CHAPTER 11
CHAPTER II

REVIEW OF LITERATURE ON FARM POWER

Most of the empirical studies on Indian agriculture have attempted to estimate the crop production, changes in prices and supply and demand elasticities of different factors of production. But little light has been thrown on the role of farm power — both animate and mechanical — as it is one of the most important issues in the broader spectrum of factors of production in agriculture. Some of the research studies on farm power are reviewed here to provide the necessary background to the present study.

These studies can be classified under five broad headings viz., (i) studies highlighting the general issues on farm power, (ii) studies dealing with the factors which are influencing the stock and use of different sources of farm power, (iii) studies analysing the utilisation patterns of farm power in agriculture, (iv) studies focussing on the economics of different sources of farm power and (v) studies
concerned with the impact of mechanisation on agriculture.

(1) Studies dealing with the general issues of Farm Power

In agriculture it is difficult to find out the extent and disaggregated share of different inputs used in relation to output since the agricultural production is conditioned by complex nature of agro environment. However, some scholars have estimated the contribution of different inputs in agricultural production. Sethuraman estimated the relative share of draught animals in farm output as 25 per cent.

According to the Gandhian school of thought labour power as well as animal power - appropriate technology - are not fully utilised and hence there is very little scope for agricultural mechanisation in India.

The Report of the National Commission on Agriculture forecasted the share of draught animal power to total farm power would be reduced to 19.8 per cent during 2000 A.D. The current availability of draught animal power share is 51 per cent. The main reason stated for the decline is that there would be an increase in machine power.
A micro level study carried out in International Crop Research Institute for Semi-Arid Tropics (ICRISAT) shows people are cultivating mixed crops in poor rainfed areas in order to avoid the risk of crop failure. Single crop cultivation was common in more rainfed areas, since the risk was less. Here the intensity of agricultural operations such as ploughing, interculture etc., differ from more risky areas from a couple of borrowings for light soil, to a more number of tillage for the deeper and hard soil. Shafi argued shortage of farm power should be increased through appropriate mechanisation for higher agricultural productivity.

Sethuraman, Sathis Chandran and Rajendran argued though there is a manifold growth in farm machineries the role of draught animal power cannot be neglected in the short run and hence more systematic effort should be made to upgrade the indigenous cattle with a view to improve the draught animal power for Indian agriculture.

(ii) Studies dealing with the factors which are influencing the different sources of farm power

The available studies broadly indicate variations in the stock of farm power sources and the role of farm power are conditioned by the varying agro-climatic conditions, techniques of production and many socio-economic factors. The Report of the Royal
Commission on Agriculture (RCU) observed factors which determine the use of animal power required in agriculture are soil condition, cropping pattern and farm size.

Another study by Rajapurohit and Muranjan observes factors like ignorance, bias and social inhibitions seem to prevent the farmers to adopt cows as draught animals, though it is suitable for draught purpose under certain conditions.

An empirical study by Muthiah in Tamil Nadu shows due to higher wage rates offered for harvesting operation in the Kuruvai season, workers hesitate to go for ploughing operation in the following thaladi season. Such shortage of labour induce mainly the big farmers to opt for (labour saving) tractor services for ploughing operation in a critical situation.

Haldipur's study on Punjab, Orissa and Andhra Pradesh shows the extent of farm mechanisation is more in the Intensive Area Development Projects (IADP) than non-IADP areas. Again within the IADP areas the modern implements are highly diffused in progressive farms than in other farms.

In a seminar on Problems of Farm Mechanisation in India, it was observed that, how farm mechanisation in several parts of the country had been induced by the intensification of HYV programmes and
opportunities of intensive cultivation offered by increased irrigation facilities causing excess demand for human and bullock labour.

Bal and others\(^{14}\) found a positive relationship between the farm size and the level of investment on farm machineries. Moreover, the large holdings made more investment for tractor and tractor drawn implements and the small farmers invested more on irrigation pump-sets.

Bharadwaj\(^{15}\) noted the number of draught cattle per acre had an inverse trend with the average size of holding. The reason for this is the maintenance cost of the bullock was very high in smaller holdings since fodder is the main input to the bullocks which incur much cost. However, the smaller farmer sometimes keep poor quality of breeds or incurs less expenditure on fodder and feeds.

By using the NSS 26th round data, Nair\(^{16}\) examined the investment pattern on draught animals in Kerala. He observed the reduction in draught animal stock had taken place primarily through price factor from the supply side and changes in the distribution of land holdings from the demand side.

Ramaswamy\(^{17}\) estimated time and effort can be reduced by 80 per cent for ploughing operation with
improved animal drawn implements and the earnings could be increased three-fold with modern carts.

Sidhu and Singh\textsuperscript{18} argued as the increased use of modern inputs signaled the beginning of a structural change in Indian agriculture. The rise in farm income due to green revolution influences the farmers to reduce the drudgery of manual work by farm machineries. In the process of technological change, labour is substituted by capital (machineries).\textsuperscript{19}

A micro level study\textsuperscript{20} in Uttar Pradesh reveals (resurveyed the village in 1984 which was surveyed in 1964) between 1964 and 1984, the farmers invested more on machineries like tractors, threshers and pumpsets in response to increase the production because of green revolution. With the limited feed supply, farmers maintain the bullocks well than cows. It led to the poor milk yield and poor quality of successive generation of bullocks.

Basant\textsuperscript{21} found in Gujarat mechanisation was restricted to limited activities like use of oil engines for lifting water and a minimal use of steam ploughs and tractors for ploughing. The stock of agricultural devices seemed to have fluctuated in different periods due to changing market conditions, natural causes and other agricultural developments.
There is a steady increase in the price of crude oil, recurrent power cuts and the non-availability of service centres in the nearby places to farmers for repairing machineries. Ultimately the farmers prefer to keep easily available traditional less cost agricultural implements with draught animals for farming.\textsuperscript{22}

Another micro level study\textsuperscript{23} which was conducted in Orissa reveals per farm draught animal holdings has positive relationship with farm size. This study concludes density of draught animals is not influenced by irrigated area, crop intensity and crop pattern.

Vaidyanathan\textsuperscript{24} observed it is possible to understand the factors shaping the bovine economy in India. However, he felt that it is not known as to how the agro-climatic conditions affect the role of animal power, the stock of work animals and their utilisation.

Reddy and others\textsuperscript{25} found development (agricultural) variables such as yield rate of foodgrains (YFG), proportion of villages electrified (PVE) and cropping intensity (CI) have turned out to be significant in explaining the variation in tractor availability.

These studies indicate the stock of farm power is highly influenced by various agro-environmental, socio-economic and other related factors. However, it
is difficult to draw a definite conclusion on which factor is responsible for such variations. This may be attributed to methodological issues like area coverage, categorisation and aggregation of farm power stock and farm holdings.

(iii) Studies dealing with the utilisation patterns of farm power use

Sarkar and Prahladachar\textsuperscript{26} found on an average tractors were utilised for 130 days per year, and only 29.2 per cent was utilised for own agricultural operations in Dharwad region. Tractors were mainly utilised for transportation on owners' farms and for others on hire basis. The limiting factor in this area seems to be the lack of irrigation facilities. Here multiple cropping is less and hence more tractor employment is unfeasible.

A disaggregated study\textsuperscript{27} from 48 farm households in Aligarh shows bullocks are extensively used in smaller farms as compared with larger farms; bullocks are employed maximum in ploughing and threshing operations and minimum in irrigation; unemployment of bullocks was more common in small sized farms; and the share of bullock labour to total input was observed maximum in wheat due to preparatory tillage and threshing, both consuming much bullock labour.

Bharadwaj\textsuperscript{28} analysed the FMS data and noted the proportion of hired bullock labour to owned bullock
labour is high on small farmers and decreases as the size of holding increases. This might be due to the possession of a single bullock which is not sufficient for the agricultural operations so that they have to supplement its services by hiring the bullocks from others. Therefore most of the small size holders are mainly dependent upon hired bullocks.

Singh and Chancellor\textsuperscript{29} observed the energy used per unit of crop and/output for the Indian wheat is much more than what is found in U S A. Singh\textsuperscript{30} analysed the patterns of energy inputs from various sources and the relationships between inputs and output during 1971-72 on 26 farm households in Meerut district. Farm households were classified into 6 categories according to the levels of energy sources. Singh noted the bullock farmers with unirrigated land used maximum energy, their yields are low and the intensity of cropping is also low. The bullock farms with Persian wheels used more muscle power. Farmers owning stationary (pumpsets) power sources used less human and animal (muscle) power than animal owning farms, but their use of machine power was high. The tractor owning farmers used the farm power maximum level and they also hired maximum number of labourers.

Study\textsuperscript{31} by Satpute found per acre bullock labour employment on irrigated farms was more (i.e., 15.70 days) as compared to unirrigated farms (i.e., 7.20
days). It clearly reveals that in irrigated regions farmers use the bullocks more intensively than in dry belt.

Bill and others\textsuperscript{32} noted the utilisation of draught animals per hectare declined with the increase in farm size for tractor as well as non-tractor owning farms in Ferozepur district. The same pattern has been witnessed for tractor use on tractor owning farms. However, utilisation of tractors (tractor hiring) on bullock farms increases with the farm size.

Another study\textsuperscript{33} in Ludhiyana concludes tractors are underutilised due to its availability is more i.e., supply is more than demand. The availability of various sources of farm power increased with an increase in size of holdings. In the mixed technology farms, bullocks are used in addition to tractors. In the case of pure bullock farms, animals are largely used. The time utilised by each farm power indicates that bullocks are used more than tractors. The utilisation of pumpsets is much more than that of tractors and bullocks.

Further, though some farmers own tractors, they are hiring-in tractors for land preparation and transport operations during peak agricultural seasons. In the mixed holdings, almost all the size holding farms are hiring-in tractors for land preparations and
hiring-in of tractors by pure bullock farms is found negligible.

By using farm level data Rajendran and others have analysed the draught power requirements and utilisation pattern of bullock power. The study was conducted in garden-land farms (wet) and dry land farms of Coimbatore district. The share of animal power in the total farm power requirement ranged from 53 per cent to 95 per cent among the selected crops in irrigated farms. However, tractor power was used more for tomato crop.

It was estimated that in the irrigated farms the requirement of farm power was 293 hp/ha. From this bullock power alone contributed by 78 per cent and only 22 per cent by mechanical power. Surprisingly, bullock power was the only source of farm power of course with labour power used in rainfed (dry) sample farms. Among the four crops, (samai, sorghum, horse-gram and cow-pea) studied in dry farms, samai and sorghum required more farm power than cow-pea and horse-gram. Altogether, for all operations samai required about 159 hp/ha, followed by sorghum (131 hp/ha), cow-pea (97 hp/ha) and horse-gram (88 hp/ha). From the above analysis it can be said that the intensity of farm power (in this case bullock and tractor) use varies depending upon the type of crops, nature of operation and above all, the availability of irrigation. The animal power was
under-utilised to the tune of about 75 per cent in the sample farms, and animals were utilised more on garden lands as compared to dry lands.

Studies by National Bank for Agriculture and Rural Development (NABARD) show on an average more than 50 per cent of the tractor time was employed for custom hiring. Fifty per cent of the custom hiring was allocated for non-agricultural purposes. This is clear that the money is being earned through the hiring out of tractors. Otherwise, it would be uneconomical to own a tractor.

Singh et. al. analysed the utilisation patterns of various sources - human, animal, tractor and pumpsets - of farm power in Deoria district of Eastern Uttar Pradesh. This study reveals big farmers are utilising more farm power than small and marginal farmers. Land preparation consumed a maximum quantum of farm power in all categories of farms. Wheat crop required more power when compared with paddy. The bullock energy use decreased with an increase in farm size and whereas it is a reverse in the case of tractor use. This is due to the substitution of bullock labour use by tractor services in large farms. Human labour utilisation decreased with an increase in size of farms. This is obviously due to surplus of human labour in small and marginal size of farms. The pumpsets were used more in marginal farms.
Another study by Singh reveals on an average an animal was utilised for 95 days in a year, including 20 days for non-farm work (mostly for transportation) in Orissa. About 43 per cent of the employment of draught animals concentrated in the Kharif tillage period—June-August. Another notable finding of this study is that there is direct association between draught animal use for farm work and farm size and an inverse relationship exists between draught animal power use for non-farm work and farm size.

Sharma found on an average, bullock and tractor operated farms utilised 103 days and 83 days per hectare of cropped area respectively in Aligarh district. Another finding of this study is that human labour employment per hectare of cropped area is inversely related to farm size for both tractor and bullock operated farms. Further break up of total human labour employment in family and hired labour showed that bullock operated farms used more of family labour than tractor operated farms and also that proportion of family labour in total human labour had an inverse relationship with farm size for both tractor and bullock operated farms. As the size of holding increased the proportion of family labour in total labour employment decreased.

Operation-wise per hectare human labour use revealed that harvesting and threshing required more
labour power in both bullock as well as tractor operated farms. However for some operations such as land preparation and sowing required more human labour in bullock operated farms. On the other hand, in tractor operated farms weeding and hoeing required more labour power.

From the foregoing review it is clear that the availability and utilisation of alternative farm power sources, intensity of irrigation, cropping intensity, cropping pattern, crop seasons, soil conditions, operations and timeliness of operation influences the utilisation of farm power. Nonetheless, from these studies it is not possible to accurately draw an inference of the intensity of farm power use and its relationship with other related issues.

(iv) Studies dealing with the economics of different sources of farm power

Gill 39 analysed the costs incurred for ploughing and threshing operations by different types (brands) of tractors, by tractor with bullocks and different methods of farming i.e., tenant cultivation by using the tractor jointly, joint cultivation with tractor, individual cultivation by tenants with bullocks. This study noted that generally the tractor farms could obtain more yield when compared with bullock farms. However, net income per acre was higher in joint cultivation farms using tractors. It was also noticed
that the human labour was not displaced, soil humidity was saved and hence the wheat yields increased. For threshing operation tractor use was more expensive than bullocks.

Jain calculated the costs of tractor and bullock farms and found that in tractor farming capital outlay was higher than in bullock farms. However, on the other hand, recurrent annual expenditure, excluding those common and similar to both types of farms was significantly lower for tractor farms when compared with bullock powered farms.

A farm management survey was undertaken in 19 villages in the Indian Punjab during 1969-70. The data for tractor and non-tractor farms were analysed in terms of the production process. It was found though the non-tractor farms were about half of the size (11.38 acres Vs. 24.78 acres) of tractor farms, they used 367 per cent more animal power per acre, 30 per cent more labour per acre, and, however, 50 per cent less physical capital per acre than did tractor farms. Average wheat yield for non-tractor farms was 2285 kg/ha Vs. 2259 kg/ha for tractor farms. Both tractor and non-tractor farms operated on the same logarithmic input-output relationship for wheat, and there were no differences between the two types of farms in technical efficiency, price or allocative efficiency with respect to labour use, and overall economic efficiency.
Pathak and others\textsuperscript{42} at the Punjab Agricultural University measured wheat yields obtained using animal draught power coupled with both conventional and improved implements. It was found that yields obtained with draught animal power were higher than those obtained with tractor power although higher levels of tractor tillage energy resulted in higher yields than did lower energy levels.

Singh and Chancellor\textsuperscript{43} have analysed the relationship between different farm power use and crop production from the selected farm households of Meerut district during 1971-72. The authors classified the farmers into three categories according to the different sources of farm power use i.e., bullock, tube-well and tractor farms. Three crops namely HYV wheat, maize and sugarcane were taken for this survey. Paired 't' tests were used to test the level of significance among the means of different categories. For wheat crop yields obtained by the tube-well and tractor farms were significantly higher than bullock farms. However, differences between the yields obtained by the tube-well and tractor farms were not significant. This is due to the fact that the tube-well and tractor farms could provide adequate timely irrigation, which also permitted them to apply more fertilizers. On the other hand, bullock farms were not able to provide sufficient irrigation due to the energy constraint.
An economic programme paper of ICRISAT, based on FMS data suggested farmers should employ the bullocks for about 173 days in a year; otherwise bullock holding would be uneconomical. Though, bullocks are employed only for a limited period, most of the farmers owned a pair of bullocks for the following reasons: (i) most of the feed and fodder requirements are met from the by-products of the crops (which is not incurring any pocket money), and (ii) during peak agricultural season it is very difficult to get the bullock labour for hire since all other farmers also prepare the land for cultivation. It was also found that the cost of farm power was very less in tractor farms when compared with bullock farms. The cost per unit of time (hp) was 50 per cent cheaper for tractor power over bullock farms. Further, the paper examined the relative efficiency of tractor and bullock power in black and red soil areas in Hyderabad. The results confirm that tractors could command an area nearly six times more than that of a pair of bullocks. However, the results of this study is based on the demonstration that the analysis is based on the demonstration plots and not on farms. Because, unlike in the farmers' field, in demonstration plots the application of other inputs is timely and scientifically prescribed. Hence results of this study may not be applicable for the remaining areas.
Jacob tried to examine the irrigation and cropping intensities along with production costs between mechanised and non-mechanised farms which were selected around Delhi during 1966-67. He found that irrigation and cropping intensities were higher on mechanised farming than non-mechanised farming. Average production costs were lower in mechanised farms when compared with non-mechanised farms.

Mandal attempted to assess the role of tractorisation in agricultural development during 1973-74 in Shahabad district of Bihar. Twenty tractor owning and operating farmers, 20 farmers not owning tractors but operating on custom and 20 farmers using draught animals were selected for this study. The important findings are: the extent of adoption of HYV was more in tractor owning and using farms than in custom hiring farms. It was less on bullock energy using farms. Cost of maintenance of machineries including substantial labour in repairs indicate the scope of offsetting displacement of human labour in farm operation in the future; total input-output per acre was highest for the tractor owning farms followed by bullock power operated farms and the custom hiring tractor farms; aggregate output per acre was the highest for tractor owning farms followed by custom hiring tractor farms and lowest for farms operating with animal power. However, net return per acre was highest for farmers using tractors on custom hiring basis followed by farmers operating
tractors and lowest for farmers who were using animal power; and the rate of return for the tractor owning farmers was 50 per cent over the investment on tractors as they are hiring out the tractors. This return is enough to promote further employment in the subsequent periods. It will enable to absorb whatever human labour is saved in the process of tractorisation in a given period.

Another empirical study highlighted the patterns of power use on farms in high and medium tractor intensity regions in South India. The results revealed that the average horse power used per hectare was very high in tractor farms in relation to bullock farms and the tractor power seemed to be economically efficient. The tractor power appears as a good alternative for bullock power in commercial crops. Though tractor farms show a moderate increase in the yield levels, the study found out that the income cost ratio is favourable to bullock farms.

The National Council of Applied Economic Research's (NCAER) study reveals cropping intensity is very high in tractor owning households followed by user households and the bullock owning farmers in all states. Further, the tractor owner and user households allocated more land for food and commercial crops. Contrary to this, the bullock owning farmers allocated more land for less remunerative crops like bajra, gram
and jowar. Tractor owning farmers obtained higher yields than bullock farms. Though the per hectare cost of cultivation is high on tractor owning farms, the per hectare gross and net returns are more than that of bullock farms.

Regarding per hectare draught power cost, the bullock farms spent about Rs 100 over tractor farms. The human labour employment per hectare of cropped area was more or less same in all three types of farms. But this was nearly three times more in ploughing operation on bullock farms. The tractorsisation withdraws the family labour from carrying out farm operations for the supervisory work. However, the demand for hired labour has increased. Though this study was attempted in many states, the survey design adopted does not permit to generalise to India as a whole. The selection of household does not have uniformity in all types of farms. In addition to these limitations the study (sample) areas are agriculturally developed.

Swaminathan and others studied the impact of machine power (tractor) on other power components in Coimbatore. It indicates tractor use for land preparation is more economical as compared to rural power. It was found total farm power for preparatory tillage operations can be minimised by replacing animals with tractors. Secondly, to some extent machine power can substitute human power, as encountered in tractor
farms, whereas in bullock farms the animal power can be replaced. The interculture operations in animal power farms required human power than that demanded by tractor farms. Regarding the cost of energy for ploughing, tractor power is economical especially for cotton, bajra and maize. The study estimated that the introduction of tractor power, in place of animal power, yields a saving of minimum Rs 107 per hectare.

Singh and others assessed the economics of tractor and bullock power use in the cultivation of vegetable crops in Delhi. They found that tractor power is more economical to the larger holdings and the animal draught power is more economical to the smaller holdings.

Another study in Ahmednagar district shows per hectare (net area) cost of cultivation on tractor owning and tractor using (by hiring) bullock farms was higher than pure bullock farms. At the same time per hectare of net return on tractor owning farms and tractor using bullock farms was higher than that of bullock farms. But the proportion of cost to return was found high in tractor owning and using farms than bullock farms. From this it can be concluded that bullock farms are economical than tractor owning and user farms, according to the data presented in this study. But the author concluded that the bullock farms are uneconomical. This contradiction may be due to
deficiency in the data collected. The benefit-cost ratio and the internal rate of return show that the additional income derived by bullock farms by making use of tractor (hire in) services was higher than in bullock farms. The tractor owning farms have earned considerably from custom hiring.

NABARD conducted an ex-post evaluation survey on bank beneficiaries (to buy tractors and tillers) in Uttar Pradesh and Tamil Nadu. This study shows that the per hectare net income is high in tractor farms and low in bullock farms by nearly 50 per cent. Another research project has been undertaken by Hinge et. al. to study the profitability of tractor use in sugarcane areas of Western Maharashtra during 1982-83. The study reveals that per hectare net return on tractor operated farms were more when compared with bullock operated farms. The net returns were higher on small tractor as well as bullock operated farms when compared with their larger counterparts. The introduction of tractors were seen to add to the farm operational efficiency, add income, and also reduce the maintenance cost of bullocks.

Subramanian found among the districts in Tamil Nadu only in Coimbatore tractor had a positive and significant influence over output. The results show that marginal value of product of tractor was greater than the factor price of tractor.
Wani and Gill found tractor operated farms spent more on both fixed and variable costs as compared with bullock operated farms. This is due to the fact that the tractor operated farms are more accessible to spend more on improved method of cultivation and timely application of inputs, which is lacking with bullock-operated farms. Again the gross returns and returns over total variable cost reveals that they are high for tractor-operated farms. Therefore, the authors arrived at the conclusion that since the tractor operated farms used more improved technology and operated at a higher level than the bullock operated farms, which, in turn, increased the yield of crops and the superiority of tractor operated farms could be visualised as they got higher returns (about 17 per cent) over variable costs than bullock operated farms.

A micro-level study in Aligarh district of Uttar Pradesh shows that the tractor farms get more return when compared with bullock farms. Average, gross and net returns per cultivated hectare in different size groups were more on tractor farms compared to corresponding size groups of bullock farms. Further, it shows that on an average, taking all farms together, the net returns per cultivated hectare were found to be Rs 1998 and Rs 2988 on bullock and tractor operated farms, respectively.
As opposed to the above set of findings, there are research studies, which argue that mechanisation especially tractorisation is unprofitable when compared with bullock farms. These studies further argue that the output and income cannot be increased merely by introducing machineries and some of these studies are reviewed here.

Binswanger and others have concluded tractors are unprofitable and even less appropriate for semi-arid areas and other areas of South Asia. The authors attributed that bullock power is more reliable, economic and well justifiable. It was also pointed out that the improved implements (wheeled tool carrier) with better soil management techniques may be able to provide substantial increase in yield in semi-arid tropical areas.

Ghose focused on the implications of variations in output on bullock and mechanical farms with traditional and modern biological inputs respectively. He called the draught (farm power) power sources as "technique" and the biological inputs (seeds, fertilizer etc) as "technology" which were developed by William Bartsch. The farms were classified as (1) Traditional technology (traditional seeds, meagre fertiliser, no irrigation etc) with modern (mechanical) technique. (2) Traditional technology with traditional technique (bullock). (3) Modern technology (HYV seeds,
more fertiliser application irrigation use etc.) with modern technique and (4) Modern technology with traditional technique. The results reveal bullock power technique with modern technology can increase labour use and output as compared with traditional technology. On the other hand it is interesting to observe that the output and labour utilisation were more on bullock farms using modern technology than mechanical farms. Ghose concludes as:

"it is perhaps due to the fact that more labour use in bullock farms might help to do weeding operation carefully, apply more irrigation and fertiliser and above all to have personal supervision more intensively and efficiently" (p. 38).

Another study\textsuperscript{60} in Kurukshetra district indicates tractor operated farms are getting less income as compared to bullock operated farms. The interest amount and loans were high on tractor operated farms, as they had obtained credit to buy tractors. The authors fitted simple linear cost function between the total annual cost and the size of the holdings. They found that the tractor holding would be economical if the farmers own more than 16 hectares of land. But in this study area only a very few farmers have an holding of above 16 hectares. Hence they are under a credit trap and it becomes very difficult to repay the installments of loans on time.

Binswanger\textsuperscript{61} and Basant\textsuperscript{62} are of the opinion that agro-mechanical devices do not increase the yields
directly. The yields may be associated with the use of other inputs such as fertiliser, pesticides and so on.

From the foregoing survey it is evident that while a few studies indicate mechanical power is relatively cheaper, other set of literature found conventional sources of farm power is profitable.

(V) Studies concerned with impact of mechanisation

The introduction of mechanisation in farms has brought about a change in the agricultural scenario in a number of ways - impact on human and animal labour, output and income and agricultural technology and some of the relevant studies are reviewed here.

Venkatappaiah's study\textsuperscript{63} shows mean requirement of labour per acre was 51 mandays with traditional source of irrigation (by Persian wheels) with normal cropping pattern. Later when high yielding varieties were used along with fertilizers, the demand for labour increases to 60 mandays. However, when pumpset, corn-sheller and tractors were used without changing the cropping pattern - the demand for labour came down to 26 mandays. But the reduction was absorbed by the additional labour required through the increase in cropping intensity. Singh\textsuperscript{64} found that mechanisation has resulted in the reduction in animal power and an increase in the demand for human labour. This study also reveals crop yield and farm income increases with
the level of mechanisation irrespective of the size of the farm.

The study\textsuperscript{65} by Johl reveals tractors, pumps, coupled with thresher replaced the bullock-power, reducing its use to less than 28 per cent. In terms of productivity, yield per acre of almost all commercial crops were found to be higher on tractor-operated farms compared with bullock operated farms.

Patil\textsuperscript{66} attempted to find out the impact of mechanisation on farm output in Ahmadnagar district of Maharashtra from 90 bullock operated holdings and 90 tractor operated holdings. This study finds net income on tractor farms was markedly higher (32.96 per cent) than that of bullock farms and also farms which hiring tractor services. This the study attributes to the combined effect of using tractors along with comparatively higher use of other inputs. Thus, farm power acts as a catalytic agent in the process of efficient utilisation of irrigation, seeds and fertiliser and assists in conducting the desired farm operations timely and effectively. This indirectly reflects on the productivity of land and crops.

Dutta and Bordoloi\textsuperscript{67} highlighted the problems and prospects of utilising power tillers in rice growing Jorhat district in Assam. This study concludes that power tillers can be used more efficiently than the bullock ploughs which results in increased crop
productivity. The main criticism of this study is that it has attempted in a rice belt and failed to analyze other crops.

Narang and others study in the demonstration plots at the Central Institute of Agricultural Engineering, Bhopal during 1986-87 reveals there was a time saving of 45 per cent and 57 per cent which required for land preparation with power tiller system over bullock system in sorghum and bengalgram crops, respectively. The human energy requirements for the sorghum-bengalgram crop mix were 616.79 and 594.33 hrs/ha under bullock and power tiller sources; the yields of sorghum and bengalgram crops under bullock power system were 33.64 and 17.35 qls/ha.

The energy output-input ratios for sorghum and bengalgram crop rotation under bullock and power tiller farm system were 12.27 and 11.17; A net profit of Rs 8,179.56 and Rs 9,621.95 per hectare was achieved for sorghum and bengalgram crop rotation under bullock and power tiller farming systems, respectively. A net profit of Rs 3,686.15 and Rs 4,493.41 per hectare was obtained under bullock farming system for sorghum and bengalgram crops as compared to Rs 4,182.69 and Rs 5,439.26 per hectare under power tiller system.

Contrary to the above findings, a group of researchers argued mechanisation does not lead to an
increase in output, it reduces the human as well as animal labour use and leads to the mal-distribution of income. For example Sarkar and Prahladachar have noticed from the sample farms in Dharwad district, after the purchase of tractor, 24.5 per cent of bullocks were replaced (208 pairs before, 157 pairs afterwards); number of permanent labourers employed was decreased from 198 to 164 i.e., 17.2 per cent; and however, the number of casual labourers employed was not reduced.

Binswanger concluded there is no evidence that tractors are responsible for considerable increase in cropping intensity, output, timeliness on farms in India, Pakistan and Nepal. Though farmers derive some benefits by the use of tractors it is very small and found statistically insignificant.

Singh and Singh attempted to measure the magnitude of labour replacement in some operations and also to estimate the complimentarity or competitiveness between the overall farm mechanisation and human labour in Western Uttar Pradesh. For the analysis 150 farm households were selected and they were categorised as (i) Bullock farms (Households which use bullocks as the main source of power and neither have tubewell nor tractor), (ii) Partially mechanised (farms own tube wells as the source of mechanical power), and (iii) Mechanical farms (farms own tractor as well as tube wells).
increase in output, it reduces the human as well as animal labour use and leads to the mal-distribution of income. For example Sarkar and Prahladachar\textsuperscript{69} have noticed from the sample farms in Dharwad district, after the purchase of tractor, 24.5 per cent of bullocks were replaced (208 pairs before, 157 pairs afterwards); number of permanent labourers employed was decreased from 198 to 164 i.e., 17.2 per cent; and however, the number of casual labourers employed was not reduced.

Binswanger\textsuperscript{70} concluded there is no evidence that tractors are responsible for considerable increase in cropping intensity, output, timeliness on farms in India, Pakistan and Nepal. Though farmers derive some benefits by the use of tractors it is very small and found statistically insignificant.

Singh and Singh\textsuperscript{71} attempted to measure the magnitude of labour replacement in some operations and also to estimate the complementarity or competitiveness between the overall farm mechanisation and human labour in Western Uttar Pradesh. For the analysis 150 farm households were selected and they were categorised as (i) Bullock farms (Households which use bullocks as the main source of power and neither have tubewell nor tractor), (ii) Partially mechanised (farms own tube wells as the source of mechanical power), and (iii) Mechanical farms (farms own tractor as well as tube wells).
As sugarcane and wheat were cultivated in a large scale in the study area, these two crops were taken for analysis. This study indicates that the use of human labour per acre decreased with an increase in the level of mechanisation for the farm business (both wheat and sugarcane crops) as a whole. The reduction in employment was almost in all the farm operations, but it was much pronounced in the case of land preparation, irrigation and threshing operations where the mechanical power has been increasingly used. The magnitude of decrease in the bullock labour was comparatively more than that of human labour for farm business as a whole. As it was found for human labour, bullock labour also the reduction was again mainly in land preparation, irrigation and post-harvesting operations.

The tractorisation in land preparation significantly reduces human and bullock labour employment which do not have sufficient off-farm opportunities. Also any further replacement of human and bullock labour through tractor would increase the cost of the operations and therefore, it is not even economically desirable. There exists a competitive relationship between the overall use of machinery and human labour but the additional use of machinery would not be able to reduce the cost. Hence the authors concluded that further mechanisation in the area under study would reduce the employment of human and bullock
power which is not justified both economic and also from the employment point of view.

According to Ghodake and Hardaker\(^2\) even though mechanisation creates more profits for large farmers it will also create unemployment, mal-distribution of income and increase the incidence of poverty. Agarwal's study\(^3\) reveals variables which were significant in explaining yield differences between plots were the expenditure on fertilizers and manure, the agro-climatic zones, the technique of irrigation and the method of sowing. Tractors were found to have a neutral yield effect in both ploughing and sowing. In contrast, the advantage of tube-well irrigation over canal irrigation was positive and marked.

Walker and Kasireragar\(^4\) attempted to find out the impact of machine threshing and its implications in semi-arid tropics of India. They found machine threshing did not increase intensity of cropping nor did it reduce costs compared to traditional methods of threshing. Basant\(^5\) has reviewed the recent research studies on the impact of various components of modern inputs on employment and crop production for various crops in Indian agriculture over the period (i.e., 1974-1982). He concluded mechanisation, especially tractorization has a negative impact on labour use at least in operations which are mechanized. This has been observed more in wheat crop when compared with paddy,
crop. Narayanamoorthy argued tractors have not increased the yield of sugarcane. However, the biochemical input (weedicides) has increased the employment of labour.

Debate on Farm Mechanisation

In the present section the arguments put forward both in favour of and against farm mechanisation are examined here in brief to highlight the issues involved in capital intensive farm power.

(i) Arguments Favouring the Adoption of Capital Intensive Technique in Agriculture:

This school of thought explains the advantages of the use of capital intensive technique in many ways. Mathur and Kapp favoured the shift from muscle power to machine power—especially tractor power—and argue that the tractor power is versatile to carry out ploughing on hard soil, timeliness in operation, weeding out the deep rooted weeds etc. These scholars argue as:

"...the shift to tractors would make it possible to plough the soil more thoroughly. The soil can be worked when it is dry and ready for ploughing, if necessary even at night, whereas bullocks have to have regular rest periods, which, at times, causes delays and exposes the soil to renewed heavy rain-fall. In areas with relatively short seasons, and for crops with relatively short production periods tractors may actually make it possible to increase the number and times of a field can be cultivated... Tractors can be used for such purposes as erosion control by more effective bunding and contour ploughing, for transport of soil as well as crops and the construction of small storage tanks or reservoirs in areas which suffer from inadequate or uneven rainfall... More important still, tractors enable the farmer to break difficult
soils or to eradicate weeds that cannot be eliminated by hand or by the traditional plough drawn by bullocks. Tractors are indispensable instruments to reclaim hitherto unusable land to extend the margin of cultivation, particularly in some parts of Central India, where the eradication of weeds requires deep ploughing and where it may take more than a month of heavy human labour to bring one acre of new land into cultivation.

Another group of scholars like Rao argued that farm mechanisation for the labour abundant economy like India is to be selective. He pointed out that land-augmenting machineries like tractors can increase the overall employment potential in the economy when compared with the labour-saving machines like harvest combines.

Voss viewed the apprehension of displacement of labour likely to be caused by farm-mechanisation and supports the increase in productivity due to mechanisation and argues as:

'what determines the standard of living of farm population is not the degree of under-employment or disguised employment, but simply the total productivity of the farm. In such cases, the introduction of technological change will be of benefit to all concerned provided that it increases total farm production, irrespective of its effects on the demand for labour and the degree of underemployment in the area.

In the long run, perpetuation of labour intensive non-mechanised agriculture will tend to maintain rural poverty and stagnation, once the beneficial effects of new inputs other than mechanisation reached a certain level.'

Some researchers argued that in spite of overpopulation in agricultural sector, during peak agricultural season it would be difficult to complete
the agricultural operations on time as the muscle power is too weak. Therefore, they argued that machine power will enable to complete the agricultural operations especially reclamation of land, heavy ploughing etc. Nervik and Haghjoo\textsuperscript{80} pointed out that in peak agricultural seasons there is shortage of labour despite agricultural over population and disguised unemployment. The muscle power is too weak to use on all types of land. Increase of cultivated acreage, reclamation of barren land, heavy operations like levelling and bunding are possible by tractors only.

Another group of research findings showed that the introduction of mechanisation in agriculture led to increased demand for human labour. For instance some of the field surveys\textsuperscript{81} conducted by the UNHSD revealed that the new technology in Asia has been accompanied by a marginal increase in human labour utilization per unit of land and a decrease in human labour per unit of production. The same conclusion has been drawn by Mandal.\textsuperscript{82}

Niho\textsuperscript{83} said that the labour intensive traditional technique would not lead to development in the course of time. The author felt and argues as:

"traditional arguments for the use of labour-intensive technique in a relatively labour abundant situation do not seem valid for development. Such factor substitution is a stabilising factor in a neo-classical economy but in the context of development it becomes a stagnating factor".
(ii) Arguments Against the Adoption of Capital Intensive Technique in Agriculture:

Contrary to the above arguments, another school of thought felt that the introduction of capital-intensive (farm machineries) technique in an underdeveloped economy would lead to some negative repercussion such as the agricultural machineries displacing human as well as draught animal power in agriculture. And it might not increase the production substantially, increase the incidence of rural poverty and creates unequal distribution of income.

Large number of economists and scholars expressed the fear that introduction of tractor might increase unemployment. Writers like Anker, Khusro and Agarwal were likewise doubtful for the time being, until industries have developed and can employ the people who leave farming. Khusro and Agarwal argued that, modern industry creates very few jobs at a high investment rate per employee.

Griffin and Sen have directed their criticisms against the use of machines in agriculture of an underdeveloped economy, where labour is abundant and capital is scarce. Griffin comments as:

"the machines use a scarce factor of production (capital) to economies on an abundant factor of production (labour) and thereby fail to use resources in the most efficient combinations" (P 63).
Another important argument is that the capital intensive machineries do not increase the yields directly. The higher yields in mechanised farms might be due to machineries coupled with other inputs like HYV seeds, higher dose of fertiliser and proper and timely irrigation.

Binswanger argued in the same line and he contended that the farm machines do not yield any direct impact to obtain more yields. Further he stressed that the labour augmenting farm power like muscle power is more reliable, economic and well justifiable especially for the tropical regions. After reviewing a few studies related to new technology in agriculture Basant has viewed that there is no direct correlation between the machine power use in agriculture and the productivity in agriculture.

The debate is still inconclusive. As Raj viewed that the available material on farm mechanisation in India and Ceylon is however not enough to determine precisely how and to what extent it has been responsible for variations in crop output and employment. Sen noted as:

"factual picture is unclear eg. the extend of the yield impact of tractorisation has not yet been isolated from variations in other factors not complementary to tractor use for a sufficiently large number of cases".

Bergmann in his book on 'Farm Mechanisation in India' argued that the debate on the economic
assessment of bullock versus mechanical power is not clear, quite contradictory and inconclusive (pp 37-94).

In this context it is appropriate to quote Pandya who said:

"Expansion of multiple cropping normally leads to increased labour use and increased output from a given area of land. But the matter may be more complex, when irrigation is combined with shorter duration high yielding varieties of crops and expansion of multiple cropping. This may be possible with some degree of mechanisation, which in turn would mean lesser labour use. The net result of these forces: irrigation, shorter duration of HYVs and mechanisation, may mean greater or lesser use of labour than before" .... "Mechanisation by breaking the time bottleneck make possible to grow an extra crop on same piece of land. But also mechanisation reduces labour demand for individual operation which is mechanised. There is no clear consensus regarding the net effect of mechanisation on farm employment".

Kumar after analysing some studies on impact of mechanisation concluded that there is no uniform pattern of effect of mechanisation on cropping pattern as well as intensity.

Another study expresses the difficulty of balancing the impact of mechanising farm operations as:

"At a more general level, while certain type of labour—using technical changes (notably the spread of irrigation and of ground water in particular) have taken place, this may be in some measure counter-balanced by the rapid mechanisation of ground water irrigation at least in so far as employment in irrigation is concerned. And mechanisation of other farm operations (including ploughing, harvesting, threshing and transport) are clearly labour saving. What the balance of these forces has been in different parts of the country ... We are not in a position to answer definitively".

52
Many of the empirical studies reviewed here are macro-level exercises, and most of them have examined the use of draught animal and tractor power independently. Only a very few research studies have attempted a comprehensive analysis of the use of various types of farm power. The studies which analysed the role of farm power at a disaggregated level are very scanty. Absence of literature on this topic at a disaggregated level has led Vyas and Agarwal to strike a note of caution that conclusions reached on the basis of macro level studies in farm power use in agriculture can be misleading.

Research Issues Identified for the Present Study

The foregoing review of literature helps in identifying some important research issues for further examination in the present study. To begin with, some studies concluded that utilisation of machine power is economical as compared to animal power. On the contrary, some other studies have found that animal power is economical to machine power. From these it is difficult to draw any inference on the economic viability of farm power use.

Since most of the existing studies have attempted to analyse issues regarding farm power at macro level, the present study highlights the issues at disaggregated levels such as cropwise, seasonwise,
sizewise and regionwise distribution and utilisation patterns of farm power with farm level data.

Most of the empirical studies which have been carried out in India and abroad clearly indicate that there is a close relationship between the application of new farm technology and the output, income and employment in agriculture. Moreover, there may exist complementary relations between new technology and farm power use in agriculture. However, it is not clearly known as to how and to what extent this relation exists. The inputs employed and output obtained per unit of area in mechanised and non-mechanised farms may turn out to be same, but the operation-wise distribution of inputs and the yield of different crops may vary across different farms and across different regions.

Numerous empirical studies are available on inputs use and their relationship with production in Indian agriculture. These studies disaggregated the inputs depending upon the data available and method of analysis. The major inputs which is carried out for different farm practices are classified and analysed in many ways such as, human labour, animal labour and machine power. Although these sources of farm power perform similar agricultural operations - providing power - many studies did not attempt to see the combined effect of this crucial input.
Therefore, there is a need to carefully study the relationship of the extent of farm power use in agriculture with output, income and employment. The present study is an attempt to examine some of the above issues identified with a focus on farm power in agriculture.
Notes and References


33 R P S Malik, "Farm Power in Punjab: A Case Study of Ludhiana District", Research Study No 82/2 Agricultural Economic Research Centre, Delhi University, Delhi, 1982.


42 B S Pathak, P K Gupta and B C Thakur, "Energy Requirements in Agriculture" (Mimeograph No F M 13-72), Agricultural Engineering Department, Punjab Agricultural University, Ludhiana, 1972.


94 Arun Kumar, "Energy Use Patterns in Hosakote Taluk of Bangalore District", M Sc Dissertation Submitted to the University of Agricultural Sciences, Bangalore, 1988.

