation for consumers on request.

5.4 Agricultural Machinery Marketing and After-sale-services

The large and medium scale manufacturers have well organized distributors and dealers through out the country to undertake advertising and product promotion in their respective territories, conduct product awareness training programmes for the prospective customers, provide after-sales-service to the customers including free services, repair and maintenance, supply of parts, etc. Therefore, this organized sector has the whole of the country as their market due to which their production volumes are large, and their information feed back about their product performance, improvements required in design, production processing or quality, and the new requirements of the farmers to undertake product developments.

Very few small-scale industries have established their marketing network and therefore provide service support

in their premises. In the absence of standardization of parts and components farmers are compelled to carry their machines to the manufactures for repair and replacement of parts and components. Due to this, their market size is limited to their proximity, and they are not able to develop their businesses.

The village artisans on the other hand are located in the villages and therefore provide immediate attention to the needs of the farmers in their immediate neighbourhoods. Therefore, the tools and implements, etc. made by them are against specific requirements of individual customers.

6. INFRASTRUCTURE FOR PROMOTION OF AGRICULTURAL EQUIPMENT

6.1 Agricultural equipment development and field verification

The ICAR is the apex institution for promotion of education, research and extension in the agricultural sector. Besides, Department of Science and Technology and Council for Scientific and Industrial Research (CSIR) also promote development of technology for mechanization and agro-processing. National Research Development Corporation and Poly-technology Transfer Center under CSIR market technology developed in the country. The District Industries Centers are the nodal department for promotion of village industries and small scale industries. Khadi and village Industries Commission (KVIC) promote and market products produced by cottage industries.

The Indian Council of Agricultural Research for the first time sponsored a scheme to conduct state-wise survey of existing tools and implements used by the farmers in 1954. The results were published in the form of a book entitled "Indigenous Agricultural Implements of India" in 1960s. During the sixties, the ICAR made serious efforts to promote research and development on improved farm implements by establishing 17 Research Training and Testing Centres (RTTCs), one in each major state, which were operated by the State Departments of Agriculture. The major mandate of these RTTCs was to test and modify existing implements and develop new improved implements suitable for different agro-climatic conditions of the country. During the latter part of the sixties (IV Five Year Plan Period) two Zonal Research and Testing Centres, one at IARI, New Delhi and the other at TNAU, Coimbatore and four research centres at Ludhiana, Pune, Hyderabad and Mandi were established to promote use of improved machinery.

Besides, All India Coordinated Research Projects (AICRPs) have been established all over the country under ICAR research system to undertake regional research needs and conduct front-line demonstrations of technology with the cooperation of State Agricultural Universities. The ICAR also sponsored All India Coordinated Research Project (AICRP) on Energy Requirement in Agriculture in 1970 to study the role of improved machinery in conservation of energy and increasing productivity. The ICAR also sponsored an AICRP on Research & Development of Farm Implements & Machinery, Production of Prototypes and their Evaluation under Different Agro-climatic conditions in 1972 to develop and promote suitable implements for different agro-climatic conditions.

The ICAR established the Central Institute of Agricultural Engineering at Bhopal in 1976 and Central Institute of Post Harvest Engineering and Technology at Ludhiana in 1989 to support R&D, technology transfer and prototype manufacturing activities. The research in the area of farm machinery was further strengthened with the creation of other AICRPs on Power Tiller (1980), Human Engineering and Safety in Agriculture (1994) and a NRC on Reducing Drudgery of Women in Agriculture (1994).

The ICAR has initiated Front Line Demonstrations of Improved Machinery for piloting the technology with the assistance of Department of Agricultural Cooperation of Ministry of Agriculture, Government of India. Receptive farmers are provided implements, service and training to create awareness. Prototype workshops have been established for developing commercial grade machines for pilot introduction. The ICAR through AICRPs on agricultural machinery conducts demonstrations on farmers field under front line demonstrations (FLD) on newly developed machinery. The ICAR has established 261 Farm Science Centers (Krishi Vigyan Kendras). The proposal is to have at least one KVK in each of the 500 districts. These KVKs are mandated for verification of the technology in addition to providing skill oriented training to the farmers and village artisans.

6.2 Popularization of agricultural machinery

The assimilation of R & D requires an effective technological infrastructure of institutions and services to develop and test prototypes, to set up pilot plants for intensive evaluation and extensive demonstrations besides, training and credit support. New technology also requires network for transfer of technology to the manufactures. Popularization of agricultural machinery in the country is undertaken by the Provincial Governments through Department of Agriculture or Department of Agricultural Engineering. The activities are coordinated by the Department of Agriculture in Cooperation with the Ministry of Agriculture,

Government of India. The Ministry of Food Processing promotes technology related to agro-processing.

The extension system deals with the first-line extension projects with a view to: (i) demonstrating the latest technologies to the farmers as well as the extension agencies; (ii) testing and verifying the technologies on the farmers field (iii) providing opportunities to get first-hand scientific feed-back; (iv) developing extension or technological models for the state extension systems; (v) providing training and communication support; and (vi) promoting research in transfer of technologies.

6.3 Central sector extension programmes

6.3.1 Promotion of agricultural mechanization

For this programme a plan outlay of Rs. 340 million has been made during VIII plan. In this scheme, subsidy for the purchase of tractors below 18 pto hp along with 3 matching implements is being provided to farmers, individually or in a group, having irrigated land between 2.4 to 3.2 ha. Subsidy rate is 30% of the cost to a maximum limit of Rs. 30000.This programme has been slightly modified during 1996-97 by enhancing the plan outlay from Rs. 340 million to 450 million and enhancing the scope of tractors to be included from 18 pto hp to fuel efficient tractors fitted with engines not exceeding 1800 cc (tractors in the range of 15-30 hp). With the revised outlay of Rs.450 million it would cover subsidy for 15000 tractors and matching implements.

6.3.2 Special food production programmes (for wheat, maize and millet)

Under these programmes subsidy is provided up to 50% of the cost limited to Rs. 1500/- per implement/ farm on bullock drawn implements. Under maize and millet programmes, subsidy is also provided on plant protection equipment limited to 50% of cost or up to Rs.600/-

6.3.3 Oil seed production programme

Under this programme subsidy is being provided on bullock drawn implements to the tune of 50% limited to a maximum of Rs.700/- to small and marginal farmers. Subsidy is also being provided on plant protection equipment up to 50% of cost limited to Rs.500/-

6.3.4 National pulse development programme

Under this programme subsidy is being provided on bullock drawn implements up to 50% of cost limited to Rs.500/-per farmer. Subsidy is also provided on plant protection equipment up to 50% of cost limited to Rs. 500 and Dal processing equipment up to 50% of cost limited to Rs. 4000 for machines of less than 1.5 hp capacity.

6.3.5 Intensive cotton development programme

Under this programme subsidy is being provided on plant protection equipment up to 50% of cost limited to Rs.600 for manually operated equipment and 25% of cost limited to Rs. 4000 for tractor mounted equipment.

6.3.6 Integrated programme for rice development

Under this programme subsidy is being provided on animal drawn implements, rice transplanter and water pumps up to 50% of cost limited to Rs.1500. Subsidy is also being provided on power tillers up to 25% of cost limited to Rs.12000.

6.3.7 Development of industrial designs of prototypes of implements

This scheme was approved for the 8th plan with an outlay of Rs.13.5 million. The scheme envisages identification of improved, nearly developed equipment and grant of financial assistance to the R&D institutions for developing industrial designs together with jigs and fixtures needed for their commercialization.

6.4 State sector extension programmes

Under the state sector programmes generally two promotional programmes are being perused by the state governments;

6.4.1 Custom hiring of implements

Under this programmes tractors with matching implements for deep ploughing, rotavation, reapers, threshers, combines, drilling and boring machines, dozers, ditchers etc are being given to farmers on subsidized hire charges.

6.4.2 Manufacture of implements

State governments having agricultural implement workshops are manufacturing a good number of improved agricultural implements and providing to farmers at nominal profits. Most of the implement popularization Schemes sponsored by the Central Government are under review to have an integrated approach to the input requirements of the farmers. Under Macro Subsidy Schemes, the State Governments are required to prepare a consolidated requirement based on the inputs to be promoted for increasing the productivity of agriculture.

7. CREDIT AND FINANCIAL INCENTIVES

The purchasing power of the farmers is low. The government provides subsidy and credit at reduced rate to the farmers who are economically and socially at disadvantageous position to adopt modern technologies.

Table 23. Institutional long-term credit availed by the farmers

(Rs. Millions)

Source	80-81	90-91	95-96	96-97	97-98	98-99	99-00*	00-01**
Cooperative Banks	36.272	11510	21480	119440	139670	169870	184290	219090
Commercial Bank/RRB	74.585	28375	53590	144670	309760	210670	261830	315950

Note :*Provisional, **Estimated.
Source : Agriculture Statistics at a Glance, 2002, Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India.

The long-term credit are usually availed for the purchase of mechanization inputs and short term for the purchase of seed, fertilizer etc. This is one of the indicators of progressive attitude of farmers. The agricultural machines and tractors are purchased through credit, available from organized financial institutions. NABARD is the main refinancing institution. The Government also provides incentives to farmers for modernization of agriculture. This is linked to crop specific programmes operated by state governments. Some of the states could not avail the advantages in the absence of adequate infrastructure for promotion of agricultural engineering programmes. The state government may have to strengthen their extension machinery for providing incentives to the farmers. Draft Agricultural Policy resolution emphasized special consideration for input support to poor farmers with fragmented land holdings and those in eastern, hilly regions, rainfed and drought prone areas.

Table 24. Financial requirement for purchase of major agricultural machinery through banking organizations

Sl. No.	Item	Estimated population (million)	Sale during 1997-98 (numbers)	Unit cost (Rs.)	Total cost (Rs. million)
Power Source					
1.	Tractors	2.043	250,378	250,000	6,2594.5
2.	Power Tiller	0.110	15,000	100,000	1500.0
3.	Diesel Pump	5.575	646,300	18,000	11633.4
4.	Electric Pump	9.973	908,300	18,000	16349.4
Powered Machinery					
5.	Self propelled combine	3,825	450	1,200,000	340.0
6.	Tractor drawn combine	6,804	300	350,000	103.0
7.	Power sprayer	0.527	98,800	4,500	444.6
8.	Power chaff cutter	17.418	268,800	5,000	1344.0
9.	Power threshers	1.76	250,000	25,000	6250.0
10.	Trailer	0.746	94,600	50,000	4730.0
11.	Plough	1.056	144400	14,000	2016.0
12.	Cultivator	1.817	142500	10,000	1425.0
13.	Disc harrow	1.348	95,000	15,000	1425.0
Hand and Animal Operated					
14.	Hand sprayer	3.557	809,800	1,200	971.8
15.	Hand chaff cutter	11.308	741,300	2,500	1853.3
16.	Animal cart	13.218	660,900	10,00	6609.0

The financial requirement for the purchase of agricultural machinery has increased considerably. The commercial and Cooperative Banks provide credit for the purchase of machinery. The total long-term institutional credit provided to agriculture sector which is usually for non-recurring expenditure during 1998-99 was Rs.132080 million. Of this, Rs.43920 million was provided from Cooperative Banks and Rs.88160 million from Commercial Banks. 1998-99. The medium and long-term loans are usually disbursed for the purchase of machinery. To simplify the credit and other financial incentives "Farmers Agri-Credit Card" facility is being introduced in few states to facilitate easy availability of credit including fiscal incentives. An estimated Rs 119580 million is required based on 1997-98 prices for the purchase of major farm machinery. This estimate does not include budgetary requirement for sprinkler and drip and processing machinery (Table 24). Farmers prefer to invest their own money for the purchase of hand tools and bullock drawn machinery and for others they avail the credits from the Banks.

8. FUTURE THRUSTS IN AGRICULTURAL MECHANIZATION

India is a large country with wide-agro ecological diversity having predominance of rainfed agriculture, with irrigated agriculture limited to 34% only. Farm holdings are small due to higher population density and land fragmentation will continue due to 'Laws of Inheritance' and 'Hindu Succession Act'. Majority of the farmers have limited surplus money to modernize farms or to invest in improved inputs. Draught animals and increasing agricultural workers population may remain to be the major source of farm power for soil manipulation and for crop handling, particularly in Hill and Mountain regions. Mechanical power for tillage, irrigation, harvesting and threshing will be preferred, including on custom hiring basis. As a result of GATT agreement, prospects of agro-export are likely to increase and product quality standards stipulated under

WTO would encourage more and more farmers to adopt modern agricultural production technologies. The future agricultural mechanization technology package therefore may have to;

- be eco-friendly utilizing land water and bio-resource catering to the varied group of farm holders,
- facilitate farming operations which are arduous and hazardous,
- increase productivity and conserve resources through effective utilization of chemical, biological and mechanical inputs, and
- modernize commercial agriculture to facilitate agro-export.

Keeping above objectives, the mechanization policy may have to be distinctly different to serve hill agriculture, low lying water logged soils, rainfed and irrigated lands and regions having agro export potential.

8.1 Hand tool/machines

Hand tools for handling of soil, improved sickle, weeder, sprayer, duster, sheller, decorticator, etc are being manufactured by unorganized and organized sector and these are being used within the means and resources of the farmers. The quality of these equipment will further improve as demand picks up and general quality consciousness increases amongst farmers. Tools for horticulture and forestry will have growing demand. The present gap in their availability could attract manufacturers to import these. This would prompt manufacture of better design and better quality tools in India.

8.2 Animal operated machines

Use of mechanical power is increasing but draught animal power will continue to be in use for many years to come. These draught animals will continue to be utilized for tillage, sowing, interculture and transport. The present available designs of farm machines for these operations are adequate but will require refinement in quality through material substitution and better manufacturing processes. For the manufacture of critical parts and components in large volumes, the role of organized sector should be encouraged to adopt the village craftsmen and small scale industries in order to help them in the assembly and production of good quality agricultural machinery.

8.3 Tractors, Power Tillers, Diesel Engines and other Agri-Machinery

8.3.1 Tractors

The present tractor industry is capable of meeting domestic requirements with 10-12% annual growth leading to stabilization at around 7-8%. The export of tractors, showing growth trends, is going to increase particularly in Africa, and many Asian and CIS countries. The tractor manufacturers are aware of these possibilities and some of them have already taken steps to make their products more export worthy through their own R&D and joint ventures. This will not only help export but also Indian farmers. The latest package of computer integrated flexible manufacturing system will not only be economical but also provide better industrial environment. The present tractor use is limited to tillage, transport and stationary operations and, thus has a lower annual utilization. In future, use of tractors will extend from primary to secondary operations like sowing, spraying, interculture, harvesting, agro-forestry, tree harvesting, plantation, land development, excavation for drainage, mulching, drilling etc. These will require introduction of specialized tractors.

8.3.2 Power tillers

Demand has not picked up in the country due to availability alternative power sources. For mechanization of hill agriculture and orchards, light weight power tillers with matching equipment for different farm operations would be required. The present designs may not suit this requirement and, therefore, more suitable designs, including imported machines, should be introduced with adequate incentives and credit support to popularize their use.

8.3.3 Irrigation equipment

Demand for irrigation equipment including drip and sprinkler is increasing, particularly in water deficit regions. The drip system is likely to increase for application of chemicals and fertilizers. The pumps are operated by electric motors or diesel engines. While quality of electric motors is satisfactory, the farmers continue to use horizontal and vertical type diesel engine operated pumps. These engines, though cheap, have higher operational costs due to poor quality and life, and high fuel consumption. Efficient lightweight diesel engines have to be developed, manufactured and promoted. Solar photovoltaic pumps and wind mill pumps have potential especially for drip irrigation systems.

8.3.4 Power operated agricultural machinery

Machines for primary and secondary tillage operations, of varying quality, are commercially available to meet the farmers needs. In the absence of quality promotion measures, the quality of these machines is rather poor. A policy should be devised to

promote the manufacture of these machines conforming to BIS specifications, and their sales subject to BIS quality certification. Till such time, the manufacturers have to be encouraged to manufacture these machines by adopting BIS certified components.

Several designs of sowing and planting machinery have been developed and commercialized. The utility of these machines in rainfed agriculture has been amply demonstrated. The R&D Institutions and BIS should work together to screen the designs for their standardization to promote manufacture of good quality implements.

8.3.5 Machines for transplanting/planting

Transplanting of paddy, sugarcane, vegetables and trees are yet to be developed to an acceptable level before these are taken up for commercial production and adopted by farmers. This should be taken up on priority by R&D Institutions and industries. Initial importation may accelerate the pace of development.

8.3.6 Machines for application of manure and liquid nitrogenous fertilizers

Equipment for application of manure and liquid fertilizers are not available in India. Handling and application of biogas slurry is also manual. These require special attention of R & D Institutions.

8.3.7 Plant Protection equipment

Plant protection manufacturing industry is fairly well organized. Hand and power operated machines are manufactured by large number of industries some of which have obtained ISI certifications. Machines for tall crops and trees including ULV and electrostatic sprayers are yet to be taken up for manufactured by the industries. The development of horticulture sector is likely to increase the demand of such sprayers.

8.3.8 Reaper harvesters

The power tiller and. Self-propelled reapers and reaper attachments for power tillers can provide an economical alternative for those farmers who can not afford the combine harvesters due to economic and land topography reasons. The pace of development and adoption of reaper is slow which needs to be accelerated.

8.3.9 Combine harvesting and other harvesting equipment

Combine harvesting is in vogue in some States and the industry is capable of meeting the present demand. The combine harvesting at present is limited to cereal crops only. However, most of the straw is left in the fields and burned. Alternative straw handling and disposal technology may have to be developed and promoted as burning of straw is creating environmental pollution and farmers are loosing valuable animal feed material.

Maize, sorghum, cotton, sugarcane, potato, peanut, sunflower, safflower, soybean and pulses are predominantly harvested manually. Large and commercial farming of these crops would require alternative harvesting and handling machinery. Initially demand could be met through limited importation which will lead to local adoption and manufacture.

Similarly, harvesting of fruits has to be mechanized for timely and damage free harvesting. Their use will also reduce danger and drudgery involved in fruit harvesting. A suitable strategy and programme should be put together for selection of appropriate designs, their field evaluation, design optimization and manufacturing in India.

8.3.10 Threshers

Threshing technology is well accepted by the farmers. The demand for cheep threshers led to design of thresher with inadequate safety measures resulting in to a large number of fatal accidents. The Government enacted Safety Laws; the **Dangerous Machine (Regulation) Act 1983.** Since, the agricultural machines are manufactured by unorganized sector, the enforcement of the **Act** has been difficult. A policy decision should be taken to make it mandatory to display the source of their origin for ensuring adherence of minimum safety standards by the manufacturers.

8.3.11 Specialized farm machinery

Machines for land development, excavation for drainage channels, mulching, trench cutting and post hole digging are not commonly available. Fodder production, tree felling, pruning etc. are performed manually. In the absence of machines for such operations, even an assessment of their requirement is difficult. Limited introduction through importation may help in projecting their need and the likely future demand.

Green house technology is increasingly becoming popular in some States for horticulture and floriculture. Implements and equipment is required for the management of crop production in green houses.

9. FUTURE PERSPECTIVE IN AGRICULTURAL MACHINERY MANUFACTURE

Equipment for tillage, sowing, irrigation, plant protection and threshing have been widely accepted by the farmers in India. Draught animal and human power

in India will continue to be used, but these are inadequate to ensure timeliness of agricultural operations. Even farmers with small holdings utilize selected improved farm equipment, including through custom hiring. The future mechanization strategy may have to be based on agro-ecological diversity and economic disparity of the farmers. The present trend in agricultural mechanization is for high capacity machines to be used on custom hiring and for contractual field operations.

Rice mechanization, sugarcane mechanization, cotton mechanization, potato mechanization, horticulture mechanization, green house and covered cultivation, drip and micro irrigation are new emerging areas which need attention of Agricultural Engineering Institutions and industries for their development, production and marketing.

Water is a scarce commodity and in future with increasing demand for more irrigation water, concerted efforts will be needed for controlled application of water through drip, sprinkler and micro-sprinkler systems to economize use of water and improving water use efficiency.

With the shift in agriculture towards diversification and agri-business, substantial areas will go under horticultural crops. This will also help to export good quality high value agri-products for better returns to farmers and to earn more foreign exchange. The green house technology offers ample scope for increasing productivity particularly of high value cash crops like exotic fruits, flowers and bio-tech plants. Design of green house with environmental control mechanized cultivation and product-handling technology package will assume greater importance.

Presently little effort has been made to mechanize hill agriculture, where there is tremendous potential of growing horticultural crops, flowers etc. In future this calls for developing appropriate technologies for mechanization.

In order to enforce quality, reliability and safety in the manufacture of agricultural implements, manufacturing of critical components need to be standardized and encouraged for mass production by medium and large scale manufacturers. Keeping long standing demand of farmers and the Ministry of Agriculture and on the recommendation of the Advisory Committee of the Ministry of Industries, the Union Budget of India 1998-99, announced the exclusion of farm implements and tools from the list of items reserved for manufacture by small scale industries sector to enable the farmers to get benefit of wider range of implements and tools at competitive prices, and with requisite after-sale-service. The decision of the Government of India to de-reserve the manufacture of farm machinery will help the organized sector to bring latest farm machinery technology for accelerated adoption by the farmers. The small-scale industries in turn will adopt the technology for local manufacturing at a much lower cost. This will help the small-scale sector to become more competitive and to enlarge their market size.

However, the constraints experienced in the growth of farm mechanization so far need to be dealt with so that the farmers are enabled to adopt new methods to produce more, to earn more through gains in productivity, quality of produce, higher prices, etc, for raising their standards of living and better life styles. The critical constraint factors are:

- Reliability and quality of agricultural machinery.
- Availability of products, spare parts and after-sales-services in close proximity.
- Availability of Bank credit on terms where currently the farmers have to mortgage both the equipment purchased and his land.
- Lack of effective consumer protection in rural areas for redressel of cases of product problems, and poor after-sales- services, etc.

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