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Trends of Tractorization in Indian Agriculture



by
T. Senthilkumar
Senior Scientist
Regional Centre
ICAR - Central Institute of Agricultural Engineering,
Coimbatore -641007
INDIA



N. S. Chandel
Scientist
ICAR - Central Institute of Agricultural Engineering,
Nabi bagh, Bhopal -462038
INDIA



C. R. Mehta
Project Coordinator
AICRP on Farm Implements and Machinery
ICAR - Central Institute of Agricultural Engineering,
Nabi bagh, Bhopal -462038
INDIA
crmehta65@yahoo.co.in



B. S. Gholap
Research Associate
AICRP on Farm Implements and Machinery
ICAR - Central Institute of Agricultural Engineering,
Nabi bagh, Bhopal -462038
INDIA

Abstract

Farm mechanization in India is still in its early stages for the last two decades and only able to achieve a meagre growth rate of less than 5%. Tractors play an important role in mechanization of Indian agriculture. The status of tractorization and growth pattern in sale of tractors in India was studied in the paper. The tractor sale increased at a Compound Annual Growth Rate (CAGR) of 9.39% during the last 54 years and reached a level of 493,764 units in 2015-16. The trend of increasing sale of tractors over the years indicates a rising acceptance of tractor operated agricultural machines and equipment with the Indian farmers. The current trend in sale of tractors indicated the highest share of 43% for 31-37 kW category tractors. The requirement of high power category tractors in India increased for using high capacity farm machines on custom hiring basis. Haryana state of India has the highest tractor density of 96 tractors per thousand hectares of net cropped area and followed by 79 for Punjab. The lowest tractor density of 4 was in Kerala with all Indian average of

43. Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, and Gujarat were the top five states in India in terms of higher sale of tractors from 1995-96 to 2004-05; however, Punjab and Haryana states were replaced by Andhra Pradesh and Maharashtra during the last decade. It was observed that there was a positive relationship between available tractor power and food grain productivity for all the major states except Assam and West Bengal. It was concluded that rainfall pattern, land holding size and government policies affected the sale of tractors in India.

Key words: Tractor Industry; Tractor density; Productivity; Land holding; Mechanization

Introduction

Indian agriculture employs over 50% of the domestic workforce and contributes to around 14% to gross domestic product (GDP) of country. In order to ensure self-sufficiency in food grain production in the backdrop of increasing population, state agencies have assumed a greater role as facilitators of technology

adoption (Anonymous, 2013). Indian agriculture especially practiced in small farms, was seen as being traditional and low productive activity. The productivity of farms depends mainly on judicious use of available farm power by the farmers. Higher production and productivity, and reduced drudgery are major contributions of farm mechanization (Van den Berg, 2007). Economic growth in Indian agricultural sector lags behind growth in industry and services, creating an ever widening rural-urban income gap (Manda and Maity, 2013). Agriculture was not considered central to economic growth and development that would instead be led by services (134 million enterprises) and manufacturing industry (92 million enterprises) in unorganized sectors. Indeed, the main role of unorganized agriculture's sector enterprises (224 million) is dual i.e. sector development and release of labour from low - marginal productivity in agriculture to industry (Anonymous, 2009).

The farm power availability and farm mechanization have a crucial role to play to enhance agricultural productivity. Agricultural implements and machinery enable the

farmers to employ the available farm power judiciously for production purposes (Cavallo, 2014). The opportunities are still huge considering the low farm mechanisation levels in the country as compared to other developed economies across the world. Agricultural machinery increases productivity of land and labour by meeting timeliness in farm operations resulting in increase work output per unit time (Panin, 1995). Agricultural mechanization technology plays a key role in improving agricultural production and productivity in developing countries, and should be considered as an essential input to agriculture. The increased use of farm machines has led to increase in cropped area, cropping intensity and agricultural production of the country (Singh, 2000). Besides, its paramount contribution to the multiple cropping and diversification of agriculture, mechanization also enables efficient utilization of inputs such as seeds, fertilizers and irrigation water (Singh, 2006; Mehta *et al.*, 2014a). The shift has also helped in diversification of agriculture from conventional crops to commercial crops. The programmes of farm mechanization such as Sub-mission on Agricultural Mechanization (SAM) resulted in adoption of farm machinery such as tractors, power tillers, combine harvesters, irrigation

pumps, plant protection equipment, threshers, improved implements and hand tools (Mehta *et al.*, 2014b).

Tractors are an integral part of Indian agricultural machinery industry. Tractor industry plays an important role in agriculture sector as major contributors to India's GDP. Tractor has a significant role in agricultural operations and remains the most important and extensive path-breaking machine in agricultural world (Iftikhar and Pedersen, 2011). The tractors in India are also used for transport and non-agricultural applications. The use of tractors in agriculture in India started during the 1950 with annual introduction of about 8,000 imported units. The tractor manufacturing process started in India during 1961-62 with the help of foreign collaborations (Jain, 2006). Presently, there are 21 tractor manufacturers producing tractors in India. The Indian tractor industry has developed over the years to become the largest in the world and accounts for one third of global production. By advancement in manufacturing of tractors, there is a possibility that could lead India to another green revolution (Mandal and Maity, 2013). Starting in 1960's, it had reached about 50,000 units in the early 1980's, but today the size of Indian tractor market has grown to over 600,000 units (Goel and Kumar, 2013; Sarkar, 2013). The

Indian tractor industry is headed for a slowdown after a splendid performance during the last decade.

Rainfall, land holding size and food grain productivity are key drivers for sale of tractors in India. A series of good or bad monsoon affects the sale of tractors. The good growth in sale and exports of tractors also depend on the initiative of the government to boost up agriculture and agricultural machinery industry. The tractor penetration level in different parts of the country is also not uniform due to many reasons. It is observed that net sown area in the country is about 140 million ha for last many decades while gross cropped area increased from 132 million ha in 1950-51 to 198.9 million ha with a cropping intensity of 140.5% during 2010-11 (Anonymous, 2014a). Tractor played a significant contribution in increasing the gross cropped area. This paper gives an insight into the trend in tractorisation of Indian agriculture. The data on power-wise and state-wise sale of tractors over the years have been analysed in the paper.

Trend in Sale of Tractors in India

The use of different types of farm machinery including hand tools, animal-drawn implements, seed drills and planters, plant protection equipment, diesel/electric pump sets, combine harvesters, threshers etc. has been accelerating over the past several years in India. Due to use of these implements, the total power available per unit area on farms has also increased. The sale of tractors in India was only 3,877 units in 1961-62 and reached to all time high of 633,656 units (163 times) in 2013-14 (Fig. 1). The sale of tractors increased at a compound annual growth rate (CAGR) of 10.3% during the last 52 years. The sale of tractors in India increased at an annual growth rate of 4.97% from 1990-91 to 2015-16. The increasing trend in sale of tractors over the years indicated a rising ac-

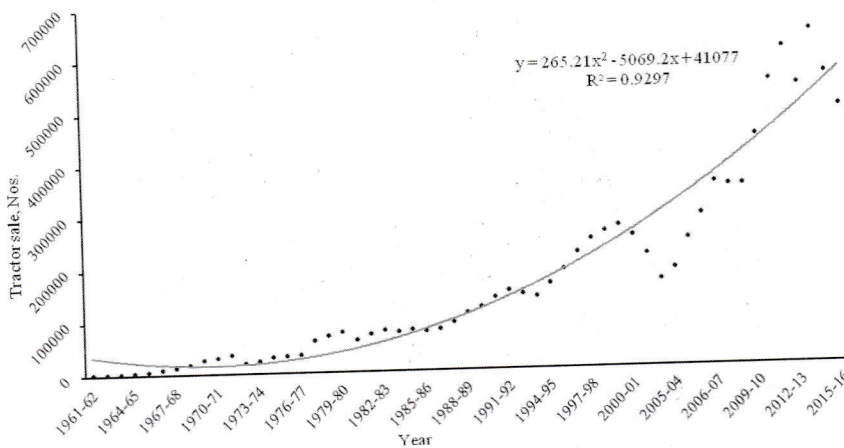


Fig. 1 Trend in sale of tractors in India

Table 1 Trend in growth in domestic sale of tractors from 1961-62 to 2015-16

Period	Compound annual growth rate (CAGR), %
1961-62 to 1970-71	24.03
1971-72 to 1980-81	5.24
1981-82 to 1990-91	6.52
1991-92 to 2000-01	5.24
2001-02 to 2010-11	9.63
2011-12 to 2015-16	-4.06

ceptance of agricultural machines and equipment with the Indian farmers. However, there was a large year-to-year fluctuation in growth rate during the period. There were five instances where growth in sale of tractors was negative for two or more successive years. The first such instance was during 1972-74 and followed during 1983-86, 1992-94, 2001-03 and 2014-16. The slowdown in tractors sale began in 1997-98 with negative or low growth rate up to 2000-01 and was followed by negative growth rate during 2001-02 and 2002-03. The sale of tractors increased rapidly from 2004-05 onwards, with output crossing the 300,000 mark in 2006-07. There was another dip in sale of tractors in 2007-08 and 2008-09 and followed by a big rise in 2008-10. The domestic sale of tractors decreased during the last two years from 633,656 units in 2013-14 to 493,764 units in 2015-16 due to poor rainfall.

The trend in growth pattern in sale of tractors at an interval of 10 years during last 54 years (1961-62 to 2015-16) is reported in **Table 1**. It is indicated that the tractor sale in India increased at a CAGR of 9.63% from 2001-02 to 2010-11. The maximum CAGR growth in domestic sale of tractors was 24.03% from 1961-62 to 1970-71. The growth in tractor sale was negative (-4.06%) during the last four years (2011-12 to 2015-16).

The Indian tractor industry is the largest in the world and accounts for one third of global production. Mahindra & Mahindra Ltd., Mumbai

is market leader with 41% share in sale of tractors in India. The population of tractors in India reached to 5.81 million in 2015-16 as compared to 3,877 units only during 1961-62. The net area sown by a tractor was 3,600 ha during 1961-62 and reduced to 24 ha by 2015-16. However, the country still lags behind the developed countries in terms of the net area sown by a tractor. India also lags behind in terms of availability of tractors not only to developed countries but also some of the developing countries of the world e.g. China.

Power-wise sale of tractors

The trend in power-wise sale of tractors in India during the last 16 years is shown in **Fig. 2**. The sale of tractors in India has grown at a CAGR of 5.62% during the last 16 years from 217,456 in 2001-02 to 493,764 in 2015-16. The domestic sale of tractors is the highest (43%) in 31-37 kW power range and followed by 36% in 23-30 kW power range during 2015-16. The percentage share in domestic sale of more than 37 kW tractors decreased from 7.3% to 6.6% and 31-37 kW tractors increased from 14% to 43% during the last sixteen years (2001-2016). It is indicated that requirement of high

power category tractors in India has increased for using high capacity farm machines on custom hire basis. However, during the same period, the percentage share in sale of medium power tractors (23-30 kW) decreased from 55 to 36% and low power tractors (15-22 kW) from 23 to 6.2%. The sale of less than 15 kW tractors was only 4.7% during 2015-16. The industry is, however, witnessing polarization, with high growth in the upper and lower power segments. The rate of growth in medium power segment (23-30 kW) is nearly constant.

A farmer's choice of tractor size is typically a trade-off between utility of the tractor (which includes transport capacity requirement) and its price. Despite higher prices, several factors have led to a structural shift in the industry towards high power tractors. The factors for share increase in sale of high power tractors in India are increasing tractor penetration in southern India due to high power requirement in paddy fields, replacement demand for high power tractors from the northern region, increasing use of tractors for non-agricultural applications and growth in export of high power tractors. Nevertheless, the growth

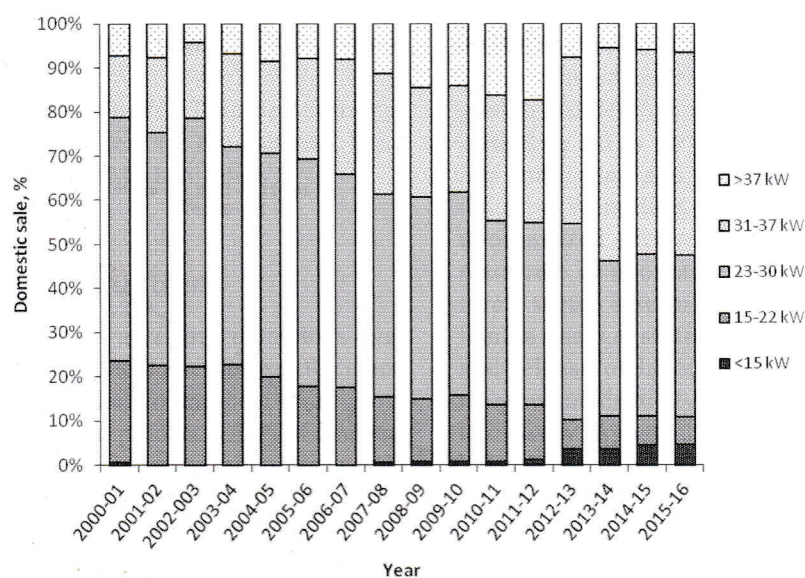


Fig. 2 Trend in power-wise sale of tractors in India

more than 31-37 kW tractors market is expected to remain strong.

The sale of less than 15 kW tractors indicated strong growth of 38.2% in 2012-13. The strong underlying demand in less than 15 kW tractor category has prompted the entry of organised players like Mahindra & Mahindra Ltd., VST Tillers Tractors Ltd., Escort Group and Kubota Agricultural Machinery India Pvt. Ltd. in Indian tractor market, a segment which is currently catered by un-organised players. With roughly 45% of the area under cultivation contributed by small and marginal farmers (less than 2 ha land holding), the opportunities in this area are plunged; more so in light of very low tractor penetration at present. Also with scarcity of farm labour and rising cost of animal power, the trend of ownership of small and less expensive tractors by small and marginal farmers is increasing. Apart from lower initial costs, these tractors deliver better fuel efficiency as compared to high power tractor, making it viable for small farmers to upgrade power sources from human, animal or

power tiller to a tractor. While currently, Mahindra & Mahindra Ltd. and VST Tillers Tractors Ltd. are the only two large players that have presence in this under INR 0.2 million (US\$ 3,000) tractor market. The other tractor manufacturers like International Tractors Ltd. (ITL) and Escorts are expected to enter this segment soon. However, restricted application to soft soil conditions, competition from second hand market of high kW tractors, and limited credit worthiness of marginal farmers are some of the factors that are influencing the growth in the under 15 kW tractor market.

Region-wise sale of tractors

In recent years, the tractor industry has registered a good growth in sales, both domestic as well as exports. This is also partly because of the initiative of the government to boost up growth in agriculture and agricultural machinery industry. The tractor penetration level in India is very low as compared to the world standard and not uniform throughout the country.

The percentage contribution of different states in sale of tractors in

India from 1995-96 to 2015-16 is reported in **Table 2**. The sale of tractors was more than 8% in the states of Uttar Pradesh, Madhya Pradesh, Rajasthan, and Maharashtra from 2010-11 to 2015-16. These four states together accounted for about 40% of the total tractors sale in the country during 2015-16. Tractors sale in Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh states have shown consistent growth during the last ten years. It is expected to increase at a faster rate due to growing of high value cash crops and adopting latest crop production/ management practices by farmers of Central and Southern regions of the country.

The differential pattern of growth in tractors sale, with faster growth in the initially laggard states, has reduced the regional concentration of tractors sale over time. The combine share of the top five states viz. Madhya Pradesh, Uttar Pradesh, Rajasthan, Punjab and Haryana in total tractors sale was 63.6% during the period from 1995-96 to 1999-00 and reduced to 41.7% from 2010-11 to 2015-16 (**Table 2**). Further,

Table 2 Percentage contribution of different states of India in sale of tractors from 1995-96 to 2015-16

State	Sale of tractors, %				CAGR
	1995-96 to 1999-2000	2000-01 to 2004-05	2005-06 to 2009-10	2010-11 to 2015-16	1995-96 to 2015-16
Andhra Pradesh (AP)	5.34	6.33	10.09	7.03	4.99
Assam (AS)	0.20	0.23	0.48	0.69	13.09
Bihar (BR)	4.18	6.66	4.84	5.23	9.45
Gujarat (GJ)	8.35	5.64	7.08	7.36	4.02
Haryana (HR)	8.97	6.12	6.32	4.39	0.86
Himachal Pradesh (HP)	0.18	0.26	0.28	0.23	9.86
Jammu and Kashmir (JK)	0.22	0.57	0.38	0.46	9.19
Karnataka (KA)	2.96	4.71	5.94	5.17	6.54
Kerala (KL)	0.32	0.14	0.22	0.08	-5.22
Maharashtra (MH)	11.91	12.70	7.06	10.03	3.59
Madhya Pradesh (MP)	6.75	4.21	7.71	7.97	6.10
Odisha (OD)	0.70	3.95	1.84	2.07	10.28
Punjab (PB)	11.82	7.52	5.48	4.34	-1.60
Rajasthan (RJ)	9.64	7.82	8.63	9.30	6.33
Tamil Nadu (TN)	4.24	3.68	5.05	2.66	1.22
Uttar Pradesh (UP)	21.26	22.23	14.92	13.66	3.75
West Bengal (WB)	1.03	1.23	1.76	2.10	11.01
Export & other states	1.93	6.02	11.93	17.22	18.17
Total India	100.00	100.00	100.00	100.00	

there is a change in the composition of the top five states with respect to tractors sale in India. Uttar Pradesh, Madhya Pradesh and Rajasthan states are among top five states in percentage sale of tractors in India during last 21 years (1995-96 to 2015-16). However, the states of Punjab and Haryana are replaced by Andhra Pradesh and Maharashtra during 2005-06 to 2009-10 and by Maharashtra and Gujarat during the last six years (2010-11 to 2015-16). The demand for tractors is also

increasing due to an increase in use of tractors for construction work. Nearly, 70% increase in the demand for tractors during the last decade is from the infrastructure sector in the states of Assam, Odisha and Bihar. The tractors sale in Bihar tripled from 1995-96 to 2015-16 due to boom in infrastructure sector in the state.

Although huge regional disparities still exist in the level of tractorisation in the country, recent data on state-level tractors sale show that

growth has been relative. In states where tractor penetration in agriculture was low initially, over the last two decades, India has emerged as the market for tractors. In the highly mechanised regions of India, the growth rate in sale of tractors is (-) 5.22% and (-) 1.60% in the states of Kerala and Punjab, respectively during the period (Table 2). **Tractor density and food grain productivity**

The state-wise tractor density per 1,000 ha of net sown area and power availability from tractors per 1,000 ha area, food grain productivity and power per unit production per unit power reported in Table 3. Overall tractor density per thousand hectares of net sown area in India is 43. It is noted that the tractor availability per 1,000 ha of net sown area is more than the India average of 43 tractors per 1,000 ha in seven states viz. Haryana, Punjab, Uttar Pradesh, Bihar, Tamil Nadu, Andhra Pradesh and West Bengal. It ranges between 30-43 tractors per 1,000 ha in four states of Andhra Pradesh, Karnataka and Jammu and Kashmir, Rajasthan, Kerala and Himachal Pradesh and less than 30 tractors per 1,000 ha in six states of Madhya Pradesh, Maharashtra, Odisha, West Bengal, Assam and Kerala. Haryana has the highest tractor density of 96 tractors per thousand hectares of net sown area and is followed by Punjab (79), Uttar Pradesh (58), Bihar (54), and Andhra Pradesh (48) states. The lowest tractor density is 4 in Kerala state and followed by Assam (14), and West Bengal (23) among the major states except the eastern states of India.

The relationship between tractor density and food grain productivity in major states of India is shown in Fig. 3. In general, the food grain productivity increases with increase in tractor density in a state. The states of India were divided into four categories based on tractor density and food grain productivity in India. The average

Table 3 State-wise tractor availability per 1,000 ha area, power availability from tractors and food grain productivity

State	Tractor density per 1,000 ha area	Power availability from tractors, kW/ha	Food grain productivity, t/ha	Power per unit production, kW/t
Andhra Pradesh	48	1.17	1.32	0.89
Assam	14	0.28	1.72	0.16
Bihar	54	1.34	2.10	0.64
Gujarat	44	1.07	1.96	0.55
Haryana	96	2.52	3.88	0.65
Himachal Pradesh	30	0.72	2.80	0.26
Jammu and Kashmir	40	0.92	2.03	0.45
Karnataka	32	0.73	1.64	0.45
Kerala	4	0.12	2.7	0.45
Madhya Pradesh	28	0.71	1.41	0.50
Maharashtra	28	0.64	1.15	0.56
Odisha	25	0.58	1.30	0.45
Punjab	79	2.29	4.34	0.53
Rajasthan	34	0.78	1.32	0.59
Tamil Nadu	46	1.29	2.69	0.48
Uttar Pradesh	58	1.55	2.50	0.62
West Bengal	23	0.51	2.68	0.19

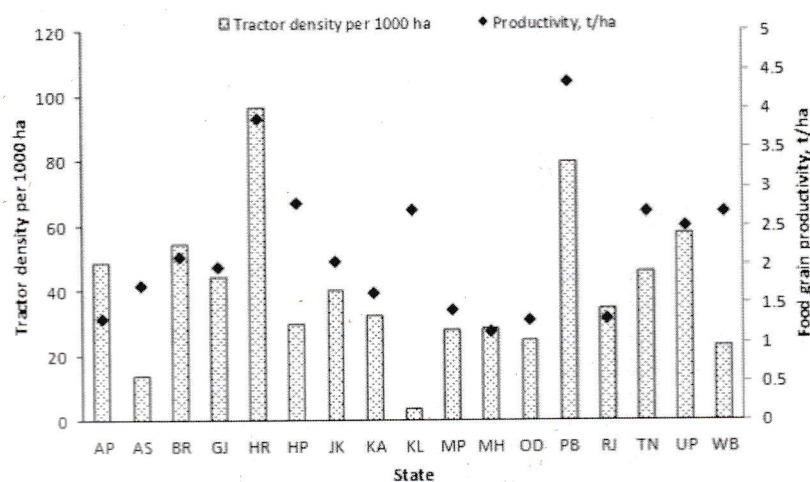


Fig. 3 Tractor density and food grain productivity in different states of India

tor density of 43 tractors per 1,000 ha and food grain productivity of 2.06 t/ha were taken as the base for categorizations of states. The first category was of high tractor density and high food-grain productivity in the states of Haryana, Punjab, Uttar Pradesh, Tamil Nadu and Bihar. These states utilized maximum tractor power for increasing food grain productivity on their farms. The food grain productivity is the highest in Punjab state and followed by Haryana state. It may be due to availability of more tractor power per unit area in these states. The second category is low tractor density and high yield in the states such as West Bengal, Himachal Pradesh and Kerala. It indicated that these states utilized more human and animal power sources than tractor power source to enhance productivity. The third category is high tractor density and low yield in states of Gujarat and Andhra Pradesh. This may be due to low rainfall and low land productivity of the states. The fourth category is of low tractor density and low yield in seven states of India.

Tractor power availability and food grain productivity

It was also observed that the highest power available from tractors was 2.52 kW/ha in Haryana and followed by states of Punjab (2.29 kW/ha), Uttar Pradesh (1.55 kW/ha), Bihar (1.34 kW/ha), Tamil Nadu (1.29 kW/ha), Andhra Pradesh (1.17 kW/ha), Himachal Pradesh (1.07 kW/ha), Jammu and Kashmir (0.92 kW/ha), Karnataka (0.73 kW/ha) and Himachal Pradesh (0.72 kW/ha). The lowest power available from tractors was in Kerala state (0.12 kW/ha) and followed by Assam (0.28 kW/ha), Odisha (0.58 kW/ha), Maharashtra (0.64 kW/ha), Madhya Pradesh (0.71 kW/ha) and Rajasthan (0.78 kW/ha) states. In case of power utilized for production of one tonne of food grain, the Assam state is leading with less power utilized (0.16 kW/t) and followed by West Bengal (0.19

kW/t), Himachal Pradesh (0.26 kW/t), Odisha (0.45 kW/t) and Kerala (0.45 kW/t) states. This may be due to highly fertile soil and good rainfall in the states of Assam, West Bengal and Kerala etc. The power utilized for production of one tonne of food grains was the highest in Andhra Pradesh (0.89 kW/t) state

and followed by Haryana (0.65 kW/t) and Bihar (0.64 kW/t) states even though the total power availability was higher in other states. This may be due to over tractorization in these states. The increased use of tractors has resulted in increase in cropped area, cropping intensity and food grain production. The shift

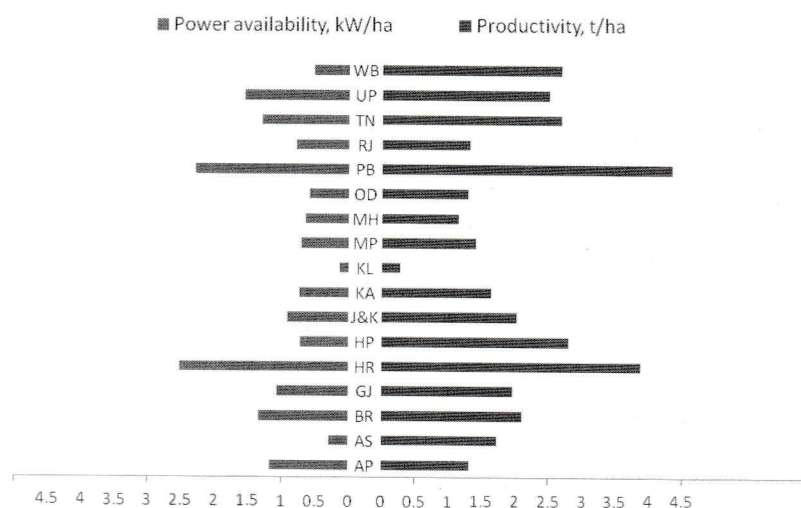


Fig. 4 Relationship between food grain productivity and available tractor power in different states of India

Table 4 Percent share of power wise distribution of sale of tractors in different states of India during 2015-16

States	Power category, kW				
	<15	15-22	23-30	31-37	>37
Andhra Pradesh	2.9	1.7	28.7	62.7	3.9
Assam	1.7	0.6	24.0	69.1	4.6
Bihar	1.6	11.2	59.7	26.2	1.3
Gujarat	20.7	2.5	45.1	28.2	3.5
Haryana	1.5	15.3	26.1	42.1	15.0
Himachal Pradesh	3.1	2.2	47.6	44.9	2.2
Jammu and Kashmir	2.5	12.9	11.1	55.0	18.5
Karnataka	4.4	8.4	28.1	53.6	5.5
Kerala	14.2	2.3	8.9	58.1	16.5
Maharashtra	18.4	17.0	8.6	49.8	6.2
Madhya Pradesh	1.3	1.4	38.0	53.4	5.8
Odisha	0.5	1.4	50.3	45.3	2.5
Punjab	0.3	6.6	7.6	54.6	30.9
Rajasthan	0.8	1.9	53.2	41.9	2.2
Tamil Nadu	4.7	1.2	7.8	77.1	9.3
Uttar Pradesh	1.5	7.8	41.6	42.6	6.4
West Bengal	2.1	3.5	18.0	62.6	13.9
Other states	1.8	3.2	37.3	45.2	12.5
Exports	0.9	1.2	5.7	25.3	66.9
Domestic sales	4.0	6.0	33.0	43.0	15.0

has also helped in diversification of agriculture from conventional crops to commercial crops.

The relationship between power availability from tractors and food-grain productivity per unit area for all major states in India is shown in Fig. 4. It was observed that there was positive direct correlation between available tractor power and food grain productivity for all the major states except Assam and West Bengal. In Assam state, even though the available power is low (0.26 kW/ha), the food grain productivity is 1.73 t/ha. This may be because of good rainfall and climate and fertile soil type etc.

Power-wise regional distribution

The tractors sold in India are of different power range from less than 15 kW to more than 37 kW. The percentage share of sale of tractors during 2015-16 in different power ranges in different states of India is

given in Table 4. From this Table, it is concluded that the sale of tractors was the highest in 31-37 kW power range in most of states of India except Bihar, Gujarat, Himachal Pradesh, Odisha and Rajasthan. The percentage share in sale of tractors in 31-37 kW power range was the highest (77.1%) in Tamil Nadu state and followed by Assam (69.1%) state. The percentage share in sale of tractors in 23-30 kW power range was the highest in Bihar (59.7%) state and followed in states of Rajasthan (53.2%), Odisha (50.3%), Himachal Pradesh (47.6%), Gujarat (45.1%), Uttar Pradesh (41.6%) and Madhya Pradesh (38%). The percentage sale in tractors of less than 15 kW power was the highest in Gujarat (20.7%) and followed in Maharashtra (18.4%) and Kerala (14.2%) states. These states used the tractors for intercultural and spraying operations in horticultural and cash crops.

The major markets for power-sale of tractors in India are given in Table 5.

The percentage sale of tractor more than 37 kW was the highest in Punjab (30.9%) and followed by Jammu and Kashmir (18.5%), Kerala (16.5%) and Haryana (15%) states. The farmers of Kerala state use these tractors with tractor mounted combine harvester. Moreover, large size tractor is also considered as a status symbol in large part of rural Punjab, Haryana and Jammu and Kashmir states. The high power tractors are not only used for custom hiring of farm machinery, but also for transport of farm produce (sugarcane, potato), construction materials, and development of infrastructure activities. The sale of high power tractors in Northern states is due to high power requirements for paddy and straw management practices and in Southern states for cultivation in black cotton soils for non-agricultural applications. In general, the margin money required for getting a loan for high-end tractors is obtained by selling the used tractor. It is estimated that replacement sale of tractors are currently around 40 to 45% of total sales. It was also observed that 66.9% of total tractors exported from India during 2015-16 are of more than 37 kW power as compared to 15% sold in domestic market.

Table 5 Major markets for tractors in India

Tractor power (kW)	Major markets
Less than 15 kW	Gujarat, Maharashtra and Kerala
15-22 kW	Maharashtra, Haryana, Jammu & Kashmir and Bihar
23-30 kW	Bihar, Rajasthan, Odisha, Himachal Pradesh and Gujarat
30-37 kW	Tamil Nadu, Assam, Andhra Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Punjab, Uttar Pradesh and West Bengal
More than 37 kW	Punjab, Haryana, Kerala, Jammu & Kashmir and West Bengal

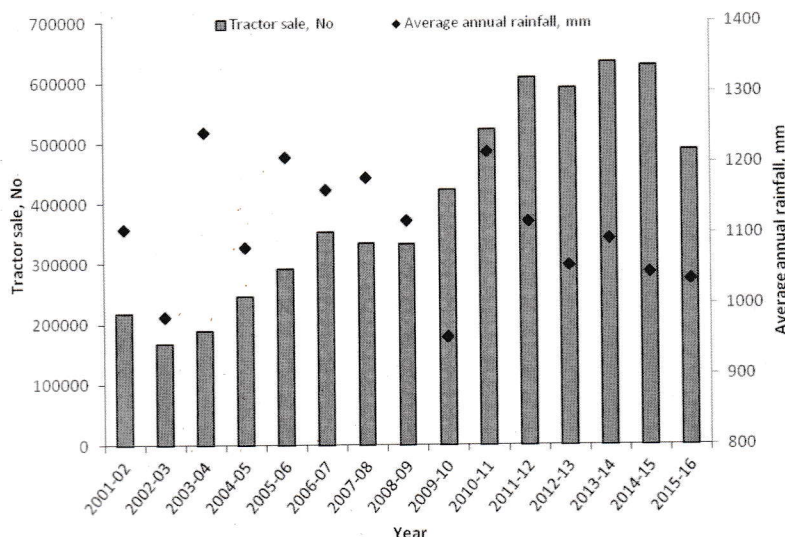


Fig. 5 Effect of average annual rainfall on sale of tractors in India

Factors Affecting Sale of Tractor in India

Monsoon and rainfall pattern

The spatio-temporal distribution and magnitude of rainfall under the South-West monsoon in India influence the *Kharif* (summer) crop output, and in-turn has a bearing on the domestic sale of tractors in India. While it is intuitive to correlate a good monsoon year with strong tractors sale, the impact of monsoons on tractor industry is reducing with reducing dependence on rain-fed farming. Although the shift from rainfed agriculture to irrigated

farming has been gradual (50% of cultivated area in India is still dependent on rains), the percentage of area under irrigation is particularly high in states such as Punjab (98%), Haryana (88.5%), Uttar Pradesh (74.9%) and Bihar (63.1%), which also have large population of tractors in the country (Anonymous, 2014a). The rainfall, below average usually leads to increase in the prices of food grains, thereby reducing the impact on the farmers. Further, in case of delayed monsoon, there is a shift towards other *Kharif* crops with smaller crop cultivation cycles.

The ability of a farmer to invest in farm mechanisation is also contingent on the cash flows from the winter Rabi crop.

Fig. 5 shows that the growth in domestic sale of tractors has not exactly followed the performance of monsoons, as represented by all India area weighted rainfall. Notwithstanding, a weak (22% lower than long period average) and delayed monsoon in 2009-10, tractor sales were buoyant during the period; although after a period of subdued industry sales in 2008-09. Rainfall activity during the monsoon season

and post-monsoon season over the country as a whole was recorded deficit during 2014-15 and 2015-16, the domestic sale of tractors dropped by 22% during 2015-16 from the peak of 634,151 units in 2013-14. The key reason behind this decline is, two successive years of deficient monsoon followed by unseasonal rains, which have impacted the crop production and rural sentiment at large (Anonymous, 2016).

Average land holding

The number of land holdings in India is increasing during the last 40 years; however, the average land holding size has declined from 2.30 ha in 1970-71 to 1.15 ha in 2010-2011. The marginal (below 1 ha) and small (1 to 2 ha) farms constitute 85% of the total number of holdings and cultivate only 44.6% of the total area; whereas 14.3% semi-medium and medium farms (2 to 10 ha) account for 44.9% of the cultivated area and 0.7% of large farms (above 10 ha) account for 10.6% of the cultivated area (Anonymous, 2011). The relationship between average land holding size and tractors sale for the years from 1970-71 to 2015-16 is shown in Fig. 6. It is observed that even though the average land holding size reduced from 2.30 to 1.15 ha, the domestic sale of tractors increased from 37,839 to 545,109 during the period. This is due to increase in farm mechanization in Indian agriculture during the period. This is contrary to the popular belief that the benefits of tractorization can be availed by large farmers only. It has been observed that small and marginal farmers are quite open to adopt equipment for tillage, sowing, plant protection, harvesting and threshing etc. on custom hiring basis.

The state-wise relationship between tractor density and average land holding size is shown in Fig. 7. It was observed that there was direct positive correlation between tractor density and average land holding size for all the major states

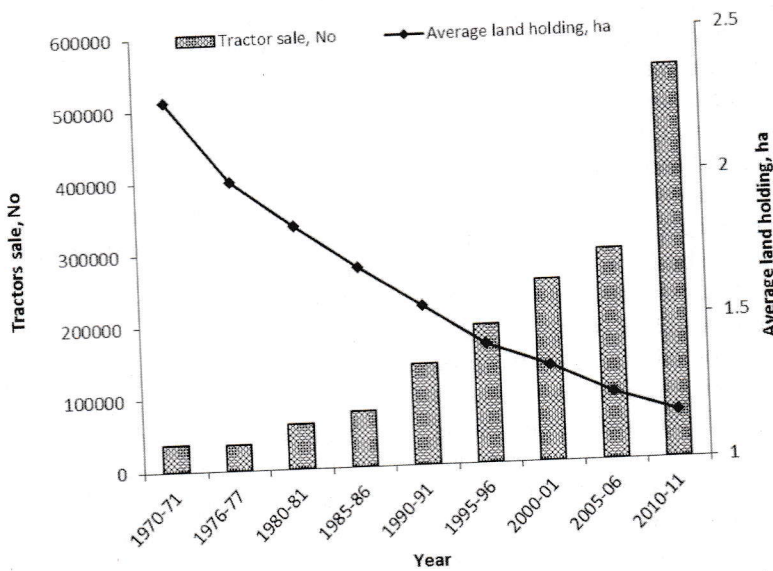


Fig. 6 Relationship between average land holding and domestic tractor sales

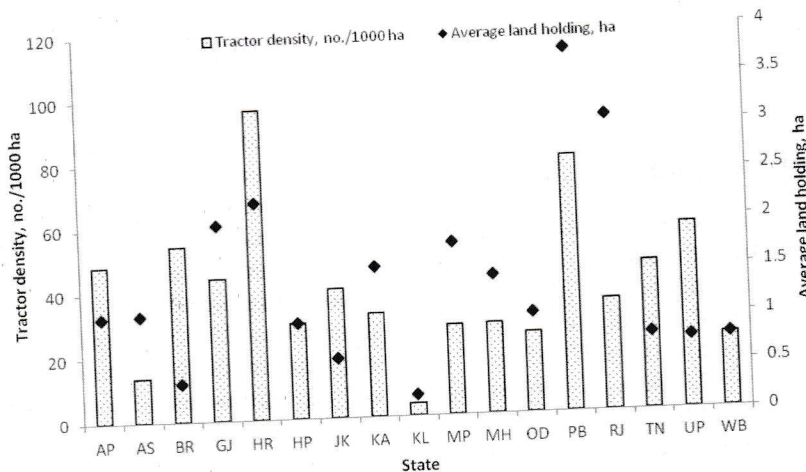


Fig. 7 Relation between tractor density and average land holding size in different states

expect Bihar, Jammu and Kashmir, Tamil Nadu and Uttar Pradesh. In these states, even though the average land holding size is small, the tractor density is high. This may be because of high tractor population density; use of tractors for non-agricultural purpose and increase in custom hiring of farm equipment etc.

Government intervention and policy

As the electricity to rural areas is subsidized for agricultural purpose in India, most farmers either individually or jointly have installed tube-wells wherever ground water is available. Exploitation of ground water and water from ponds and small reservoirs are the highest priority to increase agricultural productivity in rural areas. This is mainly done by farmers using supporting infrastructure made available by the government and necessary equipment, spare parts and maintenance provided by the private sector. With assured irrigation, farmers are able to plant high yielding variety (HYV) seeds and apply higher doses of fertilizers to get high yield. With the infrastructure assistance i.e. markets connected by rural roads and government procurement at minimum support price (MSP) of food grain, farmers are able to make reasonable profit and invest in mechanization to purchase tractors and other farm equipment. The mechanization in India was driven during initial years by assured price to farmers for their produce (wheat and rice). The rising wages of labors and maintenance cost of bullocks also contributed to higher viability of tractors and created the condition for diversification into high value crops. This helped in availability of mechanization services at competitive rates to small and marginal farmers. The benefits to smallholders could also be increased through tractor custom hiring services. There was a good growth in sale of tractors in

India due to favorable government policies for promoting machinery manufacturing in private sector by de-reserving it for small scale industries. The programmes of farm mechanization have resulted in adoption of farm machinery such as tractors, power tillers, combine harvesters, irrigation equipment, plant protection equipment, threshers and improved implements and hand tools.

The Government of India has also initiated programme like Sub-mission on Agricultural Mechanization (SMAM) with an estimated outlay of US\$ 350 million during XII plan. The objectives of SMAM are to increase the reach of farm mechanization to small and marginal farmers, promote custom hiring centres, create hi-tech, high value farm equipment hubs and create awareness among stakeholders (Anonymous, 2014b). Under mechanization component of the SMAM, there is a provision of subsidy of 40% for ownership of tractors restricted up to INR 75,000 (up to 20 PTO hp) and INR 0.10 million (above 20-70 PTO hp) for promoting agricultural mechanization. Different state governments of country offer top up subsidy for purchase of small tractors by farmers for use on their farm work.

The government's target to double farm income in five years will not only help in reducing volatility in sale of tractors, but also act as a catalyst to drive penetration of related implements.

Conclusions

The following conclusions can be drawn from the study.

- i. The sale of tractors in India increased at a compound annual growth rate (CAGR) of 10.3% from 3,877 units in 1961-62 to 633,656 units in 2013-14.
- ii. The domestic sale of tractors is the highest (43%) for the 31-37 kW power range and followed by 36%

for the 23-30 kW power during 2015-16. The requirement of high power category tractors in India increased for using high capacity farm machines on a custom hiring basis.

- iii. The states of Uttar Pradesh, Madhya Pradesh, Rajasthan and Maharashtra together accounted about 40% of the total tractor sale in India during 2015-16.
- iv. The tractor availability per 1,000 ha of net sown area is more than all India average tractors/1,000 ha in seven states: Haryana, Punjab, Uttar Pradesh, Bihar, Tamil Nadu, Andhra Pradesh and Gujarat.
- v. There was a positive direct relation between available tractor power and food grain production for all the major states except Assam and West Bengal.
- vi. There was direct positive relation between tractor density and average land holding size in all the major states except Jammu and Kashmir, Tamil Nadu and Uttar Pradesh.
- vii. The percentage sale in tractors of less than 15 kW power was highest in Gujarat (20.7%), followed in Maharashtra (14.2%) and Kerala (14.2%) states. 77 states used the tractors for agricultural and spraying operations in horticultural and cash crops.

REFERENCES

- Anonymous. 2011. Agricultural Census 2011. Department of Agricultural and Cooperation, Government of India.
- Anonymous. 2009. Report, National Commission for enterprises in unorganised sector.
- Anonymous. 2013. State of Indian Agriculture 2012-13, Department of Agriculture and Cooperation, Directorate of Economics and Statistics, Government of India, New Delhi.
- Anonymous. 2014a. Annual Report

- 2013-2014. Department of Agriculture and Cooperation, Ministry of Agriculture, Krishi Bhawan, Government of India, New Delhi.
- Anonymous. 2014b. SMAM operational guidelines (12th Five Year Plan) Mechanization & Technology Division, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.
- Anonymous. 2016. Mahindra & Mahindra Ltd. Annual Report 2015-16, 264.
- Avallio, E., E. Ferrari, L. Bollani and M. Coccia. 2014. Attitudes and behaviour of adopters of technological innovations in agricultural tractors: A case study in Italian agricultural system. *Agricultural Systems*. 130: 44-54.
- Boel, H. and V. Kumar. 2013. Kotak Institutional equities research-automobiles sixth gear. *BSE-30:19* (581): 1-32.
- Chikhar, N. and T. B. Pedersen. 2011. Flexible exchange of farming device data. *Computer and Electronics in Agriculture*. 75 (1): 52-63.
- Jain, R. C. 2006. Tractor Industry in India – Present and Future. Paper presented at roundtable forum for regional agricultural machinery manufacturers and distributors associations, Seoul, Korea, 22-23.
- Mehta, C. R., N. S. Chandel, T. Senthilkumar and K. K. Singh. 2014 a. Trends of Agricultural Mechanization in India. *CSAM Policy Brief*, 2, 1-13.
- Mehta, C. R., N. S. Chandel, and T. Senthilkumar. 2014b. Status, challenges and strategies for farm mechanization in India. *Agricultural Mechanization in Asia, Africa, and Latin America*. 45(4): 43-50.
- Panin, A. 1995. Empirical evidence of mechanization effects on smallholder crop production systems in Botswana. *Agricultural Systems*, 47 (2), 1: 99-210.
- Renpu, B. 2014. Analysis of the Trends of Agricultural Mechanization Development in China (2000-2020). *ESCAP/CSAM Policy Brief*. 1: 9.
- Sarkar, A. 2013. Tractor Production and sales in India, 1989-2009. *Review of Agrarian Studies*. 3(1): 55-72.
- Singh, G. 2000. Growth pattern and performance characteristics of tractors used in India. *Landwards*. 55(1): 17-25.
- Singh, G. 2006. Estimation of a mechanisation index and its impact on production and economic factors – a case study in India. *Biosystems Engineering*. 93 (1): 99-106.
- Mandal, S. K. and A. Maity. 2013. Current trends of Indian tractor industry: a critical review. *Applied Science Reports*. 3 (2): 132-139.
- Van den Berg, M. M., H. Hengsdijk, J. Wolf, M. K. Van Ittersum, W. Guanghuo and R. P. Roetter. 2007. The impact of increasing farm size and mechanization on rural income and rice production in Zhejiang province, China. *Agricultural Systems*. 94 (3): 841-850.

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- Ekri, S. 2008. "Using economic incentives and regulations to reduce seawater intrusion in the Batinah coastal area of Oman." *Agricultural Water Management* 95(3): 243-252.
- Tawoos LLC. 2017. Tawoos Agricultural Systems LLC, retrieved in Jan 2017. <http://www.tawoos-agriculture.com/>
- World Bank. 2013. *World Development Indicators 2013*, The World Bank, Last updated date 09/23/2013, <http://wdi.worldbank.org/table/3.2#>

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