Chapter II

REVIEW OF LITERATURE

A few attempts to mechanise cultivation in India could be traced back to the post-World War period I, when some wealthy farmers purchased foreign made tractors for mechanising their agriculture. Besides performing field operations, the mechanical power was extended to tractor-trolleys, trucks and lorries. Subsequently, power machinery also took over the jobs of grinding, milling, pressing and milling. But because of lack of power fuel, spare parts and service facilities, these innovations did not spread in rural areas of the country.

In 1938, Government gave protection to the sugar industry and there was a consequent increase in demand for sugarcane. This provided incentive for intensive cultivation of sugarcane lands. Cane growers needed deep tillage equipment and some of them, therefore, bought tractors for this purpose.

In 1937, the popular Governments tried to take up mechanisation of agriculture but World War II intervened and not much could be done in this respect.

In the post-World War period II, prices of farm products increased due to scarcity of food and agricultural raw materials in the
country. This provided further impetus to intensive cultivation for raising agricultural production. As a result, there was some emphasis on tractorisation of Indian agriculture. The Government of India established a Central Tractor Organisation to reclaim waste and 'kans-infested' lands in Madhya Pradesh and Uttar Pradesh. A fleet of 240 tractors and necessary equipment was purchased by the Government from abroad with a loan from the World Bank. The State Governments also set up their own tractor organisations, not only to clear jungles and reclaim waste lands, but also to hire out tractors to the farmers. Some more enterprising farmers also purchased their own tractors and tillage implements. But the import of tractors and their equipment declined considerably after 1951-52 partly because of tight foreign exchange situation and partly because full benefits of tractorisation could not be realised for lack of adequate guidance on the economic use of these machines.

Later, it was realised that minor irrigation projects, such as installation of pumping sets and tubewells could play an important role in developing the irrigation potentials of the country for tackling the problems of scarcity of foodgrains and agricultural raw materials for the industry. Loans and subsidies were granted by the Government to the farmers for the purchase of tractors, diesel engines and electric motors under "Grow More Food Campaign" and other agricultural developmental projects undertaken by the Government. A central workshop was established at Imtiaazar for the production of tractors and allied equipment. A large number of enterprising industrialists also took up the production of diesel engines and electric motors for pumping water and for other
stationary farm work. This development was continued under the Nation's Five Year Plans. The recent developments in farm technology gave further impetus to the mechanisation of Indian agriculture.

While these developments were in progress, researchers conducted studies regarding different aspects of mechanisation. The problems of the "economics of mechanisation of agriculture" were first discussed by the Indian economists at the Ninth Conference of the Indian Society of Agricultural Economics held at Hyderabad in December, 1948. Subsequently, scholars continued to evince interest in the study of this subject.

The studies made by various research workers on various aspects of mechanisation were reviewed and grouped as those relating to the examination of (i) relative profitability of mechanical power over animal and human power for agricultural operations; (ii) comparative costs of operating with different sizes of power plants; (iii) effect of mechanisation on agricultural productivity and farm income; (iv) impact of mechanisation on farm labour and employment; and (v) pattern of mechanisation for Indian farms.

**Relative profitability of mechanical power over animal and human power**

Subbaraju; Bhattacharjee; Sharma; Patil; Kahlon and Singh; and Kahlon and Gill studied the comparative costs of performing various agricultural operations with mechanical, animal and human power. Kahlon; Tidier; National Productivity Council; and Sandhu examined the changes in the cost structure of individual crop enterprises and the total farm situation as a result of switch over from bullock cultivation to mechanised cultivation; while Raju; and Balis compared per horse power per hour costs
of operation with different sources of motive power. These studies were reviewed with a view to examining the relative profitability of mechanical power over animal and human power as under.

Subbaraju, 1949, found that the cost of ploughing per acre to a depth of 12" to 14" in clay soils with a 100 H.P. tractor was Rs. 29.00 while the cost of excavation by manual labour in one acre to a depth of 6" to 8" with a 40 H.P. tractor in medium soils was Rs. 7.50 per acre and with bullock power Rs. 11.00.

Bhattacharjee, 1946, estimated the cost of ploughing with a 12 H.P. tractor at Rs. 4.00 per acre as against the prevalent rate of Rs. 6.00 to Rs. 10.00 for ploughing an acre of land with bullocks. The author visualised that the use of power machines in place of bullocks could facilitate double or triple cropping on Indian farms.

Sharma, 1982, worked out the costs of ploughing and tilling with a tractor and compared them with the costs of ploughing with bullocks in Matala district. He found that manual ploughing with a 30 H.P. tractor cost Rs. 4.45 and tilling Rs. 2.17 per acre, whereas one ploughing with a 'desi' plough and animal labour cost Rs. 8.20. The author pointed out that it would be appropriate to compare bullock ploughing with tractor tilling rather than with tractor ploughing.

5. Subbaraju, V., Mechanisation of Indian agriculture, Indian Journal of Agricultural Economics, 4(1), March, 1949: 104-120.
Patil, 1949⁶, compared 5 H.P. pumping set with a bullock operated shote for irrigation in Raver Taluka. He found that a 5 H.P. diesel engine drew 300 gallons of water in 5 minutes from a depth of 20 feet while the bullock operated shote drew 40 gallons in the same period and from the same depth. The author concluded that the shote irrigated ½ acre while the engine did 2 acres in 8 hours. He estimated the cost of irrigation per acre with 5 H.P. diesel engine at ₹4.88 as compared with the bullock operated shote at ₹20.00.

Kahlon and Singh, 1988⁷, compared the costs of different methods of threshing wheat in Ludhiana and found that the cost of threshing with 'phalia' was ₹7.25 and with alpha thresh at ₹5.85 per quintal when output was 840 kilograms (basis for both the methods). The threshing costs decreased to ₹6.85 and ₹2.87 per quintal respectively when output was doubled. The authors found that power threshers took minimum time and involved the least cost (₹2.07) to thresh wheat. Threshing machines compared favourably with power threshers and involved a cost of ₹2.07 per quintal. The syndicator took the largest time to thresh wheat and cost ₹2.50 per quintal. There was no need of winnowing when wheat was threshed with power threshers or threshing machines, and this resulted in the saving of labour.

Kahlon and Gill, 1987⁸, explained with the help of detailed


comparative accounting data, the extent to which the costs of production could be reduced in Patiala district (Punjab) through the mechanisation of certain selected agricultural operations. The study indicated that the cost of seed bed preparation per acre with a D.T. 14 tractor was Rs. 4.28 as against Rs. 9.84 with bullock power. Seeding and fertilizing with seed-cum-fertilizer drill with tractor power cost Rs. 6.86 as compared with the 'Kera' method costing Rs. 13.88 per acre. Irrigation with electric pump set cost Rs. 5.00 per acre while with diesel engine pump set it cost Rs. 9.41 and with persian wheel Rs. 10.44. Power threshing with drummy thresher and tractor came out to be Rs. 5.55 and with a bullock drawn phanna it was Rs. 7.85. Maize shelling with power sheller cost Rs. 1.37 per quintal as against Rs. 5.42 with manual power. The authors observed from the analysis of comparative costs that mechanisation of certain agricultural operations from the cost standpoint was clearly economical.

Kahlon, 1964, suggested that a versatile machine such as a Swiss made two wheel 'Rapid' 10 H.P. diesel tractor could be used for ploughing, harvesting and transportation, and as a stationary engine for irrigation. The author budgeted out operation-wise comparative costs of wheat enterprise with bullocks and the Swiss made tractor as follows:

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Kahlon, A.S., Farm mechanisation in the Punjab to increase food production, Mimeographed, a paper read at the seminar held by the Institution of Engineers (India), Punjab Centre, Chandigrah, 1964.
### Table: Costs of Farm Operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Cost in Rupees</th>
<th>Bullocks</th>
<th>Tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ploughing and planting</td>
<td>68.00</td>
<td>35.84</td>
<td></td>
</tr>
<tr>
<td>2. Planting and fertilisation</td>
<td>15.00</td>
<td>9.98</td>
<td></td>
</tr>
<tr>
<td>3. Hoeing and weeding</td>
<td>20.00</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>4. Irrigation</td>
<td>108.00</td>
<td>55.50</td>
<td></td>
</tr>
<tr>
<td>5. Harvesting</td>
<td>10.00</td>
<td>4.55</td>
<td></td>
</tr>
<tr>
<td>6. Threshing</td>
<td>19.50</td>
<td>12.05</td>
<td></td>
</tr>
<tr>
<td>7. Winnowing and binding</td>
<td>8.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>241.75</strong></td>
<td><strong>125.70</strong></td>
<td></td>
</tr>
</tbody>
</table>

The study showed that costs of all the farm operations were lower for the 'Rapid' tractor than the bullocks.

Taylor, 1925, conducted a study which indicated that the use of animal power was more economical than tractor power. The annual cost of operation with two heads of cattle worked out to $190 while with one tractor it was $280. The author, however, emphasized the need for the introduction of tractors for faster operations which made it possible to reduce expenses on other items such as hired labour wages.

National Productivity Council, 1967, undertook a comparative study...
study of the mechanised versus non-mechanised farms around Delhi during 1896-97. The results of this study indicated that the average cost of cultivation per acre in the former case was Rs. 405.00 while in the latter case it was Rs. 814.12. The council concluded that the economy was in favour of mechanised farms in spite of the lower utilisation of tractors and equipment on individual farms.

Sandhu, 1989, developed work efficiency standards and other related coefficients for Iseor 25 and D.T. 14 tractors in respect of selected improved practices for general crop farms in the 'upper dhaya' revenue assessment circle of Ludhiana district and compared them with those for bullocks. He extended his study to examine the overall effect of adoption of more economical techniques on costs on a 20 acre farm operated with bullock power and a 5 H.P. diesel engine. The author found that costs could be reduced by 46.95 per cent (Rs. 2,085.55) through the introduction of improved practices on this farm and that the requirements for manual and bullock labour could be brought down by 1931 and 2,994 hours respectively.

Raju, 1986, calculated the relative costs of different types of energy per horse power per hour as under:


<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Source of energy</th>
<th>Cost per H.P. per hour in rupees</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Manual labour</td>
<td>1.50</td>
<td>1 man = 1/3 H.P.</td>
</tr>
<tr>
<td>2.</td>
<td>Bullock power</td>
<td>0.28</td>
<td>1 bullock = 1/2 H.P.</td>
</tr>
<tr>
<td>3.</td>
<td>Diesel engine power</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Electric motor</td>
<td>0.18</td>
<td></td>
</tr>
</tbody>
</table>

Balis, 1984, estimated the costs of operating with different sources of power, viz., bullocks, 10 H.P. and 25-50 H.P. tractors as follows:

<table>
<thead>
<tr>
<th>Source of power</th>
<th>Rough estimates of initial cost per horse power</th>
<th>Operating cost per horse power per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bullocks</td>
<td>₹ 500</td>
<td>₹ 0.15 - 0.22</td>
</tr>
<tr>
<td>10 H.P. tractor</td>
<td>₹ 200</td>
<td>₹ 0.08 - 0.19</td>
</tr>
<tr>
<td>25-50 H.P. tractor</td>
<td>₹ 120</td>
<td>₹ 0.08 - 0.16</td>
</tr>
</tbody>
</table>

These studies brought out the superiority of mechanical power over animal and human power for reducing per unit costs of farm operations.

Comparative costs of operating with different sizes of power plants

Russel and Elrod studied the costs of operating with tractors of various sizes while Bhatia examined the relative economies of various sizes of pumping sets/subwells operated with diesel oil and electricity. Their findings are reviewed below.

Russel and Elrod, 1968, conducted a study of the cost of operating tractors and farm equipment on 149 farms on their 1960 farming operations and concluded that the small tractors (7-14 H.P.) were used for 417 hours, medium (15-25 H.P.) for 608 hours, large (26-31 H.P.) for 785 hours and extra-large (32 H.P. or more) for 829 hours with an overall average of 696 hours annually. The study showed that the total average cost of operation of a tractor was $10.17 per 10 hour day, of which $5.78 was operating costs and $4.41 as fixed costs. The cost of tractor operation increased as the size of tractor increased; small tractors averaged $9.37 per 10 hour day, medium $9.71, large $10.72 and extra large $14.86. Fuel accounted for approximately 61 per cent of total operational costs and gasoline was the common type fuel used. Depreciation accounted for approximately 35 per cent of total fixed costs. The type of operations performed affected annual cost of tractor operations. Small tractors used 4.6 and extra large used 11.1 less gallons of gasoline per 10 hour day in performing light operations than heavy operations.

18. Russel, J.R. and Elrod, J.C., Cost and utilization of tractor power and equipment in the coastal plain of Georgia, College of Agriculture Bulletin M.S. 104, Georgia Agricultural Experiment Station, University of Georgia, June, 1968.
Bhatia, 1968, studied the comparative costs of irrigation per acre of important crops with electricity and diesel oil pumping sets and tubewells in Ludhiana district and found that a 5 H.P. electric tubewell with a 3" x 3" pump up to a maximum total head of 80 feet in the Bet area took 2½ hours and consumed 15 units of electricity costing Rs.1.50 to give rainfed irrigation of 5 acre inches. A 5 H.P. electric motor with a 3" x 3" pump took 4 hours and consumed 16 units of electricity costing Rs.1.60.

Generally, an irrigation of 2 acre inches was given subsequent to rainfed irrigation to most crops. A 5 H.P. motor took 4 hours and consumed 9.6 units of electricity costing 0.24 paisa. In the lower dhaia area, 4 acre inches rainfed irrigation to sugarcane and cotton crops with a 3 H.P. electric motor up to a total head of 30 feet took 9 hours and consumed 21.6 units of electricity costing Rs.2.28. A 5 H.P. motor with 3" x 3" pump took 2½ hours and consumed 25 units of electricity costing Rs.2.80. For giving an irrigation of 2½ acre inches, a 5 H.P. motor with 3" x 3" pump at a total head of 30 feet took 9 hours and consumed 14.4 units of electricity costing Rs.1.44. A 5 H.P. motor took 4.5 hours and consumed 10 units of electricity costing Rs.1.40. In the upper dhaia area, a rainfed irrigation of 4 acre inches with a 5 H.P. motor with a 3" x 3" pump at a total head of 35 feet took 9 hours and consumed 56 units of electricity costing Rs.3.60. For giving a 2½ acre inches irrigation, it took 5 hours and consumed 24 units of electricity costing Rs.2.40.

The author concluded that the cost of irrigation on sandy soils was higher than on clay soils and suggested the construction of porous water channels or alkathine lining to minimise loss of water due to seepage.

**Effect of mechanisation on agricultural productivity and farm income**

There is a considerable divergence of opinion about the contribution of mechanisation towards agricultural productivity and farm income. Jussawala; Board of Economic Inquiry, Punjab; Schiller; Faulkner, Reed and Brown; Giles; and Gupta suggested that agricultural productivity and farm income were positively related to mechanised cultivation.

Jussawala, 1946, observed that yield per acre increased on Government experimental stations by 40 per cent and often more because of mechanised farming.

The Board of Economic Inquiry, Punjab, 1956–57, found that returns per family worker per year and per day were 4 times higher for tractor cultivated holdings as compared with bullock cultivated holdings.

Schiller, 1959, observed that in spite of the fact that agrarian structure of Western Germany was characterised by small and medium sized farms, mechanisation of agriculture in the post-war period increased agricultural production manifold.

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Faulkner, Reed and Brown, 1965, while suggesting a programme to the Government of India to increase the cut-turn or yield of edible rice from paddy, stated that mechanical threshing at the optimum moisture content, bulk handling, off-farm mechanical dryers and off-farm fully protected scientific storage were essential to increase rice cut-turn by 68 to 72 per cent level but were less important to the lower levels of rice cut-turn. Mechanical harvesting, threshing at 20 to 24 per cent moisture followed by immediate delivery to a mechanical dryer and modern storage facility would permit farmers to plant a second crop 10 to 30 days quicker. The authors argued that these were very important gains both to the farmer and to the nation's supply.

Giles, 1966, observed that preliminary analysis indicated a positive relationship between crop yield and horse power availability per hectare but emphasised that this should be investigated more fully for developing a scientific base for programming the addition of mechanical power and equipment to the "input-mix". The author indicated that since the major problem of developing countries was one of increasing food production, the power and equipment should be of the kinds that will contribute to increased yields on a top priority. He stated that power and equipment accomplished this through more timely and effective operations.


Gupta, 1986, applied budgeting technique to explore the possibilities of increasing farm income on a 25.00 acre bullock operated farm through the introduction of tractor cultivation in Galib Kalan village in Ludhiana district. His analysis brought out that returns to fixed farm resources rose by 15.7 per cent over the suggested optimum farm organisation with bullocks as a motive power, and 32.0 per cent over the existing farm organisation. The rate of capital turn-over increased from 29.70 per cent at the existing level of production to 58.67 per cent at the improved level of production for bullock operated and 55.75 per cent for tractor operated farm situation. The decrease in the rate of capital turn-over for tractorised situation was due to proportionately larger increase in the fixed farm assets compared to gross income. Since returns to fixed farm resources and net farm earnings increased considerably in case of tractor operated situation over the bullock operated one at the existing and improved levels of production technology and rate of capital turn-over was quite high, the author concluded that it was profitable to change the motive power from bullocks to tractor.

The above studies provided evidence to show that agricultural productivity and farm income were positively related with mechanised cultivation. Yet, there were a few studies which showed that mechanisation did not bring about substantial change in agricultural productivity and farm income.

The Board of Economic Inquiry, Punjab, 1937-38, found from a study of 10 tractor cultivated and 17 bullock cultivated holdings in five districts of the Punjab that there was no significant difference in income and expenditure per acre of tractor cultivated and bullock cultivated holdings. The tractor cultivated holdings had an overall average gross income of Rs.280.96 per acre from irrigated areas and Rs.118.75 per acre from unirrigated areas while the bullock operated holdings had Rs.298.56 and Rs.140.12 per acre respectively. The expenditure (excluding rent and land revenue) per acre on tractor cultivated holdings was Rs.186.09 for irrigated areas and Rs.116.83 for unirrigated areas as against Rs.217.84 and Rs.99.01 respectively on bullock operated holdings. The expenditure per acre on manual labour on both irrigated and unirrigated areas was higher for bullock operated holdings than for tractor cultivated holdings. But expenses on other items more than offset this advantage on the latter holdings.

Hawkins, 1934, observed that tractors carried out deeper ploughings and deeper cultivations but maintained that experiments had shown that they did not increase yields. He pointed out that there was evidence to show that excellent crops of wheat were grown after potatoes without ploughing, and good crops were grown with light cultivations on a clean barley stubble. The author, however, argued that tractor and tractor implements produced a soil surface which had the properties that


suited agricultural crops, namely, a good tilth, firmness, moistness and freedom from weeds.

There was, thus, lack of unanimity among economists over the contribution of mechanisation towards agricultural productivity and farm income.

**Impact of mechanisation on farm labour and employment.**

There was little doubt about the capability of sophisticated machines to release animal and human labour and to minimise their drudgery.

Iyengar, 1949, discussed the importance of new automatic pick-up hay baler, the self-propelled combine, the cotton picker, and the harvester-thresher in U.S. agriculture. He opined that the pick-up hay baler made a one-man job of what had usually been a four-man job. The mechanical cotton picker would harvest in a day as much cotton as could be picked up by 40 to 50 hand pickers.

Norbly, 1988, studied the role of agricultural machine stations in Norway and observed that farm machinery had the effect of reducing the amount of hired help for 35 per cent farmers and 17 per cent were able to do more difficult work. There was no change in the proportions of various crops nor in any change from animal production to

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plant production. The author, however, emphasized that insufficient
time had elapsed to bring about any shift in the type of farming.

The Board of Economic Inquiry, Punjab, 1964-65, found that
the time required for ploughing one acre with a tractor using tillers was
0.72 hours as against 8.55 hours with a pair of bullocks. Combination
of disc harrow and wooden planker (sebaga) took 1.00 hour per acre with
tractor power while the cultivator and sebaga combination covered an acre
in 0.77 hours, and sebaga alone took 0.45 hours. It took 3.5 hours to
irrigate an acre of land with a tractor operated tubewell.

Sarkar and Prahladachar, 1966, studied the employment pattern
of tractors and the impact of tractorisation on certain aspects of
farming in Dharwar district. The study showed that there was, on the
whole, a reduction of 17.2 per cent in human labour and 24.5 per cent
in bullock labour on selected holdings. The authors feared that farmers
in this district could not avail fuller utilisation of tractor capacity
because of lack of irrigation facilities and their consequent inability
to raise two or more crops in a year.

These studies indicated that a necessary corollary of
mechanisation was surplus farm labour. In India, where there was already
an acute problem of unemployment and under-employment of human labour,

28. Board of Economic Inquiry Punjab, Economics of tractor cultivation in Punjab
1964-65, Publication No. 48, Controller of Printing
and Stationery, Punjab, Chandigarh, 1966.

29. Sarkar, K.K. and Prahladachar, M., Mechanisation as a technological
change, Indian Journal of Agricultural Economics, 31(1),
mechanisation could aggravate the situation. But some other studies showed that mechanisation bore a complementary relationship with human labour, when a farmer exploited his irrigation potentials, reorganised his farm for optimal resource use and practised multiple cropping.

Sivasamy, 1949, quoted from the United States Department of Agriculture bulletin "Progress of farm mechanisation", October, 1947, that from 1939 to 1945, gross production increased considerably more than during the previous 21 years. But the total man hours required in farm operations did not decrease ___ instead they increased by one per cent.

Patil, 1949, examined the impact of mechanical irrigation on rural employment and found that the village artisans such as carpenter, blacksmith and cobbler got additional work for building engine houses, making certain spare parts for engine and repairing belts. The educated gardeners were found taking more personal interest where irrigation was done with the engine and even the younger sons were quite willing to operate the engine while they avoided work at the shot.

The author observed that pump irrigation enabled diverse multiple cropping which required human labour throughout the year.

Sarkar, 1949, examined the impact of mechanisation on farm labour in Bharat district and concluded that there was no relationship

M. Sivasamy, M.C., Farm mechanisation, Indian Journal of Agricultural Economics, 4(1), March, 1949: 183-188.


52. Sarkar, K.K., A note on the impact of mechanisation on farm labour, Indian Agriculturist, 10(2), July, 1949: 152-164.
between year of the purchase of tractor and percentage reduction in human and bullock labour. The author pointed out that the experience of western countries suggested that in the first phase of mechanisation, the effect was to lighten the work load rather than to reduce labour requirements. He argued that India was still in a very early stage of the first phase of farm mechanisation.

The mechanisation of Indian farms, therefore, was not likely to release human labour to the extent that it posed an immediate problem to the nation. A part of the labour released through mechanisation could be absorbed on the farm itself by growing two or more crops a year while others could be absorbed in the secondary and tertiary sectors engaged in the production and repair of tractors, engines, motors and allied equipment. The employment opportunities in those occupations would further increase with the growth of mechanised cultivation in the country.

**Pattern of mechanisation**

*For Indian farms*

Dalis suggested the partial mechanisation of Indian agriculture with diesel engines and electric motors for stationary jobs while Ara; ECAFÉ; Syanns; and Giles recommended complete mechanisation through the introduction of power tillers and tractors which could serve as versatile multi-purpose machines for both field and stationary work on the farms. Kahlon and Sharma suggested complete mechanisation with a combination of a tractor for field operations and a diesel engine or an electric motor for stationary work. These studies were reviewed with a view to highlighting the need for increasing the level of horse power.
availability on Indian farms to ensure timeliness and thoroughness in agricultural operations for higher income.

Balis, 1984, remarked that increased agricultural production required increased power input in farming operations alongside increase in all other inputs. He recommended increase in power inputs on Indian farms through the introduction of partial mechanization and suggested that bullock power could be supplemented by using stationary engine/electric motor for irrigation pumps, threshing machines, chaff cutters, etc.

Ara, 1984, stated that it was difficult to differentiate between Japanese 5 H.P. kerosene or diesel power tiller from tractors. The author advocated the utility of the Japanese power tillers with 3-5 H.P. or 5-6 H.P. with suitable implements to work with for intensive cropping programmes such as vegetable production and horticultural enterprises. He observed that farmers who had irrigation wells and had intensive cropping programmes but not necessarily vegetables, might even need such small size tractors for other jobs on the farm such as lifting water, hauling manure, spraying insecticides and transporting farm produce.

The ECAFE Survey, 1985, concluded that small power tillers having a multipurpose use including irrigation and transportation could

34. Ara, V.K. Mallaraj, Small size tractors in Japan and their utility in India, Souvenir issued on the occasion of first annual ploughing championship, Agricultural Machinery Association of India, L-1, M芝麻-nd-din, West, New Delhi, December, 1984: 15-16.
35. ECAFE Survey, Power tillers for small farms, Agricultural Situation in India 20(2), May, 1985: 89.
be of more value than tractors in India, where human labour was in surplus.

Sayanna, 1949, suggested a two plough tractor with a minimum of 30 H.P., fitted with electric lights for ploughing hard set Indian soils in cooler hours of the summer nights of April and May. Such a tractor, he continued, must be able to serve as the farmer's overall power plant for ploughing, seeding, water pumping and as an automobile with rubber wheels with field speeds of 5 to 4 miles per hour and road speed of 10 to 15 miles per hour for transporting seeds and manures to the fields and farm produce to the market.

Giles, 1963, pointed out that agricultural operations in India and South East Asia were practically unchanged for centuries and that they needed to be invaded with a new force—mechanical power. The author observed that small mechanical power units in the range of 5 to 15 H.P. offered the best opportunity for bringing to bear more power for agricultural operations immediately and on a wide front.

Kahlon and Sharma, 1969, budgeted tractor hour use on 10-20 acre farms for different levels of cropping intensity. They found that on a 16.4 acres farm in Ludhiana district where soils were light and


57. Giles, G.D., Opportunities for advancing agricultural mechanisation in India and South East Asia, Agricultural Engineer, 9(83-84): 5-14.

the existing cropping pattern indicated a cropping intensity of 162.86 per cent, a small 10 H.P. tractor could be profitably introduced as a multi-purpose machine. This machine could be supplemented with a 7.5 H.P. diesel engine (or electric motor) for stationary farm operations when the optimal shifts in the cropping pattern were incorporated for higher profits and cropping intensity was raised to 191.83 per cent.

The available literature did not provide adequate information about the pattern of mechanisation for farms of various sizes and for different agricultural regions. But, farmers needed this information for equipping their farms with appropriate power units and matching equipment for increasing their income while manufacturers required it for expanding their production in the right direction.

It appeared from the foregoing review of the available literature that quite a few isolated projects had been taken up in India with a view to examining the profitability or otherwise of mechanising certain selected agricultural operations. The opinion regarding the qualitative contribution of mechanisation was divided while there was a consensus regarding its quantitative contribution to Indian agriculture. The mechanisation of agricultural industry was considered essential for solving the national shortage of food and agricultural raw materials through timely and thorough agricultural operations and increased cropping intensity.

There had been no systematic effort to develop input-output coefficients for various sizes of farm machinery and allied equipment for various agro-climatic regions to provide sufficient data for taking
rational decisions for mechanising Indian agriculture. The need for such data was highlighted in one of the meetings of the Scientific Committee of the Indian Council of Agricultural Research held in 1931. But, in spite of this emphasis, the coefficients for working out appropriate patterns of mechanisation for Indian farms have not been developed. Most of these coefficients for foreign countries could be obtained from the engineering research studies but these were not available for Indian conditions in the available literature.

Keeping in mind the urgency of mechanising Indian agriculture, this study was taken up with a view to developing input-output coefficients of various sizes of farm machinery and power through the survey method; working out a suitable pattern of mechanisation for various sizes of crop farms with the help of these coefficients; and determining possible adjustment opportunities for farmers through the introduction of desirable mechanisation on their crop farms.