SOCIAL RESPONSIBILITY COUNCIL

सत्यमेव जयते

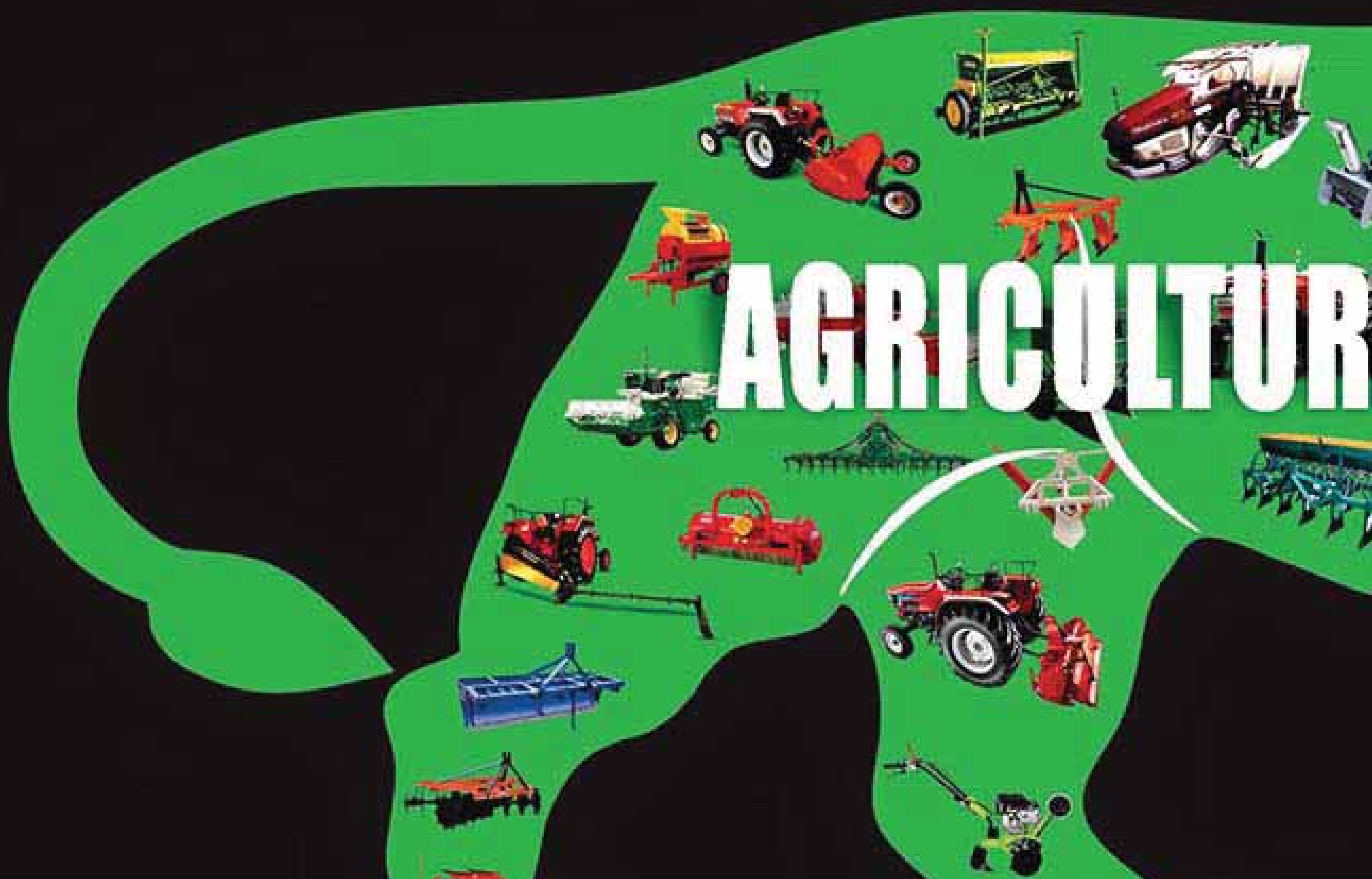
Ministry of Agriculture & Farmers Welfare
Government of India

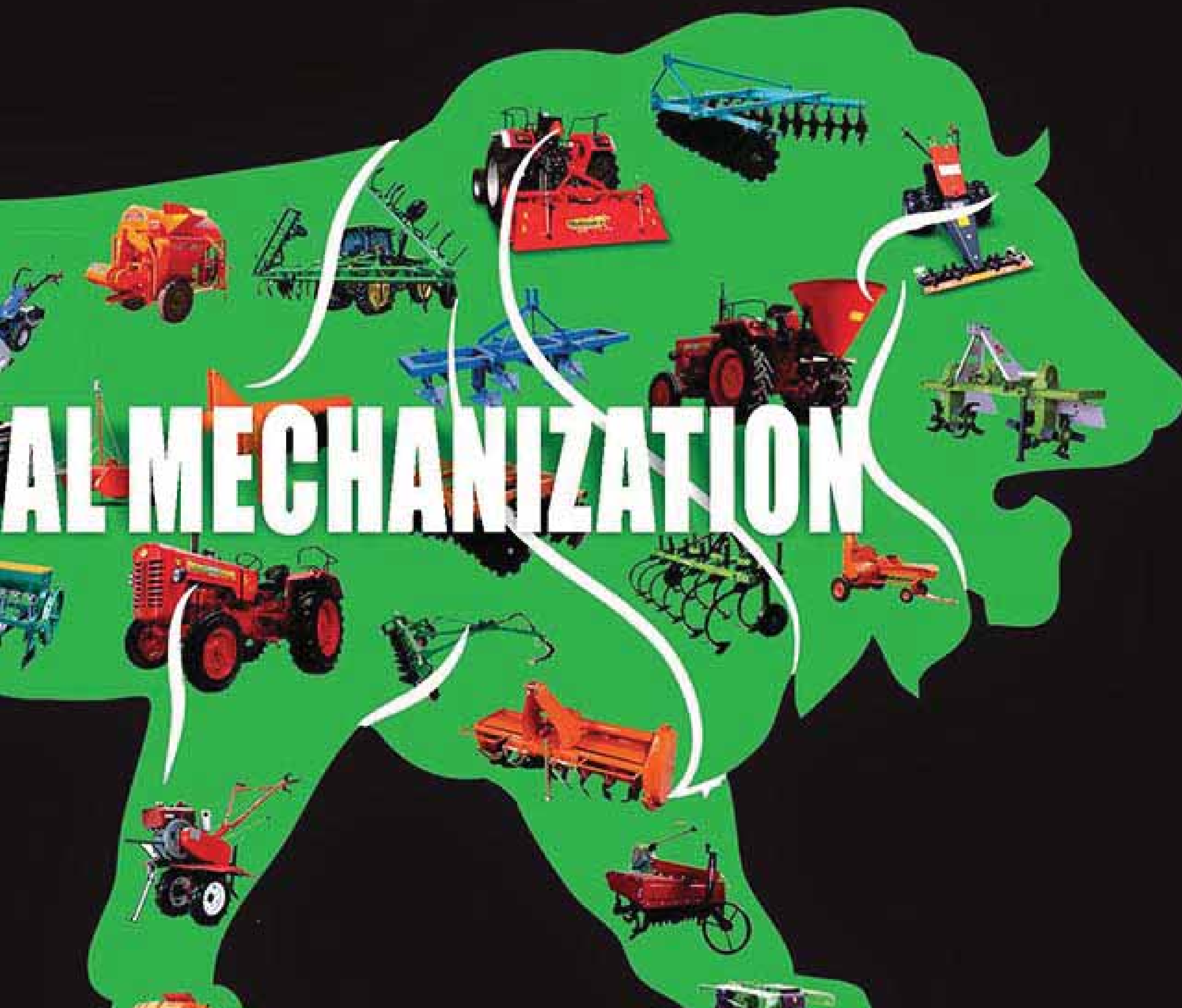
AGRICULTURAL MECHANIZATION

for MAKE IN INDIA

Design & Media Partner

DEGREE 360 SOLUTIONS PVT. LTD.


AGRICULTUR


AL MECHANIZATION

SOCIAL RESPONSIBILITY COUNCIL

Arun Khurana
Founder, SRC

This Coffee Table book on "Agri-Mechanization for Make In India" is an exercise undertaken by Social Responsibility Council (SRC) towards national well-being and development. An introductory overview of agricultural mechanization as a theme is given. The background information needed to support such an illustration is provided in the form of description of history of agriculture, introductory overview of Indian agriculture, including its scope, environmental impact and aspects related to agronomy and its relevance. The history of Indian agriculture and global developmentsin the field of agriculture relevant to India are presented with highlights on agriculture as art, science and business of crop production; branches of agriculture; and development of scientific agriculture. An overview India's agriculture sector has been described in detail, including its contribution to national income; its market size and investments involved; government initiatives; contribution of manpower to agriculture industry; interdependence between agriculture and industry; contribution to capital formation and purchasing power of people. The state of affairs of global agriculture mechanization is discussed with the help of select examples of advanced applications of global agricultural mechanization. The history of evolution of agricultural machinery is presented. The techniques and technologies involved in intensive farming is described with illustration. The future of Indian agriculture, particularly its role in global agriculture is discussed with highlights on government's vision for the agriculture sector and India's leadership in the agricultural revolution. An overviewfarm machinery and mechanization in India is made with focus on importance of farm mechanization and its penetration in India. The theme of agriculture mechanization in India is described with illustrations on its current status; level of mechanization and region wise development; market segmentation; competitive landscape; farm mechanism and farm machinery tradein India. Major sources of farm power in India is presented with focus on human power; animal power; mechanical power; electrical power; and wind power. The scope of farm mechanization in India is illustrated with highlights on social consideration to farm mechanization; major farm machinery used in India; drivers of growth in mechanization; research and development in agricultural mechanization; and benefits of farm mechanization. The need for farm mechanization in India is described with focus on growing population and productivity; rapid urbanization and farm labour; global benchmarking and lessons from other countries; concept of Custom Hiring Centres (CHCs) for farm equipment; innovations in agricultural mechanization; and public-private linkage. Indian Government's role in agricultural mechanization sector is summarized,withadditional highlights on National Food Security Mission (NFSM); Rashtriya Krishi Vikas Yojna (RKVY); Mission for Integrated Development of Horticulture (MIDH); and National Mission on Agricultural Extension and Technology (NMAET). ASWOT analysis of the agriculture equipment industry in India is presented with highlights on strengths; weaknesses; opportunities; threats; and challenges faced by the industry. The future focus areas have been identified, such as, rural mechanization and the factors affecting the historical spread of small-scale rural machinery in India vis-à-vis neighbouring countries, especially with regard to engines of up to 20 horsepower; and conservation agriculture and the technology involved. The future prospects of mechanization of agriculture is evaluated with focus on the impact of mechanization on productivity; advancement from simple mechanization to cyber-physical systems; and worksite and value chain productivity. The CTB also provides conclusion, bibliography and abbreviations. As an appendix, the highlights of Sub-Mission on Agricultural Mechanization Operational Guidelines (Twelfth Five Year Plan), Revised in 2016-17 is given herein. I am sure that that CTB would be of great help to comprehend all the associated aspects of agricultural mechanization in India and its contribution for "Make In India" initiative.

Dr. (Prof.) Prabhas Chandra Sinha
Chief Advisor,SRC

SOCIAL RESPONSIBILITY COUNCIL

We all know that the long journey of human civilization began 10,000 years ago when humans survived as hunters and gatherers. The advent of agriculture provided humans with access to a food surplus. This also led to the formation of permanent human settlements. Since then till three centuries ago, the development of human society was based on technical development of tools and facilities dedicated to this primary agriculture economy sector. Hence, it can be said that the "agricultural engineering", in its earliest forms, was the first of technological innovation. In fact, it may be considered the mother of all future innovations. Second major step took place in the Middle Age when significant improvements took place in the agricultural techniques and technologies. With the advent of the "Age of Enlightenment" in 1700 AD(which extends the application of the analytical methods and mark the beginning of modern science), agriculture sector experienced a major transformation in the farming system and the technical means that from "tools" evolve into "machines". Thus began the dramatic development of mechanization of the last three centuries that led to increase by more than a thousand times the productivity of human labour. This reduced employees in agriculture sector to 1-2% of active population in more industrialized countries.

Due to the change of the agriculture world, the agriculture industry had to change as well. The politics and the public opinion started demanding steps in the favor of human welfare, animal welfare, and environmental conservation. The development of integrated systems of powerful equipment allowed each agricultural worker to produce many tons of food or other agricultural materials. The complex systems of agricultural equipment performed their tasks reliably and efficiently, thereby reducing economic risks. Environmental sustainability could also be promoted by contemporary intensive farming systems. Precision agriculture technologies insure that the needed inputs are supplied to maximize production while minimizing negative environmental impacts. Other aspects of agricultural mechanization systems were also designed, manufactured, and managed to efficiently perform their needed tasks.

Today, agricultural mechanization is a crucial input to agricultural crop production, processing and transport. It has become very capital intensive, compared to other farming inputs. Therefore, agricultural mechanization also has repercussions on the efficiency of input use, including seeds; fertilizer; insecticide; pesticide; water; time; and labour. Agricultural mechanization has also become much more complex in its application, requiring not only correct use, but also a service infrastructure for custom hiring, maintenance and repair. For this reason, it has become much more essential to embrace the agricultural mechanization sector and raise its efficiency in the context of sustainable crop production intensification. One needs to constantly keep in mind the fact that whilst agricultural mechanization is indispensable for increased agricultural production, it can also have detrimental effects on the environmental sustainability of farming, particularly on soil compaction and erosion, tillage, chemical pollution, etc. Today, agricultural mechanization is also facing a twin challenge, one from producing ever increased food supplies for a growing population that is expected to rise to 10 billion in a few decades; and the other in protecting and preserving the environment. However, the main challenges for agricultural mechanization in India still remain in following terms:

- small land holdings (average size is only about 1 ha) and majority of the farmers have low investment capacity; and
- the use of sub-standard manufacturing technology producing poor quality products, performing poor quality work.

No doubt, the level of mechanization varies from crop to crop, even within the same country. Present low level of mechanization in many countries provides opportunities for growth by improved efficiency of utilization of machines available with farmers through custom hiring to neighbouring farmers and or through larger operational holdings. Future holds for lot of need-based improvements in India's agricultural mechanization sector.

SOCIAL RESPONSIBILITY COUNCIL

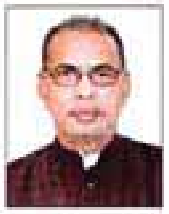
MAKE IN INDIA

Publisher	:	*Social Responsibility Council*
Writer, Editor & Researcher	:	*Baishnab Padhee*
Photo Co-ordinator	:	*Aamir Khan*
Design & Visualization	:	*Arvind Kumar Rastogi* *Desh Raj*
Marketing	:	*Kapil Kumar* *Mukesh Kumar*
Media Marketing	:	*Mahesh Mamgain* *Subodh Dabral*
Production	:	*Vipin Khurana* *Jitendar Gupta*

Published by Social Responsibility Council, 114, 1st Floor, Pratap Bhwan, 5, BSZ Marg, New Delhi-110002.

राधा मोहन सिंह
RADHA MOHAN SINGH

D.O. No. 2156 /AM



कृषि एवं किसान कल्याण मंत्री
भारत सरकार
MINISTER OF AGRICULTURE
& FARMERS WELFARE
GOVERNMENT OF INDIA

8th **September, 2016**

MESSAGE

I am happy to know that Social Responsibility Council (SRC) is coming up with a Coffee Table Book on "Agri-Mechanization for Make In India" in collaboration with the Department of Agriculture, Co-operation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare.

In congratulate our agricultural engineers and scientists who have contributed greatly for increasing the productivity of crops through mechanization. Undoubtedly, agricultural mechanization is essential for agricultural modernization. Also, its benefits need to be extended to all categories of farmers in each agro-climatic zones of the country. There is a need to transfer the latest technology to the farmers, so that their income may be doubled by way of reducing the cost of cultivation and increasing production. I request all the manufacturers to come forward for the commercialization of technology so that the appropriate technology may reach to the farmers to benefit them.

In addition, there is an urgent need for saving water in the agriculture sector, and the mantra for realizing this should be "Per drop, More crop". Four new Farm Machinery Training & Testing Institutes have been established, each one in Bihar, Gujarat, Maharashtra and Uttar Pradesh. Our government has taken multiple initiatives, by which the farmers of the country have benefited, especially by the Pradhan Mantri Gram Sinchayee Yojana; Solar Pumping Set System; Soil Health Cards; etc. We need to adopt those technologies in agriculture which can save water, and thereby sustain profitability. However, due to small land holding size in majority of the States in India, using compatible equipment has not been economically advantageous. We need to enable the Custom Hiring Centers of agricultural machinery to support farmers in this regard, on an urgent nation-wide basis.

I am convinced that this particular initiative by SRC would be of much help in propagating agricultural mechanization in India and provide sustainable solutions. I wish them all success in their efforts, in times to come.

Radha Mohan Singh

(Radha Mohan Singh)

Office : Room No. 120, Krishi Bhawan, New Delhi-110 001 Tel.: 23383370, 23782691 Fax : 23384129

परषोत्तम रूपाला
PARSHOTTAM RUPALA

कृषि एवं किसान कल्याण और
पंचायती राज राज्य मंत्री
भारत सरकार

**Minister of State For Agriculture & Farmers Welfare and Panchayati Raj
Government of India**

DO No.2(a)/MoS(AC & FW)/PR/2016/ 124

September 14, 2016

Message

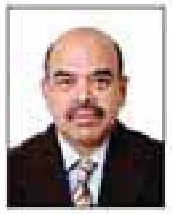
Farm mechanization is an important element of modernization of agriculture. Farm Productivity is positively correlated with the availability of farm power coupled with efficient farm implements and their judicious utilization. Agricultural mechanization not only enables efficient utilization of various inputs such as seeds, fertilizers, plant protection chemicals and water for irrigation but also it helps in poverty alleviation by making farming an attractive enterprise. The Department of Agriculture, Cooperation and Farmers Welfare is following multi-pronged strategy for promoting Farm Mechanization. The Department is promoting Farm Mechanization by making agricultural equipment available among farmers at cheaper rates. A level of 25-50% subsidy on procurement cost is made available under revised "Sub-Mission of Agricultural Mechanization (SMAM)" scheme for different categories of equipment. The subsidy on tractors and power tillers is available on the models approved by the department under institutional financing. Besides tractors and power tillers, combine harvesters are also available to the farmers as per approved pattern of subsidy. As an individual farmer may not be in a position to purchase high cost equipment on his own, Self Help Group of farmers (SHGs), user groups, cooperative societies of farmers etc. are also made eligible for assistance under the programme. As a result of different programmes implemented by the Government of India, the level of mechanization has been increasing steadily over the years. This is evident from the sale of tractors and power tillers, taken as indicator of the adoption of the mechanized means of farming.

It makes me very happy to know that Social Responsibility Council (SRC) is coming up with a Coffee Table Book on "Agri-Mechanization for Make in India" in collaboration with the Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare. I am sure that this particular initiative by SRC would be of much help in promoting agricultural mechanization in India. My best wishes are with them.

(Parshottam Rupala)

Room No. 322, 'A' Wing, Krishi Bhawan, Dr. Rajender Prasad Road, New Delhi-110001
Tel. : +91-11-23383975/76 Fax: +91-11-23383971, E-mail : p.rupala@sansad.nic.in

S.K. PATTANAYAK
SECRETARY



भारत सरकार
कृषि एवं किसान कल्याण मंत्रालय
कृषि, सहकारिता एवं किसान कल्याण विभाग
Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture, Cooperation
& Farmers Welfare

MESSAGE

Agriculture sector today faces formidable challenges in the form of shrinking land base, dwindling water resources, shortage of farm labour, increasing costs and uncertainties associated with volatility in international markets. These challenges need to be addressed on priority if we have to realize farm productivity. Appropriate intervention in mechanization of farming activities for labour and land efficiency in agriculture is a key element in this direction. It is learnt that some innovations like variable rate fertilizer applicator, check basin former, turmeric rhizomes planter, ultrasonic sensor based sprayer, unmanned autonomous vehicle for agriculture, etc., have been offered for commercialization to realize this objective.

I am glad to know that the Social Responsibility Council (SRC) is coming up with a Coffee Table Book titled "Agri-Mechanization for Make in India" in collaboration with this Department in the Union Ministry of Agriculture & Farmers Welfare. I am convinced that this book will create interest in furthering innovation in the process of developing, introducing and sustaining new technologies and applications in Indian farming system. The holistic and integrated perspective on the subject brought out in the book will also help provide an opportunity to all the stakeholders of agricultural mechanization for engaging each other in a mutually beneficial manner. I am sure that this initiative by SRC would be of much help in promotion of agricultural mechanization in India.

I compliment all those involved in bringing out this publication.

Sd/-
(S.K. Pattanayak)

Date: September 19, 2016

Office : Krishi Bhawan, New Delhi-110001, दूरभाष / Phone : 23382651, 23388444 फैक्स सं० / Fax No. : 23386004
E-mail : secy-agri@gov.in

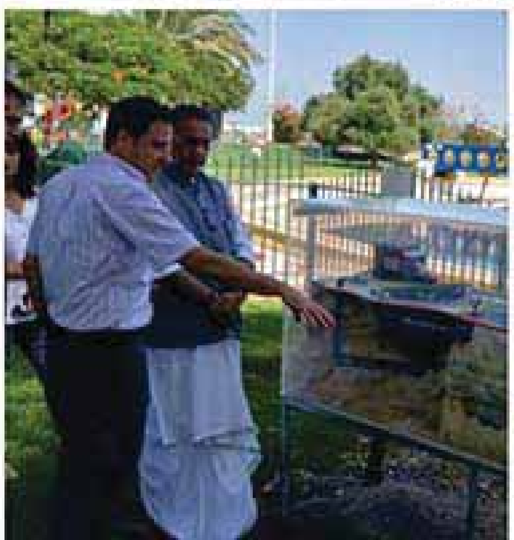
TABLE OF CONTENTS


BROWNS

India: A leading Global Player in the Field of Innovations in Agricultural Mechanization


श्री नरेन्द्र मोदी
PULSES: SECURING INDIA'S SELF-RELIANC
उत्पादन में आत्मनिर्भरता के लक्ष्य
Shri Radha Mohan Singh (Hon.Minister of Agriculture, Govt of India)
Shri Muralidhar Rao (National General Secretary, BJP)
Sh.Radha Mohan Singh
INDIA
AGRICULTURAL SUMMIT
AGRI@8%

India's Agriculture Sector: Embracing "Make In India" Vision to the Maximum



UNIT: 1

Introductory Overview of Agricultural Mechanization

Mechanization is defined as the art of using machineries to hasten production, accomplish task and reduce fatigue and human labour in order to produce better quality goods and services. Mechanization is useful and important as it takes place in almost every facet of human endeavour to meet required target and to boost efficiency. It speeds up the rate at which jobs are accomplished and are carried out in the nation's economy such as in banking, agriculture, building, construction, education etc.

- FARM MECHANIZATION: is technically equivalent to agricultural mechanization but refers to only those activities normally occurring inside the boundaries of the farm unit or at the farm unit level (example: village, community, co-operatives etc.).

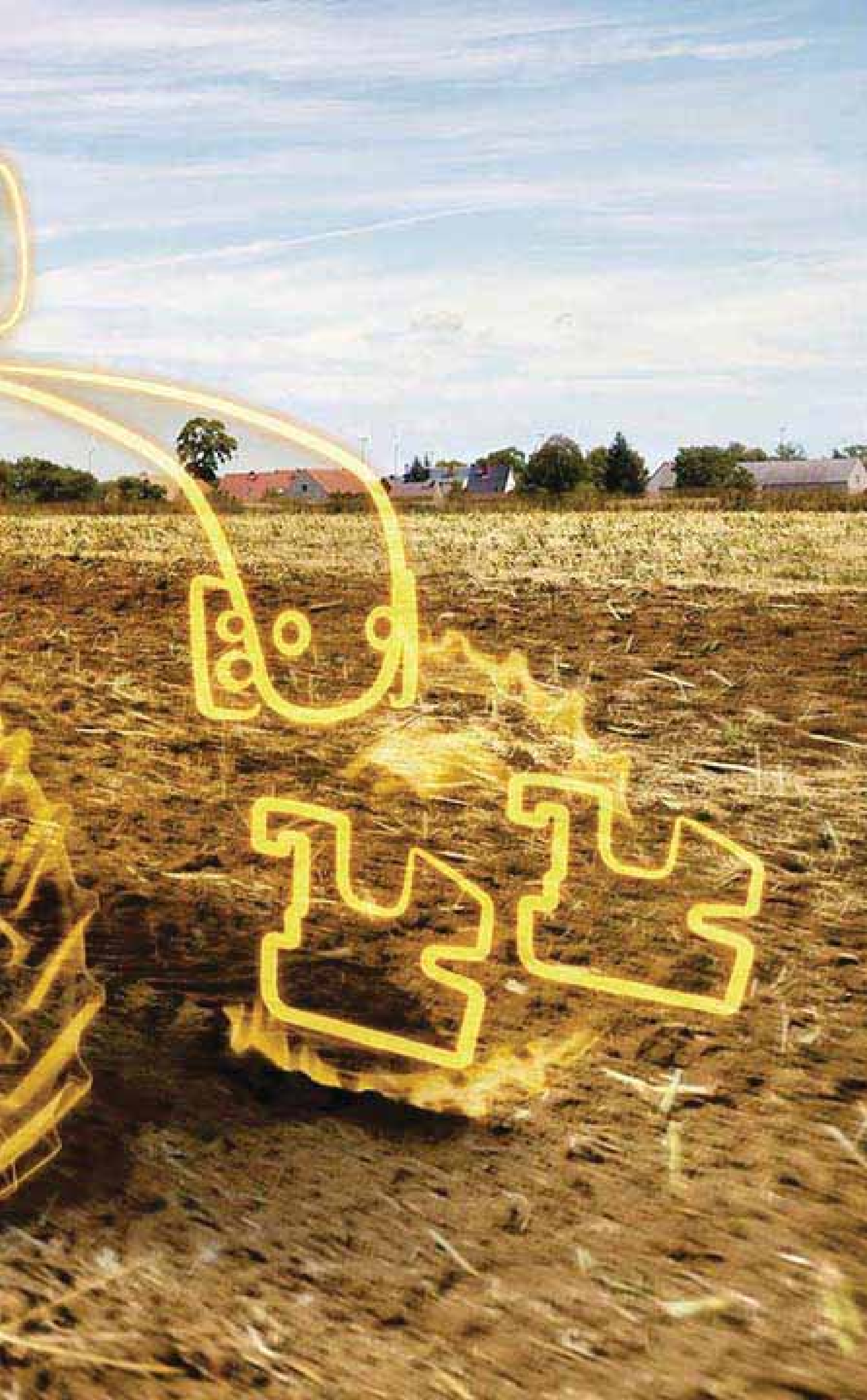
- TRACTORIZATION: refers to the application of any size tractor to activities associated with agriculture.

- MOTORIZATION: refers to the application of all types of mechanical motors or engines, regardless of energy source, to activities related to agriculture.

- AGRICULTURAL IMPLEMENTS: are devices attached to, pulled behind, pushed, or otherwise used with human, animal or mechanical power source to carry out an agricultural operation.

- AGRICULTURAL MACHINERY: is a general term used to describe tractors, combines, implements, machines and any other device more sophisticated than hand tools which are animal or mechanically powered.

- AGRICULTURAL EQUIPMENT: generally refers to stationary mechanical devices such as irrigation pump-set.

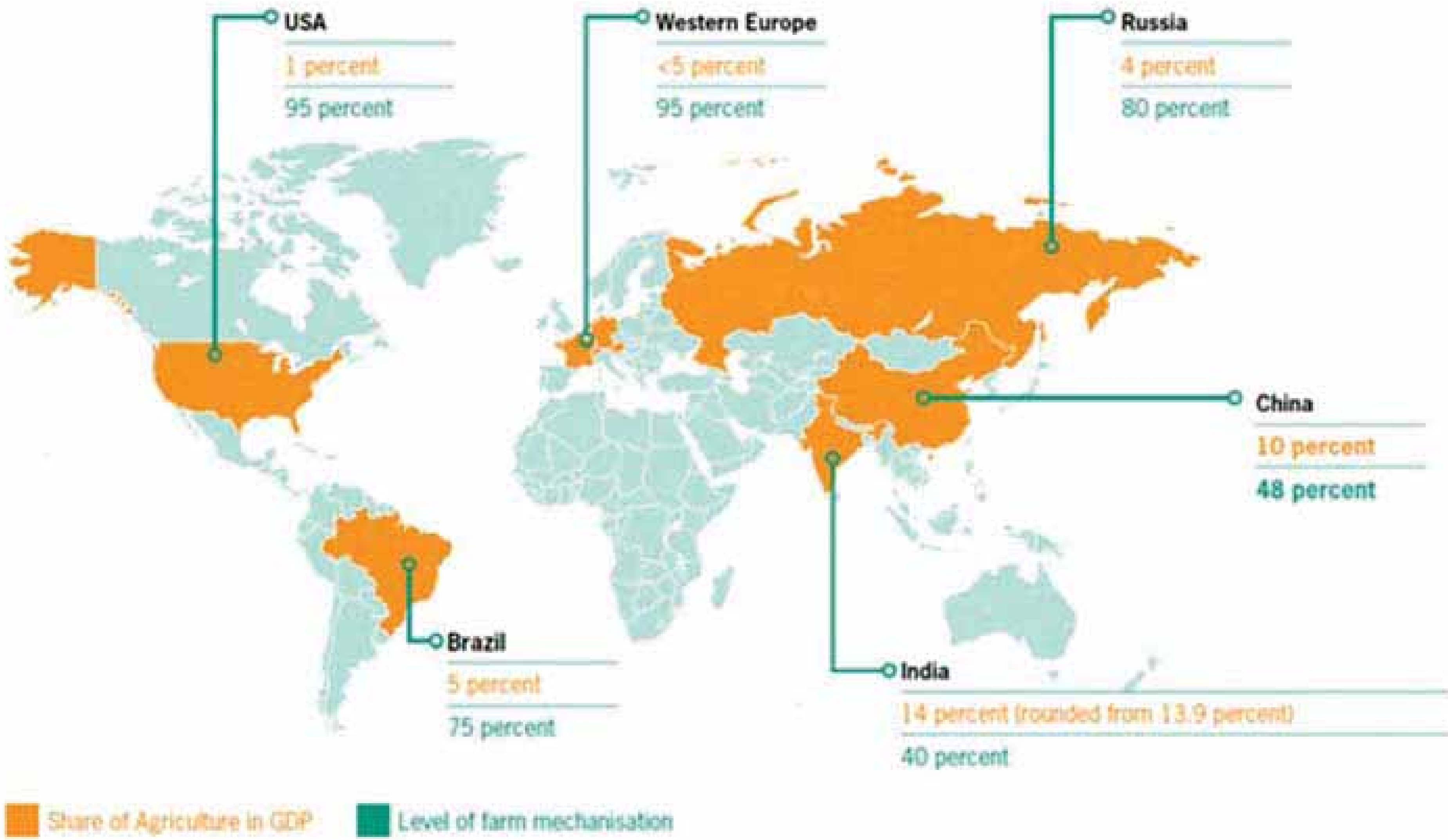


Agricultural Mechanization / Farm Mechanization refers to the development and use of machines that can take the place of human and animal power in agricultural processes. The mechanization of agriculture that took place during the 20th century led to major changes in how farmers plant, irrigate and harvest crops. Combines, tractors, harvesters and other machinery have enabled farmers to increase their production while relying less upon an extended labor force. In other words, agricultural mechanization is the process whereby equipments, machineries and implements are utilized to boost agricultural and food production. It is the application of machineries, equipments and implements in the day to day farm activities to increase marginal output in food production and poverty eradication. Agricultural mechanization reduces drudgery which hitherto makes it difficult for large scale food production and which has also been making it difficult for nations who have to meet their food requirements for the teeming population. In order to solve the problem of drudgery and other problems associated with food production, various measures has been introduced to combat these problems through mechanization.

Increase productivity through intensification, reduce post-harvest losses, increase added value and maintain the quality of farm product are the multiple objectives of farm mechanization. In addition to that multiple objectives, the ultimate goals of farm mechanization are also include increase of farm household welfare, and create employment opportunity in the rural area. All of these objectives may not be completed by a single strategy e.g. increasing the number of machinery use for farm production. It will include the long term strategy to re-energize rural development as a whole system, which enable farmers to adjust and improve their own capacity to adopt the suitable technology for their farm business efficiently. Farm mechanization is not only the use of physical machines like tractor, irrigation pump, thresher, or rice milling machinery, but it include the changes of farm culture, process of invention, innovation, adoption and commercialization of technology.

It is estimated that the global demand for agricultural equipment will reach nearly US$ 200 billion by 2018, with Asia contributing more than 60 percent to the total.

Global spotlight: Share of agriculture in GDP vs. level of mechanisation



Agricultural mechanization involves the design, manufacture, distribution, use and servicing of all types of agricultural tools, equipment and machines. It includes three main power sources: human, animal and mechanical with special emphasis on mechanical (tractive power).

It is quite true that the farmers of developing countries have the lowest earnings per capita because of the low yield per hectare they get from their land holdings. One of the few important means of increasing farm production per hectare is to mechanize it. Mechanization may have to be done at various levels. Broadly, it can be done in three different ways:

- By introducing the improved agricultural implements on small size holdings to be operated by bullocks
- By using the small tractors, tractor-drawn machines and power tillers on medium holdings to supplement existing sources.
- By using the large size tractors and machines on the remaining holdings to supplement animal power source.

As a matter of fact, the progress of the country should be mainly judged on the basis of degree of farm mechanization (production per worker and the horsepower under his command per unit area). Large amount of labour or draft power, which can be replaced through machines, provides a strong incentive to mechanize. From the energy application point of view, the Indian agriculture is in the transition from: Stage 1 (human power) and stage 2 (animal power) to Stage 3 and 4 (power tiller or four wheel tractor).

The major objectives associated with farm mechanization include the following:

- *·nhancement of timeliness and profitability in farm operations:* For the purpose of obtaining maximum returns or desirable results farm operations, most farm operation need to be timely (right on time). For example, a 3 – disc plough can successfully complete the work of over one hundred and twenty strong men in eight hours.
- *Provision of good finishes for manually unattainable farm operations:* Some farm operations are difficult or impossible in nature to carry out manually with good finishes such as machine. For example, the finishing desired in land clearing (it consist of stumping, root – raking and windrowing operations) is unachievable manually especially in a thickly forested areas.
- *Reduction of boredom and drudgery in farm operations:* Unlike mechanical workings, manual work from human power is boring, burdensome and constrained to sustain heavy duty jobs. Mechanization also helps to avert the negative effect of premature death of drudges due to undernourishment.
- *Reduction of labor requirements and enhancement of agricultural production through higher rates of work output:* The depletion of labor from the land or farm to other industries with higher demand for workers and higher wage rates marked the epoch – making advances in farm mechanization. Farm machines provide higher work output rates to sustain higher demand for increased agricultural production. The increased production engenders adequate food for the increasing populace as well as providing extra for export and development of agro – based industries.
- *Circumventing of the inherent problems of procurement and management of large forces:* For the avoidance of the listed problems, some farmers may prefer to mechanize their farm operations in some situations despite the fact that their net profit may be slightly reduced.

Agriculture mechanization benefits us as it helps agricultural areas to develop all kinds of agricultural produce and agricultural products evaluation process to fulfill objectives used with all kinds of energy sources, mechanical tools and equipment design, construction development, distribution, marketing, publishing, education, operation and use-related issues is included. Agricultural mechanization is a production technology. In some countries, different levels of mechanization and application development is. This difference can be monitored, especially in the agricultural business. In other words, mechanization, agricultural business in each business, depending on the technical and economic structure is being implemented at different levels. Major benefits of agricultural mechanization are the following:

- To enable the new technology in production applications.
- Production is dependent on natural conditions as possible to recover and to get more qualified products.
- Manufacturing operations in the most appropriate time to complete, without delay to avoid losses resulting product.
- Working conditions in rural areas more comfortable, attractive and safe to bring a case and agricultural workers to improve work efficiency.
- On the one hand, increase in agricultural products, on the other hand, developments in agricultural tools industry with the opening of new jobs to the area to allow.
- Human and animal agricultural operations cannot be achieved with power to machine power, and new areas for agriculture and managed to make up.

In sum, these are the various benefits of farm mechanization:

- Timeliness of operation
- Precision of operation
- Improvement of work environment
- Enhancement of safety
- Reduction of drudgery of labour
- Reduction of loss of crops and food products
- Increased productivity of land
- Increased economic return to farmers
- Improved dignity of farmers
- Progress and prosperity in rural areas

Farm mechanization is the application of engineering and technology in agricultural operations, to do a job in a better way to improve productivity. This includes development application and management of all mechanical aids for field production, water control, material handling, storing and processing. Mechanical aids include hand tools, animal drawn equipment, power tillers, tractors, engines, electric motors, processing and hauling equipment.

There is a good scope of farm mechanization in India due to the following factors:

- Improved irrigation facility in the country.
- Introduction of high yielding varieties of seeds.
- Introduction of high dose of fertilizers and pesticides for different crops.
- Introduction of new crops in different parts of the country.
- Multiple cropping system and intensive cultivation followed in different parts of the country.

Some other factors which are responsible to encourage farm mechanization are:

- Population of the country is increasing at the rate of about 2.2% per year. Steps have to be taken to arrange food and fibre for such large population by adopting intensive farming in the country. Intensive farming requires machines on the farm.
- In multiple cropping programme, where high yielding variety of seeds are used, all farm operations are required to be completed in limited time with economy and efficiency. This is possible with the help of mechanization.
- Farm mechanization removes drudgery of labour to a great extent. A farmer has to walk about 66 km on foot while ploughing 1 ha land once by bullocks with a country plough having 15 cm furrow width.
- A large number of females and children work on farm. So, with mechanization females can work at home and children go to school.
- The proper utilization of basic inputs like water, seeds and fertilizers will be possible with proper equipment.
- There are certain operations which are rather difficult to be performed by animal power or human labour such as:
  - I. Deep ploughing in case of deep rooted crops.
  - II. Killing the pernicious weeds by deep tillage operations.
  - III. Levelling of uneven land.
  - IV. Land reclamation.
  - V. Application of insecticides during epidemic seasons. These operations need heavy mechanical equipment.

The present status of farm mechanization is quite appreciating. We have:

- Improved manual tools.
- Improved animal drawn implements.
- Tractor operated implements.
- Custom hiring units on the farm.
- Other stationary equipments like threshers, irrigation pumps, sprayers, dusters etc.

There are various limitations in adopting farm mechanization:

- Small and fragmented land holdings.
- Less investing capacity of farmers.
- Agricultural labour is easily available.
- Adequate draught animals are available in the country.
- Lack of availability of suitable farm machines for different operations.
- Lack of repair and servicing facilities for machines.
- Lack of trained man power.
- Lack of co-ordination between research organization and manufacturers.
- High cost of machines.
- Inadequate quality control of machines.

Indian agriculture is plagued with many problems such as low productivity in rainfed areas, decline in soil fertility, receding water tables, change in ecology due to monoculture and indiscriminate use of resources, increasing environmental pollution, staggering losses of perishables (30-40 %), absence of scientific post-harvest infrastructures, inadequacy of energy for production and post-harvest agriculture, low exports, due to low quality and high cost of production, as well as non-conformance to global quality assurance and management norms. The WTO regime has created an urgency to bring about a paradigm shift in Indian agriculture and mind-sets of all concerned. Ecologically sustainable agriculture by adopting conservation farming together with diversification of agriculture in problem areas, greater private investment and setting up chains of agro-processing centres in the rural areas are the new focus of Indian Agriculture. The country has about 60 million tonnes of wheat and paddy in the central food reserve and to avoid further complications and wastage, urgent steps need to be undertaken to promote exports and provide food to nearly 40% of the population which does not have economic access to food, even though the county has plenty of it in the reserve.

In the sixties and early seventies debates were often held by the policy makers, economists, sociologists, engineers and all those concerned with agricultural modernization regarding relevance of agricultural mechanization in a labour abundant economy. Literature is replete with studies commissioned by the Planning Commission through National Council of Applied Economic Research (NCAER), SAU's and other bodies to find out the impact of agricultural mechanization on agricultural productivity, cropping intensity, labour employment and returns to the farmers. These studies conclusively proved that adoption of tractors & farm mechanization led to significant increase in cropping intensity, increase in production & productivity and reduction in the cost of production. For certain operations like harvesting, use of machines did displace the labour but taking into account direct labour on the farm, indirect labour employed for manufacturer, repair, maintenance and subsidiary labour, farm mechanization led to higher employment generation. Timeliness of operations, precision, better quality of operations, accurate placement, uniform distribution, reduction in losses, better quality of produce, reduced cost of production, reduction in drudgery to human beings and animals and enhancing the dignity of labour are the major advantages offered by farm mechanization. It is now agreed that introduction of tractors & machines has also helped to check migration of educated youth, skilled and unskilled man power from the rural to urban areas.

Notwithstanding the wide agro ecological diversity, variation in soil types, climate, precipitation, irrigation intensity, cropping systems, land topography and industrial infrastructure, India has done remarkably well in mechanization of Agriculture. We have evolved a unique model by way of selective mechanization wherein we have utilized both the animate and inanimate sources of farm power namely, human labour, draft animals, tractors, diesel engines and electric motors, The country's farmers presently employ over 205 million agricultural labourers, 63 million pairs of draft animals, 3.0 million four wheel tractors, 110000 power tillers and over 18 million irrigation pumps, One of the commonly used indicators to express the level of mechanization of agriculture in a state/country is the availability of farm power per unit area (kW/ha). For India, it stands at 1.12 kW/ha and that for the most mechanized state of Punjab, at 2.96 kW/ha, followed by 2.33 kW/ha for Haryana, 2 kW/ha for Tamil Nadu and 1.48 kW/ha for UP. Table below gives the power availability, irrigation intensity, cropping intensity and yield for different states in India, which clearly demonstrates that states with higher power availability per ha also have higher yields per hectare.

FAO publishes a Year Book each year which gives the number of tractors and harvesters per 1000 ha for all countries and continents. For India, the number of tractors available as of now is 14 tractors /1000 ha as against 82 tractors per 1000 ha for the state of Punjab. Indeed, Punjab occupies a place of pride in the development and introduction of farm mechanization technology in India. The beginning was made with the use of stationary power sources (engines and electric motors for pumps, tube wells and threshers) in the late fifties followed by mobile power sources like tractors and combines for a wide range of field operations from land preparation to crop harvesting. India's first power thresher was innovated in Punjab in 1957, so also the animal and tractor operated seed drills, potato planters and diggers, sunflower thresher, seed planters, sugarcane planter, strip till drill, high clearance sprayer, straw combine, various types of weeders, cleaners, graders & vegetable seed extracting machines. Mechanization of a crop or operation always begins from Punjab and spreads first to the adjoining states and later to every nook & corner of India. The role of Agricultural engineers, manufacturers & farmers in mechanizing agriculture is commendable

Table: Power availability, cropping intensity, percent irrigated area, fertilizer consumption and grain yield for different states in India

State	Annual rainfall (mm)	Irrigated area %	Power (kW/ha)	Fertilizer (kg/ha)	Cropping intensity	Grain equivalent yield (ton/ha)
Jammu & Kashmir	617	40	0.71	69.8	1.48	2.01
Himachal Pradesh	494	13.1	1.61	50.9	1.71	2.4
Punjab	555	93.7	2.96	299.5	1.8	5.26
Uttar Pradesh	837	64.7	1.48	150.6	1.49	3.58
Haryana	494	78.6	2.33	202.5	1.68	3.63
Rajasthan	421	29.3	0.53	39.2	1.2	0.93
Assam	1449	27.9	0.56	18.2	1.42	1.61
Bihar	1024	44.3	0.82	93.5	1.38	1.91
West Bengal	1355	24.7	1.21	158.9	1.65	3.11
Madhya Pradesh	1021	25.2	0.71	42.2	1.24	1.38
Gujrat	609	31.1	0.9	81.1	1.13	1.08
Orissa	1123	28.6	0.48	37.7	1.38	1.23
Maharashtra	920	13.4	0.78	76.6	1.24	1.28
Andhra Pradesh	594	40.8	1.18	158.9	1.21	1.83
Karnataka	802	24.9	0.8	90.2	1.15	1.58
Tamil Nadu	950	53.6	2	135.4	1.21	2.81
Kerala	1927	19.3	0.86	90.5	1.36	1.45
Total	880	38.3	1.02	97.6	1.32	1.96

One can better appreciate the Indian farm mechanization scenario by looking at the extent of mechanization of various crop production operations such as seed bed preparation, sowing & planting, weed & pest control harvesting, threshing & post-harvest operations. According to the estimates prepared by Ministry of Agriculture, tillage is mechanized to the extent of 37%, sowing and planting 63%, threshing 20%, irrigation 54%, plant protection 43% and harvesting 2%. Hence there is ample scope for further mechanization of Indian agriculture.

India is today the largest tractor producing nation of the world with an installed capacity of over 4.79 lakh tractors per year. As many as 2.2 to 2.5 lakh tractors are manufactured and sold in the country every year. Apart from 15 tractor manufacturing firms, there are about 3500 farm machinery manufacturers, over two dozen colleges and departments of agricultural engineering, one Central Institute of Agricultural Engineering at Bhopal, One Central Institute of Post-Harvest Engineering and Technology at Ludhiana and four Farm Machinery Training and Testing Institutes located in different parts of the country. All these agencies are engaged in R&D, testing and evaluation as well as commercialization of various types of equipment.

Following are some highlights of Agricultural Mechanization:

- Mechanisation helps in raising farm income by increasing productivity and limiting post-harvest losses
- The Government of India has released a new subsidy for the establishment of 988 Farm Machinery Banks during 2014-15 under Sub–Mission on Agricultural Mechanisation.
- Allocation of USD223 million has been made for the establishment of Farm Machinery Banks and distribution of farm machinery and tools to farmers in various states
- India is the largest manufacturer of tractors in the world, accounting for about one-third of global production
- The availability of farm power increased from 0.36 kilowatts per hectare in 1971 to 1.4 kilowatt per hectare in 2006, while the share of animated labour (that includes animal and human labour) to farm power dropped from 60 per cent to less than 14 per cent during this period
- The Government of India focuses on increasing its reach of farm mechanisation to the regions where availability of farm power is low and to small and marginal farmers
- Sale of tillers increased at a CAGR of 8.6 per cent to 48,000 units over FY07-15
- About 20 per cent of world's tractor production is carried out in India. Domestic tractor market contracted by 2.4 per cent YoY during the first five months of FY15, while export volumes grew by 16.9 per cent during the same period
- In FY14, domestic sales of tractors recorded 350,000 units annually while exports reached 60,000 units
- The government has set up a number of Farm Machinery Training and Testing Institutes to train farmers on the operation and maintenance of agricultural equipment
- DAC proposes to initiate National Mission on Agricultural Mechanisation (NMAM) to spread the benefits of mechanisation among all levels of farmers especially small and marginal ones

Agri/Farm Mechanism faces a lot of bottle-necks, some of them being:

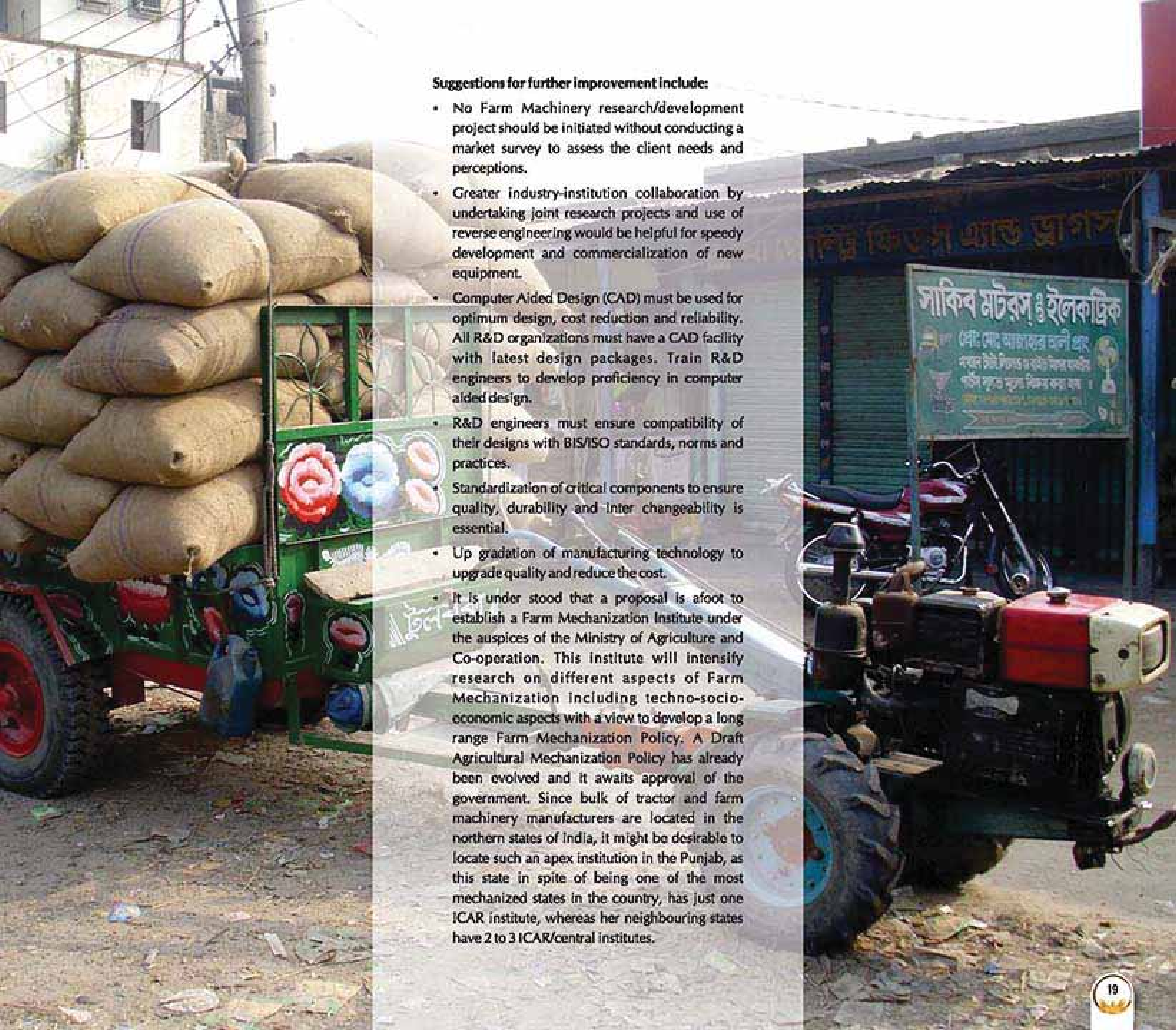
- Low annual use of tractors (only 500-600 hrs. /year against recommended 1000 hrs. /yr.).
- Non-availability of matching equipment.
- Cumbersome and energy inefficient designs.
- Poor reliability, frequent breakdowns and high repair and maintenance cost.
- Low quality.
- Use of ungraded materials, absence of inter-changeability of components.
- Inadequate R&D, Testing &Training facilities and inadequate Research funding.
- Inadequate user education.
- Lack of standardization.
- Non-availability of relevant literature like operator's manual, parts catalogues etc.

Priority areas for Indian agricultural mechanization include:

- Intensification of R & D to introduce energy efficient machines for relatively un-mechanized crops such as cotton, sugarcane, oil seeds, pulses, vegetables & fruits. Use reverse engineering and enforce close collaboration with farm machinery manufacturers. Assist Indian manufacturers in seeking collaboration with well-known foreign firms wherever desired engineering technologies are not available.
- Intensify research in the area of tractor design engineering due to their extensive use in Indian farming. India is now the largest tractor manufacturer in the world. TMA needs to be involved in this task.
- Farm machinery management research to find out use patterns, annual usage, breakdown frequencies, repair & maintenance cost and above all reliability.
- Research on safety, comfort, exhaust emissions and health hazards in the use of mechanical power sources and machines needs to be expedited.
- Emphasis be laid on conservation farming and energy saving/energy efficient tools and machines.
- An area of utmost importance from environmental point of view is proper utilization of about 540 million tonnes of crop residues available in India. Punjab alone has 10 million tonnes paddy straw which is mostly burnt. Burning needs to be banned. Appropriate machines for incorporation of residues into the soil, for mulching, for collection, handling & transport for briquetting, gasification, power generation, and/or allied usage is a priority area in the field of mechanization.
- Research on alternate engine /tractor fuels including bio-diesel, ethanol, producer gas need to be intensified.
- Greater emphasis be laid on design and manufacture of high capacity and precision machines for multi farm use, for corporate/contract farming as well as for custom hiring through Agri. Business Centres being promoted by Govt. of India for the benefit of rural youths.
- Equipment for post-harvest transport, bulk handling, cleaning grading drying milling packaging and storage are urgently required. These could be imported wherever non-existent. Next revolution in agriculture must be ushered in the area of efficient food processing & agro industries to transform the rural areas & utilize the surpluses. Mechanization packages will be crucial to ensure success of contract/corporate farming.
- Mandi mechanization with a view to introduce bulk handling of grains is an urgent need.
- Mechanization of hill-agriculture (20% total cultivated area), horticulture and floriculture, forage production and handling equipment, forestry mechanization, and efficient transport equipment are some important areas.
- Women-friendly tools and gadgets need to be

evolved by modifying the existing ones and designing the new tools to reduce drudgery to women workers.

- Mechanization of experimental plots is an important area requiring urgent attention. A mission mode project under the NATP has recently been sanctioned in this area.
- Nearly two-third of the cultivated area is rainfed. Farm power available in these areas is barely 0.3 kW/ha. Hence, mechanization of these areas should be under taken on priority basis. Large horse power tractors and suitable equipment for conservation of soil moisture, seed bed preparation, seeding/planting, harvesting etc., are required.
- The benefits of farm mechanization have so far remained confined to mainly wheat-based cropping systems. These need to be expanded to all cropping systems including horticulture.
- The present credit policy based on land mortgage is not favourable to small farmers to own mechanical prime movers. It excludes them from the benefits of farm mechanization and supplementing their incomes through hiring out their spare operational capacity. Instead of land mortgage, viability and hypothecation of the machinery may be better criteria.
- There being a positive relationship between power availability and agricultural productivity, power constraint should be removed. An annual growth rate of 4% over 1996 base in power supply to raise it from 1kW/ha to 2kW/ha by 2020 will be adequate to maintain a growth rate of 3% or more in agricultural production. This is based on "power-production relation" studies in India and abroad. The additional power will be supplied by tractors, power tillers, self-propelled machines, engines and electric motors.
- For precision farming, precision equipment for planting and plant protection are required.
- Increasing emphasis on Integrated Pest management and Organic farming would require use of efficient cultivation machinery for weeding and hoeing. Research in this area would be necessary to evolve optimum planting geometry and practices.
- Under the WTO regime with liberalization of markets foreign countries might take advantage of dumping their machinery in India, especially such equipment as sugar-cane harvesters, paddy transplanters, potato combines, cotton pickers, horticultural machinery, sprayers unless required equipment are expeditiously developed indigenously and have cost and quality competitiveness. Joint projects by R&D organizations and Indian firms would be desirable.



Suggestions for further improvement include:

- No Farm Machinery research/development project should be initiated without conducting a market survey to assess the client needs and perceptions.
- Greater industry-institution collaboration by undertaking joint research projects and use of reverse engineering would be helpful for speedy development and commercialization of new equipment.
- Computer Aided Design (CAD) must be used for optimum design, cost reduction and reliability. All R&D organizations must have a CAD facility with latest design packages. Train R&D engineers to develop proficiency in computer aided design.
- R&D engineers must ensure compatibility of their designs with BIS/ISO standards, norms and practices.
- Standardization of critical components to ensure quality, durability and inter changeability is essential.
- Up gradation of manufacturing technology to upgrade quality and reduce the cost.
- It is under stood that a proposal is afoot to establish a Farm Mechanization Institute under the auspices of the Ministry of Agriculture and Co-operation. This institute will intensify research on different aspects of Farm Mechanization including techno-socio-economic aspects with a view to develop a long range Farm Mechanization Policy. A Draft Agricultural Mechanization Policy has already been evolved and it awaits approval of the government. Since bulk of tractor and farm machinery manufacturers are located in the northern states of India, it might be desirable to locate such an apex institution in the Punjab, as this state in spite of being one of the most mechanized states in the country, has just one ICAR institute, whereas her neighbouring states have 2 to 3 ICAR/central institutes.

To sum up, it may be concluded that farm mechanization is a dynamic technology. It evolves with changes in agriculture in a region/state/country. With diversification of agriculture and adoption of frontier technologies with a view to have eco-friendly sustainable agriculture with globally competitive outputs, cutting edge farm mechanization technologies will need to be developed and introduced expeditiously. Reduction in cost and up-gradation of quality are the twin goals to be achieved. Farm mechanization technology being capital intensive, all farm mechanization R&D projects must be demand-driven and reverse engineering approach must be followed. Up-gradation of manufacturing capabilities, use of computer-aided design and close co-operation with industry through joint projects will help improve the quality and reliability of farm equipment. Conformance to global standards and norms will be necessary. In coming years, higher horse power tractors and high capacity machinery will be required to meet the needs of export oriented agriculture, corporate farming, custom hiring and multi-farm use. Human engineering applications to ensure safety, comfort and compatibility in respect of noise levels and exhaust emissions will be necessary. The future of farm mechanization in India is bright. However, we will have to intensify research funding and efforts in frontier areas.

The need to increase agricultural output of food and non-food products while at the same time improving labour productivity on-farm and in the value chains requires that agricultural manpower has access to tools, equipment and machinery to carry out farm operations efficiently from the view point of financial and capital costs as well as social and environmental costs. Farm power is determined by a combination of the source of energy (e.g. manual, or animal traction, or motorized) and the tools and equipment utilized to carry of farm operations. To improve and maintain competitiveness and keep consumer price as low as possible, cost of production must be kept low too. One major approach to achieving this is through mechanization and effective demand for agriculture products improve and greater volumes are needed to meet local and international demand for food, feed and industrial raw materials. As national economies in developing countries diversify and grow and offer greater economic opportunities in the non-agricultural sectors, there will be a continuing need to for labour-saving mechanical technologies to supplement decreasing labour supply and off-set rising labour costs. In situations where family labour remains the main source of farm power, there is also a need to reduce labour requirement and improve labour productivity as well as total output so that any child labour and drudgery can be eliminated and generating employment for hired labour becomes possible. Thus, agricultural mechanization that improves farm power and labour as well as total productivity is not an isolated activity but is part of a complex array of interactions between numerous stakeholders both on-farm as well as in supply chains. Besides agronomic, technical, environmental and social aspects there is also an important role played by institutional aspects such as agricultural education, extension and research. The rural infrastructure, domestic supply chains and service providers, and local manufacturers and world markets in equipment and machinery are all of vital importance. The demand for sustainable mechanization and services will continue to rise naturally with a growing population's demand for food, feed and biological industrial raw materials from agriculture, particularly in view of the rural out-migration taking place and as the younger generation responds to economic opportunities in the agricultural service sectors and non-agriculture sectors, and in the growing urban centres for employment and improved quality of life. Indeed there are already labour shortages at critical stages in the cropping calendar in many developing countries in Asia and increasingly in Africa. What is now increasingly important is to encourage sustainable private sector development that can offer farmers the right choice of technology at the right price to increase agricultural productivity to support rural economic development, contribute to local and national food security, reduce post-harvest losses and promote local manufacturing of equipment and machinery.

Sustainable Agricultural Mechanization

Farm mechanization is a crucial input for improving agricultural production. Without farm power and the appropriate tools, implements and machines that can support the production of marketable surpluses, farmers would struggle to emerge from subsistence farming. With increasing demands for food and agricultural products being exerted on the planet's natural capital base, the essential role for sustainable mechanization in production systems development becomes increasingly obvious.

Sustainable intensification necessarily means that the protection of natural resources and the production of ecosystem services go hand-in-hand with intensified production practices and methodologies. Thus, farm mechanization forms an integral plank in the implementation of sustainable crop production intensification approaches as elaborated in the FAO "Save and Grow" paradigm.

Conservation Agriculture (CA) is an approach to production system management that complies with the notions of sustainable production intensification. However, at field level and for up-scaling of rainfed or irrigated CA systems, including arable systems, crop-livestock mixed-farming systems, or horticulture systems, or plantation systems, the approach also requires specific mechanization measures to allow crops to be established with no or minimum soil disturbance, to enable the soil surface to be protected by organic cover for as long as possible, and to manage crop rotations and associations to enhance soil and agro-ecosystem health and to conserve and utilize crop nutrients from various soil horizons.

Hence sustainable intensification is the way of 'treating' soils and cropping systems for agricultural production that links sustainable mechanization and CA in a mutually interdependent and beneficial relationship.

Indian Scenario

No doubt, farm mechanization in India is a process of technological evolution and it is the advanced technological inputs that are required to improve the modernization process. It has a strategic role in the dynamic transformation from the subsistence to modern farm. The role include:

- Increase production and productivity,
- increase efficiency of the process and natural resource utilization,
- improve quality and added value of the agricultural produce, and
- increase income of the farm households.

Government of India could play an important role in facilitating the favourable role such as extension, training, and education for quality human resources development. It is also providing the contribution directly or indirectly to build the infrastructure (road, irrigation facilities, electrification etc.). In another words, farm mechanization should be developed based on the market mechanism. However, the government could also encourage the development process by enhancing mechanization development, but this policy must be designed without any distortion to the market mechanism to avoid so called premature mechanization. The future prospect of farm mechanization in India for the next five to ten years (2015- 2025) will still be dominated by small to medium mechanization. The following will be more prospective in the next mechanization development:

- Small and suitable field production machinery (precision planting, nursery industry, and efficient use of water) for small farm where the improvement of agricultural technology and system management will be strongly needed. Post-harvest mechanization for processing of agricultural product will be strongly needed in the rural industrial process and it will more rapidly adopted by the farmers since the nature of its contribution to the beneficiary is more significant than pre harvest mechanization.
- Renewable Energy Technology which will strongly emerge that related to Clean Development Mechanism (CDM).

As a source of livelihood, agriculture (including forestry and fishing) remains the largest sector of Indian Economy. While its output share fell from 28.3% in 1993-94 to 14.4% in 2011- 12, employment share declined from 64.8% to 48.9% over the same period. Therefore, almost half of the workforce in India still remains dependent on agriculture. Given the low share of this workforce in the GDP, on average, it earns much lower income poorer than its counterpart in industry and services. Therefore, progress in agriculture has a bearing on the fate of the largest proportion of the low income population in India. There are five important aspects of agriculture that need immediate attention to bring economic advantages to millions of farm families. First, output per hectare, which is a common measure of agricultural productivity, remains low for many crops when compared to many other countries. There are also large regional variations within the country. Reasons include low and faulty input uses, poor access to modern technology and no real technological breakthrough in recent times. Second, on average, farmers do not realize remunerative prices due to limited reach of the minimum support prices (MSP) and an agricultural marketing system that delivers only a small fraction of the final price to the actual farmer. Third, the farm size of the majority of the household has declined to unviable levels inducing farmers to leave land and look for better job opportunities elsewhere. Because land leasing laws make it risky to lease land, increasingly, productive land is being left uncultivated. Changes in the land leasing laws may bring consolidation of land holding at operational level and attract better investment along with access to credit and relief to tenants. Fourth, relief measures in the event of natural disasters are inadequate and suffer from procedural inefficiencies and delays. The risk adaptation measures are poorly executed and have not worked effectively. This situation needs to be rectified with at least minimum quick relief to farmers for crop loss in case of natural calamities. Finally the potential of the eastern region needs to be harnessed with suitable interventions. This region is unique for its suitability to the production of certain commodities. However, taking advantage of this potential would require institutional support and investment in technological innovations.

Agriculture in India is unique in its characteristics, where over 250 different crops are cultivated in its varied agro-climatic regions, unlike 25 to 30 crops grown III many of the developed nations of the world. Moreover, the use of various sources of power from the humble arm of the farmer to the mightiest of tractors is ubiquitous. India is the largest producer of tractors in the world. The quantum of research outlay for the farming sector is a meagre 0.86 % of the GDP as against 2-3 % in the developed world. In spite of this disparity, India has emerged as a net exporter of food grains and continues to forge ahead in the adoption and indigenisation of many of the advanced technologies developed elsewhere in the world.

In 1951, when the country was in its formative years after centuries of colonial rule, there were only 8635 tractors in use and all of them were imported. Production of tractors commenced during 1961-62, turning out 880 of them. This figure has peaked to over 262,000 in 1999-2000. The sale of tractors in 2003-2004 was 172,000. The quantum of power available for the farming sector rose from 45.29 million kW in 1971-1972 to over 170 million kW in 2000-2001. Correspondingly, power intensity on the Indian farm increased from 0.2 kW/ha to 1.30 kW/ha on the basis of net-cropped area. The state of Punjab has the highest average farm-power intensity of 3.5 kW/ha and also has the highest productivity levels.

During the same period, contribution of animate power reduced from 60% of the total farm power to less than 17% and mechanical and electrical power sources increased from 40% to over 83%. It is also seen that the adoption of mechanical and electrical power was higher for stationary applications than for traction required for field operations. Power for traction (tractors and power tillers) increased from 8.46% to 32.85%, indicating that more and more power-operated equipment were coming into use. Human power continues to be a significant component for digging, clod breaking, sowing, interculture, harvesting, threshing, cleaning, and grading for which traditional tools and implements have evolved over time in different parts of the country. The small and marginal farmers rely on draught animals for field operations, transport and agro-processing. The extent of area under the command of draught animals is about 57%.

The need to achieve timeliness of field operations and effective utilisation of inputs has resulted in the development of appropriate machinery, which also reduce drudgery. Traditional tools and implements such as bullock-operated country plough, and bakhar for tillage, dufan or tifan, enatigoru and funnel and tube-attachment on country ploughs as sowing devices; sickles, khurpi, spades and a/pad thresher for harvesting, digging and threshing; and swing basket, Persian wheel (rahat) and cradle pump for irrigation, etc. have been very popular in India. Use of electric or diesel engine-operated irrigation pumps, animal and tractor-operated cultivator and disc harrow for seed-bed preparation; seed drill or seed-cum-fertilizer drill and planter for line sowing with fertilizer application; and mechanical power thresher and combine harvesters has also increased. Farmers have also adopted sprinkler-and drip-irrigation systems in commercial crops.

Sun drying, winnowing, paddy hulling, pulse milling, oil expelling, wheat milling, pickle making, gur and khandsari, ghee and khoa making etc. are the major processing activities undertaken by the farmers. The traditional processing equipment used by the farmers include supa, chalni, chakiya, fanta, silbatta, okhli, mathani, puffing pan, mini oil ghanis/kolhus, rice hullers and flour chakkis etc. High capacity modem machines introduced in urban and suburban areas for processing of agricultural produce have helped in increasing the income of the processors.

Use of wind and solar energy for winnowing and drying have been in vogue from times immemorial. India receives about 5xlO15 kWh/year solar energy, which can profitably be utilised for over 200 days in a year. The availability of solar photovoltaic devices has encouraged their use for water pumping and lighting. Several designs of cookers and water heaters are also available. Cooking needs of the villages are mostly met by the burning of biomass. Anaerobic fermentation of animal excreta for the generation of methane has attained considerable attention and several designs of biogas plants are in use. Biomass can also be gasified to obtain a combustible gas mixture mainly consisting of carbon monoxide and hydrogen in specially designed apparatus. This gas can be utilised for thermal applications and also for running engines. Cellulose based waste and non-edible oils of plant origin can be converted by bio-chemical processes to alcohol and esters for use in internal combustion engines to provide motive power and reduce the dependence on fossil fuels.

The manufacture of agricultural machinery in the country is carried out by village artisans, tiny units, small- scale industries and the State Agro-Industrial Development Corporations. Production of tractors, motors, engines and process equipment is the domain of the organised sector. The traditional artisans and small-scale industries rely upon own experience; user's feedback and government owned research and development institutions for technological support and operate from their backyards or on road side establishments without regular utility services. Medium and large-scale industries operate in their own premises with sound infrastructure, usually forming a part of an industrial estate, well-established manufacturing and marketing facilities and employ skilled manpower. Diesel engines, electric motors, irrigation pumps, sprayers and dusters, land development machinery, tractors, spare parts, power tillers, post-harvest and processing machinery and dairy equipment are produced in this sector. They have professional marketing network of dealers and provide effective after sales service. They also have in-house research and development facilities or have joint ventures with advanced countries for technology upgradation. India is recognized, the world over, as a leader in the manufacture of agricultural equipment and machinery such as combine harvesters, plant protection equipment, drip irrigation and micro-sprinkler. Sizeable quantities of farm implements are exported to Africa, Middle East, Asia, South America and other countries.


Innovations in Agricultural Mechanization
EICHER
किसान

Farm mechanization automates the agricultural process by utilizing the agricultural machinery with the aim to increase the productivity and profitability of farm workers. This mechanized farming technique helps the farmers to gain accuracy in farm operations, delivers precision in metering and placement of inputs, lowers the available input losses, enhances the utilization efficiency of expensive inputs such as seed, chemical, fertilizer, irrigation, and water, and reduces the unit cost of the total produce. Farm mechanization also aids in the conservation of the agricultural produce and by-products from quantitative and qualitative damages, enables the establishment of agro-processing enterprises for additional income, and employment generation from farm produce.

Views on Agri-Mechanization

by

Shri Ashwani Kumar

Joint Secretary to Government of India

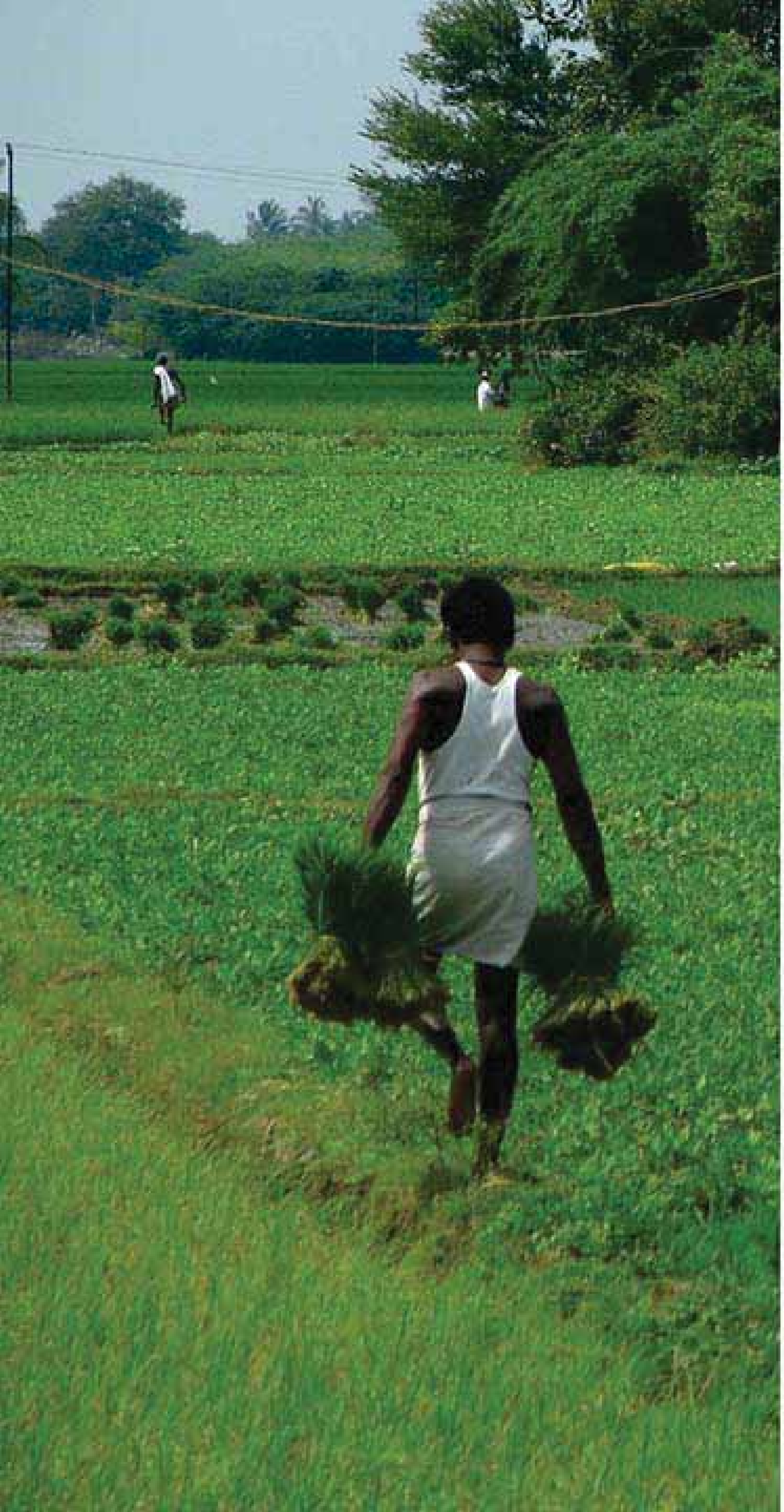
Mechanization refers to improved tool and implement of machinery that supplement and substitute human labour, enhances worker's output, avoids drudgery and stresses, etc. The mechanization of farm would help farmers in following ways:-

- reducing the input costs of sowing seeds and planting crops saplings in fields significantly
- reducing the dependence of farmers on labour and reduce their exposure to the risk of fluctuating labor costs.
- quick and timely plantation of crops in the fields and reaping them at the end of the crop season which would further help in timely selling of farm produces in the market or to FCI at proper price.
- would also help in efficient addition or spray of fertilizers and pesticides in appropriate amounts so that each portion of the field receive the proper amount needed .
- · farming in developed countries is highly mechanized and that's why farm outputs are high there. Implementation of these techniques in developing countries also would increase productivity significantly, reducing the burden of farmers, apart from increased income.
- The global farm mechanization market is largely dependent on agricultural land and farm output.

Global agricultural production affects the market substantially as it grows in tandem with the demand for food. However, in various phases, the global agricultural production has slowed down in recent years as the demand for agricultural products has decreased. Recent environmental changes are also significantly affecting global agricultural production. An overview perspective on global agricultural mechanization today can be presented as followed:

- Investments in small machinery and equipment (e.g., GPS technology) have resulted in large savings to farmers.
- Technologies such as the mechanical tomato harvester require very little hand labor, while crops such as lettuce need both mechanical harvesters and hand-labor harvesting crews.
- Not all mechanical innovations have been successful. For example, because of plant diseases such as citrus greening, sorting problems have arisen that have caused the demand for orange mechanical harvesters to decrease.

- Many innovations have occurred through investment by the private sector; one of the exceptions is the mechanical tomato harvester, which was developed with both private and public funds.
- Due to data confidentiality, it is often difficult to estimate the rates of return to investment in agricultural mechanization by the private sector.
- Even though many of the agricultural technologies are developed by US manufacturers, they are used worldwide, especially in high-income countries. Examples include the adoption of the cotton harvester in Israel and Turkey.
- A given mechanical harvester, with minimal adaptations, can be used to harvest many different grains and oilseeds (e.g., the same harvester can be used to harvest both wheat and canola). Because of the huge acreage seeded to these crops, machinery manufacturers can capitalize on economies of scale in any given line of machinery production. This is in contrast to the specialized nature of citrus harvesting, where economies of scale are limited due to the relatively small acreage on which citrus is grown.
- In many cases, it is not profitable or feasible for small farms to adopt large-scale agricultural technologies. In Russia and Ukraine, for example, small, labor-intensive farms operate alongside large, highly capital-intensive farms.
- The advent of small machinery and equipment technologies—such as hydraulics—has had a profound effect on agriculture. For example, this has enabled individual farmers to engage in several enterprises such as grains and livestock on a large-scale basis.
- It is common for new mechanical technologies to be coupled with new crop varieties (e.g., tomatoes, rice, and sugarcane). For example, the commercialization of high-yielding sugarcane varieties was possible because of the development and adoption of the mechanical sugarcane harvester that was capable of dealing with lodging associated with the new varieties. Therefore, the payoff to R&D in varietal development may be understated if it does not also include the benefits associated with mechanical harvesting.
- One cannot over-emphasize the labor component of mechanization. The adoption of the mechanical harvester resulted in a situation where the compensation principle was met, but not the Pareto principle, since compensation was not paid to displaced workers.
- Agricultural mechanization has resulted in large, concentrated feeding operations. With this type of animal feeding comes the debate over the violation of animal rights.
- Agricultural laborers, including workers in packing houses, often receive low wages.
- Growing adoption of tractors using alternative fuels will be a key trend for market growth. Fuel and tractor technologies have evolved over the years, and tractors now utilize liquefied natural gas, compressed natural gas, kerosene, vegetable oil, diesel, and propane. Due to the rise in the price of conventional fuels and rising concerns over environmental pollution, farmers are shifting to alternative fuels to power farm machinery. Although bio-diesel tractors are expensive as bio-fuels are high priced, farmers are increasingly preferring them as they provide lower operating costs due to longer life span of fuel engines and low maintenance. Vendors are extensively investing in R&D to manufacture tractors that can run on alternative fuels. The growing demand-supply gap in agricultural sector will be a key driver for market growth. Population growth is one of the major drivers of the



food demand in India. The population of India has increased from 930 million in 1996 to about 1.29 billion in 2015. The real value of agri-food demand in India will rise by 136% in 2009-2050. The demand for food has increased with the increase in population. However, the area of arable land has not increased in proportion to the rise in the demand for food. So, farmers are trying to increase efficiency and accelerate production by adopting advanced agricultural machinery and efficient farm cultivation techniques to meet the increased demand for food.

- There are two most crucial challenges that Indian agriculture will face in the coming years. If the shrinking resources of land and water are one, the other more serious concern is the availability of human resources. The 2011 Census points to another important trend. The movement of labour away from agriculture has gathered momentum in recent decades, although the share of workers living off the land still remains substantial at 54.6 per cent of the work force. The result that has attracted the most attention is that the farmer population has shrunk by nine million between 2001 and 2011. Another interesting trend highlighted by the Census is the steady rise in the number of agricultural labourers, who outnumber cultivators in 2011. This may be reflective of the fact that agricultural growth has been sluggish, although overall GDP growth has been robust at 7.5 per cent per annum. Owing to the pressure of population, the average size of land holding is getting even more fragmented over time.
- Till recently, experts believed that agriculture needs infusion of technologies, including mechanization, as there is scarcity of labour to undertake activities such as weeding in corn cultivation or manual transplantation in rice cultivation. The future of agriculture is dependent on penetration of scale-neutral technologies. The trend has already begun in some ways, with those who remain in farming turning to newer methods of optimizing the output on their farms, including adopting newer technologies to save cost and time. The use of tractors and tillers increasing five-fold in the last four decades is a testimony to this fact. According to the Department of Agriculture, the share of agriculture workers and draught animals (farm power sources in agriculture) has come down from 63.5 per cent in 1971-72 to 13.67 per cent in 2009-10, whereas the share of tractors, power tillers, and motors has gone up from 36.51 per cent to 86.33 per cent during the same period. The increasing cost of agriculture labour and upkeep of draught animals has also partly resulted in the greater adoption of tractors for farm operations. With newer farm techniques such as zero-tillage, raised-bed planting, precision farming, drip or sprinkler irrigation, the dependence on farm mechanization has increased. Although India is the largest manufacturer of tractors in the world, accounting for one-third of the global production, farm mechanization in India is still at a nascent stage, with the average farm power availability in the country lower than in countries such as Korea, Japan and the US. The Ministry of Agriculture is giving a major thrust to farm mechanization through its various schemes. A dedicated Sub-Mission on Agricultural Mechanization has been proposed for the Twelfth Plan, which includes custom-hiring facilities for agricultural machinery as one of its major components. Its focus is on increasing the reach of farm mechanization to small and marginal farmers and to the regions where availability of farm power is low. In order to attain the projected demand of 280 MT of food grains by 2020-21, farm power availability in the country has to be scaled up to at least 2.0 Kw/ha by the end of the Twelfth Plan. For achieving this, farm mechanization has to be given primacy. It is now well recognized that increase in agricultural production would have to come mainly from enhancement in farm productivity in the existing cultivated area. To meet future global grain demand, FAO estimates suggest that about 90 per cent of crop production growth is expected to come from higher yields, but land available

for farming will also have to expand by approximately 120 million hectares in developing countries. We can only grow more food from less land, using fewer resources, by providing farmers with the innovation and the knowledge to use natural resources more efficiently.

- The government is indeed coming up with innovative schemes to increase farm mechanization. It would also help if it could come up with good public-private partnership (PPP) models that would bring more private players into the fray with the latest in farm mechanization. Private players also have the fully integrated 'tool box' — from genetics to various aspects of chemistry — to tackle the various productivity challenges.
- Currently in agriculture sector of India, the production costs are rapidly increasing while eroding the profit margin of farmers. Hence there is a need of farm mechanization to reduce costs, enhance productivity and efficiency. The farm mechanization market in India to grow at a CAGR of 7.53% during the period 2016-2020. The market is divided into the following segments based on product, such as, Harvester; Laser Land Leveler; Power Tiller; Rice Transplanter; Tractor; etc.
- Today, as far as challenges in agricultural mechanization in India are concerned, attention is urgently needed on the following.
- Land holding is going down. So, requirement of efficient but less costly agricultural tools and equipment suitable for small farmers will continue to exist – whether owned or on hire.
- Higher economic efficiency of scale of operation may compel farmers for co-operative / contract farming. High capacity but precision equipment are needed for irrigated and dry land conditions. Planters for vegetable seeds and transplanters for vegetable nursery are of significance.
- Plant protection equipment – precision applicators to minimize excess application of pesticide to plants for good environment and soil health.
- The area under upland rice is expected to increase where rainfall is decreasing. Thus a need for implement set-up.
- Commodity specific mechanization package development.
- The fact remains that even today, there is no separate National Policy on Agricultural Mechanization in India. However, this aspect is covered under the agriculture policy of the National government which promotes agricultural mechanization with the following goals in mind:
- Agricultural mechanization should lead to a sustainable increase in yields and cropping intensity with the objective of meeting the planned growth rate in agricultural production and maintaining it.
- The income of agricultural workers should rise at a satisfactory rate so that the disparity between urban and rural incomes is contained and they get opportunity to lead a dignified life.
- The benefits of agricultural mechanization should apply to all types of farmers including small and marginal ones in different regions of the country, particularly rain fed areas.
- Agricultural mechanization should create a worker friendly environment especially for women workers by lessening hard labour, health hazards and improve safety in production operations.
- Agricultural mechanization should lead to a reduced cost of production agricultural thereby increase the income of farmers and impart a price advantage while competing for export contracts in the international market.
- In sum, the "Agricultural Mechanization" industry in India is expected to grow at a

rapid pace owing to the government efforts to bridge the supply and demand gap of agriculture through R & D and technology efforts in next five year plan (2013-2017). Shrinking farm holdings also demands the need for mechanization so that the agricultural yield can be maximized with optimal efforts through mechanization. Agricultural equipment sector in India has been witnessing robust demand and stands to gain maximum due to the need to use technologically advanced equipment in the farms in the future. Key growth drivers for Indian agricultural equipment industry include:

- 100 percent Foreign Direct Investment allowance in the Space
- Increase in Investment for R & D.
- Funding through World Bank, Indian Public and Private Entities
- Improved availability of credit to the farmers
- Shortage of skilled labor supply
- Government subsidies on farming equipment
- Government has thrust on agricultural mechanization to increase productivity and provides farm machinery at subsidized rates to encourage farmers to use agriculture machinery for operations. Some of the measures which Government has taken to support mechanization are listed below:
- Bharat Nirman and Flagship Programmes to support rural infrastructure through increasing rural water supply, irrigation, rural housing, rural electrification, rural telecommunication, etc.
- Minimum Support Price (MSP) to support farmers in selling their produce and minimize risk
- Subsidy on agriculture machinery so that farmers could afford machinery and lower their total cost of ownership
- Rural Infrastructure Development Fund (RIDF) to finance rural infrastructure through of channelizing of funds through banks.
- Strategies and programmes have been directed towards replacement of traditional and inefficient implements by improved ones, enabling the farmers to own tractors, power tillers, harvesters and other machines, availability of custom hire services, support services of human resource development, testing, evaluation and research & development. A huge industrial base for manufacturing of the agricultural machines has also been developed. Introduction of technologically advanced equipments through extension and demonstration besides institutional credit has also been taken up. Equipments for resource conservation have also been adopted by the farmers. Under various government sponsored schemes like Macro Management of Agriculture, Technology Mission for Oilseeds, Pulses and Maize, Technology Mission on Horticulture, Technology Mission on Cotton and National Food Security Mission, financial assistance is provided to the farmers for the purchase of identified agricultural implements and machines.
- I am so happy to know that Social Responsibility Council (SRC) is coming up with a Coffee Table Book (CTB) on "Agri-Mechanization for Make In India" in collaboration with the Department of Agriculture, Co-operation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare. I believe that with the publication of this CTB, this vital sector of our economy will get a definite push. I wish SRC the best for this new effort and their many more similar proactive initiatives in near future.

Rajesh Jejurikar
President & Chief Executive
Farm Equipment & Two Wheelers
Mahindra & Mahindra Ltd.

MODERNIZING AGRI MECHANIZATION

The 'Make in India' initiative by the Government of India is a breath of fresh air for India Inc. The world is now looking at India with greater fervor and enthusiasm as an investment destination of choice – across industries. We at Mahindra, have always had a deep rooted connection with the nation's progress by creating technology driven products that enable its customers to Rise. The 'Make in India' initiative validates our long standing belief in growing the 'Made in India' brand globally.

These are fruitful times for the Indian farm equipment industry, estimated at approximately USD 6.5 billion. In India, tractor penetration has increased from one per 150 hectares to one per 30 hectares and the level of mechanization has increased to 40-45 percent. Tractors account for most of the farm mechanization in India. Our country is also the largest tractor market in the world. The future looks positive with an estimated growth of over 10 percent CAGR in 2013-18. Farmers are increasingly investing in high-end equipment to improve farm productivity, labour efficiency, quality of cultivation and to reduce post-harvest losses.

The Government's focus on agri & rural development is one more step towards farm prosperity. The 2016-17 budget's increased focus on Agriculture by 44%, the target of "doubling the agri income by 2022", interventions like strengthening agri infrastructure (irrigation) and creating platforms to sell produce will drastically boost the farming community and improve the entire farming cycle. The future of the Farm Mechanization industry in India will depend on the role of OEMs and the Government in ensuring affordable & accessible technology to the farmers.

Mahindra's journey in the Indian tractor industry began in the early 1960s and our achievements till date are truly a testament to the 'Make in India' dream. Since inception, we have been enabling FarmTech prosperity through technology led innovation and quality driven excellence. This has given us the impetus to become the World's No. 1 tractor brand by volumes, and garner a formidable global presence across 40 countries in 6 continents. We have consolidated our leadership position in India for over 3 decades with a market share of 40.9% and take pride in being the only tractor company to win the Deming prize and Japan Quality Medal. Strengthening the manufacturing eco-system and skill excellence is core to 'Make in India' and we have partnered with our suppliers to enhance capabilities and establish Zero defect processes. Through our internal skill development initiatives like dexterity schools and skill excellence programs, we aspire to raise Mahindra's manufacturing skills to global levels and eventually bring India to the forefront of the global skills arena. Extending our partnership with the Government in ensuring its vision of 'Skill India' will help the industry benefit to a great extent.

Our state-of-the-art Research and Development facility in Chennai, Mahindra Research Valley, spread across 125 acres, with an investment of USD 150 million is our cradle of innovation for the Mahindra Group as well as our Farm Equipment business. With regular patent applications, our more than 1500 engineers work towards creating world class farm machinery solutions that are frugal and innovative. Apart from in-house R&D, we are also collaborating with Agricultural Universities and Government led Research Labs to fuel and co-create innovative solutions.

Our technology driven product portfolio is based on our in-depth understanding of the farmers requirements and the need to create an effective value proposition. Going beyond selling tractors, we aspire to offer a wide range of farming solutions. Through our recently launched Farm Machinery rental services, TRRINGO, we are making farm machinery accessible to small and marginal farmers and digitally empowering them. Our independent entity, Mahindra Agri Solutions Ltd. (MASL) through its Samriddhi centers gives farmers end to end advisory and soil testing solutions, provides farm inputs (seeds, irrigation, etc.) and imparts in-depth knowledge of crop care.

We have also been closely working with our global partners and forging alliances for Technology Centers of Excellence to grow the 'Made in India' brand globally to bring high-end technology into the Indian farm value chain. The global farm machinery industry (sales of tractors and other equipments) is valued at USD 156 billion with an estimated global demand for agricultural equipment of nearly USD 200 billion by 2018 (Asia contributing > 60 percent). Going forward, Mahindra's key focus areas will be growing the Rice Value chain and the Combine Harvesters business. Harvesters is the second largest segment after tractors in the global market and hence our strategic partnership with Finland based Sampo Rosenlew, will help bring a range of combine harvester product line into India. Our 33% equity stake with Mitsubishi Agri Machinery in Japan, will focus on separate product lines for global and domestic markets as well as leverage technology and product development synergies.

These are definitely exciting times for Indian Agriculture and we at Mahindra, look forward to initiatives like 'Make in India', 'Skill India' and 'Digital India' to fillip the booming agri mechanization industry as well as the overall Indian economy.

Nejurikar

Rajesh Jejurikar
President & Chief Executive
Farm Equipment & Two Wheelers
Member of the Group Executive Board
Mahindra & Mahindra Ltd.


Mahindra
Rise.
A COMMITMENT
TO FARM
PROSPERITY
THAT SPANS
6 DECADES

The Mahindra family has always held a strong belief in India's ability to indigenously develop future-ready mobility solutions. The 'Make in India' movement validates this belief and allows Mahindra to take its vision to even greater heights. From its fundamental beginnings in steel manufacturing in 1945, the Mahindra group is today a US $17.8 billion global federation of companies.

Currently employing over 2 lakh people, Mahindra has helped the country make great strides in industries ranging from automobiles to rural financing and information technology, financial services to energy and business productivity management. The group continues to empower its stakeholders around the world to Rise.

MAKE IN INDIA

Hon. PM Narendra Modi and the Mahindra leadership team at the Mahindra pavilion during 'Make in India' week 2016 in Mumbai.

Hon. PM Narendra Modi visiting Mahindra's display at the Krishi Unnati Mela, PUSA, Delhi

Overview of Mahindra's Farm Equipment Business

GLOBAL OVERVIEW

World's No. 1
tractor brand by volumes

Manufacturing Plants:
10

Total Employment:
7,000+

INDIAN OVERVIEW

Leader in the domestic market for over
3 decades

Market Share (FY 16)
40.9%

Total Tractors sold since inception
> 3.7mn

Manufacturing Plants spanning across
327 acres

Total Plant Capacity:
> 4 lakhs

Input Material:
98.5%
sourced from India

Sourcing from MSMEs:
~ ₹780 crs

www.mahindratractor.com

Working towards farm prosperity

In many ways, India's roots are Mahindra's roots too. Since the 1960s, Mahindra has been working towards enriching the Customer Value Proposition while delivering world class products. Today Mahindra is among the top three tractor companies in the world, exporting 'Made in India' tractors to over 40 countries in 6 continents.

Our philosophy of Manufacturing Excellence includes a high focus on Quality, Innovation and Sustainability. Being the only tractor company to win a Deming Prize and Japan Quality Medal is a validation of the same. Through dexterity schools and skill development programs across its manufacturing eco-system, Mahindra raises indian manufacturing to global standards.

Our Presence

Giving Indian manufacturing the reputation it deserves

Pioneering technology-led innovation in India

The reputation Mahindra enjoys is a direct result of its commitment to innovation, its growing global presence, as well as by bringing modern technology to India and maintaining its leadership position.

Our state-of-the-art Mahindra Research Valley (MRV) in Chennai, validates our commitment towards technology driven innovation. This world-class research & development facility, gives Mahindra products a competitive edge through product and technology development, indigenous design and people capabilities.

Driving technology enabled prosperity

With innovations that accommodate greater loading and a high engine power, our flagship products Arjun NOVO and Mahindra YUVO makes technology accessible to farmers across the nation.

Mahindra has always laid great emphasis on pioneering products and services aimed at transforming the rural economic landscape. By driving rural prosperity, Mahindra seeks to enable development that's fundamental and sustainable.

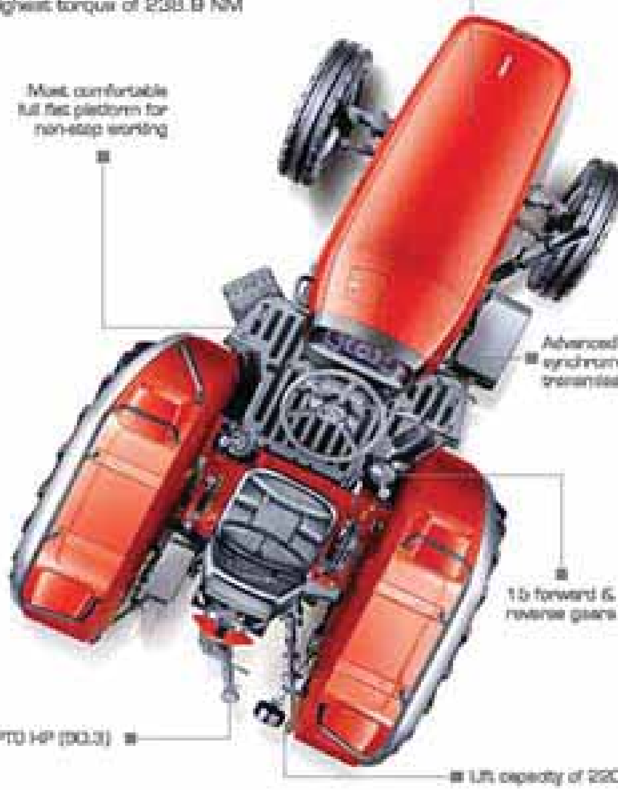
Mahindra
YUVO
MORE. FASTER. BETTER.
www.mahindratractor.com/yuvo.aspx

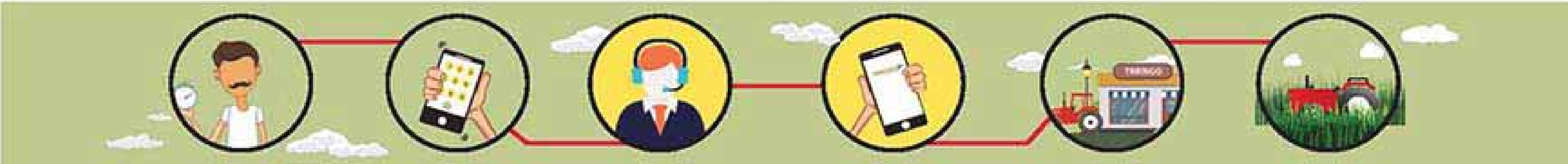
The versatile Yuvo is India's first tractor designed for over 30 different applications, giving farmers capabilities ranging from land preparation to post-harvest operations.

In a bid to digitise and empower India, Trringo is a digital platform by Mahindra that makes tractors and implements accessible to small and marginal farmers.

TRRINGO
AB TRACTOR CALL KARO
www.trringo.com

ARJUN
NOVO
ADBHUT TECHNOLOGY KI MISAAL
www.arjunnovo.com





SWARAJ

15HP - 60HP

www.swarajtractors.com

A favourite among Indian farmers for its power, quality and reliability, Swaraj is India's fastest growing tractor brand. Swaraj's market strength lies in its customer loyalty and 800+ dealers spread across the country.

With its own foundry, Swaraj makes majority of its gears and parts at its 'Deming Prize-winning' and 'TPM Consistency Award-winning' manufacturing plants. Its vendor partners also play a significant role in its growth story.

Mahindra's farm machinery range

From ploughs to harvesters, Mahindra provides a range of implements to farmers with the latest farming technologies across the farm value chain.

A footprint that refuses to accept boundaries

Through strategic global partnerships, Mahindra is proudly taking its brand to the global arena.

Mahindra Yueda Yancheng Tractor Company Ltd. (MYYTCL)

Mahindra Yueda Yancheng Tractor Company Ltd. (MYYTCL) was established in 2008. Its manufacturing facility in Yancheng, Jiangsu - China, has a staggering annual capacity of 1,00,000 tractors and its products are exported to many countries worldwide.

Mahindra USA's tractors, implements, XTVs and UTVs enjoy an exceptional reputation and a loyal following in USA, making them the 3rd largest tractor selling company in USA.

Mahindra USA

> When compared to similar sized tractors from other companies, Mahindra is built stronger, heavier, with easier controls and is more comfortable to operate. Mahindra is the tractor of choice.

Jody Stafford
Kress Creek Farms,
Roanoke, IN

Global farm machinery solutions

Mahindra has entered into strategic partnerships with Mitsubishi Agricultural Machinery of Japan and Sampo Rosenlew of Finland to address the global rice value chain and combine harvesters business respectively.

Mitsubishi Mahindra Agricultural Machinery

www.mam.co.jp/english

Product Range:
25 HP to 50 HP tractors & rice transplanters

Annual Revenue:
USD 440mn (FY16)

Channel Partners:
>600

Total Employees:
1700

Sampo Rosenlew

www.sampo-rosenlew.fi/en

Products:
Combine harvesters from 120 HP to 300 HP

Market Presence:
Europe, Eurasia & North Africa

Total Sales:
50,000 till date

Total Employees:
>400

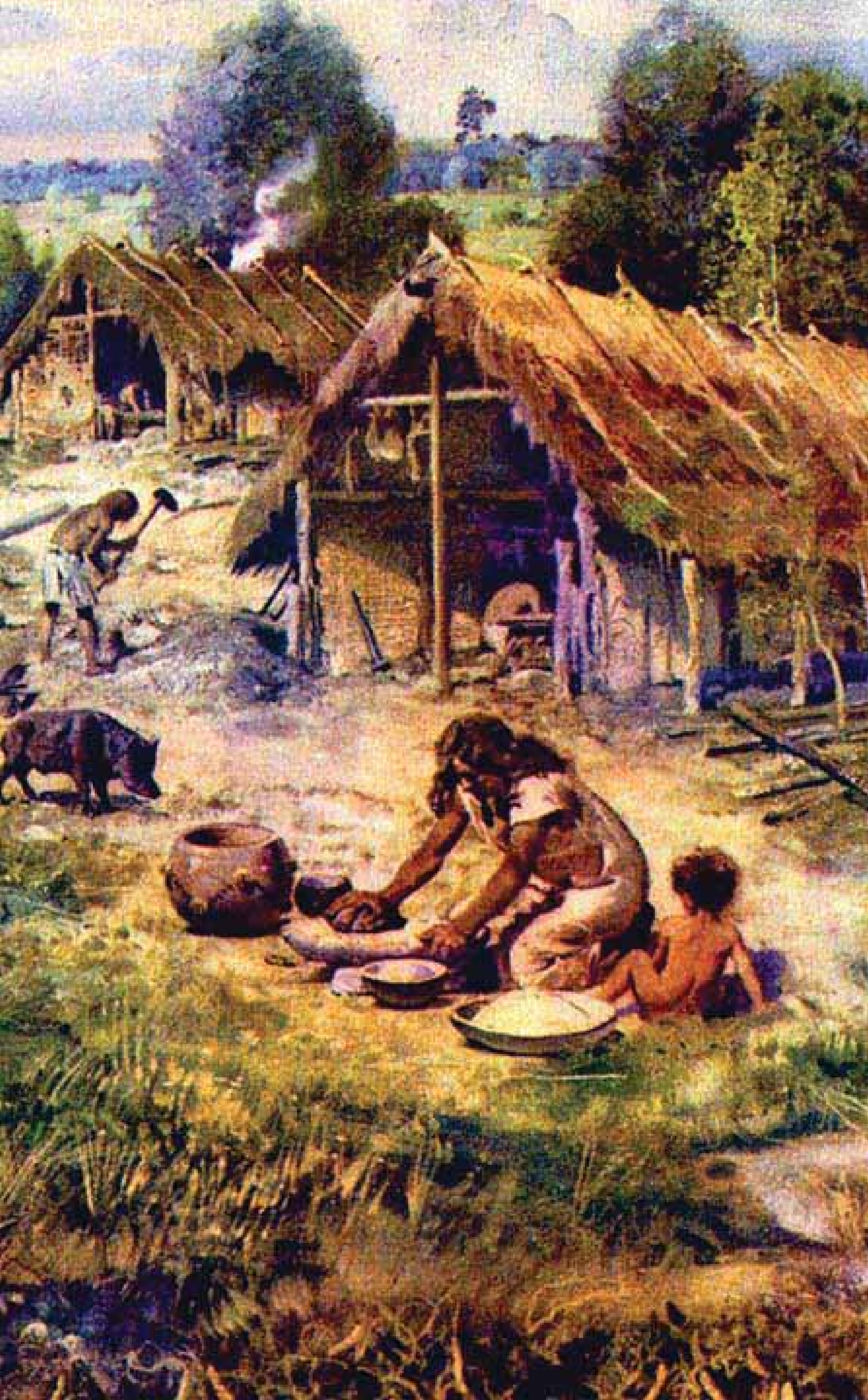
Awards and Accolades

1. Mahindra Tractors was awarded the Deming Prize in 2003.
2. Mahindra Tractors was the world's first and only tractor manufacturer to win the Japan Quality Medal in 2007.
3. Swaraj Division bagged the Deming Prize in 2012.
4. Mahindra bagged two CII Industrial Intellectual Property Awards 2015 in 'Top Design Driven Industry' and 'Top Trademark Driven Industry'.
5. Mahindra Tractors received the TPM Special Award and Swaraj Tractors received the TPM Consistency award by JIPM in 2015.
6. Mahindra Swaraj won 4 awards in South Korea for 'Quality Circles' in 2015.
7. Mahindra Tractors reinforced its SUPERBRAND status in 2015.
8. Mahindra's Automotive and Farm Sector was ranked the 1st Great Place to Work in the Manufacturing category of the "Best Places to Work Survey" in 2016 by Economics Times & GPTW® Institute.

Celebrating India's success stories

The Mahindra Samriddhi India Agri Awards felicitate excellence performance and innovation in the field of agriculture.

The awards serve as a platform to share best practices in farming and celebrate the unsung heroes of India's agrarian economy.



UNIT: 2

History of Agriculture

For most of our existence, humans were hunter-gatherers. This means that people lived a nomadic lifestyle, moving with the seasons to follow the food supply. As the glaciers retreated and plant life patterns and growth areas changed in response, it meant that the need to move so often became slightly less essential - though undoubtedly the lifestyle carried on for thousands of years as people sought to maximize their resource acquisition. Hunter-gatherer societies would have known which crops were best to exploit with each season.

The "hunter-gatherer" moniker can be a misnomer as it is believed today that nomadic communities didn't suddenly just decide one day to stop moving and to set up permanent settlements - though the reasons for the transition have been explored in great deal and is still not settled. It is likely that some degree of semi-nomadic lifestyle developed where people simply set up camps for several years at a time, cordoning off areas of wild crops that had the most abundant resources. It is also likely that they had herds of livestock that they took with them wherever they moved, keeping them secure to exploit for milk, meat, fur and other resources. The need to protect stores of food for the next season may also have played a part.

Archaeologists and palaeontologists have traced the origins of farming to around 10,000 years ago, to somewhere in the Indus Valley, and possibly as a separate development in China along the Yangtze River. It is known that humans first domesticated crops and later livestock in great enough numbers to recognize the signs of deliberate exploitation.

Early Civilization

Early civilization can be considered a boom time in agricultural science and technology. Around 5500 BC, the Sumerian civilization of the Middle East and other early pre Greco-Roman civilizations understood the need for a specialized agricultural workforce for their societies to thrive. It is in this period that we saw the invention of irrigation amongst other things, and this specialised workforce, and focus on agricultural technology allowed the development of the first cities. In turn, these drove the first written laws and led to the development of complex societies. From this point of view, agriculture drives civilisation: including religious practices, social attitudes and legal codes.

Ancient Egypt had one of the most complex societies of the ancient world before the rise of the Greek civilization, and it was mostly thanks to their agricultural system. The River Nile relied heavily on the seasons and each year, the river would flood its banks and part of the surrounding countryside (called The Inundation). Their civilization and indeed their religious structure, was built around the life-giving nature of the River Nile and the kingdom's heavy reliance on the river and delta system. Most of Egypt was and still is desert with a few key oases, which means that the agriculture centered on a very small part of the country.

The Greeks and Romans took much of their agricultural technology from other civilizations with which they had contact - most notably those of the ancient Near East such as Mesopotamia, via Sumeria. From Egypt, those societies took direct influence once the country was conquered by Alexander the Great and later by the Roman Republic. It was here at the birth of modern civilization that we saw true large-scale animal and plant agriculture. Technology may not have advanced a great deal, but the processes made agriculture efficient enough to sustain the empire's large cities, making it a necessary industry.

Early to Modern Civilization

The Middle East continued to see much innovation in the agricultural industries, something that historians refer to as The Arab Agricultural Revolution. This was thanks to the diversity of the local topographies, the crops grown in the Middle East and Indus Valley that European societies coveted, and later acted as a trade bridge between Far East and Europe.

In Europe, little changed before the rise of the kingdoms around the 11th century when the Church became major landholders and traders, leaders, educators and held both temporal and spiritual powers. The systems instigated through feudalism, whether secular lords or church holdings, sought to improve yields with the growing population, and naturally we saw significant technological advances in this period too. It was a period of massive selective cross-breeding, particularly in animal livestock, and systems of organisation. In some areas of Europe, we can see the remnants of the agricultural system today in the form of medieval ridge and furrow strip farming. It is thanks to the monasteries of Europe that we see advances into what we call "marginal landscapes" - areas where crops do not grow in great numbers there we saw agricultural engineering on an unprecedented scale. Floodplains were drained, wild woodlands converted to plains and bracken cleared for pasture, areas with low fertility were converted or altered to make proper use of them; for example, barley grows well on salty soil, making it ideal to grow on floodplains. Modern agricultural practices saw its final modern development in the 16th century when farmers came up with crop rotation - the idea that one could increase yields by switching land use around every year in order not to exhaust the soil. One year the field would have crops planted, the following year it would be used for livestock and the third it would be kept fallow. Though earlier societies had used it to a certain extent, only in the 16th century was the method perfected.


CultiRapid

Modern Farming

Modern farming began around the 18th century in what is generally referred to as "The Agricultural Revolution" when several advances and changes were made to farming in a short space of time that saw massive increases in yield and a more efficient process. The three field crop rotation system was replaced with a four field system and sweeping enclosure acts regulated land management, selective cross-breeding began on an industrial scale to increase crop size as well as yields creating several cultivars in the process. Animal husbandry also improved, leading to a greater surplus than had been permissible under the old system. It is said that these changes permitted the industrial revolution and even greater concentration of urban development, fuelling the empire. How so? More crops for fewer workers, better methods of keeping and replacing nutrients in the soil meant that more people could work in industry. At this time, Charles Darwin's Theory of Evolution put agriculture on the modern path of a science as we began to understand the development of crops.

The next changes would not be until the World War years when the military powers developed (and needed with rationing) intensive farming; it has been a god-send, and since 1970, global cereal production has quadrupled. New plastics as well as the development of nitrates allowed even greater yields once more and it has through this system, now in place for almost a century, allowed greater access to food much more cheaply. Yet for some, the environment has paid a price that some agricultural scientists have tried to address.

The Ecological Age

"Sustainability" is the buzzword today as we look to balance several conflicting needs - to protect the environment and to instigate practices that protects it while providing for the growing needs of the future population growth. Today, our food supply feeds 7 billion people and there is still enough surplus for more going forward. We know though that some of these practices have had an adverse effect on the land. Too many trees are being cut down to make way for agricultural land (livestock and crops), and soils are becoming exhausted quickly while destroying ecosystems.

UNIT: 3
Introduction to Indian Agriculture

India is mainly an agricultural country. Agriculture is the most important occupation for most of the Indian families. In India, agriculture contributes about sixteen percent (16%) of total GDP and ten percent (10%) of total exports.

Over 60 % of India's land area is arable making it the second largest country in terms of total arable land. Agricultural products of significant economic value includes rice, wheat, potato, tomato, onion, mangoes, sugar-cane, beans, cotton, etc.

Agriculture helps to meet the basic needs of human and their civilization by providing food, clothing, shelters, medicine and recreation. Hence, agriculture is the most important enterprise in the world. It is a productive unit where the free gifts of nature namely land, light, air, temperature and rain water etc., are integrated into single primary unit indispensable for human beings. Secondary productive units namely animals including livestock, birds and insects, feed on these primary units and provide concentrated products such as meat, milk, wool, eggs, honey, silk and lac. Agriculture provides food, feed, fibre, fuel, furniture, raw materials and materials for and from factories; provides a free fare and fresh environment, abundant food for driving out famine; favours friendship by eliminating fights. Satisfactory agricultural production brings peace, prosperity, harmony, health and wealth to individuals of a nation by driving away distrust, discord and anarchy. It helps to elevate the community consisting of different castes and clauses, thus it leads to a better social, cultural, political and economic life. Agricultural development is multidirectional having galloping speed and rapid spread with respect to time and space. After green revolution, farmers started using improved cultural practices and agricultural inputs in intensive cropping systems with labourer intensive programmes to enhance the production potential per unit land, time and input. It provided suitable environment to all these improved genotypes to foster and manifest their yield potential in newer areas and seasons. Agriculture consists of growing plants and rearing animals in order to yield, produce and thus it helps to maintain a biological equilibrium in nature.

Terminology

Agriculture is derived from Latin words Ager and Cultura. Ager means land or field and Cultura means cultivation. Therefore the term agriculture means cultivation of land. i.e., the science and art of producing crops and livestock for economic purposes. It is also referred as the science of producing crops and livestock from the natural resources of the earth. The primary aim of agriculture is to cause the land to produce more abundantly, and at the same time, to protect it from deterioration and misuse. It is synonymous with farming–the production of food, fodder and other industrial materials.

Definitions

Agriculture is defined in the Agriculture Act 1947, as including 'horticulture, fruit growing, seed growing, dairy farming and livestock breeding and keeping, the use of land as grazing land, meadow land, osier land, market gardens and nursery grounds, and the use of land for woodlands where that use ancillary to the farming of land for Agricultural purposes". It is also defined as 'purposeful work through which elements in nature are harnessed to produce plants and animals to meet the human needs. It is a biological production process, which depends on the growth and development of selected plants and animals within the local environment.

Highlights

Following are some highlights of the current state of Indian agriculture and its trends:

- Agriculture and allied sectors contribute approximately 14 percent to India's GDP.
- It is expected to employ approximate 205 million people by 2019-20.
- Rapid urbanization growing population and growth of other sectors promising employment is impacting the farm productivity.
- Use of proper equipment can increase the farm productivity by up-to 30 percent and reduce the input cost by about 20 percent.
- By the year 2050, the annual food grain production would need to grow 333 million tonnes from the levels of 257 million tonnes recorded in 2014.
- India, with a mechanization level between 40-45 percent, lags in comparison to other BRIC countries such as Brazil and China.
- Agricultural machinery market in India is estimated to grow at a CAGR of over 10 percent during the period 2013-18.
- The size of the farm equipment sector is estimated at approximately US$ 6.5 billion and has seen strong growth in recent years.
- The Indian agriculture market is dominated by 1,500 micro units, 2,500 small-scale units and 250 medium sized companies.
- Tractor accounts for most of the mechanization in India. The country is also the largest market in the world for tractors.
- Indian thresher market remains largely unorganized.
- Problems such as small and scattered land holdings, affordability and financing of farm equipment, poor levels of procurement mechanism, poor after sales service and over dependency on tractors instead of other kinds of machinery are some of the challenges.


Global leader in Farm Mechanization,
Redefining Indian Agriculture
CNH INDUSTRIAL
CASE AGRICULTURE
SUGARCANE HARVESTER
AUSTOFT
4000
DOUBLE PLUS+
Uniflow Hydraulics and
Turbo Air Drag Cleaning System ensures
• More Productivity
• More Reliability
• Better Cleaning
NEW HOLLAND AGRICULTURE
New Holland Tractor with Baler
Ultimate cleaning of land without polluting the
environment & optimum utilization of
crop by-product for Enhanced Profitability
New Holland Tractor with Rake
The most reliable machine for stacking straws in
a row without leaving any residue
New Holland Tractor with Mower-38
Finest in the craft of fine fodder cutting
Technologically Superior range of
35HP-90HP New Holland Tractors and
Farm Mechanization Solutions.
The Choice of Every Progressive Farmer
Our International range of farm mechanization equipment, developed after years of extensive research, now available in India
New Holland Fiat (India) Pvt. Ltd.: Plot No. 03, Udyog Kendra, Greater Noida, District Gautam Budh Nagar, Uttar Pradesh.
Tel.: +91-120-3056000 | Fax: +91-120-3056989
Toll Free No.: 1800 419 0124
www.newhollandindia.co.in

Scope of Indian Agriculture

In India, population pressure is increasing while area under cultivation is static (as shown in the land utilization statistics given below) or even shrinking, which demand intensification of cropping and allied activities in two dimensions i.e., time and space dimension. India is endowed with tropical climate with abundant solar energy throughout the year, which favours growing crops round the year. There is a vast scope to increase irrigation potential by river projects and minor irrigation projects. In additional to the above, India is blessed with more labourer availability. Since agriculture is the primary sector, other sectors are dependent on agriculture.

Total geographical area	: 328.848 million ha.
Total reporting area	: 304.300 million ha.
Area under cultivation	: 143.000 million ha.
Total cropped area	: 179.750 million ha.
Area sown more than once	: 36.750 million ha.
Area not available for cultivation	: 161.300 million ha.
Area under forest	: 66.400 million ha.

In India, major allocation has been done in each five-year plan to agriculture. In 8th five-year plan, nearly 23% of the national budget allocation goes to agriculture and allied agro-based cottage industries run on small scales. More than 60% of the Indian population (60 million/1.05 billion) depends or involved in agriculture and allied activities. Nearly 40% of the net national product is from agricultural sector. Approximately 35% employment is generated from agriculture, out of which 75% is found in rural areas either directly or indirectly.

In India, food grain production increased almost four folds from about 50 million tonnes at independence to more than 220 million tonnes in 2005 through green revolution. Despite variation in the performance of individual crops and regions, total food grain production maintained a growth of 2.7% per annum, which kept ahead of population growth at about 2.2% per annum. Through white revolution, milk production increased from 17 million tonnes at independence to 69 million tonnes (1997–98). Through blue revolution, fish production rose from 0.75 million tonnes to nearly 5.0 million tonnes during the last five decades. Through yellow revolution, oil seed production increased 5 times (from 5 million tonnes to 25 million tonnes) since independence. Similarly, the egg production increased from 2 billion at independence to 28 billion, sugarcane production from 57 million tonnes to 276 million tonnes, cotton production from 3 million bales to 14 million bales which shows our sign of progress. India is the largest producer of fruits in the world. India is the second largest producer of milk and vegetables.

In future, agriculture development in India would be guided not only by the compulsion of improving food and nutritional security, but also by the concerns for environmental protection, sustainability and profitability. By following the General Agreement on Trade and Tariff (GATT) and the liberalization process, globalization of markets would call for competitiveness and efficiency of agricultural production. Agriculture will face challenging situations on the ecological, global climate, economic equity, energy and employment fronts in the years to come.

Environmental Impact of Agriculture

Agriculture, as implemented through the method of farming, imposes external costs upon society through pesticides, nutrient runoff, excessive water usage, loss of natural environment and assorted other problems. A 2000 assessment of agriculture in the UK determined total external costs for 1996 of £2,343 million, or £208 per hectare. A 2005 analysis of these costs in the USA concluded that cropland imposes approximately $5 to 16 billion ($30 to $96 per hectare), while livestock production imposes $714 million. Both studies, which focused solely on the fiscal impacts, concluded that more should be done to internalize external costs. Neither included subsidies in their analysis, but they noted that subsidies also influence the cost of agriculture to society. In 2010, the International Resource Panel of the United Nations Environment Programme published a report assessing the environmental impacts of consumption and production. The study found that agriculture and food consumption are two of the most important drivers of environmental pressures, particularly habitat change, climate change, water use and toxic emissions. The 2011 UNEP Green Economy report states that "agricultural operations, excluding land use changes, produce approximately 13 per cent of anthropogenic global GHG emissions. This includes GHGs emitted by the use of inorganic fertilisers agro-chemical pesticides and herbicides; (GHG emissions resulting from production of these inputs are included in industrial emissions); and fossil fuel-energy inputs. "On average we find that the total amount of fresh residues from agricultural and forestry production for second- generation biofuel production amounts to 3.8 billion tonnes per year between 2011 and 2050 (with an average annual growth rate of 11 per cent throughout the period analysed, accounting for higher growth during early years, 48 per cent for 2011–2020 and an average 2 per cent annual expansion after 2020)."

Livestock issues

Livestock are one of the most significant contributors to today's most serious environmental problems. Livestock production occupies 70% of all land used for agriculture, or 30% of the land surface of the planet. It is one of the largest sources of greenhouse gases, responsible for 18% of the world's greenhouse gas emissions as measured in CO2 equivalents. By comparison, all transportation emits 13.5% of the CO2. It produces 65% of human-related nitrous oxide (which has 296 times the global warming potential of CO2,) and 37% of all human-induced methane (which is 23 times as warming as CO2.) It also generates 64% of the ammonia emission. Livestock expansion is cited as a key factor driving deforestation; in the Amazon basin 70% of previously forested area is now occupied by pastures and the remainder used for feed crops. Through deforestation and land degradation, livestock is also driving reductions in biodiversity. Furthermore, the UNEP states that "methane emissions from global livestock are projected to increase by 60 per cent by 2030 under current practices and consumption patterns."

Land and water issues

Land transformation, the use of land to yield goods and services, is the most substantial way humans alter the Earth's ecosystems, and is considered the driving force in the loss of biodiversity. Estimates of the amount of land transformed by humans vary from 39 to 50%. Land degradation, the long-term decline in ecosystem function and productivity, is estimated to be occurring on 24% of land worldwide, with cropland overrepresented. The UN-FAO report cites land management as the driving factor behind degradation and reports that 1.5 billion people rely upon the degrading land. Degradation can be deforestation, desertification, soil erosion, mineral depletion, or chemical degradation (acidification and salinization).

Eutrophication, excessive nutrients in aquatic ecosystems resulting in algal blooms and anoxia, leads to fish kills, loss of biodiversity, and renders water unfit for drinking and other industrial uses. Excessive fertilization and manure application to cropland, as well as high livestock stocking densities cause nutrient (mainly nitrogen and phosphorus) runoff and leaching from agricultural land. These nutrients are major nonpoint pollutants contributing to eutrophication of aquatic ecosystems.

Agriculture accounts for 70 percent of withdrawals of freshwater resources. Agriculture is a major draw on water from aquifers, and currently draws from those underground water sources at an unsustainable rate. It is long known that aquifers in areas as diverse as northern China, the Upper Ganges and the western US are being depleted, and new research extends these problems to aquifers in Iran, Mexico and Saudi Arabia. Increasing pressure is being placed on water resources by industry and urban areas, meaning that water scarcity is increasing and agriculture is facing the challenge of producing more food for the world's growing population with reduced water resources. Agricultural water usage can also cause major environmental problems, including the destruction of natural wetlands, the spread of water-borne diseases, and land degradation through salinization and waterlogging, when irrigation is performed incorrectly.

Pesticides

Pesticide use has increased since 1950 to 2.5 million short tons annually worldwide, yet crop loss from pests has remained relatively constant. The World Health Organization estimated in 1992 that 3 million pesticide poisonings occur annually, causing 220,000 deaths. Pesticides select for pesticide resistance in the pest population, leading to a condition termed the "pesticide treadmill" in which pest resistance warrants the development of a new pesticide.

An alternative argument is that the way to "save the environment" and prevent famine is by using pesticides and intensive high yield farming, a view exemplified by a quote heading the Center for Global Food Issues website: 'Growing more per acre leaves more land for nature'. However, critics argue that a trade-off between the environment and a need for food is not inevitable, and that pesticides simply replace good agronomic practices such as crop rotation. The UNEP introduces the Push–pull agricultural pest management technique which involves intercropping that uses plant aromas to repel or push away pests while pulling in or attracting the right insects. "The implementation of push-pull in eastern Africa has significantly increased maize yields and the combined cultivation of N-fixing forage crops has enriched the soil and has also provided farmers with feed for livestock. With increased livestock operations, the farmers are able to produce meat, milk and other dairy products and they use the manure as organic fertiliser that returns nutrients to the fields."

Climate change

Climate change has the potential to affect agriculture through changes in temperature, rainfall (timing and quantity), CO_2, solar radiation and the interaction of these elements. Extreme events, such as droughts and floods, are forecast to increase as climate change takes hold. Agriculture is among sectors most vulnerable to the impacts of climate change; water supply for example, will be critical to sustain agricultural production and provide the increase in food output required to sustain the world's growing population. Fluctuations in the flow of rivers are likely to increase in the twenty-first century. Based on the experience of countries in the Nile river basin (Ethiopia, Kenya and Sudan) and other developing countries, depletion of water resources during seasons crucial for agriculture can lead to a decline in yield by up to 50%. Transformational approaches will be needed to manage natural resources in the future. For example, policies, practices and tools promoting climate-smart agriculture will be important, as will better use of scientific information on climate for assessing risks and vulnerability. Planners and policy-makers will need to help create suitable policies that encourage funding for such agricultural transformation.

Agriculture in its many forms can both mitigate and worsen global warming. Some of the increase in CO_2 in the atmosphere comes from the decomposition of organic matter in the soil, and much of the methane emitted into the atmosphere is caused by the decomposition of organic matter in wet soils such as rice paddy fields, as well as the normal digestive activities of farm animals. Further, wet or anaerobic soils also lose nitrogen through denitrification, releasing the greenhouse gases nitric oxide and nitrous oxide. Changes in management can reduce the release of these greenhouse gases, and soil can further be used to sequester some of the CO_2 in the atmosphere. Informed by the UNEP, "agriculture also produces about 58 per cent of global nitrous oxide emissions and about 47 per cent of global methane emissions. Cattle and rice farms release methane, fertilized fields release nitrous oxide, and the cutting down of rainforests to grow crops or raise livestock releases carbon dioxide. Both of these gases have a far greater global warming potential per tonne than CO_2 (298 times and 25 times respectively)."

There are several factors within the field of agriculture that contribute to the large amount of CO_2 emissions. The diversity of the sources ranges from the production of farming tools to the transport of harvested produce. Approximately 8% of the national carbon footprint is due to agricultural sources. Of that, 75% is of the carbon emissions released from the production of crop assisting chemicals. Factories producing insecticides, herbicides, fungicides, and fertilizers are a major culprit of the greenhouse gas. Productivity on the farm itself and the use of machinery is another source of the carbon emission. Almost all the industrial machines used in modern farming are powered by fossil fuels. These instruments are burning fossil fuels from the beginning of the process to the end. Tractors are the root of this source. The tractor is going to burn fuel and release CO_2 just to run. The amount of emissions from the machinery increase with the attachment of different units and need for more power. During the soil preparation stage tillers and plows will be used to disrupt the soil. During growth watering pumps and sprayers are used to keep the crops hydrated. And when the crops are ready for picking a forage or combine harvester is used. These types of machinery all require additional energy which leads to increased carbon dioxide emissions from the basic tractors. The final major contribution to CO_2 emissions in agriculture is in the final transport of produce. Local farming suffered a decline over the past century due to large amounts of farm subsidies. The majority of crops are shipped hundreds of miles to various processing plants before ending up in the grocery store. These shipments are made using fossil fuel burning modes of transportation. Inevitably these transport adds to carbon dioxide emissions.

Sustainability

Some major organizations are hailing farming within agroecosystems as the way forward for mainstream agriculture. Current farming methods have resulted in over-stretched water resources, high levels of erosion and reduced soil fertility. According to a report by the International Water Management Institute and UNEP, there is not enough water to continue farming using current practices; therefore how critical water, land, and ecosystem resources are used to boost crop yields must be reconsidered. The report suggested assigning value to ecosystems, recognizing environmental and livelihood trade-offs, and balancing the rights of a variety of users and interests. Inequities that result when such measures are adopted would need to be addressed, such as the reallocation of water from poor to rich, the clearing of land to make way for more productive farmland, or the preservation of a wetland system that limits fishing rights.

Technological advancements help provide farmers with tools and resources to make farming more sustainable. New technologies have given rise to innovations like conservation tillage, a farming process which helps prevent land loss to erosion, water pollution and enhances carbon sequestration.

According to a report by the International Food Policy Research Institute (IFPRI), agricultural technologies will have the greatest impact on food production if adopted in combination with each other; using a model that assessed how eleven technologies could impact agricultural productivity, food security and trade by 2050, IFPRI found that the number of people at risk from hunger could be reduced by as much as 40% and food prices could be reduced by almost half.

An Introduction to Agronomy and Its Relevance

The word agronomy has been derived from the two Greek words, agros and nomos having the meaning of field and to manage, respectively. Literally, agronomy means the "art of managing field". Technically, it means the "science and economics of crop production by management of farm land".

Definition: Agronomy is the art and underlying science in production and improvement of field crops with the efficient use of soil fertility, water, labourer and other factors related to crop production. Agronomy is the field of study and practice of ways and means of production of food, feed and fibre crops. Agronomy is defined as "a branch of agricultural science which deals with principles and practices of field crop production and management of soil for higher productivity.

Importance: Among all the branches of agriculture, agronomy occupies a pivotal position and is regarded as the mother branch or primary branch. Like agriculture, agronomy is an integrated and applied aspect of different disciplines of pure sciences. Agronomy has three clear branches namely, (i) Crop Science, (ii) Soil Science, and (iii) Environmental Science that deals only with applied aspects, i.e. Soil-Crop-Environmental relationship. Agronomy is a synthesis of several disciplines like crop science, which includes plant breeding, crop physiology and biochemistry etc., and soil science, which includes soil fertilizers, manures etc., and environmental science which includes meteorology and crop ecology.

Basic Principles

- Planning, programming and executing measures for maximum utilization of land, labourer, capital and other factors of production.
- Choice of crop varieties adaptable to the particular agro-climate, land situation, soil fertility, season and method of cultivation and befitting to the cropping system;
- Proper field management by tillage, preparing field channels and bunds for irrigation and drainage, checking soil erosion, levelling and adopting other suitable land improvement practices;
- Adoption of multiple cropping and also mixed or intercropping to ensure harvest even under adverse environmental conditions;
- Timely application of proper and balanced nutrients to the crop and improvement of soil fertility and productivity. Correction of ill-effects of soil reactions and conditions and increasing soil organic matter through the application of green manure, farm yard manure, organic wastes, bio fertilizers and profitable recycling of organic wastes;
- Choice of quality seed or seed material and maintenance of requisite plant density per unit area with healthy and uniform seedlings;
- Proper water management with respect to crop, soil and environment through conservation and utilization of soil moisture as well as by utilizing water that is available in excess, and scheduling irrigation at critical stages of crop growth.
- Adoption of adequate, need-based, timely and exacting plant protection measures against weeds, insect-pests, pathogens, as well as climatic hazards and correction of deficiencies and disorders;
- Adoption of suitable and appropriate management practices including intercultural operations to get maximum benefit from inputs dearer and difficult to get, low-monetary and non-monetary inputs;
- Adoption of suitable method and time of harvesting of crop to reduce field loss and to release land for succeeding crop(s) and efficient utilization of residual moisture, plant nutrients and other management practices;
- Adoption of suitable post-harvest technologies.
- Agronomy was recognized as a distinct branch of agricultural science only since about since about 1900. The American Society of Agronomy was organized in 1908.

UNIT: 4

History of Indian Agriculture

Vedic literature provides some of the earliest written record of agriculture in India. Rigveda hymns, for example, describes ploughing, fallowing, irrigation, fruit and vegetable cultivation. Other historical evidence suggests rice and cotton were cultivated in the Indus Valley, and ploughing patterns from the Bronze Age have been excavated at Kalibangan in Rajasthan. Bhumivargaha, an Indian Sanskrit text, suggested to be 2500 years old, classifies agricultural land into 12 categories: urvara (fertile), ushara (barren), maru (desert), aprahata (fallow), shadvala (grassy), pankikala (muddy), jalaprayah (watery), kachchaha (contiguous to water), sharkara (full of pebbles and pieces of limestone), sharkaravati (sandy), nadimatruka (watered from a river), and devamatruka (rainfed). Some archaeologists believe that rice was a domesticated crop along the banks of the river Ganges in the sixth millennium BC. So were species of winter cereals (barley, oats, and wheat) and legumes (lentil and chickpea) grown in northwest India before the sixth millennium BC. Other crops cultivated in India 3000 to 6000 years ago, include sesame, linseed, safflower, mustards, castor, mung bean, black gram, horse gram, pigeon pea, field pea, grass pea (khesari), fenugreek, cotton, jujube, grapes, dates, jackfruit, mango, mulberry, and black plum. Indian peasants had also domesticated cattle, buffaloes, sheep, goats, pigs and horses thousands of years ago.

Some scientists claim agriculture was widespread in the Indian peninsula, some 3000–5000 years ago, well beyond the fertile plains of the north. For example, one study reports 12 sites in the southern Indian states of Karnataka and Andhra Pradesh providing clear evidence of agriculture of pulses (Vigna radiata and Macrotyloma uniflorum), millet-grasses (Brachiaria ramosa and Setaria verticillata), wheats (Triticum dicoccum, Triticum durum/aestivum), barley (Hordeum vulgare), hyacinth bean (Lablab purpureus), pearl millet (Pennisetum glaucum), finger millet (Eleusine coracana), cotton (Gossypium sp.), linseed (Linum sp.), as well as gathered fruits of Ziziphus and two Cucurbitaceae.

Some claim Indian agriculture began by 9000 BP as a result of early cultivation of plants, and domestication of crops and animals. Settled life soon followed with implements and techniques being developed for agriculture. Double monsoons led to two harvests being reaped in one year. Indian products soon reached trading networks and foreign crops were introduced. Plants and animals—considered essential to survival by the Indians—came to be worshiped and venerated.

Excavations, legends and remote sensing tests reveal that agriculture is 10,000 years old. Women by their intrinsic insight first observed that plants come up from seeds. Men concentrated on hunting and gathering (Palaeolithic and Neolithic periods) during that time. Women were the pioneers for cultivating useful plants from the wild flora. They dug out edible roots and rhizomes and buried the small ones for subsequent harvests. They used animal meat as main food and their skin for clothing. The following table gives an idea about agriculture development scenario.

The middle ages saw irrigation channels reach a new level of sophistication, and Indian crops affected the economies of other regions of the world under Islamic patronage. Land and water management systems were developed with an aim of providing uniform growth.

Despite some stagnation during the later modern era the independent Republic of India was able to develop a comprehensive agricultural programme.

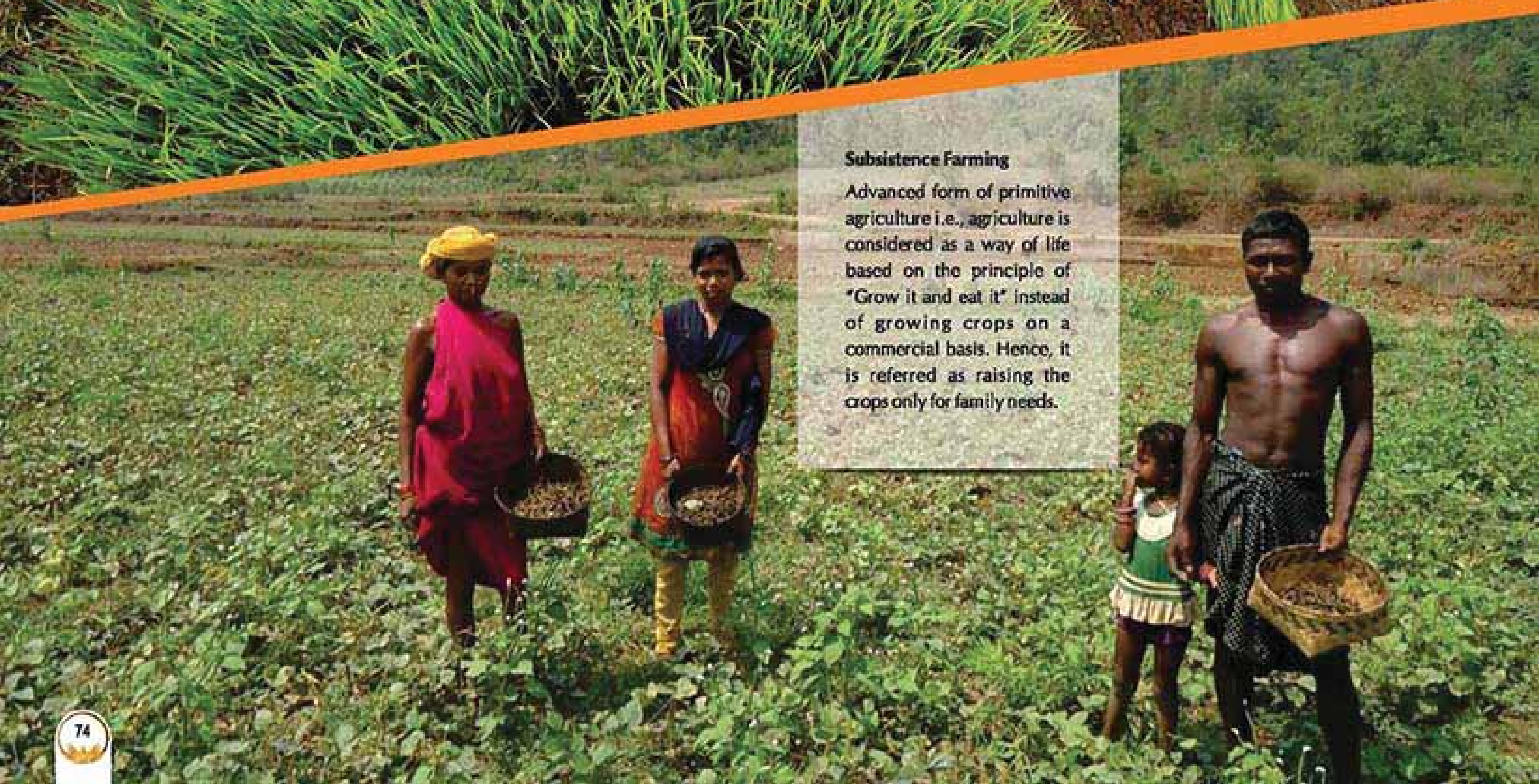
Table. Agriculture Development Scenario				
Agricultural System	**Cultural stage or Time**	**Average cereal yield (t/ha)**	**World population (millions)**	**Per capita land availability (ha)**
Hunting and Gathering	Palaeolithic	-	7	-
Shifting Agriculture	Neolithic			
(about 7,000 B.C.)	1	35	40.00	
Medieval Agriculture	500–1450 A.D	1	900	01.50
Livestock farming	18th Century	2	1800	00.70
Fertilizer/Pesticide in Agriculture	20th Century	4	4200	00.30

Shifting Cultivation

A primitive form of agriculture in which people working with the crudest of tools, cut down a part of the forest, burnt the underneath growth and started new garden sites. After few years, when these plots lost their fertility or became heavily infested with weeds or soil-borne pests, they shifted to a new site. This is also known as Assartage system (cultivating crops till the land is completely worn-out) contrary to the fallow system. Fallow system means land is allowed for a resting period without any crop. In India, shifting cultivation existed in different states, with different names as jhum cultivation in Assam, podu in Andhra Pradesh and Orissa, kumari in Western Ghats, walra in south east Rajasthan, penda bewar in Madhya Pradesh and slash and burn in Bihar.

Subsidiary Farming

Rudimentary system of settled farming, which includes cultivation, gathering and hunting. People in groups started settling down near a stream or river as permanent village sites and started cultivating in the same land more continuously, however the tools, crops and cropping methods were primitive.



Subsistence Farming

Advanced form of primitive agriculture i.e., agriculture is considered as a way of life based on the principle of "Grow it and eat it" instead of growing crops on a commercial basis. Hence, it is referred as raising the crops only for family needs.

Mixed Farming

It is the farming comprising of crop and animal components. Field crop-grass husbandry (same field was used both for cropping and later grazing) was common. It is a stage changing from food gathering to food growing.

Advanced Farming

Advanced farming practices includes selection of crops and varieties, seed selection, green manuring with legumes, crop rotation, use of animal and crop refuse as manures, irrigation, pasture management, rearing of milch animals, bullocks, sheep and goat for wool and meat, rearing of birds by stall feeding etc. Agriculture and Colonialism

Over 2500 years ago, Indian farmers had discovered and begun farming many spices and sugarcane. It was in India, between the sixth and fourth centuries BC, that the Persians, followed by the Greeks, discovered the famous "reeds that produce honey without bees" being grown. These were locally called Sakhara. On their return journey, the Macedonian soldiers carried the "honey bearing reeds," thus spreading sugar and sugarcane agriculture. People in India had invented, by about 500 BC, the process to produce sugar crystals. In the local language, these crystals were called khanda, which is the source of the word candy.

Before the 18th century, cultivation of sugarcane was largely confined to India. A few merchants began to trade in sugar — a luxury and an expensive spice in Europe until the 18th century. Sugar became widely popular in 18th-century Europe, then graduated to becoming a human necessity in the 19th century all over the world. This evolution of taste and demand for sugar as an essential food ingredient unleashed major economic and social changes. Sugarcane does not grow in cold, frost-prone climate; therefore, tropical and semitropical colonies were sought. Sugarcane plantations, just like cotton farms, became a major driver of large and forced human migrations in 19th century and early 20th century — of people from Africa and from India, both in millions — influencing the ethnic mix, political conflicts and cultural evolution of Caribbean, South American, Indian Ocean and Pacific Island nations.

The history and past accomplishments of Indian agriculture thus influenced, in part, colonialism, slavery and slavery-like indentured labour practices in the new world, Caribbean wars and world history in 18th and 19th centuries.

Scientific Agriculture (19th Century)

During 18th century, modern agriculture was started with crop sequence, organic recycling, introduction of exotic crops and animals, use of farm implements in agriculture etc. During 19th century, research and development (R&D) in fundamental and basic sciences were brought under applied aspects of agriculture. Agriculture took the shape of a teaching science. Laboratories, farms, research stations, research centres, institutes for research, teaching and extension (training and demonstration) were developed. Books, journals, popular and scientific articles, literatures were introduced. New media, and audio-visual aids were developed to disseminate new research findings and information to the rural masses.

Indian Agriculture after Independence

In the years since its independence, India has made immense progress towards food security. Indian population has tripled, and food-grain production more than quadrupled. There has been a substantial increase in available food-grain per capita.

Before the mid-1960s India relied on imports and food aid to meet domestic requirements. However, two years of severe drought in 1965 and 1966 convinced India to reform its agricultural policy and that they could not rely on foreign aid and imports for food security. India adopted significant policy reforms focused on the goal of foodgrain self-sufficiency. This ushered in India's Green Revolution. It began with the decision to adopt superior yielding, disease resistant wheat varieties in combination with better farming knowledge to improve productivity. The state of Punjab led India's green revolution and earned the distinction of being the country's bread basket.

The initial increase in production was centred on the irrigated areas of the states of Punjab, Haryana and western Uttar Pradesh. With the farmers and the government officials focusing on farm productivity and knowledge transfer, India's total foodgrain production soared. A hectare of Indian wheat farm that produced an average of 0.8 tonnes in 1948, produced 4.7 tonnes of wheat in 1975 from the same land. Such rapid growth in farm productivity enabled India to become self-sufficient by the 1970s. It also empowered the smallholder farmers to seek further means to increase food staples produced per hectare. By 2000, Indian farms were adopting wheat varieties capable of yielding 6 tonnes of wheat per hectare.

With agricultural policy success in wheat, India's Green Revolution technology spread to rice. However, since irrigation infrastructure was very poor, Indian farmer innovated with tube-wells, to harvest ground water. When gains from the new technology reached their limits in the states of initial adoption, the technology spread in the 1970s and 1980s to the states of eastern India — Bihar, Odisha and West Bengal. The lasting benefits of the improved seeds and new technology extended principally to the irrigated areas which account for about one-third of the harvested crop area. In the 1980s, Indian agriculture policy shifted to "evolution of a production pattern in line with the demand pattern" leading to a shift in emphasis to other agricultural commodities like oilseed, fruit and vegetables. Farmers began adopting improved methods and technologies in dairying, fisheries and livestock, and meeting the diversified food needs of a growing population.

As with rice, the lasting benefits of improved seeds and improved farming technologies now largely depends on whether India develops infrastructure such as irrigation network, flood control systems, reliable electricity production capacity, all-season rural and urban highways, cold storage to prevent spoilage, modern retail, and competitive buyers of produce from Indian farmers. This is increasingly the focus of Indian agriculture policy.

India's agricultural economy is undergoing structural changes. Between 1970 and 2011, the GDP share of agriculture has fallen from 43% to 16%. This isn't because of reduced importance of agriculture or a consequence of agricultural policy. This is largely because of the rapid economic growth in services, industrial output, and non-agricultural sectors in India between 2000 and 2010.

Agricultural scientist M. S. Swaminathan has played a vital role in the green revolution. In 2013 NDTV awarded him as 25 living legend of India for outstanding contribution to agriculture and making India a food sovereign country.

Two states, Sikkim and Kerala have planned to shift fully to organic farming by 2015 and 2016 respectively.

Present Day Agriculture in 21st Century

Today agriculture is not merely production oriented but is becoming a business consisting of various enterprises like livestock (dairy), poultry, fishery, piggery, sericulture, apiary, plantation cropping etc. Now, a lot of developments on hydrological, mechanical, chemical, genetically and technological aspects of agriculture are in progress. Governments are apportioning a greater share of national budget for agricultural development. Small and marginal farmers are being supplied with agricultural inputs on subsidy. Policies for preserving, processing, pricing, marketing, distributing, consuming, exporting and importing are strengthening. Agro-based small scale industries and crafts are fast developing. Need based agricultural planning, programming and execution are in progress.

ESCORTS
AGRI MACHINERY

A PROGRESSIVE WORLD

At Escorts it all starts by developing new technologies that help you perform better and progress further.

Our foray into farm mechanization has helped transform the farmland challenges of rural India, into yields of opportunity. While rural India continued to evolve, our brand remained a stable constant, in this flux. A core part that is central to every rural life.

We pioneered the concept of farm mechanization and represent a brand legacy trusted across generations. We have enriched the value of our rural customers' most precious asset – land.

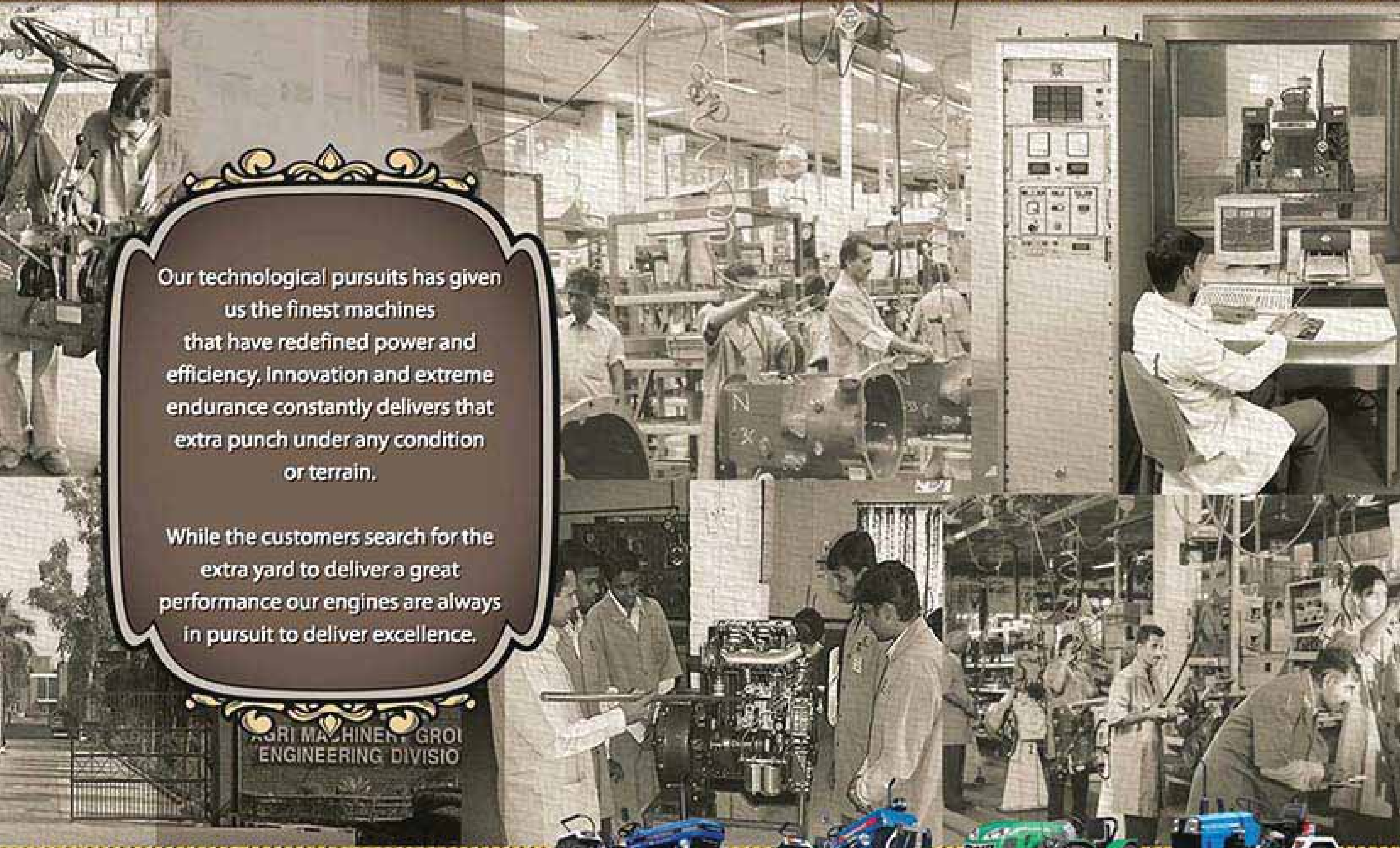
We considered Escorts Agri Machinery to help India strengthen its presence in the agri sector by customizing our products around specific farmer needs and contributing significantly to the national economy.

The strong connect between our products and our customers have helped liberate precious farmer time, enhance productivity and augment profitability. Today we are not just mere participants in India's great leap from 'the manual' to 'the mechanized', we are an active catalyst in its symbolic synergy of man and machine.

FARMTRAC POWERTRAC FERRARI STEELTRAC

THE RIDE OF PRIDE & EXCELLENCE

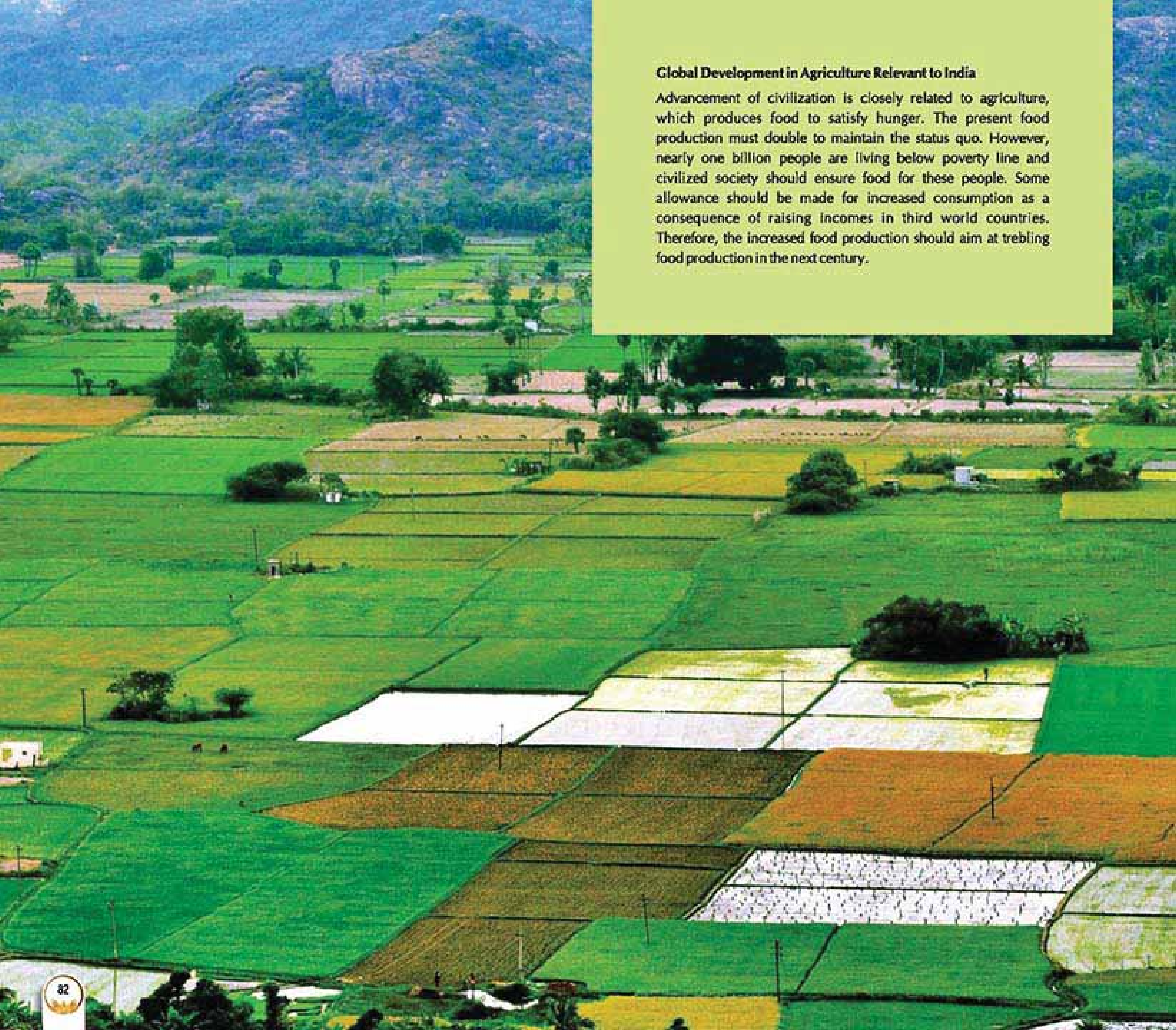
ESCORTS
AGRI MACHINERY



Our technological pursuits has given us the finest machines that have redefined power and efficiency. Innovation and extreme endurance constantly delivers that extra punch under any condition or terrain.

While the customers search for the extra yard to deliver a great performance our engines are always in pursuit to deliver excellence.

PROGRESS IS BEHIND EVERYTHING WE DO.
WE THINK BIG, WE DELIVER BIGGER.



Global Development in Agriculture Relevant to India

Advancement of civilization is closely related to agriculture, which produces food to satisfy hunger. The present food production must double to maintain the status quo. However, nearly one billion people are living below poverty line and civilized society should ensure food for these people. Some allowance should be made for increased consumption as a consequence of raising incomes in third world countries. Therefore, the increased food production should aim at trebling food production in the next century.

Development of Indian Agriculture till the 16th Century:

70 million years ago	:	Trees evolved
40 million years ago	:	Monkeys and apes evolved
10 million years ago	:	Dogs were domesticated in Iraq
8700 B.C.	:	Sheeps were domesticated in Iraq
7700 B.C.	:	Goats were domesticated in Iraq
7500 B.C.	:	Invention of polished stone implements, cultivation of crops like wheat and barley in middle-east.
6000 B.C.	:	Cattle and pigs where domesticated in Middle East
4400 B.C.	:	Maize was cultivated in Mexico
3500 B.C.	:	Potato was grown in South America
3000 B.C.	:	Bronze was used to make tools in Middle East
2900 B.C.	:	Plough was used in Middle East
2700 B.C.	:	Silk moth was domesticated in China
2300 B.C.	:	Poultry, buffalo and elephant were domesticated in Indus valley.
2200 B.C.	:	Rice cultivation started in India
1800 B.C.	:	Ragi cultivation started in Karnataka (India)
1780 B.C.	:	Kulthi (Dolichus biflorus) was cultivated in Karnataka
1725 B.C.	:	Jowar (Sorghum) cultivation started in Rajasthan
1700 B.C.	:	Horse husbandry started in Central Asia
1500 B.C.	:	Pulses (Green and Black gram) were cultivated in Madhya Pradesh Cultivation of Barley and Sugarcane started in India. Irrigation from wells started.
1400 B.C.	:	Iron was in use in Middle East
1000–1600 B.C.	:	Iron ploughs were in use
15 century A.D.	:	Cultivation of sweet orange, sour orange, wild brinjal, pomegranate was there
16 century A.D.	:	Introduction of crops like potato, sweet potato, cassava, tomato, chillies, pumpkin, papaya, pineapple, guava, custard apple, groundnut, cashew nut, tobacco, American cotton, rubber was done into India by Portuguese.

Land Resources

For crop production the basic input is land. Planet earth is of 15.2 billion ha avails 3.8 ha per person (Canada 50, Australia 50, S. America 10, USSR 10, USA 4, France 1.2, India 0.8 and Japan 0.4). The continuing population increase will result in available cultivable land per capita world-wide from 0.3 ha in 1988 to 0.17 ha in 2050, with only 0.11 per capita in developing countries. The nutrient losses due to soil erosion of one of good top soil in kg are 4 N, 1 P_2O_5, 20 K_2O and 2 CaO, besides organic matter. Only 10 to 11 per cent of cultivated area is reasonably free from all constraints for crop production. The FAO's analysis of growth patterns in crop output in 93 developing countries shows that 63 per cent of the growth in production must come from higher yields and 15 per cent from higher cropping intensity. Only 22 per cent is expected from land reserve.

Of the total 6444 m. ha of rainfed agricultural potential, only 30 per cent is suitable, 10 per cent marginal and 60 per cent unsuitable in different countries. The semiarid tropics (SAT) comprise of all or part of 50 countries in five continents of the world (Central America, SW Asia, Africa, South America and South East Asia) is the home of 700 million people who are under perpetual threat drought and occasional famine. About 65 per cent of the arable land carries untapped potential cereals, pulses and oilseeds, the biggest gains to the food ladder of the globe would be from improvement of agriculture. India has the largest SAT area (10%) of any of the developing countries.

Environmental degradation is increasing at a pace that is impairing the productivity of land and undermining the welfare of rural people. Global Assessment of Soil Degradation (GLASoD) defines soil degradation as a process that describes human induced phenomena, which lower the current and/or future capacity of the soil to support human life. The causes for degradation are:

- Removal of vegetative cover through agricultural clearing,
- Decrease in soil cover through removal of vegetation for fuel wood, fencing, etc.
- Overgrazing by livestock leading to decrease in vegetative cover and trampling of the soil
- Agricultural activities like cultivation in steep slopes, farming without anti-erosion measures in arid areas, improper irrigation and use of heavy machinery, and
- Soil contamination with pollutants such as waste discharges and over use of agrochemicals.

Modern farm technologies are more productive on good soils than on poor soils. Technology may sustain yields by making the effects of soil degradation temporarily. Yield increase through technology might have been greater if the soil has not been degraded.

Water Resources

Of the total volume of 1400 million cubic km (M cu km) water, 97 per cent is sea water. Of the balance 3 per cent, 22 per cent is ground water and 77 per cent locked up glaciers and polar ice caps, leaving less than one per cent of fresh water to take part in hydrological cycle. Global water use doubled between 1940 and 1980 and is expected to double again by 2010 A.D. with two-thirds of the projected water use going to agriculture. Today one-third of the world's crops come from its 280 M ha of irrigated land. After World War II, foreign aid helped carry irrigation even to arid corners of the world. As on 1990, about 270 M ha of area, contributing to 17 per cent of the total cropped area, was under irrigation in the world. Today, irrigated farming systems of the past are under serious threat of extinct due to salinity, poor drainage and weak management. Irrigated land damaged through salinization for the top five countries, as percentage of total area irrigated by 1985 are: India 36, China 17, USSR 18, USA 44 and Pakistan 25. Irrigated area per capita for India (1989) is 0.057 ha as against 0.049 ha for the world. In rainfed agriculture, the cropping intensity of world is 0.74. Under irrigation, the current intensity of 1.21 may increase to 1.29. To maintain a diet of 2000 Cal day-1 requires 300 m3 of water per day and 420 for a diet of 3500 Cal. Bringing one ha of new land under cultivation will produce 0.9 tonnes of cereal grain, one year supply of food for about five people at FAO minimum nutritional standard of 1600 Cal day-1. If the land is irrigated, the total production increases four folds to 3.5 tonnes ha-1. At this level, if future irrigated area of the world reaches 1.0 billion ha, enough food for 10 billion people at twice the FAO level.

In spite of the fact that irrigation can provide food for ever increasing population, experience in the recent decades in expansion of irrigated area ran into several problems leading to land degradation. Year to year changes in world irrigated area reflect the sum of the addition of the new capacity and loss of established capacity due to aquifer depletion, lowered water tables, abandonment of waterlogged area and salted land, reservoir siliting and diversion of irrigation water to non-agricultural use. The future food production from irrigated areas depends more on the gains in water use efficiency than on additional new supplies.

Food Scenario

Cereals area grown throughout the world to provide food for the human consumption and feed and fodder for livestock. They are grown in 73.5 per cent of the world's arable land and contribute 74.5 per cent of the global calorie production. Demand for food is growing with ever increasing world population. Compared with present production of about 1.9 billion tones, the demand for cereals is likely to go up to 2.4 billion by the year 2000 A.D. While demand for wheat and rice may be increased in the next two decades by 31 and 53 per cent, respectively, the demand for coarse grains may double. Developed nations may meet their cereal demand by increasing production at 1.8 per cent per annum. However, most of the developing countries with growth rate of 2.5 per cent per annum in cereals production fall short of this requirement, which is increasing at the rate of 3.3 per cent per annum due to high population growth rate. The FAO estimates clearly indicate the increasing shortage of cereals in 90 developing countries.

Increase in food all over world during the decades of 1972–92 was remarkable. Productivity and production in the technologically advanced agriculture of the developed countries rose to heights that would have been unbelievable half a century ago, mainly due to introduction of high yielding varieties (HYVs) responsive to inputs of fertilities and irrigation water, besides increase in area under cultivations.

Developing countries presented a different picture. Only about a third of their population (excluding China) lived in countries with satisfactory performance in agricultural production. Elsewhere, output was raising more slowly than population. Africa in 1970s became the striking example of production inadequacy. There were many constraints limiting agricultural productivity, particularly that of small farmers in developing countries.

- Land remained so unequally distributed that farms were too small and steadily became smaller as rural population grew.
- Input supplies and services were insufficient and access to them most unequal,
- Resources devoted to research, training and extension were very limited, and
- Priority was given to industry, not agriculture, and food prices were shaded in the interest of urban consumers rather than of rural producers.

The FAO aimed at doubling the agricultural production in the developing countries between 1980 and 2000. The hopeful outcome depends on achieving an ambitions transformation involving widespread modernization in technology, based primarily on massive increase in inputs to agriculture. Developed countries do not come directly into the exploration of the future as they continue to raise their farming. The strategy is:

- Heavy investment in agricultural sector to make full use of the improved technology.
- Increasing crop production sources through arable land growth, cropping intensity and crop productivity.
- Expanding and conserving the land, based through land reforms directed at bringing underused land in to more intensive exploration and soil and water conservation to the dangers of land degradation, and
- Intensifying land use in crop production through irrigation, fertilizers, improved cultivates, plant protection and mechanization.

Towards 21st Century

According to World Bank projections, the world population could reach a stationary level of just under 10 billion by around the end of 21 century, compared with 6.2 billion during 2000 A.D. Significance of these projections is faster growth in population than in food requirements. Almost all the population increase (95%) takes place in the present day developing countries, which have low per capita consumption levels. Simple lesson from projection is that world demand could increase by 50 per cent in the next 20 years, would more than double again in the first half of the next century.

Doubling the world's food and agricultural production between 2000 and 2055 A.D. sounds daunting. To meet satisfactorily the food and agricultural demands of about 10 billion people, taking in to account the non-agricultural use of the land and seas, will require at least indicative global source use planning. It is clear that sustained rapid increase in crop and livestock yields must be the main stay of future output growth. A continuation to the middle of the 21st century of the expansion of arable land for the next 20 years would mean that virtually all of the potential arable land would be cultivated. The backup of agricultural research and extension must be more oriented to the problem of developing country agriculture.

The 21st century must inherit a food and agricultural system in the developing countries which is much more productive and equitable than it is now. By of continuously absorbing further innovations. The foundations for enormous increase in output needs in the first part of the 21st century must, therefore, be laid in what is left of this century. Attaining the targets proposed for this later period is a pre-requisite for improving the lives not only of those now living but also of further generations.

Development of Scientific Agriculture in World

1. Francis Bacon (1561–1624 A.D.) : Found the water as nutrient of plants
2. G.R. Glanber (1604–1668 A.D.) : Salt peter (KNO_3) as nutrient and not water
3. Jethrotull (1674–1741 A.D.) : Fine soil particle as plant nutrient
4. Priestly (1730–1799 A.D.) : Discovered the oxygen
5. Francis Home (1775 A.D.) : Water, air, salts, fire and oil from the plant nutrients
6. Charles and Francis (1780 A.D.) : Isolated and characterized Indole-3-Acetic Acid (IAA)
7. Thomas Jefferson (1793 A.D.) : Developed the mould board plough.
8. Theodore-de-Saussure : Found that plants absorb CO_2 from air and release O_2; soil supply N_2 and ash to plants
9. Justus van Liebig (1804–1873 A.D.) : A German chemist developed the concept called "Liebig's law of minimum". It states as follows:

   "A deficiency or absence of the necessary constituent, all others being present, renders the soil barren for crops for which that nutrient is needed"–It is referred as "Barrle concept". If the barrel has stones of different heights, the lowest one establishes the capacity of the Barrel. Nitrogen has the lowest share, establishes the maximum capacity of the barrel. Accordingly, the growth factor in lowest supply (whether climatic, edaphic, genetic or biotic) sets the capacity for yield. Similarly a soil deficient in nitrogen (N) can't be made to produce well by adding more calcium (Ca) or potassium (K) where they are already abundant.

10. In 1875, Michigen State University was established to provide agriculture education on college level.
11. Gregor Johann Mendel (1866) discovered the laws of heredity.
12. Charles Darwin (1876) published the results of experiments on cross and self-fertilization in plants.
13. Thomas Malthus (1898) Proposed "Malthusian Theory" that the human race would run or later run out of food for everyone in spite of the rapid advances being made in agriculture at that time, because of limited land and yield potential of crops.
14. Neo Malthusians have proposed birth control as answer to the problem.
15. F.T. Blackman's (1905) Theory of "Optima and Limiting Factors" states that, "when a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the pace of the slowest factor."
16. E.A. Mitsherlich (1909) proposed a theory of "Law of diminishing returns" states that, 'The increase in any crop produce by a unit increment of a deficient factor is proportional to the decrement of that factor from the maximum and the response is curvilinear instead of linear'. Mitscherlich equation is dy/dx = C (A-Y) where,

    d – increment or change

    dy – amount of increase in yield

    dx – amount of increment of the growth factor x.

    A – Maximum possible yield

    Y – Yield obtained for the given quantity of factor 'x' and

    C – Proportionality constant that depends on the nature of the growth factor
17. Wilcox (1929) proposed "Inverse Yield–Nitrogen law" states that, the growth and yielding ability of any crop plant is inversely proportional to the mean nitrogen content in the dry matter.
18. Macy (1936): Proposed a concept of "Critical Percentages of Plant Nutrients". He suggested a relationship between the sufficiency of nutrients and plant response in terms of yield and nutrient concentration of plant tissues. Macy proposed critical percentages for each nutrient in each kind of plant.

    In the tissues minimum percentage range, an added increment of a nutrient increases the yield but not the nutrient percentage. In the poverty adjustment range, an added increment of a nutrient increases the nutrient percentage but not the yield. In the luxury consumption range, added increment of nutrient have little effect of yield. But increase the nutrient composition percentage.

    The point between poverty adjustment and luxury consumption was the "Critical percentage". Macy suggested that Liebig's law holds well in the tissue minimum percentage range because there is not enough of a nutrient to allow much plant growth. Liebig's law holds good again in the luxury consumption range. Because there is a large supply of nutrient, some other nutrient becomes limiting and stops growth. Mitscherlich's law of diminishing returns holds during the poverty adjustment range because the response curve is linear representing the diminishing yield to added increments.
19. Zimmerman and Hitchcock (1942) reported that 2, 4-D could act as growth promoter at extremely low concentration. Now 2, 4-D is used to overcome the problem of seediness in Poovan banana.
20. In 1945, herbicide 2, 4, 5-T was developed.
21. In 1954, Gibberlic acid structure was identified by Japanese.
22. In 1950's Bennet and Clark identified ABA (Abscessic acid), which inhibits plant growth and controls shedding of plant parts.

Agriculture as Art, Science and Business of Crop Production

Agriculture is defined as the art, the science and the business of producing crops and the livestock for economic purposes.

As an art, it embraces knowledge of the way to perform the operations of the farm in a skilful manner. The skill is categorized as;

Physical skill: It involves the ability and capacity to carry out the operation in an efficient way for e.g., handling of farm implements, animals etc., sowing of seeds, fertilizer and pesticides application etc.

Mental skill: The farmer is able to take a decision based on experience, such as (i) time and method of ploughing, (ii) selection of crop and cropping system to suit soil and climate, (iii) adopting improved farm practices etc.

As a science, it utilizes all modern technologies developed on scientific principles such as crop improvement/breeding, crop production, crop protection, economics etc., to maximize the yield and profit. For example, new crops and varieties developed by hybridization, transgenic crop varieties resistant to pests and diseases, hybrids in each crop, high fertilizer responsive varieties, water management, herbicides to control weeds, use of bio-control agents to combat pest and diseases etc.

As the business, as long as agriculture is the way of life of the rural population, production is ultimately bound to consumption. But agriculture as a business aims at maximum net return through the management of land, labour, water and capital, employing the knowledge of various sciences for production of food, feed, fibre and fuel. In recent years, agriculture is commercialized to run as a business through mechanization.

Branches of Agriculture

Agriculture has 3 main spheres viz., Geoponic (Cultivation in earth-soil), Aeroponic (cultivation in air) and Hydroponic (cultivation in water). Agriculture is the branch of science encompassing the applied aspects of basic sciences. The applied aspects of agricultural science consists of study of field crops and their management (Arviculture) including soil management.

Crop production - It deals with the production of various crops, which includes food crops, fodder crops, fibre crops, sugar, oil seeds, etc. It includes agronomy, soil science, entomology, pathology, microbiology, etc. The aim is to have better food production and how to control the diseases.

Horticulture - Branch of agriculture deals with the production of flowers, fruits, vegetables, ornamental plants, spices, condiments (includes narcotic crops-opium, etc., which has medicinal value) and beverages.

Agricultural Engineering - It is an important component for crop production and horticulture particularly to provide tools and implements. It is aiming to produce modified tools to facilitate proper animal husbandry and crop production tools, implements and machinery in animal production.

Forestry - It deals with production of large scale cultivation of perennial trees for supplying wood, timber, rubber, etc. and also raw materials for industries.

Animal Husbandry - The animals being produced, maintained, etc. Maintenance of various types of livestock for direct energy (work energy). Husbandry is common for both crop and animals. The objective is to get maximum output by feeding, rearing, etc. The arrangement of crops is done to get minimum requirement of light or air. This arrangement is called geometry. Husbandry is for direct and indirect energy.

Fishery Science - It is for marine fish and inland fishes including shrimps and prawns.

Home Science - Application and utilization of agricultural produces in a better manner. When utilization is enhanced production is also enhanced. e.g., a crop once in use in south was found that it had many uses now.

On integration, all the seven branches, first three is grouped as for crop production group and next two for animal management and last two as allied agriculture branches. Broadly in practice, agriculture is grouped in four major categories as,

A. Crop Improvement

(i) Plant breeding and genetics

(ii) Bio-technology

B. Crop Management

(i) Agronomy

(ii) Soil Science and Agricultural Chemistry

(iii) Seed technology

(iv) Agricultural Microbiology

(v) Crop-Physiology

(vi) Agricultural Engineering

(vii) Environmental Sciences

(viii) Agricultural Meteorology

C. Crop Protection

(i) Agricultural Entomology

(ii) Plant Pathology

(iii) Nematology

D. Social Sciences

(i) Agricultural Extension

(ii) Agricultural Economics

Allied disciplines

(i) Agricultural Statistics

(ii) English

(iii) Mathematics

(iv) Bio-Chemistry etc.

Development of Scientific Agriculture

Early man depended on hunting, fishing and food gathering. To this day, some groups still pursue this simple way of life and others have continued as roving herdsmen. However, as various groups of men undertook deliberate cultivation of wild plants and domestication of wild animals, agriculture came into being. Cultivation of crops, notably grains such as wheat, rice, barley and millets, encouraged settlement of stable farm communities, some of which grew into a town or city in various parts of the world. Early agricultural implements-digging stick, hoe, scythe and plough-developed slowly over the centuries and each innovation caused profound changes in human life. From early times too, men created indigenous systems of irrigation especially in semi-arid areas and regions of periodic rainfall.

Farming was intimately associated with landholding and therefore with political organization. Growth of large estates involved the use of slaves and bound or semi-free labourers. As the Middle Ages wanted increasing communications, the commercial revolution and the steady rise of cities in Western Europe tended to turn agriculture away from subsistence farming towards the growing of crops for sale outside the community i.e., commercial agricultural revolution. Exploration and intercontinental trade as well as scientific investigations led to the development of agricultural knowledge of various crops and the exchange of mechanical devices such as the sugar mill and Eli Whitney's cotton gin helped to support the system of large plantations based on a single crop.

The industrial revolution, after the late 18th century, swelled the population of towns and cities and increasingly forced agriculture into greater integration with general economic and financial patterns. The era of mechanized agriculture began with the invention of such farm machines as the reaper, cultivator, thresher, combine harvesters and tractors, which continued to appear over; the years leading to a new type of large scale agriculture. Modern science has also revolutionized food processing. Breeding programmes have developed highly specialized animal, plant and poultry varieties thus increasing production efficiency greatly. All over the world, agricultural colleges and government agencies attempt to increase output by disseminating knowledge of improved agricultural practices through the release of new plant and animal types and by continuous intensive research into basic and applied scientific principles relating to agricultural production and economics.


mahindra

UNIT: 5

India's Agriculture Sector: An Overview

Agriculture forms the backbone of the Indian economy and despite concerted industrialization in the last 40 years, agriculture still occupies a place of pride. Agriculture is contributing nearly 15 per cent of the national income, providing employment to about 70 per cent of the working population and accounting for a sizable share of the country's foreign exchange earnings. It provides the food grains to feed the large population of 1.252 billion. It is also the supplier of raw material to many industries. Thus the very economic structure of the country rests upon agriculture.

Agriculture being one of the primary employment sector to millions across the country becomes vital for the country's growth. India ranks third in farm and agriculture output globally. It is also the largest producer, consumer and exporter of spices and related products. Agricultural exports constitute 10 percent of the country's exports, and is the fourth-largest exported principal commodity. India is also among the top producers of wheat, rice, sugarcane and fresh fruits. But production of some of the major crops such as wheat, rice, pulses and oilseeds, declined in 2014 on account of poor monsoons and other local challenges. Production of major crops in India is summarised below

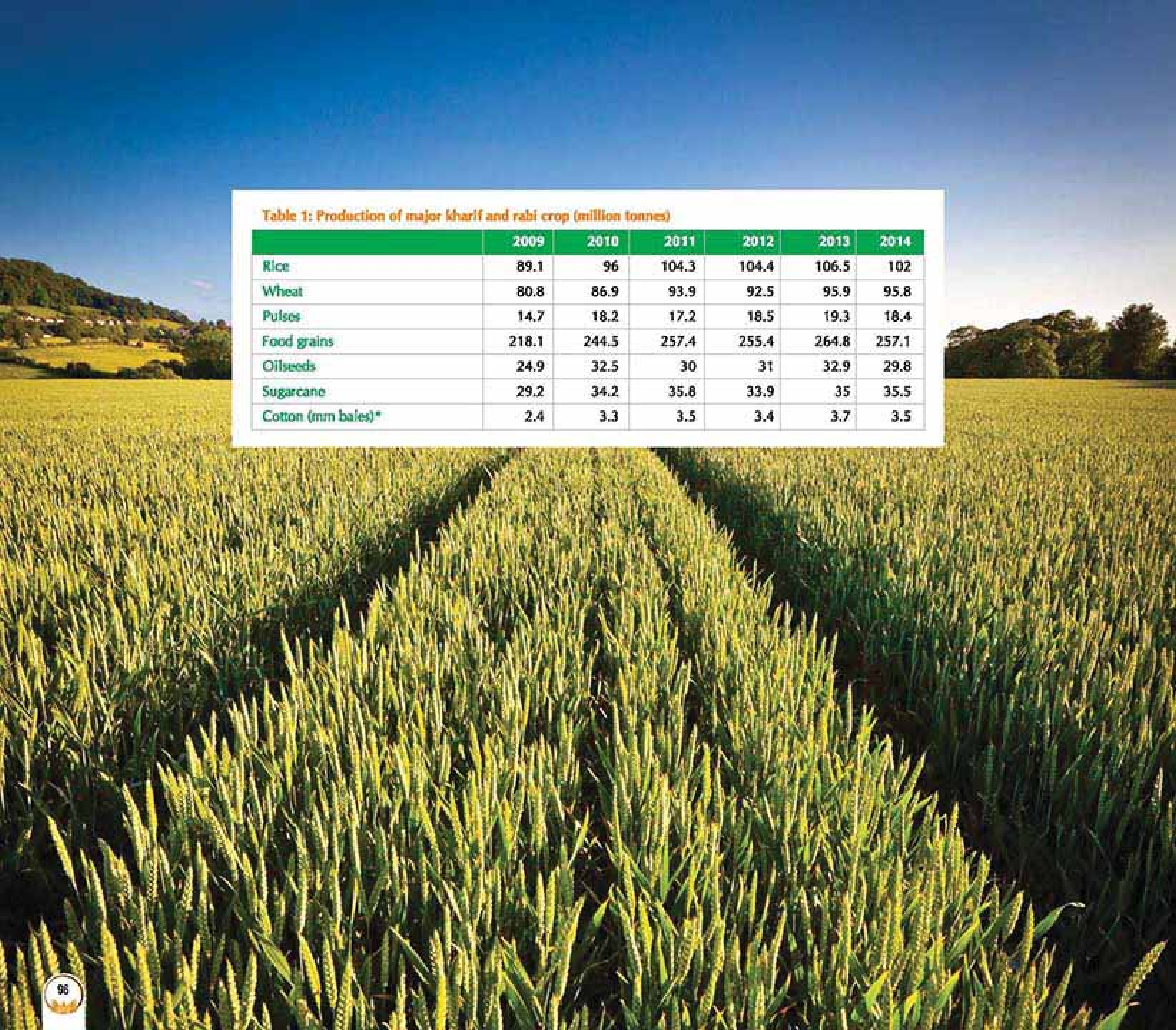


Table 1: Production of major kharif and rabi crop (million tonnes)

	2009	2010	2011	2012	2013	2014
Rice	89.1	96	104.3	104.4	106.5	102
Wheat	80.8	86.9	93.9	92.5	95.9	95.8
Pulses	14.7	18.2	17.2	18.5	19.3	18.4
Food grains	218.1	244.5	257.4	255.4	264.8	257.1
Oilseeds	24.9	32.5	30	31	32.9	29.8
Sugarcane	29.2	34.2	35.8	33.9	35	35.5
Cotton (mn bales)*	2.4	3.3	3.5	3.4	3.7	3.5

Contribution to National Income

Financial reforms in the past one decade, tighter monetary policies aimed at securing the Indian economy from the turbulent global market conditions have not just helped the Indian market to grow but have also helped in attracting investments from around the world. Rising levels of reforms, presence of a large section youth population and growth across sectors have contributed to the overall growth.

Agriculture plays a vital role in India's economy. Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood. Agriculture, along with fisheries and forestry, is one of the largest contributors to the Gross Domestic Product (GDP).

Gross Domestic Product (GDP) composition by sector (Constant 2004-05 prices)

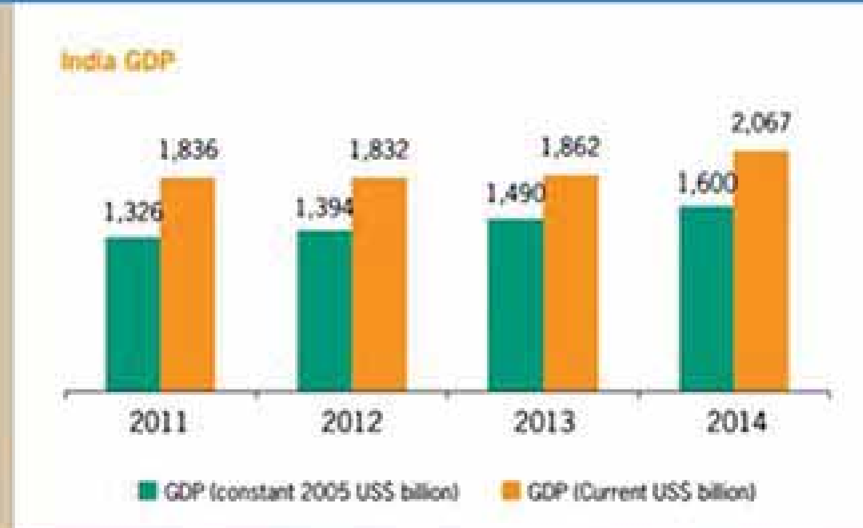
Services
59
percent

Industry
27
percent

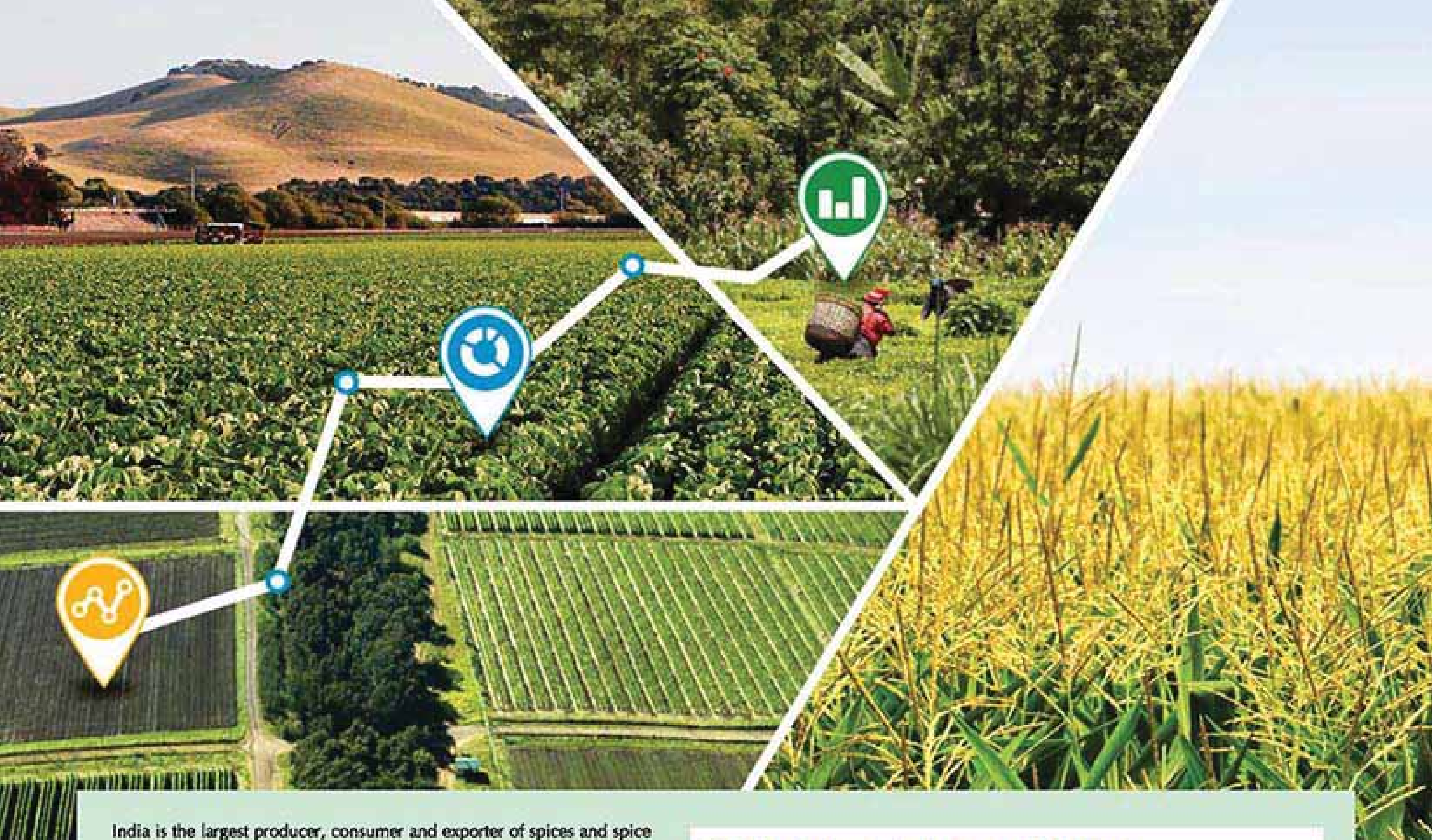
Agriculture and allied sector
14
percent (rounded from 13.9 percent)

India's GDP has performed well in the last one decade. Post the recession of 2008, growth rebounded in 2013 and 2014. India's GDP crossed US$ 2 trillion for the first time in 2014. Per capita GDP in India has been increasing at a steady pace as well with a CAGR of 6.0 percent between 2005 and 2014.

As per estimates by the Central Statistics Office (CSO), the share of agriculture and allied sectors (including agriculture, livestock, forestry and fishery) was 15.35 per cent of the Gross Value Added (GVA) during 2015–16 at 2011–12 prices.



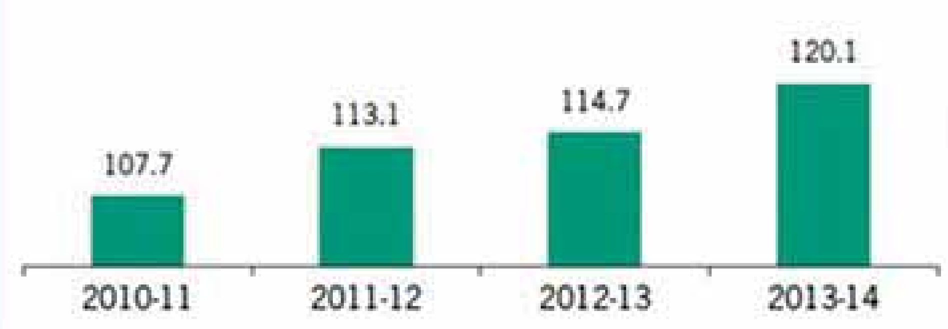
While the country is now known as the services hub for the entire world, its agriculture sector plays a key role globally. Geographically, India accounts for 2.4 percent of the world's total area and 4 percent of its water resources. While it is home for about 17 percent of world's population and 15 percent of the livestock, the country has seen a steady growth in the population, averaging an annual growth of 1.3 percent between 2011 and 2014, reaching 1.26 billion in 2014.



India is the largest producer, consumer and exporter of spices and spice products. India's fruit production has grown faster than vegetables, making it the second largest fruit producer in the world. India's horticulture output, comprising fruits, vegetables and spices, has reached to a record high of 283.5 million tonnes (MT) in 2014-15. It ranks third in farm and agriculture outputs. Agricultural export constitutes 10 per cent of the country's exports and is the fourth-largest exported principal commodity. The agro industry in India is divided into several sub segments such as canned, dairy, processed, frozen food to fisheries, meat, poultry, and food grains.

The Department of Agriculture and Cooperation under the Ministry of Agriculture is responsible for the development of the agriculture sector in India. It manages several other bodies, such as the National Dairy Development Board (NDDB), to develop other allied agricultural sectors.

GDP of agriculture and allied sector (US$ billion)



Market Size

Over the recent past, multiple factors have worked together to facilitate growth in the agriculture sector in India. These include growth in household income and consumption, expansion in the food processing sector and increase in agricultural exports. Rising private participation in Indian agriculture, growing organic farming and use of information technology are some of the key trends in the agriculture industry.

As per the 3rd Advance Estimates, India's foodgrain production has increased marginally to 252.23 million tonnes (MT) in the 2015-16 crop year. Production of pulses is estimated at 17.06 million tonnes.

With an annual output of 146.31 MT, India is the largest producer of milk, accounting for 18.5 per cent of the total world production. It also has the largest bovine population. India, the second-largest producer of sugar, accounts for 14 per cent of the global output. It is the sixth-largest exporter of sugar, accounting for 2.76 per cent of the global exports.

Spice exports from India are expected to reach US$ 3 billion by 2016–17 due to creative marketing strategies, innovative packaging, strength in quality and strong distribution networks. The spices market in India is valued at Rs 40,000 crore (US$ 5.87 billion) annually, of which the branded segment accounts for 15 per cent. In fact, the Spices Board of India has decided to set up a spice museum at Willingdon Island in Kochi to attract and educate tourists and seafarers about the history and growth of Indian spices industry.

The procurement target for rice during marketing season (MS) 2015–16 has been finalised as 30 MT.

Investments

Several players have invested in the agricultural sector in India, mainly driven by the government's initiatives and schemes.

According to the Department of Industrial Policy and Promotion (DIPP), the Indian agricultural services and agricultural machinery sectors have cumulatively attracted Foreign Direct Investment (FDI) equity inflow of about US$ 2,261 million from April 2000 to December 2015.

Some major investments and developments in agriculture in the recent past are as follows:

- ITC Ltd, one of India's leading fast-moving consumer goods (FMCG) company, plans to make Andhra Pradesh a hub for its agricultural business operations.
- Mahindra and Mahindra Ltd has acquired 35 per cent stake in a Finnish combine harvesters manufacturer, Sampo Roselnew Oy, for US$ 20.46 million and will jointly focus on the combine harvester business in Asia, Africa and Eurasian Economic Union countries.
- The Small Farmers' Agri-Business Consortium (SFAC) plans to organise camps in Madhya Pradesh and Chhattisgarh to promote its venture capital assistance scheme (VCAS), which seeks to provide capital and project development facility (PDF) to agri-business entrepreneurs.
- Agri-research institute ICRISAT's incubation arm is looking to set up a Rs.100 crore (US$ 14.67 million) fund in a year, an initiative that could help small entrepreneurs from the agri-business and nutrition space raise money.
- Mahindra & Mahindra (M&M), India's leading tractor and utility vehicle manufacturer, announced its entry into pulses retailing under the brand 'NuPro'. Going forward, the company plans to foray into e-retailing and sale of dairy products.
- Fertiliser cooperative IFFCO launched a joint venture with Japanese firm Mitsubishi Corp for manufacturing agrochemicals in India.
- Acumen, a not-for-profit global venture fund, has invested Rs 11 crore (US$ 1.7 million) in Sahayog Dairy, an integrated entity in the segment, based at Harda district in Madhya Pradesh.
- Rabo Equity Advisors, the private equity arm of Netherlands-based Rabo Group, raised US$ 100 million for the first close of its second fund – India Agri Business Fund II. The fund plans to invest US$ 15–17 million in 10–12 companies.
- Oman India Joint Investment Fund (OIJIF), a joint venture (JV) between the State Bank of India (SBI) and State General Reserve Fund (SGRF), invested Rs 95 crore (US$ 13.94 million) in GSP Crop Science, a Gujarat-based agrochemicals company.
- The world's seventh-largest agrochemicals firm, Israel-based ADAMA Agrochemicals plans to invest at least US$ 50 million in India over the next three years.

Government Initiatives

Given the importance of the agriculture sector, the Government of India, in its Budget 2016–17, planned several steps for the sustainable development of agriculture.

Budget 2016-17 proposed a slew of measures to improve agriculture and increase farmers' welfare such as 2.85 million hectares to be brought under irrigation, Rs 287,000 crore (US$ 42.11 billion) grant in aid to be given to gram panchayats and municipalities and 100 per cent village electrification targeted by May 01, 2018.

The government has already taken steps to address two major factors (soil and water) critical to improve agriculture production. Steps have been taken to improve soil fertility on a sustainable basis through the soil health card scheme and to support the organic farming scheme 'Paramparagat Krishi Vikas Yojana'. Other steps include improved access to irrigation through 'Pradhanmantri Gram Sinchai Yojana'; enhanced water efficiency through `Per Drop More Crop'; continued support to Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) and the creation of a unified national agriculture market to boost the incomes of farmers.

The Government of India recognises the importance of micro irrigation, watershed development and 'Pradhan Mantri Krishi Sinchai Yojana'; thus, it allocated a sum of Rs 5,300 crore (US$ 777.6 million) for it. It urged the states to focus on this key sector. The state governments are compelled to allocate adequate funds to develop the agriculture sector, take measures to achieve the targeted agricultural growth rate and address the problems of farmers.

The Department of Agriculture and Cooperation under the Ministry of Agriculture has inked MOUs/agreements with 52 countries including the US. In addition, the Department of Agriculture Research & Education (DARE) and the Department of Animal Husbandry, Dairying & Fisheries (DAHD&F) under the Ministry of Agriculture have signed MOUs/agreements with other countries, taking the number of partnerships with other countries to 63. These agreements would provide better agricultural facilities in areas such as research and development, capacity building, germ-plasm exchange, post-harvest management, value addition/food processing, plant protection, animal husbandry, dairy and fisheries. The agreements could help enhance bilateral trade as well.

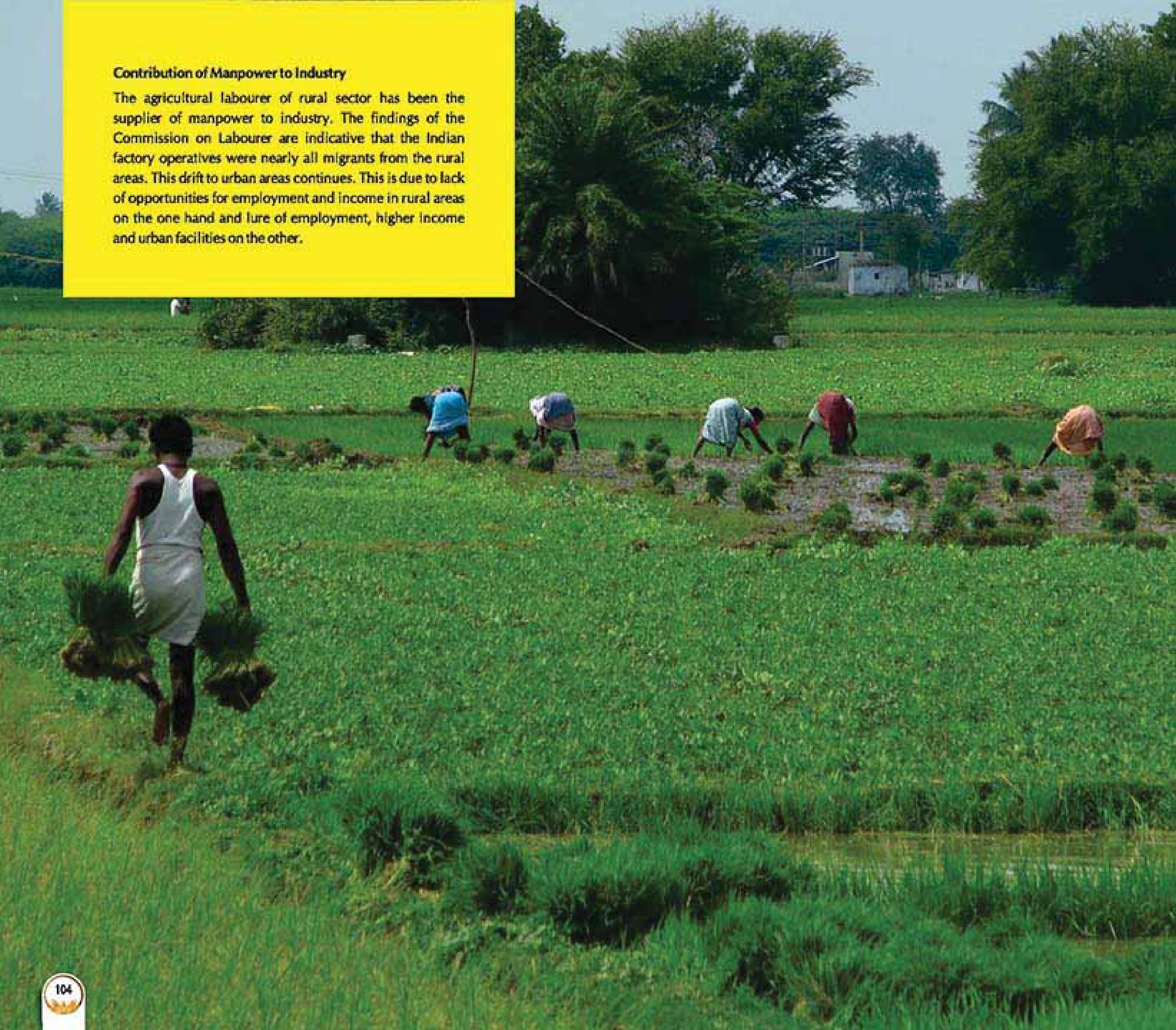
Given the correlation between improvement in agriculture and the development of the country, the Government of India adopted several initiatives and programmes to ensure continuous growth. It allocated Rs 25,000 crore (US$ 3.67 billion) for the Rural Infrastructure Development Fund (RIFD), Rs 1,500 crore (US$ 220 million) for the long-term rural credit fund, Rs 45,000 crore (US$ 6.60 billion) for the short-term cooperative rural credit finance fund and Rs 25,000 crore (US$ 3.67 billion) for the short-term Regional rural bank (RRB) refinance fund. It also marked an ambitious target of Rs 8.5 lakh crore (US$ 124.71 billion) of agriculture credit during 2015–16.

Some of the recent major government initiatives in the sector are as follows:

- Hon'ble Prime Minister Sri Narendra Modi Ji has unveiled the operational guidelines for the Pradhan Mantri Fasal Bima Yojana which aims to provide farmers with crop insurance as well as
- The Cabinet Committee on Economic Affairs (CCEA) has approved 'Blue Revolution', an umbrella scheme for integrated development and management of fisheries by Government of India, with total financial outlay of Rs 3,000 crore (US$ 440.15 million) for a period of five years.
- Hon'ble Sri Piyush Goyal, Minister of Power, Coal, New and Renewable Energy has announced that government's plans to invest Rs 75,000 crore (US$ 11.08 billion) in an energy-efficient irrigation scheme over the next three to four years.
- The new crop insurance scheme for farmers 'Bhartiya Krishi Bima Yojana' aims to cover 50 per cent of the farmers under the scheme in the next two-three years,
- India and Lithuania have agreed to intensify agricultural cooperation, especially in sectors like food and dairy processing.
- Gujarat Government has planned to connect 26 Agricultural Produce Market Committees (APMCs) via electronic market platform, under the National Agriculture Market (NAM) initiative.
- The State Government of Telangana plans to spend Rs 81,000 crore (US$ 11.88 billion) over the next three years to complete ongoing irrigation projects and also undertake two new projects for lifting water from the Godavari and Krishna river.
- The National Dairy Development Board (NDDB) announced 42 dairy projects with a financial outlay of Rs 221 crore (US$ 32.42 million) to boost milk output and increase per animal production of milk.
- Government of India has set up an inter-ministerial committee, which will look into ways to examine the potential of Indian agriculture, identify segments with potential for growth, and work towards doubling farm incomes by 2022.
- The Government of India has allocated Rs 200 crore (US$ 29.9 million) for electronically linking 585 major wholesale agriculture markets across the country, thereby creating a National Agriculture Market (NAM). in July 2015 for three years

Contribution of Manpower to Industry

The agricultural labourer of rural sector has been the supplier of manpower to industry. The findings of the Commission on Labourer are indicative that the Indian factory operatives were nearly all migrants from the rural areas. This drift to urban areas continues. This is due to lack of opportunities for employment and income in rural areas on the one hand and lure of employment, higher income and urban facilities on the other.



Interdependence between Agriculture and Industry

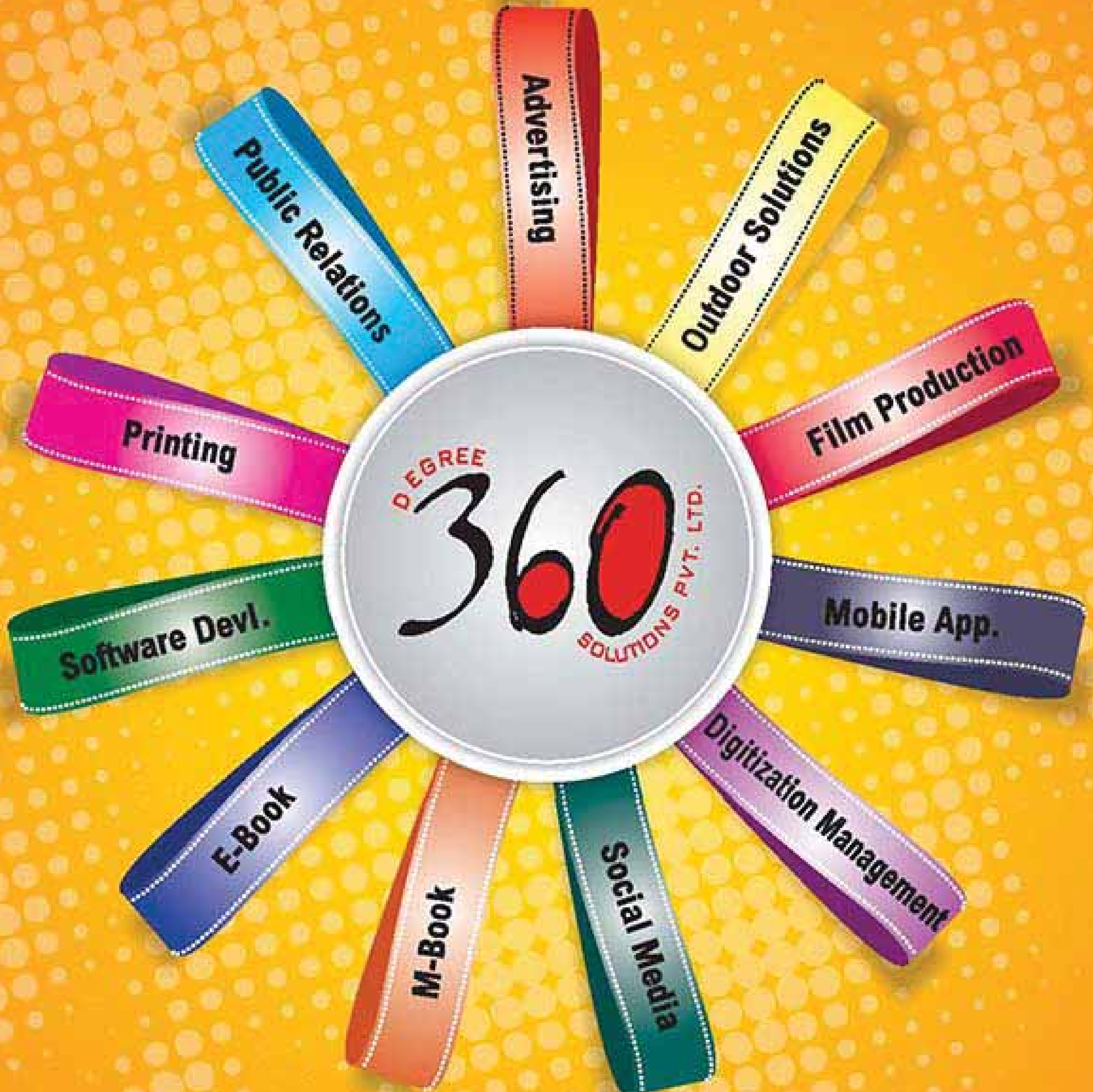
There is a close interdependence between agriculture and industry. This is to the supply of raw materials and inputs from agriculture to industry and vice-versa; secondly, the supply of wage goods to the industrial sector; thirdly, the supply of basic consumption goods to the agricultural population; and finally, the supply of materials for the building up of economic and social overheads in the agricultural sector. The interdependence between agriculture and industry is becoming stronger as the economy is developing. The application of science and technology in agriculture induces innovations in respect of industrial products, which are used for agricultural production. Agricultural inputs like fertilizers, pesticides, diesel oil, electric motor, diesel engines, pump sets, agricultural tools and implements, tractors, power tillers etc., are supplied by the industry and oil, sugar, jute and cotton textiles and tobacco industries rely heavily on the agricultural sector. Even the processing industries, which are utilizing agricultural raw material, and developing fruit canning, milk products, meat products etc.

Contribution to Capital Formation

The pace of development is largely determined by the rate at which production assets increase. Before independence, the capital formation in Indian agriculture was of a low order. During this period, agriculture suffered from constant low yield technology, inequitable land tenure system and exploitation of the rural masses. The capital formation includes land development, construction of houses etc. Since independence, much more investment both public and private has been made in agriculture. The creation of physical assets has generally taken the form of land development, construction of irrigation facilities, roads and communication, farm buildings, agricultural machinery and equipment, warehouses, cold storages, market yard etc. This capital formation is helping not only development of agriculture but also the entire economy

Contribution to Purchasing Power of People

Agriculture provides purchasing power not only to those directly engaged in it but to others also who are in the industries and services. When farmers earn more they also spend more. In the process, they create new markets and new opportunities for hundreds of blacksmiths, carpenters, masons, weavers, potters, leather workers, utensil-makers, tailors, cotton ginners, oil pressers, transporters and countless others. Thus, there are many industries, the prosperity and employment of which are dependent upon the purchasing power of the agricultural population. Hence, it is concluded that besides purchasing food for non-agricultural workers and raw materials for consumer industries, it has created demands for a great many new industries, which, in turn, have provided high and well paid employment. This existing role of agriculture in the Indian economy points out the necessity for the development of Indian agriculture to the fullest extent possible as the prosperity of agriculture largely stands for the prosperity of the economy. The significance of agriculture lies in the fact that the development in agriculture is an essential condition for the development of the national economy.


DEGREE
360
SOLUTIONS PVT. LTD.
Advertising
Outdoor Solutions
Film Production
Mobile App.
Digitization Management
Social Media
M-Book
E-Book
Software Devl.
Printing
Public Relations


380
CASE IH

UNIT: 6

Global Agriculture Mechanization - An Overview

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity. In modern times, powered machinery has replaced many jobs formerly carried out by manual labour or by working animals such as oxen, horses and mules. Current mechanized agriculture includes the use of tractors, trucks, combine harvesters, airplanes (crop dusters), helicopters, and other vehicles. Modern farms even sometimes use computers in conjunction with satellite imagery and GPS guidance to increase yields. Mechanization was one of the large factors responsible for urbanization and industrial economies. Besides improving production efficiency, mechanization encourages large scale production and improves the quality of farm produce. On the other hand, it displaces unskilled farm labour, causes environmental pollution, deforestation and erosion.

Jethro Tull's seed drill (ca. 1701) was a mechanical seed spacing and depth placing device that increased crop yields and saved seed. It was an important factor in the British Agricultural Revolution. The seed drill is a mechanical device for spacing and planting seed at the appropriate depth. It originated in ancient China before the 1st century BC. Saving seed was extremely important at a time when yields were measured in terms of seeds harvested per seed planted, which was typically between 3 and 5. The seed drill also saved planting labour. Most importantly, the seed drill meant crops were grown in rows, which reduced competition of plants and increase yields. It was reinvented in 16th century Europe based on verbal descriptions and crude drawings brought back from China. Jethro Tull patented a version in 1700; however, it was expensive and unreliable. Reliable seed drills appeared in the mid-19th century.

Since the beginning of agriculture threshing was done by hand with a flail, requiring a great deal of labor. The threshing machine, which was invented in 1794 but not widely used for several more decades, simplified the operation and allowed the use of animal power. Before the invention of the grain cradle (ca. 1790) an able bodied laborer could reap about one quarter acre of wheat in a day using a sickle. It was estimated that for each of Cyrus McCormick's horse pulled reapers (ca. 1830s) freed up five men for military service in the U.S. Civil War. Later innovations included raking and binding machines. By 1890 two men and two horses could cut, rake and bind 20 acres of wheat per day.

In the 1880s the reaper and threshing machine were combined into the combine harvester. These machines required large teams of horses or mules to pull. Steam power was applied to threshing machines in the late 19th century. There were steam engines that moved around on wheels under their own power for supplying temporary power to stationary threshing machines. These were called *road engines,* and Henry Ford seeing one as a boy was inspired to build an automobile.

With internal combustion came the first modern tractors in the early 1900s, becoming more popular after the Fordson tractor (ca. 1917). At first reapers and combine harvesters were pulled by tractors, but in the 1930s self-powered combines were developed.

Since the beginning of agriculture threshing was done by hand with a flail, requiring a great deal of labour. The threshing machine (ca. 1794) simplified the operation and allowed it to use animal power. By the 1860s threshing machines were widely introduced and ultimately displaced as much as a quarter of agricultural labour. In Europe, many of the displaced workers were driven to the brink of starvation.

Before c. 1790 a worker could harvest 1/4 acre per day with a scythe. In the early 1800s the grain cradle was introduced, significantly increasing the productivity of hand labour. It was estimated that each of Cyrus McCormick's horse pulled reapers (Ptd. 1834) freed up five men for military service in the U.S. Civil War. By 1890 two men and two horses could cut, rake and bind 20 acres of wheat per day. In the 1880s the reaper and threshing machine were combined into the combine harvester. These machines required large teams of horses or mules to pull. Over the entire 19th century the output per man hour for producing wheat rose by about 500% and for corn about 250%.

Advertising for motorized equipment in farm journals during this era did its best to compete against horse-drawn methods with economic arguments, extolling common themes such as that a tractor "eats only when it works", that one tractor could replace many horses, and that mechanization could allow one man to get more work done per day than he ever had before. The horse population in the U.S. began to decline in the 1920s after the conversion of agriculture and transportation to internal combustion. Peak tractor sales in the U.S. were around 1950. In addition to saving labor, this freed up much land previously used for supporting draft animals. The greatest period of growth in agricultural productivity in the U.S. was from the 1940s to the 1970s, during which time agriculture was benefiting from internal combustion powered tractors and combine harvesters, chemical fertilizers and the green revolution.

Farm machinery and higher crop yields reduced the labour to produce 100 bushels of corn from 35 to 40 hours in 1900 to 2 hours 45 minutes in 1999. The conversion of agricultural mechanization to internal combustion power began after 1915. The horse population began to decline in the 1920s after the conversion of agriculture and transportation to internal combustion. In addition to saving labour, this freed up much land previously used for supporting draft animals.

The peak years for tractor sales in the U.S. were the 1950s. There was a large surge in horsepower of farm machinery in the 1950s.

Although farmers of corn, wheat, soy, and other commodity crops had replaced most of their workers with harvesting machines and combines enabling them to efficiently cut and gather grains, growers of produce continued to rely on human pickers to avoid the bruising of the product in order to maintain the blemish-free appearance demanded of consumers. The continuous supply of illegal workers from Latin America that were willing to harvest the crops for low wages further suppressed the need for mechanization. As the number of illegal workers has continued to decline since reaching its peak in 2007 due to increased border patrols and an improving Mexican economy, the industry is increasing the use of mechanization. Proponents argue that mechanization will boost productivity and help to maintain low food prices while farm worker advocates assert that it will eliminate jobs and will give an advantage to large growers who are able to afford the required equipment.

Select Examples of Advanced Applications of Global Agricultural Mechanization

Asparagus harvesting: Asparagus are presently harvested by hand with labor costs at 71% of production costs and 44% of selling costs. Asparagus is a difficult crop to harvest since each spear matures at a different speed making it difficult to achieve a uniform harvest. A prototype asparagus harvesting machine - using a light-beam sensor to identify the taller spears - is expected to be available for commercial use.

Blueberry harvesting: Mechanization of Maine's blueberry industry has reduced the number of migrant workers required from 5,000 in 2005 to 1,500 in 2015 even though production has increased from 50-60 million pounds per year in 2005 to 90 million pounds in 2015.

Chili Pepper harvesting: As of 2014, prototype chili pepper harvesters are being tested by New Mexico State University. The New Mexico green chili crop is currently hand-picked entirely by field workers as chili pods tend to bruise easily. The first commercial application commenced in 2015. The equipment is expected to increase yield per acre and help to offset a sharp decline in acreage planted due to the lack of available labor and drought conditions.

Orange harvesting: As of 2010, approximately 10% of the processing orange acreage in Florida is harvested mechanically. Mechanization has progressed slowly due to the uncertainty of future economic benefits due to competition from Brazil and the transitory damage to orange trees when they are harvested.

Raisin harvesting: As of 2007, mechanized harvesting of raisins is at 45%; however the rate has slowed due to high raisin demand and prices making the conversion away from hand labor less urgent. A new strain of grape developed by the USDA that dries on the vine and is easily harvested mechanically is expected to reduce the demand for labor.

Strawberry harvesting: Strawberries are a high cost-high value crop with the economics supporting mechanization. In 2005, picking and hauling costs were estimated at $594 per ton or 51% of the total grower cost. However, the delicate nature of fruit make it an unlikely candidate for mechanization in the near future. A strawberry harvester developed by Shibuya Seiki and unveiled in Japan in 2013 is able to pick a strawberry every eight seconds. The robot identifies which strawberries are ready to pick by using three separate cameras and then once identified as ready, a mechanized arm snips the fruit free and gently places it in a basket. The robot moves on rails between the rows of strawberries which are generally contained within elevated greenhouses. The machine costs 5 million yen. A new strawberry harvester made by Agrobot that will harvest strawberries on raised, hydroponic beds using 60 robotic arms is expected to be released in 2016.

Tomato harvesting: Mechanical harvesting of tomatoes started in 1965 and as of 2010, nearly all processing tomatoes are mechanically harvested. As of 2010, 95% of the U.S. processed tomato crop is produced in California.[17] Although fresh market tomatoes have substantial hand harvesting costs (in 2007, the costs of hand picking and hauling were $86 per ton which is 19% of total grower cost), packing and selling costs were more of a concern (at 44% of total grower cost) making it likely that cost saving efforts would be applied there.

According to a 1977 report by the California Agrarian Action Project, during the summer of 1976 in California, many harvest machines had been equipped with a photo-electric scanner that sorted out green tomatoes among the ripe red ones using infrared lights and color sensors. It worked in lieu of 5,000 hand harvesters causing displacement of innumerable farm laborers as well as wage cuts and shorter work periods. Migrant workers were hit the hardest. To withstand the rigor of the machines, new crop varieties were bred to match the automated pickers. UC Davis Professor G.C. Hanna propagated a thick-skinned tomato called VF-145. But even still, millions were damaged with impact cracks and university breeders produced a more tougher and juiceless "square round" tomato. Small farms were of insufficient size to obtain financing to purchase the equipment and within 10 years, 85% of the state's 4,000 cannery tomato farmers were out of the business. This led to a concentrated tomato industry in California that "now packed 85% of the nation's tomato products". The monoculture fields fostered rapid pest growth, requiring the use of "more than four million pounds of pesticides each year" which greatly affected the health of the soil, the farm workers, and possibly the consumers.

TAFE

Cultivating The World

The genesis of one of the world's largest manufacturers of tractors is surprisingly from Alwarkurichi, a village deep in the Southern part of Tamil Nadu. S. Anantharamakrishnan, born into a agricultural family, qualified as an accountant and moved to Madras as it was known then as an articled clerk with a leading accounting firm. He joined Simpson & Co Ltd in 1930 as the Secretary and in 16 years, rose to become Chairman of the Simpson group or Amalgamations group of Companies as it is now known.

In 1960 when an opportunity, to take over and progressively manufacture Massey Ferguson Tractors in India, from Massey Ferguson India Limited presented itself to Simpson's, the group took advantage of it. On December 15th, 1960, Anantharamakrishnan announced his plans to manufacture agricultural tractors and farm implements at a factory to be set up at the group's industrial estate at Sembium, in association with Massey Ferguson.

The plant went on stream with a licensed capacity of 7000 tractors a year, indeed a far cry from the present production of about 600 tractors a day from 3 plants in India and a plant in Turkey. Beginning with just one model, the now iconic MF 1035, TAFE pioneered farm mechanization in India, through the relentless efforts of a sales team, who often had to cajole back farmers who fled at the appearance of the tractor fearing it to be monster!

The initial years were challenging. Indian industry was just beginning to grow and components shortage was a daily routine. TAFE's first manufacturing facilities at Sembium near Chennai went on stream in 1961-62 and a machine shop for critical components was set up in 1963. These were further expanded and added to during 1965-1967. The R&D centre was also started at this point.

Under the often draconian controls imposed on the tractor industry then, it was impossible to even raise prices to offset increased input costs, without government approval. The manufacturing and the R&D team were extended tremendously in ensuring that the products developed and manufactured were within the price controls imposed by the then government, while maintaining quality.

Former Chairman of TAFE, Mr. A. Sivasailam driving out first tractor produced in Sembium

TAFE established a distribution network of professionally run, well equipped tractor dealerships that were the best in the automobile industry. To maintain the quality of the distribution network and ensure that its products received the best of product support after sales, TAFE established its Product Training Centre at J Farm, Kelambakkam about 50 kilometres from Chennai in 1964. J Farm is a Government recognised Adaptive research centre, about which a detailed report is available elsewhere in this volume. The training centre trains TAFE's employees, dealer personnel, agriculture students and other stakeholders. Equipped with the entire product range of TAFE and staffed by multi lingual experienced trainers, the centre offers class room, field and work shop training, with ample audio visual training films and hands on experience in stripping and re-assembling various tractor aggregates, trouble shooting, field adjustments on farm Machines and in operating them safely, effectively and efficiently.

Despite challenges, to meet the growing demand, CKD packs were imported from Yugoslavia and assembled in India at multiple assembly points and distributed. TAFE continued to grow and the demand for its tractors far outstripped the production capacity. The government enacted the Tractor Distribution and Sale Control order in 1971, which had its own set of procedures to be followed and tractors were allocated to dealers on pro-rata basis depending on the waiting list for tractors at each dealership which had to be on the basis of Post Office Savings Book with a Rs. 1000 deposit as evidence of the booking being genuine! TAFE's second tractor model, a 50 HP tractor powered by a Perkins four cylinder engine was introduced in 1974. This was followed a few years later with the MF 245, the first Indian tractor with power steering!

With this the product portfolio of tractors at TAFE included MF 1035, TAFE 504 and MF 245. Assembly of tractors continued till the mid-eighties at two assembly points in South India viz., Kumbakonam and at Madurai, using the facilities of other group companies apart from Chennai. A new 25 HP tractor was introduced in 1987. The second tractor plant was established in 1988 at Doddaballapur. 1998 saw the establishing of TAFE's state of the art plant for tractor manufacture at Kallidaipatti near Madurai.

TAFE pioneered the introduction of Direct Injection technology in tractors with the launch of MF 1035 DI tractor in 1989, which went on to become a run-away success. In 1992, a new tractor, TAFE 30 DI was launched and TAFE had a range of tractors in the 25 to 50 HP segment with 5 models to choose from. Export of TAFE's tractors commenced in 1992 with initial exports going to Sri Lanka and Bangladesh, the next year tractors were exported to the US, Croatia and the Maldives and during the decade, went on into New Zealand, Turkey, Canada, Tunisia, UK, Zambia and South Africa. Four wheel drive tractors were introduced and even exported. As sales increased and distribution channels grew, the need for upgrading systems was felt and 1999 saw the introduction of SAP across the company with plants, offices and depots connected by v-sat linkages for real time data processing and communication, a first in this industry.

This was also decade of growth in sales brought about by greater availability and the initiation of innovative brand building activities and customer loyalty programs. The Nineties saw the launch of planned advertising and promotional activities across India. TAFE brought about a paradigm shift in the market place by bringing customers closer to it through All India tractor operation skills contests such as Krishi Ratna and pioneered customer visits to its facilities to enable two way communication with the final customers. TAFE introduced India's first 75 HP tractor in 1997. The end of the nineties however, saw the entire tractor industry go through a very traumatic meltdown that lasted till 2003.Being a lean organisation, TAFE was able to weather this storm and continue to remain profitable.

The HR function grew in strength from the 90s with well-designed performance management programs, skill development programs, employee career planning and accelerated growth programs for high achievers being initiated. Employee diversity increased with more women and more employees from various parts of India coming together to form a cross cultural amalgamation that strived towards achieving corporate goals.

*In the new millennium, post 2003, TAFE's sales began to grow rapidly. 2005 was a landmark in TAFE's history. TAFE acquired Eicher's tractor business, its engine plant at Alwar and transmission components plant at Parwanoo, in a move that surprised industry, through a wholly owned subsidiary **TAFE Motors and Tractors Limited**, TMTL for short.*

Eicher tractors came into being in 1961 about the same time as TAFE's inception. It was well known for its products and had a very strong brand pull and user base, especially in markets like UP, Bihar and MP where the latent need for graduating from animal power to tractor power was ably met by Eicher tractors. Beginning with air- cooled tractors of 24 HP the brand moved into water cooled tractors also but had a limited market for them then.

The acquisition was very clearly and meticulously carried out and has been a great success with both TAFE and TMTL registering individual growth in sales numbers, revenues and profitability. The product portfolios of both companies

Massey Ferguson | TAFE Tractors | Eicher Tractors
Diesel Engines | Gears & Transmissions
Engineering Plastics | Batteries
Hydraulic Pumps | Vehicle Sales | Plantations

complemented each other and the synergies of this coming together were ably leveraged by both organisations.

This decade also saw a slew of products and variants being launched in the domestic and international markets by TAFE and TMTL. This included the first oil immersed brakes, special purpose tractors for orchards, paddy, compressor and several other applications under the MF brand. TMTL was not left behind and they quickly leveraged the synergies of the coming together with a number of new air and water cooled models in the higher than 30 HP range. TMTL has also introduced a number of new product features and has invested extensively in technology and development initiatives in manufacturing, marketing and R & D. TMTL has progressively increased capacity and is now producing and selling about 3 times its volumes at the time of takeover. From being a less than 30 HP tractor seller, today close to 80 % of its sales is from the higher than 30 HP segment and from predominantly being an air cooled tractor producer, half its current production and sale is of water cooled tractors.

The first decade of the new millennium saw TAFE move from ISO certification to following the Business Excellence Model with a fair amount of success culminating in garnering recognition at the CII- EXIM Bank Business Excellence assessments. Extensive modernisation, increased efforts on supply chain performance, tremendous work with vendors and collaborators in joint product development and joint market development, have resulted in TAFE acquiring extensive experience and skills to address a cyclical market as well as meet the demands of

discerning customers in both developed and developing economies.

Till the early nineties, TAFE was actively supplying a range of farm implements and accessories to match the tractors it produced. Consequent to this sector being reserved for the small scale, it slowly moved out of the segment. However the last decade has seen the sector being thrown open to all and TAFE estimates this to be a great growth opportunity. Consequently TAFE's Applications Business Unit has been set up to produce and distribute a range of implements and other equipment for mechanising Indian farms. A range of rotary tillers and combine harvesters have already been launched successfully and more innovative products are on the anvil.

The year 2013 saw TAFE foray overseas by establishing a green field venture in Turkey that produces a range of Massey Ferguson Tractors there for sale through our collaborators distribution network. The factory, located at Manisa, near Izmir has been producing a range of tractors for the Turkey market and because of its strategic location, could also service other markets nearby. TAFE has also established recently a component facility for tractors in China to service global demands for components and aggregates.

TAFE today is recognised as a quality mass manufacturer of reliable cost effective and dependable tractors with a strong commitment to quality and a customer centric approach to business. TAFE's success over the years can be attributed to a number of factors but at TAFE, we believe, it has been our consistent focus on our core values that has brought us to this level and will continue to sustain and strengthen us in the coming years.

The genesis and vision of Jfarm

TAFE's former chairman, Dr. A. Sivasailam's vision extended beyond design, production and sale of tractors and farm equipment. He was deeply committed to improving the wellbeing of farmers by empowering them with advanced farm technologies to increase farm productivity and meet India's growing food needs. This led to his establishing J farm in 1964 in barren marginally rain fed scrub land near Chennai ,to effectively demonstrate how transition from traditional labor intensive, low productivity farming to situation relevant, cost effective, viable and sustainable farming could be a reality.

The TAFE's J farm is an adaptive research centre, spread over 200 acres of land. It incorporates the well-equipped Product Training Centre of TAFE, which is one of the earliest such institutions in India offering multi- lingual training in operation and maintenance of farm machinery and tractors through class room , workshop and field training.

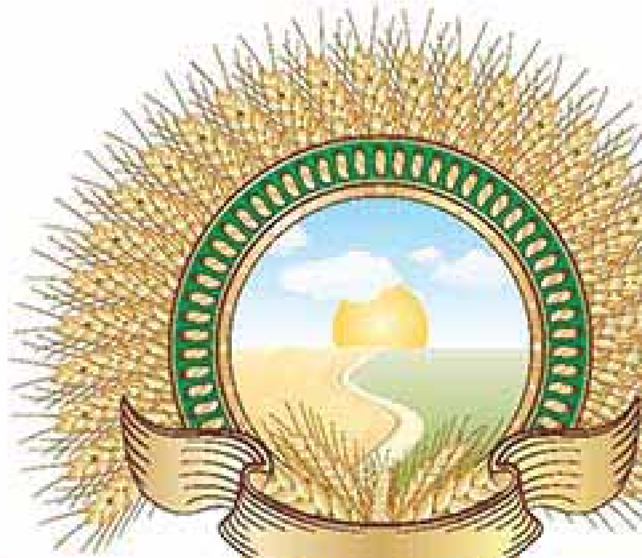
Now verdant J farm was the result of dedicated efforts by a team of farm scientists. With just 19 days of rain at the most in a year, J farm depended on limited ground water. Farmers of surrounding areas traditionally cultivated paddy and farming was not remunerative.

Over the years, TAFE's J farm has worked in this challenging situation to develop a viable and sustainable model using a mix of proper seed selection, appropriate mix of food and cash crops, scientific and ecofriendly farming, relevant mechanization and rigorous assessment of farm economy. Today its model of multi cropping, effective irrigation, balanced nutrient, integrated farming is being emulated by others nearby and cash crops like fruits and vegetables have transformed the economy of the surrounding area.

The objectives of J farm are:

- Propogate TAFE's integrated farming model and mechanisation that brings together farming & animals husbandry, relevant mechanisation and balanced nutrient management
- Demonstrating reduction of drudgery in agriculture through the use of appropriate farm technology and farm equipment.
- Identifying improved varieties in crops such as rice, pulses and oilseeds that offer good yield, high quality and can be grown at low risk.
- Producing and distributing seeds of these varieties to farmers
- Demonstrating of sustainable farming through multi- cropping.
- Disseminating information on modern farm practices through different media and TAFE's farm portal www.jfarmindia.com
- Training all stake holders on farm practices and mechanization
- Field testing of implements/equipment/machineries
- Encourage and empower people to continue in farming
- Promote and propagate eco-friendly farming


9000 MASSEY FERGUSON
PLANETARY DRIVE
TAFE



Partnering in the Green Revolution and beyond

The Green revolution ushered several high yielding varieties of wheat and rice along with improved agricultural technologies involving use of proven seeds, fertilizers and pesticides into the country. J farm is credited with popularizing several varieties of rice, pulses and oilseeds as well as releasing several varieties of rice for large scale multiplication.

Rice

J Farm promoted IR50 rice variety in TamilNadu, India and developed new varieties like super fine table varieties of White Ponni and J13 (100 days crop), J18 (organic rice) and the super-fast J66 (85 days crop), catering to requirements of different cultivating regions and categories of farmers

Mango

This centre identified a drought tolerant mutant strain 'Yahuti Rumani' from the traditional Rumani mango variety. The model "Yahuti Rumani" orchard spread over 20 acres with about 2500 trees firmly establishes the fact that mango is a highly profitable option for drought prone areas.

Vegetables

Organic cultivation of a wide range of tropical vegetables is undertaken using enriched vermi-compost. The dairy maintained at Jfarm is the source of raw material for vermicomposting. The vegetables and fruits cultivated include okra, brinjal, pumpkin, water melon and an array of tropical gourds. Seeds of promising varieties are also distributed to farmers.

Oilseeds

'J' farm developed the popular drought tolerant red kernel groundnut variety J20 that matures in 80 days and contains 52% oil.

Pulses

The centre took upon itself the task of popularizing several varieties of black gram like T9, ADT3 and ADT5 to demonstrate that cultivation of pulses can be remunerative even in dry areas.

Biodiversity Park

A biodiversity park consisting of 132 trees belonging to 31 tree species has been created in an area of one acre. Also, a pure forestry area consisting of 350 trees like teak, white teak, Melia is maintained in an area of 1.5 acres.

Agri portal-www.jfarmindia.com

Launched in the year 2000, this unique multi-lingual(English,Tamil and Hindi) portal supported with over 200,000 photographs provides in depth and relevant information on crop production, protection and processing technologies for major and minor crops of India in English, Hindi and Tamil. Adopting technologies presented in the portal, farmers can increase yield by 15-20% over the present yield.

The portal provides a visually rich and extensive information on pests and diseases, their symptoms and their reliable season-long management techniques using proper pesticides and bio-agents, where feasible. Additionally, information on cultivation of 30 medicinal and 20 aromatic crops and description of laboratory processes leading to isolation of their active principles is shared in the site. A photo gallery of 58 lesser known medicinal plants and claims of their therapeutic use and information on 31 forest trees is also described in the portal.

Trends in the use of farm implements, equipment and machinery (manual/animal drawn/tractor operated) available for various farm operations are presented in the site. In addition, exhaustive information with photographs on prototypes / models of implements /equipment/ machinery developed for various operations in 24 major crops is offered. The portal also provides addresses of agri-input and machinery dealers and rainfall data.

A collection of 44 allied topics, relevant to farming and cropping systems are hosted in the portal.

Other Initiatives

Various extension services are being carried out at 'J' farm including farm advisory services to associated farmers, publication of articles in various media, agricultural journals, presenting & participation in seminars & symposia organized by Government institutions.

Integrated Farming for small and marginal farms

J farm has evolved suitable strategies to augment farm income by integrating various agricultural enterprises viz. cropping, animal husbandry, agro forestry, orchard farming etc. Integrated farming takes care of optimal utilization of resources and recycling of waste for productive purposes.

Seeds

The objective of seed distribution at J farm is not commercial but akin to the mini kit trials in agricultural research station and only small quantity of seeds of high yielding varieties is handled. The farmer who obtains the seeds from J farm helps his neighbours and friends to grow this variety thus enabling its rapid spread.

Organic Farming

J farm has over the past decade taken a lead in organic farming and has shown farmers the way to reap richer harvests. Some of the techniques demonstrated in J farm include use of vermicompost enriched with bio fertilizers and bio pesticides to increase soil fertility and the use of neem seed kernel extract to combat pests. This is in addition to the traditional technologies like green manuring, use of oil cakes and farm yard manure.

Soil Conservation and Management

Different soil conservation methods viz., erosion control with conservation tillage, crop rotation, growing of cover crops and wind break vegetation and perimeter run off control is practiced. J farm also gives solution for reclamation of problem soils such as acidic, acid sulphate, saline, sodic and saline-sodic soils.

Water Management

J farm has successfully demonstrated the benefits accrued from rainwater harvesting by harnessing water stored in huge tanks for agricultural operations. The water is collected in a huge tank spread over an area of 5 acres and this water is used for recharging open wells and sustains crops over the period of next 10 months.

Prior to the onset of monsoon rains, the sub soiler is used to break the hard pan in the fields and to promote the percolation of water into the deeper layers of soil.

Formation of compartmental bunds, scoops, crescent bunding and shelter belts to conserve soil forms an integral part of the model.

Viability of the JFarm model for developing economies

Fertilizers

Indiscriminate use of chemical fertilizers has resulted in soils becoming acidic, saline or saline sodic. Reclamation of these problem soils poses a challenge to Indian agriculture. J farm has successfully demonstrated the reclamation of saline soils for mango cultivation. Besides, reduced application of NPK fertilizers blended with organic inputs like farm yard manure, vermicompost and bio fertilizers in an integrated way is also advocated for producing crops.

Mechanization solutions

Appropriate use of farm implements and machinery in various crops, including their imaginative use to suit local farming conditions by changing planting geometry of crops is regularly practised and demonstrated. Several farmers have benefited using them and saved cost, time and labour.

Farm Economics

The technologies imparted at J farm are not only easily accessible but also cost effective. It demonstrates how to get the maximum profit at the lowest costing, making farming a viable business enterprise.

***Venkatapathy Reddiar** is today an acknowledged authority on tissue culture of Crossandra infundibuliformis (fire cracker flower) and Casuarina equisetifolia Forst (acacia) and recognized for his work both in India and overseas. He started with J Farm on sustainable agriculture, transitioning from mono-cropping to multi-cropping and today is an acclaimed success in his area. He has been honored with the President of India's award and holds several patents for his work in developing crossandra.*

***Kuttanad** is a low lying area on the western coast of India, where paddy is cultivated at 1.5 to 2 metres below sea level. As the area has extensive monsoon rains and because of the low level of land, the fields are waterlogged and the presence of the sea nearby results in leaching of the sea water into the fields. The farmers in the area have a unique co-operative system of farming by which groups of farmers, collectively put up high walls around the field and have a system of drainage canals around them. The water in the fields is lower than the drain level and is therefore continuously pumped out as a collective exercise. Each individual farmer then cultivates paddy and at the time of harvest, the entire group of fields or **Padasegara** as it is called is harvested with machinery. This is a well acknowledged success story, recognized worldwide. As, the soil is acidic because of a combination of causes, the fields were traditionally being limed. However this cost was escalating and J farm was approached for solutions. We evolved a combination of efforts that include cultivation of other short term crops to counter the acidity other suitable methods on a case to case basis and we have achieved significant success.*

UNIT: 7

Agricultural Machinery – History Depicting Evolution

The history of agriculture contains many examples of tool use, such as the plough. Mechanization involves the use of an intermediate device between the power source and the work. This intermediate device usually transforms motion, such as rotary to linear, or provides some sort of mechanical advantage, such as speed increase or decrease or leverage.

The Industrial Revolution

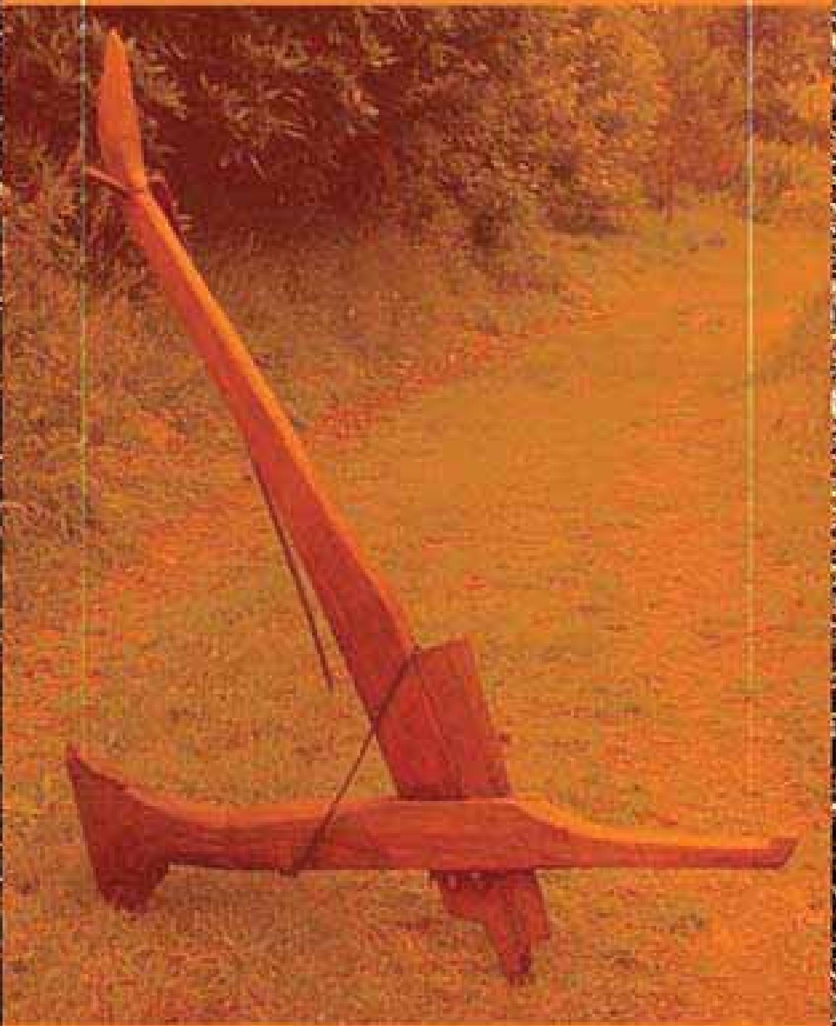
With the coming of the Industrial Revolution and the development of more complicated machines, farming methods took a great leap forward. Instead of harvesting grain by hand with a sharp blade, wheeled machines cut a continuous swath. Instead of threshing the grain by beating it with sticks, threshing machines separated the seeds from the heads and stalks. The first tractors appeared in the late 19th century.

Steam power

Power for agricultural machinery was originally supplied by ox or other domesticated animals. With the invention of steam power came the portable engine, and later the traction engine, a multipurpose, mobile energy source that was the ground-crawling cousin to the steam locomotive. Agricultural steam engines took over the heavy pulling work of oxen, and were also equipped with a pulley that could power stationary machines via the use of a long belt. The steam-powered machines were low-powered by today's standards but, because of their size and their low gear ratios, they could provide a large drawbar pull. Their slow speed led farmers to comment that tractors had two speeds: "slow, and damn slow." relationship are hard.

Internal combustion engines

The internal combustion engine; first the petrol engine, and later diesel engines; became the main source of power for the next generation of tractors. These engines also contributed to the development of the self-propelled, combined harvester and thresher, or combine harvester (also shortened to 'combine'). Instead of cutting the grain stalks and transporting them to a stationary threshing machine, these combines cut, threshed, and separated the grain while moving continuously through the field.




MAXIM

UNIT: 8

Intensive Farming – Techniques and Technologies

Intensive farming or intensive agriculture also known as industrial agriculture is characterized by a low fallow ratio and higher use of inputs such as capital and labour per unit land area. This is in contrast to traditional agriculture in which the inputs per unit land are lower.

Intensive animal husbandry involves either large numbers of animals raised on limited land, usually confined animal feeding operations (CAFO) often referred to as factory farms, or managed intensive rotational grazing (MIRG). Both increase the yields of food and fiber per acre as compared to traditional animal husbandry. In a CAFO feed is brought to the animals, which are seldom moved, while in MIRG the animals are repeatedly moved to fresh forage.

Intensive crop agriculture is characterized by innovations designed to increase yield. Techniques include planting multiple crops per year, reducing the frequency of fallow years and improving cultivars. It also involves increased use of fertilizers, plant growth regulators, pesticides and mechanization, controlled by increased and more detailed analysis of growing conditions, including weather, soil, water, weeds and pests.

This system is supported by ongoing innovation in agricultural machinery and farming methods, genetic technology, techniques for achieving economies of scale, logistics and data collection and analysis technology. Intensive farms are widespread in developed nations and increasingly prevalent worldwide. Most of the meat, dairy, eggs, fruits and vegetables available in supermarkets are produced by such farms.

Smaller intensive farms usually include higher inputs of labor and more often use sustainable intensive methods. The farming practices commonly found on such farms are referred to as appropriate technology. These farms are less widespread in both developed countries and worldwide, but are growing more rapidly. Most of the food available in specialty markets such as farmers markets is produced by these smallholder farms.

Livestock

Confined animal feeding operations

Intensive livestock farming, also called "factory farming" is a term referring to the process of raising livestock in confinement at high stocking density. "Concentrated animal feeding operations" (CAFO) or "intensive livestock operations", can hold large numbers (some up to hundreds of thousands) of cows, hogs, turkeys or chickens, often indoors. The essence of such farms is the concentration of livestock in a given space. The aim is to provide maximum output at the lowest possible cost and with the greatest level of food safety. The term is often used pejoratively. However, CAFOs have dramatically increased the production of food from animal husbandry worldwide, both in terms of total food produced and efficiency.

Food and water is delivered to the animals, and therapeutic use of antimicrobial agents, vitamin supplements and growth hormones are often employed. Growth hormones are not used on chickens nor on any animal in the European Union. Undesirable behaviours often related to the stress of confinement led to a search for docile breeds (e.g., with natural dominance behaviours bred out), physical restraints to stop interaction, such as individual cages for chickens, or physically modification such as the de-beaking of chickens to reduce the harm of fighting.

The CAFO designation resulted from the 1972 US Federal Clean Water Act, which was enacted to protect and restore lakes and rivers to a "fishable, swimmable" quality. The United States Environmental Protection Agency (EPA) identified certain animal feeding operations, along with many other types of industry, as "point source" groundwater polluters. These operations were subjected to regulation.

In 17 states in the U.S., isolated cases of groundwater contamination were linked to CAFOs. For example, the ten million hogs in North Carolina generate 19 million tons of waste per year. The U.S. federal government acknowledges the waste disposal issue and requires that animal waste be stored in lagoons. These lagoons can be as large as 7.5 acres (30,000 m2). Lagoons not protected with an impermeable liner can leak into groundwater under some conditions, as can runoff from manure used as fertilizer. A lagoon that burst in 1995 released 25 million gallons of nitrous sludge in North Carolina's New River. The spill allegedly killed eight to ten million fish.

The large concentration of animals, animal waste and dead animals in a small space poses ethical issues to some consumers. Animal rights and animal welfare activists have charged that intensive animal rearing is cruel to animals.

Other concerns include persistent noxious odour, the effects on human health and the role of antibiotics use in the rise of resistant infectious bacteria.

According to the U.S. Centers for Disease Control and Prevention (CDC), farms on which animals are intensively reared can cause adverse health reactions in farm workers. Workers may develop acute and/or chronic lung disease, musculoskeletal injuries and may catch (zoonotic) infections from the animals.

Managed intensive rotational grazing

Managed Intensive Rotational Grazing (MIRG), also known as cell grazing, mob grazing and holistic managed planned grazing, is a variety of forage use in which herds/flocks are regularly and systematically moved to fresh, rested grazing areas to maximize the quality and quantity of forage growth. MIRG can be used with cattle, sheep, goats, pigs, chickens, turkeys, ducks and other animals. The herds graze one portion of pasture, or a paddock, while allowing the others to recover. Resting grazed lands allows the vegetation to renew energy reserves, rebuild shoot systems, and deepen root systems, resulting in long-term maximum biomass production. MIRG is especially effective because grazers thrive on the more tender younger plant stems. MIRG also leave parasites behind to die off minimizing or eliminating the need for de-wormers. Pasture systems alone can allow grazers to meet their energy requirements, and with the increased productivity of MIRG systems, the animals obtain the majority of their nutritional needs, in some cases all, without the supplemental feed sources that are required in continuous grazing systems or CAFOs.

Crops

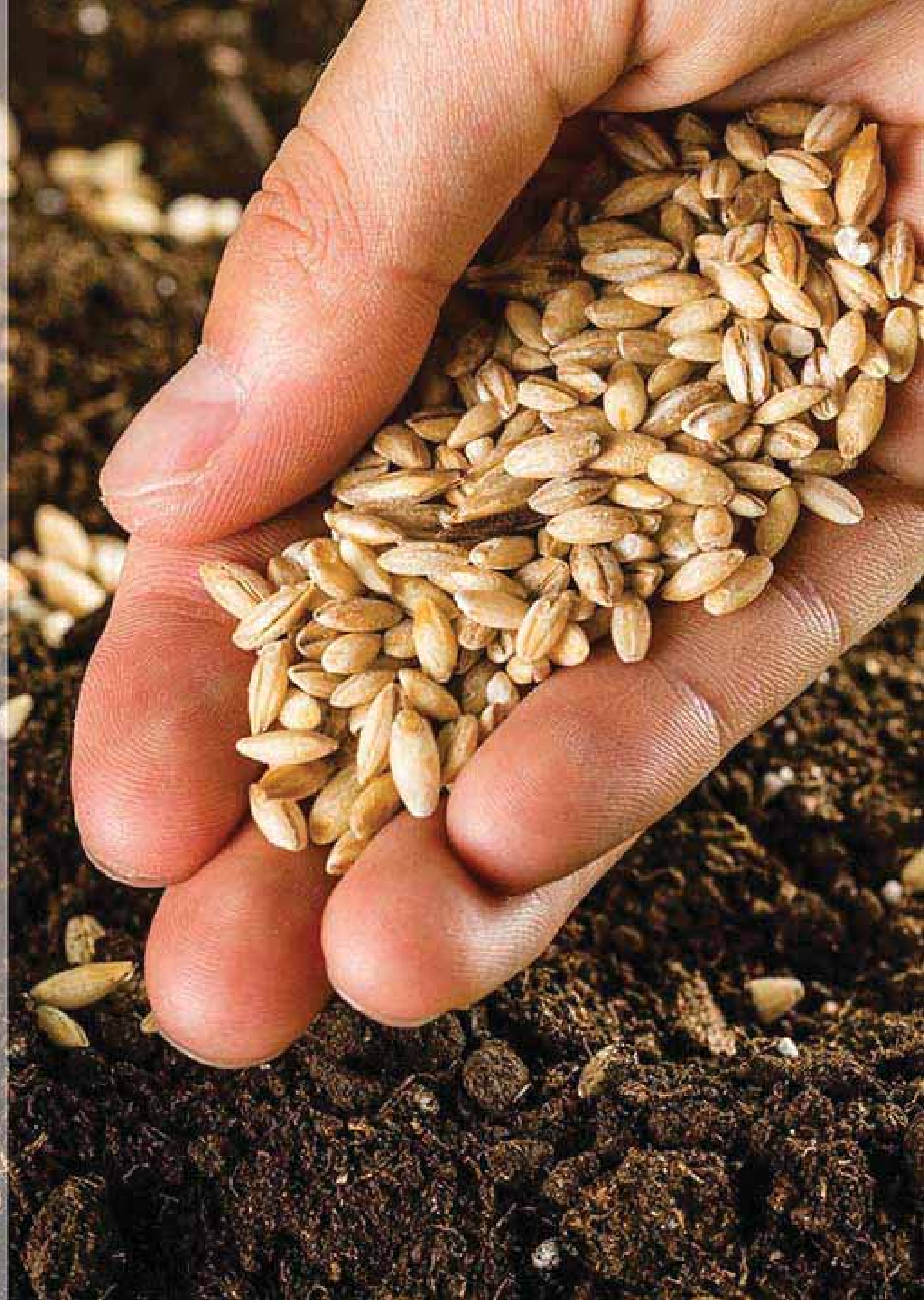
The Green Revolution transformed farming in many developing countries. It spread technologies that had already existed, but had not been widely used outside of industrialized nations. These technologies included "miracle seeds", pesticides, irrigation and synthetic nitrogen fertilizer.

Seeds

In the 1970s scientists created strains of maize, wheat, and rice that are generally referred to as high-yielding varieties (HYV). HYVs have an increased nitrogen-absorbing potential compared to other varieties. Since cereals that absorbed extra nitrogen would typically lodge (fall over) before harvest, semi-dwarfing genes were bred into their genomes. Norin 10 wheat, a variety developed by Orville Vogel from Japanese dwarf wheat varieties, was instrumental in developing wheat cultivars. IR8, the first widely implemented HYV rice to be developed by the International Rice Research Institute, was created through a cross between an Indonesian variety named "Peta" and a Chinese variety named "Dee Geo Woo Gen."

With the availability of molecular genetics in Arabidopsis and rice the mutant genes responsible (reduced height (rht), gibberellin insensitive (gai1) and slender rice (slr1)) have been cloned and identified as cellular signalling components of gibberellic acid, a phytohormone involved in regulating stem growth via its effect on cell division. Photosynthetic investment in the stem is reduced dramatically as the shorter plants are inherently more mechanically stable. Nutrients become redirected to grain production, amplifying in particular the yield effect of chemical fertilisers.

HYVs significantly outperform traditional varieties in the presence of adequate irrigation, pesticides and fertilizers. In the absence of these inputs, traditional varieties may outperform HYVs. They were developed as F1 hybrids, meaning seeds need to be purchased every season to obtain maximum benefit, thus increasing costs.



Crop rotation

Crop rotation or crop sequencing is the practice of growing a series of dissimilar types of crops in the same space in sequential seasons for benefits such as avoiding pathogen and pest build-up that occurs when one species is continuously cropped. Crop rotation also seeks to balance the nutrient demands of various crops to avoid soil nutrient depletion. A traditional component of crop rotation is the replenishment of nitrogen through the use of legumes and green manure in sequence with cereals and other crops. Crop rotation can also improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants. One technique is to plant multi-species cover crops between commercial crops. This combines the advantages of intensive farming with continuous cover and polyculture.

Irrigation

Crop irrigation accounts for 70% of the world's fresh water use. Flood irrigation, the oldest and most common type, is typically unevenly distributed, as parts of a field may receive excess water in order to deliver sufficient quantities to other parts. Overhead irrigation, using center-pivot or lateral-moving sprinklers, gives a much more equal and controlled distribution pattern. Drip irrigation is the most expensive and least-used type, but delivers water to plant roots with minimal losses. Water catchment management measures include recharge pits, which capture rainwater and runoff and use it to recharge groundwater supplies. This helps in the replenishment of groundwater wells and eventually reduces soil erosion. Dammed rivers creating Reservoirs store water for irrigation and other uses over large areas. Smaller areas sometimes use irrigation ponds or groundwater.

Weed control

In agriculture, systematic weed management is usually required, often performed by machines such as cultivators or liquid herbicide sprayers. Herbicides kill specific targets while leaving the crop relatively unharmed. Some of these act by interfering with the growth of the weed and are often based on plant hormones. Weed control through herbicide is made more difficult when the weeds become resistant to the herbicide. Solutions include:

- Cover crops (especially those with allelopathic properties) that out-compete weeds or inhibit their regeneration.
- Multiple herbicides, in combination or in rotation
- Strains genetically engineered for herbicide tolerance
- Locally adapted strains that tolerate or out-compete weeds
- Tilling
- Ground cover such as mulch or plastic
- Manual removal
- Mowing
- Grazing
- Burning

GREAVES
SINCE 1859

Sunil Pahilajani
Managing Director, CEO

"GREAVES COTTON LIMITED

is committed to
'Make In India'
Initiative Through Advanced
Agri - Mechanization"

India ranks third in farm and agriculture output globally. It is also the largest producer, consumer and exporter of spices and related products. Despite agriculture sector being a key contributor to employment in the country, its contribution to the overall GDP has seen a decline. Despite the decline, the sector remains a dominant source of and contributor to overall employment and the GDP. A solid 49 percent of the labour force is still employed in the sector and over 60 percent of rural households still depend on agriculture as their principal source of livelihood.

Agricultural machinery market in India is estimated to grow at a CAGR of over 10 percent during the period 2013-18. Farm mechanisation has been known to provide a number of economic and social benefits to farmers. Primary among the economic benefits is the improved yield that comes as a result of greater level of mechanisation. Looming water scarcity crisis along with the need to ensure food security in the country, the benefits of farm mechanisation makes it a crucial component of shaping the future of Indian agriculture.

Innovation in farm machinery sector will drive the next phase of agricultural growth in the country. The Government of India has been encouraging mechanisation through different policy interventions. The technologies that have evolved in the farm machinery sector in last few years have enormous potential to realise the vision of 'Make in India' initiative which promotes innovation and investment.

Greaves Cotton Limited has been at the core of the Indian Industrial progress story for more than 150 years. The Company is one of the most trusted brands in rural India and offers the widest product range in every product category. Greaves offers world-class products such as: portable pumpsets, power tiller, inter cultivator, mini combine harvester, reaper and brush cutter. With a plethora of product offerings, Greaves offers farmers a trusted solution for every crop cycle.

The Company also offers the widest range of lightweight petrol/ diesel/kerosene pumpset range for varying farming needs. With irrigation looked upon as a critical factor in delivering a successful farm output, Greaves has been at the heart of increasing farm output for thousands of farmers for decades.

In line with the 'Make In India' initiative, Greaves Cotton Limited also launched a new range of farm equipment products - Mini Power tiller (8 HP Cat), Paddy Weeder & Power Weeder. Company's R&D centre has developed exclusive products to meet high standards of quality and reliability, equipped with features meticulously designed after detailed understanding of Indian farming requirements.

The new range of products is powerful, fuel efficient and easy to maintain. They are also designed to be light weight and are easy to operate and can be comfortably operated by women.

Greaves farm equipment business is focused on transforming the lives of small and marginal farmers by enabling them to mechanise various farming practices. Our products are backed with strong service network and offer easy availability of spare parts in rural markets at affordable prices. All Greaves products are certified by Government of India as per the latest standards and are backed by a nationwide network of authorised dealers. The Company is also a leading exporter to SAARC countries which enjoy the same climate and ecological background.


5520 Pumpset


8DIL Mini Power Tiller


MK-12 Pumpset


15 DIL Power Tiller

GREAVES
SINCE 1859

GREAVES COTTON LIMITED

Registered Office: 3rd Floor, Motilal Oswal Tower, Junction of Gokhale & Sayani Road, Prabhadevi, Mumbai 400 025, India
Tel: +91 22 33551700 Fax: +91 22 33812799 Email: info@greavescotton.com

Terracing

In agriculture, a terrace is a levelled section of a hilly cultivated area, designed as a method of soil conservation to slow or prevent the rapid surface runoff of irrigation water. Often such land is formed into multiple terraces, giving a stepped appearance. The human landscapes of rice cultivation in terraces that follow the natural contours of the escarpments like contour ploughing is a classic feature of the Island of Bali and the Banaue Rice Terraces in Banaue, Ifugao, Philippines. In Peru, the Inca made use of otherwise unusable slopes by drystone walling to create terraces.

Rice paddies

A paddy field is a flooded parcel of arable land used for growing rice and other semiaquatic crops. Paddy fields are a typical feature of rice-growing countries of east and Southeast Asia including Malaysia, China, Sri Lanka, Myanmar, Thailand, Korea, Japan, Vietnam, Taiwan, Indonesia, India, and the Philippines. They are also found in other rice-growing regions such as Piedmont (Italy), the Camargue (France) and the Artibonite Valley (Haiti). They can occur naturally along rivers or marshes, or can be constructed, even on hillsides. They require large water quantities for irrigation, much of it from flooding. It gives an environment favourable to the strain of rice being grown, and is hostile to many species of weeds. As the only draft animal species which is comfortable in wetlands, the water buffalo is in widespread use in Asian rice paddies.

Paddy-based rice-farming has been practiced in Korea since ancient times. A pit-house at the Daecheon-ni archaeological site yielded carbonized rice grains and radiocarbon dates indicating that rice cultivation may have begun as early as the Middle Jeulmun Pottery Period (c. 3500-2000 BC) in the Korean Peninsula. The earliest rice cultivation there may have used dry-fields instead of paddies.

The earliest Mumun features were usually located in naturally swampy, low-lying narrow gulleys and fed by local streams. Some Mumun paddies in flat areas were made of a series of squares and rectangles separated by bunds approximately 10 cm in height, while terraced paddies consisted of long irregularly shapes that followed natural contours of the land at various levels.

Like today's, Mumun period rice farmers used terracing, bunds, canals and small reservoirs. Some paddy-farming techniques of the Middle Mumun (c. 850-550 BC) can be interpreted from the well-preserved wooden tools excavated from archaeological rice paddies at the Majeon-ni Site. However, iron tools for paddy-farming were not introduced until sometime after 200 BC. The spatial scale of individual paddies, and thus entire paddy-fields, increased with the regular use of iron tools in the Three Kingdoms of Korea Period (c. AD 300/400-668).

A recent development in the intensive production of rice is System of Rice Intensification (SRI). Developed in 1983 by the French Jesuit Father Henri de Laulanié in Madagascar, by 2013 the number of smallholder farmers using SRI had grown to between 4 and 5 million.

Aquaculture

Aquaculture is the cultivation of the natural products of water (fish, shellfish, algae, seaweed and other aquatic organisms). Intensive aquaculture takes place on land using tanks, ponds or other controlled systems or in the ocean, using cages.

Sustainable intensive farming

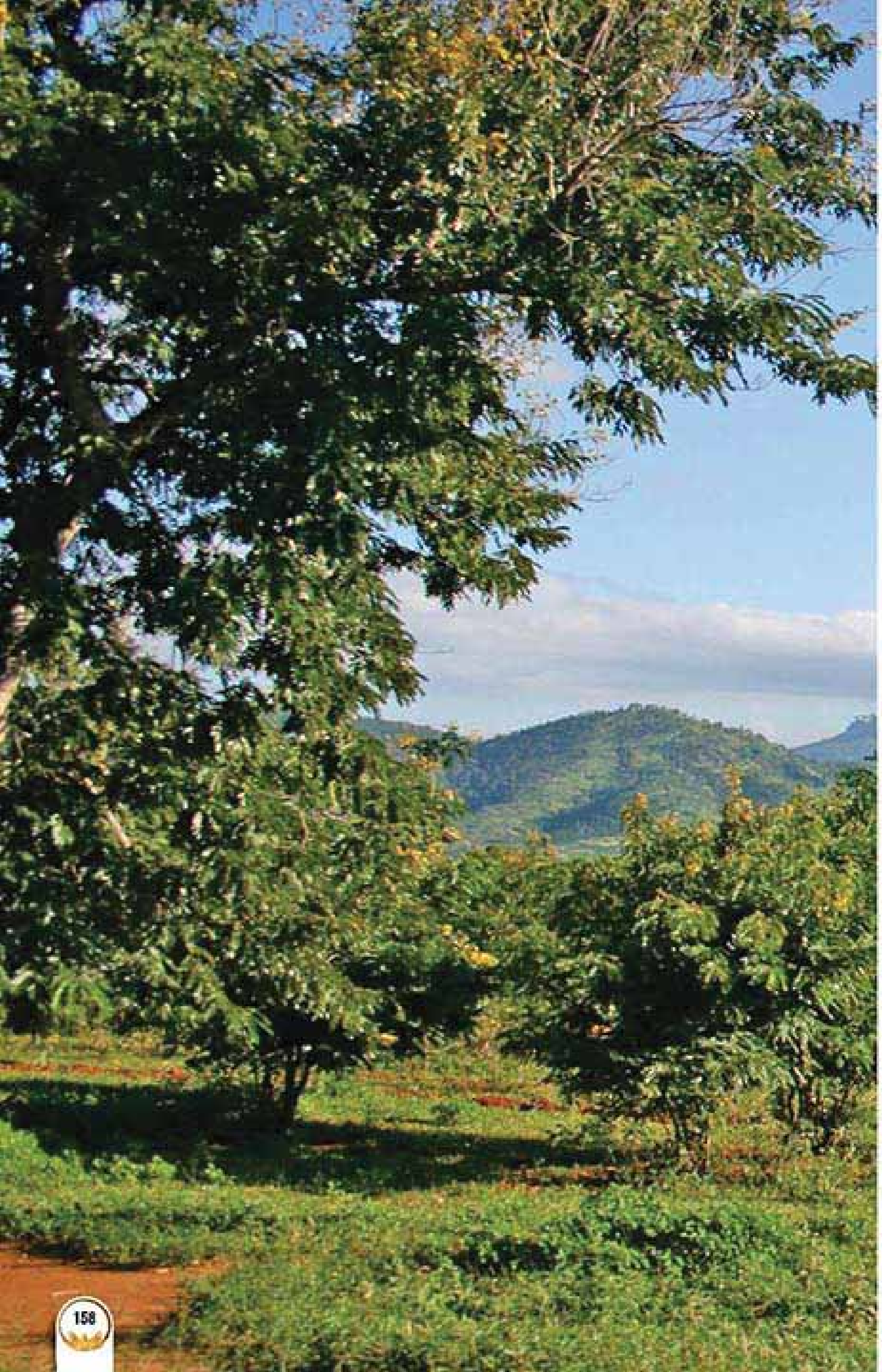
Sustainable intensive farming practises have been developed to slow the deterioration of agricultural land and even regenerate soil health and ecosystem services, while still offering high yields. Most of these developments fall in the category of organic farming, or the integration of organic and conventional agriculture.

As per Dr Charles Benbrook, Executive Director, US House Agriculture Subcommittee, and Director, Agricultural Board - National Academy Sciences (FMR), "Organic systems and the practices that make them effective are being picked up more and more by conventional agriculture and will become the foundation for future farming systems. They won't be called organic, because they'll still use some chemicals and still use some fertilizers, but they'll function much more like today's organic systems than today's conventional systems."

The System of Crop Intensification (SCI) was born out of research primarily at Cornell University and smallholder farms in India on SRI. It uses the SRI concepts and methods for rice and applies them to crops like wheat, sugarcane, finger millet, and others. It can be 100% organic, or integrated with reduced conventional inputs.

Holistic management is a systems thinking approach that was originally developed for reversing desertification. Holistic planned grazing is similar to rotational grazing but differs in that it more explicitly provides a framework for adapting to four basic ecosystem processes: the water cycle, the mineral cycle including the carbon cycle, energy flow and community dynamics (the relationship between organisms in an ecosystem) as equal in importance to livestock production and social welfare. By intensively managing the behaviour and movement of livestock, holistic planned grazing simultaneously increases stocking rates and restores grazing land.

Pasture cropping plants grain crops directly into grassland without first applying herbicides. The perennial grasses form a living mulch understory to the grain crop, eliminating the need to plant cover crops after harvest. The pasture is intensively grazed both before and after grain production using holistic planned grazing. This intensive system yields equivalent farmer profits (partly from increased livestock forage) while building new topsoil and sequestering up to 33 tons of CO_2/ha/year.



The Twelve Aprils grazing program for dairy production, developed in partnership with USDA-SARE, is similar to pasture cropping, but the crops planted into the perennial pasture are forage crops for dairy herds. This system improves milk production and is more sustainable than confinement dairy production.

Integrated Multi-Trophic Aquaculture (IMTA) is an example of a holistic approach. IMTA is a practice in which the by-products (wastes) from one species are recycled to become inputs (fertilizers, food) for another. Fed aquaculture (e.g. fish, shrimp) is combined with inorganic extractive (e.g. seaweed) and organic extractive (e.g. shellfish) aquaculture to create balanced systems for environmental sustainability (biomitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices).

Biointensive agriculture focuses on maximizing efficiency such as per unit area, energy input and water input. Agroforestry combines agriculture and orchard/forestry technologies to create more integrated, diverse, productive, profitable, healthy and sustainable land-use systems.

Intercropping can increase yields or reduce inputs and thus represents (potentially sustainable) agricultural intensification. However, while total yield per acre is often increased dramatically, yields of any single crop often diminish. There are also challenges to farmers relying on farming equipment optimized for monoculture, often resulting in increased labour inputs.

Vertical farming is intensive crop production on a large scale in urban centers in multi-story, artificially-lit structures that uses far less inputs and produces fewer environmental impacts.

An integrated farming system is a progressive biologically integrated sustainable agriculture system such as IMTA or Zero waste agriculture whose implementation requires exacting knowledge of the interactions of multiple species and whose benefits include sustainability and increased profitability. Elements of this integration can include:

- Intentionally introducing flowering plants into agricultural ecosystems to increase pollen-and nectar-resources required by natural enemies of insect pests
- Using crop rotation and cover crops to suppress nematodes in potatoes

Challenges

The challenges and issues of industrial agriculture for society, for the industrial agriculture sector, for the individual farm, and for animal rights include the costs and benefits of both current practices and proposed changes to those practices. This is a continuation of thousands of years of invention in feeding ever growing populations.

When hunter-gatherers with growing populations depleted the stocks of game and wild foods across the Near East, they were forced to introduce agriculture. But agriculture brought much longer hours of work and a less rich diet than hunter-gatherers enjoyed. Further population growth among shifting slash-and-burn farmers led to shorter fallow periods, falling yields and soil erosion. Ploughing and fertilizers were introduced to deal with these problems - but once again involved longer hours of work and degradation of soil resources (Boserup, The Conditions of Agricultural Growth, Allen and Unwin, 1965, expanded and updated in Population and Technology, Blackwell, 1980).

While the point of industrial agriculture is to profitably supply the world at the lowest cost, industrial methods have significant side effects. Further, industrial agriculture is not an indivisible whole, but instead is composed of multiple elements, each of which can be modified in response to market conditions, government regulation and further innovation and has its own side-effects. Various interest groups reach different conclusions on the subject.


ആത്മ പ്ലസ് 2014–15

UNIT: 9

Future of Indian Agriculture

At 157.35 million hectares, India holds the second largest agricultural land in the world. With 20 agri-climatic regions, all 15 major climates in the world exist in India. India is the largest producer of spices, pulses, milk, tea, cashew and jute; and the second largest producer of wheat, rice, fruits and vegetables, sugarcane, cotton and oilseeds. Further, India is 2nd in global production of fruits and vegetables, and is the largest producer of mango and banana. It also has the highest productivity of grapes in the world.

Total food grains production in India reached an all-time high of 251.12 million tonnes (MT) in FY15 (as per 3rd Advance Estimates). Rice and wheat production in the country stood at 102.54 MT and 90.78 MT, respectively. India is among the 15 leading exporters of agricultural products in the world.

The Government of India has introduced several projects to assist the agriculture sector. They are Pradhanmantri Gram Sinchai Yojana: The scheme aims to irrigate the field of every farmer and improving water use efficiency to achieve the motto `Per Drop More Crop'. Overall the scheme ensures improved access to irrigation.

Paramparagat Krishi Vikas Yojana (PKVY): The scheme aims to motivate groups of farmers to take up organic farming.

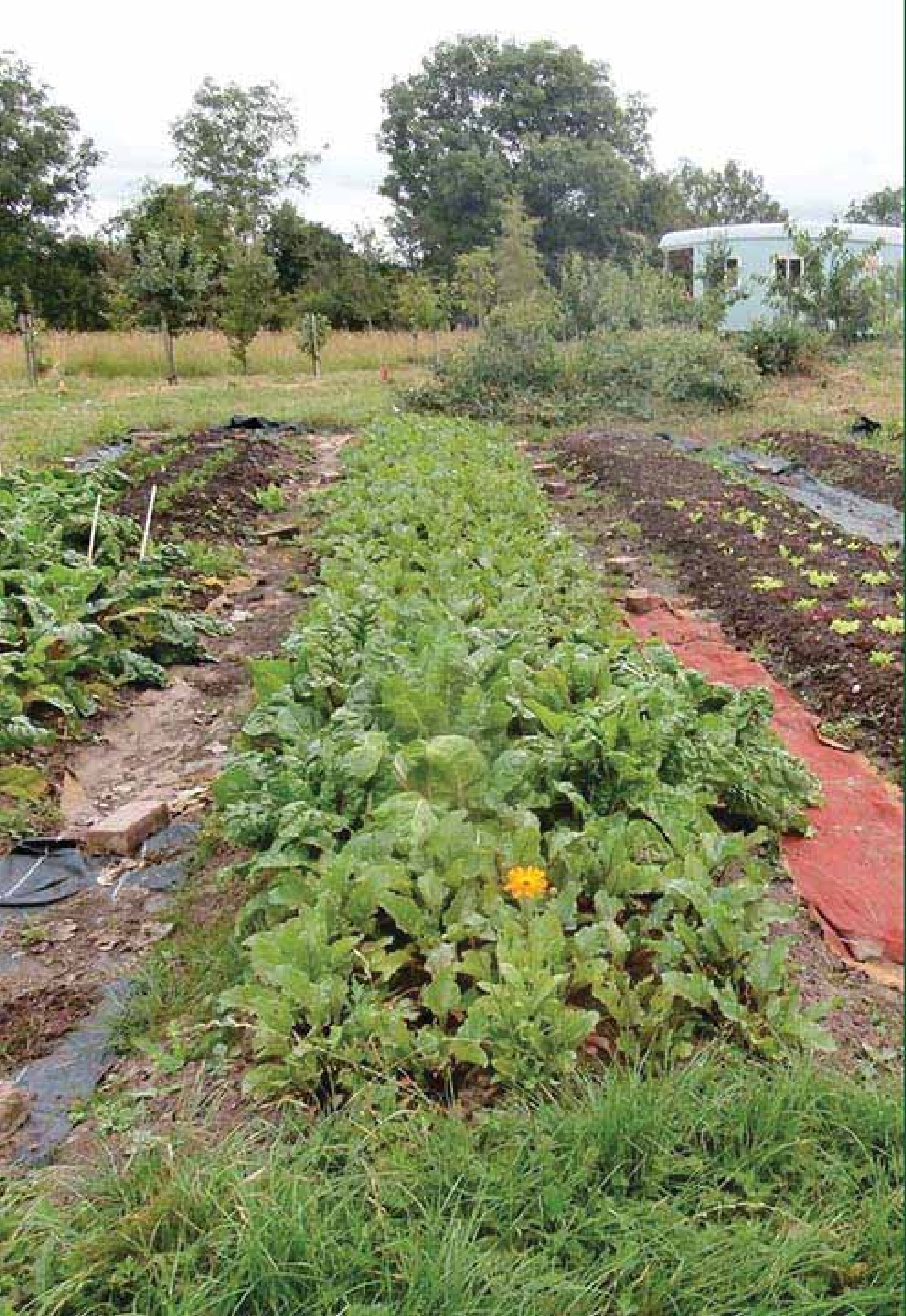
Government of India has released a new subsidy for the establishment of 988 Farm Machinery Banks during 2014-15 under Sub–Mission on Agricultural Mechanization

The agriculture sector in India is expected to generate better momentum in the next few years due to increased investments in agricultural infrastructure such as irrigation facilities, warehousing and cold storage. Factors such as reduced transaction costs and time, improved port gate management and better fiscal incentives would contribute to the sector's growth. Furthermore, the growing use of genetically modified crops will likely improve the yield for Indian farmers.

According to the National Institution for Transforming India Aayog (NITI Aayog), India's agriculture sector is expected to grow 6 per cent in FY 2016-17 in case of normal monsoon during the June-September period. The 12th Five-Year Plan estimates the foodgrain storage capacity to expand to 35 MT. Also, a 4 per cent growth would help restructure the agriculture sector in India in the next few years.

India's Role in Global Agriculture

Unknown to many, India's agricultural products fetches higher earnings than trade in services or manufacturing. With proactive support, India can further enhance its farm exports and contribute to its prosperity.



The anatomy of global agriculture has undergone a complete metamorphosis in recent decades and is structurally very different now. According to the World Factbook of the CIA in 2014, the global agricultural output was $ 4,771 billion. But a full 42 percent of this output comes from just six countries – China ($ 1,005 billion) is the largest producer, followed by India ($ 367 billion). The US is third ($ 279 billion), followed by Brazil ($ 130 billion), Nigeria ($ 122 billion) and Indonesia ($ 121 billion). As one can see, five of the six global leaders in agricultural output are developing countries. In fact, China and India alone account for close to 30 percent of the global total.

According to the Food and Agriculture Organization (FAO), there are more than 570 million farms in the world, and 70-80 percent of them are family farms, accounting for more than 80 percent of the world's food in terms of value. Only four percent of these farms are present in high-income countries. Clearly, family farming forms the backbone of agriculture in developing countries.

Meanwhile, the world's population is projected to grow from about 7 billion in 2012 to 9.6 billion people by 2050. Food supplies need to increase by 60 percent (estimated at 2005 food production levels) in order to meet the food demand in 2050. India's domestic demand for food and fibre is expected to go up considerably as the country has the second-largest economically active population in the world.

The need of the hour is strategic thinking and rapid but thoughtful action that will result in increase in production and reduction in wastage. The UN-FAO estimates that nearly 30 percent of foods produced are wasted post-harvest, resulting in huge economic losses in addition to a negative environmental footprint. Food availability and accessibility can be made better by increasing production, improving distribution, and reducing these losses. Thus, reduction of post-harvest food loss is a critical component of ensuring global food security.

In the next 10-15 years, it is expected that 75 percent of primary agricultural production will come from Asia, South America and Africa. Efforts have to be made to protect crops from pre-planting to post-harvest for ensuring enough food is produced to feed the world. Thus, crop protection is a key component in guaranteeing food security.

Government's Vision for the Agriculture Sector

Sector's continued growth, its contribution towards employment generation, its significance for rural population in the country, and its role in ensuring food security has made the government more inclined towards bringing reforms across the sector. As per government estimates, during the Twelfth Five Year Plan (2012-17) period, the sector employed 57 percent of the rural population. Agriculture and allied sectors has witnessed an accelerated annual growth and rose to 3.7 percent in the eleventh plan from the earlier 2.4 percent in the tenth plan.

As the sector witnessed growth in the past decade, the Ministry of Agriculture, Government of India had planned on focussing on sustaining the current growth momentum by stabilising food grain production and ensuring food security in the longer run. The focus is also on the conserving high production areas in the country. Thus, in recent times, the need for new technologies to break yield barriers, utilise inputs more efficiently and diversify to more sustainable and higher value cropping patterns has been considered.

Government witnessed some key challenges for the sector before initiating the Twelfth Five Year Plan:

- Shortage of farm labour
- Youth participation in agriculture
- Inadequate mechanization
- Distribution of subsidies vs public investment

The Plan aimed at correcting the shortcomings through incurring public expenditure on agriculture and infrastructure to ensure proper functioning of the market and increase productivity and overall efficiency by better delivery of credit services and quality inputs.

- To enhance farm viability, the Plan focused on
- Including small and women farmers at all points of value chain.
- Use information technology for precision farming

The plan was directed towards achieving the following Missions-

1. National Food Security Mission
2. National Mission on Agriculture Extension and Technology
3. National Mission on Sustainable Agriculture
4. National Horticulture Mission

The aim of the government is to increase the growth of agriculture sector through its Rashtriya Krishi Vikasa Yojana (RKVY). The Scheme is being implemented throughout India with 100 percent central assistance. And increasing the level of farm mechanization in India's agriculture sector is a part of the scheme. Under this, substantial funding have already been allocated in the budget 2014-15.

In addition to this, through a number of other schemes, 10 percent assistance for women beneficiary is allocated to procure agricultural machinery, implements and equipment by the government. In order to reduce the drudgery and increasing efficiency in farm operations, a number of agricultural implements and hand tools suitable for farm women have been developed by research and development organisations under Indian Council of Agricultural Research (ICAR).

India: Leading the Agriculture Revolution

Contrary to popular perception, India's agriculture is a success story, worthy of professional discussions in global forums. India ranks 11th and 12th globally in services and manufacturing sectors respectively, and second in the world in the agricultural sector. Indian agriculture in the 21st century is structurally dissimilar, diverso, stronger and superior to the one that existed during the Green Revolution.

In the three decades from the 1970s until the late 90s, India's agricultural GDP grew from \$ 25 billion to \$ 101 billion registering an absolute growth of \$ 76 billion. However, in the next 14 years from 2000 to 2014, it leaped from \$ 101 billion to \$ 367 billion, registering an astonishing growth of \$ 266 billion. In other words, the growth in agriculture in the last 14 years was 350 percent higher than the one achieved in the previous 30 years.

Another fact that many are unaware of is that this growth is being led by states not conventionally perceived as agriculturally progressive. The drivers of India's growth are actually high-value segments such as dairy, horticulture and inland fisheries. These three segments provide farmers with year-round income and account for 60 percent of India's agricultural GDP. No wonder, the states of Uttar Pradesh, undivided Andhra Pradesh and Maharashtra now make up the top three in agricultural production, relegating grain-centric states like Punjab and Haryana to 10th and 12th rank respectively.

Indian agriculture is no longer an underdog. It has progressed rapidly in recent years and ranks now as the second-largest food producer in the world, touching \$ 367 billion in 2014. The country's agricultural production is far above that of the US, which once supplied food grains to India to tide over our domestic food shortage. Unknown to many, India's international trade in agricultural products fetches higher earnings for the country than trade in services or manufacturing.

As a nation, we have several strengths that poise us well. India has a high diversity of topography, climate and soil, so it is inherently a multi-product agricultural powerhouse. No other country produces as many crops as we do. India's cropping intensity is the highest in the world. The country's small-sized, family farms practice a unique kind of mixed agri-horti-livestock farming, which is a cost-effective model ideal for other developing nations with small farms. Indian farmers multi-task, and shift with ease from crop cultivation to animal husbandry, thereby remaining engaged throughout the year. By and large, this versatility has transformed the Indian agricultural sector into a global leader.

As per the WTO, India ranks 19th in merchandise exports, but 6th in agricultural exports. This shows India's global competitiveness in agriculture. In 2014, the world's exports in agricultural products stood at $ 1,765 billion and India's share of this was 2.5 percent. With better focus, India's agri-exports can easily achieve at least 5 percent share within next three years.

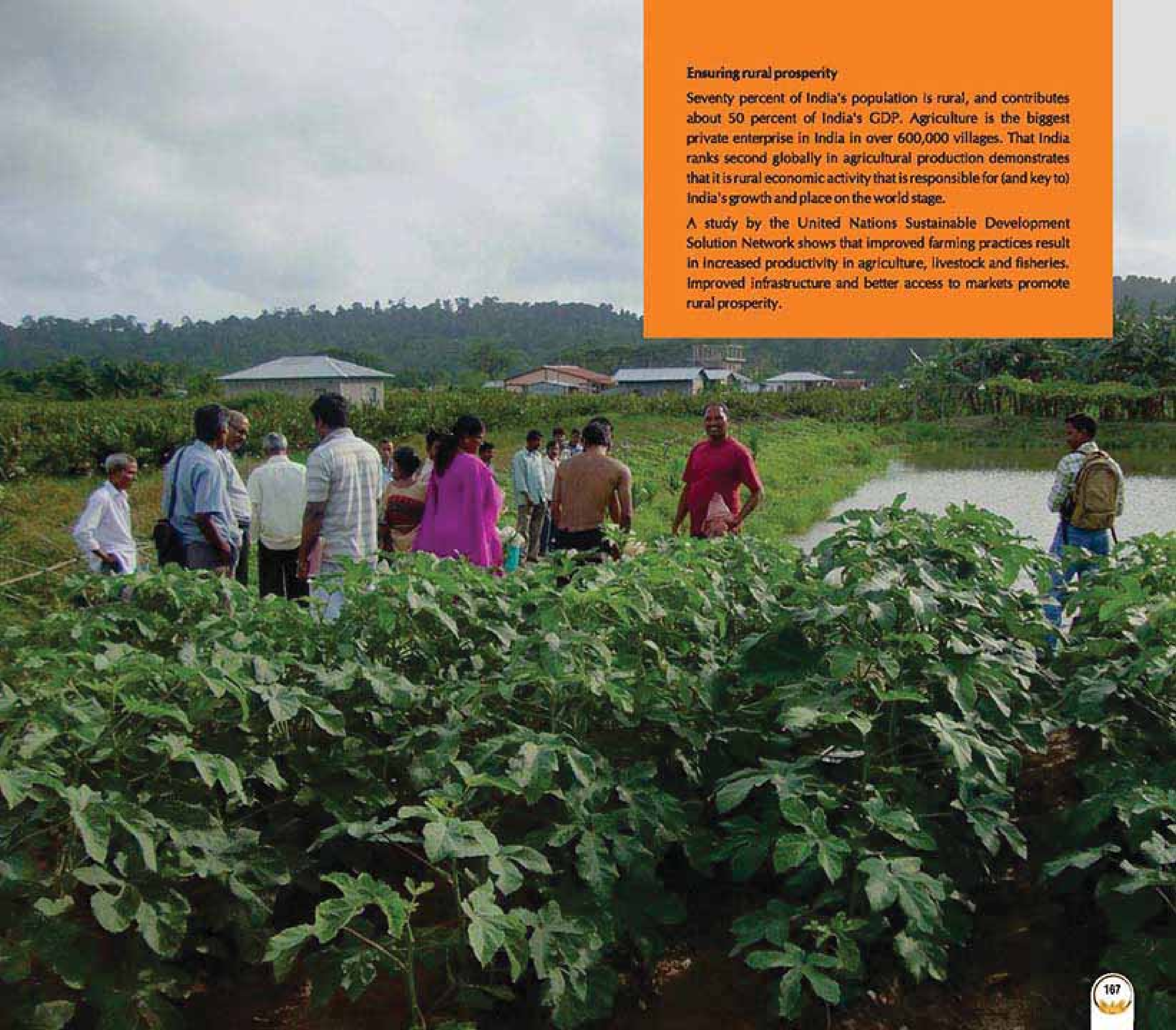
India must focus its resources, attention, skills and expertise on the agriculture sector to ensure self-reliance in terms of future food supply, and a steady growth of income from exports.

The government has to take steps to aid and enhance India's agricultural production with proven farming technologies and agriculture-inputs. For instance, despite India growing the maximum varieties of edible oils, it is the largest importer with 14 million tonnes, worth $ 10 billion per year. The second largest agriculture commodity that India imports is pulses, predominantly dry peas (*Pisum sativum*). There is an urgent need to change this. Step by step, efforts have to be made to move India forward to achieving self-sufficiency in these crops, furthering the country's food security.

Ensuring rural prosperity

Seventy percent of India's population is rural, and contributes about 50 percent of India's GDP. Agriculture is the biggest private enterprise in India in over 600,000 villages. That India ranks second globally in agricultural production demonstrates that it is rural economic activity that is responsible for (and key to) India's growth and place on the world stage.

A study by the United Nations Sustainable Development Solution Network shows that improved farming practices result in increased productivity in agriculture, livestock and fisheries. Improved infrastructure and better access to markets promote rural prosperity.



Encourage 'Farm in India' for a bright future

According to the World Bank, India has brought about a landmark agricultural revolution that has transformed the nation from chronic dependence on grain imports into a global agricultural powerhouse that is now a net exporter of food. The government must recognise Indian agriculture as being export-oriented and a significant foreign exchange earner.

This recognition and aggressive promotion will build the right image of Indian agriculture and also stop the negative narratives. Proactive promotion will further increase India's farm exports, in turn bringing price and income stability and contribute to its rural prosperity. Finally, fast-track clearance of investment, production proposals including innovative technologies for agriculture inputs will considerably help, too. The Make in India initiative is a stage with great potential to recognise and champion Indian farmers, and provide the country with opportunities for a brighter future.

Equipments, Machineries and Implements required for Agri-Mechanization

Tractor: Farm Tractor is a self-propelled machine or equipment that pulls or pushes tools or implements over the land. It is equipment designed and used for farm operations for the purpose of land preparations, cultivation and harvesting of crops. A tractor is sub-divided into three (3) major parts namely (a) engine system (b) transmission system and (c) hydraulic system:

- Engine – Generally a tractor makes use of four (4) stroke cycle, internal combustion, compression ignition (diesel), thermosyphon cooling, heat engine of various cylinders depending on the horsepower of the engine.
- Transmission: The transmission system of the tractor consists of the clutch assembly, gear train, final drive etc.
- Hydraulic system: The hydraulic system of a tractor consists of hydraulic fluid, Ramshaft, three (3) point linkage i.e. lower links and top link, hydraulic pump, selectmatic valves, quick coupling point, draft control, control valve.

Rotary Power Tiller: Rotary power tiller also known as two wheeled tractor is light duty agricultural equipment used for tilling operation. It is affordable in price when compared with the four wheeled tractors, for the small and medium scale farmers. It could be used on undulating terrain and fragile soil. It is portable and can be used or taken to the interior farmlands where there is no access road for big tractors. The affordability of this equipment in terms of low price to local farmers will make food production to increase considerably. The rotary power tiller, apart from tilling operation could also perform the following, these are: ploughing, wet pudding, ridging, cultivating, water pumping, cassava planting and weeding operations making use of appropriate implement. The equipment in conjunctions with the trailer could be used to transport the appropriate implement to be used to the field and could also be used to bring or conveyed farm produce from the field to the barn. The equipment is economical, safe and efficient in use than manual operation. It can perform tilling operation of about 1.25 hectares of land per day. The equipment is sub-divided into (3) three major parts, these are:

- Engine
- Transmission
- Implement

Other equipments or machines in this category are:

- Track Laying Tractor
- Crop Thresher
- Combine Harvester

The implements are:

- Disc plough and mouldboard plough
- Disc Harrow and mouldboard Harrow
- Disc Ridger and mouldboard Ridger
- Boom Sprayer and Gun Sprayer
- Seed Planter and Cassava Planter
- Fertilizer Spreader
- Mower

All these aforementioned machineries, equipments and implements plays vital role in the enhancement of sustainable food production, if properly utilized and made affordable within the reach of small and medium scale farmers.

Food Production Stages

The food production stages consist of the followings:

- Land clearing
- Planting and weeding
- Harvesting
- Transportation
- Processing
- Storage
- Consumption

Land Clearing: In the past, the traditional method of land clearing for food and agricultural production was by manual labour with the use of cutlass, axe, hoe and other farming hand tools. The problem associated with this system includes fatigue on the part of the labourers, inability to get enough man power to carry out the operation as at when needed or required. Most times when lands are cleared for farming purpose, there still left behind stumps of shrubs, and trees felled which makes it difficult for the rest of operation like ploughing, ridging etc. The stumps damage equipment when used on the land and causes injury to labourers working on the farm at long run. After land clearing operation by manual method, most farmers gathers the grasses, off-cut trees branches and shrubs on the farm site and have them burnt, this practice is one of the problems associated with land clearing, as the heat of the fire burns most of the soil nutrients that could have been used to improve soil fertility for bumper harvest of the crop planted. In other to alleviate this aforementioned problems associated with the traditional method of land clearing, mechanized system is introduced with the use of track laying tractors otherwise called Bulldozer in construction site, to push down trees and lift them to the edge of the land in such a way that the soil nutrients will not be eroded from the surface of the soil.

- *Track Laying Tractor (Bulldozer):* With this mechanized system, the area of land that will be cleared for several weeks or months by several people using manual labour will be cleared and accomplished within two (2) days. The use of track laying tractors and other heavy duty earth moving equipment for land clearing is efficient, economical and fast in operation. When used properly, soil nutrients and fertility are preserved since there is no need for the use of fire to burn the grasses and off cut trees, instead they are heaped at the edge of the farm land and left there to decay which ultimately increase the soil fertility at that portion. When land clearing operation is performed in a mechanized way the area to be cultivated will be much within a limited time and it will boost food security in the nation

Planting: Mechanization plays a vital role in enhancing sustainable food production, thereby boosting food security as exemplified in various mechanized operations in the farm that has to do with planting, germination, growth and weed control of the crops. To start with, the land to be cultivated go through the first tillage operation of soil breaking making use of Disc Plough which is one of the first tillage implement. Harrowing operation which is breaking of the soil into smaller particles so as to achieve fine soil texture, making use of either tractor mounted or trailing Disc Harrow is carried out. It is much easier and faster to carry out ridging operation especially for tuber crops like cassava, making use of the combination of tractor and disc ridger which is a mechanized system, than the use of manual labourer using hoe. There are several equipments, machineries and implements now made available and affordable to both small and medium scale farmers that will make planting easier, faster and economical. There is now made available, grain crop planters that could be calibrated such that the farmer could calculate the quantity of grain seed that would be required to plant a particular size of plot or farmland, thereby minimizing if not totally eradicating wastage of grain seeds during planting. The use of agro-chemicals for the control of weeds has been seen as another form of mechanized operation that plays major role in the enhancement of sustainable food production and which must be encouraged. The use of tractor mounted boom sprayers and manually operated knapsack sprayer to spray chemical such as herbicides for the control of weeds on farm crops, are fast, efficient and economical if properly utilized. The operation is less fatigue and the farmer will be able to cover a large area of farmlands within a very short and limited time.

Harvesting: The use of combine harvester and tractor mounted harvester makes agricultural and food production to be easier, economical and fast. It also reduces wastage usually encountered when manual method of harvesting is employed. The use of combined harvester for the harvesting of grain crops such as rice, maize, cowpea and soybean will definitely reduce wastage that the farmers usually faced when manual labourers were utilized. This is so because the harvester will cover a large area of farm land and harvested large crops within a short period of time when compared with what manual labourers will harvest in days. Most combined harvester for grain crops perform three in one operations of harvesting, threshing or shelling (depending on the type of crop) and winnowing (blowing) that is the removal of chaffs and unwanted particles and by extension bagging of the crops. This practice of harvesting in a mechanized way makes farming operation to be less drudgery and less fatigue. It also makes farming to be interesting and satisfactory, which ultimately brings about increase in food production. There are available and affordable, several large, medium and small scale combined harvesters for the harvesting of grain and root crops to farmers, hence the role of agricultural mechanization in the enhancement of sustainable food production in the country cannot be over-emphasized. In the harvesting of tuber crops such as cassava, agricultural mechanization plays a vital role with the use of the implement known as cassava harvester. It is a tractor mounted implement designed to uproot cassava tubers with little or no remnant of cassava tubers in the soil. Some soil are so hardened especially during dry season, such that the labourers finds it extremely difficult or impossible to uproot the cassava crops planted therein, this type of problem is overcome with the use of mechanization.

Transportation: It is no longer gain saying that several tones of farm produce got rotten away on the farm after harvesting due to lack of adequate transportation facilities for the evacuation of the produce to either the barn or market. When food crops are harvested the traditional method of transportation is by means of human labours with the use of head pan and containers to carry the crops to the barn or markets. This practice has major disadvantage on food crop production especially grain crops that are being harvested during raining season. Most of the times after the crops have been harvested; rain comes upon them and gets damaged unless they are immediately evacuated from the field to the barn for processing before it rains. To solve this problem, there now available three (3) wheeled, light weight tricycles and vehicles that will be used to transport grain crops that are vulnerable to rot and damage to the barn. The greater advantage derived from the use of tractor coupled trailer for this purpose cannot be over emphasized, for the method has being in practice for a very long time hence farmers are encouraged to embrace this mechanized form of transportation for the reduction or total elimination of losses occasioned by rain and other factors so as to bring about maximum food production. After the food crops have been harvested and processed, for it to get to the reach of the consumers, from the farm or the processing firm, transportation plays a major role. Without the availability of adequate transportation system, food crops harvested and or processed will not get to the markets, hence good roads, vehicles, transporting equipments and implements are also relevant in the enhancement of sustainable food production. The use of human labour for the transportation of food crops from the field to the processing site and markets are more costly, slow, unsafe and bring about drudgery on the part of the labourer and wastage to farm produce.

Processing: Processing is the method of converting raw materials into useful finished products. With this definition, it will be seen that processing is one of the important factors that will enhance food security in the nation if properly harnessed. Processing starts from the removal of the unwanted elements from food crops to the stage that the food crop is ready for consumption. Examples of these are the removal of chaffs and unwanted particles from grain crops such as rice, cowpea, soybeans, maize, millet and so on. It also includes removal of peelings from tuber crops such as yam, cocoyam, and cassava.

- *Grain Crop Processing:* The traditional method of chaffs and particles removal from grain crops are by means of spreading the grain crops on the cemented or concrete floor after harvesting and have the crops beating by several people with the use of wooden rods after which the women collects the grain into flat trays for winnowing. This method is quite stressful, slow and tedious but with the advent of agricultural mechanization these problems have been overcome by making use of threshing and shelling machine (depending on the type of crop) combined with blowers which winnows the crop and blows away the unwanted particles. Most of these threshing and shelling machines perform three in one operations of threshing, winnowing (blowing) and bagging.
- *Tuber Crop Processing:* In tuber crops, the traditional method of removing the outer coat (peelings) is by manual operation. Women and children are engaged in the peeling operation making use of knife. This method is time consuming, tedious and costly, but thanks to agricultural mechanization, this problem has been solved with the use of peeling machine that perform the dual operation of peeling and washing especially on cassava tubers. Finally, food crops also pass through either of milling, frying, grating, pressing, and slashing operations depending on the type of food crop before it is ready for consumption.

All these aforementioned operations are mechanized in nature and they enhance sustainable food production. The quantity and quality of food products to be produced which will ultimately makes food get to the reach of millions of people will be many when mechanization is employed or utilized in carrying out these operations.

UNIT: 10
Farm Machinery and Mechanization in India: An Overview

Mechanization has been identified as a key tool to increase the production globally. As our market too is considerably reliant on increasing agriculture produce, further promotion of farm mechanization is essential.

The agriculture sector value chain includes all the steps involved from preparation of soil to harvesting and post-harvest processing. For every step in the production lifecycle, use of equipment enhances the efficiency of the unit involved. Farm mechanization not just reduces labour time and post-harvest loss but also helps to cut down production cost in the long term.

VALASUMANI

30 YEARS OF EXCELLENCE

Mr. M. Mani, Managing Director

Revolutionized Farming *with* Path Breaking Farm Machines

Valasumani Farm Machines Private Limited, Sivagiri, Erode, Tamil Nadu (India) was established in the year 1986. It has not looked back since then, churning novel concepts and designs regularly to meet pertaining challenges of the beloved farmers. We, at the company, take stock of their tuned ourselves in the widespread streams of farming. Ever since the company's inception, we have employed great resolve in manufacturing quality products. Our upward approach has led us to become the leader of our trade in the entire Indian peninsular region. We are proud to announce that our eclectic clientele includes several Central and State Government agriculture marketing federations and institutions; agriculture promotion corporation; and private customers from agriculture business segment. We specialize in exclusive optimum quality tractor driven agricultural implements to ensure that top quality is met at a reasonable price. Over the seasons, we have grown as an agri-mechaization company, thanks to our continual offerings of finest products that have made their marks not only in India but are being lapped in International markets too.

Over the time, we have nurtured a house of talent who lend their expertise and dedication in all our undertakings. With prominent back-ups for each of our works, we make sure that our operational machinery runs smooth and consistent. Whether they are engineers, technicians or the sheet metal craftsmen, all of them are the leading lights in their specialization and have helped us garner no mean achievements in recent years.

As far as the quality assurance of our products is concerned, we see to it that even when churning out vast quantity of manufacturing designs, we back premium ratings in quality quotient. This is our watch-word in diverse sections of agro-work. We employ only cherished starting materials to ensure that our end-products are always a force to reckon with.

Similarly, in our after sales support services, we happily propose after sales assistance to enrich our clients and customers with all vital information. We are easily accessible just in case our customers feel off-hand in attaining best results from our carefully created products. Our after sales services can be availed for installation; user manual; onsite support; query handling; and repairing.

Valasumani modern multicrop thresher is a high capacity tractor Driven multicrop thresher. Tractor Operated Multicrop Threshers can be run through tractor of 30hp and above. The multicrop thresher can be operated by coupling to the PTO of any type tractor. Crops that can be threshed using our Multicrop Thresher are paddy, maize, sunflower, wheat, millet, ragi, soya, horsegram, red gram, jawar, bengalgram, blackgram, coriander , groundnut; etc.

Valasumani modern conveyor model multicrop thresher is fitted with conveyor system for both feeding and loading purposes. This system has reduced the manpower to 3 which was 5 in case of multicrop thresher operated without conveyor. Due to the high demand for manpower these days, this model is a very convenient one. Crops that can be threshed using multicrop thresher are maize, sunflower, corn, etc.

Valasumani Multipurpose Shredder has following main product features:

- Excellent for solid waste management (dry), composting, vermiculture, feedstuff, etc.
- Can shred 1.2 to 3tons/hour* of wet organic waste (*depending on prime mover type)
- Can shred coconut husk (buko or bunot), dry leads, tree branches up to 10mm, corn stalk, rice straw, sunflower stalks, etc.
- Can chip woody materials of 3" diameter and below.
- Can also grind grits, cassava, coconut meat, copra or copra meals, composted material to powder, etc.

Valasumani Tractor Trailers are manufactured using quality material and are precisely engineered to give high performance. Highly resistant to corrosion, these trailers have high tensile strength and comply with the various requirements of the agricultural industry.

Valasumani Spring Loaded Cultivators are double-spring cultivator. It levels the surface of soil to prepare a perfect seed-bed. Our cultivators ensure that the seeds are buried at the desired depths in the soil.

Valasumani Rigid Loaded Cultivators are light weight but posses a sturdy construction. Quality material and precision in engineering, gives these cultivators the strength to withstand long and tough working hours. These cultivators consists of Frame, Tynes, Angle, Bracket, Side Support and Shovels, which makes them capable to perfectly uproot stubbles to leave the ground perfectly worked. Our array of quality cultivators includes both "Rigid Type Cultivators" and "Rigid Clamp Type Cultivators".

Valasumani Dripline Implement has following main product features:

- Can be operated under various types of soil and also for varying soil conditions.
- Designed with strong main frame with high quality steel Tines.
- Can be adjusted easily for accurate row depth & width
- Adjustable laying depth
- Available with single & double row options
- Excellent for solid waste management (dry), composting, vermiculture, feedstuff

Valasumani Turmeric Steamer has following main product features:

- Boiling Capacity: 1000Kgs per hour
- Easy for transportation and user friendly in operation
- Steamer Attached
- All types of farm washers can be used
- Made up of high quality steel plates and pipes

Valasumani Turmeric Polisher (Trolley Attached) has following main product features:

- Polishes 1100kgs per hour
- 12 HP Diesel Engine attached
- Designed with high quality steel meshes, sheets, cast pulleys and bearings
- Removes all the dust particles, Sediments from turmeric

As far as major credentials of Valasumani Farm Machines Private Limited are concerned, our work in designing Multicrop Thresher has been appreciated and awarded the L-Ramp Award of Excellence for the best technological innovation, Product Design and Development. We share this award with LEMELSON FOUNDATION, USA. It was handed to our Managing Director Mr. M. Mani by the esteemed scientist and Hon'ble Ex. President of India Dr. A. P. J. Adbul Kalam, in a grand function held at Indian Institute Of Technology, Chennai, on 28.11.2007. We have also bagged the patent and design rights for our Multicrop Thresher, a step that should lead towards resounding success. Our Managing Director has been honoured with Great Achiever of Industrial Excellence Award - 2005 in recognition of Sterling Merit, Excellent Performance and Outstanding Contribution for the Progress of the Nation. This Award has been delivered to our managing Director in a function held at New Delhi, on 07.12.2006.


SHORTS
AGRICULTURAL
01344 621715
www.shorts-group.co.uk
JOSKIN
JOSKIN
CAUTION!
OU12 DYP

Agriculture Value Chain and Types of Equipment

Indian agriculture has marked its presence at the global level. India ranks either first or second in terms of total production of rice, wheat, sugarcane, fruits and vegetables in the world. However despite this potential, two major bottlenecks that have emerged and can become insurmountable problem in foreseeable future is the stagnant productivity per hectare and shortage of agriculture labour. Empirical evidence confirms that there is strong correlation between farm mechanization and agricultural productivity. It has been further estimated that use of proper equipments can increase the productivity by up-to 30% and reduction in costs at about 20%.

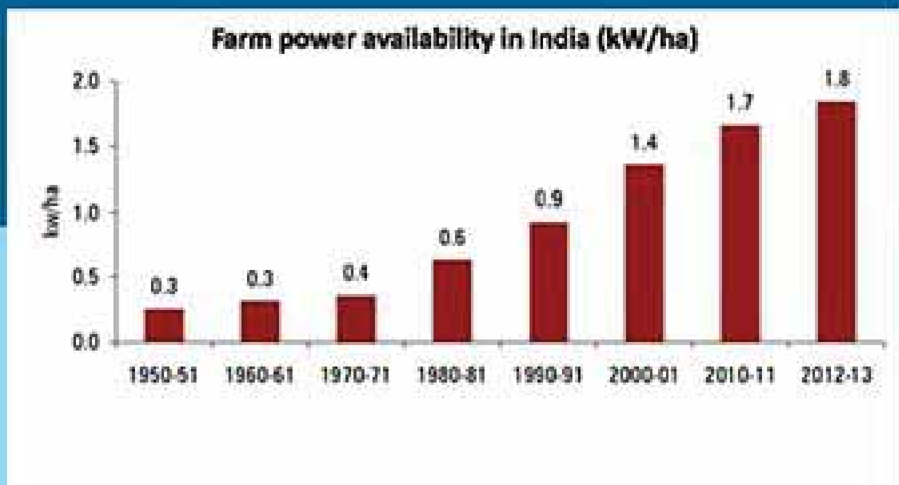
Although India is one of the top countries in agricultural production the current level of farm mechanization, which varies across states, averages around 40%. In order to meet the demand in future and achieve the target of an average farm power availability level of 2.5 kW/ha, the country needs to work on intended level of mechanization.

Innovation in farm machinery sector will drive the next phase of agricultural growth in the country. The Government of India has been encouraging mechanization through different policy interventions. A dedicated Sub-Mission on Agricultural Mechanization has been initiated in the Twelfth Plan, with focus on spreading farm mechanization to small and marginal farmers and regions that have low farm power availability.

As a result, Indian farmer is fast adapting farm mechanization than ever before. The agriculture equipment market in India is presently valued at 6.5 billion USD and has enormous potential for further growth. The tractor market is expected to grow at a CAGR of 8-9 % in next five years. The joint efforts made by Government and farm equipment industry in the country have led to such progress in mechanization over the years.

The role of farm mechanization has now gone beyond tractorization with much more emphasis on increasing productivity of land and labour and increasing work output per unit time. Efficient machinery is being introduced in the country for crops that entails high manpower requirement such as cotton, sugarcane etc., supported by favourable policy, testing facilities and infrastructure. This indicates that transformation has begun in the country and usage of farm machinery is expected to accelerate over the years providing customized solutions to different crops, land holdings and varied agro climates

Tracking the level of farm mechanization in India through the globally accepted Index of Agriculture Mechanization i.e. power availability per unit area, it has been observed that mechanization levels have improved in India over a period of time. The speed, however, has been a tad slow.




Commercial

Importance of Farm Mechanization

The efficiency of mechanization can be judged from the fact that modern plough is about 200 to 300 % efficient than indigenous plough, efficient machinery helps in increasing productivity by about 30% besides, enabling the farmers to raise a second crop or multi crop making the Indian agriculture attractive and a way of life by becoming commercial instead of subsistence. There is a need to double the food production by 2020. This will call for raising more crops in a year thus limiting the turnaround time. Increased production will require more use of agricultural inputs and protection of crops from biotic and abiotic stresses. This will call for greater engineering inputs which will require development and introduction of high capacity, precision, reliable and energy efficient equipment.

Earlier, it was considered that mechanization creates unemployment. The myth has been broken and it has been observed that, agricultural mechanization besides increasing production and productivity, also generates income and employment opportunities. Several studies conducted in different parts of India have shown that mechanization has helped in increasing production, productivity, generation of income and employment. Punjab, a highly mechanized state, employs 7.0 lakh labourers from adjoining states, out of which 3.5 lakh are employed on a regular basis and remaining during the main cropping season. Total farm power availability has increased from 0.25 kW/ha in 1951 with animate power contributing 97.4 percent to 1.15 kW/ha in 1997 with animate sources contributing only 22.7 percent, mechanical sources 43.5 percent and electrical sources 33.8 percent.

The availability of draft animals is reducing, thus shortfalls have to be met mostly through electromechanical power sources. The number of land holdings is increasing and holding size has declined from 2.30 ha in 1970-71 to 1.57 ha in 1990-91. Small (1 to 2 ha) and marginal (below 1 ha) farms numbering 78 per cent of the total number of holdings, cultivate only 32.1 percent of the area; whereas 20.4 percent medium farms (2 to10 ha) account for 50.4 percent of the cultivated area and 1.7 percent large farms (above 10 ha) account for 17.5 percent of the cultivated area.

However, it is heartening to note that average emerging land holdings are large enough for mechanized farming as evidenced in Punjab and Haryana. As discussed in the earlier paragraph, one of the major constraints of increasing agricultural production and productivity is the inadequacy of farm power and machinery with the farmers. The average farm power availability needs to be increased from the current 1.15 kW/ha to at least 2 kW/ha to assure timeliness and quality in field operations, undertake heavy field operations like sub soiling, chiselling, deep ploughing, summer ploughing, handling agricultural produce and by-products efficiently, process them for value addition, income and employment generation. All these works in agricultural operations is possible to be attended only when adequate agricultural mechanization infrastructure is created.

Penetration in India

Tractors, tillers at the forefront of mechanization wave Tractors and power tillers have been at the forefront of driving the mechanization wave in India. Tractor sales have grown at a CAGR of 9.0% in FY05-15 to ~5.5 lakh tractors in FY15 (~2.3 lakh in FY05) while sales of power tillers have grown at a CAGR of 10.6% in FY05-15 to 48,000 power tillers in FY15 (17481 in FY05).

Savings from Farm Mechanization

- Savings generated from farm mechanization include savings of inputs viz. seeds (~15-20%), fertilisers (~15-20%), increase in cropping intensity (~5-20%), saving in time (~20-30%) and reduction in manual labour (~20-30%) with an overall increase in farm productivity at ~10-15%.
- It has been observed that farm mechanization is directly proportional to farm efficiencies and enhanced crop yields. On the yield front, average domestically food grain yield has increased from 522 kg/hectare in 1950-51 to 1930 kg/hectare in 2010-11 primarily on the back of increasing penetration of irrigation facilities, hybrid seeds and farm mechanization.

Main Drivers for Increasing Farm Mechanization Domestically

Increasing demand for food grains

As per the Vision 2030 document released by the Indian Council of Agricultural Research, domestic demand for foodgrain is expected to increase at ~2% CAGR in CY00-30. Foodgrain demand is expected to reach 355 million tonne (MT) in CY30 vis-à-vis 192 MT in CY10. Fruits & vegetables demand is expected to reach 290 MT in CY30 vis-à-vis 136 MT in CY10. India's domestic population has grown from 36.1 crore in 1950-51 to 121 crore in 2010-11 (at 2% CAGR). Going forward, as per the estimates of United Nations (UN), India's population is expected to grow at 1% CAGR to 145 crore by 2028, giving rise to tremendous demand for foodgrain. However, given the limitations in land use and in increasing cropping intensity over a certain period, increasing the yield from the same land is an urgent necessity to meet the needs of a growing domestic population.

Therefore, given the growing population domestically and change in population demographics, there is strong demand for foodgrain including cereals, fruits and vegetables, going forward. An increase in crop yields is the only solution to this problem since there is very limited opportunity to increase sowable farm land. Among methods of increasing farm productivity domestically, farm mechanization is the most sought after solution. The others are increasing usage of agro-chemicals, correcting the composition of fertilisers (N: P: K ratio), increasing usage of hybrid seeds and better irrigation facilities. Farm mechanization is also essential in augmenting the earning capacity of rural farmers and consequent progress of Indian society, as a whole. Growth in agri GDP is a prerequisite to achieve an overall national GDP growth target of 8% & above in the long term, going forward.

Therefore, given the current emphasis of the central government on augmenting the share of manufacturing in total GDP and consequent shortage of farm labour, farm mechanization is the way forward for Indian agriculture. The only perennial risk is adverse weather conditions.

UNIT: 11

Agriculture Mechanization in India

Farm mechanization in India is still in its nascent stages and during the last two decades has been able to achieve a meager growth of less than 5%. The sector faces critical challenges in terms of large share of small and marginal farmers, declining land holding sizes, high cost of farm machinery and equipment, inappropriate technology, undeveloped markets, complex operations, maze of legislation and insufficient policy framework. Land size, cropping pattern, market price of crops including Minimum Support Price (MSP), availability of labour and cost of labour are the major factors deciding the growth of agricultural mechanization in India. Unlike other agricultural sectors, farm mechanization sector in India has a far more complex structural composition. With continued decrease in average farm size, more farms will fall into the adverse category thereby making individual ownership of agricultural machinery increasingly uneconomical.

Agriculture, as a significant contributor to employment and livelihood creation, continues to be the mainstay of India's rural economy. The sector remains crucial for the economy, in order to create a ripple effect on the services and manufacturing sectors of the economy, to meet food and nutritional requirements of our population and to contribute to macroeconomic stability.

Despite its vital role, the sector suffers from major hindrances and roadblocks in production, intermediaries and water scarcity, which have restrained growth. With increasing population leading to rapidly growing food demand, it is critical to build efficiencies in agriculture to achieve food security for the Nation. Hence, it is imperative to focus on increase in production, productivity and profitability in agriculture by improving the intensity of farm mechanization in the country.

Though farm mechanization has improved the state of agriculture in certain parts of the country, it is crucial to take concrete steps to propel farmers in large numbers towards adoption of efficient, cost effective and scalable mechanization technologies. With the right focus from various stakeholders, farm mechanization has the potential to play a significant role in decreasing labor drudgery and intensiveness and increasing efficiency in farm operations.

Implementation of the Sub-Mission on Agricultural Mechanization (SMAM) program by the Ministry of Agriculture is a positive step towards increasing farm productivity across the country. The program will be a catalyst for inclusive growth of agricultural mechanization in India by ensuring last mile reach of farm mechanization to small and marginal farmers.

Globally, the concept of Custom Hiring encompasses sowing operations and all mechanization interventions in the crop cycle till harvest; while India is yet to see intermediate custom hiring interventions. Business models in India are still evolving and will see exponential growth once stakeholders start getting returns on their investments. Early entrants into the sector are therefore covering new geographies, crops and also diverse models, including custom hiring services.

The concept of custom hiring has potential provided there is integration of all operations viz. provision of agri inputs like seeds, fertilizers and equipment, through partnerships with various partners in the ecosystem. With appropriate policy support for adoption, development and promotion of farm mechanization technologies through training, demonstration and use of ICT, the true potential of custom hiring can be harnessed.

Custom Hiring envisages promoting establishment of farm machinery banks for hiring by way of providing financial assistance to self-help groups or farmers' co-operatives since the prohibitive cost of hi-tech and high productive equipments renders it difficult for individual ownership. The Custom Hiring Centres (CHCs) offer farm equipments and machineries on rental basis to farmers who cannot afford to purchase high-end agricultural machineries and equipments. The CHCs play a pivotal role in introducing high technology agricultural machinery to even small farmers with the objective to boost crop production, improve quality, timeliness and efficiency of agriculture operations. It is also amply clear that the current dispensation of the Custom Hiring sector in India is in two interventions predominantly:

- Pre-harvest: nursery preparation, transplanting, seed bed preparation, puddling etc.
- During harvest of crops like wheat, sugarcane etc.

VST SHAKTI

VST TILLERS TRACTORS LIMITED:

Empowering Rapid Agri-Mechanization *in* INDIA

VST TILLERS TRACTORS LIMITED, Bangalore, was incorporated in the year 1967 and was promoted by the VST Group of Companies, a reputable industrial house in South India. The factory, located on a 20 acre plot, was set up in the year 1970 along with Mitsubishi Heavy Industries Ltd. and Mitsubishi Corporation of Japan, as joint venture partners for the manufacture of Power Tillers. In the year 1985, the Company entered into a technical collaboration with M/s. Mitsubishi Agricultural Machinery Co., for the manufacturing of small Tractors.

The Company has set up a new plant located on a 13 acres plot at Hosur in Tamil Nadu which is capable of producing 30,000 Tractors since the later half of 2012.

Presently the Company is manufacturing and marketing Power Tillers, Tractors, Diesel Engines and Component Parts of Diesel Engines. The Company's products are marketed under the brand name, "MITSUBISHI SHAKTI" and "VST SHAKTI". Tractors and Power Tillers manufactured by the Company are exported in small quantities to Europe, and in big quantities to African countries.

The Company is also into the trading business of agricultural machinery, such as: Rice Transplanters (riding & walk behind types), Power Weeders, Power Reapers, etc.

Apart from meeting the captive needs for manufacturing of Tillers and Tractors, the Engines are marketed as prime movers for other applications, like: generators, air conditioners for buses, and for marine applications.

Critical Engine component parts like Crank Shafts, Connecting Rods, Cam Shafts, etc., are exported to UK, other countries in Europe, Thailand and Korea from the division located at Mysore.

With the range of products suitable for land preparation to harvesting, VST Tillers is also well equipped to provide total crop solution. During the year 2016-17, it is in the process of setting up 90 Custom Hiring and Service Centres in Karnataka, in Association with Karnataka State Government under the Brand name of YANTRA DHARA.

The Company has a strong dealership network all over India, numbering more than 200 for marketing its products, spare parts and rendering after sales services. It has regional offices in six locations to facilitate the requirements of the dealers. Presently it has a work force of nearly 1000 personnel comprising of Executives, Staffs, Skilled and Non-Skilled Workmen.

The Company has sold over 27000 Power Tillers and 7000 Tractors during the financial year 2015-16. The total turnover of the Company for this period was Rs.625 crores (USD 94 million). The Company is listed on the Stock Exchanges in India, and has an excellent dividend track and shareholders' value.

www.vsttillers.com
18 HP
2 Wheel Drive
TRACTOR
VST SHAKTI MT 180
130DI
Power Tiller
MT 270
Viraat 4 W Rotary
TRACTOR
VST SHAKTI MT 270
YANJI
Shakti Rice
Transplanter
POWER
REAPER
Toll Free Number
18004190136
VST SHAKTI
V.S.T. TILLERS TRACTORS LTD
Plot No- 1, Dyavasandra Indl. Layout, Whitefield Road, Mahadevapura Post, Bengalore-560048, Karnataka. INDIA
Phone: +91 - 80 - 67141418/23 | +91 - 80 - 67141111, Fax: +91 - 80 - 28510221, CIN: L34101KA1967PLC001706.
A VST GROUP
ENTERPRISE

As the small/marginal holdings constitute 80% of total land holdings in India, the potential for CHCs which will cater to the farm machinery requirement of such a vast area, is quite huge. Government of India, in recognition of this potential had envisaged increase of farm power availability from the present level of 0.93 kW/ha to 2 kW/ha during the 12th plan period (2012-2017). "Sub-Mission on Agricultural Mechanization (SMAM)" is one such initiative towards achieving this objective. Custom hiring facilities for agricultural machinery is one of the major components of this mission. States governments of Karnataka, Andhra Pradesh, Madhya Pradesh and Punjab have been promoting Custom Hiring on Public Private Partnership (PPP) basis through training, demonstration and financial incentives.

Private sector participation in promoting farm mechanization in India through establishment of CHCs is gradually evolving with unique business models. EM3, is creating a pan India network of farm service centres – "Samadhan Kendras" which are the specialized centres started as CHCs equipped with various kind of modern agro machinery used for all field practices. Zamindara Farm Solutions uses a combination of library model and radio taxi model to provide farm equipment services. For better backward linkages, corporates like OLAM have been running CHCs for sugarcane harvesting in Madhya Pradesh through a tie up with the local agri tech service providers.

As majority of Indian farmers belong to small and marginal category, purchase of farm equipment is a significant investment for them. Reasonable financing norms are a must for making farm equipments and machineries available at affordable price and enhance farm mechanization. An issue that has been persistent in financing is the purchase of standalone implements. This adds to the "tractorization" trend that is visible in the industry and doesn't add to overall mechanization. Industry stakeholders feel that commercial banks must be encouraged to provide adequate financing various farm equipments. This is seen by many industry sources as the biggest impediment to growth. Banks can finance the custom service units managed by individuals, institutions or organizations who maintain a fleet of tractors, bulldozers, well-boring equipment, threshers, combines, etc., and undertake farm work for farmers on contract basis, under Priority Sector Lending (PSL) policy of Reserve Bank of India (RBI).

Custom Hiring in India faces constraints like high initial cost of equipments, lack of knowledge in the aspects of operation, maintenance and repair of equipment, repair and maintenance under individual ownership coupled with lack of space for shelter, orientation towards the use of tractors and allied equipments, sub- optimal asset capacity utilization on account of crop specific requirements. To overcome this, virtual or real consolidation of the widely fragmented and scattered land holdings in many parts of the country, extension of benefits of mechanization to all cropping systems including horticultural crops, enhancement of the average farm power availability to minimum 2.5 kW/ha to assure timeliness and quality in field operations and use of precision and efficient equipments to improve the quality of operations is required.

The Custom Hiring model holds the potential to be the best way to introduce capital intensive, high quality and efficient farm mechanization to the small farming structures prevalent in India. The Custom Hiring model enables new machines to be used at their maximum capacity and enables farmers to gain access to latest technology they would otherwise not be able to afford. Custom Hiring can significantly facilitate diversification in agriculture specifically from wheat and paddy to other crops. However, Custom Hiring through private entrepreneurs or co-operatives will help to increase annual use of these equipments thereby making them viable.

Custom Hiring is the evolving concept in India and holds an immense potential to change the farm mechanization landscape of India. With increased participation of stakeholders across the agri supply chain and handholding farmers by supplying all equipments for entire life cycle of a crop sequentially, Custom Hiring concept can be successful. There is a need to study and replicate successful business models along with incentivization and policy support for the adoption, capacity building and skill enhancement, development and promotion of farm mechanization technologies. Innovation in Custom Hiring model by institutionalization for high cost farm machinery such as combine harvester, sugarcane harvester, potato combine, paddy transplanter, laser guided land leveller, rotavator etc. is critical.

Farm mechanization can elevate the agricultural economy and raise farmers' incomes. Following the Green Revolution, India witnessed a remarkable development: India today is the largest producer of milk, pulses and tea and it is the second largest producer of wheat, rice, fruits and vegetables. The country today is largely self- sufficient in food grains – and it has also become a net exporter of food items. Furthermore, India is fast emerging as a sourcing hub of processed food. Against the background of a growing middle class with rising incomes and a high population density, the potential for the development of the sector is enormous. It is therefore expected that the near future will see increasing investment in cold storages, modern processing units and packaging machinery, transport and logistics as well as storage capacities. But a strong food processing sector in India needs to be based on an efficient and sustainable Indian agriculture: All areas of the food processing sector depend on high quality agricultural produce, be it dairy, fruits and vegetables, grain, meat and poultry or fisheries.

However, Indian agriculture still faces major challenges: effects of global climate change, the need to develop strategies for a sustainable productivity enhancement with the main objective to significantly raise quantity and quality of food, an average low income of farmers, wastage of agri produce during the food supply chain, and lack of financial inclusion. A sustainable productivity enhancement and the achievement of the targeted 4 % growth in agriculture can therefore not be imagined without significant improvement in soil health, water management and irrigation, improved seed varieties and hybrids, and integrated pest management, credit financing and – farm mechanization. Innovative technological solutions at all stages of the value chain are the key to a modern, efficient and sustainable agricultural production in India.

Some 50 years ago, a farmer could only feed 10 people. Today, a farmer can feed 142 people. This could only be reached through the mechanization of agriculture and through a strong partnership between farmers and companies, who not only offer the technology but also provide knowledge and training. However, to facilitate the transfer and implementation of new innovative technologies, proper and predictable policy interventions are absolutely required. Already a number of important measures have been initiative by the Central and State governments to drive productivity, to encourage investment and to cease the limitation of the current Agri-Marketing System. The support of different measures to make machinery and equipment accessible and at the same time affordable for Indian farmers is surely a very important one. At the same time, the deployment of modern equipment can allow the efficient and sustainable use of inputs.

- Agriculture continues to remain a major sector of the Indian economy, it contributes to 60 % of employment and continues to be the primary source of living for 70 % of the population. Hence, by making farming a profitable business proposition, economic, social and ecological development of the country can be achieved.
- Agriculture and allied sectors contributes approximately 14 percent to GDP and 49.6 percent of labour force.
- Importance of agriculture is higher in rural areas with 57 percent of rural population employed in the sector and 60 percent of the households dependent on it.
- Agriculture sector is facing a number of challenges — Small farm holdings, which are continuing to decrease in size. — Decreasing farm labour (estimated to drop to approximately 26 percent of labour force by 2050). — Future water scarcity crisis.
- Farm power availability in India is estimated at 2.02 kw/hectare.
- Mechanization level in India is about 40-45 percent with states such as UP, Haryana and Punjab having very high mechanization levels but north-eastern states having negligible mechanization.
- Overall industry estimated at approximately US$ 6.5 billion.
- Tractor is the largest segment with approximately 627,000 units sold in FY'15 (including exports); India is the largest tractor market in the world.
- Other major segments are threshers, rotavators and power tillers.
- These segments have similar structures with a few major players dominating most of the market share.

Agricultural mechanization helps in increasing production, productivity and profitability in agriculture by achieving timeliness in farm operations, bringing precision in metering and placement of inputs, reducing available input losses, increasing utilization efficiency of costly inputs (seed, chemical, fertilizer, irrigation, water etc.), reducing unit cost of produce, enhancing profitability and competitiveness in the cost of operation. It also helps in the conservation of the produce and by products from qualitative and quantitative damages; enables value addition and establishment of agro processing enterprises for additional income and employment generation from farm produce. It is one of the important inputs to usher in all round development in the rural India.

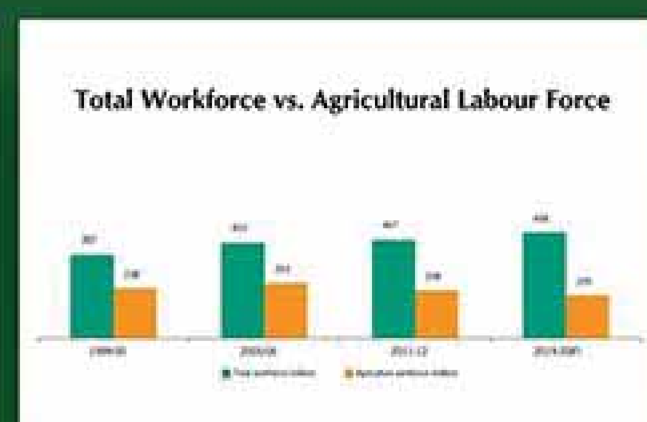
India commands ~2.4% of the global geographic area and has access to ~4% of the total water reserves to support a mammoth ~18% of the total global population and ~15% of the total global livestock. Thus, lack of natural resources like land & water and increasing infrastructural development limits the ability to increase cultivable land. Hence, this makes a compelling case for increasing crop yields domestically. Farm mechanization i.e. usage of machinery and technology (e.g. tractors, tillers, transplanters, harvesters, pumps, etc.) in farming is the most sought after solution for increasing farm yields. This is given the increasing concerns over pesticide residues in our food value chain, shortage of farm labour on account of a shift in labour from rural to urban areas and diversion of workforce in MGNREGA.

Comparing India vis-à-vis its global competitors in the agri space, the level of mechanization in India as of 2010-11 is ~40% while the share of the population engaged in agriculture is ~55%. The corresponding figures for developed countries like the US are 95% and 2.4%. For a developing country like Brazil the corresponding figures are 75% and 14.8%, depicting the high intensity of manual labour in India vis-à-vis its global competitors.

Current Status

Despite agriculture sector being a key contributor to employment in the country, its contribution to the overall GDP has seen a decline. According to the Central Statistical Organisation (CSO), the agriculture and allied sector contributed approximately 13.9 percent of India's GDP (at constant 2004-05 prices) during 2013-14, down from 14.6 percent in 2010-11. This decline in agriculture sector's and increase in service sector's share of GDP is consistent with a growing economy. A similar trend is also seen in the agricultural labour force. During last decade, the overall workforce in agriculture and allied activities has dipped by 11 percentage points, indicating a rise in secondary and tertiary sectors, self-employment and regular jobs, which is also consistent with economic growth.

Despite the decline, the sector remains a dominant source of and contributor to overall employment and the GDP. 49 percent of the labour force is still employed in the sector and over 60 percent of rural households depend on agriculture as their principal source of livelihood. The number of people employed in the agriculture sector stood at 228 million in 2011-12 and while this number is predicted to drop further to 205 million people by 2019-20, that would still represent over 40 percent of the work force. Additionally, a significant chunk of the GDP still comes from this sector.



Level of Mechanization and Region Wise Development

Farm mechanization in India stands at about 40-45 percent. This is still low when compared to countries such as the US (95 percent), Brazil (75 percent) and China (57percent). While the level mechanization lags behind other developed countries, the level of mechanization has seen strong growth through the last decade. The farm power availability on Indian farms has grown from 1.47 kW/ha in 2005-06 to 2.02 kW/ha in 2013-14.

In India, the level of mechanization varies greatly by region. States in the north such as Punjab, Haryana and Uttar Pradesh have high level of mechanization due to the highly productive land in the region as well as a declining labour force. The state governments in these states have also provided timely support in promoting mechanization of farms. The western and southern states in the country have a lower level of mechanization due to the smaller land holdings prevalent in these regions as well as the land holding being more scattered. As a result, in many cases, mechanization has been uneconomical leading to the lower development.

India Relative Development of Mechanization

In north-eastern states, the level of mechanization is extremely low. There are a number of reasons behind this. Factors such as hilly topography, high transportation cost, lack of state financing and other financial constraints due to socio-economic conditions and dearth of agricultural machinery manufacturing industries have hindered the growth of farm equipment sector within these states.

Level of mechanization in percent, by crop and value-chain process

Crop	Seedbed Prep Transplanting	Sowing/ Planting/	Weed and pest control threshing	Harvesting and
Paddy	85-90	05-10	80-90	70-80
Wheat	90-95	80-90	70-80	80-90
Potato	90-95	80-90	80-90	70-80
Cotton	90-95	50-60	50-60	0
Maize	90-95	80-90	70-80	50-60
Gram	90-95	50-60	60-70	30-40
Sorghum	80-90	30-50	60-70	20-30
Millets	80-90	30-40	60-70	20-30
Oilseeds	80-90	30-40	60-80	20-30
Sunflower	80-90	40-50	80-90	60-70
Fodder Crop	80-90	20-40	80-90	10-20
Vegetable Crop	70-80	5-10	80-90	< 1
Horticulture Crop	60-70	30-40	40-50	< 1

Operation-wise, the level of mechanization varies from 42 percent for soil working and seed bed preparation, 29 percent for seeding and planting, 34 percent for plant protection and 37 percent for irrigation.

Market Segmentation

The four major segments of equipment, tractors, threshers, tillers and rotavators have shown steady growth over the past five years.

Tractor is, by far, the largest segment in the equipment category with an annual sale of 600,000-700,000 units. FY'14 witnessed sales of 697,675 (including exports) tractor units. Despite a sales slowdown in FY'15 (to 626,839 including exports), the tractor market (including exports) is expected to grow at a CAGR of 8-9 percent7 in the next five years as long term industry drivers remain favourable.

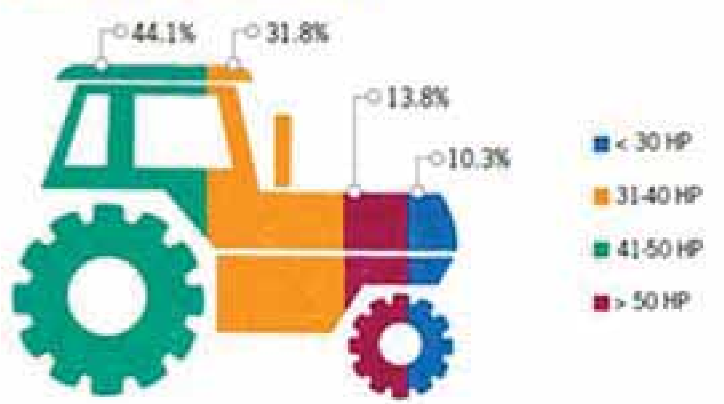
Within the tractor market, the 41-50 HP segment is the largest selling unit, registering about 44 percent of the total tractor sales (domestic + exports) in FY'15. Next largest segment is the 31-40 HP segment, which has gained 2.2 share points in share of volume, which has been sourced mainly from the > 50 HP segment.

Tractor sales by segment, FY'11 and FY'15

The tractor market has grown at a CAGR of 15.2 percent till FY'14. However, there was a sharp downturn seen in FY'15. This has been attributed to a reduction in farm incomes due to the decline in production of major crops as well as softening commodity prices with lower procurements by the government on account of adequate buffer reserves. In the same time period, the tiller market grew at 10 percent.

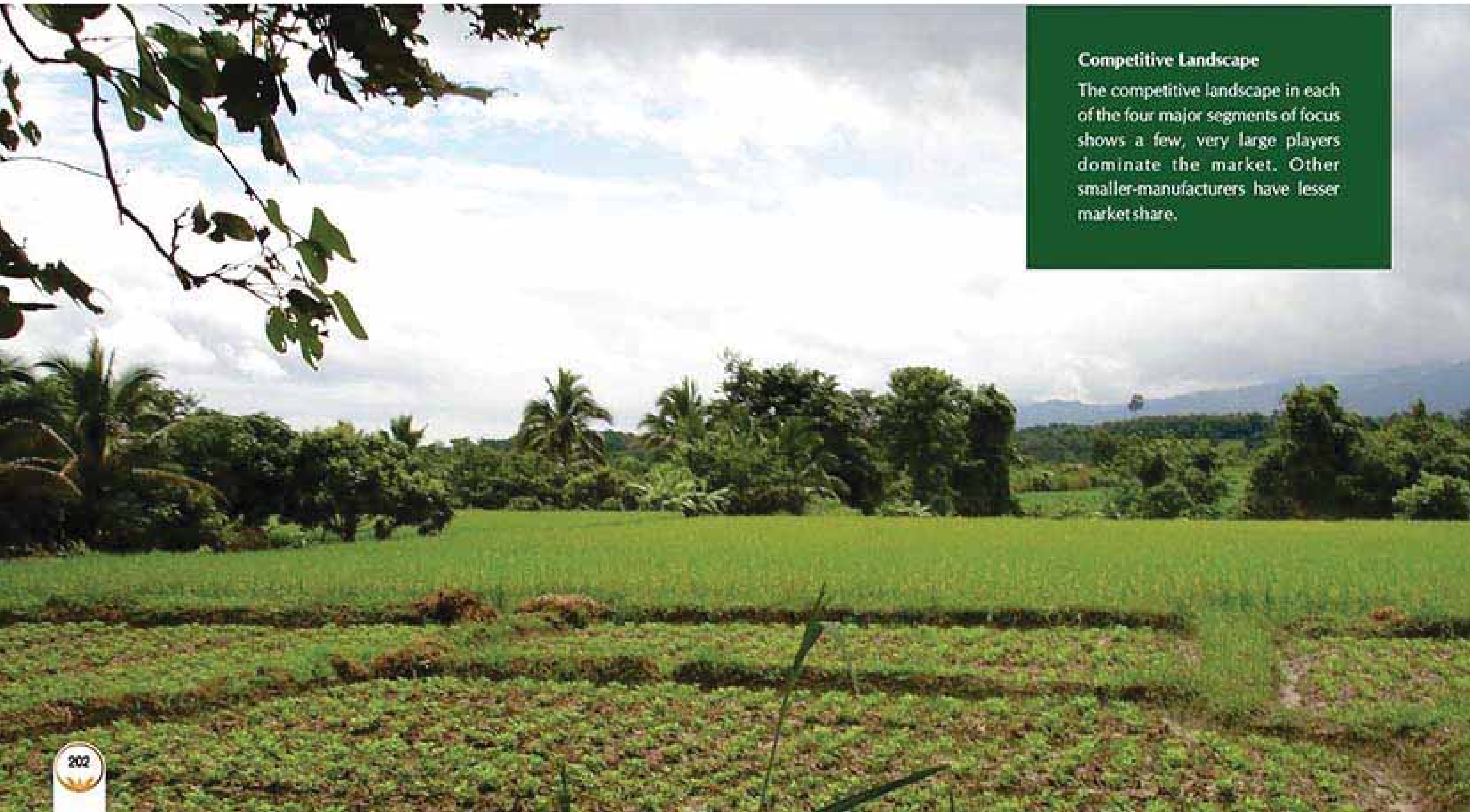
Between FY'08 and FY'13, the thresher and rotavator markets grew at 2.0 and 21.0 percent respectively

Tractor sales by segment FY'11



Tractor sales by segment FY'15

Tractor and thresher market (Estimated)**



Competitive Landscape

The competitive landscape in each of the four major segments of focus shows a few, very large players dominate the market. Other smaller-manufacturers have lesser market share.

Tractor Market:

The largest tractor manufacturers not only cater to the Indian market, but are also major exporters of tractors to regions such as the US, China, Australia, Latin America, the Middle East and South Asia.

Rotavator Market:

The Indian rotavator market is also dominated by a number of smaller firms. The top four Rotavator manufacturers hold more than 80 percent of the market.

Power Tiller Market:

This market is dominated by two Indian companies collectively catering to more than 65 percent of the market. The remaining market is catered to by small firms and primarily by those importing Chinese power tillers. The key Indian tiller manufacturers also cater to the export market, exporting to regions such as the Middle East, Russia, Turkey, the European markets and other parts of Asia.

Thresher Market:

The majority of the thresher marker in India remains unorganised. Only one large manufacturer stands out and holds about a third of the market. The other is divided up into numerous smaller players.

Farm Mechanism in India

The agriculture sector in India has witnessed a considerable decline in the use of animal and human power in agriculture related activities. The trend has paved a way for a range of agricultural tools. A large number of these are driven by fossil fuel operated vehicles such as tractors, diesel engines. This has resulted in a shift from the traditional agriculture process to a more mechanised process. Though the level of mechanization in India is lower as compared to other developed countries, it is certainly on growing.

The role of tractors in the Indian agriculture sector reflects the growing trend of tractorization in the country. Custom hiring of farm equipment is a prevalent practice in India, especially among small land owners who find ownership of large farm machines expensive and uneconomical. The government is therefore promoting farm mechanization by subsidising purchase of equipment as well as supporting bulk buying through front-end agencies.

The government also provides credit and financial assistance to support local manufacturing of farm mechanization equipment. Given the labour scarcity and the government's subsidy programs, adoption of farm mechanization is set to increase.

Indigenously developed agricultural hand tools and implements have also evolved over time and despite the strides agricultural machinery has made, continue to play a critical role in agriculture. This is on account of the small and irregular farm sizes, lack of machinery available for smaller land holdings, lack of awareness and skills among farmers and inability of farmers to afford more advanced technologies.

Hand tools have also been developed for all levels of the value chain. In 2010, when the size of the agricultural labour force was 269.74 million, the estimated number of hand tools in use was 809.22 million, which equates to about 3 hand tools per labourer. However, the prevalence of these tools comes with the issue of safety.

An ICAR study (2004-2007) showed that 34.2 percent of accidents in agriculture were due to hand tools, with sickles and spades involved in 46 percent of farm injuries. Implications of injuries due to hand tools are severe as these injuries are very painful and disabling due to delayed treatment. A survey conducted in India showed that 70 percent of agricultural hand tools injuries had a recovery time of more than seven days. Thus, developing farm machinery more suited to the local conditions is essential so that injuries and problems that come with the use of hand tools can be abated while making agricultural practices more productive.

Farm Machinery Trade

Globally BRICS nations (Brazil, Russia, India, China and South Africa) with Japan and Turkey are joining the ranks of heavy weight agricultural machinery markets. India is too involved in the international trade of a number of different farm equipment.


ESCORT 335

Tractor trade (units):

India is considered to be the largest tractor market in the world. While the country produces a large volume of tractors, it also exports tractor units to other countries across the world. On an average, the country exports an average of 60,000 tractors annually. India's tractor export markets primarily include African countries and ASEAN countries where soil and agro-climatic conditions are similar to India. In FY' 2009, India exported 38,198 units of tractors to 62,890 in FY' 2013 growing at a CAGR of 13 percent.

India's tractor export markets majorly include African countries and ASEAN countries where soil and agro-climatic conditions are similar to India. In FY' 2009, India exported 42,380 units of tractors to 65,650 in FY' 2014 growing at a CAGR of 9.1 percent.

India combine harvesters trade (units):

FARM IMPLEMENTS (INDIA) PVT. LTD. *New Generation Farm Machines*

Farm Implements (India)

Serving Nation With Need Based Domestic Agricultural Mechanization

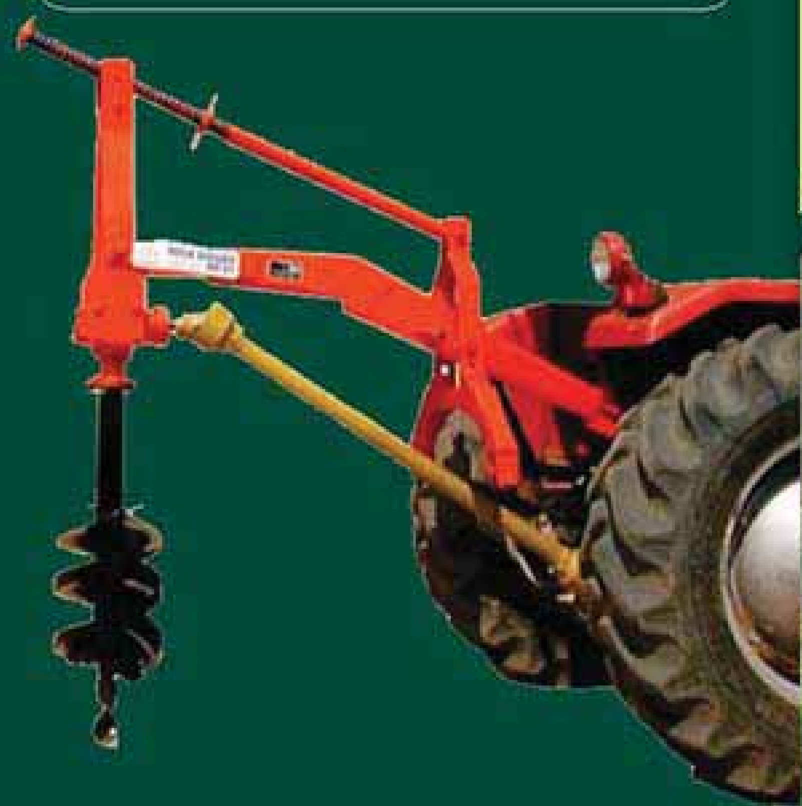
Small Beginning!

We are the pioneers in introducing state–of–the art Tractor PTO operated machines to suit Indian farmers' need. Our Company was started in 1984. We started with the product, "ROTAVATOR".

Different products!

Through our wide Dealership Network, we have been supplying the machines and have already made our existence felt in the whole Indian market. At present we have different products for Seed Bed Preparation (For Both Dry and Wet Fields), Planting Equipment, Post Harvesting Equipment, etc. to offer. Interestingly, all our products are unique.

Thus, we bring in new technology for Indian farmers on a regular basis.



ROTAVATOR

ROTAVATORS are best suitable for both Dry and Wet field operations. Rotavator requires NO TRACTION. The Tractor and Rotavator combination prepares field for commencement of cultivation much sooner after rain than other implements. Howard Brand ROTAVATORS with 24, 30, 36, 42, and 48 Blade arrangements are available.

ROTAVATOR RICE HARROW (ROTO PUDLER)

RICE HARROW (ROTO PUDLER) is a combination of Rotavator and perfect levelling device. It suppresses the weed which is highly recommended for Paddy fields using Paddy transplanter.

POWER HARROW

A rotary power harrow, or simply POWER HARROW, has multiple sets of vertical tines. Each set of tines is rotated on a vertical axis and tills the soil horizontally. The result is that, unlike a rotary tiller, soil layers are not turned over or inverted, which is useful in preventing dormant weed seeds from being brought to the surface. Also, there is no horizontal slicing of the subsurface soil that can lead to hardpan formation.

ROUND BALER

RB510W ROUND BALER is a Tractor PTO operated (540rpm) attachment. This baler is useful in collecting all the straw (Harvested manually or by Harvester Machine) from the field, compressas it in round shape and eject automatically.

CASSAVA PLANTER

DOUBLE ROW CASSAVA PLANTER is attached to normal tractor with the 3 point linkage. The space between the rows is as per the standard requirement. The planters are easy to operate and very easy to maintain.

BUND FORMER MACHINE

BUND FORMER/LEVEE PLASTERING MACHINE is a boon to the farmer where rat menace and seepage of water are perennial problems. It makes a perfect Bund which reduces the damages occurred due to rat, and water leakage. By using BUND FORMER equipment, bunds will get both proper size and perfect cemented shape. With the help of this equipment with lesser operating cost, higher number of bunds' forming is achievable.

RATOON MANAGER FOR SUGARCANE

RATOON MANAGER is an equipment attached to a tractor and operated by tractor PTO. RATOON MANAGER manages the ratoons in the sugarcane field after harvesting. The ratoons are shaved off evenly, barring the older roots, inter-cultivating the soil, and earthing-up is done in a single pass. Fungicide and Fertilizer Applicator in band form can also be attached on a need basis.

ROTASLASHER

ROTASLASHER is a Tractor PTO operated equipment. It helps in providing a green carpet without disturbing the soil. Therefore, it is highly useful in Public Gardens, Zoos, Airport Runways Sides, School Play Grounds, Golf Clubs and Palm Oil Fields. Available sizes are having 3 ft, 4 ft and 5 ft widths.

SUGARCANE DETOPPER CUM LEAF STRIPPER

Leaf Stripper is useful in stripping of Sugarcane and Sweetcorn leaves without any damage to the harvested material.

HOWARD

Farm Implements (India) Pvt Ltd

No.13, Kumarappa Street, Nungambakkam, Chennai 600034, India

Phone: +9144 28261676, 28273493 Fax No. +9144 28265345

Email: rotavato@vsnl.com & admin@fipl.in | Website: www.tech2farms.com & www.fipl.in

UNIT: 12

Sources of Farm Power in India

The different sources of power available on the Indian farm for doing various mobile and stationary operations are mobile power viz. human (men, women, children), Draught animals (bullocks, buffaloes, camels, horses and ponies, mules and donkeys), tractors, power tillers and self-propelled machines (combines, dozers, reapers, sprayers etc.); and stationary power i.e. diesel/oil engines (for pump sets, threshers, sprayers and other stationary operations) and electric motors (for pump sets, threshers, sprayers and other stationary operations).

Table. Farm Power Population in India

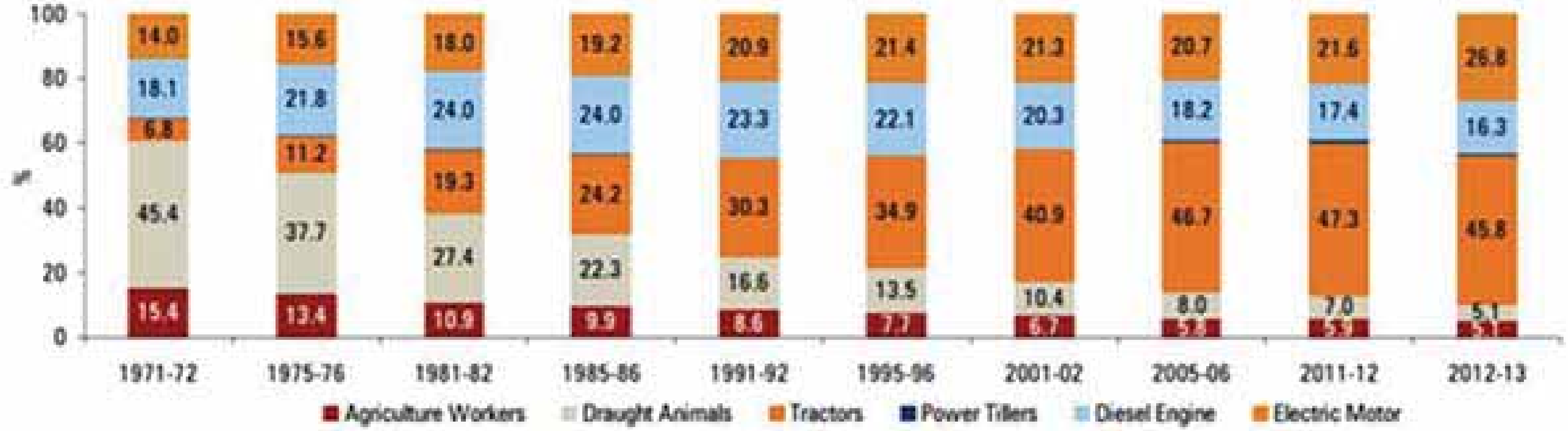
Year	Agriculture Workers	Draft Animal Power	Tractors	Power Tillers	Diesel Engines	Electric Motors
Population of farm power sources in millions						
1960-61	131	80.4	0	0	0.23	0
1970-71	126	83	0	0	2	2
1980-81	148	73	1	0	3	3
1990-91	185	71	1	0	5	8
2000-01	234	60	2.531	0	6	13
2010-11	263	54	4	0	8.2	16.5
2011-12	266.08*	53	5	0	8.3	16.7
2012-13	269.20*	52.8	4.858	0.4021	8.35	16.8
2013-14	272.00*	52	5.237	0.4409	8.45	17
CAGR, % :						
1960-61 to 1990-91	1.16	-0.42	12.27	6.25	10.66	13.12
1991-92 to 2013-14	1.54	-1.33	6.65	12.03	2.50	3.29
1960-61 to 2013-14	1.38	-0.82	9.79	9.30	7.04	8.74

(CAGR – Compound Annual Growth Rate) *Estimated

Table. Sources of farm power available in Indian agriculture (kW/ha)

Year	Agriculture workers	Draught Animals	Tractors	Power Tilers	Diesel Engine	Electric Motor	Total Power
1971-72	0.045	0.133	0.02	0.001	0.053	0.041	0.293
1975-76	0.048	0.135	0.04	0.001	0.078	0.056	0.358
1981-82	0.051	0.128	0.09	0.002	0.112	0.084	0.467
1985-86	0.057	0.129	0.14	0.002	0.139	0.111	0.578
1991-92	0.065	0.126	0.23	0.003	0.177	0.159	0.76
1995-96	0.071	0.124	0.32	0.004	0.203	0.196	0.918
2001-02	0.079	0.122	0.48	0.006	0.238	0.25	1.175
2005-06	0.087	0.12	0.7	0.009	0.273	0.311	1.5
2011-12	0.1	0.119	0.804	0.014	0.295	0.366	1.698
2012-13	0.093	0.094	0.844	0.015	0.3	0.494	1.841

Composition of farm power in India



Thus, it can been observed that slowly and steadily India has been progressing towards greater farm mechanization with the share of agricultural workers in total farm power declining from 15.4% in 1971-72 to 5.1% in 2012-13. On the other hand, the share of tractors in total farm power has increased from 6.8% in 1971-72 to 45.8% in 2012-13.

A farm power for various agricultural operations can be broadly classified as:

- Tractive work such as seed bed preparation, cultivation, harvesting and transportation, and
- Stationary work like silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water.

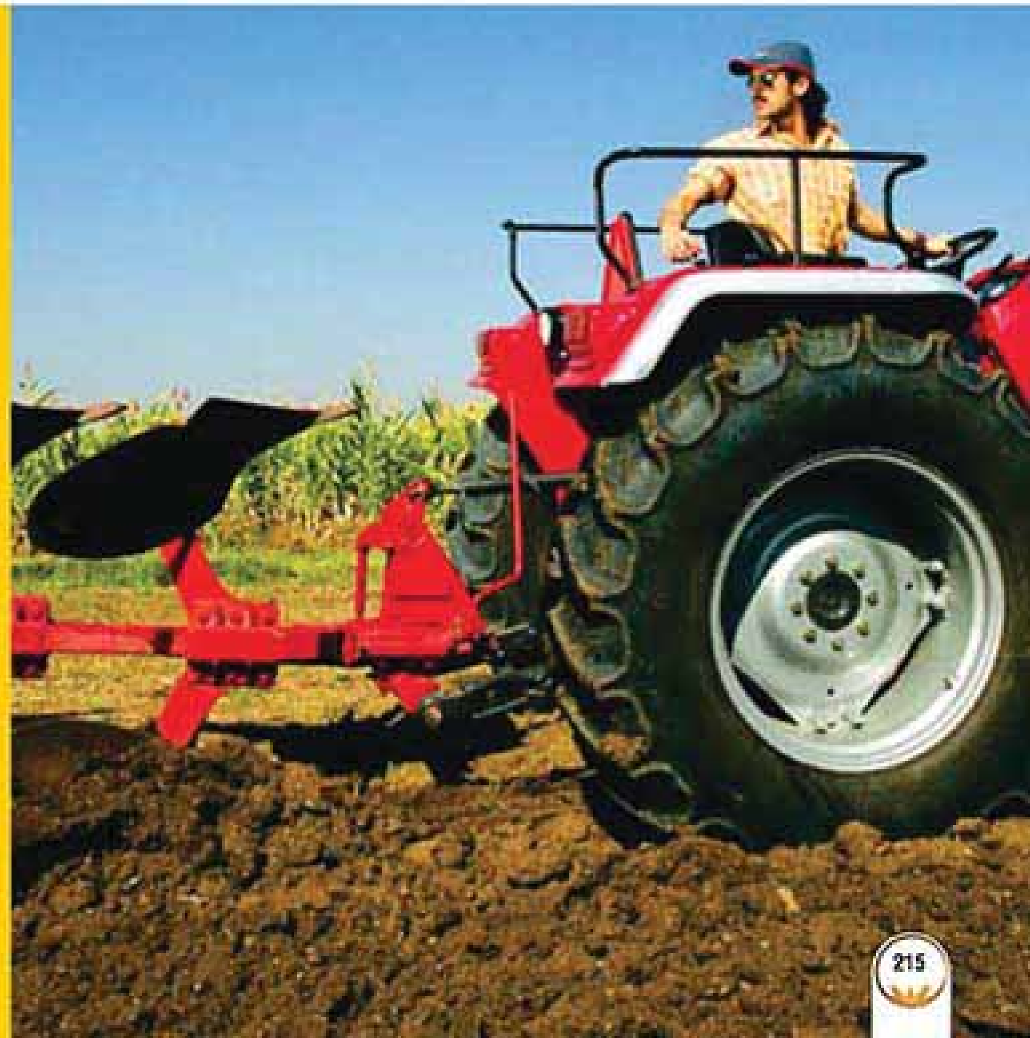
These operations are done by different sources of power, namely human, animal, oil engine, tractor, power tiller, electricity and renewable energy (biogas, solar and wind).

Measurement of Power

- Power is measured in terms of work accomplished in a given period of time.
- A large tractor can do more work in a given period of time than a small tractor, and therefore is said to be more powerful.
- The formula for determining power is: *P (Power)* = F Force × D(Distance)/ T(Time)

Horsepower

- Horsepower is the most common measure of engine power.
- The term had its origin in the era when engines were competing with horses as a source of power. An engine's ability to do work was compared with that of a horse.
- One hp is equivalent to 4500 kg m per min.
- Horsepower is measured by using dynamometer.



Agriculture has been the main occupation of the rural people and largely dependent on use of animate power sources. Human energy is predominantly used for all operations in agriculture. Before green revolution, animate energy had been widely used for various farm operations like seedbed preparation, sowing, inter-cultivation, harvesting, threshing and transportation to and from the field. Wider job opportunities in urban areas have set in a trend of rural youth preferring to take up other profession than cultivation. However, in specific situations as hill agriculture, plantations, tea industry etc human energy would continue to serve as principal source of energy. Even in specialized operations as rice transplanting, harvesting of cotton, horticultural and plantation crops, human power is the only source of energy. The labour/land ratio has been steadily increasing over time and thus technological changes through mechanization process have been land-saving in nature with focus on increasing land productivity. Mechanization process in India thus, did not follow the process of creating surplus labour from agricultural sector for consumption in the industrial sector, as had been in the cases of developed countries.

While the population of agricultural workers as percentage of rural population has gone down from about 69.4% in 1951 to about 55% in 2012 but in absolute terms, due to increase in overall population, the number of agricultural workers available in rural areas has increased from 131.1 million in 1960-61 to 272 million in 2013-14 and thereby registered an annual compound growth rate of 1.38% during the last 53 years. These agricultural workers are Agricultural Engineering Today 48 engaged in different farm operations and depend on agriculture for their livelihood, even when they are not fully employed throughout the year. Due to too much involvement of labour in different farm operations, the cost of production of most of the crops in our country is quite high as compared to developed countries. Human power availability for agriculture had been 0.043 kW/ha in 1960-61 and reached to 0.096 kW/ha in 2013-14 registered an annual compound growth rate of 1.53% during the previous 53 years of time. Share of agricultural workers in total power availability in 1960-61 was 14.7% reduced to 4.66% in 2013- 14 . Time series trend suggests that share of power from agricultural workers to total power available will further reduced in near future.

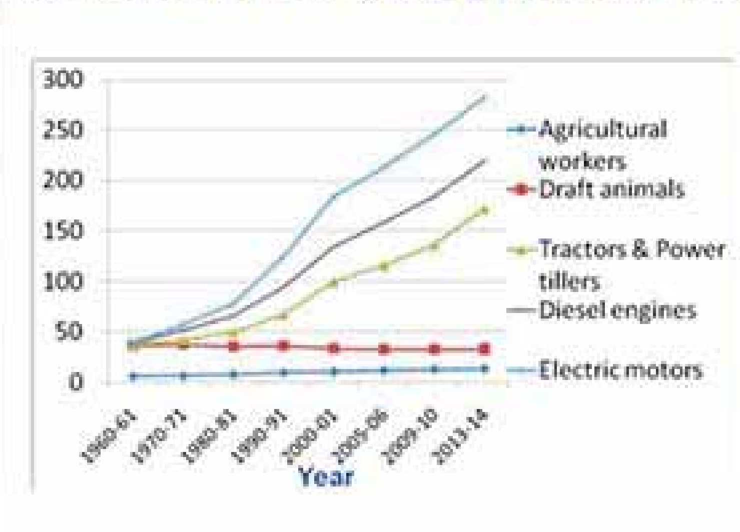


Figure: Power available from different power sources in India

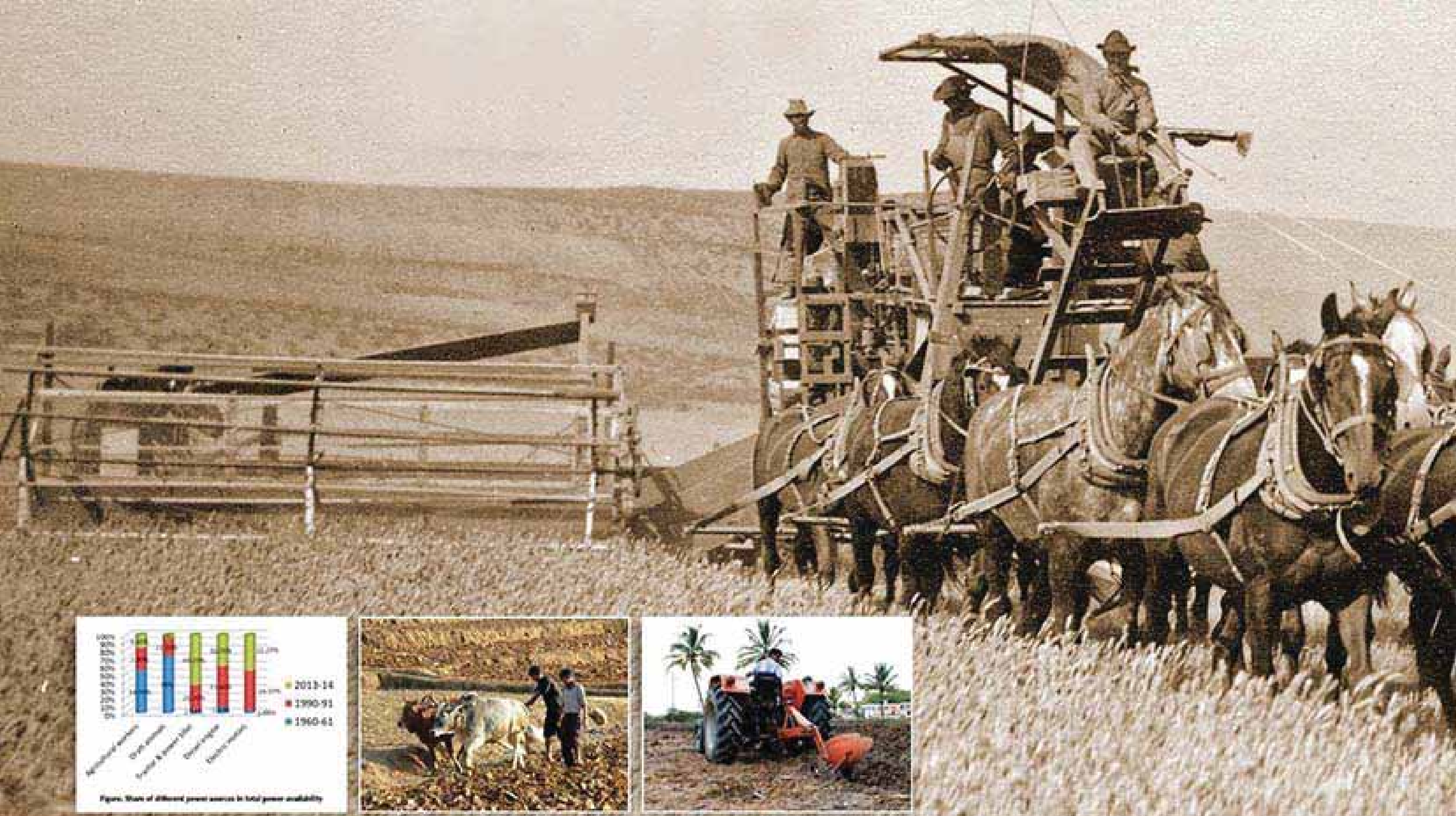
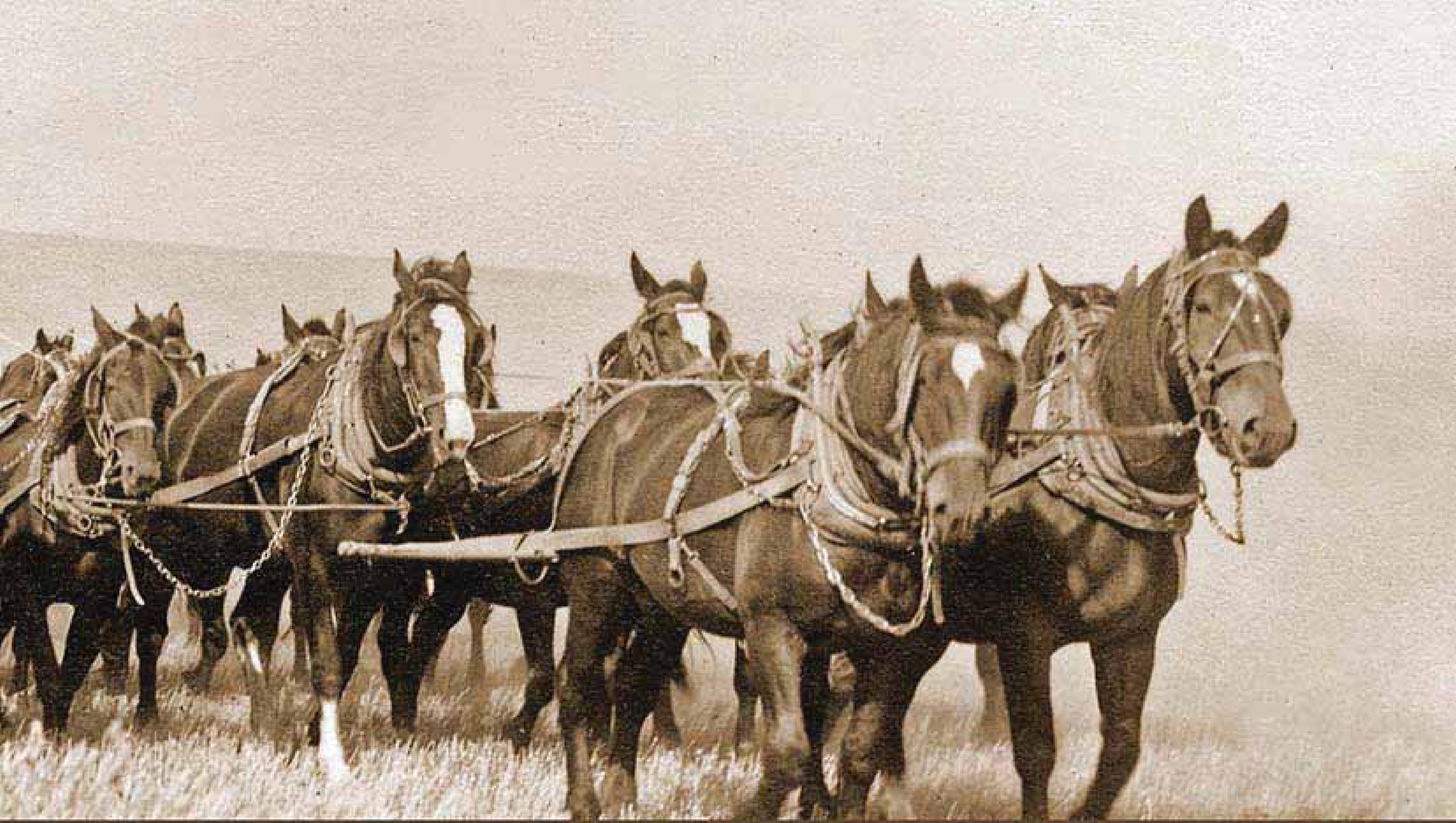


Figure. Share of different power sources in total power availability

Draught animal power, available mainly as progenies of milch animals, has long remained an important source of tractive energy for production agriculture, rural agro-processing and transport in India and other developing countries of Asia, Africa and Latin America. Traditional agriculture in India largely depended upon this power source for farm operations like tillage, sowing, weeding, water lifting, threshing (by animal trampling), oil extraction, sugarcane crushing and transport. With modernization of agriculture production systems and use of mechanical power sources, draught animal use has drastically reduced in power intensive operations as water lifting, oil extraction and threshing. The choice of farm power to be used for an operation is largely decided by the available time period, alternatives available (including custom hiring services) and associated economics. In sloppy hill regionsand on small farms machines like tractor or combine are difficult to operate, and thus draught animal use besides human is likely to continue as major power source. Increased cost of maintenance of animals has also brought in compulsions among the farmers to reduce draught animal ownership as far as practicable. Apart from the economic importance, livestock still continues to have symbiotic bond with rural people.

Draught animals, particularly bullocks, are still the predominant source of mobile power on about 60% of the cultivated area consisting of about 85 million ha. They are very versatile and dependable source of power and are used in sun and rain under muddy and rough field conditions. They are born and reared in the village system and maintained on the feed and fodder available locally. They are ideal for rural transport where proper roads are not available. They reduce dependence on mechanical sources of power and save scarce petroleum products. Their dung and urine are also used as indirect source of energy-farmyard manure, biogas. They also help in maintaining ecological balance.



Under Indian conditions where majority of the people are vegetarian and even amongst non-vegetarians, majority of them don't eat beef, draught animals as by-product of milch animals; will continue to be available for draught purposes in future also. About 4-5 decades back most of the farm operations, water lifting, rural transport, oil extraction, sugarcane crushing, chaff cutting etc, were being done using draught animals only. But with the modernization of agriculture, development of concrete roads connecting village and availability of electricity in villages, most of the jobs earlier being done using draught animals, except field operations, are now being done using other convenient and cheaper options i.e. electricity and diesel. Over the years the annual use of draught animals is going down. While earlier a pair of animals was being used for about 1200-1800 hours annually, their average annual use has now come down to about 300-500 hour only, that too for tillage, sowing, weeding and rural transport. The time series population of draught animals during 1960-61 to 2013-14 is given in Table below shows that the population of draught animals during the last 43 years has been going down. This declining trend of draught power was more visible especially in those states where the demand of tractors and power tillers has gone high. It has been observed that on an average a tractor is replacing about 5 pairs and power tiller about 2 pairs of animals. Draught animal population, mainly derived from bovines, was 80.40 million in 1960-61 and reduced to 52 million by 2013-14 with a negative annual compound growth rate of -0.82% during the period of 53 years. Share of draught animal power was 78% of the total farm power in 1960-61 reduced to 7% only in 2013-14. Draught animal power availability in India decreased from 0.229 to 0.224 kW/ha between 1960 and 1970. The power availability further reduced to 0.200 kW/ ha in 1980, 0.162 kW/ha in 2000 and 0.14 kW/ha by 2013-14 .

For meeting the increased demand of mobile power for timely farm operations and increased intensity of cropping, additional power is available mainly from tractors and power tillers. Self-propelled reapers and combines also provide mobile power specially for harvesting operations. India presently is the largest manufacturer of tractor in the world. There are more than 20 manufacturers of tractors in the country producing about 60 models of tractors in different hp ranges. Tractor population in India has grown from 0.037 million in 1960-61 to 5.237 million units in the year 2013-14 at an annual compound growth rate of about 10 per cent during the last 53 years. Farm power availability from tractor has consequently increased from 0.007 kW/ha in 1960 to 0.218 kW/ha in 1990 at an annual compound growth rate of 12.14%. The growth rate in the next decade decreased to 8%. Farm power availability in the year 2000 was 0.47 kW/ha, reaching to 0.97 kW/ha in 2013-14 at an overall growth rate of 9.80% during the last 53 years. Power tiller, or two-wheel tractor, came in India with import of two units from Japan in 1961.There are mainly 2 manufacturers of power tillers in the country producing about 6 models in the range of 5.97-8.95 kW (8-12 hp). In addition to them there are many others who are importing power tillers and selling in the country. Contribution of tractors and power tillers was only 2.54% of the total farm power in 1960-61 increased to about 50% in 2013-14. Sale of tractors and power tillers has constantly increased during last 10 years with some exceptions.

Stationary power sources in agriculture comprise of diesel engines and electric motors used for irrigation equipment, operating threshers and other stationary machines. Diesel engine and electric motor are widely used by the farmers mainly for lifting irrigation water, apart from operating stationary farm machines like threshers and chaff cutters. The populations of these prime movers have increased tremendously since the green revolution. Diesel engine population in the country increased about 37 times between 1960-61 and 2013-14, while the annual compound growth rate had been 10.66% during the period 1960-61 to 1990-91, with increased availability of electricity it reduced to 7.04% during the period of 1990-91 to 2013-14. Farm power from diesel engines increased from 0.009 kW/ha in 1960-61 to 0.247 kW/ha in 2000-01 and 0.335 kW/ha in 2013-14, registered an annual compound growth rate of about 7% during the last 53 years.

Figure. Tracor and power tiller sales data for last 10 years

The rural electrification programme launched by the Government of India in the mid-sixties undertaken through the Rural Electrification Corporation has helped in making available electricity to 18.5 per cent villages in 1970-71 and increased to 100% villages by 2004-05. Preferential supply to rural sector at subsidized price has led to rapid increase in use of electric motors in the agricultural sector. Electric motor population thus increased 85 times between 1960-61 and 2013-14 at an impressive annual compound growth rate of 8.7%. Farm power availability consequently increased exponentially from 0.005 kW/ha to 0.445 kW/ha with an annual compound growth rate of about 8.74% during the same period.

For adoption of higher level of technology to perform complex operations within time constraints and with comfort and dignity to the operators, mechanical power becomes essential. Thus, the extent of use of mechanical power serves as an indicator of acceptance of higher level of technology on farms. Over the years the shift has been towards the use of mechanical and electrical sources of power, while in 1960-61 about 92.30% farm power was coming from animate sources. In 2013-14 the contribution of animate sources of power reduced to about 11.80% and that of mechanical and electrical sources of power increased from 7.70% in 1960-61 to about 88.20% . It is apparent that the cropping intensity increasing with increase in per unit power availability. It was 114% with power availability of 0.32 kW/ha during 1965-66 that increased to about 141 per cent with increase in power availability of 2.02 kW/ha in 2013-14. Net sown area per tractor shows the reverse trend during the same period, which observed 2162 ha/tractor in 1965-66 reduced to 27 ha/tractor in 2013-14. Between 1960-61 and 2013-14, the growth rate in power was 3.81% to reach 2.02 kW/ha.

Human Power

Human beings are the main source of power for operating small tools and implements. They are also employed for doing stationary work like threshing, winnowing, chaff cutting and lifting irrigation Water. It is generally believed that there is surplus human power available for agricultural operations in India. According to 2001 census figures, the total Indian rural population is about 74 crores. Of the total rural population only 30 per cent is available for doing farm work. Hence the total number of persons available would be about 74 x 0.30 = 22.2 crores. This figure includes both the landless labourers as well as the owners of farms in the country. On the average a man develops nearly 0.1 horsepower (hp.). Therefore, the total power available through human source may be about 2.2 crore hp. But there is a steady decline in the number of landless labourers available for doing farm work in rural areas.

Managing Labour Peaks: In crop production system, labour peaks develop due to high labour demands in operations, which cannot be or have not been mechanized so far. For example, the operations like transplanting of paddy, weeding and inter-culture operations or harvesting of crops demand large number of human labour on each of the farms in the region. Such peaks have got to be managed if one desires to have high return from his enterprise. In general, the peaks are managed as follows:

i) Increasing the working hours.
ii) Extending the time period of operations.
iii) Adjusting the cropping pattern.
iv) Mechanizing the operations, wherever possible.
v) Decreasing the intensity of some operations

- Advantages: Easily available and used for all types of work.
- Disadvantages: Costliest power compared to all other farms of power, very low efficiency, requires full maintenance when not in use and affected by weather condition and seasons.

Animal Power

The most important source of power on the farm all over the world and particularly in India is animal. It is estimated that nearly 80 per cent of the total draft power used in agriculture throughout the world is still provided by animals, although the number of agricultural tractors has become double after every ten years since 1930. India with its 22.68 crore cattle possesses the largest number of cattle in the world. Among them the bullocks and buffaloes happen to be the principal sources of animal power on Indian farms. However, camels, horses, donkeys, mules and elephants are also used for the farm work. The average force a bullock can exert is nearly equal to one tenth of its body weight. But for a very short period, it can exert many more times the average force. Generally a medium size bullock can develop between 0.50 to 0.75 hp. Thus the variation in power developed by animals is considerable. Actually small size bullocks are not able to develop even 0.50 hp and most of them are not fit for heavy work. Animals can be a very cheap source of farm power if raised by the farmer himself. It becomes the most costly source if the animal has to be bought from outside. Considering the overall situation of the draft animals available in the country, it is estimated that the total work animals may be about 7.56 crores in number that is 33 per cent of the total horse power output from the animals would be about $7.56 \times 0.50 = 3.78$ crore hp.

- Advantages: Easily available, Used for all types of work, Low initial investment, Supplies manure to the field and fuels to farmers and Live on farm produce.
- Disadvantages: Not very efficient, Seasons and weather affect the efficiency, Cannot work at a stretch, Require full maintenance when there is no farm work, Creates unhealthy and dirty atmosphere near the residence and Very slow in doing work

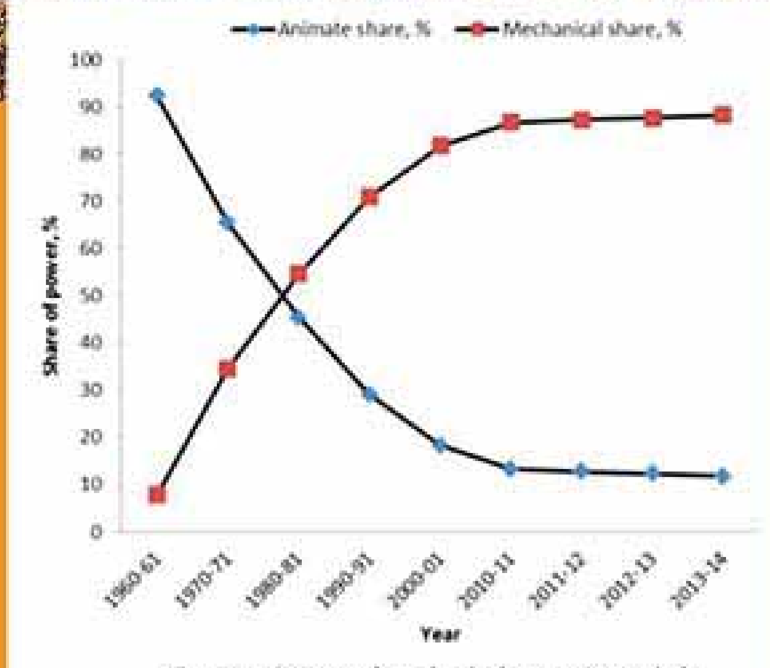


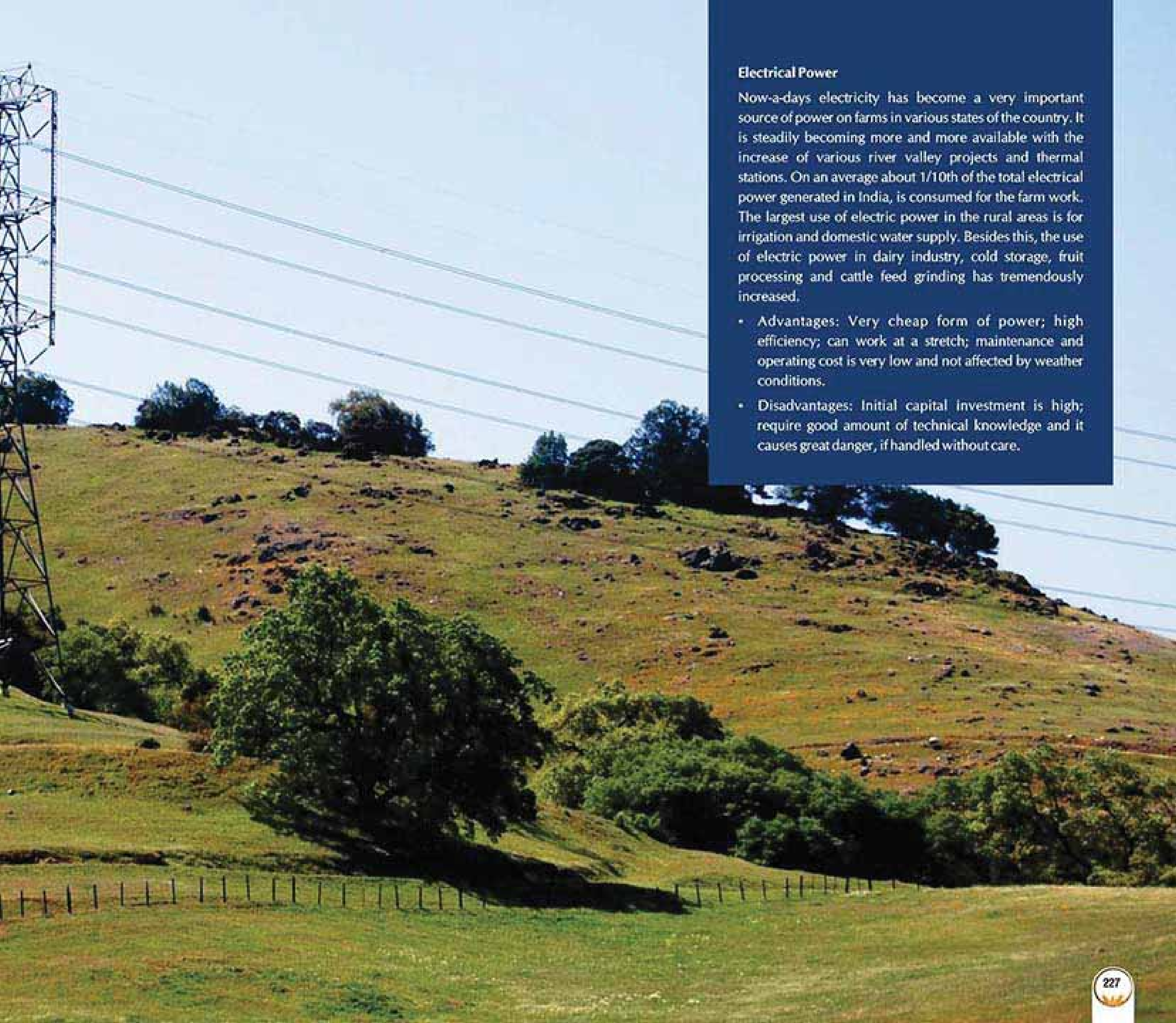
Figure. Animate and mechanical power scenario in Indian agriculture

Mechanical Power

The third important source of farm power is mechanical power that is available through tractors and oil engines. The oil engine is a highly efficient device for converting fuel into useful work. The efficiency of diesel engine varies between 32 and 38 per cent, whereas that of the carburettor engine is in the range of 25 and 32 per cent. In recent years, diesel engines and tractors have gained considerable popularity in agricultural operations. Small pumping sets within 3 to 10 hp range are very much in demand. Likewise, oil engines of low to medium speed developing about 14 to 20 hp are successfully used for flourmills, oil ghanis, cotton gins, etc. Diesel engines of the larger size are used on tractors. It is estimated that about one million tractors of about 25 bhp range are in use for agricultural operations in India. Similarly, the total number of oil engines for stationary work may be taken as about 60 lakhs of 5 hp each. Thus the total power available from mechanical source would work out to be 55 million hp (Oil engines = 0.60 x 5 = 3.0 crore hp, tractors = 0.1 × 25 = 2.50 crore hp.

- Advantages: Efficiency is high; not affected by weather; can run at a stretch; requires less space and cheaper form of power
- Disadvantages: Initial capital investment is high; fuel is costly and repairs and maintenance needs technical knowledge.

BHEEM™
www.renppl.com
Rotovator
Marvel Tiller
Excel Tiller
Paddy Weeder
Baby Weeder
Pixel Weeder
For All your Agri Machinery Needs!
For All your Mat Handling Needs!
Electric Barrow
Power Barrow
Vibratory Roller Compactor
Self-Loading Mini Loader
RENAAISSANCE POWER PRODUCTS PVT LTD.
Door NO. 1/138, SF No. 92-A/2, Karadivavipudur, Karadivavi (PO)
Palladam Taluk, Coimbatore 641 658 India
Tel.: +91 4255 265933 Web: www.renppl.com email: sales@renppl.com
DDW
www.ddwent.com



Electrical Power

Now-a-days electricity has become a very important source of power on farms in various states of the country. It is steadily becoming more and more available with the increase of various river valley projects and thermal stations. On an average about 1/10th of the total electrical power generated in India, is consumed for the farm work. The largest use of electric power in the rural areas is for irrigation and domestic water supply. Besides this, the use of electric power in dairy industry, cold storage, fruit processing and cattle feed grinding has tremendously increased.

- Advantages: Very cheap form of power; high efficiency; can work at a stretch; maintenance and operating cost is very low and not affected by weather conditions.
- Disadvantages: Initial capital investment is high; require good amount of technical knowledge and it causes great danger, if handled without care.

Wind Power

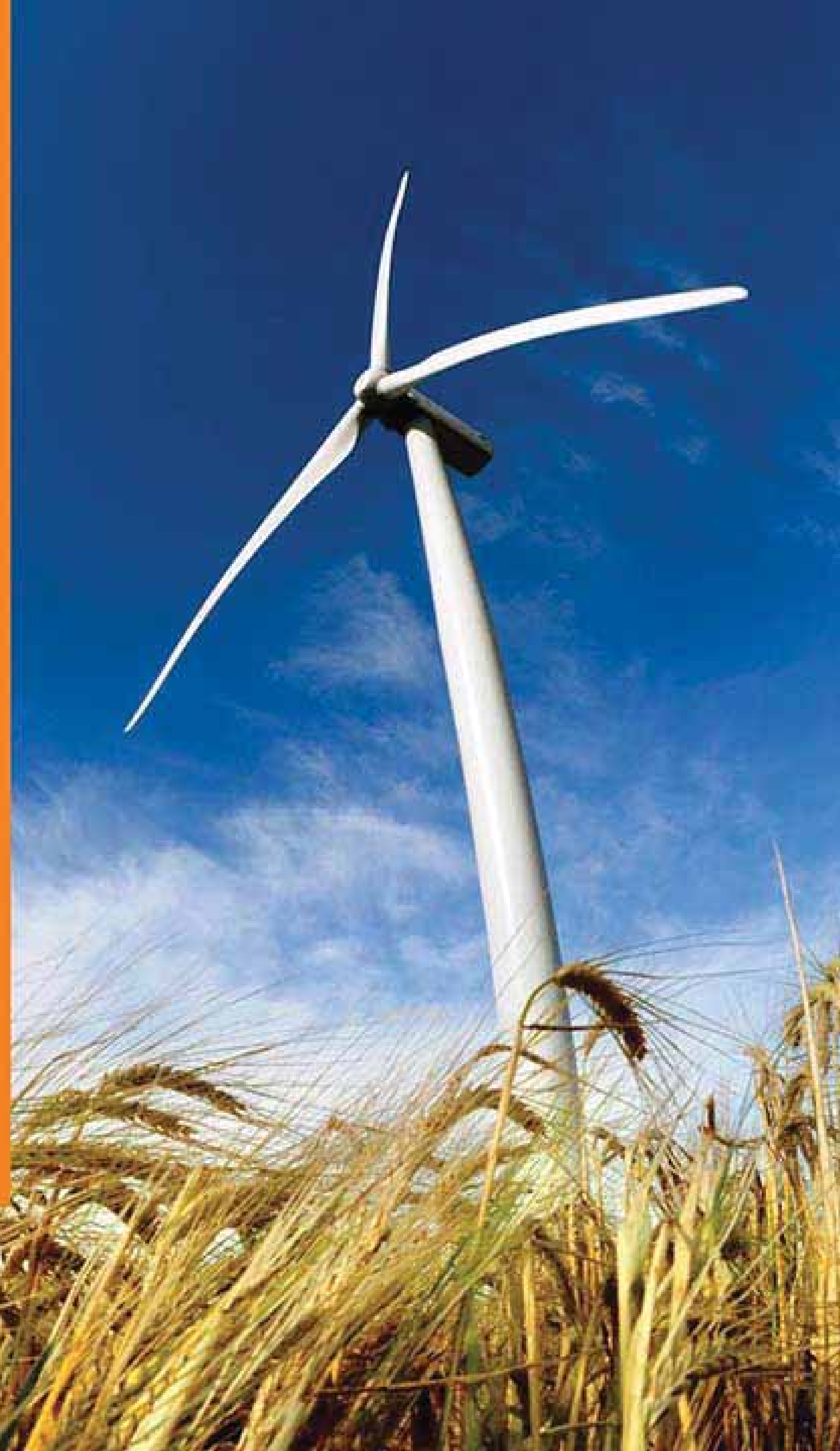
The availability of wind power for farm work is quite limited. Where the wind velocity is more than 32 kmph, wind mills can be used for lifting water. Even today in India the wind power has not been fully harnessed. The most important reason is its uncertainty.

Experimental results show that a wind mill having 3.6 diameter wheel mounted on 12.0 m tower is able to produce from 0.1 to 0.9 hp with the wind velocity varying from 6.4 to 37 km/h. Thus the average capacity of a wind mill would be about 0.50 hp. There are about 2540 mills installed in India. Hence the total output may be about 1250 hp only, but it is one of the cheapest sources of farm power available in the country.

Ministry of Non-Conventional Energy, Govt. of India have been making efforts to popularise the wind mill for power generation and water lifting in rural areas. But this source could not become attractive due to the following limitations of the system:

- Initial investment is high,
- Repair facilities are not available in rural areas,
- Even the matching pump sets and electric generators are not readily available in the country,
- It not suitable for all situations in the country. For the present, the wind mills have limited scope of the use in the country.

In sum, the source of farm power includes human, animal, tractors, power tillers, diesel engine and electric motor. Information about the availability of these power sources under time-series is very essential in planning and prediction of farm mechanization as this directly and indirectly provides vast potential for manufacturers, entrepreneurs, sales and repair etc. During last 53 years the average farm power availability in India has increased from about 0.30 kW/ha in 1960-61 to about 2.02 kW/ha in 2013-14. Over the years the shift has been towards the use of mechanical and electrical sources of power, While in 1960-61 about 92.30% farm power was from animate sources, in 2013-14 the contribution of animate sources of power reduced to about 11.80% and that of mechanical and electrical sources of power increased to about 88.20%. Food grains productivity is positively associated with unit power availability. It is visualized that the additional requirement of food grains in future will be met, to a great extent from the demand of mechanical power sources and matching farm equipment.



Comparison of Tractor and Animal Power

S. No.	Basis	Tractor/Power Tiller	Animal Power
1.	Availability	Only large size tractors above 25 hp size are available. Tillers up to 12 hp size are available	They are available in plenty.
2.	Overload capacity	Limited overload capacity	Very high overload capacity for short time.
3.	Acceptability	Not very common because of high initial investment	The most important source of power at present.
4.	Tractive work	This the best source of power for any traction job. With cage wheels it can be use for puddling also.	They are quite suitable for all kind of farm work.
5.	Stationary work	All kinds of stationary works can be performed.	Bullocks have limited use for such works.
6.	Transport work	It is a quick means of medium distance transport	Bullocks are also used for short and medium distance transport work.
7.	Initial investment	Through cost per horsepower is low but overall investment per unit area os very high.	Cost per horsepower is high but overall investment is less.
8.	Cost of maintenance	Reasonable	Very high.
9.	Rate of depreciation	It is about 10 per cent year.	In fact the value increases in the beginning and then decreases.
10.	Cost of operation	Cheaper per horsepower hour.	It is costlier than tractor.
11.	Limitations	The technical know how of the people in general is low and as such farmers get discouraged to buy a tractor. This may no longer be valid in next 20 years. Tractor gives low field efficiency in small fields.	Constant care is required to keep the animal in good health. To some extent medical facilities are now available and as such it is not very difficult to cure a sick animal in rural areas.
12.	Idleness	It does not consumer any fuel or lubricant while not in use.	Even during Idle period, it needs care, feed and fodder. But, on the other hand, it provides manure for the crops.
13.	Output	Very high and suitable for timely operations.	Low output.

Direct correlation of higher productivity with higher Mechanization level

UNIT: 13

Scope of Farm Mechanization

Farm mechanization i.e. usage of technology and equipment in performing various tasks in the agricultural field has wide scope. It entails major agri tasks like seedbed preparation, sowing/planting, fertiliser application, irrigation and harvesting, among others.

In India, it has been observed that maximum mechanization is undertaken while preparing the seed bed (penetration levels at ~40%) and irrigation (penetration levels ~45%) while the total mechanization rate is ~40-45%.

It is quite true that the Indian farmers have the lowest earnings per capita because of the low yield per hectare they get from their holdings. One of the few important means of increasing farm production per hectare is to mechanize it. Mechanization in India may have to be done at various levels. Broadly, it can be done in three different ways:

I. By introducing the improved agricultural implements on small size holdings to be operated by bullocks.

II. By using the small tractors, tractor-drawn machines and power tillers on medium holdings to supplement existing sources.

III. By using the large size tractors and machines on the remaining holdings to supplement animal power source.

But many people are of the opinion that Indian agriculture cannot be fully mechanized. Only the improved animal-drawn implements should be introduced. It is felt that:

1. There is a surplus of agricultural labour in India.
2. There are enough draft animals available in the country to do the farm work effectively.
3. The size of farm holdings of the majority of the Indian farmers is too small to justify the use of a tractor on their farms.
4. The investing capacity, of the farmers is too poor to buy a tractor and tractor-drawn implements.
5. The technical know-how of the people in the country is low.
6. In the absence of suitable farm road system, the tractor and tractor-drawn machines cannot be effectively utilized under the present conditions.
7. It will not be possible to increase the yield by using mechanical power.
8. Mechanization will not result in lowering the cost of production.
9. It will not be possible to mechanize every bit of farm operation.
10. A large labour force will get displaced from agriculture.

History indicates that the development in farm mechanization is very closely related to the shortage of human labour and industrial development in the country. Farmers of India like their counterparts in other countries are interested to improve their income, life style and general wellbeing. They see mechanization as a means for achieving their objectives. In spite of the limitations with which they exist, their performance has been noteworthy. There is a positive correlation between application of improved technologies and the land productivity.

The technical know-how of the people in the country is quite satisfactory. It always develops with the opportunities and experience. The repair, maintenance and overhaul facilities for tractors and other machines are expanding, even in the small towns, with the expansion of rural electrification in the country.

Drudgery and physical exertion are typical of much Indian agriculture today. It scares away men of intelligence and ability from agriculture. All people would favour minimizing this to a considerable extent. The development of improved riding type animal drawn machines can improve the present condition, but they cannot be a substitute for the tractor drawn machines. By using mechanical power, man will be able to control larger areas and as such his family members will get more free time.

More power is essential in carrying out operations effectively at the right time and for changing the attitudes and uplifting the social status and dignity of those who work in agriculture. There are three ways in which progress can be made towards increased power, all of which must be worked on simultaneously in combination with integrated and matched implements.

1. By improving bullock harness and hitches;
2. By developing and introducing small tractors;
3. By increasing the number of large horsepower tractors.

These machines will be helpful in providing power efficiently for good seedbed preparation, which is quite essential for maximizing the germination of the seed and seedling growth. In addition to this, the mechanization of the following fields of agriculture-is equally essential.

I. Shaping and levelling of farm fields for getting even distribution and depth of irrigation water;
II. Development of planting and fertilizing machines to place the seed more precisely in rows and to place the fertilizer correctly with respect to seed or plant;
III. Spraying and dusting machinery to apply chemicals for weed and pest control;
IV. After production operations such as harvesting, threshing, winnowing and drying.

Agricultural system all over the world has undergone changes in terms of cropping system, type of power sources used and application of inputs to achieve high level of productivities. Even in India, mechanization of agriculture has advanced considerably. In certain region, the level of mechanization has gone far ahead of the average level in the country. Human and animal power sources are no longer the predominant sources on Indian farms. The annual addition of tractor population is more than one hundred thousand tractors. Similarly about the hundred thousand pump sets are being installed on Indian farms annually. On the basis of annually critical review of the mechanization position, one observes that the shortage of labour and high labour wages are the factors which strongly propel mechanization. Consequently, the more labour intensive operations, such as pumping of irrigation water, land preparation and threshing are the first operations, which are mechanized. Large amount labour or draft power, which can be replaced through machines, provides a strong incentive to mechanize. The farm operations, which can be categorised as:

I. Highly power intensive operations,
II. Intermediate power and control intensive operations,
III. Highly control intensive operations.

Operation	Highly Power Intensive	Intermediate Level	Highly Control Intensive
Water Pumping	✓	-	-
Tillage	✓	-	-
Direct Seeding	-	✓	-
Transplanting	-	-	✓
Weeding	-	-	✓
Plant protection	-	✓	-
Harvesting	-	✓	-
Threshing	✓	-	-
Milling	✓	-	-
Transport	✓	-	-

Social Consideration to Farm Mechanization

The steps towards development of an appropriate agricultural technique in India are not working with the motto of saving labour but of improving and increasing agricultural production. Most people believe that India is burdened with surplus labour and that there are far too many draft animals for the cultivation of available farmland. Above all, there is an unfounded fear that farm mechanization will precipitate widespread rural unemployment as agriculture contributes over two-thirds of all jobs in India. The fact is however, that India's increased food requirements must be met through increased productivity of the land from higher yields and more multiple cropping which would require additional labour for carrying out different farm operations.

From the energy application point of view, the Indian agriculture is in the transition from stage 1 (human power) and stage 2 (animal power) to stage 3 and 4 (power tiller or four wheel tractor). However, animal power will co-exist with mechanical power in the country. Animal drawn machines must be provided with tiding arrangements so that walking behind the machine can be avoided.

The following can help in increasing the agricultural production in the country:

I. Agriculture must continue to productively employ as many or more labourers per cultivated hectare in the foreseeable future.

II. The small & scattered land holdings and the poor economic conditions of the average farmer restrict the use of units designed for large-scale mechanization. The power tillers and related equipment, therefore, find a greater scope to be used on such farms. Power tillers attached with Rotavator are better suited for puddling operations in rice growing regions.

III. The power availability on the farm should be increased by 2.5 times more to achieve objectives under intensive agriculture in low intensive energy use areas.

IV. Cropping intensity should be increased to 200 to 250 per cent level from the present level of 100 to 180 per cent.

V. Due to the fragmentation of lands, the number of holdings has gone up and therefore, appropriate size of farm machines have to the introduced for the tillage, planting transplanting and harvesting of crops. Custom hiring of machines will have large scope in future.

VI. An economical multi-crop thresher may be developed to suit farmers' need. High capacity threshers capable of threshing wheat and paddy crop at 15 to 20 per cent moisture content need immediate attention.

VII. Custom hiring of farm equipment should be encouraged as it has resulted to the increased power availability on the farms and in turn increased land productivity.

VIII. Post-harvest technology deserves special attention on Indian farms.


SANTOSH AGRI MACHINERY
MODERN AGRI ENGINEERING REVOLUTION
Santhosh Agri Machinery
SANTHOSH HAY RAKE - 2229
SANTHOSH MINI ROUND BALER - 2220
SANTHOSH FORAGE HARVESTER MULTI CROP CHOPPER - 2227
SREE
NETT WT. 50 KG
No. 282, Kartar Complex, Salem Main Road, Attur - 636108, Salem Dt. Tamilnadu. Cell : 73730 32415, 99429 32400
E-mail : santhosh.machinery@gmail.com | Web : www.santhoshagrimachinery.com


DLX
Mahindra
Arjun
ultra-1
605 DI

Major Farm Machinery Used in India

Major farm machinery used in India includes tractors, threshers and power tillers, among others. Among these, the biggest market in terms of annual sales is that of tractors (~ 6 lakh units annually), threshers (~ 1 lakh units annually) and power tillers (~ 56,000 units annually).

Major farm machinery used in India (June 2014)

Name of Machinery	Market Size Annually (units)	Per unit costs (US$/unit)	Average per unit costs (INR/unit)	Annual Industry Size (INR crore)
Tractor	600000	7000-12000	570000	34200
Power Tiller	56000	2100	126000	706
Combine Harvester	4000-5000	22000-35000	1710000	770
Thresher	100000	1600-2500	123000	1230
Rotavator	60000-80000	1300-2000	99000	693
Rice Transplanter				
Walking Type				
Riding Type	1500-1600			
2500-4200				
3300-16600				
201000				
597000	62			
Self-propelled reaper	4000-5000	1300-2000	99000	45
Zero till seed drill	25000-30000	750-850	48000	132
Multi-crop planter	1000-2000	850-1000	55500	8
Laser land leveller	3000-4000	5800-6500	369000	129
Power Weeder	25000	8500	510000	1275

The tractor market is by far the largest (both in volume and value terms). Among farm machinery, tractors are most widely used by domestic farmers with the total market size estimated at ~ | 34,000 crore annually (~ 6 lakh units).

Drivers of Growth in Mechanization

There are a number of factors that can contribute to the growth in farm mechanization. In order to meet the demand in future and achieve the target of an average farm power availability level of 2.5 kW/ha, country needs to the intended level of mechanization.

Low penetration of farm equipment:

Penetration of farm equipment in India provides a strong growth opportunity. As mentioned above, only about 40-45 percent of agriculture in India is mechanised. In 2012-13, it was estimated that the penetration of tractors was about 20 per 1,000 hectares. The penetration is lower with the small and marginal farmers who own land less than 5 hectares. This segment forms over 80 percent of the land holdings in the country. Thus, there is a lot of potential for increasing the penetration and therefore growing the market size.

Contract farming:

Business establishments provide farmers with specialised farm equipment and various amenities to improve crop yield through the adoption of latest agricultural technologies. Many companies in the country have participated in such practices before. The continuation and growth of contract farming with more entities getting involved provides future opportunities for the expansion of the industry.

Credit availability:

Agricultural sector requires adequate financing with such a large portion of land holdings falling into the category of small and marginal farmers. With a greater focus on meeting the future production demand, various national and commercial banks have devised special plans to support the farmers through different schemes. There are several wrinkles in the procedure but a combine effort between the government and the institutions, dialogues for which are already underway, provides a good indication for the future of the industry. The government has also taken a keen interest in the industry and has provided special budget allocations under the 12th five year plan.

Research and Development in Agricultural Mechanization

Research and development efforts and approaches in agricultural mechanization in India have been directed towards finding cost-effective solutions to location-specific problems of agriculture. Indian Council of Agricultural Research (ICAR), New Delhi is the apex body which primarily looks after the need of research and development activities, need based region specific technologies and specific-problem related issues. The engineering division of ICAR comprises five research institutes, six All India Coordinated Research Projects (AICRPs), one network project/outreach programme and National Initiative on Climate Resilient Agriculture project. The thrust areas identified are:

- Development of precision machinery and strategies for carrying out timely and efficient agricultural operations in irrigated, rain-fed and hill agriculture, horticulture, livestock and fisheries production.
- Increasing work efficiency for human, animal and mechanical systems and reduction of occupational hazards in agricultural operations,
- Energy management and utilization of conventional and non- conventional energy sources in agricultural production and processing activities.
- Utilization of surplus agricultural residues for decentralized power generation, and
- Reduction of post-harvest losses, value addition to agricultural produce, processing and utilization of by-products.

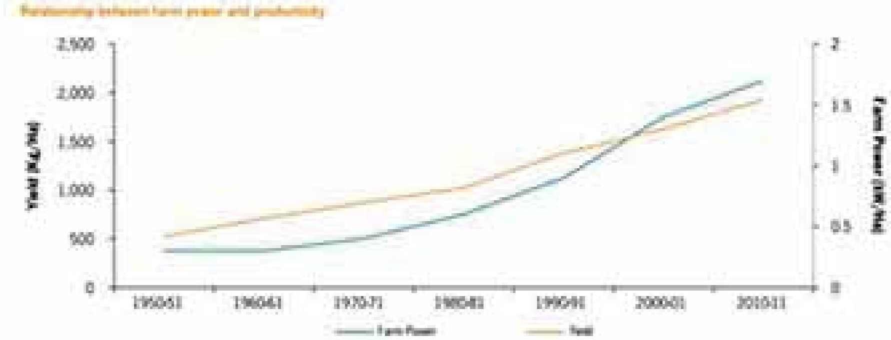
Four Coordinating Cells of AICRPs with their centres are operating from the Central Institute of Agricultural Engineering, Bhopal, which caters to the engineering needs emphasizing on sustainable agricultural mechanization of the country. These are i) Farm Implements and Machinery (24 centers), ii) Ergonomics and Safety in Agriculture (10 centres), iii) Renewable Energy Sources (18 centers) and iv) Utilization of Animal Energy (13 centres).

Benefits of Farm Mechanization

Farm mechanization has been known to provide a number of economic and social benefits to farmers. Primary among the economic benefits is the improved yield that comes as a result of greater level of mechanization. Looming water scarcity crisis along with the need to ensure food security in the country, the benefits of farm mechanization makes it a crucial component of shaping the future of Indian agriculture.

Input savings: Studies have shown a direct relationship between farm mechanization (farm power availability) and farm yield. Farm mechanization is said to provide a number of input savings:

- Seeds (approximately 15-20 percent)
- Fertilizers (approximately 15-20 percent)
- Increased cropping intensity (approximately 5-20 percent)



Relationship between farm power and productivity

Increase in efficiency: Aside from the above stated inputs, farm machinery also helps in increasing the efficiency of farm labour and reducing drudgery and workloads. It is estimated that farm mechanization can help reduce time by approximately 15-20 percent. Additionally, it helps in improving the harvest and reducing the post-harvest losses and improving the quality of cultivation. These benefits and the savings in inputs help in the reduction of production costs and allow farmers to earn more income.

Social benefits: There are various social benefits of farm mechanization as well:

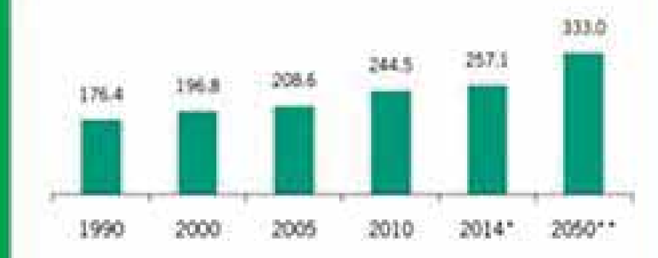
- Helps in conversion of uncultivable land to agricultural land through advanced tilling techniques and also in shifting land used for feed and fodder cultivation by draught animals towards food production.
- Decrease in workload on women as a direct consequence of the improved efficiency of labour.
- Improvement in the safety of farm practices.
- Helps in encouraging the youth to join farming and attract more people to work and live in rural areas.

UNIT: 14

Need for Farm Mechanization in India

Growing Population and Productivity

Growing at 1.3 percent annually, India's population stood at 1.26 billion in 2014. This is estimated to reach to 1.6 billion by the end of 2050.5 Owing to the large geographical area under cultivation, the Indian agriculture and allied sectors support 18 percent of the world's population and 15 percent of the global livestock. With land and water being limited, there is stress on their availability. Rising population, boost in infrastructure development and limited availability of resources restrict the availability of cultivable land.



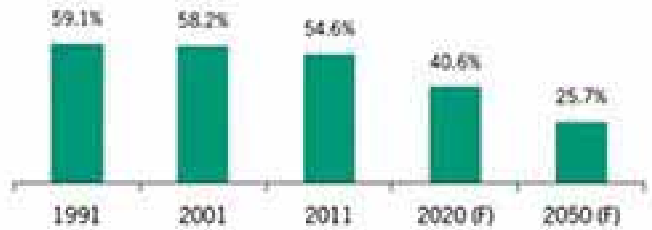
India food grain production (million tonnes)

Even though food grain production in India has increased significantly over the years, it is variable due to the dependence on monsoons. However, to meet the future demand for food by the year 2050, the annual food grain production needs to grow to the level of 333 million tonnes. Thus, there is a need for significant increase in the productivity levels to meet this demand. In comparison to other countries, India's productivity in terms of wheat and rice growth is much lower as shown in figure below.

India's relative rice and wheat productivity (yield per hectare)

Rapid Urbanization and Farm Labour

The agriculture sector in India, for a long time, has depended on cheap and surplus labour. One of the stated reasons behind sufficient supply of such labour was lack of opportunities. However, the situation is now changing with more opportunities available in factories and services as well as the government's rural employment creation program, which guarantees 100 days of employment on public-works projects.



Percentage of agricultural workers to total workers (percent)

Another ongoing trend in India is rapid urbanization. The trend has been consistent with a growing economy and growth of infrastructure. The World Bank estimates suggest that by year 2050 over half of the Indian population would be urban, a marked change from 2005 when only 29 percent of the population was in that bracket. Rapid urbanization reduces the availability of farm hands and thus puts strain on farm labour. Estimates suggest that by 2050, percentage of agricultural workers of the total work force would drop to 25.7 percent from 58.2 percent in 2001.

With the strain for diminishing resources, added value placed on the productivity of agricultural practices and growing urbanization resulting in a reduction of available farm labour, there needs to be a greater push to ensure further proliferation of technologies that allow for better usage of the land.

Population demographics (percent)

Global Benchmarking

Within the Asian region, China dominates in terms of production and sale of agriculture equipment. China is also predicted to contribute the most to growth of the agricultural equipment industry in Asia-Pacific and is expected to have a share of 59.5 percent of revenue generated by the industry in the region in 2018, reaching a value of US$ 103,659.7 million during the year. While India, Japan and Australia are expected contribute 7.2 percent, 3.0 percent and 1.5 percent respectively.

Global benchmark: Key facts and figures

Country		India	China	Japan	Australia
Production	Revenue (US$ Billion)	6.37	58.87	5.03	1.92
	Volume (Units)	7,47,826	42,13,212	17,51,510	22,300
Major players	Domestic	Mahindra & Mahindra and Sonalika	YTO Group's First Tractor Co. Ltd and Foton Lovol	Kubota and Yanmar	Gernonimo and John Berends implements
	International	John Deere and Case New Holland	John Deere and Case New Holland	John Deere	John Deere, Case IH and Kubota
Export (US$ billion)		NA	9.38	1.71	0.14
Import (US$ billion)		NA	2.25	NA	1.6
Types of Equipment		Tractors, rotavators, threshers, power tillers, combine harvesters, rice transplanters	Tractors, rice, transplanters combine harvesters, cotton processing machinery, etc.	Bush cutter, tractors, rice transplanter, power sprayer and duster, etc.	Tractors, combine harvesters, balers

In 2011, China overtook the European countries and the US to become the largest producer of farm equipment in the world. In order to cover the technological gap between the domestic and international firms in China, the government is open to the establishment of joint ventures between Chinese and foreign enterprises. In return, the multinational companies enjoy access to the vast Chinese market.

In India, presence of a large number of non-banking financial Corporations (NBFCs) has encouraged farmers to buy agriculture machinery on credit. Of the entire machinery, tractors have the highest number of share in the overall sales. These accounted for 66.1 percent share in the total number of agricultural equipment sold in India in FY'2013. However, the overall market for agriculture equipment has witnessed a slowdown recently, largely due to reduced sales of tractors and combine harvesters.

Lessons from Other Countries

While farm mechanization in India has made strong strides, there is much that is needed. Countries such as the United States and other European countries are completely mechanised. Countries such as China and Japan have also seen higher penetration of farm machineries. In comparison to these, Indian agricultural sector still lags and requires an increase in farm equipment.

Economy Overview					
Region	GDP (US$ Billion)	GDP- per capita (US$)	GDP agriculture sector share (percent)	GDP- real growth rate (percent)	Labour force in agriculture (percentage)
USA	17,419	54,800	1.6	2.4	0.7
France	2,829	40,400	1.7	0.4	3
Canada	582	44,800	2	3	2
China	10,360	12,900	9.2	7.4	33.6
Japan	5,960	37,400	1.2	-0.1	2.9

Region	Major Agriculture Products	Import of agriculture Machinery (percent)	Export of agriculture products (percent)
USA	Wheat, corn, maize, soya beans, sugar cane, sugar beet, potatoes, tomatoes, rice, paddy, barley, cotton seed etc.	4.9	9.2
France	Wheat, Sugar beets, Cereals, Wine grapes, Dairy products, Fish, Potatoes		
Canada	Wheat, Barley, Oilseed, Tobacco, Dairy product, Fish, Forest products, soya bean, oat, lentils.	6	70 (pulses and crops)
China	Rice, Wheat, Potato, Corn, Peanuts, Tea, Barley, Cotton, Millet, Apple, Oilseed, Fish, Pork.	15	20
Japan	Vegetables, rice, fish, poultry, dairy products, pork, beef, barley, sugarcane, wheat, potato, legumes.	-	Fishery and Forestry only.

Canada

Mechanization: Over 95 percent of agricultural activities are have been mechanised in Canada. The productivity has increased both because of mechanization and improvements and innovations through biotechnology. Canadian farmers buy over US$ 2 billion worth of machines and implements annually, including an average of 19,000 tractors, 3,500 swathers, 4,000 grain combines and balers, plows, dickers and other tillage and harvesting tools. Farming is carried out using seeding equipment, hay and forage equipment, grain-harvesting equipment and tractors in large extents.

Government Support: Cash advances are provided to young farmers and new entrants. The whole farm profit is subsidised rather than crop prices or farm revenues. The agricultural policies are restrictive in Canada but the farmers benefit in the form of higher output prices, less competition. There are loans and credit facilities at low interest rate to purchase farm equipment.

Unites States of America

Mechanization: In the US, 95 percent of the farming is mechanised. The level of mechanization can be gauged by the fact that a farmer who supplied food for 26 persons in 1960 supplies food for 144 people as a result of higher levels of farm mechanization. Almost all the farm activities in the US are carried out using advanced machinery and equipment. Farmers make large capital investments, from US$ 97,000 for a 160 horsepower tractor to US$ 170,000 for a 4-wheel drive model.

Government Support: US government heavily subsidises grains, oilseeds, cotton, sugar, and dairy products. Farmers receive subsidies in the form of direct payment, price supports, regulations that set minimum prices by different characteristics, export subsidies, import barriers in the form of quotas, tariffs etc.

France

Mechanization: France boasts a 99 percent level of mechanization, with 54 percent of the metropolitan France under agriculture comprising of total 680,000 highly mechanised farms. The market for agricultural equipment is large amounting to about Euro 6.3 bn. Most of the agricultural equipment used for farming include tractors, combine harvesters, balers and haymaking, self-propelled forage cutters, soil tillers and agriculture transport vehicles.

Government Support: French farmers rely on European Union subsidies for half their income. The exports are subsidised and farmers also get subsidies to import agricultural machinery and equipment.

China

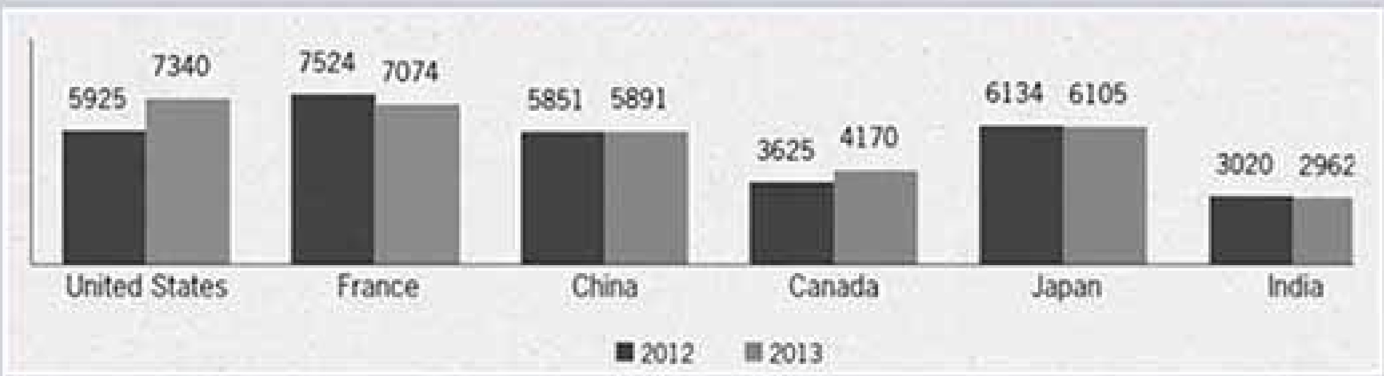
Mechanization: China has around 60 percent of farm activities mechanised. Main agricultural equipment used include tractors, combine harvesters (self-propelled and tractor-mounted), rice transplanters and cotton processing machinery. Level of mechanization for various activities such as ploughing, planting and harvesting levels are 76.1 percent, 49.2 percent and 46.9 percent, respectively.

Government Support: The Government of China provides subsidies on agriculture equipment and machinery purchase, which is approximately 30 percent of the price of the equipment. Both direct and indirect subsidies are given to the farmers. Direct subsidy includes mainly price subsidies whereas indirect subsidies are in the form of remitting agricultural tax, special discount rates etc.

Japan

Mechanization: Japan is one of the most agriculturally mechanised nations in Asia Pacific region and the tractor power per hectare of agricultural land is 7 HP which is at par with that of the US, the UK and France. The main equipment used comprises of bush cutter, plant protecting machinery, walking type tractor, tractors, rice transplanters and grain combine harvesters.

Government Support: Government subsidies for agriculture in Japan amounted to US$ 68,266.5 in 2014. Government grants subsidies to the farmers on the loss incurred to make them competitive in the market. Government impose high import tariffs on agricultural imports.



There is direct relationship between the productivity level and farm mechanization. Countries with higher levels of farm mechanization are able to increase their productivity and therefore are better equipped to meet their demand factors. India's demand factors are likely to rise dramatically. Thus, there is a need to enhance the level of farm mechanization in the country.

Concept of Custom Hiring Centres (CHCs) for Farm Equipment

Custom hiring of farm machinery (CHCs) was introduced in Indian agriculture in as early as 1912. Organised move to promote multi-farm use of agricultural machinery was made in mid-1960 when Agro-Industries Corporations were established within the states.

CHCs are a unit comprising a set of farm machinery, implements and equipment for hiring by farmers. These centres give farm machinery on a rental basis to farmers who cannot afford to purchase high-end agricultural machinery and equipment, apart from servicing old machinery. Farm machineries/equipment available at CHCs include tractor, rotavator, multi-crop thresher, MB plough, cultivator, leveller blade, blade harrow, seed cum fertilizer drill, knapsack sprayer, power weeder, winnowing fan, electronic balance, repairing tools.

These units are generally located in close proximities to large and small land holdings, which supply machinery and equipment to villages close to it reducing transport cost and transportation time.

States such as Punjab, Haryana, Uttar Pradesh, Uttarakhand, Gujarat, Maharashtra, Karnataka and TN, which are highly mechanised, have maximum number of registered and unregistered CHCs catering to the machinery and equipment requirements of the farmers.

Other states do have operational CHCs but farm mechanization still remains a serious concern. Custom hiring centres, in order to work effectively and efficiently require a sound infrastructure setup for its operations, which include all weather roads, spatial distribution of machinery ownership and servicing network.

The government also recognises the value of these centres and the role they can play in mechanization of farm operations. As a result, establishment of farm machinery banks for custom hiring is one of the core components of the Sub-Mission on Agricultural Mechanization (SMAM) and government provides financial assistance for setting them up. However, there is a need for enhanced participation from the private sector in an endeavour of setting up CHCs and capacity building. Only then the subsequent upskilling and training can bring a sustainable and more inclusive growth

China's perspective:

The Government of China pays great attention to farm mechanization, recognising and appreciating its importance. It has launched a number of policies in support of custom hiring of agricultural equipment. In 2004, congress adopted the 'Law on Promoting Agricultural Mechanization of the People's Republic of China' and in 2010, released the 'Opinion on Promoting Sound and Fast Development of Agricultural Mechanization and Agricultural Machinery Industry'.

Under these, the responsibilities of all levels of government and agricultural authorities were outlined with respect to promoting agricultural mechanization in their respective regions and measures and requirements for promoting custom hiring of equipment were laid out.

China also has a subsidy policy for farmers, which has promoted farmers' willingness to purchase machinery, which in turn, has laid a solid foundation for custom hiring. There are number of steps the government took to help foster custom hiring and as a result. Statistics from the year 2013 show that China had 5.24 million machinery service-providing households, 168,000 organisations, 201,000 machinery maintenance plants and stops, and 7,000 intermediary service organisations. In particular, machinery cooperatives, specialised in cooperative use of machinery have seen strong growth. Custom hiring of farm machinery including leasing, cross-region operations, order placement and contract management, has met the diversified needs of the farmers.

Innovations in Agricultural Mechanization

Innovation is intrinsic to agriculture. Ever since humans discovered the technique of multiplying wild seeds into food and other products, an unbreakable relationship between agriculture and creativity was born. India presents unique opportunities with its small land holdings, variety of climatic zones and different soil types across different regions. Thus, innovation is essential for Indian agriculture as a result of the above-stated factors. In order to adapt to these, furthering the innovative spirit among all stakeholders (individual farmers to large-scale manufacturers) is necessary.

Below are just some examples of innovations in agricultural equipment that came about to address specific but real issues farmers face on the farms on a daily basis:

Mobile groundnut thresher-cum-collector:

The machinery was invented on account of the farm labour scarcity. Non-availability of farm labour during peak season of sowing and harvesting delays the collection and ultimately results in yield losses. To overcome these problems, a tractor mounted PTO powered mobile thresher was developed. This has a separate chamber for collection of groundnut pods and stalk. The manufacturer of the machine was awarded at the 7th National Award Function of the National Innovation Foundation – India (NIF) in 2013. The salient features of this innovation are:

- Provision of storage chambers and feeding mechanism making it suitable for threshing while moving around the field.
- It reduces time and labour cost

Groundnut digger:

Labour scarcity also promoted the development of a groundnut digger. One of the major challenges faced by farmers is the shortage of labour for harvesting operations. The machine has a tractor-mounted, PTO-powered groundnut digger. The innovator was awarded at the 7th National Award Function of the National Innovation Foundation – India (NIF) in 2013. The salient features of this innovation are:

- This machine not only mechanises the digging but also undertakes cleaning and drying.
- Damage to the pods is much lesser than the alternatives currently available.
- The machine can be used in different kinds of soil. On an average the machine can harvest about 0.4 acre per hour

Sugarcane Bud Planter:

Sowing of sugarcane buds in field is cumbersome. Not maintaining uniform distances between the buds and varying the depth while sowing manually, may result in less productivity. As an attempt to address these issues, the Sugarcane Bud Planter was born, which is a tractor operated bud planter.

Using this planter the plantation cost is estimated to reduce to about INR 800/acre from about INR 6,000/acre using labour. The plant-to-plant sowing distance can also be adjusted according to the requirements. It can also be used for simultaneous application of fertilizer, pesticides or herbicides in the field. For this purpose, the machine is equipped with a sprayer pump. The machine can also be used for intercropping along with sowing of sugarcane buds. Pulses, wheat, and peanuts can be planted in between two rows of sugarcane. Apart from these, the machine can also be used for planting potatoes. The machine becomes helpful for those farmers, who face constant scarcity of farm workforce. The machine requires manpower only to fill the bud box whenever it gets empty. The innovator was awarded at the 8th National Award Function of the National Innovation foundation – India (NIF) in 2015.

Solar-powered water pumps:

These pumps use the abundant solar power available to pump water from the ground. These provide an energy-efficient way to farmers for irrigating their land.

These also have the potential of providing additional income to the farmer. The saved power on the farms can be sold back to the grid.

Taking a cue from countries such as Japan and China, both of which invest heavily in research and development for technological innovation in farming, India must also take more steps to promote and foster an innovative environment in agriculture. This can help the country in achieving higher penetration levels as well as a more productive labour force.

Public-Private Linkage

The private sector involvement in Indian agriculture is a recent development. Future breakthrough technologies in agriculture mechanization will come increasingly from the private sector, and India's private sector has the strength to multiply those technologies and to reach millions of farmers (small and big) in the fastest possible way. There is a need to channelize these sources in an orderly manner, so that in the process, apart from the private sector profitability, the farming community is also benefited. This will assist in pushing Indian agriculture to a higher and more sustainable growth which would be the most powerful engine for poverty reduction. For areas where the private sector has not shown much interest such as rain-fed areas, tribal areas, natural resource management, pulses, millets, the role of public research system would continue to be critical. In addition, a number of equipment is being developed in public-private partnership mode by involving manufacturers at the research and development stage.

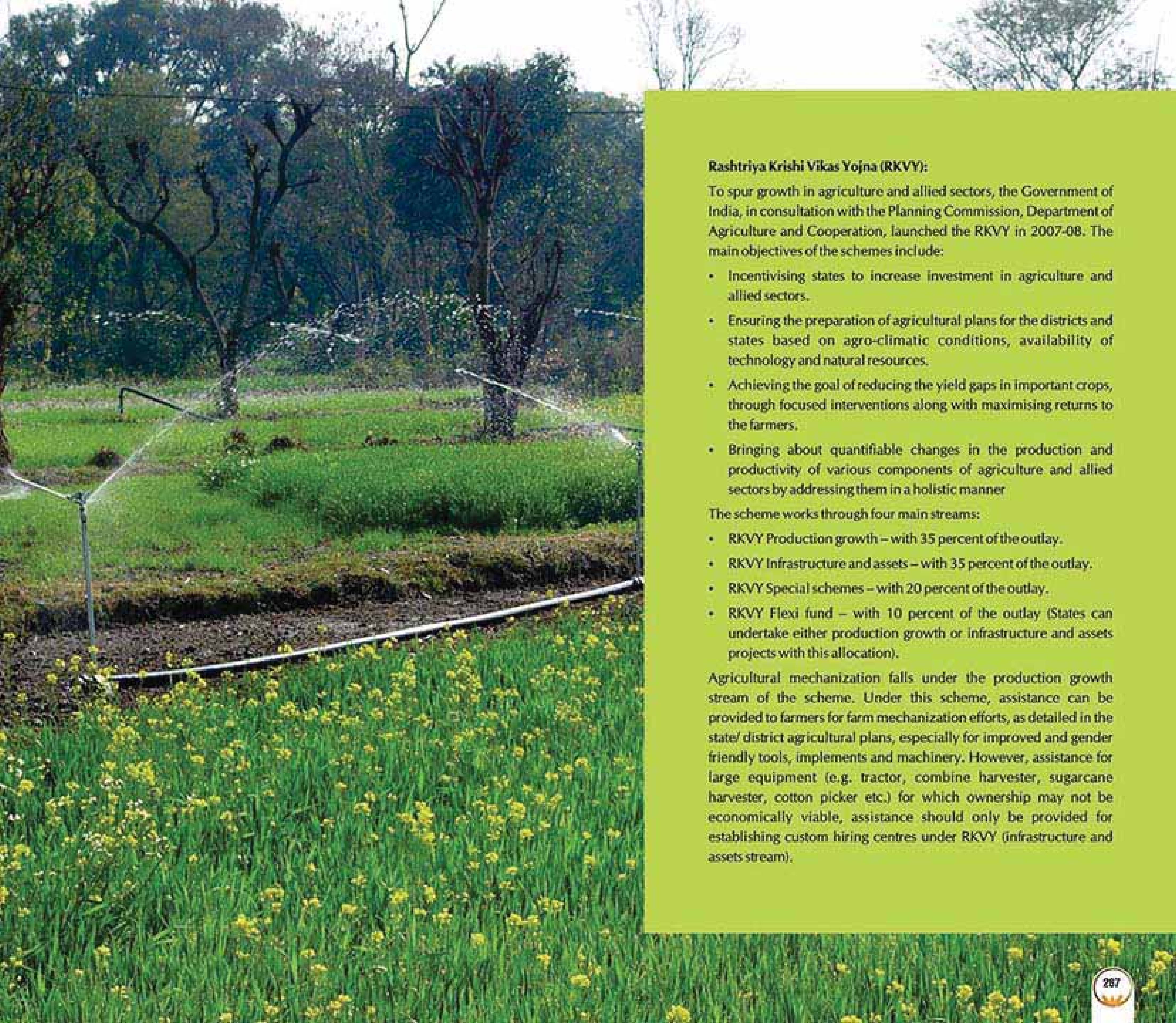

explorer

UNIT: 15
Government's Role in Agricultural Mechanization Sector

The Government has implemented various farm mechanization programmes in the country through schemes such as Rashtriya Krishi Vikas Yojna (RKVY), Mission for Integrated Development of Horticulture (MIDH), National Mission on Oilseeds and Oil Palm (NMOOP) and National Food Security Mission (NFSM). In addition to development of such schemes, the government has also implemented the National Mission on Agricultural Extension and Technology (NMAET) to strengthen the extension machinery and utilise the same for synergising the interventions under these schemes.

National Food Security Mission (NFSM):

The National Development Council (NDC) adopted a resolution to launch a food security mission comprising of wheat, rice and pulses to increase production of wheat by 8 million tons and pulses by 2 million tons by the end of the XI[th] five-year plan. Accordingly, the National Food Security Mission (NFSM) was launched in October, 2007. The mission is being continued in the XII[th] five-year plan with revised targets. The plan now targets additional production of food grains of up to 25 million tons (10 million tons of rice, 8 million tons of wheat, 4 million tons of pulses and 3 million tons of coarse cereals) by the end of the five-year plan. In accordance with that, the Mission makes provisions for assistance (up to 50 percent the cost of machinery) to be provided for adoption of farm machinery such as pump sets, tractor mounted sprayers, seed drills, zero till seed drill etc. to varying degrees.



Rashtriya Krishi Vikas Yojna (RKVY):

To spur growth in agriculture and allied sectors, the Government of India, in consultation with the Planning Commission, Department of Agriculture and Cooperation, launched the RKVY in 2007-08. The main objectives of the schemes include:

- Incentivising states to increase investment in agriculture and allied sectors.
- Ensuring the preparation of agricultural plans for the districts and states based on agro-climatic conditions, availability of technology and natural resources.
- Achieving the goal of reducing the yield gaps in important crops, through focused interventions along with maximising returns to the farmers.
- Bringing about quantifiable changes in the production and productivity of various components of agriculture and allied sectors by addressing them in a holistic manner

The scheme works through four main streams:

- RKVY Production growth – with 35 percent of the outlay.
- RKVY Infrastructure and assets – with 35 percent of the outlay.
- RKVY Special schemes – with 20 percent of the outlay.
- RKVY Flexi fund – with 10 percent of the outlay (States can undertake either production growth or infrastructure and assets projects with this allocation).

Agricultural mechanization falls under the production growth stream of the scheme. Under this scheme, assistance can be provided to farmers for farm mechanization efforts, as detailed in the state/ district agricultural plans, especially for improved and gender friendly tools, implements and machinery. However, assistance for large equipment (e.g. tractor, combine harvester, sugarcane harvester, cotton picker etc.) for which ownership may not be economically viable, assistance should only be provided for establishing custom hiring centres under RKVY (infrastructure and assets stream).

Mission for Integrated Development of Horticulture (MIDH):

MIDH is a centrally sponsored scheme for the overall growth of the horticulture sector covering fruits, vegetables, root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa and bamboo. The Central Government provides 85 percent of the assistance and the remaining 15 percent is provided by the states (except in the north-eastern and Himalayan states where the central government's contribution is 100 percent). One of the key interventions under the scheme is 'Horticulture Mechanization' which aims to improve farm efficiency and reduce drudgery of the workforce. Assistance in this regard is provided for activities such as procurement of power operated machines and tools, besides import of new machines. Assistance is also available to grower associations, farmer groups, self-help groups, and women farmer groups etc. (with more than 10 members) that are engaged in cultivation of horticulture crops. 60 percent of the cost of machines will be borne by such groups.


GOMADHI
50 Years
1964-2014 Golden Jubilee Year
Gomadhi Engineering Service is one of the leading manufacture and exports of various agricultural implaments and tractor attachements.
Gomadhi Engineering Service is a family owned business based in South INDIA. We as a company have been contributing ourselves to the agricultural growth of our nation. We have been working towards empowering our farmers by providing innovative and sustainable agricultural implements. All of our products are designed and fabricated according to the requirements of farmer, which ranges from rotary tillers, multi-row tillers, shredders, round baler & spading machine.
The range of agricultural implements spare-parts manufactured by us are tested at varied stages to ensure quality, precision and dimensional accuracy. Our reputation in the Indian market under the brand name GOMADHI has been growing many folds since inception among the O.E.Ms, distributors and the farmer communities. We are exporting our products to various countries across the globe.
Baler
AB1000
Shredder
AS Series
ROTARY
TILLER
GES Reguler & HD SERIES
GES Super HD SERIES
K SERIES
AE AQUA SERIES
SPADING MACHINE
214, Athiyur Road, Chinnegoundan Valasu, Tirupur District, Kunnathur - 638103, Tamil Nadu, INDIA. | Phone: +91 4294 - 263445 / 264133
E-mail: info@gomadhi.com | Web: www.gomadhi.com
Smart equipments for sustainable agriculture

National Mission on Agricultural Extension and Technology (NMAET):

Agricultural technology, including the adoption/ promotion of critical inputs and improved agronomic practices, was being disseminated under 17 different schemes of the Department of Agriculture and Cooperation during the 11th plan. The Modified Extension Reforms Scheme was introduced in 2010 with an objective to strengthen the extension machinery and utilise it for synergising the interventions under these schemes under the umbrella of Agriculture Technology Management Agency (ATMA).

NMAET was envisaged as the next step towards this objective through the amalgamation of these schemes. It includes four sub-missions:

- Sub-Mission on Agriculture Extension (SMAE)
- Sub-Mission on Seed and Planting Material (SMSP)
- Sub-Mission on Agricultural Mechanization (SMAM)
- Sub-Mission on Plan Protection and Plant Quarantine (SMPP)

These sub–missions are inextricably linked to each other. The common thread running across all four sub-missions is 'Extension and Technology'. The objectives of this Scheme can be achieved through a judicious mix of extensive physical dissemination, use of ICT, popularisation of modern and appropriate technologies, capacity building and institutional strengthening to promote mechanization, availability of quality seeds, plant protection and also encouragement of aggregation of Farmers Interest Groups (FIGs) to form Farmer Producer Organisations (FPOs).

UNIT: 16

Agriculture Equipment Industry: SWOT Analysis

A SWOT analysis is important to promote mechanization of Indian agriculture.

Strengths

Large infrastructure of over 20,000 manufacturers in small scale industry; vast network of academic and R&D institutions including AICRPs under NARS for human resource development and R&D.

- Trained manpower for R&D in agricultural engineering.
- Over 100 cooperating centres of AICRPs is the area of agricultural engineering.
- Computer aided design adopted by the institutes for high pace of R&D.

Weaknesses

- Unreliable after sales service of agricultural equipment.
- Poor liaison with industries for R&D and commercialisation.
- Non-effective feedback system.
- Absence of non-land economic activities.
- Non-systematic marketing of agricultural equipment

Opportunies

- Development of entrepreneurship for custom hiring of farm machinery and agro-processing equipment.
- Post-harvest loss reduction and value addition at the production catchments through rural level agro-processing centres.
- Establishment of value chain for commercial supply, transport and marketing of agricultural produce.
- Opportunity to increase the irrigated area by introducing micro-irrigation.
- Reducing yield gaps and increasing productivity through precision farming technologies.

Threats

- Migration of farmers from agriculture to other industries.
- Fragmentation and continuous reduction of operational holdings.
- Slow pace of R&D and commercialisation.
- Inadequate infrastructure back up, for after sales support of farming equipment.
- Renewable energy technology is still subsidy dependent

Challenges Faced by the Industry

There are a number of obstacles in achieving the target level of 2.5 Kw/ha farm power availability. It is imperative that all stakeholders in farm equipment sector have a clear understanding of these challenges and can collaborate to overcome these issues.

Small and scattered land holdings:

Average farm size in India is less than 2 hectares, which is far lower than regions like European Union (14 hectare) and the US (170 hectare). Large farm machineries are difficult to operate on such land holdings, which in some cases are completely unsuitable.

Another factor to consider is mechanising small and non-contiguous group of small farms is against economies of scale, especially in operations such as land preparation and harvesting. As land holdings get smaller, more and more farmers fall into the adverse category and therefore make ownership of machinery lesser economical.

Equipment cost, quality and after-sale service:

Farm equipment, especially the energy-efficient options, are capital intensive and are a major investment for most of the farmers in India. A majority of them belong to the low-income bracket. This s evidenced by the fact that almost 90 percent of the tractors sold in India are done so with the assistance of some financial institution.

The quality and after-sales service of farm equipment is another concern, since agriculture is largely carried out in rural parts of India and there is still an inadequacy of service-centres for proper maintenance.

'Tractorization' and not mechanization:

Tractors have an annual market of 600,000-700,000 units in India whereas, threshers, the next largest segment, has an annual market of just 100,000 units. The penetration of tractors has grown from one per 150 hectares to one per 30 hectares on agricultural land.

However, such a growth in penetration has not been seen in other agricultural implements. This phenomenon has been dubbed as 'tractorization' by many industry stakeholders. It is to be noted that for a sustainable agricultural future, other farm implements, and not just tractors, need to be advanced to farmers in the country.

Tendering process:

There are various inefficiencies in the tendering process, especially with regard to the time and length of the process. In some states, the tendering process goes through the months of August and September (even October in some cases), due to which a time lag crops up. By this time the main season has already ended. Hence, farmers are unable to draw the optimal benefit of the available machinery. The tiller market is especially impacted by this, as virtually all the tillers sold in the country are done so on subsidy (since subsidy applies to imported tillers as well). Therefore, ensuring timely completion of the tendering process (before the beginning of April) is paramount to safeguard the interests of the farmers.

Procurement process for the farmer:

The entire process of acquiring farm equipment is very tedious and cumbersome for a farmer. A farmer has to go through various levels/ departments to get his land records verified. Post clearance, he has to go through further checks from the District Agriculture Officer in order to obtain approval and clearance for the purchase. This process itself becomes a big hindrance and discomfort to the farmer.

Financing of farm equipment:

Purchase of farm equipment is a significant investment for most of the farmers in India. Hence, reasonable financing norms are a must for ensuring mechanization. An issue that has been persistent in financing is the purchase of standalone implements. The only exception is seen in case of tractors where the required details of the equipment e.g. engine number, chassis number etc. are available. Hence, institutions insist on purchase of the tractor along with other farm implements. This seems to discourage farmers from investing at large, as they need to shell out a huge amount. This adds to the 'tractorization' trend that is visible in the industry and doesn't add to overall mechanization. Industry stakeholders also feel that commercial banks must be encouraged to provide adequate financing for various farm equipment. This is seen by many industry sources as the biggest impediment to growth. Industry believes that as commercial banks are reluctant to provide financing for agricultural equipment, owing to the risk it poses.

Other challenges the industry faces:

A host of other challenges are faced by the industry and impacts proper functioning of the system.

There is a lack of proper mandatory safety standards for use of machinery as well as absence of standardised norms to ensure quality of the equipment. As a result, there is no premium for the higher quality products, which leads to lesser incentives for manufacturers to invest in quality and also to invest in new and cutting-edge technologies.

Another problem the industry faces is the lack of data/information. Also, there is a clear absence of farm machinery management data regarding use-patterns, annual-use, breakdown-frequency, repair and management cost, reliability, granular information on the extent/ penetration of mechanization etc. In absence of data, requirements of the scope of market growth remains unclear and are often targets are missed.

Some manufacturers also face issues of excise duties that need to be paid on intermediate parts such as higher-quality gear-boxes that are imported and used in assembling the final product. Therefore, even if parts are imported and assembled and used in the country, the manufacturers have to bear the cost.

UNIT: 17

Rural Mechanization as Future Focus Area

In the past few years, patterns of rural mechanization have taken on a new significance with concerns about, among other issues, future global food supplies, food wastage and debates around land grabs, food security, rural employment, energy generation and use, and water scarcity. These concerns encompass the broader questions of whether, and under what circumstances, rural development should be seen as an important development goal. Despite the media's presentation, during the past 60 years smaller-scale equipment has been spreading throughout much of East and South Asia. Many Green Revolutions have come about not as a result of the spread of larger 4WT and large combine harvesters but as a result of the spread of smaller scale equipment such as two-wheel tractors (2WT), shallow tubewells, smaller-scale low-lift pumps, small engines on boats, and artisan-made three- and four-wheel rural transport vehicles. Whereas much attention has been given to the role of high-yielding crop varieties in past Green Revolutions, little has been paid to the equally important role of engineering equipment for timely land preparation and sowing, careful water management, harvesting, threshing, and the local processing, transporting, and marketing of agricultural and other rural products, all of which lead to productivity gains and increases in cropping intensification. And while use of machinery in farming does not directly lead to increase in yields it can facilitate the intensification of production through quicker turnaround times, careful and timely use of water, plant protection, harvesting, and so forth, which do increase yields, reduce losses, and often reduce drudgery.

Most past Asian Green Revolutions relied on cheap energy policies for the agricultural sector through subsidized fossil fuels, electricity, and urea. In addition, agricultural machinery was often subsidized with capital grants and low-interest loans. The future for many South Asian countries will depend on a more careful investigation of the short- and long-term outcomes of alternative patterns of rural mechanization. In the 1970s and 1980s, there were major choice of technique policy debates concerning rural mechanization, but by the 1990s the debates had nearly ceased. Since the 1970s many patterns of rural mechanization have taken place in different parts of the world. In the past, the choices of techniques have been limited to

commercially available, Western-manufactured, large-scale machinery. Paradoxically, after the decline of the debates, the choice of techniques greatly expanded in the origins and numbers of manufacturers and expanded in scale to commercial small-scale machinery.

The term rural mechanization, rather than agricultural mechanization, should be used because it is only rarely that one can separate agricultural mechanization from other rural economic activities. Paradoxically, the term tractor conjures in many people's minds a tractor that is used for agricultural uses. However, in many parts of Asia, tractors and especially 2WTs and 4WTs are often used as much for transportation purposes as for agricultural purposes. There is a need to open up the policy debate on rural mechanization rather than just examining detailed technical issues. Although technical engineering details are important, so are the historical, economic and social research information; it is this overarching policy analysis, which should be the focus. A comprehensive review of the same is required. A national, local, and regional analysis involving local expertise is probably the most critical policy issue at the moment. We concentrate on engineering equipment because analysis of engineering technologies appears to have been neglected in past agricultural technology policy debates in favour of plant science. There are of course many situations in which the interaction of genetic changes in crop varieties and engineering technology have played complementary roles, for example, shorter-season crops and equipment needed to decrease turnaround times necessary for intensification. However, attention has often then been given to the importance of the improved seeds rather than to the engineering technologies that have enabled the intensification and economic use of land, water, soils, timeliness of operations, and so forth. Although mechanization has been taking place, there have not been national and global studies of these processes and the outcomes of these changes, especially with regard to the spread of smaller-scale equipment.

Historical Spread of Small-Scale Rural Machinery in India vis-à-vis Neighbouring Countries, Especially with Regard to Engines of up to 20 Horsepower

The common thread among most of the small machinery is the use of single-cylinder and mostly diesel engines that power 2WTs, pump sets for shallow tubewells and low-lift pumps, threshers, and road and water transport.

The Table below gives a general time line of the historical spread of smaller equipment in some South Asian countries going back to the early 1960s. 5 From this one can see the diversity of patterns found among the countries. What the table does not show are the regional diversities within each country. For instance, within Nepal there are zones with higher levels of mechanization and different agricultural machines compared to the country as a whole. The differences within the country are due to factors such as agrarian structure, topography, remoteness, and proximity to trade route and to other countries. Indeed, higher and lower levels of mechanization in the central west correspond to the regional variations within neighbouring states, which indicates cross-border diffusion.

Vietnam

In the early 1960s, the South Vietnamese government and a US program were promoting larger-scale irrigation schemes, and at the same time small, 3- to 10-horsepower, US-made engines were silently spreading and used to power small boats and locally made axial flow pumps. After the mid-1980s, these small-horsepower engines (now being made in various countries in East Asia) expanded exponentially into the millions in Vietnam. In this case, the original machines were the US Clinton and Kohler petrol engines. The small, light, 5-horsepower Kohler engines became so ubiquitous that any small engine that powers a boat or a pump is called a "may ko-le." Significant to the early spread of the small engines was the way local innovators and rural entrepreneurs redesigned the long-tailed motorboat propellers for use with the "shrimp-tailed" axial flow pumps.

Similar to the Nepal experience, the 2WTs initially coming from Japan, Korea, and Taiwan were first replaced by the lower-cost Chinese ones. Also, similar to the Thai and Indian experiences, the Vietnamese government established several engine and 2WT factories with the aid of other Eastern companies with concomitant import substitution. Perhaps the most important factor on Vietnam is that like Thailand and now Bangladesh, there has been a long history of a sustained, smaller-scale rural mechanization process. As with Thailand, larger 4WTs and combine harvesters have found a market share in the county. However, the majority of tillage and other agricultural machinery are powered by smaller, single-cylinder diesel engines.

Table. Historical spread of select smaller equipment in some Asian countries

Country	Technology	1960 1970 1980 1990 2000 2010 2020
Nepal	2WTs	--Japanese-- --Korean-Chinese in KTM-Pokhara- --Chinese All Nepal--
	Small Engines	--Single cylinder Indian Irrigation Diesel Pump------Chinese Engines------
	Threshers	--Wheat threshers--------------Rice threshers--------
Vietnam	2WTs	-- Import Japanese and Chinese-----Vietnamese ------
	Small Engines	-- USA Engines------Japanese Engines -------Chinese Engines for pumps and boats--
	Threshers	
Bangladesh	2WTs	--Japanese, Korean --Rapid Expansion of Chinese ---I-----------
	Small Engines	--Japanese Diesel Pump---Rapid Expansion of Chinese for pumps, boats, etc--
	Threshers	--Wheat threshers -------- Rice threshers --------
India	2WTs	----Japanese Indian tie ups-------------- Chinese ----------
	Small Engines	----------Indian Listeriod Diesel Pump-------------------Chinese for pumps, etc----------
	Threshers	--Wheat threshers ------------------ Rice threshers ---------------
Sri Lanka	2WTs	----Sri Lankan design UK made -------- Chinese ------------------
	Small Engines	--British-Indian Listorids--------Chinese diesel-----------------
	Threshers	-------Rice threshers ------------------------------
Thailand	2WTs	-----Thai developed -----------------------------
	Small Engines	--USA petrol for pumps long-tail boat ---Japanese -Thai Tie ups ---Chinese diesel and petrol--
	Threshers	---(IRRI) Axial flow rice threshers developed and manufactured ----------

Bangladesh

Bangladesh also has a long history of smaller-scale rural mechanization in which small engines in rural areas have powered boat and road transportation, pump sets, and 2WTs, among other usages. Before independence, the irrigation policy in Bangladesh concentrated on large-scale canal systems and deep tubewells but with at least half the country being irrigated by local small-scale equipment such as swing buckets and dhones. Large heavy engines were used for low-lift pumps in the public and private sectors where rural entrepreneurs were selling water. After independence, the irrigation policy changed radically, and the government promoted groundwater development policies, especially shallow tubewells, and the use of small horsepower, low-lift pumps for lifting water from surface sources. After the change of policy, there was much formal and informal experimentation with different sizes and types of shallow tubewells and low-lift pumps and with different institutional models, such as landless labourer groups selling water and private ownership. However, it was not until the 1980s that there was a major expansion of shallow tubewells powered by Chinese diesel engines, which were cheaper and lighter in weight compared to the conventional Japanese and Indian small-horsepower diesel engines.

Some of the early introductions of 2WTs took place in the mid-1970s when a Japanese aid program established a training center for 2WTs near Dhaka. However, use of the Japanese 2WTs did not spread. During visits to China in the 1970s, Bangladeshi entrepreneurs began to add a few small diesel engines to their container shipments, but it was not until the restrictions on the import of Chinese equipment (because they were considered of inferior quality) were lifted in the late 1980s that the rapid spread of Chinese-made engines (for irrigation) and 2WTs took place. Table 2.2 demonstrates how by 2011 smaller-scale equipment spread in Bangladesh to 420,000 2WTs7 and 1.4 million shallow tubewells.

Table. Small machinery used for agriculture purposes in Bangladesh

Machine	1977	1984	1989	1996	2006	2008	2009	2010	2011
2WT	200	500	5,000	1,00,000	3,00,000	3,43,000	3,66,700	4,00,030	4,20,027
Deep Tubewells	4,461	15,519	22,448	24,506	28,289	31,302	32,174	32,912	-
Shallow Tubewells	3,045	67,103	2,23,588	3,25,360	11,82,525	13,04,973	13,74,548	14,25,136	-
Low Lift Pumps	28,361	43,651	57,200	41,816	1,19,135	1,38,630	1,46,792	1,50,613	-
Threshers (Open)	-	500	3,000	10,000	1,30,000				1,90,000
Threshers (Closed)	-	100	1,000	5,000	45,000				65,000
Maize Sheller				100	850				5,000
Combine Harvester						±30			100
Winnower						±500			±200
Backpack Sprayer						12,50,000			12,50,000
Reaper						±40			±50
2WT Seed Drills					451	481	620	890	1,220

Thailand

The spread of smaller engines in Thailand also has a long history. The use of 2WTs in the rainfed region of the Northeast of Thailand rose rapidly after the beginning of the 1980s. In 1983 there were 40,000 2WTs, and the number rose to 1,250,000 in 2003. Agricultural holding households owning 2WTs rose from 2 percent to 47 percent in 2003. By 2003, 89 percent of households were using 2WTs, and hiring practices were widespread. In this case, the 2WTs were part of the intensification of a rainfed rural economy. In other parts of Thailand, the pattern of small-scale mechanization was different. There are 1.8 million 2WTs, and nearly 2 million to 3 million small horsepower pump sets. The history of Thailand's small-scale pump set irrigation was different from that of Bangladesh as the use of surface water from canals, small rivers, and farm ponds has been much greater. But the importance of small pump sets to pump from these canals is just as important. The types of pumps also differed. In the early 1960s, Thailand developed locally produced axial flow pumps, likely an innovation borrowed from the Vietnam shrimp tailed/propeller pumps. Although axial flow pumps are one and a half to two times more expensive than conventional centrifugal pumps, they have half or less the energy consumption of centrifugal pumps at lifts below 3 meters. However, in the mid-2000s there has been an explosion of shallow tubewell development in certain parts of the Chao Phraya delta, which perhaps indicates that the availability of surface water may have reached its limits.

The history of the spread of smaller equipment in Thailand has been characterized by the strong support and promotion by the government of private agromachinery industrial development. Since the early 1960s, there have been substantial programs for the promotion of manufacturing of both the earlier small and the more recently larger agricultural machinery. Chins wan and Cochran (1985) describe a government-led program for the development and manufacturing of axial flow pumps. The "Thai"-type 2WT was initially developed in the late 1950s by M. R. Debriddhi, head of the engineering division of the Thai Rice Department of the Thai Ministry of Agriculture and Cooperatives8. Debriddhi spent many years cooperating with several manufacturers to promote the spread of this technology. Referring to the spread of axial flow rice threshers in Thailand in the 1980s and 1990s, it is also related that the International Rice Research Institute, in the 1970s and early 1980s, "through its newly created Industrial Extension Program had extended axial-flow threshers to Thailand" and that the "government of Thailand had responded with a relatively large program for their promotion with many local manufacturers." Later, a series of these government projects took place, beginning in 1983 with the development of locally made track-type combine harvesters that led to the first commercially manufactured combines in 1989. Thepent attributes the success of the combines to building on the earlier success in the development of the axial flow rice threshers that were incorporated in the combine harvester's designs.

Today, Thailand is a mixed system where Thai-made 2WTs still do most of the land preparation for rice (although in the last few years 4WTs have begun to spread but mostly in the upland maize areas north of Bangkok) but where larger-horsepower Thai-made threshers and combine harvesters greatly aid in the harvest of rice. Thepent relates that Thai farm holdings continue to fragment and get smaller but that if the high support prices for rice from the Thai government do not continue this could slow or even reverse the land fragmentation.

Sri Lanka

Sri Lanka is especially interesting as regards 2WTs because one of the early designs of a South Asian 2WT was by Sri Lankan Ray Wijewardene in 1955. This model ended up being manufactured in the United Kingdom by Landmaster with exports back to Sri Lanka. By 1975, there were 11,000 2WTs in Sri Lanka. The UK 2WTs gave way to Chinese imports in the 1980s. By 2007, there were 125,000 2WTs in Sri Lanka. As with Bangladesh, these 2WTs are generally used for multiple purposes such as transport, tillage, and harvesting. Rural entrepreneurs who own them, but who do not necessarily operate them, hire out services. It is estimated that more than 80 percent of all tillage operations are mechanized, and much of this is done by 2WTs. In addition it is estimated that by 2000 there were more than 100,000 smaller-scale engines used for shallow tubewell pumps.

India

Since the 1980s the Indian government has made significant investment in smaller-scale equipment through agricultural research and extension policies. The All India Coordinated Research Project on Farm Implements and Machinery and the various departments of agricultural engineering in the many agricultural universities in India have long-term projects for the research, development, and promotion of small-scale agricultural machinery. Other central and state-funded programs provided large and long-term subsidies for 2WTs and small machinery. However, if one looks at access to powered machinery for tillage, harvest, and threshing, India looks very different from its neighbours. In Bangladesh and Sri Lanka more than 80 percent of tillage operations are mechanized—mainly by 2WTs—whereas in India mechanized tillage and crop establishment makes up 45 percent.

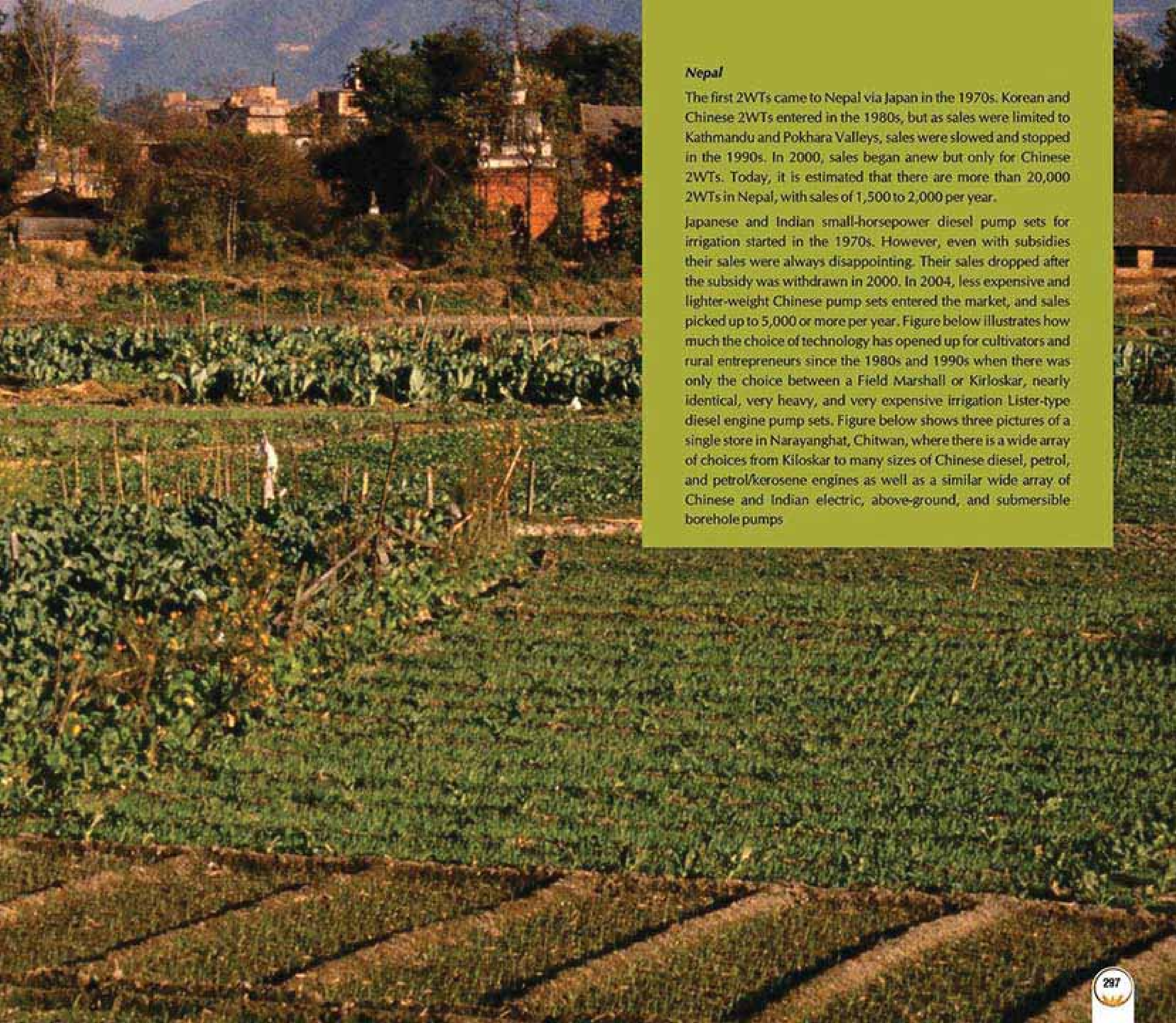
The slow spread of smaller-scale equipment in India is a paradox. Table below shows the percentage of the total 2WTs in the Asian region, by country. The unexpected figure is that the whole of India has only about 300,000 2WTs or 1.5 percent of the total, which is less than the 500,000 2WTs or 2.5 percent for Bangladesh. Ten years ago there was an even wider disparity, with 350,000 in Bangladesh and approximately 120,000 in India. From the 1970s, the government supported Japanese-Indian 2WT joint ventures of which only two survive. From the 1980s to 2000, VST Bangalore from Mitsubishi and Kamco Kerala from Kubota had nearly the whole market to themselves, selling relatively higher-quality but also much higher-priced 2WTs. Recent industry reports state that 2WTs sales started picking up in 2005, and by 2010 the industry had a growth rate around 20 percent per year. Recent sales are reported at upwards of 45,000 to 55,000 per year. In contrast, in 2001, sales were less than 20,000. In the 1990s, Chinese 2WTs began making inroads, and today, according to market reports for the past five years, they may have gained 35 percent or more of the market share.

As indicated by countries such as Bangladesh, Thailand, and Sri Lanka, the recent rapid spread of smaller-scale machinery has increased the productivity of agricultural and other rural resources. The paradox then is, How is it that even with large government support, investments in the research and development (R&D) as well as in the manufacturing of 2WTs, and the sizable potential for small-scale equipment to increase the intensity of use of agricultural and other resources, the spread of smaller-scale equipment has been so low in India?

Estimates of the two-wheel tractor population in some Asian countries

Two-wheel tractors in Some Asian countries (estimates for 2012)		
Country	Number	Percentages
Pakistan	1,000	<1
Bhutan	3,000	<1
Afghanistan	8,000	<1
Nepal	20,000	<1
Sri Lanka	150,000	<1
India	300,000	1.5
Bangladesh	500,000	2.5
Thailand	1,800,000	9.0
China	17,000,000	85.9
Total	19,782,000	100%

Part of the explanation is that agricultural mechanization in India has been largely dominated by the corporate manufacturing sector. In particular, the indigenous 4WT industry has seen the entry in the past decade of multinationals such as AGCO/New Holland, John Deere, and Deutz Farh. India became the largest manufacturer of 4WTs in the world in the late 1990s, yet it was accompanied by the neglect of the machinery requirements of cultivators and other rural entrepreneurs in rural areas, especially in the poverty areas of the eastern and central regions of India. Consequently, for the sake of this review of the long-term sustained spread of smaller-scale equipment in the intensification of agriculture and the rural economy, surprisingly India has limited knowledge to share, although that may now be changing.



Nepal

The first 2WTs came to Nepal via Japan in the 1970s. Korean and Chinese 2WTs entered in the 1980s, but as sales were limited to Kathmandu and Pokhara Valleys, sales were slowed and stopped in the 1990s. In 2000, sales began anew but only for Chinese 2WTs. Today, it is estimated that there are more than 20,000 2WTs in Nepal, with sales of 1,500 to 2,000 per year.

Japanese and Indian small-horsepower diesel pump sets for irrigation started in the 1970s. However, even with subsidies their sales were always disappointing. Their sales dropped after the subsidy was withdrawn in 2000. In 2004, less expensive and lighter-weight Chinese pump sets entered the market, and sales picked up to 5,000 or more per year. Figure below illustrates how much the choice of technology has opened up for cultivators and rural entrepreneurs since the 1980s and 1990s when there was only the choice between a Field Marshall or Kirloskar, nearly identical, very heavy, and very expensive irrigation Lister-type diesel engine pump sets. Figure below shows three pictures of a single store in Narayanghat, Chitwan, where there is a wide array of choices from Kiloskar to many sizes of Chinese diesel, petrol, and petrol/kerosene engines as well as a similar wide array of Chinese and Indian electric, above-ground, and submersible borehole pumps

A paradox also exists in Nepal. After the introduction of Japanese 2WTs in the 1970s in the Kathmandu and Pokhara Valleys, 2WTs made significant contributions to increased agricultural productivity in those valleys. However, the paradox is that there was little governmental and donor support for this type of smaller-scale mechanization until the late 1990s. At that point, new demonstrations and research on 2WTs were initiated on the Terai and initiatives taken to encourage the import and sale of 2WTs. There is now an estimated population of 20,000 2WTs in Nepal.

Another paradox in Nepal was that discussions of rural mechanization were left out of early five year development plans, and the national Agricultural Perspective Plan (APP) in 1996 excluded a discussion of agricultural and rural mechanization. Although the irrigation sector received some recognition in the APP, the critical inputs of small-scale groundwater development and local canal water systems were assumed to be addressed through the technical abilities of other ministries and institutional coordination between ministries. However, little research on the effective, careful use of water at the farmer level took place, and little communication took place. In the early 2000s, the minister of agriculture and the Asian Development Bank (ADB) tried to address these issues and modify the APP, but little changed. Hence, it can be seen that the APP itself was one of the reasons why the intensification of agriculture and the development of the rural economy through smaller-scale rural mechanization was not addressed earlier.

In addition, the main banks in Nepal are still traditional and slow to create financial products for poorer people who do not have land or other collateral that would allow them to invest in smaller-scale equipment.

A relatively new entrant onto the mechanization scene of Nepal is the spread of smaller horsepower 2WTs or mini-tiller tractors. These were initially brought in around 2005 by a few private-sector agricultural input traders who saw them on trips to China. The mini-tillers initially spread in peri-urban areas for vegetable production. There has been some government-sector support, and they are now spreading in rural and mountainous areas where the larger 12- to 15- horsepower 2WTs are too large for the small terraces and difficult access conditions. There are ten or more mini-tiller importers, and they sold an estimated 500 units in 2012. The government of Nepal and donor-funded projects are attempting to backstop their spread and attempting to find additional implements and uses similar to the larger-horsepower 2WTs.

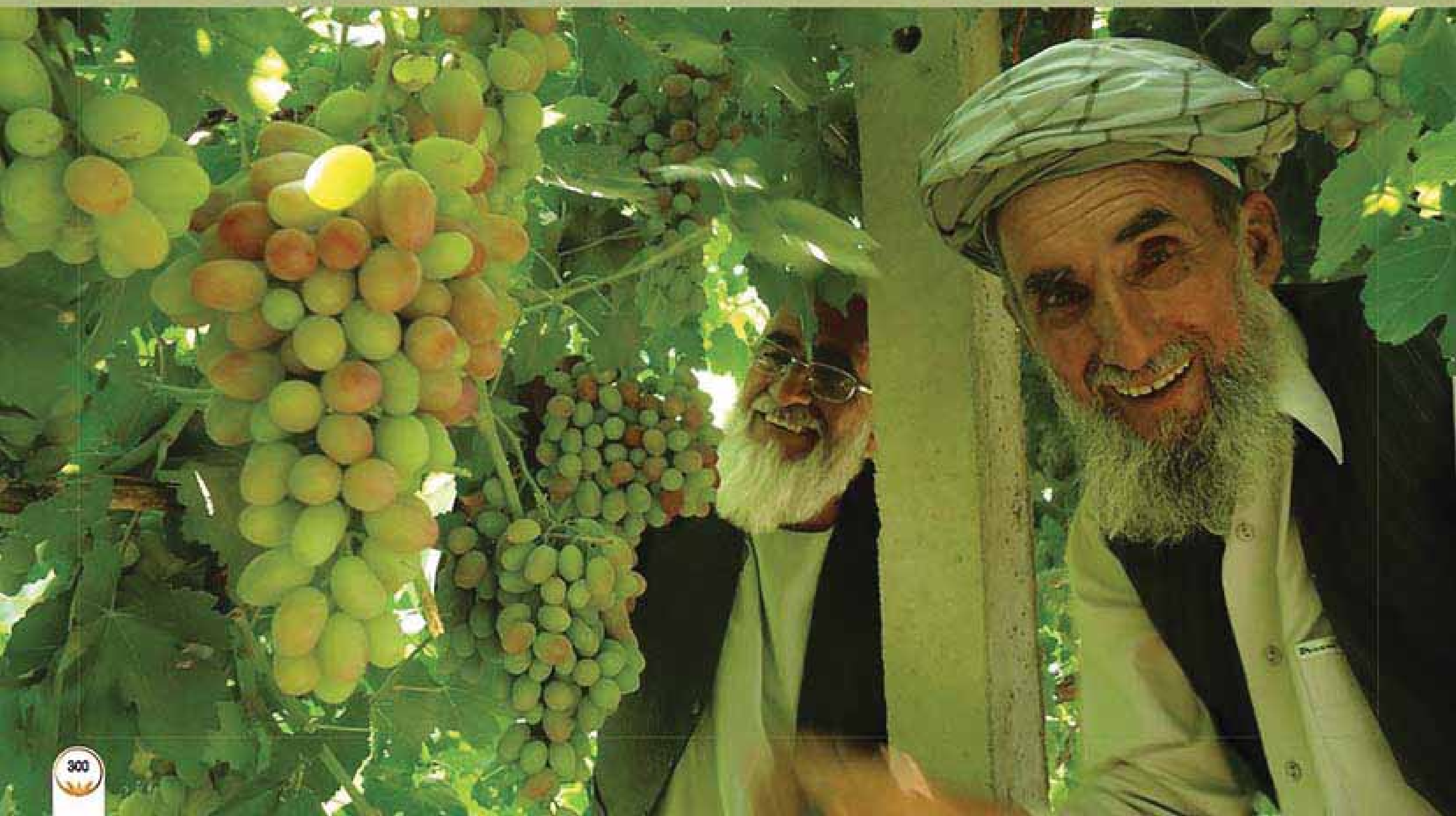
Until recently the Nepal importers had offered only mini-tillers with rotavators for ploughing. However, government and donor projects that have taken interest in these mini-tillers are now working with the importers to develop and offer other mini implements such as seed drills, irrigation pumps, open drum threshers, milling machines, and trailers that would make these mini-tiller power sources even more useful and beneficial to small-hill farmers.

Mini-tillers are part of the program of a women's micro finance group, Mahila Shayatra Microfinance Bittiya Sastha Ltd. The machines fit within the small-loan credit limits. Also, their small size allows women to operate them and opens up diversification of livelihoods for women farmers. While on a visit to this group in Makwanpur District the authors noted that one of the first users of the mini-tiller was an older couple (husband age 68 and wife age 58) whose children were working in Kathmandu. They were both operating the mini-tiller to plough their 0.66 hectares, suggesting that this small equipment might also address the problems of aging farm households.

Afghanistan

Afghanistan has perhaps one of the shortest histories of smaller engines and smaller equipment. Agricultural mechanization in Afghanistan was influenced by the former Soviet regime's collective ideals of large-scale machinery. Similarly, Pakistani influences have been mostly of the Punjab large-scale machinery type. Indeed, with an impending United States Agency for International Development (USAID)–sponsored 2WT dissemination project looming in 2009, project staff were inundated with complaints from the Department of Agriculture that were premised by, "We are a 4WT nation and these 2WTs will never sell." However, shortly thereafter, more than 4,000 2WTs with plows, reapers/harvesters, seed drills, and trailers were sold, albeit with a generous USAID-supplied 60 percent co-pay within a nine-month period. Interesting to note, another USAID Afghanistan Vouchers for Increased Production in Agriculture South project intended to distribute 15,000 small-horsepower Chinese diesel pump sets to farmers along the Helmond River. However, the provincial governor feared a water war would erupt, with river tail enders getting even less water, and stopped the project. Notwithstanding this, during the past ten years large numbers of small-horsepower Chinese single-cylinder diesel engines have been imported and sold for generating electricity for irrigation pumping and threshing. A rough estimate would put the number of 2WTs in 2013 in Afghanistan at 9,000 and small pump sets at 30,000.

Another USAID Afghanistan Vouchers for Increased Production in Agriculture South project intended to distribute 15,000 small-horsepower Chinese diesel pump sets to farmers along the Helmond River. However, the provincial governor feared a water war would erupt, with river tail enders getting even less water, and stopped the project. Notwithstanding this, during the past ten years large numbers of small-horsepower Chinese single-cylinder diesel engines have been imported and sold for generating electricity for irrigation pumping and threshing. A rough estimate would put the number of 2WTs in 2013 in Afghanistan at 9,000 and small pump sets at 30,000



Factors Affecting Rural Mechanization

Long Histories and Mixed Heritage of Smaller-scale Engines

In South and Southeast Asia there are diverse patterns of rural, smaller-scale mechanization. 16 Many of these have long histories going back to the 1960s, and some other countries and regions, such as Afghanistan, Myanmar, and Bihar, have only recently seen the more rapid spread of smaller-scale diesel engines. The history of imports and local manufacture is also varied, as is the sequencing of operations that mechanized before others. In Bangladesh, clearly small pumps for irrigation came before 2WTs. In Northeast Thailand it was the spread of 2WTs in rainfed agriculture that led to increased rural development. In Bangladesh, Vietnam, and parts of Thailand, the use of smaller-scale engines with boats and shrimp-tailed propeller pumps formed the major part of the history. In many of the countries, the use of smaller-scale engines for transport (by water and on land) as well as agricultural purposes was a central feature in understanding their spread.

- Long histories of substantial smaller-scale rural mechanization, for example, Vietnam, Bangladesh, Sri Lanka, Thailand, and parts of India and more recently spreading in Bihar, Nepal, Afghanistan, and Bhutan17
- Diverse patterns of rural mechanization
- Increasing diversity of models and sizes of machinery and their sources of fuel (diesel, electric, petrol, kerosene, compressed natural gas [CNG], and now solar sources)
- Different sequences in the mechanization of rural and agricultural operations
- The importance of the use of tractors and other engines for transport

Multiple Uses of Smaller Engines and Multiple Markets for Engine Services

Not only have small-scale engines been used for many purposes, such as powering boats, pumping water, milling, hulling, threshing, processing agricultural products, and powering 2WTs, but the same engine has been put to multiple uses. For example, a 2WT of the Kathmandu and Pokhara Valleys is generally used for transport, tillage, and other rural operations as well as for the transport of construction and other goods in the local coterminous urban areas. In Sri Lanka, 2WTs are used a great deal as taxis or buses as well as for agricultural purposes. In Nepal, pump set engines are widely used to power threshers.

Alongside the spread of smaller-scale engines and other smaller-scale equipment has been the spread of a great range of market institutions for the buying and selling of services. In the Kosi region of Bihar, the spread of bamboo tubewells was facilitated by rural entrepreneurs who sold pumping services from a heavy Indian diesel pump set mounted on bullock carts. As a result of the remunerative benefits of 2WTs custom service markets in Nepal, some have had a long life. Indeed, some of the original Japanese and Korean 2WTs are still operating and providing their owners income after 30 years. Notwithstanding this, the general payback period on total investment for a Chinese 2WT in Nepal and Bangladesh has, and continues to be very good, generally less than 2 years.

"Good Enough," Profitable Equipment with Smaller Engines Is Owned by Rural Entrepreneurs

The third factor is that it was good enough equipment, owned by rural entrepreneurs, that has spread. In the overall picture, the light, single-cylinder diesel Chinese engine played a major role. Before the imports of Chinese equipment to Nepal, the Japanese and Korean 2WTs proved to be robust over the long term with some still in operation in the Kathmandu Valley. We use the term "good enough"19 to highlight the issue of who sets the standards for the manufacture /import of equipment, its promotion, or both. The Bangladesh case illustrates how technical standards set by the relevant government authority prevented the importation of 2WTs from China. When the government lifted the restriction, importation of equipment expanded rapidly. However, the change came after five to ten years of government, donors, and nongovernmental organizations' (NGOs') formal and informal experimentation with different types of equipment and institutions. The paradox of India's low numbers of 2WTs is brought out again in this regard. India has also set up technology vetting centers in Madhya Pradesh, Haryana, Andhra Pradesh, and Assam through which the manufacturers and importers must pass to participate in the large government agromachinery subsidy program. There is also evidence that this long-term subsidy program has driven up the prices for farmers who cannot participate in the subsidy scheme due to limited size of the scheme. Of the total number of 2WTs in India, Bangladesh, and Nepal, the majority were in Bangladesh (2.5 percent), with only 1.5 percent in the whole of India. This picture is now changing as it is estimated that about 55,000 2WTs per year are being sold in India and nearly 35 percent of this total is imported from China by Indian companies.

The second point to note is that the smaller-scale equipment is owned by rural entrepreneurs and is highly profitable. This is illustrated by 2WTs. In Bangladesh, Nepal, Sri Lanka, and Thailand, they are owned by people who may have some land, but generally their services are hired out to others for multiple purposes. Transportation is the most common nonfarm use. However, applying the "nonfarm" label to transport and other activities is problematic. In the places where smaller-scale engines have spread, the engines are used as much for nonfarm use as for farm use, and it is this flexibility that has made them attractive to rural entrepreneurs as an investment. There are numerous studies of the use and markets of services of smaller-scale equipment and their profitability. In a recent study in Bangladesh22 it was found that the time to recover full investment costs in shallow tubewells, 2WTs, and power threshers was 2.5, 1.8, and 1.5 years, respectively. The same survey shows that funds for investments in shallow tubewells, power tillers, and power thresher come mainly from investors' own savings, family, and so forth rather than from bank loans. In recent years the source of loans, especially from friends and relatives, has grown. Some of this own savings may well be coming from remittances of labourers from rural areas working in the Middle East and other countries. The same recent Bangladesh study showed that more than 90 percent of farmers who own 2WTs hire them out, and 25 percent or more of farmer/owners hire out their shallow tubewells and power threshers. In some policy and technology discussions, the idea is introduced that smaller-scale equipment is for multiple use on self-contained small farms that have little contact with outside local markets. The Asian data clearly show that this representation of a small farm agrarian/rural economy is incorrect.

In many situations the equipment is operated by paid labourers who are also responsible for renting out the machinery on a daily or monthly basis. These 2WT operators generally do not have access to savings and loans by which they can buy and operate their own machinery. In Nepal, becoming a 2WT operator is seen by some labourers as a route to a better-paid, more lucrative and respected bus or truck driver jobs.

Energy Policy Has Been a Central Component—Availability and Prices of Electricity and Fossil Fuels

India 25 percent of the horsepower in agriculture comes from electric engines, whereas in Bangladesh and Nepal it is only 6 percent and 11 percent, respectively. Two-wheeled tractors have been powered by diesel. The power source for irrigation pump sets has been more diverse, including electricity, diesel, petrol, and kerosene. In Bangladesh, shallow tubewells and low-lift pumps have been powered mainly by diesel fuel. As an overall factor, it would seem that smaller-scale shallow tubewells have spread more rapidly where diesel/petrol pump sets have been available and promoted. In some situations, the unreliability of electricity is a well-known problem, which can be costly for cultivators. The lack of the availability and promotion of lighter-weight and inexpensive Chinese diesel-powered pump sets and 2WTs in Eastern India could be some of the explanation for the slower growth of the agricultural sector and other parts of the rural economy. That now is changing with the increased spread of smaller-scale equipment, some of which in earlier days used to come over the borders from Bangladesh and Nepal. Interesting to note, a Bangladesh policy to promote the use of CNG from its own supplies for use in domestic vehicles has not led to the spread of CNG for powering these engines in rural and agricultural areas. This may be because CNG is less available in the rural areas and that the appliances needed to convert these rural engines to CNG have not been developed. However, as a result of the policy, imported diesel is freed up for use in rural areas.

	Bangladesh			India			Nepal		
Energy source	No. units	Total HP	% HP	No. units	Total HP	% HP	No. units	Total HP	% HP
Two-wheel tractor	5,00,000	75,00,000	53	3,00,000	45,00,000	2	16,000	2,40,000	13
Four-wheel tractor	35,000	4,60,000	3	35,00,000	12,25,00,000	56	30,000	9,00,000	51
Irrigation shallow tubewell pump—diesel	12,00,000	60,00,000	42	90,00,000	4,50,00,000	20	1,20,000	6,00,000	34
Irrigation pump sets— electric	1,00,000	2,00,000	1	1,20,00,000	4,80,00,000	22	10,000	40,000	2
Total		1,41,60,000	100		22,00,00,000	100		17,80,000	100

Nepal's underdeveloped hydroelectricity potential has also directly affected choice of technique as regards electric or diesel engines for pump sets. This might be beginning to change now for a number of reasons:

- more decentralized electricity user groups whereby electricity is sold in bulk to user groups and
- the spread of smaller-scale hydroelectricity plants with increased attention given to the use of electricity for economically productive purposes, such as local irrigation, processing, and other rural economic activities.

India has the highest usage of electricity at the farm level. The large and mostly state-funded electricity subsidies have led to high levels of usage by farmers, especially for irrigation. This also has led to the well-known unsustainable mining of the aquifers in the drier, and more affluent, northwest.

Importance of Informal R&D

In many of these histories, informal R&D has been important, if not central, to understanding the spread of the smaller-scale technology. In the case of Vietnam, the use of the small engine came about because a local engineer saw the potential of changing the use of the equipment for power boats and axial flow pumps. Similarly, in Bangladesh local engineers and artisans modified and adapted the Chinese engine for different purposes from those for which they were initially introduced. The spread of bamboo tubewells in the Kosi region of Bihar was a classic and well-documented example of where a government tubewell package was unpacked. The diesel pump set was then mounted on a bullock cart to sell pumping services to farmers who had cheap bamboo wells sunk on their own fragmented plots. Innovation also took place on the institutional level in the creation of local markets in services. An example of an institutional innovator was a local administrator who went against the grain and created a local government program to promote the spread of irrigation through this new technology. More recently, the efficiency of shallow tubewells has been improved by the spread of inexpensive plastic lay-flat pipes in Nepal and elsewhere (de Bont 2014). These flexible delivery hoses originated in the black plastic pipe extrusion industries in South Asia.

The lay-flat pipes rapidly became so common that in some areas local people do not even see them as being new or unusual. More recently, it has been reported that in India ice pop wrappers are now being used for drip irrigation at a cost far below the more conventional designs coming from the market or more formal R&D programs. In these cases, informal R&D has proved itself an important source of innovation for the management of irrigation water. In Bangladesh, the 2WT reduced or zero-till drill that was promoted by the International Maize and Wheat Improvement Center in the late 1990s and early 2000s for wheat and other grains spread quickly, not for reduced till wheat but as a high-speed rotavator tiller used for onion and other high-value crops. According to International Development Enterprises (2012), by 2012 their numbers had grown to more than 2,000 pieces, and importers were actively marketing them as high-speed rototillers. In all these situations, local innovators have transferred materials and equipment from one part/sector of the economy to another to create new techniques/institutions.

The Political Economy of Agrarian and Rural Change in a Broader Context

The most important political economy factor is that the spread of smaller-scale equipment in rural areas of some South Asian countries cannot be understood without looking at the structure of the agricultural and the broader rural and national economy. Factors that need to be considered are

- *the relationship of the rural economy to the rest of the economy,*
- *trade regimes,*
- *the extent of migration, and*
- *whether the country is in a conflict or a post conflict situation.*

The continuation of such partial analysis is particularly problematic now when dimensions of rural mechanization are central to policy debates on food production and security, ownership and management of land, rural equipment, land grab debates, and rural employment and migration. Any discussions concerning the implications of different patterns of land ownership will not move the debate forward unless they contextualize rural mechanization choices within national and global settings.

UNIT: 18

Conservation Agriculture as a Future Focus Area

Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA holds tremendous potential for all sizes of farms and agro-ecological systems, but its adoption is perhaps most urgently required by smallholder farmers, especially those facing acute labour shortages. It is a way to combine profitable agricultural production with environmental concerns and sustainability. CA is characterized by three linked principles, namely:

- Continuous minimum mechanical soil disturbance.
- Permanent organic soil cover.
- Diversification of crop species grown in sequences or associations.

CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. CA enhances biodiversity and natural biological processes above and below the ground surface. Soil interventions such as mechanical tillage are reduced to an absolute minimum or avoided, and external inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not interfere with, or disrupt, the biological processes. CA facilitates good agronomy, such as timely operations, and improves overall land husbandry for rainfed and irrigated production. Complemented by other known good practices, including the use of quality seeds, and integrated pest, nutrient, weed and water management, etc., CA is a base for sustainable agricultural production intensification. It opens increased options for integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes.

Conservation Agriculture Technology

Conservation Agriculture, based on integrated practices such as zero tillage, crop rotations and permanent soil cover is becoming increasingly popular. As a concept of sustainable agricultural production it is promoted by several organizations around the world, FAO - Food and Agriculture Organization of the UN being one of them. The database concentrates only on equipment and machinery for manual, animal or motorized operation which has been specially designed for the needs of Conservation Agriculture. In particular:

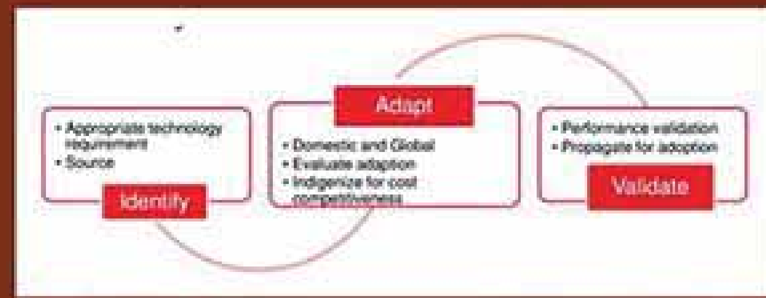
- Zero Tillage seeders and planters as well as rippers with fertilizer or seed attachments.
- Equipment such as rollers, mulch slashers or choppers, straw spreaders or choppers (including combine harvester attachments) for handling weeds and crop residues or mulch covers as well as equipment for mechanical weeding through a mulch cover.

Spray equipment which has been especially designed for the application of herbicides in small-scale no-till farming situations.


MAHINDRA 8000

UNIT: 19

Mechanization of Agriculture: Future Prospects



On the onset, it could be said that in the future, agricultural machines will become data-rich sensing and monitoring systems. Significant challenges will have to be overcome to achieve the level of agricultural productivity necessary to meet the predicted world demand for food, fiber, and fuel in 2050. Although agriculture has met significant challenges in the past, targeted increases in productivity by 2050 will have to be made in the face of stringent constraints—including limited resources, less skilled labor, and a limited amount of arable land, among others.

The metric used to measure such progress is total factor productivity (TFP)—the output per unit of total resources used in production. According to some predictions, agricultural output will have to double by 2050, with simultaneous management of sustainability. This will require increasing TFP from the current level of 1.4 for agricultural production systems to a consistent level of 1.75 or higher. To reach that goal, we will need significant achievements in all of the factors that impact TFP. Mechanization is one factor that has had a significant effect on TFP since the beginning of modern agriculture. Mechanized harvesting, for example, was a key factor in increasing cotton production in the last century. In the future, mechanization will also have to contribute to better management of inputs, which will be critical to increasing TFP in global production systems that vary widely among crop types and regional economic status.

For example, a scarce, basic resource that will have to be managed much better is water, a critical input in agricultural production. Both the efficiency and effectiveness of water use will have to improve dramatically. Today, approximately 70 percent of withdrawals of fresh water are used for agriculture. By 2025, 1.8 billion people are expected to be living in areas with absolute water scarcity, and two-thirds of the world population will live in water-stressed areas. Improving water management will have to be achieved by more efficient irrigation technology and higher efficiencies in whatever technologies farmers are currently using.

Impact of Mechanization on Productivity

Agricultural mechanization, one of the great achievements of the 20th century, was enabled by technologies that created value in agricultural production practices through the more efficient use of labor, the timeliness of operations, and more efficient input management with a focus on sustainable, high-productivity systems. Historically, affordable machinery, which increased capability and standardization and measurably improved productivity, was a key enabler of agricultural mechanization. In the 19th century, as our society matured, a great many innovations transformed the face of American agriculture. Taking advantage of a large labor base and draft animals, farmers had been able to manage reasonable areas of land. This form of agriculture was still practiced in some places until the middle of the 20th century. Early innovations were implements and tools that increased the productivity of draft animals and assisted farmers in preparing land for cultivation, planting and seeding, and managing and harvesting crops. The origins of the John Deere Company, for example, were based on the steel-surfaced plow developed by its founder. This important innovation increased the productivity of farmers working in the sticky soils of the Midwest. A major turning point occurred when tractors began to replace draft animals in the early decades of the 20th century. Tractors leveraged a growing oil economy to significantly accelerate agricultural productivity and output. Early harvesting methods had required separate process operations for different implements. With tractors, the number of necessary passes in a field for specific implements was reduced, and eventually, those implements were combined through innovation into the "combination" or combine harvester.

For most of the 20th century, four key factors influenced increases in the rate of crop production: more efficient use of labor; the timeliness of operations; more efficient use of inputs; and more sustainable productions systems. These four drivers played out at different rates in different crop production systems, but always led to more efficient systems with lower input costs. Technological innovations generally increased mechanization by integrating functional processes in a machine or crop production system and by making it possible for a farmer to manage increasingly large areas of land. By the late 20th century, electronically controlled hydraulics and power systems were the enabling technologies for improving machine performance and productivity. With an electronically addressable machine architecture, coupled with public access to global navigation satellite system (GNSS) technology in the mid-1990s, mechanization in the last 20 years has been focused on leveraging information, automation, and communication to advance ongoing trends in the precision control of agricultural production systems. In general, advances in machine system automation have increased productivity, increased convenience, and reduced skilled labor requirements for complex tasks. Moreover, benefits have been achieved in an economical way and increased overall TFP.

Advancement from Simple Mechanization to Cyber-Physical Systems

Today's increasingly automated agricultural production systems depend on the collection, transfer, and management of information by ICT to drive increased productivity. What was once a highly mechanical system, is becoming a dynamic cyber-physical system (CPS) that combines the cyber, or digital, domain with the physical domain. Following examples of CPS suggest the future potential of ICT for achieving the target TFP of 1.75 and beyond:

Precision Agriculture: Precision agriculture, or precision farming, is a systems approach for site-specific management of crop production systems. The foundation of precision farming rests on geospatial data techniques for improving the management of inputs and documenting production outputs. As the size of farm implements and machines increased, farmers were able to manage larger land areas. At first, these large machines typically used the same control levels across the width of the implement, even though this was not always best for specific portions of the landscape that might have different spatial and other characteristics. A key technology enabler for precision farming resulted from the public availability of GNSS, a technology that emerged in the mid-1990s. GNSS provided meter, and eventually decimeter, accuracy for mapping yields and moisture content. A number of ICT approaches were enabled by precision agriculture, but generally, its success is attributable to the design of machinery with the capacity for variable-rate applications. Examples include precision planters, sprayers, fertilizer applicators, and tillage instruments. The predominant control strategies for these systems are based on management maps developed by farmers and their crop consultants. Typically, mapping is done using a geographic information system (GIS), based on characteristics of crops, landscape, and prior harvest operations. Sources of data for site-specific maps can be satellite imaging, aerial remote sensing, GIS mapping, field mapping, and derivatives of these technologies. Some novel concepts being explored suggest that management strategies can be derived from a combination of geospatial terrain characteristics and sensed information. All of these systems are enabled by ICT. A competitive technology for map-based precision farming is on-the-go sensing systems, based on the concept of machine-based sensing of agronomic properties (plant health, soil properties, presence of disease or weeds, etc.). The immediate use of these data drives control systems for variable-rate applications. These sensor capabilities essentially turn the agricultural vehicle into a mobile recording system of crop attributes measured across the landscape. In fact, current production platforms are increasingly becoming tools for value-added applications through ICT.

Precision Guidance: Around the turn of the 21st century, GNSS technology had become so precise and accurate that it had outpaced the requirement for the early phases of precision farming and become commercially viable for enabling a number of automatic-guidance applications. Advances in GNSS technologies include decimeter to centimeter accuracy by using signals from a geospatially known reference point to correct satellite signals. One premium example is a real-time kinematic global positioning system (RTK-GPS) technology that reduces fatigue and lowers the skill level required to achieve high-performance accuracy in field operations. In short, in less than 20 years, GPS technology went from being an emergent technology to a robust, mature technology that has optimal capabilities for production agriculture. A number of solutions are emerging today for achieving high-precision accuracy through various reference-signal configurations (e.g., RTK-GPS, multiple satellite systems, sensor fusion with complementary sensors, and multiple sources of corrections). Operator-guidance aids that provide feedback to the operator about required steering corrections through audio and visual cues were the first systems on the market for precision guidance. This feature allowed a vehicle system to follow paths parallel to prior operations across a field. These types of systems worked well at decimeter accuracy and required no major control-system integration into the vehicle. The major benefits of these systems were to reduce overlap/underlap in field operations with extremely wide implements, typically for spraying chemicals and fertilizers. The decrease in overlap meant the parsimonious use of resources. The decrease in underlap meant that chemicals and fertilizers were applied to every part of the field. On the next level of evolution, automatic guidance systems appeared that managed steering for an operator through automatic control. Automatic guidance systems enabled precision operations depending on the type of GNSS signal and how it was integrated into the requirements of the agricultural operations. GNSS technology enabled the management of inputs such as seed, pesticides, and fertilizers with precision across the field. For example, the chemical application to buffer zones and grassy waterways was reduced based on sensing of the field location of these features. John Deere's software product, Swath Control Pro, enabled farmers to manage the definition and execution of this capability. GNSS technology provided the reference signal that enabled accurate vehicle location at the GNSS sensor, but precision control of the machine required several additions to the system (e.g., attitude correction, inertial sensors, implement control, etc.). With these features, a mobile CPS could correct the attitude of the vehicle on uneven terrain and manage the vehicle system path for precision in the execution of complex functions. The ultimate in un-manned automation is the capability of driving complete field patterns under autonomous management of the tractor-implement functions without frequent operator intervention. Path management can be programmed to reduce time loss caused by navigation (e.g., turning around) and implement management. Like precision agriculture, precision guidance creates data from its precision operations that could be used in crop management. Examples of these data include information on the "as-applied" state of operations, vehicle paths, and operational state variables. The data can then be used to meet the needs of other ICT in systems automation and optimization.


LANDKING Agri CONTROL INDIA
BANKURA PRECISION AGRICULTURAL EQUIPMENTS
Dedicated to Fulfill "Make In India" Dream
G.MAAN
ROTAVATOR
LANDKING Agri CONTROL INDIA
BANKURA
Precision Agricultural Equipments
Bankura Precision Agricultural Equipments
Contact Person: Joginder Singh
V.P.O. Miranpur, On Meerut- Bijnor Highway, Near Bus Stand, Miranpur Muzaffarnagar - 251315, Uttar Pradesh, India.
E-mail: bankuraprecision@gmail.com


Hosta

System Automation and Control: Until recently, automation has been focused on functions that depend on GNSS or direct sensing. However, processes that lend themselves to control based on the attributes of soil and crop properties are also being investigated. Some initial applications of these, which were coupled with GPS, mapped the yield and moisture of harvested crop operations. It is also possible to use sensing of soil or crop properties—such as controlling the cut-length of a self-propelled forage harvester (SPFH)—as part of a combination of techniques to increase machine system productivity. In this example, the cut-length is the section length into which a tree, or forage plant, is cut. When an SPFH is operated with static cutting settings, independent of the size of the forage plant, it can consume a significant amount of energy in cutting forage for ensiling (storage in silos). HarvestLab, a sensing technology, uses near infrared (NIR) reflectance sensing to detect the moisture content of forage and adjust the cut-length of harvested material. This control strategy can significantly reduce the energy consumption for harvesting forage with no degradation in the ensiling process. The results are a significant reduction in fuel consumption in the harvest operation and a high-quality cut, which enables proper forage preservation. NIR sensing has often been used in the laboratory and in grain processing and storage to measure properties (e.g., moisture oil and protein content) of biological materials, which contributes to value-added uses of corn, cereal grains, and forage. As these technologies mature, ICT has the potential to connect information about constituent properties to downstream processes.

Machine Communications: The automation methods described above generate massive amounts of data. However, the data are not limited to on-vehicle storage or even to on-the-go decision making. Inter-machine communication greatly increases the potential of these systems. In the last few years, the commercial application of telematics devices on machines has been increasing in agriculture, thus empowering a closer connection between farmers and dealers in managing machine uptime and maintenance services. Other applications for machine communication systems include fleet and asset management. In addition, inter-machine communications are expanding machine system data applications, such as diagnosing and prognosticating machine health. Inter-machine communications can also include implements and tools (e.g., monitoring seeding rate in tractor implement applications). Functionally, a modern, high-end agricultural machine system is effectively a mobile, geospatial data-collection platform with the capacity to receive, use, sense, store, and transmit data as an integral part of its operational performance. As we strive for higher TFP levels, these high-end applications are moving toward systems with increasingly advanced ICT capabilities, including data communication management from machine to off-machine data stores. Other ICT capabilities under development include vehicle-to-vehicle operations management in the field. It is clearly within the vision of the industry to develop advanced capabilities (such as those listed below) that leverage these ICT innovations:

- machine knowledge centers that enable improved design, faster problem resolution, and higher system productivity, increased uptime, and lower operating costs
- stores of agronomic knowledge that can lead to optimization of farm-site production systems
- stores of social knowledge related to customer or consumer value-drivers

As ICT continues to penetrate production systems, a massive network is being developed of machine systems that are platforms for value creation—well beyond productivity from agricultural mechanization intended for the farmer or the farm site. These systems are collecting and managing information with potential value in downstream value-chain operations that use crop or drive systems to achieve environmental sustainability.

Worksite and Value Chain Productivity

The next step in automation and control is to move beyond individual vehicle systems to the optimization of production systems and farm worksites. To achieve this goal, we have developed the beginnings of vehicle and machine systems that can both sense and control with precision. These systems can be driven by data from a variety of sources to provide precision control. For example, they are capable of collecting, storing, and transferring information about the crop, field, and machine state at the time of field operation. They can also receive data from public and private data sources. Furthermore, data collected by machines can be transferred to farm-management systems as well as to public and private sources that require information about production management for quality, compliance, or value-added purposes. Thus, we are entering an era of emerging field and farm optimization systems that can drive up TFP of the worksite, including machines, geographies, and cropping systems. As intelligent mobile equipment for worksite solutions has evolved over the last 20 years, agricultural mechanization has also evolved from a bottom-up integration of the foundations of ICT applied to basic mechanization systems required for crop production. The primary machine capabilities of precision sensing, advanced control systems, and communications have created the potential for the emergence of CPS from production agricultural systems. Although these advanced technologies are not uniformly distributed among platforms and production systems, where they exist, there are opportunities to leverage ICT to increase production systems capabilities. Looking ahead, it is expected that the business value of ICT will expand to additional platforms. Technologies integrated on vehicles must work seamlessly with other systems. Drawbacks of some initial attempts for ICT capabilities have been the significant time required for setup or management, the lack of a common architecture, the lack of standardization among industries, and the lack of standardization with the farmer in mind as a user of ICT. Recently, several organizations have been working to develop standards, and some improvements have already been developed or are in process. Centers that store machine, agronomic, and social knowledge will aggregate data to provide value-added services for machinery operation and farm management. Some of these data may be collected by farmers, and some will be provided by public and private sources of agricultural information. Some data sources, such as remote sensing, have been mentioned, but a number of others will emerge as the aggregated knowledge in efficient production agriculture increases. Centers with machine knowledge can help increase equipment uptime and anticipate machine system failures based on vehicle state variables in operation. Machine data that provide a better understanding of machine use can also lead to more efficient system designs that meet the needs of farmers. Agronomic data will create new opportunities for intensive modeling and simulation that can improve production efficiency by anticipating the impact of weather and various production methods.

In the future, ICT will enable the development of new platforms that can provide more support to production agriculture by taking advantage of opportunities to connect farmers, the value chain, and society in ways that are beyond present capabilities. The German-funded iGreen project, for example, is working on location-based services and knowledge-sharing networks for combining distributed, heterogeneous public and private information sources as steps toward future ICT systems. Today, we are extremely close to having true CPS and control systems for measuring the "pulse" of agricultural productivity on planet Earth.

No doubt, Agricultural Mechanization will be a key factor to achieving our TFP goals and feeding a growing planet. Looking ahead, agricultural machines will become data-rich sensing and monitoring systems that can map the performance of both machines and the environment they work on with precision resolution and accuracy, and this capability will unlock levels of information about production agriculture that were heretofore unavailable.


HOULE

UNIT: 20
Conclusion

Level of mechanization in farming is still below 50% in India. The level of farm mechanization in India requires more to be done in terms of introduction of better equipment for each farming operation in order to reduce drudgery, to improve efficiency by saving on time and labour, improve productivity, minimize wastage and reduce labour costs for each operation.

With shortage of labour for agricultural operations owing to rural urban migration, shift from agriculture to services and rise in demand for labour in nonfarm activities, there is need to use labour for agricultural operations judiciously, which makes a strong case for mechanization of farming.

An updated incisive insight into the opportunity in the Indian agriculture mechanization current market scenario, structure and practices will be of great help, particularly with reference to agriculture machinery; tractors; power tillers; combine harvesters; cultivators; seed drills; and sprayers.

Another notable aspect of Indian agriculture is the high proportion of female workforce in both the cultivation and processing stages of farming. Therefore, ergonomically designed tools and equipment for reducing drudgery, enhancing safety and comfort and also to suit the needs of women workers would help in better adoption of technologies in agriculture.

The overall level of mechanization in farming is below 50 per cent in the case of majority of the farming operations in India.

According to the Agricultural Machinery and Manufacturers Association in India, tractor penetration is 38 per cent for large farmers (with more than 20 acres), 18 per cent for medium farmers (5-20 acres) and just around 1 per cent for marginal farmers. With increase in fragmentation of landholdings and low rates of tractor penetration among small farmers, there is need for a market in tractor rentals, akin to cars and road construction equipment, driven by private participation.

With suitable mobile and internet applications, manufacturers of tractors along with other stakeholders need to deliberate on this, since it will also increase demand for tractors.

Bibliography

GHI (Global Harvest Initiative). 2011. GHI website. Available online at http://www.globalharvestinitiative.org/.
Han, S., G. Zhang, B. Ni, and J.F. Reid. 2004. A guidance directrix approach to vision-based vehicle guidance systems. Computers and Electronics in Agriculture 43(3): 179–195.
Hendrickson, L. 2009. Landscape Position Zones and Reference Strips. PowerPoint Presentation. Available online at http://nue.okstate.edu/Nitrogen_Conference2009/Hendrickson.ppt.
ICT Standards Board. 2006. . . . to coordinate the standardization activities in the field of Information and Communications Technology. Available online at http://www.ictsb.org/.
iGreen. 2011. Welcome to iGreen! Available online at http://www.igreen-projekt.de/iGreen/.
National Academy of Engineering (NAE). 2000. Greatest Engineering Achievements of the 20th Century. Available online at http://www.greatachievements.org/.
http://content.icicidirect.com/mailimages/IDirect_FarmMechanisation_ThematicReport.pdf
Postel, S.L., G.C. Daily, and P.R. Ehrlich. 1996. Human appropriation of renewable fresh water. Science 271(5250): 785.
Sevila, F., and S. Blackmore. 2001. Role of ICTs for an Appropriate World Market Development. Presentation at the 12th Members Meeting, Club of Bologna, Bologna, Italy, November 18–19, 2001. Available online at http://www.clubofbologna.org/ew/documents/Proc2001.pdf
UN FAO (United Nations Food and Agriculture Organization). 2007. Coping with Water Scarcity: Challenge of the Twenty-First Century. Available online at http://www.fao.org/nr/water/docs/escarcity.pdf.
U.S. Access Board. 2010. Draft Information and Communication Technology (ICT) Standards and Guidelines.
Park J and R.A.F Seaton. 1996. Integrative Research and Sustainable Agricultural Systems. Elsevier Applied Science.
Anonymous, 2013. State of Indian Agriculture 2012-13. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi, 221 p.
Binswanger, H. P. 1986. Agricultural mechanisation: a comparative historical perspective. World Bank Research Observer, 1(1): 27-56.
Bishop, C. 1997. A Guide to Preparing an Agricultural Mechanization Strategy, AGSE. FAO, Rome, Italy.
Clarke, L. J. 2000. Strategies for Agricultural Mechanization Development: The Roles of the Private Sector and the Government. Agricultural Support Systems Division, FAO Publication, Rome, Italy.
FAO. 2014. Asia Pacific Food Price and Policy Monitor. FAO Regional Office for Asia and the Pacific, Economic, Social and Policy Assistance Group (ESP), 11, June 2014.
Giles, G. W. 1975. The reorientation of agricultural mechanization for the developing countries. FAO Report on Effect of Farm Mechanization on Production and Employment. Food and Agricultural Organisation (FAO), Rome, Italy.
Mehta, C. R. and R. K. Pajnoo. 2013. Role of Japan in promotion of agricultural mechanization in India. Agricultural Mechanisation in Asia, America and Latin America, 44(4): 15-17
NCAER. 1981. Implication of tractorization for farm employment, productivity and income. National Council of Applied Economic Research, Parisila Bhawan, New Delhi
Rasouli, F., H. Sadighi, and S. Minaei. 2009. Factors affecting agricultural mechanization: A case study on sunflower seed farms in Iran. J. Agric. Sci. Technol., 11, 39-48.
Renpu B. 2014. Analysis of the Trends of Agricultural Mechanization Development in China (2000-2020). ESCAP/CSAM Policy Brief, Issue No.1, 9 p
Rijk, A. G. 1989. Agricultural mechanisation policy and strategy the case of Thailand. Asian Productivity Organisation, Tokyo, Japan

Singh, G. 2006. Estimation of a mechanisation index and its impact on production and economic factors —a case study in India. Biosystems Engineering, 93(1): 99-106.
Singh, S. P., R. S. Singh, and S. Singh. 2011. Sale trend of tractors and farm power availability in India. Agricultural Engineering Today, 35(2): 25-35.
Soni, P., O. Y. Ou. 2010. Agricultural Mechanization at a Glance Selected Country Studies in Asia on Agricultural Machinery Development, Report of United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery (UNAPCAEM), 2010.
Van den Berg, M. M., H. Hengsdijk, J. Wolf, M. K. Van Ittersum, W. Guanghuo, and R. P. Roetter. 2007. The impact of increasing farm size and mechanization on rural income and rice production in Zhejiang province China. Agricultural Systems, 94, 841-850
Ade Asefeso (2012). CEO Guide to Doing Business in Australia, p. 54.
Number of employees of John Deere (Deere & Company) from 2002 to 2013. Accessed 25.11.2014.
Revenue of tractor & agricultural machinery manufacturing (NAICS 33311) in the United States from 2009 to 2014 (in billion U.S. dollars). Accessed 25.11.2014.
Anonymous, 2013. State of Indian Agriculture 2012-13. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi,
Renpu B., 2014. Analysis of the Trends of Agricultural Mechanization Development in China (2000-2020). ESCAP/CSAM Policy Brief, Issue No.1, 9 p.
Mehta, C.R., Pajnoo, R. K. (2013). Role of Japan in Promotion of Agricultural Mechanization in India. Agricultural Mechanization in Asia, America and Latin America, 44(4), 15-17.
Singh, G., 2004. Agricultural Machinery Industry in India (Manufacturing, marketing and Mechanization promotion), Central Institute of Agricultural

Abbreviation

A&C	Agriculture & Cooperation
AAP	Annual Action Plan
ADC	Additional Commissioner
ADG	Assistant Director General
ADM	Additional District Magistrate
AIBP	Accelerated Irrigation Benefit Programme
AICRP	All India Coordinated Research Project
AMMA	Agriculture Machinery Manufacturers Association
ASEAN	Association of Southeast Asian Nations
ATMA	Agriculture Technology Management Agency
BIS	Bureau of Indian Standards
Breeder seeds	Seeds move from germ-plasm (research) stage to breeder stage
BRICS	Brazil, Russia, India, China and South Africa
CAGR	Compound Annual Growth Rate
CCEA	Cabinet Committee on Economic Affairs
Certified/ quality seeds	Foundation seeds are further multiplied to get certified seeds, which are sold to farmers
CFMTTI	Central Farm Machinery Training & Testing Institute
CHC	Custom Hiring Centres
CIPHET	Central Institute of Post-Harvest Engineering & Technology
CMVR	Central Motor Vehicle Rules
CSAM	Centre for Sustainable Agricultural Mechanization
CSIR	Council of Scientific and Industrial Research
CSO	Central Statistics Office
DAC	Department of Agriculture & Cooperation
DAO	District Agriculture Officer
DC	Deputy Commissioner
DD (A)	Deputy Director (Agriculture)
DDG	Deputy Director General
DIPP	Department Of Industrial Policy and Promotions
DLEC	District Level Executive Committee
EC	Executive Committee
EE (A)	Executive Engineer (Agriculture)
EFC	Expenditure Finance Committee
EU	European Union
FDI	Foreign Direct Investment
FFS	Farmers Field Schools
FIG	Farmers Interest Groups
FMTTI	Farm Machinery Training and Testing Institutes
Foundation seeds	Breeder seeds are multiplied as foundation seeds
FPO	Farmer Producer Organisations
GDP	Gross Domestic Product
GFR	General Financial Rules
GOI	Government of India
GVA	Gross Value Added
ha	Hectare
HP	Horse Power
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crop Research Institute for Semi-Arid Tropics
ICT	Information Communication Technology
IFFCO	Indian Farmers Fertilizer Cooperative
IPM	Integrated Pest Management
IRRI	International Rice Research Institute

JD (A)	Joint Director (Agriculture)
JICA	Japan International Cooperation Agency
JV	Joint Venture
KAMCO	Kerala Agro Machinery Corporation Limited
KCC	Kisan Credit Card
KVK	Krishi Vigyan Kendra
kW	Kilo-Watt
M&M	Mahindra and Mahindra
M&T	Mechanization & Technology
MIDH	Mission for Integrated Development of Horticulture
MIP	Mission Integration Planning
MIS	Management Information System
MSP	Minimum Support Price
NABARD	National Bank for Agriculture & Rural Development
NERFMTTI	North Eastern Region Farm Machinery Training & Testing Institute
NFSM	National Food Security Mission
NIAE	National Institute of Agricultural Engineering
NIF	National Innovation Foundation- India
NMAET	National Mission on Agriculture Extension and Technology
NMAM	National Mission on Agricultural Mechanisation
NMOOP	National Mission on Oil Seeds & Oil Palms
NRFMTTI	Northern Region Farm Machinery Training & Testing Institute
NSC	National Steering Committee
NSSO	National Sample Survey Organisation
OIJIF	Oman India Joint Investment Fund
PGN	Plant Growth Nutrients
PHT	Post Harvest Technology
PHTM	Post-Harvest Technology and Management
PPP	Public Private Partnership
PRI	Panchayati Raj Institutions
PSU	Public Sector Undertaking
PTO	Power Take Off
QPR	Quarterly Progress Report
R&D	Research & Development
RKVY	Rashtriya Krishi Vikas Yojana
SAME	Sub-Mission on Agriculture Extension
SAU	State Agricultural University
SBI	State Bank of India
SC	Scheduled Caste
SEWP	State Extension Work Plan
SFAC	Small Farmers Agri-Business Consortium
SGRF	State General Reserve Fund
SHG	Self Help Groups
SLEC	State Level Executive Committee
SMAM	Sub-Mission on Agriculture Mechanization
SMPP	Sub-Mission on Plan Protection and Plant Quarantine
SMSP	Sub-Mission on Seed and Planting Material
SRFMTTI	Southern Region Farm Machinery Training & Testing Institute
ST	Schedule Tribes
TAFE	Tractors and Farm Equipment Limited
TSP	Tribal Sub Plan
UG	User Groups
UT	Union Territory


MP04
F7146

Government of India
Ministry of Agriculture and Farmers Welfare
Department of Agriculture, Cooperation & Farmers Welfare (Mechanization & Technology Division), Krishi Bhavan, New Delhi-110001

SUB-MISSION ON AGRICULTURAL MECHANIZATION OPERATIONAL GUIDELINES (Twelfth Five Year Plan), Revised in 2016-17

1.0 Introduction

(i) Agricultural land area in the world has limit, but the demand for food is ever increasing due to population growth. To increase productivity in the limited land so as to meet the expanding demand arising from population growth as well as higher income is very important mission.

(ii) The task assumes greater importance to India, than the rest of the world considering that India accounts for 2.4% of the world's geographical area and 4% of its water resources, but has to support 17% of the world's human population and 15% of the livestock.

(iii) To increase productivity, timely and precise field work is necessary. To make it possible, agricultural machines take an important role.

(iv) Among the states, farm power availability in Punjab, Haryana, Western Uttar Pradesh and western part of Rajasthan is higher than the National average of 1.84kW/ha. In rest of the country, especially in Eastern and North-East Regions, it is significantly lower which necessities promotion of farm mechanization as a special Mission.

(v) Sub Mission on Agricultural Mechanization (SMAM) will be implemented in accordance with guidelines described hereunder.

(vi) The scheme will be implemented in all the states, to promote the usage of farm mechanization and increase the ratio of farm power to cultivable unit area up to 2 kW/ha.

(vii) SMAM will have Central Sector Schemes under component No.1 & 2. Centrally Sponsored Schemes are covered under component No. 3 to 8 in which Government of India contributes 60% and states contribute 40%. Funding pattern for states of Northern-Eastern and Himalayan region, the share of Govt. of India & State Govt. is 90:10.

2.0 Mission Objectives

The Mission objectives are as follows:

(i) Increasing the reach of farm mechanization to small and marginal farmers and to the regions where availability of farm power is low;

(ii) Promoting 'Custom Hiring Centres' to offset the adverse economies of scale arising due to small landholding and high cost of individual ownership;

(iii) Creating hubs for hi-tech & high value farm equipments;

(iv) Creating awareness among stakeholders through demonstration and capacity building activities;

(v) Ensuring performance testing and certification at designated testing centers located all over the country.

3.0 Mission Strategy

To achieve the above objectives, the Mission will adopt the following strategies:

(i) Conduct performance testing for various farm machineries and equipments at the four Farm Machinery Training and Testing Institutes (FMTTIs), designated State Agricultural Universities (SAUs) and ICAR institutions;

(ii) Promote farm mechanization among stakeholders by way of on-field and off-field training and demonstrations.

(iii) Provide financial assistance to farmers for procurement of farm machinery and implements

(iv) Establish custom hiring centres location and crop specific farm machinery and implements

(v) Provide financial assistance to small and marginal farmers for hiring machinery and implements in low mechanized regions.

4.0 Mission Components

4.1 Promotion and Strengthening of Agricultural Mechanization through Training, Testing and Demonstration: Aims to ensure performance testing of agricultural machinery and equipment, capacity building of farmers and end users and promoting farm mechanization through demonstrations.

4.2 Demonstration, Training and Distribution of Post-Harvest Technology and Management (PHTM): Aims at popularizing technology for primary processing, value addition, low cost scientific storage/transport and the crop by-product management through demonstrations, capacity building of farmers and end users. Provides financial assistance for establishing PHT units.

4.3 Financial Assistance for Procurement of Agricultural Machinery and Equipment: Promotes ownership of various agricultural machinery & equipments as per norms of assistance.

4.4 Establish Farm Machinery Banks for Custom Hiring: Provides suitable financial assistance to establish Farm Machinery Banks for Custom Hiring for appropriate locations and crops.

4.5 Establish Hi-Tech, High Productive Equipment Hub for Custom Hiring: Provides financial assistance to set up hi-tech machinery hubs for high value crops like sugarcane, cotton etc.

4.6 Promotion of Farm Mechanization in Selected Villages: Provides financial assistance to promote appropriate technologies and to set up Farm Machinery Banks in identified villages in low mechanized states.

4.7 Financial Assistance for Promotion of Mechanized Operations/hectare Carried out Through Custom Hiring Centres: Provides financial assistance on per hectare basis to the beneficiaries hiring machinery/equipments from custom hiring centres in low mechanized areas.

4.8 Promotion of Farm Machinery and Equipment in North-Eastern Region: Extends financial assistance to beneficiaries in high-potential but low mechanized states of North-East.

5.0 Position of Ongoing Schemes

Farm Mechanization programmes are also being implemented through other missions/schemes such as RKVY, MIDH, NMOOP & NFSM, which would continue to be implemented subject to these guidelines. The Central Sector schemes 'Promotion and Strengthening of Agricultural Mechanization through Training, Testing and Demonstration' and 'Post-Harvest Technology & Management' stand merged with this Sub-Mission.