CHAPTER I

INTRODUCTION

India's well-orchestrated Green Revolution began in the mid sixties. It was ushered in through the adoption of high yielding varieties, use of balanced doses of chemical pesticides and fertilizers, expansion of irrigation facilities. The increased use of the above purchased inputs in agriculture necessitated to raise their use efficiencies through mechanization. The increase in the use of human and bullock labour and rising wage rates and cost of up-keep of bullock further made the case of farm mechanization still stronger. Agricultural machinery, particularly tractorisation helped the farmers to go for timely land preparation and sowing of crops and intensive cultivation.

Agriculture, being seasonal in nature requires all the operations to be completed during specific times leading to the shortage of human labour during the peak work load periods. The crop pattern has undergone fast changes in favour of labour intensive crops like paddy and wheat. Increase in the area under cultivation, cropping intensity and increased application of higher and split dozes of fertilizers have further enhanced the labour use in state agriculture. The seasonal index of labour use was as high as 196.1 in October and as low as 44.3 in March 2004-05 leading to over employment/under employment of agriculture labour at different points of time in a year (Singh and Singh 2006). Owing to the implementation of Mahatma Gandhi National Rural Employment Guarantee Scheme, wages for labour throughout India have gone up leading to scarcity of farm labourers for performing agricultural operations (EPWRF 2003). The shortage of labour creates problems for the farmers to perform various farm operations in peak periods. The use of tractors, therefore, became indispensable for making an optimal use of other resources and timely performance of various farm operations.

India has already crossed the state of self-sufficiency in food grain production and been marching ahead with surplus stocks. However, the per unit production costs of food grains are still so high even after crossing self sufficiency in food grain production, unless there is price support mechanism, farmers cannot get a reasonable price which would cover their expenses on crop production. This can be mainly attributed to low productivity levels and inefficient production and input management systems. Besides, with the trade liberalization, free entry of agricultural imports into the domestic market, may create a severe competition with their low prices. Such a situation necessitates looking for alternative production systems which are not only cost effective but also more productive. Mechanisation seems to be suitable option, which in addition to the timely carrying out operations thereby helping out in increasing yields and reducing the per unit cost of production (Rao 1972). Though the mechanisation of agriculture started way back, along with the introduction of

green revolution technology, it is mainly restricted to irrigated areas. Increased irrigation facilities coupled with short duration crop varieties had intensified the crop production thereby necessitated the quicker completion of farm operations by mechanisation. Thus, cropping intensity and irrigation facilities proved to be the most important factors determining tractorisation. Hence, the tractorisation which is the basis of farm mechanisation became very crucial for further development of agriculture, because the time saved, in completing different operations well in time gives the crop more time to mature, affords the farmer to be more flexible in his farming operations and facilitates multiple and relay cropping.

Though it has been widely recognised that mechanisation in general and tractorisation in particular has played a revolutionary role in modernisation of agriculture, still tractorisation has been a controversial issue with regard to its impact on production, productivity, human employment and more importantly regarding the economic rationale of investment in farm machinery. A brief review of literature on the issue highlighted that some studies concluded that tractorisation has displaced human labour and created unemployment. The share of agricultural workers continuously declined since 1981 and expected to be only 5.09 per cent by 2011-12 and that of draught animal power from 27.23 per cent to 6.37 per cent in 2011-12. The increase in power has been mainly through introduction of tractors, whose contribution has increased from 7.5 per cent in 1971 to 51.08 per cent in 2011-12 (Kulkarni 2011). While other showed that tractorisation shifted cropping pattern in favour of more intensive crops and therefore, created additional employment. As a study conducted on tractorised and non-tractorised farms in nine States of India revealed that tractor-owning farms had a higher cropping intensity of 137.5 per cent as compared to 131.8 per cent in the case of those without a tractor and thereby creating additional employment opportunities (NCAER 1974).

The tractor penetration level in India has been very slow and not remained uniform throughout the country. Punjab, Haryana and western UP constituted the major Tractor market in 1980's with 55-57 per cent 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 per cent in early 1990's to 30-32 per cent by the close of the decade. The share of eastern states, namely Bihar, Orissa, West Bengal and Assam had been consistently low at 35 per cent 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 per cent 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 per cent in 1990, had increased to around 25 per cent in 1997 when the farmers suffered on account of uneven monsoons, poor cotton crops, etc. This region is expected to contribute more than 30 per cent 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 (Jain 2006). Although the controversy of tractorisation, its form and extent, stands unresolved, yet there has been consistent increase in the demand for tractors in the country as well as in Punjab. The number of tractors increased from 0.1 million in 1971 to 2.7 million in 2004 and increased to 5.8 million in 2011-12 in the country. Whereas, the numbers of tractors in Punjab were 0.047 million in 1974-75 to 0.33 million in 1993-94 which further increased to 0.52 million in 2011-12 (GOP 2012). Therefore it becomes pertinent to examine the factors responsible for this consistent increase in the number of tractors both in India as well as Punjab.

In this context of new challenges and changing order in the tractor industry, an extensive research is needed to understand the growth pattern, factors governing them. The present study is carried out in this regard with these specific objectives:

i. To assess the growth and distributional pattern of tractors in leading agricultural states of India;
ii. To identify the various factors influencing the demand for tractors in India as well as in Punjab; and
iii. To project future demand for tractors in the country as well as in Punjab state.

Limitations of the study

The present study is subject to following limitations:

1. Farm income/ unit of area could also be an important variable in determining the demand for tractors but the same is not included among explanatory variables because of the non- availability of data for such a long period.
2. The weighted average price of tractor would have been a better variable but the same could not be included as the model-wise data on number of tractors were not available.
3. Credit is one of the important factors which influence the demand for tractors. But data on loan advanced for purchase of tractor in India were not available and for Punjab too, the loan advanced by one financial institution i.e. Punjab Agriculture Development Bank has been taken into account as a proxy to the total loan advanced by all the financial institutions for the purchase of tractors.

CHAPTER II

REVIEW OF LITERATURE

With a view to evaluate the objectives of the study, it was considered desirable to have an idea of the findings of some of the studies conducted earlier by the researchers and the methodology adopted by them. This chapter deals with such reviewed articles published in this area of study. Consistent with the objectives of the study, the review of literature is presented under the following sub heads:

2.1 Growth and Distributional pattern of tractors

2.2 Factors influencing the demand for tractors

2.3 Projection of demand for tractors

2.1 Growth and distributional pattern of tractors

Saxon and Hinkley (1965) analysed the growth pattern of tractors in Australia. The total number of tractors in Australia was also estimated. The study revealed that the total number exceeded 2.8 lakhs but it was observed that the rate of increase in tractors was declining overtime. This decline happened due to the fact that demand was primarily for replacement. The study concluded that demand for tractors in Australia had almost reached to a saturation point and tractor number would be stabilized at around 3 lakhs.

Fox (1967) estimated demand for farm tractors in United States. A single equation regression model was used to explain aggregate tractor horse power purchased for United States between 1920 and 1962. Total farm power available to the farmers increased from about 40 million horse power in 1920 to 385 million horse power in 1962. Tractor horse power purchases were expressed as a function of economic, technological and personal preference variables. The author included crop production, ratio of tractor prices to prices received for products sold, size of new tractors purchased, age of tractors and number of farms. Both short run and long run elasticities were estimated by considering the influence of earlier time periods. The elasticity of demand for tractor purchases with respect to the real price of tractors ranged between 1.7 to 2.7.

Rayner and cowling (1968) conducted the econometric studies to compare the demand for tractors in United States and United Kingdom. The study brought out the relative importance of various factors that differed greatly in two countries. Four studies of tractor investment in the United States and one study of investment in farm tractors in United Kingdom had been the real price of tractors relative to farm wages and in United States, it appeared to be the price of tractors relative to crop prices. It was observed that farm size changes had affected the use of tractor stock in United States and consequently, the demand for tractors, whereas in United kingdom farm size variable was non significant. Other major factors that caused the differences in investment behaviour in two countries were found to be

the farm size variable non significant. Other major factors that caused the differences in investment behaviour in two countries were found to be the farm size, government policy toward agriculture and labour cost. The study concluded that in the long run, demand for tractors in United Kingdom was likely to become more like that in United States as labour costs became less important in the production expense budget and increased the farm size.

Nieuwoudt (1973) studied the demand for tractors and lorries in South Africa. The study revealed that the number of tractors in South Africa increased from 1,300 in 1926 to about 1,50,000 in 1968. Tractors per farm in the north western state increased from 0.7 in 1945 to 4.7 in 1966-67. An attempt was also made to estimate the demand for tractors empirically and the factors contributing to this mechanization process.

Sisodia (1973) investigated the trends in farm mechanization in Madhya Pradesh. The study also examined growth and distributional pattern of tractors for the period 1956-57 to 1969-70. It was found that there had been substantial increases in the number of tractors in the state and the number which was 1,311 in 1956-57, increased to 3,544 in 1969-70. District-wise analysis showed that tractor population recorded a significant increase in almost all the districts, and seven districts accounted for more than fifty per cent of the total tractor population in the state during 1969-70. The study further revealed that the growth rate of tractors was highest during the first quinquennium i.e. 1956-1961. Indore district recorded the maximum growth rate during this period. It was observed that in terms of gross cropped area, the number of tractors per 10,000 acres of gross cultivated land increased steadily from 0.30 in 1956-57 to 0.70 in 1969-70. The study concluded that although the tractor population recorded a sharp rise in absolute number but in terms of average area covered, the progress was still insignificant.

N.C.A.E.R (1974) studied the demand for wheeled tractors during the fifth plan period. A single equation model was used to estimate the stock demand of tractors for 1973-74 and 1978-79. The variables tried in the model were relative price of the tractor, irrigated area, agricultural production and gross cultivated area. The study projected the stock demand level between 2.42 and 2.44 lakh tractors. Further, the annual demand for 1973-74 was estimated at 38 to 40 thousand units rising to about 79 thousand by 1978-79.

Conley and Lambert (1981) studied the demand for tractors in IIIinois. The study used single equation demand model to estimate the farm tractor purchases. The factors which affect the demand for farm tractors were also examined. Real price of tractors, acres planted, the number of self-propelled combines and time were found to be significant variables. Various measures of income and interest rates were also tried but these variables were found to be non significant.

Umesh and Mathew (1990) studied the growth in production, imports and sales of tractors in Indian agriculture over the period 1960-61 and 1987-88. The study revealed that

tractorisation had proceeded much faster in states such as Punjab and Haryana which have gone through green revolution while many other states had not made much progress.

Chatha and Grewal (1991) conducted a study on tractorisation in Punjab. It was observed that there had been consistent increase in the number of tractors which was only 2,902 in 1955-56 increased to 2.60 lakh during the last three decades. The number of tractors which was only 2,902 in 1955-66 increased to 2.60 lakh during the period 1989-90. The overall compound growth rate during the period 1955-56 to 1989-90 was 15.16 per cent per annum. The intensity of tractorisation was found to be the highest in Punjab i.e. the area operated through tractors in Punjab was estimated to be 60 per cent of the total cultivable area while in Haryana and Uttar Pradesh it was 38.05 and 10.69 per cent of the total cultivable land. The overall intensity of tractorisation in the country was quite low being 5.62 tractors per thousand hectares of the cultivable land. The district wise distribution of tractors for the year 1987-88 was also examined. The study revealed that tractor population in different districts was quite skewed and it varied between 37.73 and 84.61 per thousand hectares of cultivated land in Gurdaspur and Ludhiana districts respectively. The growth pattern of tractorisation for the previous period was analyzed and used for estimating the future demand for tractors in the state. The demand projections showed that demand for tractors in the state during the year 2000-01 and 2030-31 would be 4.10 lakhs and 5.60 lakhs respectively. The study concluded that the saturation point of the demand for tractors would be reached sometime during the period 2010-11 to 2025-26 and afterwards only the replacement demand would continue which worked out to be around 25 to 32 thousand tractors annually.

Kumar *et al* (1995) conducted a study to determine the pattern of farm mechanization in Punjab. The study observed that there had been a steady increase in the population of tractors and the number of tractors which were 13,320 in 1967 increased to 2, 75,000 in 1992. Growth of tractors was observed to be maximum i.e. 209 per cent during 1967-72. However, in absolute terms, highest increase in number was seen during 1987-1992. The maximum annual growth in tractors during 1967-72 was attributed to up rise of wheat high-yielding variety seeds in Punjab; however, the latest increase in tractors was due to steady adoption of mechanized field ploughing by small and marginal farmers by hiring-in tractors.

Grover and Sharma (2000) conducted a study on growth and distributional pattern of tractors in leading states of India. The results revealed that the tractors in the country increased at a rate of 17.06 per cent per annum during period I (1974-75 to 1983-84) but the rate of growth declined to 10.41 per cent in period II (1984-85 to 1994-95). The overall annual rate of growth was observed to be 12.49 per cent. State –wise analysis showed that during period I, the maximum growth rate of 24.13 per cent was recorded for Haryana followed by Madhya Pradesh (21.48 %) and Uttar Pradesh (19.34 %). The growth rate in Kerala (1.98 %) was minimum. During the period II, Rajasthan attained the maximum growth

rate of 19.42 per cent followed by Madhya Pradesh (17.00 %) and Andhra Pradesh (10.89 %). The minimum rate of growth was observed for Tamil Nadu (1.69 %). The overall picture of two decades indicated that Madhya Pradesh recorded the highest rate of growth (17.66 %) followed by Haryana (17.31 %) and Rajasthan (13.81%). The rate of growth was the lowest in Tamil Nadu (2.93 %).Thus, two clear cut observations from the study were, firstly, the rate of growth of tractors was observed to be higher in those states where there was low level of tractors (absolute number) in the base period. Secondly, the growth of tractors, in general, was higher during the period I as compared to period II. This dramatic rise in the rate of growth of tractors during the period I was attributed to the green revolution and new technology.

Raghuram (2000) conducted a case study on logistics of tractor. The results revealed that during the late 1990's, tractor markets in the northern region of the country reached a saturation point, with growth rates in Punjab, Haryana hovering around 1-2 per cent. The northern states of India Punjab, Haryana and Uttar Pradesh accounting for 44 per cent of total sales compared with 54 per cent in early 1990's.

Evcim *et al* (2005) conducted a study on Machinery situation of Turkish agriculture. The results revealed that in 1952 there were 31,415 tractors in Turkey. This number reached 997,620 in 2003. However, this number is still low when compared to the developed countries. In this 50-year period, improvements in these numbers were slow in the first 20 years, in the following 30 years, domestic tractor manufacturing increased rapidly.

Bhalla (2007) conducted a study on Tractor market in India. The study observed that the tractor market in India has grown at a compound annual growth rate (CAGR) of 5.81 per cent since 1989-90. Its growth during the period 2004-05 to 2006-07 has been quite impressive i.e. 18.79 per cent. The emerging market with tremendous growth potential are states like Maharashtra, Andhra Pradesh, Tamil Nadu, Gujarat, Karnataka, Rajasthan, Orissa and West Bengal, all of which has CAGR value much higher than the All India value. The tractor sales in Bihar & Madhya Pradesh have sharply fallen during the period 2004-05 to 2006-07. The study concluded that the tractor industry should pay special attention to the potential buyers expectation regarding tractors features like good style and appearance, state-of-the-art technology, higher comfort level, fuel economy and effective after sale service. The marketing approach for growth of tractor industry includes focus on customer needs and their satisfaction, combined marketing of tractor and innovative matching farm machinery and follow up of rural marketing sale promotion techniques.

Singh and Rangi (2008) conducted a survey on Marketing System and Market Structure for Second hand Tractors in Punjab. Out of 600 farmers, 295 tractors were owned by 292 farmers, of whom 137 had purchased second hand tractors, i.e. there was a ratio of 54: 46 between new and second hand tractors On an average about 25,000 new tractors are sold in

Punjab; in a good crop year, this number may even cross 30,000, while in a bad (failure) crop year, it may come down to 10,000 only.

Singh and Singh (2011) conducted a study on sale trends of tractors and farm power availability in India. The study revealed that the tractor growth in the country in terms of production and sale was many folds. A tractor could be found after every 36 ha cultivated area in span of 60 year. Current trend of sale of Indian tractors indicated that about 9.3 per cent tractors (< 20 HP, 21-30 HP, 41-50 HP and > 51 HP) are exported. Within the country, sale of different hp range of tractors indicates the highest share (46.2 %) is of 31-40 HP tractors followed by 27.62 per cent of 41-50 HP, 13.83 per cent of 21-30 HP, 11.61 per cent of above 51 HP and 0.75 per cent less than 20 HP tractors. Sale trend of tractors less than 20 HP range revealed that the Maharashtra has highest share (65.1 %) followed by Gujarat (19.8 %), Karnataka (6.9 %), Tamil Nadu (2.7 %) and Madhya Pradesh (2.2 %). Of total sale of 21-30 HP range tractors in the country, Uttar Pradesh is having the largest share (36.2 %) followed by Bihar (16.6%), Haryana (11.3 %), Madhya Pradesh (9.0 %) and Gujarat (6.2 %). In 31-40 HP range of tractors, again Uttar Pradesh ranked first (16.2%) followed by Madhya Pradesh (14.7 %), Gujarat (10.5 %), Rajasthan (9.9 %) and Andhra Pradesh (9.3 %). So for as the sale of higher HP (41-50 HP) was concerned, Punjab stand first (14.8%) followed by Maharashtra (14.4 %), Madhya Pradesh (12.5 %), Uttar Pradesh (10.5 %) and Haryana (9.9%) of tractors of above 51 HP range was found highest again in Punjab (27.0 %) followed by Uttar Pradesh (13.4%), Maharashtra (12.3 %), Madhya Pradesh (8.7 %) and Haryana (8.6 %). This indicates the farmers' inclination towards high range of power.

Bhalla and Singh (2012) conducted a study on state wise density of tractors. States like Punjab, Haryana and Uttar Pradesh showed the highest tractor density with 79,56 and 47 tractors per thousand hectares of net area sown. The lowest tractor density was showed by the states like Assam, Orissa and West Bengal with 0.5,3 and 4 tractors per thousand hectares of net area sown. Thus clearly showing the regional disparities that exist in the level of tractorisation in the country.

Sarkar (2013) conducted a study on Tractor production and sales in India (1989-2009). The growth in production of tractors is divided into three phases: a phase of high growth from 1989–90 to 1997–98, followed by a phase of recession between 1998–99 and 2003–04, and, finally, a recovery phase from 2004–05 to 2009–10. These three phases of growth correspond roughly to three phases of change in India's agrarian economy. An analysis of tractor sales across Indian States showed that growth was more rapid in States with an initially low level of tractorisation, resulting in a decline in the concentration of sales over time. In particular, growth declined or was even negative in Punjab, Haryana, and Uttar Pradesh, while it rose in states from the south, east, and west of India. In the early 1990s (1990–91 to 1994–95), Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, and Rajasthan were

the top five States in terms of average sales of tractors per year, but by the late 2000s (2004–05 to 2009–10), Punjab, Haryana, and Madhya Pradesh had been replaced by Andhra Pradesh, Maharashtra, and Gujarat in the list of the top five States.

2.2 Factors influencing the demand for tractors

Hochstein (1969) examined the factors determining demand for tractors in West Germany. The study used both monetary and physical variables in the multiple regression analysis. The important factors were found to be the price of tractors or price per horse power, 'indebtedness of agriculture' as a measure of the future availability of borrowed capital, the average age of tractors in current use as an index of market saturation, the index of the size structure of farms, the index of agricultural wage as the price of the substitute labour etc.

Naidu and Rao (1977) studied the trends in farm mechanisation in India and the variables associated with it. It was observed that there was a dramatic rise in the number of tractors during the period of mid-sixties due to Green revolution. Tractorisation was found to be positively correlated with variables such as double cropped area to percentage of net area sown, percentage area irrigated to the net area sown, percentage area under high yielding varieties to the net area sown, percentage area of holding with more than twenty hectares to net area sown, wages of agricultural labour and annual growth rate of agricultural output. However, there was a negative correlation of tractors with agricultural labour per 100 acres of net area sown. The study revealed that in tractorisation, Punjab and Uttar Pradesh occupied the top positions. It was observed that tractorisation was significantly associated with higher levels of high-yielding varieties and HVY's were positively correlated with irrigation. Thus, the interaction between tractors high yielding varieties and irrigation had led to the observed association between tractors and rate of growth of agricultural output.

Sandhu (1977) examined the growth and determinants of tractorisation in Punjab. The study revealed that the number of tractors in the state increased 12 times over a period of about one and a half decade i.e. 1961 to 1975. The growth of tractors during the period was the highest in Amritsar (26 times) and the lowest in Faridkot district (6 times). Rank correlation of tractor density with some important variables was established and found that the variables such as rural literacy, irrigation and cropping intensity, whose significance in determining tractorisation was not clear under static technology, became important in the context of dynamic technology.

Singh (1979) studied the growth pattern of tractorisation in different districts of Punjab during the years 1960-61 to 1976-77. The study revealed that the annual growth of tractors was 24.57 per cent in the period 1961-66 which increased to 45.75 per cent during 1966-72 and again declined to 16.49 per cent during the period 1972-77. Ropar district witnessed the highest annual growth rate of 87.69 per cent during 1961-66 whereas; Gurdaspur district attained the maximum growth of 135.54 per cent during 1966-72. Tractor

density, which was quite low being 1.31 per cent prior to Green Revolution, moved up to 18.03 per cent in 1976-77. Important determinants of tractorisation were studied using both rank correlation analysis. The study concluded that variables such as farm size distribution, agricultural productivity, irrigation, rural literacy, and wages of agricultural labour were positively correlated with tractor density and draft animal density. The projections revealed that the stock of tractors would be in the range of 1.4 to 1.6 lakhs tractors at the end of 1990-91, keeping in view the given level of technology.

Singh and Jain (1981) estimated the utilisation of tractor on an average farm in Punjab. It was observed that the utilisation of tractor was positively correlated with the irrigation facilities by 25 per cent could lead to an increase in the tractor use by about 6 per cent and when irrigation facilities were doubled, the tractor use increased to about 9 per cent. The study concluded that the tractor density was higher in those areas where relatively more irrigation facilities were available.

Stock *et al*. (1982) studied the demand for tractors in Brazil. The main determinants of tractorisation were also examined. The study used simple models to determine role of agricultural income the study used simple models to determine role of agricultural income, the prices of modern and traditional inputs and of other factors in explaining the demand for investment and stocks were price-inelastic, however, both demand for investment and stock were income elastic and it was observed that labour and tractors were substitutes in short run.

Singh and Singh (1983) studied the determinants of tractorisation and their changing significance over time in Punjab. Econometric model was fitted to estimate the demand for tractors in the state. The agricultural productivity and the labour force were found to be the important variables in the estimation of demand for tractors in the state. However, the influence of variables such as price of tractors and irrigation was low. It was estimated that the stock of the tractors in Punjab by the end of the century would vary between 1.70 to 2.40 lakhs. The annual absorption of tractors would lie in the range of 10,000 to 16,000 which was considered quite compatible with the growth of labour force and agricultural productivity.

Mui (1984) studied the factors affecting the demand for new farm wheel tractors in USA in terms of total tractor horse power. A mixed multiple time series analysis–econometric approach was employed. The study indicated that the rate of interest and lagged quantity demanded were among others, important factors affecting the demand for farm tractors. The results also showed that all the identified factors, except cash receipts from selling crops, had distributed lag effects on the demand.

Gajja *et al* (1985) carried out study on the determinants of tractorisation in arid areas of Western Rajasthan reported that the agricultural productivity, size of holding, labour density, draught animal density and rural literacy were important factors that had a positive impact on the tractorisation in the area. It was suggested that a concrete policy to provide

sufficient tractors would help to increase agricultural productivity without replacing human labour and draught animal power in arid districts of Western Rajasthan.

Vanzetti and Quiggin (1985) conducted a study on the investment in tractors. This study used an implicit rental price approach to analyse the determinants of farm tractor investment at the aggregate level. Three models were compared and it was observed that variation in the rental price of tractors appeared to have less effect on demand than variation in factors affecting the profitability of the cropping enterprise as a whole.

Sethi (1992) examined the optimum land use pattern and normative demand for tractors in Punjab. The existing pattern of six synthetic farm situations in the selected villages of Ludhiana district was analysed. These farm situations were classified according to farm size and tractor hiring/ ownership and normative plans were developed, using linear programming technique. The study revealed that all the six farm situations were operating close to normative level. For the tractor hiring farm situation, the tractor hiring decreased by 4.98 per cent over the existing plan in the normative plans, however, on the tractor owned farm situations the percentage increase in tractor hours use over the existing plan came to be 4.15. On the whole, it was concluded that the normative requirements of tractor use were marginally higher than the existing tractor use and tractorisation in the area had reached a point where it could meet the normative demand for tractor use. It was also observed that the adjustments to tractor density in the region of study had almost reached a saturation point and the demand for tractors in such a case would be mainly for in terms of replacement of tractors.

Singh (1992) studied the growth of tractorisation and the factors associated with inter-district variation in tractorisation and Projections of demand for tractors were carried out. The study revealed that number of tractors in Punjab increased from 10.636 in 1965-66 to 2, 75,000 in 1990-91. The annual growth rate in the number of tractors which was 14.08 per cent during the period 1972-77 increased to 26.60 during 1977-83 and again declined to 11.02 per cent during the period 1983-1989.in this period (1983-89) Ropar district attained maximum growth rate. The tractor density in the state increased from 10 per thousand hectares in 1971-72 to about 60 per thousand hectares in 1988-89. The inter-district tractor concentration revealed that the intensity of tractor population was largely correlated with the availability of irrigation facilities and the districts with more intensity of irrigation had higher concentration of tractors.

Singh and Jindal (1993) conducted a study to find out the various aspects of utilization of existing tractors in Punjab agriculture. The study revealed that more than 80 per cent of the tractor use was made for productive purposes on the own farms and 8.09 per cent of its total use was made for custom hiring work while 6.60 per cent of its use was made for social purposes. It was found that tractor use was dependent mainly on the cropping pattern of

the area, farm size, type of soil, cropping intensity etc. and nearly 30 per cent of its use was made for ploughing operation alone. Marketing, planking and sowing together also accounted for about one third of the total use.

Pawlak (1999) conducted a study on impact of some selected factors on the sale of agricultural tractor. Single- and multiple-variable regression methods were used to survey the demand for agricultural tractors on the Polish market. The results showed that the demand for tractors depended mostly on the real income from agricultural production. During the period 1989–1997 a change in income level by one percentage point caused a drop or an increase in the sales of about 890 brand-new agricultural tractors per year. The effect of changes in the value of commercial agricultural production was much less evident.

Pingali (2004) revealed that the formal credit plays a major role in financing the purchase of machinery. Investment in machinery such as tractors and pump sets constitutes a major component of private investment in agriculture. Nearly 95 per cent of purchases of mechanised power in India were through loans taken from banks and agricultural institutions. A decline in agricultural credit, along with higher interest rates, is likely to have an adverse effect on tractor purchases.

Singh (2004) revealed that as the price of tractor is very huge and this makes credit as an important determinant of tractor sales as 80-90 per cent of the total tractor sales are due to bank credit.

Sarkar (2013) examined the factors affecting the growth in tractor sales are many, but has examined two in detail: long-term (direct) credit for agriculture from scheduled commercial banks and public investment in agriculture. It was found that changes in these two have had a positive and significant effect on the growth of tractor sales. Further, during the 2000s, exports grew rapidly and export demand boosted domestic manufacturing.

2.3 Projection Of Demand For Tractors

Soto *et al* (1989) developed a methodology to estimate the evolution of the farm tractor stock in Chile based on annual import reports and estimation of the appropriate normal distribution describing tractor replacement. The expected tractor life was about 16 years, far longer than official estimates. Their estimation of the tractor demand function was made with fewer than two hypotheses about the adjustment process between the desired and actual stock (‘fixed’ and liquidity-constrained, or ‘variable’, with adjustment for growth). Although both models found price and interest rate elasticity to be quite low (except for the long-term interest rate elasticity), the variable growth model estimation proved to be a better approach to the tractor demand analysis because it gave an understanding of the crucial role played by liquidity constraints. The fixed-speed model found a mean adjustment period of 6.2 years, while the variable speed model found that it ranks from 4.8 to 9.5 years.

Singh (1992) studied the growth of tractorisation and the factors associated with

inter-district variation in tractorisation. Projections of demand for tractors were also made. The study revealed that number of tractors in Punjab increased from 10,636 in 1965-66 to 2, 75, 000 in 1990-91. The annual growth rate in the number of tractors which was 14.08 per cent during the period 1972-77 increased to 26.60 per cent during the period 1977-83 and again declined to 11.02 per cent during the period 1983-89. In this period (1983-89) Ropar district attained maximum growth rate. The tractor density in the state increased from 10 per thousand hectares in 1971-72 to about 60 per thousand hectares in 1988-89. The inter- district tractor concentration revealed that the intensity of tractor population was largely correlated with the availability of irrigation facilities and the districts with more intensity of irrigation had higher concentration of tractors. Rank correlation analysis indicated that agricultural productivity and irrigation were important determinants of tractorisation. The study brought out that the total annual demand for tractors would vary from 15000 to 17000 during the period 1988-89 to 1994-95 to 2000-01.

Cooper (1994) examined investment in agricultural tractors in United States and compared econometric models of investment. A net investment series was calculated from quality adjusted gross investment figures which showed limited negative net investment over time but with substantial variability. Four time series modelling techniques were compared as representations of the demand for tractors over the period 1964-90. The study brought out that future expectation of agricultural policy had major influence on investment.

Sharma and Grover (1998) conducted econometric studies to forecast demand for tractors in Punjab. The studies showed demand to be 4,14,115 and 9,90,435 tractors in the years 1997-98 and 2024-25 respectively. The corresponding required supply was worked as 4,22,397 and 10,10,244 tractors in the years 1997-98 and 2024-25, respectively.

Grover and Sharma (2000) estimated the future demand and required supply of tractors in the country. The demand projections showed that the total demand in India during coming years would vary between 17.01 lakh tractors in the year 1997-98 to 22.58 lakh tractors in 2024-25. Keeping in view the errors in estimation of demand for tractors the required supply of the tractors was worked out to be 17.35 lakh tractors in the year 1997-98 and 23.03 lakh tractors in the year 2024-25.

Unakitan and Akdemir (2007) studied demand projection in Turkey. In this study, data of the tractor stock for the 1961-2003 time series were used in this model. The data were taken from the statistics of Food and Agricultural Organisation (FAO 2005). The study showed that the number of tractors in Turkey that was around 40,000 in the 1960s increased to one million in 2003, an annual growth rate of 2.05 per cent. An autoregressive integrated moving average (ARIIMA) univariate model was used to predict the tractor demand. The trend of the tractor stock was calculated by using coefficients of the model for 2004-2015. According to the model result, the demand may vary between 13,000 and 15,000 tractors per

year, with an accumulated stock of 1.183 million by 2015. According to model results, the tractor stock will increase at a reducing rate in Turkey. One of the most important reasons for the decreasing rate of tractor demand is the decrease in the active population dealing with the agricultural sector. While 75 per cent of the active population was employed in agriculture in the 1950s, in recent years this percentage has gone down to 35 per cent. The other causes of this result are the loss of attraction in agriculture due to economic problems, increasing number of holdings and decreasing size of the fields due to inheritance laws. These results show that the tractor market will become narrow.

Kim *et al* (2013) developed methodology for the demand forecast of tractor, riding type rice transplanter and combine harvester from 2012 to 2021 in South Korea using exponential smoothing model and an ARIMA (autoregressive integrated moving average) model. In this study, an ARIMA model for forecasting the demands of tractor, riding type rice transplanter and combine harvester were constructed and the demands of three machines from 2012 to 2021 was forecasted. Two kinds of series, supply series and stock series of each machine, were used for the forecast. ARIMA models were constructed by following the three stages: Identification, estimation and diagnosis. The forecasted tractor demand by using supply series was 14,217 in 2012 to 14,361 in 2021, that of riding type rice transplanter 5,104 to 5,330, and that of combine harvester 3,261 to 3,834. The three demand series forecasted by using the supply series commonly showed slow increase and a fluctuation with two-year period. It could be caused by the order of the ARIMA model. The forecasted demand of tractor by using stock series was 12,632 in 2012 and 13,606 in 2021, and that of combine harvester was 5,948 in 2012 and 4,323 in 2021. The differences between forecasted value by using supply series and stock series were relatively small. The two demand series also showed slow increase and a fluctuation with two-year period which were similar with the cases of forecast by supply series. The range of fluctuation, however, was wider than that by using supply series. This is caused by the policy change of agricultural machinery supply, presence of outlier, and insufficiency of data. It is expected to eliminate fluctuation and to reduce variation by using more advanced ARIMA models, which are incorporating treatment of outliers or combination with another forecast method such as regression.

From the reviewed studies, it could be observed that a good deal of research was conducted on the growth and distributional pattern of tractor. Rare attempt has been made to study the determinants and project the future demand of tractors. Moreover, no recent study has been conducted on these issues. So the present study would be an attempt in this direction and help in formulating the demand models with better specifications of the variables both for India as a whole as well as Punjab.

CHAPTER III

MATERIALS AND METHODS

The present chapter deals with the study area, data collection, and analytical tools used to quantify the objectives, under following sub-headings.

3.1 Description of the study area

3.2 Data Collection

3.3 Analytical tools and techniques used

3.4 Terms and concept

3.1 Description of the study area

3.1.1 Location

The study was carried out in the leading agricultural states of India with special reference to Punjab. The leading agricultural states include Gujarat, Haryana, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, and Tamil Nadu. Punjab is located in the North-Western region of India. The state is bordered by Jammu and Kashmir in the North, Haryana and Rajasthan in the South, Himachal Pradesh in the East and Pakistan on the West. It lies within 29^{o} 33′ to 32^{o} 32′ N latitude and 73^{o} 53′ to 73^{o} 56′ E longitude.

3.2 Collection of data

The study was undertaken on a macro framework based on secondary data. To meet the objectives of this study, data on different variables such as number of tractors, cultivated area, total cropped area, irrigated area, cropping pattern, area under high yielding varieties, prices of major agricultural crops such as paddy, wheat and cotton and credit availability for purchase of tractor were obtained from various issues of Statistical Abstracts of India, Statistical Abstract of Punjab and the Economic Surveys etc. The data on loan advanced for purchase on tractor was obtained from annual reports of Punjab Agriculture Development Bank. The data on prices of tractors were taken from various dealers, Ludhiana.

3.3 Analysis of data

3.3.1 Trend analysis

Time series data on number of tractors in leading agricultural states of India and Punjab for the period of 1974-75 to 2010-11 were collected and the growth trends were worked out. To study the comparative pattern of growth of tractors in leading agricultural states of India and in various districts of Punjab over time, the whole period under the study was divided into two periods. Period I is characterised by high rate of growth in agriculture mainly due to technological revolution that occurred during mid sixties and spread during this

period and where as II period is characterised by moderate rate of growth in agriculture .The classification is as follows

i. Period I (1974-75 to 1994-95) ;

ii. Period II (1995-96 to 2010-11) and

iii. Overall Period (1974-75 to 2010-11).

The growth of tractors in India and Punjab was studied through compound growth rates (CGR), which was computed by fitting the exponential trend equation, i.e.

$$Y = AB^t$$

Where

Y = number of tractors

A = constant

B = regression coefficient

t = time period

Compound growth rate in per cent (r) was thus estimated as under:

$$r = (B-1) \text{ X } 100$$

The significance of growth rate was tested by applying Student's- test statistics

To see the inter-state and inter-district variations in the tractor concentration, the percentage share of different states and districts in the total tractor population of the country and of the state was worked out. But as the size of different states and districts is not uniform with regard to cultivatable area, the tractor population per thousand hectares of total cropped area, net area sown, gross irrigated area, net irrigated area and area under high yielding variety was also worked out for three points of time. Tractor density was calculated as follows:

$$\text{Tractor density} = \frac{\text{Number of tractors}}{\text{Net area sown}} \times 1000$$

3.3.2 Factors influencing the demand for tractors

The variation in the demand for tractors is caused by a number of factors. To investigate the factors determining the demand for tractors in India as well as Punjab, multiple regression analysis was carried out. Both linear and log linear type functions were tried but finally, log linear function was retained as results obtained from this function were better in terms of level of significance etc. The regression equations were fitted for three time periods so as to examine the changing significance of different variables over time. The general form of the demand model (log linear) is:

$$\text{Log } Y = a + b_1 \text{ Log } x_1 + b_2 \text{ Log } x_2 + b_3 \text{ Log } x_3 + \ldots\ldots + b_n \text{ Log } x_n + u$$

Where

Y= Number of tractors demanded

a = Constant term

u = Error term

$b_1, b_2, b_3 \ldots b_n$ = Elasticities of different explanatory variables.

$x_1, x_2, x_3 \ldots x_n$ = Explanatory variables

The explanatory variables tried in the form of various combinations in the different demand models were:

D_T : Demand for tractors in current year

D_{t-1} : Demand for tractors in previous year

CA : Cultivated area

TCA : Total cropped area

NAS : Net area sown

GIA : Gross irrigated area

NIA : Net irrigated area

HYV : Area under high yielding varieties

CI : Cropping intensity

CP : Cropping pattern

WAP : Weighted average price

RPAP : Real price of agricultural products

RPT : Real price of tractor

LI : Loan Index

3.3.3 Statistical analysis

Simple statistical tools such as percentages, frequencies and averages were applied. Moreover, statistical techniques like compound growth rates and tractor density was worked out to study the growth and distribution pattern of tractorisation.

To investigate the factors determining the demand for tractors in India as well as Punjab, multiple regression analysis was carried out. Further, demand projections were made using the various predicted explanatory variables based on set of assumptions.

3.4 Terms and concept

Although, standard concepts and terms are used in the study, a brief of the concepts used in the study is given below

Demand for tractors (D_t)

The number of tractors overtime was taken as dependent variable.

Demand for tractors in previous year (D_{t-1}):

Lagged demand for tractors was considered one of the relevant variables in the demand function as it covers in a way the effect of social status and demonstration involved in purchasing a tractor.

Total cropped area (TCA)

The total cropped area used in the model comprised the area covered by all the crops in different seasons in a year.

Net area sown (NAS)

This represents the total area sown with crops and orchards. Area sown more than once in the same year is counted only once.

Area under high- yielding varieties (HVY)

The area under high yielding varieties included the area under paddy, wheat, maize and bajra.

Cropping intensity (CI)

Cropping intensity which shows the number of times, a particular land is sown was calculated as:

$$CI\ (\%) = \frac{\text{Total cropped area}}{\text{Net area sown}} \times 100$$

Cropping pattern (CP)

The variable of cropping pattern was defined as the area under paddy and wheat taken together or the area under these crops as a percentage to the total cropped area.

Weighted Average Price (WAP)

Weighted average price of major crops, i.e. wheat, paddy and cotton was calculated as:

$$\text{Weighted average price} = \frac{P_W \text{ x Prod.} + P_p \text{ x Prod.} + (P_{DC} \text{ x Prod.} + P_{AC/BC} \text{ x Prod.})}{\text{Total Prod. (W+P+C)}}$$

Where $P_{W,}$ $P_{P,}$ $P_{DC,}$ $P_{AC/BC}$ referred to prices of wheat, paddy, Desi cotton and American cotton/Bt cotton respectively.

Real Prices of Agricultural Products (RPAP)

The weighted average price thus calculated, was deflated using price index of agricultural products to remove the effect of inflationary trend in the series.

Real price of tractor (RPT)

The prices of model of tractor i.e. Massy Ferguson were collected and it was deflated using price index for manufactured products to remove the effect of inflationary trend in the series.

Loan Index (LI)

The data on loan advanced for purchase of tractor (absolute) in t year were available for Punjab only. Further, a base year 2004-05 is considered and an index was developed.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter includes the discussion of the results obtained from the analysis of the data. Based on the objectives, the results are presented into following sections:

SECTION- I

4.1 Growth, distributional pattern and density of tractors in India

4.1.1 Growth of tractors in India

The compound growth rates of tractors in leading agricultural states of India have been presented in Table 4.1.1. The growth rates were worked out for three time periods, i.e. 1974-75 to 1994-95 (period I), 1995-96 to 2010-11 (period II) and 1974-75 to 2010-11 (overall).

A glance on the table 4.1.1 revealed that the tractors in the country increased at a rate of 12.55 per cent per annum during the period I but the rate of growth declined to 6.24 per cent during the period II. The overall annual rate of growth was observed to be 9.72 per cent.

The state–wise analysis showed that during Period I i.e.1974-75 to 1994-95, the maximum growth rate of 19.52 per cent was recorded for Madhya Pradesh followed by Haryana (17.08 %), Rajasthan (14.37 %) and Uttar Pradesh (13.49 %). Among other states Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Punjab, Kerala and Tamil Nadu had the growth rates 12.66, 12.14, 11.06, 10.90, 10.85, 5.06 and 3.55 per cent respectively. The growth rates in the states of Madhya Pradesh, Haryana, Rajasthan, Gujarat and Uttar Pradesh were observed to be higher than the average for India as a whole (12.55 %).

During the period II (1994-95 to 2010-11), Karnataka attained the maximum growth rate of 11.1 per cent followed by Maharashtra (8.13 %), Madhya Pradesh (7.61 %), Andhra Pradesh and Rajasthan (6.89 %), Uttar Pradesh (6.57 %), Tamil Nadu (6.45 %), Haryana (6.30 %) and Punjab (1.90 %). Kerala showed a negative rate of growth of -0.37 per cent. The rate of growth during the period 1995-96 to 2010-11, compared to earlier period of 1974-75 to1994-95 was lower in almost all the states with an exception of Karnataka and Tamil Nadu where it increased from 10.47 and 2.93 per cent in period I to 11.13 and 9.35 in period II (1995-96 to 2010-11) respectively. Further it was found that in the states namely Gujarat, Haryana, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Madhya Pradesh and Tamil Nadu, the growth rates were higher than that of India as whole (6.24 %) during the period II.

When the overall picture of two periods was analysed, it indicated that Madhya Pradesh recorded the highest rate of growth i.e. 13.63 per cent, followed by Rajasthan (12.02 %), Haryana (11.62 %), Tamil Nadu (10.35 %), Maharashtra (10.30 %) and Gujarat (10.09 %). The rate of growth was the lowest in Kerala (3.65 %).

Few points clearly emerge from the preceding discussion. Firstly, the growth of tractors, in general, was higher during the period I (1974-75 to 1994-95) as compared to period II (1995-96 to 2010-11). This impressive rise in the rate of growth of tractors during the Period I could be credited to the Green revolution which started in mid sixties but spread during this period. Thus it was the impact of Green revolution and new technology that contributed significantly and positively towards the demand for tractors during these years (1974-75 to 1994-95). Secondly, in period II (1994-95 to 2010-11) it can be seen that growth has been relatively high in states where tractor penetration was low initially viz. states like Tamil Nadu and Karnataka. The more heavily mechanised regions particularly Punjab, Haryana, and Uttar Pradesh, overtime the pace of tractorisation in these states had slowed down significantly reason being that the number of tractors have almost reached a saturation level from both economic as well as operational point of view. A study conducted by Bhattathiri (2013) indicated that Kerala has exhibited decreased and negative growth rate overtime, mainly citing the reason of declining trend in the paddy cultivation due to escalating cost of rice production, hike in diesel prices etc.

Table 4.1.1: Compound growth rates of tractors in different states of India

(Per cent)

States	Period I (1974-75 – 1994-95)	Period II (1995-96 – 2010-11)	Overall (1974-75 – 2010-11)
Gujarat	12.66*** (0.73)	6.74 *** (0.23)	10.09*** (0.33)
Haryana	17.08*** (0.78)	6.30*** (0.43)	11.62*** (0.53)
Maharashtra	12.14*** (0.60)	8.13*** (0.37)	10.30*** (0.26)
Punjab	10.85*** (0.65)	1.90*** (0.17)	6.26*** (0.44)
Rajasthan	14.37*** (0.92)	6.89*** (0.22)	12.02*** (0.41)
Uttar Pradesh	13.49*** (1.0.3)	6.57** (3.29)	9.36*** (0.76)
Andhra Pradesh	11.06*** (0.49)	6.89*** (0.22)	9.51*** (0.55)
Karnataka	10.90*** (0.45)	11.13*** (2.87)	9.70*** (0.26)
Kerala	5.06*** (1.45)	-0.37^{NS} (1.82)	3.65*** (0.60)
Madhya Pradesh	19.52*** (1.36)	7.61*** (1.37)	13.63*** (0.71)
Tamil Nadu	3.55*** (0.89)	6.45** (2.34)	10.35*** (0.82)
Other States	9.30*** (2.26)	9.35*** (1.91)	10.70*** (0.81)
India	12.55*** (0.42)	6.24*** (0.14)	9.72*** (0.29)

Note: ***1 % significance level, **5 % significance level
Figures in parentheses are standard errors

4.1.2 Distribution of tractors in India

It is evident that, the pattern of tractorisation was not uniform in all the states, the relative share of each state in the total number of tractors of the country has been worked out and demonstrated in Table 4.1.2.

The number of tractors which was only 1.64 lakh during 1974-75 increased to 53.1 lakh in 2011-12 (Table 4.1.2). The interstate analysis for distributional pattern of tractors revealed that six states namely, Punjab, Uttar Pradesh, Gujarat, Rajasthan, Maharashtra and Karnataka accounted for about 77 per cent of the total tractor population in the country during 1974-75. During 1993-94, about 79 per cent was concentrated in six states i.e. Uttar Pradesh, Punjab, Haryana, Rajasthan and Gujarat and Madhya Pradesh.

Table 4.1.2: Distribution of tractors in different states of India at different points of time

(Number)

States	1974-75	1993-94	2011-12
Gujarat	16054(9.79)	120951(7.23)	495136 (8.53)
Haryana	6598(4.02)	192815(11.53)	516658 (8.9)
Maharashtra	9260(5.65)	83088(4.96)	419291(7.22)
Punjab	47611(29.06)	338494(20.24)	518915(8.92)
Rajasthan	13444(8.20)	185576(11.09)	699881(12.05)
Uttar Pradesh	30702(18.7)	360415(21.55)	1064284(18.32)
Andhra Pradesh	6929(4.22)	50780(3.03)	342416(5.9)
Karnataka	8370(5.10)	56189(3.36)	363993(6.27)
Kerala	2466(1.50)	11675(0.69)	11602(0.2)
Madhya Pradesh	8022(4.89)	126288(7.55)	517743(8.91)
Tamil Nadu	4799(2.92)	15604(0.93)	186670(3.22)
Other States	9576(5.84)	130188(7.78)	689147(11.86)
India	163831(100.00)	1672063(100.00)	5811131(100.00)

Figures in the parentheses are percentage to the total tractors in the country.

In 2011-12, Uttar Pradesh, Rajasthan, Madhya Pradesh, Haryana and Punjab occupied first five positions in terms of percentage share in the total tractor population. These states taken together accounted for about 57 per cent of tractor population in the country.

The most impressive fact which came out of above analysis was that 40-50 per cent of total tractors in India were concentrated only in two states – Punjab and Uttar Pradesh during 1974-75 and 1993-94 mainly because of the higher level of agricultural development

and size of cultivated area in these states respectively. During 2011-12, Rajasthan and Uttar Pradesh occupied more than 30 per cent of the total tractors concentrated in the country. This is mainly because of higher MSP‘s, limited availability of labour forcing higher mechanisation , greater availability of finance for the purchase of tractor, and increasing non-agricultural use of tractors and size of cultivated area in these states respectively.

4.1.3 Tractor density in India

The higher percentage share of any state in total tractor population or the more tractors in terms of absolute number does not signify in any way the higher level of tractorisation in that particular state. The size of states with regard to cultivable land in India varies too much. It is, therefore, the tractor density i.e. tractor population per thousand hectares of total cropped area, or gross irrigated area or net area sown or net irrigated area which presents the comparative picture of intensity of tractorisation in different states of the country.

Tractor population per thousand hectares of total cropped area, net area sown, net irrigated area or gross irrigated area has been worked out to have a comparative picture of intensity of tractors in various states of India. The higher the gap between the number of tractors available per thousand hectares of gross cropped area or gross irrigated area or net area sown and net irrigated area implied the lower level of irrigation facilities available in a particular state.

Table 4.1.3 showed that the number of tractors availability per thousand hectares of net area sown in India was only 1.19 in 1974-75 which moved up to 11.76 in 1993-94 and 35.74 in the year 2009-10. The inter-state analysis of tractor concentration brought out that in the states like Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Rajasthan, the tractor availability per thousand hectares of net area sown was even less than one.

Tractor density was found to be the highest in Punjab, being 11.64 thousand hectares of net area sown followed by Gujarat with 2.02 tractors and Haryana with 1.87 tractors per thousand hectares of net area sown. The tractor population per thousand hectares of net area sown was found to be lowest in Madhya Pradesh (0.43). In the period (1993-94) too, Punjab maintained the highest position with regard to density of tractors. It was 80.32 per thousand hectares of net area sown. Haryana with 54.88 tractors and Uttar Pradesh with 20.89 tractors were next to Punjab. The other states such as Madhya Pradesh, Kerala, Maharashtra, Andhra Pradesh, Tamil Nadu, Karnataka, had less than 7 tractors per thousand hectares of net area sown.

During 2009-10, Haryana was found to be the highest with 138.2 tractors per thousand hectares of net area sown, Punjab and Uttar Pradesh were next to Haryana with 119.6 and 57.5 tractors respectively.

Table 4.1.3: Number of tractors per thousand hectares of Net area sown (NAS), Total cropped area (TCA), Net irrigated area (NIA), Gross irrigated area (GIA) in India and major states

	1974-75				1993-94				2009-10			
STATES	**NAS**	**TCA**	**NIA**	**GIA**	**NAS**	**TCA**	**NIA**	**GIA**	**NAS**	**TCA**	**NIA**	**GIA**
Gujarat	2.02	1.88	11.71	10.79	12.87	11.33	47.61	39.18	39.8	36.8	94.67	83.21
Haryana	1.87	1.36	3.71	2.54	54.88	33.15	72.4	42.7	138.2	77.2	159.93	88.51
Maharashtra	0.51	0.47	5.74	4.79	4.61	3.88	31	25.47	19.06	15.69	101.93	76.21
Punjab	11.64	8.06	14.96	9.98	80.32	44.4	86.19	46.76	119.6	63.18	122.15	64.49
Rajasthan	0.96	0.86	5.08	4.28	11.43	9.63	40.36	33.16	35.67	27.84	103.51	82.84
Uttar Pradesh	1.79	1.35	3.94	3.34	20.89	14.1	31.16	22.02	57.5	38.52	70.88	50.48
Andhra Pradesh	0.6	0.52	2.07	1.57	4.9	4	24.14	10.11	26.17	20.82	62.05	45.36
Karnataka	0.81	0.76	6.61	5.62	5.2	4.51	36.03	18.91	30.64	24.76	94.05	77.84
Kerala	1.12	0.81	5.3	3.78	5.21	3.83	23.62	28.26	5.12	3.99	27.62	23.43
Madhya Pradesh	0.43	0.39	4.91	4.72	6.39	5.08	5.57	22.84	30.62	21.41	66.51	64.01
Tamil Nadu	0.86	0.72	1.97	1.58	2.64	2.64	14.8	4.4	30.75	26.99	52.52	46.45
India	1.19	1	4.86	3.92	11.76	8.96	32.4	24.36	35.74	26.04	44.91	57.91

The above description indicated that although increase in tractor population (absolute number) was observed more or less in all the states yet number of tractors per thousand hectares of net area sown was still very low in some states. It was observed that the tractor population per thousand hectares of net area sown in different states was quite skewed and varied between 5.12 and 138.2 tractors per thousand hectares of net area sown in Kerala and Haryana respectively. Furthermore, it indicated that Haryana, Punjab, Uttar Pradesh and Gujarat had the highest concentration of tractors while Kerala, Maharashtra, Andhra Pradesh and Madhya Pradesh were the states with lower tractor density in the country. The density of tractors in Haryana was the highest at 138.2 tractors per thousand hectares of net area sown, thereby establishing the fact that the Haryana agriculture is highly mechanised.

4.2 Growth and Distributional Pattern and density of tractors in Punjab

4.2.1 Growth of tractors in Punjab

The compound growth rates of tractors in different districts of Punjab have been worked out pertaining to the periods 1974-75 to 1996-97 (period I) , 1996-97 to 2011-12 (period II) and 1974-75 to 2011-12 (overall), and the same have been depicted in Table 4.2.1. The district-wise numbers of tractors for different years have been given in Appendix II.

It was obvious from the table that the annual compound growth rate of tractors in Punjab was 9.92 per cent during Period I and it declined to 1.32 per cent in Period II. The overall rate of growth over the span 1974-75 to 2011-12 was observed to be 5.71 per cent per annum. The district-wise position revealed that all the districts recorded a significant rate of growth in tractors throughout the period under review. Furthermore, it was observed that during period I i.e. 1974-75 to 1996-97. The highest rate of growth was attained by Sangrur district (16.50 %) followed by Faridkot (14.08 %), Rupnagar (12.23 %) and Amritsar (11.67 %). The lowest rate of growth was recorded by Jalandhar (7.41 %). In the districts Sangrur, Faridkot, Rupnagar, Amritsar and Gurdaspur the growth rates was higher than the state's overall average (9.92 %)

In the period II (1997-98 to 2011-12) Hoshiarpur district witnessed highest growth rate of 3.09 per cent followed by Patiala (2.61 %), Rupnagar (2.17 %), and Jalandhar (2.12 %) while Faridkot showed the lowest growth rate of 0.57 per cent per annum. The districts which showed growth rates higher than that of state average (1.32 %) were Hoshiarpur, Patiala, Rupnagar, Jalandhar and Kapurthala.

The overall growth rate (1974-75 to 2011-12) was maximum in the district of Sangrur (8.71 per cent) followed by Faridkot (7.7 %), Rupnagar (7.19 %) and Amritsar (6.11%). The minimum rate of growth was observed for Bathinda (4.70%). Among other districts, Firozpur, Hoshiarpur, Gurdaspur, Patiala and Kapurthala showed growth rates of 5.72, 5.67, 5.66, 5.60 and 5.22 per annum respectively.

Thus, one of the striking observation which came out of above discussion was that all those districts where there was less number of tractors in the base period, exhibited higher rate of growth. Another point that emerged from the above analysis was that growth rates of tractors showed a decline in all the districts in period II as compared to period I.

The higher growth rates during this period (period I) may be attributed to the 'technological revolution' which initiated in mid sixties and the higher rate of growth of tractors in this period (during seventies and mid eighties) was in quick response to the increased power requirements which were consequence of intensive cultivation and incredible increase in the cropping intensity. The results hereby indicate that overtime the pace of tractorisation in the state has slowed down.

Table 4.2.1: Compound growth rates of tractors in different districts of Punjab

(Per cent)

District	Period I (1974-75-1996-97)	Period II (1997-98-2011-12)	Overall (1974-75-2011-12)
Gurdaspur	10.73***	0.79***	5.66***
	(0.74)	(0.06)	(0.53)
Amritsar	11.67***	1.11***	6.11***
	(0.87)	(0.09)	(0.58)
Kapurthala	8.45***	1.55***	5.22***
	(0.50)	(0.13)	(0.73)
Jalandhar	7.41***	2.12***	4.75***
	(0.34)	(0.04)	(0.27)
Hoshiarpur	7.45***	3.09***	5.67***
	(0.19)	(0.10)	(0.19)
Rupnagar	12.23***	2.17***	7.19***
	(0.44)	(0.08)	(0.49)
Ludhiana	7.54***	1.20***	4.76***
	(0.38)	(0.07)	(0.30)
Firozpur	11.29***	0.61***	5.72***
	(1.29)	(0.02)	(0.67)
Faridkot	14.08***	0.57***	7.72***
	(1.46)	(0.04)	(0.77)
Bathinda	7.57***	0.84***	4.70***
	(0.17)	(0.03)	(0.29)
Sangrur	16.50***	1.23***	8.71***
	(1.22)	(0.08)	(0.82)
Patiala	8.60***	2.61***	5.60***
	(0.58)	(0.18)	(0.34)
Punjab	9.92***	1.32***	5.71***
	(0.59)	(0.04)	(0.44)

Figures in parentheses are the standard error
***: significant at 1 per cent level
NS: Non-significant

Table 4.2.2: Distribution of tractors in different districts of Punjab at different points of time

(Number)

District	1975-76	1994-95	2011-12
Gurdaspur	1960 (3.54)	12614(3.55)	14812(2.85)
Amritsar	3267(5.90)	32288(9.10)	39954(7.69)
Kapurthala	2709(4.90)	11979(6.94)	17224(3.32)
Jalandhar	6183(11.18)	24632(6.94)	36525(7.03)
Hoshiarpur	3361(6.07)	12858(3.62)	24403(4.70)
Rupnagar	1043(1.89)	9285(2.61)	13247(2.55)
Ludhiana	9191(16.61)	37722(10.63)	50364(9.70)
Firozpur	4021(7.27)	49278(13.89)	58832(11.3)
Faridkot	3448(6.23)	41973(11.83)	55508(10.96)
Bathinda	11752(21.24)	48448(13.66)	59437(11.45)
Sangrur	1846(3.34)	41794(11.78)	54813(10.56)
Patiala	6546(11.83)	31789(8.96)	52503(10.11)
Punjab	55327(100.00)	354660(100.00)	518915(100.00)

4.2.2 Distribution of tractors in Punjab

The district-wise position of tractor population along with the percentage share of each district in total tractor population in the state has been presented in Table 4.2.2. The number of tractors which was only 55,327 recorded a phenomenal rise (during the period 1975 to 2012) to 5,18,915 tractors. The inter-district analysis of distributional pattern brought out that the districts namely Bathinda, Ludhiana, Patiala, Jalandhar, and Firozpur occupied first five positions and these districts collectively constituted approximately about 70 per cent of the tractor population in the state during the period 1975-76.

During 1994-95, Firozpur, Bathinda, Faridkot, Sangrur and Ludhiana taken together accounted for about 60 per cent, whereas all the remaining districts shared only about 40 per cent of the total tractor population in the state. In 2011-12, 65 per cent of the total tractor population of the state was concentrated in the districts of Bathinda, Firozpur, Faridkot, Sangrur, Patiala and Ludhiana.

The foregoing analysis indicated that tractors in the state were concentrated in the districts of Bathinda, Firozpur, Ludhiana, Patiala, Jalandhar, Sangrur, and Faridkot whereas Rupnagar, Gurdaspur, Hoshiarpur districts being sub mountainous regions had relatively low percentage share in total tractor population of the state.

4.2.3 Density of tractors in Punjab

As the geographical size of the districts varies from one to another, the density of tractors was worked out to have a comparative picture of different districts with regard to the degree of tractorisation.

The tractor population per thousand hectares of net area sown, total cropped area, net irrigated area and area under high-yielding variety seeds has been presented in Table 4.2.3. It is clear from the table that tractor density i.e. tractor population per thousand hectares of net area sown in the state which was 13.31 in 1975-76, increased rapidly to 112.57 in 2010-11. The inter-district analysis showed that during 1975-76, the tractor population per thousand hectares of net area sown was found to be highest in Ludhiana with 28.46 tractors followed by Bathinda with 23 tractors and Jalandhar with 21.10 tractors. The lowest tractor density i.e. tractor population per thousand hectares of net area sown was observed to be in Sangrur, being 4.07 tractors .

During the period 1993-94, Bathinda showed the highest tractor density. It was 153.26 tractors per thousand hectares of net area sown. Ludhiana and Patiala districts were next to Bathinda district with 113.79 and 96.94 tractors respectively. The tractor population per thousand hectares of net area sown was the lowest in Gurdaspur with 43.87 tractors**.**

In the period 2010-11, the highest tractors density was noticed in Faridkot district. It was 433.87 per thousand hectares of net area sown. Patiala and Bathinda districts were next to Faridkot district in terms of tractor population per thousand hectares of net area sown where it was 195.45 and 194.64 tractors respectively. The tractor density was the lowest in Gurdaspur being 51.47 tractors per thousand hectares of net area sown. The higher the gap between the number of tractors available per thousand hectares of gross cropped area and total area under high yielding varieties implied relatively the less area under high yielding varieties in a particular district. So the analysis showed that the tractor availability per thousand hectares of net area sown was much more in the districts of Bathinda, Faridkot, Patiala, Ludhiana and the tractor density in the districts of Gurdaspur and Hoshiarpur was relatively low.

The whole analysis leads to the conclusion that although the role of other factors cannot be ruled out but it was higher cropping intensity (obviously higher levels of irrigation facilities also) which contributed remarkably towards the higher level of concentration of tractors in these districts.

Table 4.2.3: Number of tractors per thousand hectares of Net area sown (NAS), Total cropped area (TCA), Net irrigated area (NIA), Gross irrigated area (GIA), Area under high yielding variety (HYV) in Punjab and major districts

Districts	1975-76					1993-94					2010-11				
	NAS	TCA	NIA	GIA	HYV	NAS	TCA	NIA	GIA	HYV	NAS	TCA	NIA	GIA	HYV
Gurdaspur	7.6	4.76	11.63	7.32	10.32	43.87	25.5	61.98	31.54	32.99	51.47	29.27	59.36	33.13	33.38
Amritsar	8	5.19	8.55	5.42	9.25	69.81	37.42	69.84	37.46	50.66	182.13	93.21	182.13	93.12	105.11
Kapurthala	20.37	15.84	25.06	18.45	27.64	85.5	44.07	85.24	44.07	50.76	125.23	62.15	125.23	62.05	73.6
Jalandhar	21.1	13.8	24.45	15.92	25.66	77.64	46.17	78.31	46.79	61.5	150.41	87.21	150.41	87.17	104.09
Hoshiarpur	13.23	8.8	31.01	24.99	29.33	53.34	33.32	83.31	49.49	47.14	115.6	64.7	124.97	72.81	80.55
Rupnagar	8.41	5.27	21.2	13.27	20.44	77.61	44.34	117.84	65.61	60.02	158.64	85.84	179.04	100.42	100.26
Ludhiana	28.46	16.99	32.72	19.31	32.94	113.79	59.67	114.01	59.73	70.58	164.47	82.64	164.47	82.71	95.94
Firozpur	8.29	5.66	10.87	8.45	10.87	92.11	51.83	95.21	52.7	75.93	122.79	65.4	123.57	65.65	88.53
Faridkot	6.56	4.77	7.92	5.6	12.01	76.46	41.97	78.46	42.81	71.21	433.87	216.9	437.31	291.7	252.76
Bathinda	23	16.32	34.65	21.4	60.58	153.26	89.47	163.24	92.84	169.91	194.64	103.62	195.3	103.79	135.56
Sangrur	4.07	2.57	4.97	2.94	5.46	90.15	45.85	90.42	45.96	56.76	172.25	86.95	172.25	86.93	96.27
Patiala	16.83	10.7	19.45	23.16	14.21	96.94	52.35	103.23	55.21	63.62	195.45	99	195.47	99.3	109.15
Punjab	13.31	8.83	17.57	11.19	19.4	80.45	44.47	86.31	46.86	61.45	112.57	59.35	114.93	60.56	72.32

SECTION-II

4.3 Determinants of demand for tractors

An attempt has been made in this section to investigate the different factors affecting the demand for tractors overtime. In the context of differential rate of agricultural growth in different time periods, the relative significance of various factors which affect the demand for tractors is expected to change. In order to study the changing significance of different factors overtime, the functional analysis was carried out for three time periods viz.

1) Period I (1974-75 to 1994-95)
2) Period II (1995-96 to 2010-11)
3) Overall Period (1974-75 to 2010-11)

The models constructed to obtain the relationship between tractorisation and different factors affecting it were tested using both linear and log- Linear regression. The results showed that log- linear models fitted best with small standard errors of estimate and the number of significant variables also increased in this regression model. Therefore, only log-Linear function was retained and considered for discussion. The different independent variables tried in the model were: demand for tractors in the previous year (D_{T-1}), cultivated area (CA), net area sown (NAS), total cropped area (TCA), gross irrigated area (GIA), net irrigated area (NIA), area under high yielding variety seeds (HVY), cropping intensity (CI), cropped area under paddy and wheat (CP), cropped area under paddy (CPP), cropped area under wheat (CPW), weighted average price of agricultural products (WAP), real price of agricultural products (RPAP), price of tractor (PT), real price of tractor (RPT), .Various regression equations using different combinations of explanatory variables were tried. From all these equations regressed pertaining to the different periods, one each (best fit in terms of level of significance of explanatory variables, coefficient of multiple determination and signs of variables) was selected for discussion.

4.3.1 Determinants of Tractorisation in India

Period I (1974-75 to 1994-95)

The independent variables included in the equation of period I are gross irrigated area (GIA), area under high yielding variety seeds (HVY), and cropping pattern (CP) and real price of agricultural products (RPAP). The significant variables were gross irrigated area (GIA), area under high yielding variety seeds (HVY) .The coefficient of multiple determination (R^2) came out to be 0.99 which indicated that 99 per cent of the total variation in the demand for tractor was explained by the independent variables included in the model.

The coefficient of area under high yielding variety seeds (HVY) was found to be 1.39 being significant at 5 per cent probability level, indicated that 1 per cent increase in area under high yielding variety would raise demand of tractors by 1.39 per cent.

The regression coefficient of demand for tractors with respect to gross irrigated area came out to be 2.35 and it was found statistically significant at 1 per cent probability level. It revealed that increase in gross irrigated area in the country had positive impact on the tractor demand i.e. 1 per cent increase in the gross irrigated area would result in 2.35 percent increase in demand for tractors in the country.

Period II (1995-96 to 2010-11)

A glance on the equation of period II revealed that demand for tractors in the previous year (D_{T-1}) and real price of tractor were significant variables which influenced the demand for tractors in India during Period II. The coefficient of multiple determination (R^2) showed that all the independent variables included collectively explained about 99 per cent of variation in the demand for tractors.

It may be observed that the coefficient of lagged demand was 0.74 and it was found significant at 1 per cent level. It implied that with 1 per cent increase in the demand for tractors in the current year would increase 0.74 per cent increase in demand for tractors in the succeeding year. The regression coefficient of real price of tractor was found to be -0.63 per cent being statistically significant at 5 per cent of probability level which indicated that 1 per cent increase in real price of tractor would result in 0.63 per cent decline in demand for tractors.

Importance of variables overtime

A comprehensive view of above mentioned regression equation for Period I and Period II clearly expounded the changing significance of different factors determining the demand for tractors overtime. The only variable real price of tractor which found to be significantly influencing the demand in both the Periods I &II. To sum up the foregoing discussion, it could be inferred that gross irrigated area and the area under high yielding variety were the significant factors that determined the tractor demand in Period I. So it may be inferred that with the technology transformation i.e. spurt in the area under high yielding varieties of paddy and wheat and due to up rise of irrigated area during this period (1974-75 to 1994-95), the tractors were adopted at a faster pace irrespective of high price of tractors.

During the period II, lagged demand showed the significant and positive association with tractor demand. The real price of tractor emerged out significant and showed negative association with tractor demand. The total cropped area came out as non significant in this period. The elasticity of lagged demand was found to be 0.74 in Period II. So, it may be inferred that with the demonstration effect there was tremendous increase in demand during II period.

Period III (1974-75 to 2010-11)

Equation of Period III in the table 4.3.1 brought out that gross irrigated area and area under high yielding variety had been responsible for increased demand for tractors in India. But, the real price of tractor showed significant and negative association with the demand for tractors.

The coefficient of area under high yielding variety seeds (1.63) was found to be statistically significant at 1 per cent probability level. This implied that with 1 per cent increase in the area under high yielding variety, the demand for tractors would increase by 1.63 per cent.

The elasticity coefficient of gross irrigated area was found to be 1.73, significant at 1 per cent level of probability. It revealed that with 1 per cent increase in gross irrigated area; demand for tractors would increase by 1.73 per cent. Thus, it revealed that gross irrigated area was important variable which largely influenced the demand for tractors in India during this period.

The regression coefficient of real price of tractor (-0.32) showed significance at 5 per cent level of probability. It revealed that with 1 per cent increase in real price of tractor; the demand for tractors would decrease by about 0.32 per cent.

So, an important conclusion that emerged out of this analysis is that in the initial stage of tractorisation (during 1974-75 to 1994-95) area under high yielding variety seeds and gross irrigated area were only significant factors determining the demand for tractors in the country. However, the role of other variables was not apparent. But, of late, during (1995-96 to 2010-11) social factors involved in owning tractor came out to be important variable. So farmers are purchasing tractor widely not only of their farming necessities but also because tractor has became a status symbol for the farming community.

Table 4.3.1: Results of regression equations developed for tractors affecting demand for factors in India

Period	Intercept	DT-1	CA	TCA	NAS	GIA	NIA	HYV	CI	CP	RPAP	RPT	R^2
1974-75 to 1994-95	-8.08	-	-	-	-	2.35^{***} (0.72)	-	1.39^{**} (0.53)	-	2.03^{NS} (2.03)	-0.21^{NS} (0.36)	-	0.990^{***}
1995-96 to 2010-11	3.2	0.74^{***} (0.08)	-	0.073^{NS} (0.47)	-	-	-	-	-	0.72^{NS} (0.59)	0.16^{NS} (0.25)	-0.63** (0.28)	0.992^{***}
1974-75 to 2010-11	-7.1	-	-	-	-	1.73^{***} (0.47)	-	1.63^{***} (0.28)	-	-	-0.41^{NS} (0.21)	-0.32** (0.16)	0.993^{***}

Note: ***1 per cent significance level, ** 5 per cent significance level, * 10 per cent significance level
Figures in parentheses are standard error of associated coefficients

D_{t-1} : Demand for tractors in previous year
CA : Cultivated area
TCA : Total cropped area
NAS : Net area sown
GIA : Gross irrigated area
NIA : Net irrigated area
HYV : Area under high yielding varieties
CI : Cropping intensity
CP : Cropping pattern
RPAP : Real price of agricultural products (weighted)
RPT : Real price of tractor

4.3.2 Determinants of Tractorisation in Punjab

To examine the different factors affecting the demand for tractors in Punjab, both Linear and Log- Linear regression were tried. The results showed that Log- Linear models fitted best. So, Log-Linear function was selected ultimately for discussion. The different independent variables tried in the model were: Demand for tractors in the previous year (D_{T-1}), cultivated area (CA), net area sown (NAS), total cropped area (TCA), gross irrigated area (GIA), net irrigated area (NIA), Area under high yielding varieties (HVY), cropping intensity (CI), cropped area under paddy and wheat (CP), cropped area under paddy (CPP), cropped area under wheat (CPW), weighted average price of agricultural products (WAP), real price of agricultural products (RPAP), real price of tractor (RPT). Various regression equations using different combinations of explanatory variables were tried. From all these equations regressed pertaining to the different periods, one each (best fit in terms of level of significance of explanatory variables, coefficient of multiple determination and sign of prior expectation of variables) was selected for discussion. The same have been demonstrated in Table 4.3.2.

Period I (1974-75 to 1994-95)

The independent variables included in the equation of period I are Demand for tractors in the previous year (D_{T-1}), Area under high yielding varieties (HVY), Cropping intensity (CI), Cropped area under paddy and wheat (CP), Real price of agricultural products (RPAP), Real price of tractor (RPT) and Loan index (LI). The significant variables were Demand for tractors in the previous year (D_{T-1}), Area under high yielding varieties (HVY), Cropping intensity (CI), Real price of agricultural products (RPAP), Real price of tractor (RPT) .The coefficient of multiple determination (R^2) came out to be 0.99 which indicated that 99 per cent of the total variation in the demand for tractor was explained by the independent variables included in the model.

The elasticity of tractorisation with respect to area under high yielding variety was found to be 1.08 being significant at 10 per cent probability level which indicated that with 1 per cent increase in area under high yielding variety, the demand for tractors in the state would increase by 1.08 per cent.

Likewise, the regression coefficient of real price of agricultural products was found to be -0.31 being significant at 1 per cent probability level, which indicated that 1 per cent increase in real price of agricultural products resulted in 0.31 per cent decline in demand for tractors.

The elasticity coefficient of demand for tractors with respect to cropping intensity was found to be 2.48 and it was found statistically significant at 5 per cent probability level. It revealed that 1 per cent increase in the gross irrigated area would result in 2.48 percent increase in demand for tractors. The regression coefficient of lagged demand for tractors was

0.31 and it was found statistically significant at 1 per cent level of significance which means that 1 per cent increase in demand for tractors in current year, the demand for tractors in succeeding year would increase by 0.31 per cent.

The regression coefficient of tractorisation with respect to real price of tractor was found to be -0.26 being significant at 5 per cent probability level which indicated that 1 per cent increase in real price of agricultural products resulted in 0.26 per cent decline in demand for tractors.

Period II (1995-96 to 2010-11)

It may be seen from the equation of period II, that among three explanatory variables which were taken in this equation, demand for tractors in area under high yielding varieties and Real price of tractor were significant variables which influenced the demand for tractors in India during Period II. The value of coefficient of multiple determination (R^2) a sizable proportion (99 per cent) of the total variation in the demand for tractors during this period was explained by all the independent variables taken together.

The elasticity of demand for tractors with respect to area under high yielding varieties was 1.11 which was found to be statistically significant at 5 per cent probability level thereby indicated that increase in area under high yielding varieties contributed significantly and positively towards the demand for tractors in the state i.e. with one per cent increase in the area under high yielding varieties, the demand for tractors would increase by about 1.11 per cent.

The regression coefficient of real price of tractor was found to be -0.63 per cent being statistically significant at 5 per cent of probability level which indicated that 1 per cent increase in real price of tractor would result in 0.63 per cent decline in demand for tractors.

Importance of variables overtime

Thus, it is quite apparent from the discussion of regression equations for Period I that Demand for tractors in the previous year (D_{T-1}), Area under high yielding varieties (HVY), Cropping intensity (CI), Real price of agricultural products (RPAP), Real price of tractor (RPT) were the significant variables that determined the tractor demand in period I. To sum up the foregoing discussion, it could be inferred that lagged demand, cropping intensity and area under high yielding varieties were the significant factors that determined the tractor demand. The reason might be due to the fact that in early 1970's a great stress was laid on to encourage agricultural production and this goal was achieved by intensive cultivation and increasing area under high yielding varieties.

As it is clear from the equation of period I that the regression coefficient of real price of agricultural products came out to be negative and significant. It might be due to the reason that although the government price policy for agriculture was not conducive for growth of investment in tractors and the real price of agricultural products did not experience much

increase, yet the tractor's demand increased significantly in the country; which revealed that the non price factors such as higher area under high yielding variety, cropping intensity and social factors had been responsible for increasing the demand for tractors during the period I.

During the period II, area under high yielding variety and the real price of tractor again emerged out as significant variables. The elasticity of area under high yielding variety increased from 1.08 in period I to 1.11 in period II. It may be inferred that because of increase in the area under HVY's , the tractors were adopted at a faster pace irrespective of high price of tractors.

Period III (1974-75 to 2010-11)

Equation of the period III showed that lagged demand, cultivated area, area under high yielding variety and cropping intensity had been responsible for increased demand for tractors in Punjab. But, the real price of tractor showed significant and negative association with the demand for tractors.

The elasticity coefficient of lagged demand for tractors was found to be 0.03, significant at 5 per cent level of probability. It revealed that 1 per cent increase in demand for tractors in current year the demand for tractors in succeeding year would increase by 0.03 per cent.

The coefficient of cultivated area (2.78) was found to be statistically significant at 1 per cent probability level. This implied that with 1 per cent increase in the cultivated area, the demand for tractors would increase by 2.78 per cent. Thus, it revealed that cultivated area was important variable which largely influenced the demand for tractors in Punjab during this period.

The elasticity of demand for tractors with respect to cropping intensity was 4.13, which was found to be statistically significant at 1 per cent probability level. This implied that with 1 per cent increase in the cropping intensity, the demand for tractors would raise by 4.13 per cent. The coefficient of demand for tractors with respect to area under high yielding varieties was 1.20 which was found to be statistically significant at 1 per cent probability level. It means that one per cent increase in the area under high yielding varieties, the demand for tractors would increase by about 1.20 per cent.

The regression coefficient of real price of tractor (-0.36) showed significance at 1 per cent level of probability. It revealed that 1 per cent increase in real price of tractor; the demand for tractors would decrease by about 0.36 per cent.

Thus, from the foregoing discussion, it clearly emerged that the lagged demand, area under high yielding variety and real price of tractor remained significant variables in all the periods. Among these three significant variables, the elasticity of demand for tractors with respect to area under high yielding varieties was the highest in all the periods which revealed higher importance of area under high yielding variety in affecting the demand for tractors in the state. So, it may be concluded that the contribution of HVY's in determining demand for tractors increased overtime and area under HVY's was the major factor behind the increased tractor demand in the state.

Table 4.3.2: Results of regression equations developed for tractors affecting demand for factors in Punjab

Period	Intercept	DT-1	CA	TCA	GIA	HYV	CI	CP	RPAP	RPT	LI	R^2
1974-75 to 1994-95	-3.16	0.31*** (0.09)	-	-	-	1.08* (0.53)	2.48** (0.83)	-0.21^{NS} (0.73)	-0.31^{*} (0.16)	-0.26** (0.11)	-0.005 (0.01)	0.998^{***}
1995-96 to 2010-11	3.71	0.014^{NS} (0.009)	-	-	-	1.11^{***} (0.11)	-	-	-	-0.43** (0.14)	-	0.990^{***}
1974-75 to 2010-11	-15.31	0.033^{**} (0.02)	2.78^{***} (0.91)	-	-	1.20^{***} (0.12)	4.13^{***} (0.43)		-0.46^{NS} (0.12)	-0.36*** (0.07)	-	0.998^{***}

Note: ***1 per cent significance level, ** 5 per cent significance level, * 10 per cent significance level. Figures in parentheses are standard error of associated coefficients

D_{t-1} : Demand for tractors in previous year
CA : Cultivated area
TCA : Total cropped area
GIA : Gross irrigated area
HYV : Area under high yielding varieties
CI : Cropping intensity
CP : Cropping pattern
RPAP : Real price of agricultural products,
RPT : Real price of tractor & LI: Loan index

SECTION-III

Demand projections of tractors

The object of present work is to project the demand for tractors. Projections are necessary to monitor the supply side. Projections based on the simple averages cannot lead us in the right direction. So in the preceding chapter scientific assessment of various factors affecting demand for tractors was done to arrive at rational estimates. In this chapter projections are made on the basis of past trends during two periods i.e.

1) II period (1995-96 to 2010-11)
2) Overall period (1974-75 to 2010-11)

Demand projections of tractors in India

4.4. Demand projections based on period II (1995-96 to 2010-11)

For forecasting the demand for tractors more realistically, the demand model developed for the latter period i.e. 1995-96 to 2010-11 was considered. The independent variables included in the model were demand for tractors in the previous year ($D_{T-1)}$, total cropped area (TCA), cropping pattern (CP), real price of agricultural products (RPAP), and real price of tractor (RP). The function was formulated as (log form)

Log D_T = 3.2+ 0.74 (Log D_{t-1}) + 0.073 (Log TCA) + 0.72(Log CP) + 0.16 (Log RPAP) -0.63(Log RPT)

The validity of the projected demand for tractors would depend upon the validity of projections of independent variables; thus different explanatory variables were predicted under alternative set of assumptions so as to obtain more realistic and valid future values of each variable. The assumptions have been discussed below

Demand for tractors in previous year (D_{t-1})

The number of tractors increased at the growth rate of 6.47 per cent in the period 1995-96 to 2010-11. This rate of growth was assumed to prevail upto the year 2025.

Total cropped area (TCA)

It was assumed that total cropped area would increase at the compound growth rate of 0.25 per cent (as observed in period II) and would reach to 2,03,447 thousand hectares in the year 2025.

Cropping pattern (CP)

During last many years, area under rice and wheat as a percentage to the total cropped area remained 36 per cent and the same percentage (36 %) was assumed to be existing upto the year 2025.

Table 4.4.1: Different explanatory variables predicted under alternative set of assumptions

Year	DT-1	TCA	CP	RPAP	RPT	Log(DT-1)	Log(TCA)	Log(CP)	Log(RPAP)	Log (RPT)	Log(DT)	DT
2011-12	5329038	196950	36	745	227720	6.73	5.29	1.56	2.87	5.36	6.76	5731523
2012-13	5673826	197442	36	754	223393	6.75	5.3	1.56	2.88	5.35	6.79	6045052
2013-14	6040923	197936	36	764	219149	6.78	5.3	1.56	2.88	5.34	6.81	6449114
2014-15	6431770	198430	36	774	214985	6.81	5.3	1.56	2.89	5.33	6.84	6905578
2015-16	6847906	198927	36	783	210900	6.84	5.3	1.56	2.89	5.32	6.87	7367159
2016-17	7290966	199424	36	793	206893	6.86	5.3	1.56	2.9	5.32	6.89	7647157
2017-18	7762691	199922	36	803	202962	6.89	5.3	1.56	2.9	5.31	6.92	8158307
2018-19	8264937	200422	36	814	199106	6.92	5.3	1.56	2.91	5.3	6.95	8735747
2019-20	8799679	200923	36	824	195323	6.94	5.3	1.56	2.92	5.29	6.97	9198140
2020-21	9369018	201426	36	834	191612	6.97	5.3	1.56	2.92	5.28	7	9812960
2021-22	9975193	201929	36	845	187971	7	5.31	1.56	2.93	5.27	7.03	10525192
2022-23	10620588	202434	36	856	184400	7.03	5.31	1.56	2.93	5.27	7.05	11069551
2023-24	11307740	202940	36	867	180896	7.05	5.31	1.56	2.94	5.26	7.07	11655476
2024-25	12039351	203447	36	878	177459	7.08	5.31	1.56	2.94	5.25	7.1	12434548

Real price of agricultural products (RPAP)

It was assumed that the real price of agricultural products would increase at the rate of 1.27 per cent as observed in period II i.e. 1995-96 to 2010-11.

Real price of tractor (RPT)

The real price of tractor increased at the compound growth of -0.90 per cent in the period 1995-96 to 2010-11. This rate of growth was assumed to prevail upto the year 2025.

Fitness of the model

The fitness of the model was verified, before the estimates were used for predicting the future values. The model was verified by making the ex-ante prediction of the known demand for the tractors in the past. The same estimated demand model (of period II) was applied and predictions were obtained for six years i.e. 2006-07 to 2011-12. The actual and predicted values of demand for tractors for all these years (2006-07 to 2011-12) along with the percentage deviation of the predicted values from the actual values are presented in table 4.4.2. A look at the errors of the prediction suggested that the function performed well with minimum errors and was best fitted for making the projections of demand of tractors.

Estimation of future demand and requirement of tractors

The economic model thus formulated, based on ex-grounds for predictions performed well. As results from the table 4.4.2 show that the predicted values were very close to the actual values, the maximum error prediction being 3.12 per cent only. For this reason this model has been considered for predicting future values. The expected error of prediction i.e. 3 per cent was added to the projected demand for tractors to estimate the requirement of tractors, because the farmers in any case should not face the dearth of availability of tractors when demanded.

The projected demand and anticipated requirement of tractors has been presented in table 4.4.3. The projected demand for tractors in the table revealed that the total demand in India during coming years would vary between 6,045,052 tractors in 2012-13 to 12,434,548 in the year 2024-25. Keeping in view the errors in estimation of demand for tractors, the anticipated requirement of tractors was worked out to be 6,226,404 tractors in 2012-13 to 12,807,585 in the year 2024-25.

Table 4.4.2: Actual and estimated demand for tractors in India (2006-12)

Year	Actual demand	Estimated demand based on Log-Linear regression	Errors in estimation
2006-07	3957223	4010237	1.34
2007-08	4219335	4350612	3.12
2008-09	4504195	4606955	2.29
2009-10	5005201	4978976	-0.53
2010-11	5310705	5372421	1.17
2011-12	5811131	5731523	-1.37

Table 4.4.3: Projected demand for tractors and anticipated requirement of tractors in India based on period II

(Number)

Year	Projected demand for tractors	Anticipated requirement
2012-13	6045052	6226404
2013-14	6449114	6642588
2014-15	6905578	7112746
2015-16	7367159	7588174
2016-17	7647157	7876572
2017-18	8158307	8403057
2018-19	8735747	8997820
2019-20	9198140	9474085
2020-21	9812960	10107349
2021-22	10525192	10840948
2022-23	11069551	11401638
2023-24	11655476	12005141
2024-25	12434548	12807585

4.5 Demand projections based on overall period (1974-75 to 2010-11)

The demand model based on overall period has been used to make projections of demand for tractors. The independent variables included in the model were: Gross irrigated area (GIA), Area under high yielding varieties (HVY), Cropping pattern (CP), Real price of agricultural products (RPAP), and Real price of tractor (RPT). So, the function was formulated as (all in log form)

$$\text{Log } D_T = -7.1 + 1.73(\text{Log GIA}) + 1.63(\text{Log HYV}) - 0.41(\text{Log RPAP}) - 0.32(\text{Log RPT})$$

The future demand for tractors is projected with a fair accuracy by predicting each included explanatory variable under a set of alternative assumptions. The assumptions have been elaborated below:

Gross irrigated area (GIA)

The percentage of gross irrigated area to the total cropped area in the latest year i.e. 2011-12 was 47 per cent and the same was assumed to be prevailing upto the year 2025 and hence the gross irrigated area would be 91,530 thousand hectares in 2025.

Area under high yielding varieties (HVY)

About 53 per cent of total cropped area was under high yielding varieties in India in the year 2011-12. As this percentage has been same more or less same for the past few years, hence the same percentage was assumed to be there upto the year 2025 and the total area under HVY ‘s would be 1,03,400 thousand hectares in the year 2025.

Table 4.5.1: Different explanatory variables predicted under alternative set of assumptions

Year	GIA	HVY	RPAP	RPT	Log (GIA)	Log (HVY)	Log(RPAP)	Log (RPT)	Log(DT)	DT
2011-12	91530	103400	735	229461	4.97	5.02	2.87	5.37	6.74	5979550
2012-13	91530	103400	734	226822	4.97	5.02	2.87	5.36	6.74	6067557
2013-14	91530	103400	733	224214	4.97	5.02	2.87	5.36	6.74	6093458
2014-15	91530	103400	732	221635	4.97	5.02	2.87	5.35	6.74	6119483
2015-16	91530	103400	731	219087	4.97	5.02	2.87	5.35	6.74	6145611
2016-17	91530	103400	730	216567	4.97	5.02	2.87	5.34	6.75	6171868
2017-18	91530	103400	729	214077	4.97	5.02	2.87	5.34	6.75	6198232
2018-19	91530	103400	728	211615	4.97	5.02	2.87	5.33	6.75	6224719
2019-20	91530	103400	728	209181	4.97	5.02	2.87	5.33	6.75	6247806
2020-21	91530	103400	727	206775	4.97	5.02	2.87	5.32	6.75	6274513
2021-22	91530	103400	726	204398	4.97	5.02	2.87	5.32	6.76	6301326
2022-23	91530	103400	725	202047	4.97	5.02	2.87	5.31	6.76	6328272
2023-24	91530	103400	724	199723	4.97	5.02	2.86	5.31	6.76	6355339
2024-25	91530	103400	723	197427	4.97	5.02	2.86	5.3	6.76	6382513

Real Price of agricultural products (RPAP)

It was assumed that price of agricultural products would grow at the growth rate of --0.12 per cent observed in the period III i.e. 1974-75 to 2010-11.

Real price of tractor(RPT)

The real price of tractor was found to grow at the rate of -0.12 per cent in the period 1974-75 to 2010-11. This rate of growth was assumed to prevail upto the year 2025.

Fitness of the model

The verification of the model was done by making the ex-ante prediction of the known demand for the tractors in the past. The same estimated demand model (of Overall Period) was applied and predictions were obtained for six years i.e. 2006-07 to 2011-12. The actual and predicted values of demand for tractors for all these years (2006-07 to 2011-12) along with the percentage deviation of the predicted values from the actual values are presented in table 4.5.2. A close observation at the errors of the prediction suggested that the function performed well with minimum errors and was best fitted for making the projections of demand of tractors.

Estimation of future demand and requirement of tractors

As results from the table 4.5.2 show that the predicted values were very close to the actual values, the maximum error prediction being 3.91 per cent only. For this reason this model has been considered for predicting future values. The expected error of prediction i.e. 4 per cent was added to the projected demand for tractors to estimate the requirement of tractors, because the farmers in any case should not face the dearth of availability of tractors when demanded.

The projected demand and anticipated requirement of tractors has been presented in table 4.5.3. The projected demand for tractors in the table revealed that the total demand in India during coming years would vary between 6,067,557 tractors in 2012-13 to 6,382,513 tractors in the year 2024-25. Keeping in view the errors in estimation of demand for tractors, the anticipated requirement of tractors was worked out to be 6,310,260 tractors in 2012-13 to 6,637,814 in the year 2024-25.

Table 4.5.2: Actual and estimated demand for tractors in India (2006-12)

Year	Actual demand	Estimated demand based on Log-Linear Regression	Errors in estimation (per cent)
2006-07	3957223	4236430	2.01
2007-08	4219335	4884274	3.91
2008-09	4504195	4625941	2.71
2009-10	5005201	4965924	-0.79
2010-11	5310705	5305179	-0.11
2011-12	5811131	5979550	2.89

Table 4.5.3: Projected demand for tractors and anticipated requirement of tractors in India based on period III

(Number)

Year	Projected demand for tractors	Anticipated requirement
2012-13	6067557	6310260
2013-14	6093458	6337197
2014-15	6119483	6364263
2015-16	6145611	6391436
2016-17	6171868	6418743
2017-18	6198232	6446162
2018-19	6224719	6473708
2019-20	6247806	6497719
2020-21	6274513	6525494
2021-22	6301326	6553380
2022-23	6328272	6581403
2023-24	6355339	6609553
2024-25	6382513	6637814

Demand projections of Tractors in Punjab

4.6 Demand projections of tractors based on period II

The demand for tractors based on the demand model of period II was projected for Punjab. The exogenous variables included in the function were: Lagged demand (D_{T-1}), Area under high yielding varieties (HYV), Real price of tractor (RPT). Thus the demand model formulated was:

$$\text{Log } D_T = 3.71+0.014 (\text{Log } D_{T-1}) +1.11 (\text{Log HVY}) - 0.43 (\text{Log RPT})$$

Lagged demand (D_{T-1})

The number of tractors increased at the rate of 2.16 per cent in the period II (1995-96 to 2010-11).The same growth rate was assumed to be prevailing in future too.

Area under high yielding varieties

As the area under high yielding variety was 6470 thousand hectares in the year 2011-12, which is already 82 per cent of the total cropped area. As it cannot increase endlessly and one would expect the area to have maximum limit and stabilise ultimately. Hence, the same percentage 82 per cent was assumed to be existing upto the year 2025 and the total area under high yielding varieties would be 6470 thousand hectares in the year 2025.

Real price of tractor

The real price of tractor increased at a negative growth rate of 1.48 per cent in the period 1995-96 to 2010-11. This rate of growth was assumed to prevail upto the year 2025.

Table 4.6.1: Different explanatory variables predicted under alternative set of assumptions

Year	DT-1	HVY	RPT	Log (DT-1)	Log (HVY)	Log (RPT)	Log (DT)	DT
2011-12	509335	6470	228695	5.71	3.82	5.36	5.72	519424
2012-13	520388	6470	225310	5.72	3.82	5.35	5.72	522922
2013-14	531680	6470	221976	5.73	3.82	5.35	5.73	526443
2014-15	543218	6470	218690	5.74	3.82	5.34	5.73	529990
2015-16	555006	6470	215454	5.75	3.82	5.33	5.73	533558
2016-17	567049	6470	212265	5.76	3.82	5.33	5.73	537152
2017-18	579354	6470	209124	5.77	3.82	5.32	5.74	540769
2018-19	591926	6470	206029	5.78	3.82	5.31	5.74	544411
2019-20	604771	6470	202979	5.79	3.82	5.31	5.74	548078
2020-21	617894	6470	199975	5.8	3.82	5.3	5.75	551769
2021-22	631303	6470	197016	5.81	3.82	5.29	5.75	555484
2022-23	645002	6470	194100	5.81	3.82	5.29	5.75	559226
2023-24	658998	6470	191227	5.82	3.82	5.28	5.76	562992
2024-25	673299	6470	188397	5.83	3.82	5.28	5.76	566784

Table 4.6.2: Actual and Estimated demand for tractors in Punjab 2006-12

Year	Actual demand	Estimated demand based on Log-Linear Regression	Errors in Estimation (per cent)
2006-07	479845	47822	-0.01
2007-08	485781	489419	0.75
2008-09	492220	502089	2.01
2009-10	498517	507412	1.79
2010-11	499551	512626	2.62
2011-12	518915	519424	0.09

Table 4.6.3: Projected demand for tractors and anticipated requirement of tractors in Punjab based on period II

(Number)

Year	Projected demand for tractors	Anticipated requirement
2012-13	522922	538610
2013-14	526443	542237
2014-15	529990	545890
2015-16	533558	549565
2016-17	537152	553267
2017-18	540769	556993
2018-19	544411	560744
2019-20	548078	564521
2020-21	551769	568323
2021-22	555484	572149
2022-23	559226	576003
2023-24	562992	579882
2024-25	566784	583788

Fitness of model

Before the estimates were used for predicting the future values, the fitness of econometric model was verified. This was done by making ex-ante predictions of the known demand for the tractors in the past. The same estimated demand model (of period II) was applied and predictions were obtained for eight years i.e. 2004-05 to 2011-12. The actual and predicted values of demand for tractors for all these years (2004-05 to 2011-12) along with the percentage deviation of the predicted values from the actual values are presented in table 4.6.2.A close observation on the table 4.6,2 reveal that model was best fitted with an maximum acceptable error of 2.62 per cent i.e. 3 per cent.

Estimation of future demand and requirement of tractors

The expected error of prediction i.e. 3 per cent was added to the projected demand for tractors to estimate the requirement of tractors, because the farmers in any case should not face the dearth of availability of tractors when demanded.

The projected demands for tractors and corresponding anticipated requirement based on these projections have been shown in Table 4.6.3. According to the estimates the future demand for tractors in Punjab is expected to be 5,22,922 and 5,66,784 in the years 2012-13 and 2024-25 respectively. The corresponding anticipated requirement was worked as 5,38,610 and 5,83,788 tractors in the years 2012-13 and 2024-25.

Demand projections based on overall period (1974-75 to 2010-11)

The demand model based on overall period has been used to make projections of demand for tractors. The independent variables included in the model were: Demand for tractors in previous year (D_{T-1}), Cultivated area (CA), Area under high yielding varieties (HVY), Cropping intensity (CI), Real price of agricultural products (RPAP), and Real price of tractor (RPT).

Log D_T = -15.31+ 0.033 (Log $D_{t-1)}$ + 2.78 (Log CA) + 1.20 (Log HYV) + 4.13(Log CI) - 0.46 (Log RPAP) - 0.36 (Log RPT)

Lagged demand ($D_{t-1)}$

The number of tractors increased at the rate of 6.16 per cent in the Overall Period (1974-75 to 2010-11). The same growth rate was assumed to be prevailing in future too.

Cultivated area (CA)

It was assumed that it would increase at the same rate of growth (-0.0005) as observed in Overall Period (1974-75 to 2010-11) up to the year 2025 and would be 4,191 thousand hectares in the year 2025.

Area under high yielding varieties (HVY)

The percentage total cropped area under high yielding varieties in Punjab in the year 2011-12 was 82 per cent. As this percentage has been same more or less same for the past few years, hence the same percentage was assumed to be there upto the year 2025 and the total area under HVY ‘s would be 6,470 thousand hectares in the year 2025.

Cropping intensity (CI)

It is obvious that cropping intensity cannot increase endlessly and one would expect the cropping intensity to have maximum limit and stabilise ultimately, until some other major breakthrough in agricultural technology occurs. So cropping intensity was assumed to increase with the annual increment of 0.69 per cent and it would be 210 per cent in the year 2025.

Table 4.7.1: Different explanatory variables predicted under alternative set of assumptions

Year	D_{T-1}	CA	HYV	CI	RPAP	RPT	Log (D_{T-1})	Log(CA)	Log(HVY)	Log(CI)	Log(RPAP)	Log(RPT)	Log (DT)	DT
2011-12	499551	4191	6470	192	604	229693	5.7	3.62	3.82	2.28	2.78	5.36	5.73	532844
2012-13	530324	4191	6470	193	602	227281	5.72	3.62	3.82	2.28	2.78	5.36	5.74	548530
2013-14	562992	4191	6470	194	600	224895	5.75	3.62	3.82	2.29	2.78	5.35	5.8	590016
2014-15	597672	4191	6470	196	598	222534	5.78	3.62	3.82	2.29	2.78	5.35	5.81	591362
2015-16	634489	4191	6470	197	596	220197	5.8	3.62	3.82	2.29	2.77	5.34	5.82	603551
2016-17	673573	4191	6470	199	594	217885	5.83	3.62	3.82	2.3	2.77	5.34	5.88	665279
2017-18	715065	4191	6470	200	592	215597	5.85	3.62	3.82	2.3	2.77	5.33	5.89	671837
2018-19	759113	4191	6470	201	590	213333	5.88	3.62	3.82	2.3	2.77	5.33	5.91	673370
2019-20	805874	4191	6470	203	588	211093	5.91	3.62	3.82	2.31	2.77	5.32	5.96	748417
2020-21	855516	4191	6470	204	586	208877	5.93	3.62	3.82	2.31	2.77	5.32	5.98	749555
2021-22	908216	4191	6470	205	584	206684	5.96	3.62	3.82	2.31	2.77	5.32	5.99	751266
2022-23	964162	4191	6470	207	582	204513	5.98	3.62	3.82	2.31	2.76	5.31	6.01	766750
2023-24	1023554	4191	6470	208	579	202366	6.01	3.62	3.82	2.32	2.76	5.31	6.05	845169
2024-25	1086605	4191	6470	210	577	200241	6.04	3.62	3.82	2.32	2.76	5.3	6.07	854149

Real price of agricultural products (RPAP)

It was assumed that the real price of agricultural products would increase at the rate of-0.35 per cent as observed in Overall Period i.e. 1974-75 to 2010-11.

Real price of tractor (RPT)

The real price of tractor increased at the compound growth of -1.05 per cent in the period 1974-75 to 2010-11. This rate of growth was assumed to prevail upto the year 2025.

Table 4.7.2: Actual and Estimated demand for tractors in Punjab 2006-12

Year	Actual demand	Estimated demand based on Log –Linear regression	Errors in estimation
2006-07	479845	469441	-2.17
2007-08	485781	471086	-3.03
2008-09	492220	489441	-0.57
2009-10	498517	504081	1.12
2010-11	499551	514044	2.91
2011-12	517743	532844	2.92

Table 4.7.3: Projected demand for tractors and anticipated requirement of tractors in Punjab based on period III

(Number)

Year	Projected demand for tractors	Anticipated requirement
2012-13	548530	564986
2013-14	590016	607717
2014-15	591362	609103
2015-16	603551	621658
2016-17	665279	685238
2017-18	671837	691993
2018-19	673370	693572
2019-20	748417	770870
2020-21	749555	772042
2021-22	751266	773804
2022-23	766750	789753
2023-24	845169	870525
2024-25	854149	879774

Fitness of model

The fitness of econometric model was verified, before the estimates were used for predicting the future values. The ex-ante predictions of the known demand for the tractors in the past were used for the verification of the model. The same estimated demand model (of period II) was applied and predictions were obtained for eight years i.e. 2004-05 to 2010-11. The actual and predicted values of demand for tractors for all these years (2004-05 to 2010-11) along with the percentage deviation of the predicted values from the actual values are presented in table 4.12.1.A close observation on the table 4.7.2 reveal that model was best fitted with an maximum acceptable error of 2.92 per cent.

Estimation of future demand and requirement of tractors

The expected error of prediction i.e. 3 per cent was added to the projected demand for tractors to estimate the requirement of tractors, because the farmers in any case should not face the dearth of availability of tractors when demanded.

The projected demands for tractors and corresponding anticipated requirement based on these projections have been shown in Table 4.7.3. According to the estimates the future demand for tractors in Punjab is expected to be 5,48,530 in the year 2012-13 and 8,54,149 in 2024-25 respectively. The corresponding anticipated requirement was worked as 5,64,986 and 8,79,774 tractors in the years 2012-13 and 2024-25.

An important conclusion that emerged out from the above discussion is that the projections made on the basis of period II comparatively gave better results statistically. As the analysis was based on the recent past data which would depict the factors influencing the farmer's behaviour in the purchase of tractor in the very recent years which would be the same factors influencing the demand in future

Conclusions and policy implications

The results of compound growth rates of tractors in leading agriculture states of India clearly showed that the growth of tractors, in general, was higher during the period I (1974-75 to 1994-95) as compared to period II (1995-96 to 2010-11). This impressive rise in the rate of growth of tractors during the Period I could be credited to the Green revolution which started in mid sixties but spread during this period. It can also be seen that in period II (1994-95 to 2010-11) growth has been relatively high in states where tractor penetration was low initially viz. states like Tamil Nadu and Karnataka. Overtime the pace of tractorisation in these states (Punjab, Haryana, and Uttar Pradesh) had slowed down significantly reason being that the number of tractors have almost reached a saturation level from both economic as well as operational point of view. About 40-50 per cent of total tractors in India were concentrated only in two states – Punjab and Uttar Pradesh during 1974-75 and 1993-94 but during 2011-12, Rajasthan and Uttar Pradesh occupied more than 30 per cent of the total tractors concentrated in the country. There by apparently showing that overtime the rate of growth of tractors in Punjab

had slowed down. Haryana, Punjab, Uttar Pradesh and Gujarat had the highest concentration of tractors while Kerala, Maharashtra, Andhra Pradesh and Madhya Pradesh were the states with lower tractor density in the country. During 1974-75 and 1993-94 Punjab had the highest number of tractors and in 2009-10, Haryana showed the highest tractor density with 138 tractors per thousand hectares of net area sown. In Punjab also, the scenario was same as in India. All those districts, where there were less number of tractors in the base period, exhibited higher rate of growth and growth rates of tractors showed a decline in all the districts in period II as compared to period I. The higher rate of growth of tractors in this period (during seventies and mid eighties) was in quick response to the increased power requirements which were consequence of intensive cultivation and incredible increase in the cropping intensity. Tractors in the state were concentrated in the districts of Bathinda, Firozpur, Ludhiana, Patiala, Jalandhar, Sangrur, and Faridkot whereas Rupnagar, Gurdaspur, and Hoshiarpur districts had relatively low percentage share in total tractor population of the state. The tractor density was found to be the highest in districts like Faridkot, Bathinda, Patiala, and Amritsar where as it was low in districts like Gurdaspur, Hoshiarpur and Firozpur. The distribution of tractors is irrational in the country as well as Punjab. The analysis carried out confirmed the existence of considerable differences between the various regions of the country in terms of tractorisation. There is still scope for the improvement in tractorisation. The government must place greater emphasis in states/districts where the tractor penetration is low and make policies suitable for increasing the mechanisation of farms.

The analysis to investigate the different factors affecting the demand for tractors overtime brought out that in the initial stage of tractorisation (during 1974-75 to 1994-95) area under high yielding variety seeds and gross irrigated area were only significant factors determining the demand for tractors in the country. But, of late, during (1995-96 to 2010-11) social factors involved in owning tractor came out to be important variable. So farmers are purchasing tractor widely not only of their farming necessities but also because tractor has became a status symbol for the farming community. The analysis of determinants in Punjab revealed that the lagged demand, area under high yielding variety and real price of tractor remained significant variables in all the periods. Among these three significant variables, the elasticity of demand for tractors with respect to area under high yielding varieties was the highest in all the periods which revealed higher importance of area under high yielding variety in affecting the demand for tractors in the state. So, it may be concluded that the contribution of HVY's in determining demand for tractors increased overtime and area under HVY's was the major factor behind the increased tractor demand in the state. This particular analysis would guide the government to make the right choice and know which particular factor to be given more importance in order to improve tractorisation on the farms thereby increase the production and yields.

Projections are necessary to monitor the supply side. The projected demand for tractors based on Period II revealed that the total demand in India during coming years would vary between 6,045,052 tractors in 2012-13 to 12,434,548 in the year 2024-25. Keeping in view the errors in estimation of demand for tractors, the anticipated requirement of tractors was worked out to be 6,226,404 tractors in 2012-13 to 12,807,585 in the year 2024-25. The projected demand for tractors based on overall period (1974-75 to 2010-11) showed that the total demand in India during coming years would vary between 6,067,557 tractors in 2012-13 to 6,382,513 tractors in the year 2024-25. Keeping in view the errors in estimation of demand for tractors, the anticipated requirement of tractors was worked out to be 6,310,260 tractors in 2012-13 to 6,637,814 in the year 2024-25. In Punjab, according to the estimates based on period II the future demand for tractors is expected to be 5,22,922 and 5,66,784 in the years 2012-13 and 2024-25 respectively. The corresponding anticipated requirement was worked as 5,38,610 and 5,83,788 tractors in the years 2012-13 and 2024-25 respectively. Where as the estimates based on overall period, the future demand for tractors in Punjab is expected to be 5,48,530 in the year 2012-13 and 8,54,149 in 2024-25 respectively. The corresponding anticipated requirement was worked as 5, 64,986 and 8, 79,774 tractors in the years 2012-13 and 2024-25. The projections will guide the policy makers and the manufacturers to plan their future production accordingly. The dealers can have a idea of how to adjust the supply.

CHAPTER V

SUMMARY

Agriculture is an important sector in the Indian economy as it plays a key role in generating income and employment. India has a very large population which depends on agriculture for its livelihood. It continues to be the key segment of the country with a production level of 255.36 million tonnes of food grains (2012-13) and a sectorial contribution of 13.9 per cent of the gross domestic product (2011-12). India has already crossed the state of self-sufficiency in food grain production and been marching ahead with surplus stocks. With a considerable contribution of 12.4 per cent in the total exports and 1.7 per cent share in world's agricultural export market, the Indian agriculture has traversed a long way from subsistence level to that of commercial farming mainly after the advent of green revolution. This has been made possible due to evolution of high yielding crop varieties, increased use of chemical fertilizers, development of irrigation facilities and plant protection measures accompanied by effective price support programmes of farm products. The increased use of purchased inputs in agriculture necessitated to raise their use efficiencies through mechanization. Agricultural machinery, particularly tractorisation helped the farmers to go for timely land preparation and sowing of crops and intensive cultivation.

The number of tractors increased from 0.1 million in 1971 to 2.7 million in 2004 and increased to 5.8 million in 2011-12. The tractor penetration level in India has been very slow and not remained uniform throughout the country. The northern region especially Uttar Pradesh, Punjab, Rajasthan, Madhya Pradesh, Haryana and Gujarat is now almost saturated in terms of tractor uses; the southern region is still under penetrated (Jain 2006).

The numbers of tractors in Punjab were 0.047 million in 1974-75 to 0.33 million in 1993-94 which further increased to 0.52 million in 2011-12 (GOP 2012). Therefore it becomes pertinent to examine the factors responsible for this consistent increase in the number of tractors both in India as well as Punjab.

In this context of new challenges and changing order in the tractor industry an extensive research is needed to understand the growth pattern, factors governing them. The present study is carried out in this regard with these specific objectives:

i. To assess the growth and distributional pattern of tractors in leading agricultural states of India;
ii. To identify the various factors influencing the demand for tractors in India as well as in Punjab; and
iii. To project future demand for tractors in the country as well as in Punjab state.

Time series data for number of tractors in the state as well as in country, Cultivated area , Net area sown , Total cropped area , Gross irrigated area , Net irrigated area , Area

under high yielding varieties, Cropping intensity , Cropped area under paddy and wheat , Cropped area under paddy, Cropped area under wheat , average price of agricultural products will be collected from various issues of Statistical Abstract of India and Statistical Abstract of Punjab and other secondary sources such as Economic Surveys etc. The price of tractors was collected from various local dealers and the details regarding loan advanced was collected from Punjab Primary Agriculture Development Bank.

Inspite various limitations in the availability of data, the study was quantified effectively using some statistical techniques. To measure the growth compound growth rates were employed, which was computed by fitting the exponential trend equation. The inter-state and inter-district variations in the tractor concentration, the percentage share of different states and districts in the total tractor population of the country and of the state was worked out. But as the size of different states and districts is not uniform with regard to cultivatable area, the tractor population per thousand hectares of total cropped area, net area sown, gross irrigated area and net irrigated area was also worked out for three points of time. The factors determining the demand for tractors was investigated in India as well as Punjab, by using multiple regression analysis. Both linear and log linear type functions were tried but finally, log linear function was retained as results obtained from this function were better in terms of level of significance etc. Further, demand projections were made using the various predicted explanatory variables of best fit model based on set of assumptions. The main findings of the study have been summed up as below:

The examination of compound growth rates of various states of India revealed that tractors increased at the rate of 12.55 per cent per annum during the period I. The maximum growth rate of 19.52 per cent was recorded for Madhya Pradesh followed by Haryana (17.08 %). The minimum growth rate was recorded for Tamil Nadu (3.55 %). During the period II (1994-95 to 2010-11), Karnataka attained the maximum growth rate of 11.1 per cent followed by Maharashtra (8.13 %) and Kerala showed a negative rate of growth of -0.37 per cent. it was found that in the states namely Gujarat, Haryana, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Madhya Pradesh and Tamil Nadu, the growth rates were higher than that of India as whole (6.24 %) during the period II. The analysis of overall period revealed that Madhya Pradesh recorded the highest rate of growth i.e. 13.63 per cent, followed by Rajasthan (12.02 %). The rate of growth was the lowest in Kerala (3.65 %). As the pattern of tractorisation in the country is not uniform the interstate analysis to see the distributional pattern of tractors at different points of time was carried out. The results showed that 40-50 per cent of total tractors in India were concentrated only in two states – Punjab and Uttar Pradesh during 1974-75 and 1993-94. During 2011-12, Rajasthan and Uttar Pradesh occupied more than 30 per cent of the total tractors concentrated in the country. The raise is mainly because of higher MSP s forecasted, limited availability of labour forcing higher

mechanisation and greater availability of finance for the purchase of tractor. Tractor density i.e. tractor population per thousand hectares of total cropped area, net area sown, net irrigated area or gross irrigated area has been worked out to analyse the availability of tractors in agriculture across the states. It was found that number of tractors availability per thousand hectares of net area sown in India was only 1.19 in 1974-75 which moved up to 11.76 in 1993-94 and 35.74 in the year 2009-10. Tractor density was found to be the highest in Punjab, being 11.64thousand hectares of net area sown and it was lowest in Madhya Pradesh (0.43).In period (1993-94) too, Punjab maintained the highest position with 80.32 per thousand hectares of net area sown. Karnataka showed the lowest tractor density i.e. 5.12 per thousand hectares of net area sown. During 2009-10, Haryana showed the highest tractor density i.e. tractors per thousand hectares of net area sown. And Karnataka (5.12) again had the lowest tractor density.

The analysis of growth pattern of tractors in Punjab showed that the annual compound growth rate of tractors in Punjab was 9.92 per cent during Period I and it declined to 1.32 per cent in Period II. The overall rate of growth over the span 1974-75 to 2011-12 was observed to be 5.71 per cent per annum. During period I i.e. 1974-75 to 1996-97 the highest rate of growth was attained by Sangrur district (16.50 %) followed by Faridkot (14.08 %). The lowest rate of growth was recorded by Jalandhar (7.41 %). In the period II (1997-98 to 2011-12) Hoshiarpur district witnessed highest growth rate of 3.09 per cent, while Faridkot showed the lowest growth rate of 0.57 per cent per annum. The overall growth rate (1974-75 to 2011-12) was maximum in the district of Sangrur (8.71 %) followed by Faridkot (7.7 %). The minimum rate of growth was observed for Bathinda (4.70%).The inter-district analysis of distributional pattern brought out that the districts namely Bathinda, Ludhiana, Patiala, Jalandhar, and Firozpur occupied first five positions and these districts collectively constituted about 70 per cent of the tractor population in the state during the period 1975-76. During 1994-95, Firozpur, Bathinda, Faridkot, Sangrur and Ludhiana taken together accounted for about 60 per cent, whereas all the remaining districts shared only about 40 per cent of the total tractor population in the state. In 2011-12, 65 per cent of the total tractor population of the state was concentrated in the districts of Bathinda, Firozpur, Faridkot, Sangrur, Patiala and Ludhiana. Tractor density i.e. the tractor population per thousand hectares of net area sown in the state which was 13.31 in 1975-76, increased rapidly to 112.57 in 2010-11. The inter-district analysis showed that during 1975-76, the tractor population per thousand hectares of net area sown was found to be highest in Ludhiana with 28.46 tractors followed by Bathinda with 23 tractors and the lowest tractor density i.e. tractor population per thousand hectares of net area sown was observed to be in Sangrur, being 4.07 tractors. During

the period 1993-94, Bathinda showed the highest tractor density. It was 153.26 tractors per thousand hectares of net area sown and it was lowest in Gurdaspur with 43.87 tractors per thousand hectares of net area sown**.** In the period 2010-11, the highest tractors density was noticed in Faridkot district. It was 433.87 per thousand hectares of net area sown. The lowest being Gurdaspur with 51.47 tractors per thousand hectares of net area sown. Thus, the foregoing analysis indicated that the growth of tractors, in general, was observed to be higher in those districts/states where there was low level of tractors in the initial period i.e. (1974-75 to 1994-95) . It was observed that the growth of tractors in general was higher during the period I and Green revolution which started in mid sixties but spread during this period, is the major contributor for this dramatic rise in the rate of growth of tractors during the Period I. Thus it was the impact of Green revolution and new technology that contributed significantly and positively towards the demand for tractors during these years (1974-75 to 1994-95).

The relationship between tractorisation and different factors was investigated using (log-linear) regression analysis. The regression analysis pertaining to period I (1974-75 to 1994-95) for India showed that gross irrigated area, area under high yielding variety and were the significant factors that determined the tractor demand in Period I. The increase in gross irrigated area and area under high yielding variety had positive impact on tractor demand i.e. 1 per cent increase in the gross irrigated area would result in 2.35 percent increase in demand for tractors and 1 per cent increase in area under high yielding variety would raise demand by 1.39 per cent. In the period II (1995-96 to 2010-11) the demand for tractors in the previous year (D_{T-1}) and Real price of tractor were significant variables which influenced the demand for tractors in India during Period II. The coefficient of lagged demand was 0.74 significant at 1 per cent level i.e. 1 per cent increase in the demand for tractors in the current year would increase 0.74 per cent increase in demand for tractors in the succeeding year. The regression coefficient of real price of tractor was found to be -0.63 per cent being statistically significant at 5 per cent of probability level which indicated that 1 per cent increase in real price of tractor would result in 0.63 per cent decline in demand for tractors. During period III, gross irrigated area and area under high yielding variety had been responsible for increased demand for tractors in India; the elasticities being 1.63 and 1.73 respectively which mean that 1 per cent increase in the area under high yielding variety, the demand for tractors would increase by 1.63 per cent whereas 1 per cent increase in gross irrigated area; demand for tractors would increase by 1.73 per cent. The important conclusion that emerged out of foregoing analysis that that in the initial stage of tractorisation (during 1974-75 to 1994-95) area under high yielding varieties and gross irrigated area were dominant significant factors determining the demand for tractors in the country. During (1995-96 to 2010-11) social factors involved in owning tractor came out to be important variable. So

farmers are purchasing tractor widely not only of their farming necessities but also because tractor has became a status symbol for the farming community.

The analysis of regression equation of Period I (1974-75 to 1994-95) for Punjab revealed that demand for tractors in the previous year (D_{T-1}), area under high yielding varieties (HVY), cropping intensity (CI), were significant variables which largely affected the demand for tractors in Punjab. The elasticity coefficients of lagged demand, area under high yielding varieties, cropping intensity were found to be 0.31,1.08 and 2.48 respectively which showed that that 1 per cent increase in demand for tractors in current year the demand for tractors in succeeding year would increase by 0.31 per cent; 1 per cent increase in area under high yielding variety the demand for tractors in the state would increase by 1.08 per cent and 1 per cent increase in the gross irrigated area would result in 2.48 percent increase in demand for tractors. The real price of tractor showed significant and negative association with the demand for tractors in the state. The regression coefficient of tractorisation with respect to real price of tractor was found to be -0.26 being significant at 5 per cent probability level which indicated that 1 per cent increase in real price of agricultural products resulted in 0.26 per cent decline in demand for tractors.

In the period II, the tractor demand in Punjab was positively and significantly influenced by increase in area under high yielding varieties. The regression coefficient was found out to be 1.11 which was statistically significant at 5 per cent probability level .One per cent increase in the area under high yielding varieties, the demand for tractors would increase by about 1.11 per cent. The real price of tractor showed significant and negative association with the demand for tractors in the state The regression coefficient of real price of tractor was found to be -0.63 per cent being statistically significant at 5 per cent of probability level which indicated that 1 per cent increase in real price of tractor would result in 0.63 per cent decline in demand for tractors. During period III, lagged demand, cultivated area, area under high yielding variety and cropping intensity had been responsible for increased demand for tractors in Punjab. But, the real price of tractor showed significant and negative association with the demand for tractors. The elasticity coefficients for these variables were 0.03, 2.78, 1.20 and 4.13 respectively. The elasticity coefficient of lagged demand for tractors was found to be 0.03, significant at 5 per cent level of probability. It revealed that 1 per cent increase in demand for tractors in current year the demand for tractors in succeeding year would increase by 0.03 per cent. The coefficient of cultivated area (2.78) was found to be statistically significant at 1 per cent probability level. This implied that with 1 per cent increase in the cultivated area, the demand for tractors would increase by 2.78 per cent. The coefficient of

demand for tractors with respect to area under high yielding varieties was 1.20 which was found to be statistically significant at 1 per cent probability level. It means that one per cent increase in the area under high yielding varieties, the demand for tractors would increase by about 1.20 per cent. The elasticity of demand for tractors with respect to cropping intensity was 4.13, which was found to be statistically significant at 1 per cent probability level. This implied that with 1 per cent increase in the cropping intensity, the demand for tractors would raise by 4.13 per cent. The real price of tractor showed significant and negative association with the demand for tractors in the state The regression coefficient of real price of tractor (-0.36) showed significance at 1 per cent level of probability. It revealed that 1 per cent increase in real price of tractor; the demand for tractors would decrease by about 0.36 per cent. Thus, the elaborated discussion of regression results led to the conclusion that the lagged demand, area under high yielding variety and real price of tractor remained significant variables in all the periods. Among these three significant variables, the elasticity of demand for tractors with respect to area under high yielding varieties was the highest in all the periods which revealed higher importance of area under high yielding variety in affecting the demand for tractors in the state. So, it may be concluded that the contribution of HVY's in determining demand for tractors increased overtime and area under HVY's was the major factor behind the increased tractor demand in the state.

The projections of demand (based on demand model of period II), for tractors in India, revealed that the total demand in India during coming years would vary between 6,045,052 tractors in 2012-13 to 12,434,548 in the year 2024-25. Keeping in view the errors in estimation of demand for tractors, the anticipated requirement of tractors was worked out to be 6,226,404 tractors in 2012-13 to 12,807,585 in the year 2024-25.The demand projections (based on demand model of period III), for tractors in India, revealed that the total demand in India during coming years would vary between 6,067,557 tractors in 2012-13 to 6,382,513 tractors in the year 2024-25. Keeping in view the errors in estimation of demand for tractors, the anticipated requirement of tractors was worked out to be 6,310,260 tractors in 2012-13 to 6,637,814 in the year 2024-25.The projections of demand (based on demand model of period II), for tractors in Punjab have been worked out. According to the estimates the future demand for tractors in Punjab is expected to be 5,22,922 and 5,66,784 in the years 2012-13 and 2024-25 respectively. The corresponding anticipated requirement was worked as 5,38,610 and 5,83,788 tractors in the years 2012-13 and 2024-25. According to the estimates (based on demand model of period III) the future demand for tractors in Punjab is expected to be 5,48,530 in the year 2012-13 and 8,54,149 in 2024-25 respectively. The corresponding

anticipated requirement was worked as 5,64,986 and 8,79,774 tractors in the years 2012-13 and 2024-25.

On a whole it could be concluded that the tractor industry is growing at a declining trend in the state as well as in the country. The distribution pattern of tractors is rational. The manufacturing industries need to focus on the states/districts with low level of penetration of tractors to raise the use of tractors in agriculture to improve the production and productivity levels of the farms.

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APPENDIX I

Number of tractors in India and Punjab

YEAR	Number of tractors (India)	Number of tractors (Punjab)
1974-75	163831	47611
1975-76	189029	55327
1976-77	224147	64526
1977-78	264197	74973
1978-79	271032	85766
1979-80	359546	101556
1980-81	428111	118845
1981-82	516461	146532
1982-83	577321	163550
1983-84	640727	181680
1984-85	698304	195513
1985-86	718352	208614
1986-87	738400	222183
1987-88	943703	239121
1988-89	1024837	253716
1989-90	1145132	260511
1990-91	1232896	289064
1991-92	1419119	307002
1992-93	1517869	324350
1993-94	1672063	338494
1994-95	1737264	354378
1995-96	2091598	371720
1996-97	2156871	387007
1997-98	2394917	398927
1998-99	2460183	411615
1999-00	2641223	423140
2000-01	2944116	434032
2001-02	3110245	442562
2002-03	3261904	450956
2003-04	3329232	459424
2004-05	3566769	466480
2005-06	3759753	473354
2006-07	3957223	479845
2007-08	4219335	485781
2008-09	4504195	492220
2009-10	5005201	498517
2010-11	5310705	499551
2011-12	5811131	518915

APPENDIX-II

Number of tractors in different states of India

Year	Gujarat	Haryana	Maharastra	Punjab	Rajasthan	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Madhya pradesh	Tamil Nadu	Other states	India
1974-75	16054	6598	9260	47611	13444	30702	6929	8370	2466	8022	4799	9576	163831
1975-76	16125	11346	9562	45300	14851	37025	7617	8202	8787	3425	7866	18923	189029
1976-77	16503	13651	10799	59858	14901	51115	8333	8668	5997	5724	8160	20438	224147
1977-78	16880	15955	12035	74415	14950	65204	9048	9134	3207	8022	8453	26894	264197
1978-79	18252	15955	18916	89468	28110	25077	10736	16047	3844	8022	9320	27285	271032
1979-80	20558	21955	21684	102542	39024	82206	10736	16624	4225	8022	10197	21773	359546
1980-81	24074	35160	25474	118845	32031	99029	14127	17538	3080	26123	10649	21981	428111
1981-82	45275	36329	30084	144466	36579	109642	11120	18814	3482	29749	11634	39287	516461
1982-83	49843	46656	32868	161853	39189	125726	15075	20947	3497	31693	11666	38308	577321
1983-84	54410	56982	35651	179239	41798	141809	19030	23080	3511	33637	11698	39882	640727
1984-85	61400	60368	38269	195513	39286	154910	22701	26736	4061	33637	14069	47354	698304
1985-86	62450	70368	39500	208614	39286	155430	22956	27863	4100	33637	15698	38450	718352
1986-87	63256	71590	40050	222183	40256	159280	23569	29569	4156	34280	15985	34226	738400
1987-88	74538	80236	48269	239121	65205	182659	25009	32590	6950	55962	16398	116766	943703
1988-89	78878	102688	51939	253716	76986	221176	22099	35455	8321	75113	8111	90355	1024837
1989-90	85386	107039	57157	268511	87102	237093	29431	38235	8703	84750	9021	132704	1145132
1990-91	92541	111390	63668	289064	98965	266339	34183	41640	9034	94025	10707	121340	1232896
1991-92	110546	127312	76333	324350	170102	356221	50780	52592	10294	115804	12582	12203	1419119
1992-93	115749	160064	79711	331422	177839	358318	50780	54391	10985	121046	14093	43471	1517869

Year	Gujarat	Haryana	Maharastra	Punjab	Rajasthan	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Madhya pradesh	Tamil Nadu	Other states	India
1993-94	120951	192815	83088	338494	185576	360415	50780	56189	11675	126288	15604	130188	1672063
1994-95	134479	205864	91903	354378	201124	363774	50780	63122	5045	144871	16753	105171	1737264
1995-96	151831	212716	104169	371720	222292	518598	76915	70911	15104	167449	53323	126570	2091598
1996-97	170382	220189	104169	387007	248375	471037	84904	78950	16519	188348	58087	128904	2156871
1997-98	191143	227661	134975	416198	272429	499466	95689	88768	16988	219714	68209	163677	2394917
1998-99	212432	230959	148807	398927	306608	553954	39686	92066	5567	242608	62164	166405	2460183
1999-00	230050	250959	163182	398927	334317	622404	43705	101000	6357	268455	63764	158103	2641223
2000-01	242158	330669	181775	451643	359085	66955	50555	105366	8825	106520	355822	684743	2944116
2001-02	254586	356391	186675	449158	373522	677366	58479	112260	8459	283711	70209	279429	3110245
2002-03	267113	358983	194902	450552	389489	709797	60325	119040	8702	304760	88117	310124	3261904
2003-04	275543	373373	201940	459014	407523	718082	62363	119340	9004	328380	90886	283784	3329232
2004-05	290219	382581	212466	466063	432686	742717	64456	144355	14496	355625	95344	365761	3566769
2005-06	311385	394111	229362	472873	464443	795411	66613	166685	15162	376771	102744	364193	3759753
2006-07	336986	405605	250950	478057	504002	797990	184441	132142	9644	394356	115260	347790	3957223
2007-08	362799	430365	276438	485044	537735	847329	212904	142521	10207	411424	126358	376211	4219335
2008-09	386951	473438	302249	491358	569807	893683	242305	152964	10641	432618	137829	410352	4504195
2009-10	410516	490828	331694	497551	605539	953959	261509	318844	10665	458445	150432	515219	5005201
2010-11	442737	507321	371075	504310	644305	978627	292427	341559	11209	498997	167066	557831	5310705

APPENDIX III

Number of tractors in different districts of Punjab

Year	Gurdaspur	Amritsar	Kapurthala	Jalandhar	Hoshiarpur	Rupnagar	Ludhiana	Firozpur	Faridkot	Bathinda	Sangrur	Patiala	Punjab
1974-75	1847	2963	2609	5817	3138	960	8587	3092	864	10368	1540	5816	47611
1975-76	1960	3267	2709	6183	3361	1043	9191	4021	3448	11752	1846	6546	55327
1976-77	1989	4589	2889	6808	3709	1185	9848	6835	4593	12495	2426	7160	64526
1977-78	2177	5788	3117	7366	3992	1284	10611	9897	6071	13592	3011	8067	74973
1978-79	2365	6099	3346	7924	4334	1383	11380	13118	8014	14776	3848	9189	85766
1979-80	2612	6536	3861	8909	4812	1532	12623	18023	9259	16386	6405	10598	101556
1980-81	3424	7770	3225	10230	4919	1944	14146	21195	11557	18320	8802	13313	118845
1981-82	4240	13169	4621	12492	5706	2438	17922	24293	14088	20490	11212	15666	146532
1982-83	5286	14652	5212	13144	6189	2781	19813	26489	16291	22454	13463	17786	163550
1983-84	6364	16165	6597	14152	6731	3226	21745	28567	18408	24124	16053	19558	181680
1984-85	7381	17809	7310	14998	7335	3651	23030	30157	19890	25155	17899	20898	195513
1985-86	8368	19421	7956	15809	7816	4087	24416	32037	21440	26078	18818	22368	208614
1986-87	9110	20671	8670	16748	8476	4561	25586	33847	22601	27178	20693	24042	222183
1987-88	9509	22137	9253	17811	9117	5035	27415	35928	24451	29165	23762	25538	239121
1988-89	10275	23720	9668	18804	9723	5457	28836	37899	26011	31506	25795	26022	253716
1989-90	10771	25909	10334	20779	10415	5369	27117	41455	29157	33265	28083	27653	260511
1990-91	11266	26611	103777	21049	10922	7252	31176	42092	31080	37027	32724	28222	289064
1991-92	11717	28412	10642	22278	11559	7872	32526	44333	33400	39650	35946	29192	307002

Year	Gurdaspur	Amritsar	Kapurthala	Jalandhar	Hoshiarpur	Rupnagar	Ludhiana	Firozpur	Faridkot	Bathinda	Sangrur	Patiala	Punjab
1992-93	12167	29607	11004	23670	12265	8447	33982	45885	36575	42946	38477	29900	324350
1993-94	12242	30650	11372	24380	12964	9003	35504	47533	39454	45366	39850	30732	338494
1994-95	12614	32288	11979	24632	12858	9285	37722	49278	41973	48448	41794	31789	354378
1995-96	12842	33066	12432	25586	13846	9763	38375	51000	45242	50807	43628	35611	371720
1996-97	13124	33614	12881	26350	14683	9281	40133	52530	49090	51954	44954	36715	387007
1997-98	13221	33830	13408	27127	15455	9566	41076	53396	50434	52098	45790	37022	398927
1998-99	13383	34611	14041	27550	16273	9845	43234	54005	51590	52368	46410	38244	411615
1999-2000	13581	34285	14742	27984	17013	9956	44169	54553	52047	52721	47370	39607	423140
2000-01	13766	34691	14946	28638	17713	10169	44708	55174	52868	53207	48500	41022	434032
2001-02	13883	34830	15212	29120	18392	10169	45042	55174	52868	53980	49350	42060	442562
2002-03	14107	34960	15556	29795	18921	10533	45644	55834	53307	54452	50741	43413	450956
2003-04	14340	35279	15757	30351	19645	10678	45939	56253	53502	55020	51475	45290	459424
2004-05	14436	35661	15945	30931	20137	10944	46262	56399	53719	55372	51791	47922	466480
2005-06	14485	36057	16178	31371	20623	11306	46877	56602	53952	55644	52145	49533	473354
2006-07	14578	36689	16467	32002	21221	11331	47718	56815	54358	56020	52416	49841	479845
2007-08	14601	36690	16673	32940	21927	11657	47840	57139	54508	56416	52857	50175	485781
2008-09	14628	37374	16737	33881	22514	11939	48369	57437	54670	56807	53234	50567	492220
2009-10	14664	38434	16762	34726	22838	12249	48927	57753	54885	57223	53633	51005	498517
2010-11	14723	39523	16781	35497	23120	12533	49506	58080	55102	57614	53915	51410	499551
2011-12	14812	39954	17224	36525	24403	13247	50364	58832	55508	59437	54813	52503	517743