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AGRICULTURAL MECHANIZATION IN INDIA

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Abstract: Mechanization has become the most important aspect of modern agriculture in India due to increasing demand, less yield, scarcity of farm labors, etc. To maintain the sustainability in the agricultural sector, it is essential to spread the awareness of Farm Mechanization among the farmers. The main problem for farmers to adapt mechanized alternatives is lack of knowledge and scarcity of resources such as man, machine and land. The purpose of this study is to investigate the need and challenges of farm mechanization and the current development in the field of mechanization in India. In this study, it is concluded that agriculture in India contributes 14% towards GDP. However, 48% of the population is engaged in agricultural activities for their livelihood. The demand and sales of tractors, power tillers and farm power availability are increasing year by year. This concludes the importance of implementation of mechanized alternatives for farming. Some of the problems in agricultural mechanization and measures to be taken to increase the awareness and implementation of farm mechanization are given in this study. Summary of the different machines which are currently used towards Farm Mechanization in India and their development is also studied.

I. INTRODUCTION:

The application of farm power to farming tools and machines is called "Farm Mechanization". It is an essential agricultural input in India with the potential to transform the lives and economies of millions of the rural population. Farm mechanization can facilitate increased output of higher value products and improve the way of life by eliminating the drudgery operations associated with human work in farming. Increased output advances and benefits towards the rural economic-cycle i.e. improving economy of smallholder farmers increases access to input supply chains and integration in modern food systems, these results in improved incomes, which produces numerous and renewed business opportunities, more value addition and overall better livelihoods for smallholder families. Hence, sustainable development of global food systems can be the significant contribution of mechanization in the field of agriculture. Mechanization in the field of agriculture is the most important parameter for the sustainable development in the agricultural field. It helps in increasing production with reduced cost, reduction in the deficit, better management of high-priced inputs, rise in the overall productivity of natural resources and reduction in the difficulties associated in various agricultural activities.

India's agricultural condition was totally in disguise in post-independence period. The country was facing severe food scarcity and was dependent on imports to feed the population. To mitigate this problem, "Green Revolution" took place in 1960s, where several new practices like improved high yielding hybrid seeds, chemical fertilizers, development and expansion of irrigation systems and education to farmers were practiced. Technological breakthroughs like improved water system, increased mechanization in agricultural operations helped to shape the "Green Revolution". As there was success of the "Green Revolution," cereal imports in India were generally negligible in the 1970s, except massive crop failures in 1979-80 led to renewed imports of 2.3 million tons of food grains in 1981-82. By the end of the 20th century, India had achieved self-sufficiency by producing enough food, for example, 212 million tons of food grains in the year 2001-2002. In countries like India where scarcity of capital persists and supply of labor is abundant, partial mechanization will be the most suitable remedy. The factors which are creating hurdles against the mechanization of agriculture include mounting pressure of population on land, small and fragmented holding, acute poverty and ignorance among the farmers etc.

According to the estimation of the World Bank, half of the Indian population would live in urban areas by the year 2050. It is estimated that percentage of agricultural workers in total work force would drop from 58.2% in 2001 to 25.7% by 2050. This shows the need to enhance the level of farm mechanization in the country. Moreover, country's drastic increase in level of farming and global competition facilitated the use of machines in farming operations. The Indian farm mechanization market, which was valued at Rs.320 billion in 2015-16, is expected to grow at a CAGR of 5.74% to reach Rs.400 billion by 2019-20. Scarcity of farm labor and the need to increase farm productivity are among the main reasons for increasing farm mechanization in India.

Mechanization has not only remained a local issue rather international organizations are also working for the sustainable development of agriculture and food supply. The United Nations General Assembly (UNGA) formally adopted the 17 sustainable development goals (SDGs) successfully on 25 September 2015. FAO is also carrying out its work on sustainable production intensification and developing green food value chains (FAO, 2014a) which is also part of this effort. Agricultural mechanization has a key role to play in this development process. Following are the 17 different processes observed under four varied stages of the crop.

Figure 1: The potential contribution of mechanization to green food value chain development

II. INDIA & WORLD:

The total land area of India is 297 million hectares of which 142 million ha is classed as agricultural land. The average size of land holdings in 2011 was 1.16 ha with only 0.7 per cent farmers consisting of farms of more than 10 ha but constituting about 11 per cent of the cultivated land while 67% farmers have farms of less than 1 ha, constitute about 22% of the cultivated land. The rest of the farms are in the intermediate range with the largest proportion being medium farms (4 to 10 ha) and semi-medium farms (2 to 4 ha) which cultivated 24 per cent each of the total cultivated land in 2011. Thus, the three categories comprising large, medium and semi-medium farms (20.7 million farm holdings) cultivate between them 56 per cent of the cultivated land. Maximum farmers have small farm holding and that is one of the main interruptions in mechanization.

India with the second highest population and one of five major world economies has agricultural land of 60.45% (Fig.) of the total country land. Agricultural land is the share of land area that is arable, under permanent crops, and under permanent pastures. India lacks so far in terms of many aspects like yield per hectare, machinery used, etc.

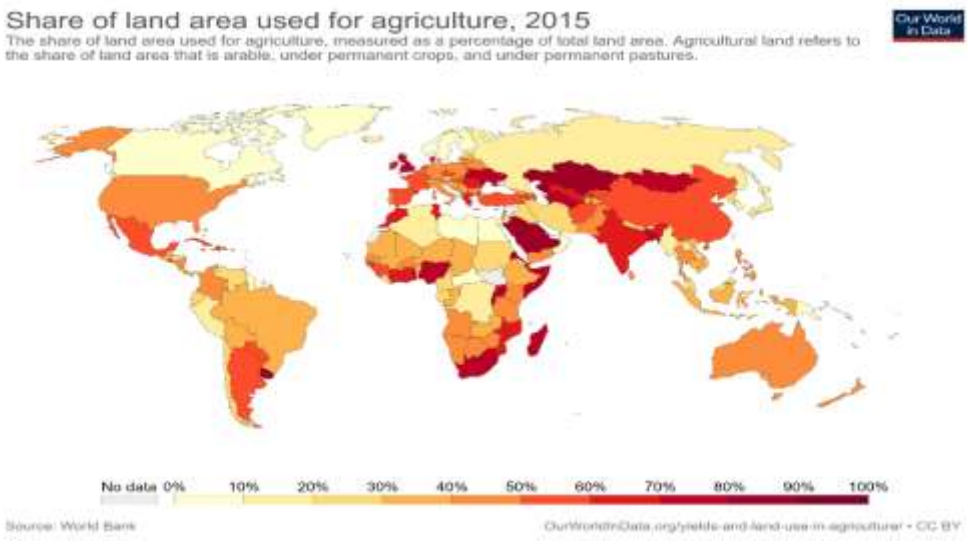


Figure 2. Share of Land under Agriculture

The yield of Wheat was 3.15 Tonnes per Hectare (Fig.) and of Rice was 3.58 Tonnes per Hectare (Fig.) for the year 2014 in India which is nearly 3 to 5 times lesser than the developed countries.

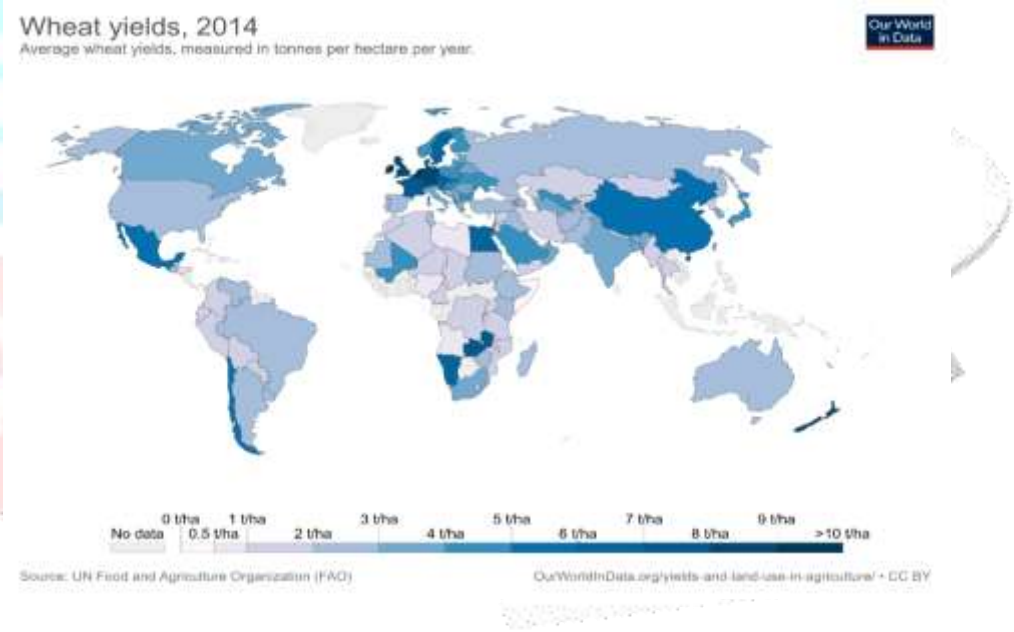
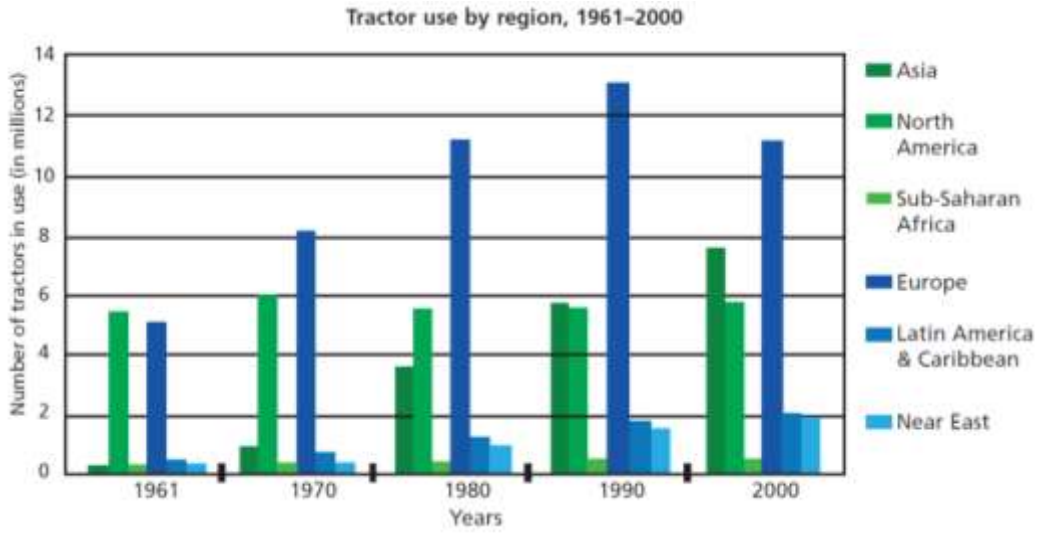


Figure 3. World Wheat Yield

Looking towards the mechanization part, following is the description of tractors used in various region year vise. It explains how the growth of mechanization took place, with the population of tractors.

FAO (2008) reports shows the advancement of mechanization taking tractors as indicator.

- In Asia, tractor numbers increased fivefold between 1961 and 1970, from 120 000 to 600 000 units. Thereafter, the number increased tenfold, reaching 6 million units in 2000.
- In Latin America and the Caribbean, tractor numbers increased 1.7 times between 1961 and 1970, from 383 000 to 637 000 units, and thereafter tripled to reach 1.8 million in 2000.
- In the Near East, the picture is similar to Latin America, as tractor numbers doubled from 126 000 to 260 000 between 1961 and 1970 and then increased 6.5 times to reach 1.7 million in 2000.
- In sub-Saharan Africa, the trend has been rather different. In 1961, the number of tractors in use (172 000) exceeded the number both in Asia and in the Near East. They then increased slowly, peaking at 275 000 in 1990 before declining to 221 000 in 2000.



Farm power is an important concept in the context of agricultural mechanization. We will understand the farm power later in the paper. The following comparison of farm power availability in the various nations shows the prosperity of mechanization in the country.

Table 2.1: Mechanization in India Comparison with other countries

Sl. No.	Country	Farm Power (kW/Ha)	No. of Tractors per 1000 Ha.	No. of Combine Harvesters per 1000 Ha.
1	India*	2.02	37	0.026
2	Japan	8.75	461.22	236.98
3	U.K.	2.50	88.34	8.3
4	France	2.65	68.5	4.93
5	Italy	3.01	211.08	4.71
6	Germany	2.35	79.817	11.41
7	Argentina	--	10.74	1.79
8	Brazil	--	13.66	0.915
9	China	--	6.98	2.53
10	Pakistan	--	16.47	0.08
11	Egypt	--	30.7	0.79

III. AGRICULTURAL EDUCATION IN INDIA:

In order to study and determine the need and potential of agricultural sectors, it is necessary to have skilled and educated human resources. The human resource development in the field of agriculture is a continuous process which is accomplished by the agricultural institutions in India. This includes sharing knowledge and current developments in various disciplines of agriculture like Agriculture, Agricultural Engineering, Forestry, Horticulture, Veterinary and Animal Husbandry, Dairy Science, Fisheries Science, Agriculture Information Technology, Food Technology, Agri Business Management etc. It gives education in various levels like diploma, degree, masters and doctoral.

The agricultural education in India started in the medieval period when study of agriculture was an important subject in the curricula of Nalanda and Takshashila Universities. However, dedicated courses for agricultural education began only in early years of 20th Century when six agricultural colleges were established at Kanpur, Lyalpur (now in Pakistan), Coimbatore and Nagpur in 1905, at Pune in 1907 and at Sabour in 1908 as General Universities. To ensure orderly growth, the Indian Council of Agricultural Research (ICAR), which is the main body for developing the research and education in agriculture in the entire country, took the lead and drafted the first Model Act for Agricultural Universities in India in 1966 and encouraged the setting up of exclusive State Agricultural Universities for research and education support. The first Agriculture University in the country began in 1960 at Pantnagar (now in Uttarakhand), which initialized the way for establishment of agricultural universities in other states. There are 73 Agricultural Universities today out of which five are deemed-to-be universities, two are Central Agricultural Universities and four are Central Universities with agriculture faculty. The intake capacity of students has increased from 5000 in 1960 to 40000. In 350 constituent colleges, the enrollment of students is about 25,000 students at UG level, over 15,000 at Masters' level and Ph.D. programs. In addition to this, there are many private affiliated colleges enrolling thousands of students annually.

Recently, Indian Council of Agriculture Research (ICAR) has recognized degree of B.Sc. Agriculture as Professional Degree in different State Agriculture Universities of the country. There are nine courses recognized as 'Professional Degrees' namely, Agriculture, Horticulture, Agriculture Engineering, Sericulture, Forestry, Food Technology, Biotechnology, Home or Community Science, Food Nutrition and Dietetics. As these courses are now being developed as professional courses, special requirements can now be imparted as there is a need of micro-level attention in the agricultural field.

IV. NEED OF MECHANIZATION:

The below pie chart shows that agriculture in India contributes about 14% towards the GDP. But the labor force engaged in agriculture is 48%. This shows the scarcity of mechanization development in India. Mechanization will contribute towards the increase in land productivity and quality of cultivation. It will give the opportunities to relieve labor shortages. It will reduce poverty and achieve food security while improving people's livelihoods.

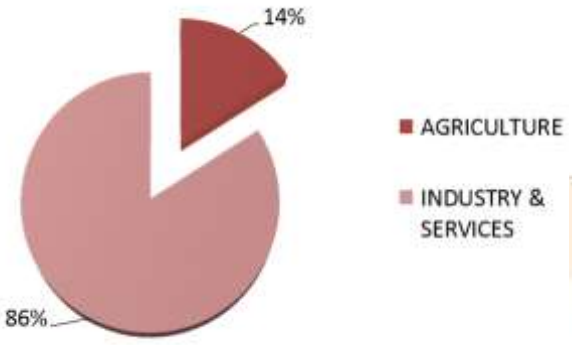


Figure 4: GDP Contribution of Agriculture and Industry Sector

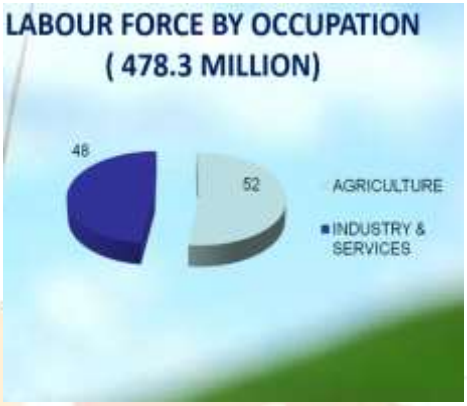


Figure 5: Labour Force engaged in Agriculture

The motivation behind mechanization in the field of agriculture is mainly driven by a wish to increase family's income, food security and the quality of life. Farmers can use custom hiring services and get advantages of significant economic and social benefits. The economic benefits include reduction in input costs, increase in the efficiency of man power, increase in the net cultivated area, undertaking timely operation, increasing farm output, improving the quality of cultivation, reduction in harvesting and post-harvesting losses, adopting crop diversification, and earning income through hiring farm-power services to others. Whereas the social benefits include reduction in workloads and drudgery (especially for women workers), improving safety and encouraging young generation and innovative people to remain in rural areas and work at farm. Due to Farm mechanization there is 15-20 per cent saving in inputs like seeds and fertilizers and increase in cropping intensity by 5-20 per cent. Hence it saves about 15-20% on the overall time spent on agricultural operations and also on farming resources. This results in increase in the efficiency of farm labor.

The agricultural field in India is depended on cheap and surplus labor from many years. Now, there is a noticeable transition as there are more opportunities available in factories and services as well as the Government's rural employment creation program, which provides 100 days of employment on public related work projects. Due to the National Rural Employment Guarantee Act., farmers are facing problems such as Labor shortage during peak seasons as these labors are now available at higher prices. This increases the demand for mechanization. It is also predicted that the percentage of agricultural workers to the total workers is declining steadily from 59.1 % in 1991 to 54.6 per cent in 2011 and expected to further decline to 25.7 per cent by 2050 leading to severe farm labor shortage.

In a study published in ICAR (2004-2007), it was showed that about 34.2% of the total accidents in agriculture were due to hand tools, of which sickles and spades resulted in 46% of farm injuries. These injuries are severe and sometime may cause a disability due to delay in treatment. In one study it was seen that about 70% of the agricultural hand tools have a high recovery time of more than seven days. Hence, development in farm machinery is very essential as this reduces farm injuries and other problems that may occur due to the use of hand tools and agricultural practices can be made more productive.

V. MECHANIZATION HISTORY:

Engineering is always welcomed by the Indian farmers and that brings up the disruption in agricultural mechanization by moving from conventional farming implements like Tifan to Cultivator, Naagar to Mold Plough, Vakhar to Rotavator, sickle reaping to Combine harvester, Rehat (Persian Wheel) to Centrifugal pumps. Traditionally most of these implements were locally manufactured by the village carpenters and blacksmiths. Sardar Joginder Singh (then Agriculture Minister, Punjab Government), introduced the steam tractors in India in 1914, which was

imported for reclamation of waste land. The number of tractors in use grew from 8000 in 1950 to 20 000 in 1955 and 37 000 units by 1960. These were used mainly on larger farms. Up to 1960, most farm operations and transport work were done using draught animals.

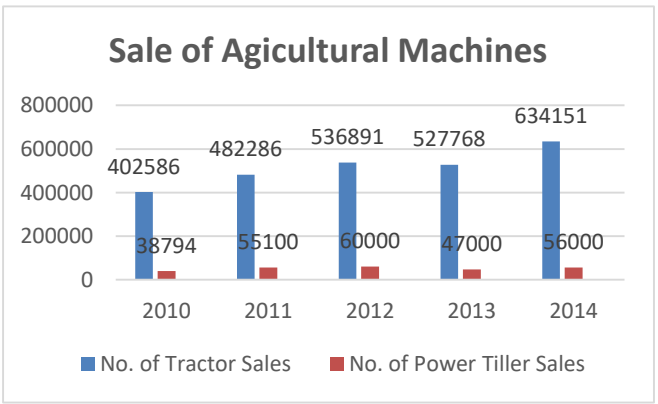
Figure 6: Wooden Plough (Naagar)

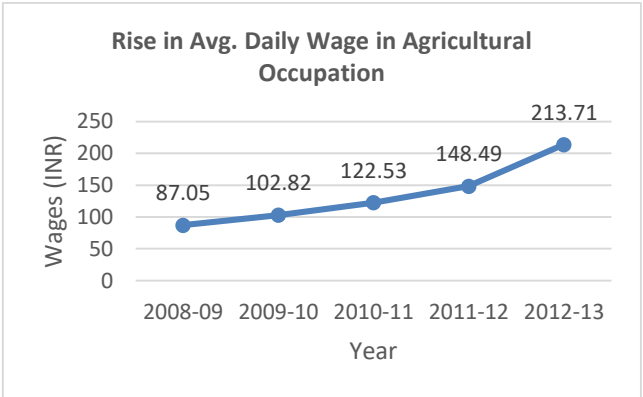
Figure 7: Iron Mold Plough

Engines (petrol, kerosene, and diesel) were being used for post-harvest processing like floor making, rice milling, grinding, etc. During the period 1960-1980, more than 90 per cent of public investment in agriculture was for the development of irrigation facilities including medium and major irrigation projects. The result was a significant increase in the area under irrigation, particularly in the states of Punjab, Haryana and Uttar Pradesh. During the era of Green Revolution, provision of a range of inputs such as agro-chemicals and farm machinery contributed towards increasing agricultural productivity. The availability of farm power registered a significant increase due to enhanced contributions from electrical and mechanical sources.

Several implements such as Mould Board Ploughs (Wah Wah Plough, U.P. No.1, U.P. No.2, Shabash Plough) hoes, cultivators and wheat thresher were introduced for the first time in India by Prof. Vaugh of Allahabad Agricultural Institute in 1940s. Farmers were using mostly wooden ploughs until Mr. Laxmanrao Kirloskar introduced India's first iron plough in 1903. Followed by India's first centrifugal water pump introduced by Kirloskar Brothers Ltd. In 1926.

Figure 8: Kirloskar's Iron Mold Plough





VI. CHALLENGES IN THE ROUTE OF MECHANIZATION:

Use of machines and machine power is affected and dependent on series of factors. Let us see some major of them.

6.1 Lack of Knowledge:

Agriculture is practiced in India from the human civilization era, traditional techniques and methods of farming can be still seen. Although the lack of knowledge of the new technologies, lack of awareness about the current farming solutions and scarce access to newfangled technologies it becomes difficult for the Indian farmer to compete in terms of production. Traditional farming practices are now a days trending because of its purity and sustainable output, but still without use of machines the productivity remains less and cost of growing increases. Again because of traditional views related to farming, farmers hesitate to take risk to use heavy machines in the farm.

There is a high rate of illiteracy among rural farming populations; which hinders the implement of mechanisation and agricultural productivity. Farmer's training for using new technologies and machines is relatively at low level, which results in limited opportunities for the farmers to imply. Farmers lack the knowledge and skills to operate mechanized equipment and when machines *are* used, this lack of proficiency leads to misuse and mismanagement of machinery – especially of more sophisticated machines.

6.2 Small Farm Size:

On an average about 90% of Indian farmers holds less than 2 Hectare of land which is comparatively too small than the other countries. The intensive farming in small land size is the main barrier for the large machines to use as machines like combined harvester, heavy duty tractors are suitable and made for large farm plots.

To use machines in the farm, the crop pattern should be kept befit according to the convenience of machine and this includes increased row width, large row length, etc. of the crops, this results in decrease in plant density per hectare. As the farmers already holds a small amount of land, they cannot bear this kind of alteration.

6.3 Non-Affordable:

Smallholder farmers are, resource poor and often have difficulty investing in physical assets in general and in agricultural machinery in particular. In Running machines for farming operations requires power source which is either fuel power or electricity. To make the comprehensive shift from manual to mechanized farming, cost of operation comparison between the manual animate charges like labor charges and animal cost and the fuel requirement for the operation. Mechanizing would be affordable if and only when the cost for running these machines will be lesser than the animate power charges.

The minimum support price of the crops and the cost of production doesn't have a big gap, that is what makes non profitable business for Indian farmers. Buying machinery requires large capital which an average farm holder of India can't afford as because of small farm holding the requirement of machines is necessary for making it mechanized but at the same time is a too big investment. An average cost of tractor of 50 HP is about 6 lac Rs. Also, additional implements will cost around 2 lac Rs. To make an investment of Rs. 8 lacs is too high for a farmer who owns farm of 2 hectares. Again to power this various machines from small weeder to tractor which runs mostly on petrol and diesel become a factor of concern, as the price of diesel and petrol is around 70 Rs/Ltr and 80 Rs./Ltr respectively and there is no subsidy on fuels like this for farmers.

Another machines like water pumps, spraying pump requires electricity which is too not so inexpensive. . The electrification of Indian agriculture sees an impressive growth, especially since the 1980s with consumption rising from 3,465 million units (mu) in 1969 (8 per cent of total consumption) to 173,185 mu in 2016 (17 per cent of total).

There is limited access to sources of financial credit due to the, lack of availability of financial products specifically focused on farm equipment investment, misconception of regarding the need of targeted financial products for investment in equipment, high-risk agriculture business, reluctance of commercial financial institutions (mainly banks) to extend credit to poor farmers with little collateral.

6.4 Inefficient Machinery Solutions:

Farmer expects effective machine solutions to shift from manual to machine for each and every operation. As because of inadequate research and development in the field of mechanization, development of perfect machine solution for farm practices remained behindhand. Indian farm requires small machines of low capacity and should perform wide range of operations. Country has variety of soil types and diversified crops and varied agro-climatic conditions from different regions which again demands for specialized machine for that soil and crop only, which again remains unsolved because of low research and development.

Also, sometimes efficient machine remains undeveloped because of the complex crop patters and their complicated operations. Crops like cotton in India, harvesting i.e. is cotton picking is done averagely three times, whereas cotton in countries like America harvesting is done one time only. Harvesting cotton is a complex operation which requires high precision and accuracy to get proper output development of machine for harvesting cotton crop of India is a complex task.

Funding by government in the field of agricultural research and development is very low to the degree that time demands. Private players have also jumped in the field of new machinery development but that too increases the cost.

6.5 Inadequate supply of spare parts and serviceability:

Most of the spare parts need to be imported from different countries as there availability is limited in India. Hence this requires a high amount of time for replacement of damaged parts. The available technical manpower to operate or service the implements and machines is also not adequate. The facilities or machinery for fabricating and repairing farm implements are mainly insufficient and ineffective where they are available.

6.6 Varied Soil Types:

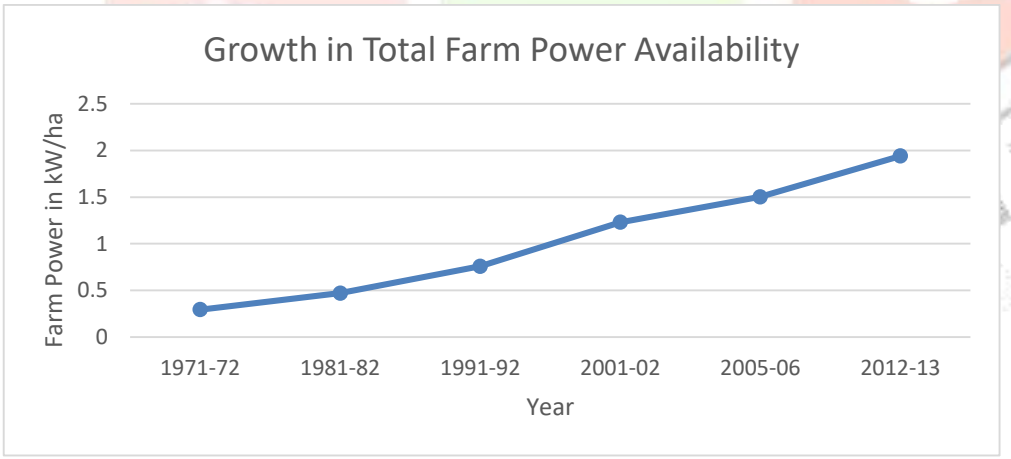
Soil types are extremely varied due to different topographical conditions throughout the country and the machines to use on them have not been developed locally. Hence, there is always the risk of damaging the implements when operated on hard soil. Mechanization leads to compaction of soil due to the movement of heavy machines on farm land.

6.7 Displacement of workers:

In farm mechanization, very few workers are required; hence, many people will be out of job when mechanization is introduced. This leads to unemployment of labors which will increase the poverty in the country.

VII. FARM POWER:

Farm Power is amount of energy to indicate the extent of mechanization the farm has in terms of kW per hectare of land. It includes animate as well as mechanical and electrical power. In India the total farm power availability from animate and mechanical sources in 1951-52 was 0.20 kW/ha which increased to 1 kW/ha in 1996-97. Animate power contributed 60% of the total farm power in 1971-72 and mechanical and electrical together contributed only 40%. In 1996-97 the contribution from animate power reduced to 21% and from mechanical and electrical power it increased to 79%. The figures show that post green revolution period found out to be not only progress in biological but also technologically in farming.



Source: *IndiaAgristat*

The statistics of 2012-13 shows that the share of power from tractor in the total farm power is increasing substantially, which contributes 45.80%, further the share of Electric Motors is also increasing i.e. 26.80% then from Diesel Engine and Power Tillers contributes 16.30% and 0.80% respectively. Whereas conventional sources like Agricultural Workers and Draught animals is decreasing and contributes 5% and 5.10% respectively. Therefore, there is a need to increase the availability of farm power from 2.02 kW per ha (2016-17) to 4.0 kW per ha by the end of 2030 to cope up with increasing demand of food grains.

7.1 Farm Mechanization Share in Farming Operation

Following data shows how much percent the farming operation is mechanised in India. Harvesting operation is the most mechanised one but only for wheat and rice crops as the crop is extensively grown and machines are comparatively affordable. Whereas the harvesting operation is <5% mechanised for other crops as the complex and efficient and affordable machines are not yet introduced. Crop like cotton is quite differently grown in India than the other developed countries thus the machines failed to penetrate in this crop and largely the operations like sowing and harvesting is carried out manually by labourers.

Table 7.2: Percentage of operation mechanised

Type of Operation	% of Operation Mechanised
Soil working & seed bed preparation	40
Seeding & planting	29
Plant protection	34
Irrigation	37
Harvesting & Threshing	60-70% (Wheat & Rice) <5% (Others)

VIII. FARM MACHINERY INDUSTRY IN INDIA:

The adoption of mechanization technology depends upon the cost, manufacturer and after-sales-services, ease of use besides credit and financial incentive provided by the Government. Manufacturer of agricultural machinery in India is comprises from village artisans, black smith units, small scale industries to large multinational players and organized tractor, engine and processing equipment industries. Traditional hand tools and bullock drawn implements are locally fabricated by village craftsmen and small-scale industries. Organized sector industries manufacture sophisticated machinery such as tractors, engines, mills and dairying equipment.

CURRENT MACHINES:

8.1 Tractor:

Tractors too were imported in post-independence period, as the subsidiary result technology availing was not affordable to the farmers for adopting mechanized practices. This nearly came to an end in 1970s when Indian companies started manufacturing the indigenous tractors. Tractor production in India started in 1961, initialized by five manufacturers – Eicher, Mahindra and Mahindra, Tractors and Farm Equipment Limited (TAFE), Gujarat Tractors, and Escorts. In the initial years, just 880 units were produced per year. The first fully developed indigenous tractor in the country was the Swaraj 724 which was of power 26.5 HP, built by Punjab Tractors Limited in 1974. Gradually the demand for tractors climbed up when the country became self-sufficient in terms of food. From 1989 to 1990, India witnessed a three-fold rise in the production of tractors with a compound annual growth rate (CAGR) of 9.2%.

Today India is the largest manufacturer and tractor market in the world. The market is also amongst the biggest segments in the category of farm equipment in the country, with annual sales of 600,000-700,000 units. The country produced 619,000 tractors in 2013, accounting for 29% of the total output worldwide. On an average, the country exports an average of 79,000 tractors annually. India exports tractors to foreign markets primarily include African countries and ASEAN countries where soil and agro-climatic conditions are similar to India. In FY' 2016-17, India exported 77490 tractors worth ` 6143.07 Crore There are 16 domestic companies alongside four global one's manufacturing tractors in the country at present. With regard to market share, five companies in India account for more than 80% of the share in the tractor industry -- Mahindra and Mahindra, TAFE, ITL-Sonalika, Escorts, John Deere. Out of this, Mahindra and Mahindra hold the largest share with a massive 43% of the market, followed by TAFE.

Presently India has more than 16 Tractor companies with market giants like Mahindra, TAFE, John Deere, etc. manufacturing a wide range of tractors from 14 hp to 120 hp. Tractor companies today offers fine technology to perform comprehensive farm operations. Some of the technological specifications are Robust four stroke diesel engines with Direct injection, Dry-type air filter with dual filter elements which achieves 99.9 percent cleaning efficiency, 4-valve Eco-Center Direct Injection System (e-CDIS) technology, Oil immersed Multiplate Sealed disc brakes, 5-finned Main Clutch, Synchromesh transmission which offers Maximum 18 gears (15 forward + 3 reverse), Precision hydraulics has been provided now a days which has Draft, position and response control.

8.2 Power Tiller:

The production of power tillers started in 1961. The power tillers are available for upland and wetland farming conditions. The walk-behind power tillers are machines which can perform most of the work which tractors perform but are of relatively very low power capacities and mostly models designed are of two wheels only, added can perform low power requirement work, thus low power and small size make it of low cost. Power tiller can operate rotary, puddler, leveler, trailers, plow disc, thresher, water pumps, etc. Its small and small tilling width make it advantageous to work in between rows of the crops. Operating power tiller is slightly different from tractors as most of the power tillers are walk-behind and have hand operated brakes. Most of the models have single cylinder diesel engine with total 8 speed gearbox (6F+2R), where 3F+R in low and high speed differently.

Their introduction coincided with that of agricultural tractors but, tractors captured large market as are more suitable for upland work and provided more comfortable work environment to the operators. Various models range from 8 hp to 15 hp of power available in market. VST Tillers, Kirloskar Oil Engine, Kubota, Greaves Cotton are some of the major players in the power tiller market. The sale of power tiller in the year 2016-17 was about 49000 units (6).

8.3 Sowing and planting equipment:

Planting in proper sequence is very advantageous as it saves seed inputs while seeding also facilitates the application of fertilizers, weedicides, pesticides, etc. Traditional way of sowing, the animal drawn *Dufan* (two row), *Tifan* (three row) are still used by the farmers as it costs less, but it takes lots of time and is the chances of error are more, which results in inferior quality of work. These traditional ways are profoundly replaced by the mechanically metered seed drills and seed-cum- fertilizer drills operated by tractors which suits the specific crops and regions. This tractor drawn seed drill attachments have much more efficiency as they can work up to nine rows. The seed cum fertilizer drill consists of a seed box, fertilizer box, seed and fertilizer metering mechanisms, seed tubes, furrow openers, seed and fertilizer rate adjusting lever and transport cum power transmitting wheel. The fluted rollers are driven by a shaft which gets power from wheels. Fluted rollers fixed in the seed box, receive the seeds into longitudinal grooves and drop them in the seed tube attached to the furrow opener. By shifting the rollers sideways, the length of the grooves exposed to the seed, can be increased or decreased and hence the amount of seed sown can be varied.

Simultaneous operation of soil tilling, ridging, seeding, covering and pressing can be carried out along with Some of the features like adjustable ridges & tynes, Bed System Planting, adjustable Seed to Seed Distance, Disc type covering device along-with press wheels.

Semi-autonomous tractor drawn planters have been developed for highly complex type of crops like sugarcane, cotton and rice. The machine for sugarcane planting has been developed in such a way that it Cuts sugarcane into setts, makes furrow, plant cut sett in furrows, cover the planted sett with soil and apply fertilizer in a single operation with a single operator required on the planter.

Still most of the cotton seed sowing is done manually by labours as cotton seeds are required to be sown in fixed numbers at fixed distance, which consumes money and time too. Machines have been developed to carry out this complex operation but yet not accepted thoroughly by the farmers, as it has its disadvantageous.

8.4 Interculture & plant protection equipment:

Weed control in irrigated and rain-fed agriculture a serious problem and the yield is affected to the extent of 20-60%, if not controlled. *Khurpi/Vila* or scythe is the most popular tool used for removal of weeds but it is very time consuming hence increases the expenses. Other manual operated equipment like long handle wheel hoe and peg weeders and Cono weeder which have their mechanical advantages and thus helps in reducing weeding time. Thou manually operated tools are time consuming but they are the most effective way of weeding as the crop damage is reduced when weeds are cut manually. Bullock operated intra row weeder and cultivator are also used for control of weeds. Most importantly if the plants are in proper pattern then the use of machines for intra row tilling operations become much easier, along with crop damage is also reduced.

Mechanical power weeders are now a days available in wide operating range powering from 52 CC vertical engine to 8 HP diesel engines. Operating width is adjustable according to the crop type and pattern. Different designs of low-cost hand operated sprayers and dusters are available for plant protection. Spraying in cotton, paddy, sugarcanes, fruits and vegetables, oilseeds and pulses is one of the important crop production activity largely practiced. Modern portable spraying pumps operating on 12 V and 8 Ah are also becoming popular among the farmers.

Figure 94: Cono Weeder

8.5 Harvesting & Threshing:

Harvesting is the most mechanised area comparing to other domains of cropping. Traditional harvesting practices includes cutting crops using sickle followed by threshing with animal trampling or manual threshing. Further stationery threshers replaced manual threshing. Most of the cereals and pulses crops are harvested in this way, like wheat, rice, gram, jowar, etc. Stationery harvesters comes in different ranges depending on the type of crop and are required rotational input energy which is either supplied electric motor or tractor PTO. Combine harvesters and tractor mounted harvesters which came in India in 1970s has acquired a major place in harvesting. It is a reaper cum thresher which works together to harvest, threshes and cleans the grains from the straw in one operation. Crops like wheat, soybean, etc which are

extensively grown are harvested using combine harvester which is either self-propelled or tractor mounted, powered by 50 HP to 120 HP diesel engines.

The technological development of harvesting and threshing equipment is pumped up by factors considering Economics i.e. reduction in cost of harvesting and reduction in harvest and post-harvest losses and quality of produce. Also, non-availability of labour during the harvesting period and to ensure timeliness, and to reduce drudgery in the operations.

IX. FARM MECHANIZATION ADVANTAGES:

9.1 Input savings & Increase in yield

- Research shows how adoption of mechanisation saves the input to the crops. Adopting farm mechanization saves approximately 15-20% of seeds and fertilizers.
- Using machines will reduce the labour deployment and can save much input cost which farmer spends on labourers.
- Farm mechanization increases the cropping intensity, resulting more plants per hectare which ultimately increases the yield per hectare. Studies shows that adopting mechanization increases cropping intensity up to 5-20%.

9.2 Increase in efficiency

- Using machines for farming operations also increases the efficiency of farm worker to carry out heavy work with ease in lesser time.
- It is estimated that farm mechanization can help reduce time by approximately 15-20 percent implying more time to invest in other activities.
- Additionally, it improves the quality of work as machines can work more precisely with less error in operations like sowing, harvesting, spraying, etc.
- These benefits not only help in the reduction of production costs but also increases the yield and ultimately the income.

9.3 Social benefits

- Uncultivable land can be brought under cultivation with the help of heavy-duty machine for tilling like operations.
- Farm labour's safety will also increase as critical operations can be carried out by the machines.
- As mechanization uses modern practices that reduces the drudgery and workloads which attracts youth farmers towards agriculture and rural sector.
- Increased farm yield and reduction in production cost can reduce the vulnerability of small farm holders towards socio-economic and environmental crisis.
- Farm mechanization actually creates new employment opportunities like manufacturing, repairing, and custom machine hiring services.

9.4 Decrease in Cost of work

- It has been accepted by all that one of the methods of reducing unit costs is to enlarge the size c* the farms and go in for more intensive farming.
- It is found that the cost of production and the yields can be adjusted properly if mechanization is resorted to.

9.5 Decrease in demand for work animals for ploughing, water lifting process

- In actual operation, cost decreases when machines are idle, whereas the cost of maintenance of draught animals remains the same during both periods of working and idleness as animals are living being and needs to be fed whether they are doing work or not.
- It is advantageous to use tractors when a great deal of work has to be done in a short time.

9.6 Reduces Fodder area and enlarges food area

- With the introduction of mechanization in agriculture the surplus animal power would be reduced so that large areas of land required for producing fodder for it can be utilized for producing food for human consumption.
- The remaining cattle population would be better attended to and better fed under mechanized agriculture, for new and nourishing varieties of feeding stuff would be grown in cultural (waste) lands after reclaiming them for cultivation.

X. IMPROVEMENTS & SUGGESTIONS:

10.1 Affordable Farm Equipment

None other farm implement segments have been succeeded as far as the tractors. Tractors are relatively pricey and thus become non-affordable for small farmer. As per-capita land holding of Indian Farmers is decreasing, small farm machineries / implements

which would be inexpensive need to be manufactured keeping in view the versatility of various crops, cropping pattern, geographical conditions and agriculture operations.

10.2 Finance

Easily available loans and subsidies would be of much help for farmers, as it will increase the buying tendency of the farmer. Along with the loans should be given at much lower rate with longer payback periods.

10.3 Awareness & Education

Education and awareness about use of machinery, servicing and maintenance of machines, importance of mechanization, economic benefits, scheme related information is very decisive for developing the farm machinery sector. Agriculture Universities along with other organization come forward to spread its importance amongst the farmers. On field demonstration and training on machines should be the part of marketing for agro-machinery manufacturers

10.4 Development of Custom Hiring Service Centres (CHC) & Uberization:

CHC is now a days becoming popular as it enables farmers to use heavy machines with relatively negligible investment. Tractor is best example of this kind of business model, in similar way other modern machines can also be brought under this business model of custom hiring which will not only provide the easy access heavy machines to the farmers but also will be a choicest opportunity for an entrepreneur. Just the business model needs to be evolutionized for the machine owners with value addition of newer technologies.

Unlike other agricultural sectors, farm mechanization sector in India has a far more complex structural composition.

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