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ASCI
Agriculture Skill Council of India

Skill Gap Analysis of Indian Farm Mechanization Sector

Sowing Skills...
...Harvesting Opportunities

AGRICULTURE SKILL COUNCIL OF INDIA (ASCI)
GURUGRAM, HARYANA

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सत्यमेव जयते

आज़ादी का अमृत महोत्सव

FOREWORD

Indian agriculture sector today makes the country self-reliant in meeting its food requirements and enables the country to export and share surplus food with the needy across the world. This achievement is due to the green revolution and various key measures taken by the government from time to time. While the success of the first green revolution depended on inputs like seed, agricultural chemicals, and water, the next quantum jump is waiting to take place from technological interventions and mechanization. Agricultural mechanization plays a crucial role in this transformation through optimization of input resources and maximization of output.

The Farm Power Availability (FPA) in the country increased from 0.31 kW/ha in 1961-62 to 2.76 kW/ha in 2020-21 and is expected to touch the 5.7 kW/ha mark by 2035 to cope with the labour shortages and improve efficiency. Agricultural mechanization in India has been skewed towards tractors until about a decade ago when the usage of machinery for sowing, crop protection, harvesting and primary processing has begun to increase. While there is a continued need for more efficient and more appropriate agricultural machines, there is an even greater need for skilled human resources for the efficient operation and maintenance of the machinery. As the pace of farm mechanization is accelerated, appropriate and adequate skilling programs must be put in place to meet the demand for skilled manpower for the farm mechanization sector at all levels from farmers to industry. India's ability to leverage its demographic advantage is linked to enhancing the skills of the existing workforce as well as the new entrants.

The Skill Analysis Report on Farm Mechanization by the Agriculture Skill Council of India (ASCI) has outlined the current landscape and ecosystem of farm mechanization, key drivers of growth and challenges, gaps, and the significance of skill development in farm mechanization. It gives an insight into various initiatives taken up by the government and private sector to augment skill development and highlights the emerging trends, key focus/intervention areas for skill development and new/upcoming technologies. I am sure that this report shall address and give a fresh perspective on skilling in agricultural mechanization for ensuring the next quantum jump in agricultural production and income generation.

16/8

[Manoj Ahuja]

New Delhi, the 16th August, 2022

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FOREWORD

Skills and knowledge are the driving forces for economic growth and social development. India faces a severe shortage of skilled workers across all economic sectors. India's ability to leverage demographic advantage is inadequate due to the lack of adequate skills of the workforce. Every year 12 million people enter the pool of the workforce. These existing and new entrants need to acquire skill and, therefore, it is required to scale up skill development efforts to meet the demand. The Ministry of Skill Development and Entrepreneurship is driving the 'Skill India' agenda in a 'Mission Mode'. Skill India Mission offers skill courses in various sectors under the National Skill Qualification Framework and helps an individual to develop the technical expertise for job readiness. Skill India is creating opportunities for the youth and evolving India into a skilled society.

The Skill Gap Report for farm mechanization by the Agriculture Skill Council of India (ASCI) outlines the skill development scenario and gives an insight into various initiatives taken up by the government and private sector to augment skill development in the sector. The report analyses gap in skill development, highlights the huge untapped potential and focuses on intervention areas for skill development in the farm mechanization sector.

I am sure that the report gives all the stakeholders a renewed outlook on skilling requirements and helps in focusing specifically on skill development in Farm mechanization in a coordinated approach.

(Himanshu Pathak)

Dated the 17th August, 2022
New Delhi


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3048DI

Foreword

Skill development has the greatest importance in the economic development of any nation, specifically a developing country. A skilled workforce is a key and critical determining factor in our country's holistic and inclusive growth. Mismatch in demand and supply of the specific type of skill sets is a common challenge across the sectors of the Indian economy. The real challenge lies in meeting the human resource demand-supply gap and specific sectoral requirements in terms of both quantity as well as quality. Further, the ability to leverage on demographic advantage of India is dependent on the availability of a skilled workforce.

Indian agriculture is a critical sector in terms of employment and livelihood for the people as nearly half of the people are dependent on agriculture and allied sectors. However, it is changing its focus subsistence to commercial agriculture with a continuous focus on self-sufficiency as well as exports. The importance and role of farm mechanization in agricultural production and post-harvest operations are unquestionable as far as optimal resource utilization, input cost reduction, increased productivity, reduced post-harvest losses, increased farmers' income, reduced human drudgery, enhanced environmental sustainability, and obviating labour shortages are concerned.

Most of the people in agriculture and allied sectors have not received formal education or training and the rural youth is more inclined to shift to other non-farm occupations, necessitating the accelerated development of skills and human resources. Considering the enhanced demand for farm mechanization and rapidly changing technological innovations, it is essential to anticipate the changes and prepare the farmers/farm workers and allied stakeholders to upgrade their skills. The skilled human resource in turn would meet the skilled workers' demand for production, operation, maintenance, and management of farm/agricultural machinery.

I appreciate the Agriculture Skill Council of India (ASCI) for bringing out the Skill Analysis Report on Farm Mechanization which has highlighted the agricultural mechanization ecosystem, key issues and the importance of skill development in farm mechanization. The report helps in recognising the huge untapped potential in the country and highlights the focus areas for sectoral skill development. I am sure that the report aids in building the skill capacity of the needy workforce and farmers.

Dr Nirmaljeet Singh Kalsi, IAS (Retd.)
Chairperson, NCVET

Date: 19th August 2022

Foreword

Agriculture, along with its allied sectors, is the largest source of livelihood for more than 60% of the rural households in India. Over the decades, there has been a significant improvement in the sector with the introduction of technologies that opened the gates to many opportunities leading to many profitable avenues. One of these opportunities is Farm mechanization which is seen as essential to boost the effective use of inputs, decrease human labor, increase food grain productivity, lower production costs, and solve concerns related to labor scarcity while ensuring the timely execution of farm operations.

The right knowledge, understanding & efficiency in handling the farm operations are the core foundation of the skilled workforce to maximize the possibilities of turning these opportunities into lucrative pathways while narrowing the supply-demand gap of skilled manpower. It is crucial to foresee changes so as to prepare & upskill the workforce in light of the increased demand for farm mechanization and quickly evolving technological advancements. In turn, the skilled human resource would satisfy the demand for skilled people in the production, operation, maintenance, and management of farm/agricultural machinery.

I am pleased to acknowledge the efforts of the Agriculture Skill Council of India in coming up with its Skill Gap Report for Farm Mechanization which describes the state of skill development and provides details on the various initiatives undertaken by the public and private sectors to boost skill development in the Farm mechanization sector. The report also focuses on intervention areas for developing skills in the farm mechanization sector & assesses the skill development gap, outlining the enormous untapped potential. I'm confident that the study gives all the interested stakeholders a fresh perspective on the need for skill development and aids in focusing specifically on skill development for farm mechanization in a coordinated manner. I would very much like them to keep on improvising/ revising the same periodically.

Maneesh Mansingka

Chairperson, Agriculture Skill Council of India

Date: 20th August 2022

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Insights into the farm mechanization skill development related issues received from Dr Gajendra Singh, Former DDG (Eng.), Dr Gyanendra Singh, Former VC, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, and Dr Surendra Singh, Technical Advisor, All India Agricultural Machinery Manufacturers Association are thankfully acknowledged. We thank Dr Mukesh Jain, Director, FMTTI Hisar, Sri PK Pandey, Director FMTTI, Budhni, and Sri Rajeev Chaudhary, Director Agriculture Engineering Department, Madhya Pradesh along with their teams for their valuable insights in skilling in farm mechanization.

This report draws heavily on the contributions of Dr. Pitam Chandra, Former Director, ICAR-CIAE, Bhopal and Dr, Swaroopa Rani, in terms of their expertise and perseverance. Our special thanks are due to the study team and colleagues at the Agriculture Skill Council of India for their valuable contributions to the publication. We take this opportunity to convey our gratitude to all those who have, in some way or the other, contributed towards the successful completion of this Skill Gap Analysis 2022 for the Farm Mechanization Sector in India.

AGRICULTURE SKILL COUNCIL OF INDIA (ASCI)

Agriculture Skill Council of India (ASCI) is the Sector Skill Council for Agriculture and Allied Sectors working under the aegis of Ministry of Skill Development & Entrepreneurship (MSDE). It also works closely with two line ministries, Ministry of Fisheries, Animal Husbandry and Dairying and Ministry of Agriculture and Farmers' Welfare, Government of India. ASCI works towards capacity building by bridging gaps and upgrading skills of farmers, wage workers, self-employed & extension workers engaged in organized / unorganized segments of Agriculture & Allied Sectors.

ASCI is contributing to nation building through Skill Development in Agriculture especially at the times when country's agriculture is experiencing stagnant growth, exodus of quality manpower to other sectors, changing climate with increased variability in production parameters and transformations in international agriculture markets that are especially too much subsidized challenging the competitiveness of Indian Agriculture.

ASCI has taken upon itself the responsibility of transforming Indian Agriculture through developing the skills of country's manpower in emerging areas of agriculture. With the development of 186 Qualification Packs, ASCI is covering following segments:

- Animal Husbandry
- Fisheries
- Dairy Farm Management
- Poultry Farm Management
- Post-Harvest Supply Chain Management
- Forestry & Agro Forestry
- Watershed Management
- Amenity Horticulture & Landscaping
- Production Horticulture
- Seeds Industry
- Soil Health Management
- Commodity Management
- Agri Entrepreneurship & Rural Enterprises
- Farm Mechanization and Precision Farming
- Agri-Information Management
- And other Allied

Objectives:

- Determining skills/competency standards and qualifications and development of National Occupational Standards (NOS).
- Preparation and maintenance of skill inventory to facilitate individual choices.
- Development of sector specific skill development plans.
- Standardization of affiliation and accreditation process.
- Affiliation, accreditation, assessment and certification of Vocational Institutes/Programmes.
- Plan and execute Training of Trainers (ToT).
- Promotion of academics of excellence.
- Establishment of a well-structured, sector specific, Labour Market Information System (LMIS) to assist planning and delivery of training.
- Adoption of global best practices

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ABBREVIATIONS

S. No	Abbreviation	Full form
1	AI, IOT and ML	Artificial Intelligence, Internet of Things and Machine Learning
2	AICRP	All India Coordinated Research Project (under ICAR)
3	ASCI	Agricultural Skill Council of India
4	IARI	Indian Agriculture Research Institute
5	ICAR	Indian Council of Agricultural Research
6	CAGR	Compounded annual growth rate
7	CEO	Chief Executive Officer
8	CHCs	Custom Hiring Centers
9	CIAE	Central Institute of Agricultural Engineering
10	CIPHET	Central Institute of Post-Harvest Engineering & Technology
11	CoE	Centre of Excellence
12	CSAM	Centre for Sustainable Agricultural Mechanization
13	CSR	Corporate Social Responsibility
14	DAE	Directorate for Agricultural Engineering
15	DDU-GKY	Deen Dayal Upadhyaya Grameen Kaushalya Yojana
16	EDP	Entrepreneurship Development Programme
17	FICCI	Federation of Indian Chambers of Commerce and Industry
18	IFPRI	International Food Policy Research Institute
19	FAAS	Farming as a service
20	FM	Farm Mechanization
21	FMBs	Farm Machinery Banks
22	FMTTI	Farm Machinery Training and Testing Institute
23	FPA	Farm Power Availability
24	FPO	Farmers Producers Organization
25	GDP	Gross Domestic Product
26	GoI	Government of India
27	GVA	Gross Value Added (GVA)
28	Ha	Hectare
29	HDR	Human Development Report

S. No	Abbreviation	Full Form
30	IFAD	International Fund for Agricultural Development
31	iVCD	Inclusive value chain development
32	ITI	Industrial Training Institute
33	KVK	Krishi Vigyan Kendra
34	Kw/ha	Kilowatt per hectare
35	MoFWA	Ministry of Agriculture and Farmers Welfare
36	NABARD	National Bank for Agriculture and Rural Development
37	NSDC	National Skill Council of India
38	NRLM	National Rural Livelihood Mission
39	PPP	Public Private Partnership
40	PLFS	Periodic Labour Force Survey
41	PMKVY	Prime Ministers Kaushal Vikas Yojana
42	PM KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
43	RKVY	Rastriya Krishi Vikas Yojana
44	SAU	State Agricultural Universities
45	SDC	Skill Development Centre
46	SMAM	Sub-Mission on Agricultural Mechanization
47	SRI	System of Rice Intensification
48	sqm	Square meter
49	TAFE	Tractors and Farm Equipment Limited
50	ToT	Training of Trainers
51	WPR	Worker Population Ratio

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Progress of Agriculture Sector has made the country self-reliant in meeting its food requirements and it goes on to share the surplus with needy people abroad. Although its share in national GDP is only about 18.8%, it currently provides livelihood to 41.50 % of the county's work force. Indian agriculture is now changing its focus from subsistence agriculture to sustainable commercial agriculture with a view to increase income and wages of farmers and farm workers, respectively, without harming the environment. Agricultural mechanization plays a crucial role in this transformation from subsistence to sustainable commercial agriculture. Sustainability of agriculture depends on the minimization of inputs and maximization of output with certain fixed objective functions.
India has the demographic advantage (around 54% of the population is below 25 years of age, old age dependency ratio is 12.5) as compared to other countries and will enjoy this advantage for another 25-30 years. However, the share of skilled to total labor force as per HDR 2020 is at 21.2% only as compared to more than 70% in advanced countries. Thus, India's ability to leverage on demographic advantage is inadequate due to the skill deficit in the existing as well as the new workforce. As the pace of farm mechanization gets accelerated, appropriate and adequate skilling programs must be in place to meet the demand of skilled manpower for the farm mechanization sector at all levels, i.e., farmers/ farm-workers, repair-maintenance, managerial, etc.

In view of the foregoing, an attempt has been made by ASCI to estimate the skill gap in the farm mechanization sector with the following objectives.

1. To present an overview of the farm mechanization in India, government policies and growth prospects in terms of employment and income generation in different segments of agricultural production and on farm processing.
2. To analyze the labor force and skilled labor dynamics in agriculture and allied sectors over time.
3. To analyze the availability of skilled labor force to handle mechanization across different segments of the agriculture value chain.
4. To analyze the existing status in skilling in farm mechanization and estimate the skill gap /requirements in farm mechanization sector.

Research methodology includes primary as well as secondary research. The primary research includes interviews/discussions which were held with a wide range of stakeholders including Government Departments, State Agriculture Universities (SAUs), ICAR institutes related to farm mechanization, Farm Machinery Training & Testing Institutes (FMTTIs), Industry/Corporates, Industry Associations, Development Institutes, skilled trainees, etc. The primary research has a comprehensive coverage of the current landscape and ecosystem of farm mechanization, current needs and gaps, key drivers of growth and challenges, role of the institutions in skill development, infrastructure available, key focus areas, emerging trends and upcoming developments. The interactions were held (online) with 52 stakeholders across 7 different categories. Secondary research has been carried out through review of available information and literature on various farm mechanization aspects, data on manufacturing workforce, agricultural workforce and skilling, data on agricultural machinery, etc.

Some of the important twentieth-century developments in Indian farm mechanization include the import of the first tractor in India in 1914, setting up of Central Tractor Organization at IARI, Pusa campus, Government of India support for production of indigenous tractors, later banning of imports, and government support to farm mechanization through various schemes. In recent past, among all the farm power sources, while the share of farm workers and draft animal power has been shrinking, the share of mechanical and electrical power sources is on the rise. There is a positive correlation between agricultural productivity and FPA. The Farm Power Availability (FPA) on Indian farms increased from 0.31 kW/ha in 1961-62 to 2.76 kW/ha in 2020-21. The FPA varies considerably from state to state; it is the highest in Uttarakhand, Uttar Pradesh, Haryana, Punjab, Bihar, Gujarat, Telangana, Tamil Nadu (>2.4 kW/hr) and the lowest (< 1 kW/hr) in the North Eastern states.

Farm mechanization value chain in case of crops includes seed bed preparation, sowing and planting, irrigation, weeding & plant protection, harvesting & threshing, post-harvest value addition, biomass and byproducts utilization, and energy management. The level of mechanization varies considerably in terms of the value chain itself, region and crop. Input Survey data for the year 2016-17indicate that the machinery usage was the highest in soil preparation (90.7%) followed by harvesting (27.5%), sowing/planting (20.5%), weeding & plant protection (16%), and straw management (6.2%). Over the years, the usage of tractors and power tillers continues to grow, there is also an emerging trend in the usage of new types of machines such as laser land levelers; self propelled harvesters, weeders and planters; straw combines, reapers and binders. Farm mechanization value chains also exist in production to value addition operations of dairy, livestock, and fishery subsectors.

Growth drivers of farm mechanization in India include drudgery, migration-based continuously reducing farm labour availability, the need for efficiency and timeliness of agriculture operations, increasing labour wages, and greater involvement of women. Challenges faced in promotion of farm mechanization are non-suitability of all machines to small land holdings, non-viability of ownership of expensive farm machinery individually by small and medium farmers, differing soils, agroclimatic zones, and cropping patterns. There are financial constraints such as high cost of precision equipment, a subsidy-boosted market, and poor access to finance. Lack of farm mechanization awareness among farmers and lower availability/lack of skilled manpower for the usage of farm machinery are also the challenges that confront farm mechanization in India. While a significant fraction of farmers has no or limited mechanization opportunity, a fraction of farm power sources remains underutilized in the country.

The stakeholders in creation of human resources through technical education and research are ICAR and its institutes, AICRPs on Farm implements and machinery, state agriculture universities, IITs and other agricultural engineering colleges including private colleges. These human resources serve to occupy management and highly technical jobs in the industry, faculty and research, state governments and so on. In respect of skilling programmes of field level personnel (farmers, youth, local repair and maintenance persons, etc.), various agencies such as FMTTIs, SAUs and KVKs, agricultural engineering colleges, government agriculture/ agricultural engineering departments through their own training centers or skill development centers, developmental agencies and manufacturers provide training programmes of a wide variety, i.e., demos, exposure visits, awareness programmes, hands-on skilling, etc.

The skill gaps identified during discussion with stakeholders include general awareness on farm mechanization and the skilling needs; operation of all farm machinery, repair and maintenance at operator and mechanic levels, and in advanced repairs and maintenance; advanced and innovative technologies; and crop-wise mechanization packages. ASCI has already notified NSQF-aligned skill development programmes for some of the job roles in farm machinery. These job roles include various Agriculture Machinery Operator, Technician and mechanic courses, Agriculture/farm Machinery Repair and Maintenance Service Provider, Custom Hiring Service Provider, Irrigation/micro-irrigation Service Technician, Farm Workshop Foreman /Supervisor/Manager and Solar Pump Technician. A summary of estimates for annual skilling needs for various skilling activities for the ASCI notified and yet-to-be notified jobs is presented in the Table ES-1 below.

The basic data for the last 3 to 5 years have been obtained on worker and managerial workforce of factories, annual sales of various agricultural machinery, dealerships under fam machinery, and other data from the annual industry surveys, economic survey, AMMA presentation, agrimech website, and others. The net additions are then calculated based on past growth percentages. The basis for projecting the incremental skilling needs for subsequent years is to apply the growth rate and the assumptions for the need of operators, mechanics/ technicians and other skill roles per 100 units. Details of the calculations are provided in Chapter 11.

Exhibit ES.1. Summary of Estimated Incremental Skill Requirement aligned with ASCI Job roles and yet-to-be notified ASCI Job roles

Summary of Estimated Incremental Skill Requirement aligned with ASCI Job roles

S. No.	ASCI Job role	Job role	2021-22 (base)	2022-23	2023-24	2024-25	2025-26	2026-27	Total from 2022-23 to 2026-27
A	**Dealerships of Farm Machinery**								
1	Agriculture Machinery Repair and Maintenance Service Provider, Farm Workshop Foreman/ Supervisor, Farm Workshop Service Manager, Service and Maintenance Technician -Farm Machinery	Service Manager	-	265	278	292	306	322	1463
2		Mechanics in Service Dept	-	1060	1113	1168	1227	1288	5855
3		Mechanics in Parts Dept, Customer-care/ Tele service	-	1193	1252	1315	1380	1449	6589
	Sub-Total		**-**	**2516**	**2642**	**2774**	**2913**	**3058**	**13903**
B	**At field level (mechanics technicians at village level and operators at farmer level)**								
1	Tractor Mechanic and Tractor Operator	Operators	370500	389025	408476	428900	450345	472862	2149609
		Mechanics/ Technicians	7410	7781	8170	8578	9007	9457	42992
2	Power Tiller operator	Operators	27100	27507	28882	30326	31842	33434	151991
		Mechanics/ Technicians	542	550	578	607	637	669	3040
3	Rice Transplanter Machine operator cum mechanic	Planters – Operators	8776	8952	9399	9869	10363	10881	49463
		Mechanics / Technicians	174	177	186	196	205	216	981
4	Harvesting Machine Operator	Harvesters operators	13506	14181	14890	15635	16417	17237	78361
		Mechanics / Technicians	90	95	99	104	109	115	522
5	Agri machinery mechanic	Power Weeders operators	21697	22131	23237	24399	25619	26900	122287
		Power Weeders mechanics/Technicians	434	456	478	502	528	554	2518
6	Agri machinery mechanic	Laser Levellers -operators	2233	2345	2462	2585	2714	2850	12956
		Laser Levellers – Mechanics and Technicians	45	47	50	52	55	57	261
7	Pesticide and fertilizer applicator,	Seed cum fertilizer drills operators	36465	38288	40203	42213	44323	46540	211567
		Seed cum fertilizer drills mechanics and technicians	729	765	804	844	886	930	4230
		Power sprayers operators	6381	6700	7035	7387	7756	8144	37022
		Power sprayers Mechanics and technicians	128	134	141	148	156	163	743

8	Green House fitter and operator	Operators	5500	5775	6064	6367	6685	7020	31911
		Mechanics and technicians	110	116	121	127	134	140	638
9	Operator - Reaper, Thresher & Crop Residue Machinery	Operators, mechanics/ Technicians for Power threshers and reapers.	58581	61511	64586	67815	71205	74766	339881
10	Micro-Irrigation Service Technician	Micro-irrigation operator, mechanic/Technician	98490	101445	106517	111843	117435	123307	560546
11	Solar Pump Technician	Operator	90000	94500	99225	104186	109396	114865	522172
		Mechanic/Technician	3000	3150	3308	3473	3647	3829	17406
12	Kisan Drone	Technicians and Operators	9000	11250	14063	17578	21972	27466	92329
13	Custom Hiring Centers		36068	40757	46055	52042	58808	66453	264115
B	**Total of incremental skill needs at Field level**		**796959**	**837637**	**885030**	**935777**	**990244**	**1048854**	**4697541**
C	**Total of Incremental skill needs of ASCI Notified Job Roles (A+B)**			**840153**	**887672**	**938551**	**993157**	**1051912**	**4711444**

Summary of Incremental Estimated Skill Requirement in numbers per annum for yet-to-be notified ASCI Job roles

S. No.	Focus area	Job role	2021-22 (base year)	2022-23	2023-24	2024-25	2025-26	2026-27	Total Incremental from 2022-23 to 2026-27
D. Factory personnel / Manufacturing									
1	Factory personnel - Workers	Mechanics /Technicians	1500	1725	1984	2281	2624	3017	11631
		Advanced Mechanics/ Technicians	1500	1725	1984	2281	2624	3017	11631
2	Factory personnel - Other than workers-managerial	Managers	500	575	661	760	875	1006	3877
		Advanced Technologies for managers	500	575	661	760	875	1006	3877
	Factory personnel	Total /year	4000	4600	5290	6082	6998	8046	31016
E	**Officials and Academia**								
1	Students	Graduation & 3-year Diploma		2750	2750	2750	2750	2750	13750
		ITI		15000	15000	15000	15000	15000	75000
2	Faculty			1000	1000	1000	1000	1000	5000
3	Agri Eng. Officials			1000	1000	1000	1000	1000	5000
	Total			**19750**	**19750**	**19750**	**19750**	**19750**	**98750**
				24350	**25040**	**25832**	**26748**	**27796**	**129766**
F	**Grand total of Incremental Skilling needs ASCI job roles and yet-to-be notified Job roles (C+D+E)**			**864503**	**912712**	**964383**	**1019905**	**1079708**	**4841210**

In addition, there would be a need for about 12.98 lakh skilled workers annually **(Exhibit ES.2),** not included in the current estimates of skilling needs in farm mechanization, for such activities as controlled environment agriculture, primary agricultural processing, biomass management, drainage equipment, testing and quality assurance services, and consulting / advisory / insurance.

Exhibit ES.2. Skilling Needs in Farm Mechanization in Other Agricultural Activities and Services

Focus area	Job role	2021-22 (base year)	2022-23	2023-24	2024-25	2025-26	2026-27	Total Incremental from 2022-23 to 2026-27
Other Agriculture Activities								
Controlled Environment Agriculture in 500,000 ha	Technicians @ 1/ha		50000	52500	55125	57881	60775	276281
	System manufacture @ 1/10 ha		5000	5250	5513	5788	6078	27629
Primary Agro-processing centers @ 1/village, i.e., 700,000 units	Operators and Technicians @1		70000	73500	77175	81034	85085	386794
Biomass management @1/200 ha	Operators and Technicians @1		75000	78750	82688	86822	91163	414423
Drainage and tube-well equipment operation and services @ 1/2000 ha	Operators and Technicians @ 1		15000	15750	16538	17364	18233	82885
Sub-Total - Other Agriculture Activities			**215000**	**225750**	**237039**	**248889**	**261334**	**1188012**
Other Agricultural Services								
Testing and quality assurance services 100,000 centers	Lab technicians @ 1	100000	10000	10500	11025	11576	12155	55256
Consulting / advisory / insurance 100000 units	Consultants @1	100000	10000	10500	11025	11576	12155	55256
Sub Total		**200000**	**20000**	**21000**	**22050**	**23152**	**24310**	**110512**
Total			**235000**	**259089**	**272041**	**285644**	**259089**	**1298524**

Exhibit. ES.3. Recommended key areas and activities for skilling under farm/ agricultural mechanization

Key area	Activity
Seed bed Preparation	• Operation of tractors and power tillers with implements /attachments • Repair and maintenance of tractors, power tillers, and implements with a view to establish rural, satellite or mobile workshops • Usage of tractor implements for better productivity
Sowing, planting, and transplanting	• Calibration and operation of seed drills and planters • Operation of transplanters including nursery raising • Repair and maintenance of transplanters
Irrigation and Drainage	• Pump installation and operation • Maintenance of electrical motors and electronic controllers • Operation and maintenance of micro-irrigation systems • Design and installation of micro- irrigation systems
Weeding & plant protection	• Operation, repair and maintenance of power operated or tractor mounted sprayers / aero blast sprayers • Operation of advanced machines such as drones and other forms of autonomous machines
Harvesting & threshing	• Operation and repairs of combine harvesters and other crop-specific harvesters • Operation and repairs of threshers • Operation and servicing of cotton pickers • Operation and maintenance of orchard management machines
On farm post-harvest value addition operations	• Operation, maintenance and repairs of threshing, dehulling, and milling machines • Dairy plant operation and management • Operation, maintenance and repairs of cleaning, de-stoning, sorting, grading, and packaging machines
Stubble/crop residue management	• Operation, maintenance and repairs of straw management system (SMS) attachments to the existing machines in addition to the stand-alone systems
CHCs/FMBs/Hitech hubs	• Awareness programmes or advisory services for selection of crop-wise, region-wise machinery to operate at these centers • Crop-wise end-to-end farm mechanization solutions • Agricultural and rural by-products management and utilization
New Areas	• Farm machinery applications in livestock and fishery sectors • Renewable energy gadgets: operation and maintenance • Agricultural sustainability through mechanization • Micro environment management in warehouses, polyhouses, dairy and poultry structures, pig rearing structures, and intensive fish production systems • Construction infrastructure for agricultural tourism, Farm resource management

The above-mentioned effort on estimation of skill gap in farm mechanization requires policy and budgetary support to bear fruits. All popularization activities and financial incentives need to be linked to the appropriate skilling programmes. All skilling programmes need to be linked to employment on merit basis. In other words, all skill providers need to be linked to prospective employers.

SKILL GAP ANALYSIS OF INDIAN FARM MECHANIZATION SECTOR

1. INTRODUCTION

Agriculture continues to play an important role in India and the Indian economy. Progress of the agriculture sector has made the country self-reliant in meeting its food requirements and it goes on to share the surplus with needy people abroad. The latest success story of Indian agriculture is that of attaining self-sufficiency in pulse production. Although the share of agriculture in the national GDP is only about 18.8%, it provides livelihood to 41.5 % of the country's workforce as per the latest Economic Survey (2021-22). Of the total geographical area of 328.7 M ha, 42.4% (139.4 M ha) is the net sown area and 200.2 M ha is the gross cropped area with 143.6% cropping intensity (Annual report of MoAFW). India's agriculture success story has been possible due to the continued importance and support lent by the Government of India to the agriculture sector. There is, however, a considerable potential for improvement in agricultural productivity, production, loss reduction, resource conservation, and value addition to make agriculture more profitable, sustainable, and respectable.

Indian agriculture is now changing its focus from subsistence agriculture to sustainable commercial agriculture with a view to increase the income and wages of farmers and farm workers, respectively, without harming the environment. One way to sustainably raise farm productivity is by using modern inputs (such as high-yielding seeds, fertilizers, pesticides, farm machinery, precision farming practices, etc.) to ensure feeding the rising population with access to higher per capita income while augmenting farmers' incomes. While the success of the first green revolution depended on inputs like seed, agricultural chemicals, and water, the next quantum jump is expected from technological interventions, be it mechanization, ICT, GPS, IOT, or AI. The sustainability of agriculture depends on the minimization of inputs and maximization of output while maintaining certain objective functions. Agricultural mechanization plays a crucial role in this transformation, i.e., increasing agriculture productivity, sustainability, and production; doubling the farm income; mitigating farm worker shortages; eliminating physical drudgery; improving safety; and judicious use of natural resources and farm inputs.

Increasing farm mechanization levels leads to the timeliness of farm operations, minimization of input resources including labour, and enhanced output. Today's youth look at agriculture from this new perspective. The role of farm mechanization in agricultural production, harvesting and post-harvest operations has been well appreciated. Farm power availability (FPA) on Indian farms in 2020-21 stood at 2.76 kW/ha as compared to just about 1.0 kW/ha in the year 1995 and 0.31 kW/ha in 1961-62. However, agricultural mechanization in India has been skewed towards the use of tractors till just a decade ago and it is only recently that usage of other machinery has begun to pick up.

Farm productivity depends, among various factors, on the availability and judicious use of farm power. Well-designed agricultural implements and machines enable the farmers to utilize the available power judiciously for production and value addition purposes. Agricultural machines increase the land and labour productivity by meeting the timeliness of farm operations and enhancing work output per unit time as well as making multiple cropping and diversification possible. Indian farmers earlier depended mainly upon human and animal power that remained constrained in time and space. However, Government schemes and industrial growth, with the passage of time, have resulted in enhanced availability and use of power and power-driven agricultural machines in Indian agriculture for increased farm productivity, production, and profitability. The importance of farm mechanization has now been well accepted. As a result, there is now a greater emphasis on the development and commercialization of new farm implements/equipment.

There is still a long way to go for enhancing farm mechanization in the country to an adequate level. While there is a continued need for more efficient and appropriate machines for agricultural mechanization in India, there is an even greater need for skilled human resources for the efficient operation and maintenance of the machinery.

India has a demographic advantage (around 54% of the population is below 25 years of age, old-age dependency ratio of 0.125) compared to other countries and will enjoy this advantage for another 25-30 years. However, the share of skilled to total labour force as per HDR 2020 is at 21.2% only as compared to advanced countries such as the European Union countries, the USA, Singapore, Australia, etc. where the share is more than 70%. Thus, India's ability to leverage demographic advantage is inadequate due to deficient skills in the existing as well as the new workforce. Twelve million people enter the labour force in India every year who need to be skilled.

The government of India in the recent past has initiated several programmes to promote farm mechanization that has led to improvements in farm outputs and farmers' welfare. But high growth in farm output can only be achieved through a concerted effort involving all the ecosystem components. Sustainable technology absorption depends upon four essential inputs. The technology must be science based: those not based on science fall apart quickly. The technology must be competitive economically to attract its adoption. The technology has no competing alternative; it could sustain itself even in the face of high cost. In addition, without an adequate policy framework, the technology suffers from poor uptake. Finally, the need for skilling cannot be over emphasized. Normally, technology vendors provide minimum skills to handle and utilize the technology. However, there is always a gap between the minimum and adequate levels of skill. Thus, a generalized framework for sustainable technology absorption can be summarized as STEPS (science-technology-economics-policy-skill).

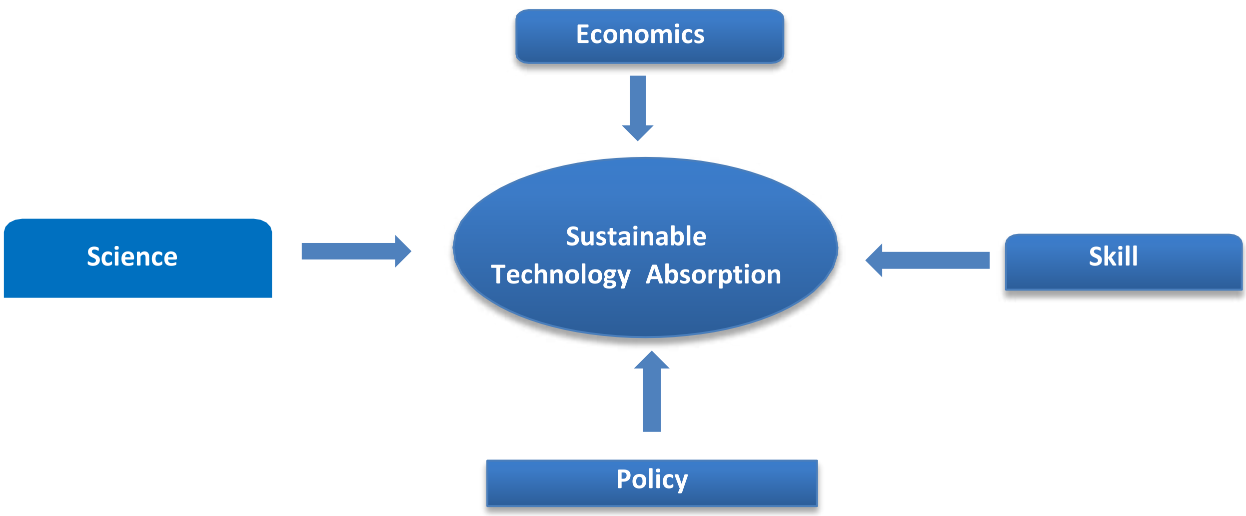

Figure 1. Framework for Sustainable Technology Absorption

As per India Census 2011, the agricultural workforce (consisting of both cultivators and workers) reduced from 58.2 % to 54.6 % during 2001- 2011. NSDC agriculture sector skills report states that there is a sharp increase in the percentage of marginal workers (defined as the percentage of the workforce who worked for less than six months in a year). There is a significant level of variation in workforce concentration among the states. Agriculturally advanced states, like Punjab, have a much lower agriculture sector workforce due to mechanization

As the pace of farm mechanization gets accelerated, appropriate and adequate skilling programs must be in place to meet the demand for skilled manpower for the farm mechanization industry at all levels, at farmer's level/ground level, repairs/maintenance level, managerial level, etc. State agricultural universities, ICAR institutes, ITIs, agricultural equipment and machinery manufacturers/ industries, FMT & TIs, and development agencies have been conducting training and skill development programmes for quite some time. Various field reports have identified skill gaps in terms of lower availability of skilled workers to provide technical services in custom hiring centres; inadequate infrastructure and mechanism of capacity building and skill enhancement of operators and service providers of precision farm equipment; inadequate capacity-building opportunities; lack of skilled human resource for the use of high-cost and/ or specialized farm machinery, etc. Moreover, considering the enhanced demand for farm mechanization and rapidly changing technological innovations, it is the need of the hour to anticipate the changes and prepare the farmers/farm workers, industries and all other stakeholders to upgrade their skills and meet the demand for more trained manpower. Therefore, this study on Skill Gap Estimate in Farm Mechanization has been taken up with the following objectives.

2. OBJECTIVES

The objectives of the skill gap analysis are as follows:

1. To present an overview of the farm mechanization in India, government policies and growth prospects in terms of employment and income generation in different segments of agricultural production and on farm processing.
2. To analyze the labour force and skilled labour dynamics in agriculture and allied sectors over time.
3. To analyze the availability of a skilled labour force to handle mechanization across different segments of the agriculture value chain.
4. To analyze the existing status in skilling in farm mechanization and estimate the skill gap/ requirements in the farm mechanization sector

3. METHODOLOGY

The research methodology includes primary research through discussions and field visits to stakeholders who include government departments, agriculture universities, ICAR institutes, industries, industry associations, training & testing institutes, skill trainees, etc. and secondary research through a review of available literature and secondary data on various aspects of farm mechanization, farm mechanization markets and skill requirement reports.

3.1. Primary Research

The research methods include primarily the discussions and field visits with stakeholders across the Farm Mechanization ecosystem. Interviews/discussions were held with a wide range of stakeholders including Central and State Government Departments, State Agriculture Universities (SAUs), ICAR institutes related to farm mechanization, Farm Machinery Training & Testing Institutes (FMTTIs), Industry/Corporates, Industry Associations, Development Institutes, skilled trainees, etc. The primary research comprehensively covers the current landscape and ecosystem of farm mechanization, current needs and gaps, key drivers of growth and challenges, the role of the institutions in skill development, infrastructure available, key focus areas, emerging trends and upcoming developments. Overall, the interactions were held (online) with 53 stakeholders across 7 different categories **(Exhibit No.1)**

Exhibit 1. Broad Categories of Stakeholders who participated in Discussions

S.No.	Category	Number
1	Central and State Government Departments including ICAR	8
2	State Agricultural Universities (SAU) and Research Institutes like IARI and CIAE	10
3	Farm Machinery Training & Testing Institutions (FMTTIs)	4
4	Industry/Corporates/Agri machinery manufacturers including their training centers	11
5	Industry Association	1
6	Development Institutions	2
7	Candidates received Skill training	17
	Total	**53**

3.2. Secondary Research

Secondary research has been carried out through a review of available information and literature on various farm mechanization aspects, skill gap reports, etc. The following important resources were referred to and the data utilized for conducting the Skill Gap Analysis on Farm Mechanization.

1. Economic Survey 2021-22.
2. Annual Report, 2019-20, Department of Agriculture, Cooperation and Farmer Welfare, GoI.
3. Demand & Supply Projections towards 2033-Crops, Livestock, Fisheries and Agricultural Inputs -The working Group Report Feb 2018, NITI Aayog report.
4. Monitoring, concurrent evaluation and impact assessment of Sub-Mission on Agricultural Mechanization (SMAM), 2020, by WAPCOS for MoAFW.
5. All India Report of Input Survey, various years, MoAFW.
6. Annual Industry Surveys and PLFS surveys.
7. National Sectoral Paper on farm mechanization, 2018, NABARD.
8. Farm mechanization: Ensuring a sustainable rise in farm productivity and income, 2019, PWC and FICCI.
9. Agriculture Machinery Industry in India, Surendra Singh and Balachandra Babu. The 6th Regional Forum for Sustainable Agricultural Mechanization in Asia and the Pacific - Enabling Environment for the Private Sector 25 October 2018, Wuhan, China.
10. Data from website - https://agrimachinery.nic.in.
11. Gajendra Singh, Agriculture Mechanization development in India, Ind. Jn. of Agri.Econ. Vol.70, No.1, Jan.-March 2015.

The secondary data was used in understanding the current status of farm mechanization in India, growth drivers, gaps, issues and challenges, gaps in skill development, skilling requirements, etc. The broad methodology for estimation of skill gap is as given below:

A. Basic Data regarding the number of managerial counts and workers count in manufacturing (factories) of agricultural machinery from Annual Industry surveys was collected from various reports and growth rate was applied to calculate incremental employment. The skill requirement is estimated by ascertaining the percentage based on the previous growth rates.

B. Basic data on numbers of various agricultural machinery was obtained from reports (C, E and I of the above references) and estimated the perspective sales in a year spread over the next 5 years based on the previous growth rate, replacement rate and present situations. Data was collected on the requirement of operators, and mechanics/technicians required for the maintenance of 100 machines and calculated the skilling requirement.

C. With regard to dealerships of agricultural machinery, data on the number of dealers was collected from the website tractorjunction.com. The organizational structure and an approximate number of personnel and qualifications associated with a typical dealer from the industry were used for estimating the incremental manpower requirement in service and its related areas. From incremental manpower, the skilling requirement was estimated.

D. With regard to students, faculty and state agricultural engineering departments, the number of internships tapped for skill requirements was 25%, 5% and 5% in each state.

Further, the specific/detailed methodology and calculations are furnished in chapter 11 under respective heads. The Skill gap analysis report covers a brief view of the agricultural situation in the country, the status of farm mechanization in terms of past, present and future, farm power availability, level of mechanization, usage of agricultural machinery and equipment, farm machinery markets, growth drivers and challenges, policies and support from the government, existing practices and technological advances, agricultural workforce and skilling, skilling in farm mechanization and skill gap analysis and estimates.

4. AGRICULTURE IN INDIA – A BRIEF VIEW

Agriculture plays a vital role in India's economy. Indian Agriculture sector accounted for approximately 18.8 percent of the country's Gross Value Added (GVA) for the year 2021-22 (at current prices) (Exhibit.2). The decline in agricultural GVA, except for the Covid period, is attributed to structural changes in India and rise in GVA of other sectors. There has been a gradual decline in agriculture GDP to total GDP ratio, except for the past two years, and there is also a declining trend of the agriculture workforce to the total workforce. The workforce in agriculture was 51.52% of the total workforce in 2010 which decreased to 41.49% in 2020 (Statista.com).

Exhibit 2 . GVA of Agriculture and Allied Sectors & its share in total GVA

Crore Rupees

Items	Years							
	2014-15	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**
GVA in Agricult-ure and Allied sectors	2093612	2227533	2496358	2670147	2775852	3047187	3618830	3499373
Percent-age of Agricult-ure GVA to total GVA	18.2	17.7	17.9	17.2	16.1	16.5	20.2	18.8

Source: Economic Survey, 2021-22

India’s arable land resource is the 10th largest in the world. There are 20 Agro-climatic regions in the country and all the 15 major climates exist here. India is home to 46 of the 60 soil types available in the world. In the year 2020-21 (as per fourth advance estimates), total food grain production in the country was estimated to be 308.65 million tons; 3.74% higher than the production in 2019-20 (Economic Survey 2021-22) as against just 50 million tons in 1950-51. The production data of major crops (MoAFW) is furnished in Exhibit.3. The following Exhibit indicates that the area under cultivation is more or less the same, productions of total food grains, oil seeds and cotton are increasing and the overall productivity has also been showing an upward trend during the 2017-18 to 2019-20 period.

Exhibit 3. Production and productivity of major crops in India

Crops	Area (Mha)				Production (MT)				Yield (kg/ha)			
	2017-18	2018-19	2019-20*	2020-21*	2017-18	2018-19	2019-20*	2020-21*	2017-18	2018-19	2019-20*	2020-21*
Rice	43.77	44.16	43.78	45.10	112.80	116.50	118.40	122.30	2576	2638	2705	2713
Wheat	29.65	29.32	31.45	31.60	99.90	103.60	107.60	109.50	3368	3533	3421	3464
Nutri-cereals	24.29	221.5	24.02	23.80	47.0	43.10	47.50	51.10	1934	1944	1976	2146
Pulses	29.81	29.16	28.34	28.8	25.40	22.10	23.20	25.70	853	757	817	892
Food grains	127.52	124.78	127.59	129.30	285.00	285.20	296.60	308.60	2235	2286	2325	2386
Oil seeds	24.51	24.79	27.04	28.80	31.50	31.50	33.40	36.10	1284	1271	1236	1254
Sugar cane	4.74	5.06	4.57	4.90	379.90	405.40	355.70	399.3	80	80	80	82
Cotton	12.59	12.61	13.37	13.00	32.80	28.00	35.50	35.4	443	378	451	462
Jute and Mesta	0.74	0.70	0.68	0.7	10.00	9.80	9.90	9.60	2435	2508	2641	2595

***Advanced estimates**

Source: Annual Report of MoAFW and Economic Survey 2021-22

The total number of operational holdings in the country was 146.45 million in 2015-16 with 68.5% in the marginal category followed by small (17.6%), semi-medium (9.6%), medium (3.8%) and large category (0.6%). The small and marginal holdings both taken together (less than 2.00 ha) constituted 86.08% of the total land holdings. The all- India average size of holding is 1.08 ha which is reducing over the years (about 2.28 ha in 1970-71).

MECHANICAL TRANSPLANTING

5. STATUS OF FARM MECHANIZATION

Farm or agricultural mechanization refers to the application of implements, tools, and machinery to efficiently utilize the available human, animal, mechanical, and electrical power in agricultural activities for better management of the inputs, materials, operations and time for higher productivity, profitability and sustainability. Agricultural machines increase the land and labour productivity by reducing drudgery, ensuring timeliness of farm operations and enhancing work output per unit time as well as making multiple cropping and diversification possible. Farm mechanization status in India is being discussed in this chapter.

5.1. History of Farm Mechanization

Farm mechanization in India is almost as old as agriculture, i.e., about 10,000 years. Early tools were made of sharp edged or pointed stones, bones, and wood. There is a clear reference to the use of a bullock drawn plough in Ramayana for cultivation. Balarama, the elder brother of Krishna, always carried a plough with him. There is archaeological evidence of animal-drawn plough in the Indus Valley Civilization in 2500 BC. Agriculture, including tools for ploughing, seeding, and harvesting and warehouses for food storage, was well developed during the Mauryan period.

Suitable tools and implements were available to ancient farmers to carry out all the agricultural operations. Appropriate know-how existed for moulding the artifacts and innovations to suit the nature of the soil, dimensions of the cultivable field and the techniques involved in a particular operation. The use of rollers has been mentioned in Taitriya Samhita for making the field even. The plough, either small or heavy, described in the Rigveda is essentially a traction plough. These ploughs were pulled by oxen, sheep and camels. The dimension of the plough dictated the number of animals required to pull it. Accordingly, animals needed for dragging the plough were six, twelve, or twenty-four.

Old imported tractor from Bealarus

Rigveda mentions three types of tools for corn-cutting. The three types are datra (a type of crooked knife shaped sickle), reaping hook, and sickle. The applications of sieve and winnowing fan, probably for grain cleaning, have been indicated in Rigveda. Carts and wagons were used for transporting agricultural produce. In addition, chariots were also mentioned to be used for transporting agricultural produce from the field. Ox, ram, stallion, and dog were the animals employed for drawing these carriers. Vedic literature and Krishi-Parashara (400 BC) mention the applications of the plough, disc plough, seed drill, blade harrow (bakhar), wooden spike tooth harrow, plankers, axe, hoe, sickle, supa for winnowing and a vessel to measure grain (udara).

Vedic Aryans (1500 - 1600 BC) practised agriculture for their livelihood. The origin of the term Arya is linked to the root, 'Ar', which means 'to stir', i.e., to stir the soil by either a stick or a plough. The importance of off-season ploughing was well understood by the Vedic people; the ploughing was begun as and when the rain was received. The farmers celebrated the first ploughing of the season using a large and heavy type of plough with fan-fare.

Technologies for water lifting and its conveyance for irrigation were developed using manual and animal power sources. The period spanning almost a millennium prior to 1947 witnessed stagnation in the growth of agricultural mechanization in India; agricultural activities experienced a downturn instead. Rising from the ashes, post-independence agricultural mechanization was slow initially due to social and economic reasons. However, it has picked up momentum since 2005.

The first tractor was imported by India in 1914 by the Britishers for the purpose of clearing degraded forest land to be used for agricultural use (Bhattarai, et al, 2018). The same paper of IFRI indicated that these developments led to the birth of the indigenous industry in the 1930s for supplying tractor spare parts and engines in order to maintain the imported tractors in operation. The manufacture of engines promoted the evolution of pump sets in the 1930s. However, the manufacturing of irrigation pump sets had to wait for another two decades and started only in the late 1950s.

The British Government imported war-surplus high horsepower crawler tractors and bulldozers for land reclamation and cultivation in the mid-1940s. Keeping in view the need for assurance of quality and efficiency of the imported tractors, Central Tractor Organization was created by the Government of India and located on the present day campus of IARI, New Delhi. Several State Governments also decided to set up their own State Tractor Organizations. Bhattarai et al, 2018 reported that tractors were being imported such that there were 8,500 tractors in use in 1951, 20,000 in 1955 and 37,000 by 1960.

It was in 1961 that indigenously manufactured tractors began to be made available in India. While Eicher Motors, Gujarat Tractors, TAFE Ltd., Escorts Tractors Ltd., and Mahindra & Mahindra began their tractor production, tractors continued to be imported from the former Soviet Union, Poland, Romania, Czechoslovakia, United Kingdom, and other countries. In 1973, the Indian government banned tractor imports and encouraged indigenous manufacturing of tractors. It was during the subsequent years that new tractor manufacturing companies came up in India and the manufacturing capacities kept on increasing. As a result, the tractor population in the country began growing faster.

The tractor population in India was estimated to be 168,000 in 1970-71, more than four times the number in 1960-61. The tractor population reached about one million by 1990. At the end of 2010-11, the estimated tractor population was 4.2 million; doubling every 10 years during the past two decades. Tractor production in India continued to grow and the country began exporting tractors to other countries by 1980.

Farm mechanization growth in India has followed the same pattern found generally worldwide. The first category of farm operations mechanized are those that require high power inputs and low control, e.g., tillage, transport, water pumping, milling, threshing, etc. It is so because it is rather easier and less expensive to meet the higher power needs of the farm operations as compared to converting human knowledge into machine knowledge. The second category of farm operations to be mechanized are those requiring a medium level of control and varying levels of power, e.g., seeding, spraying, intercultural operations, etc. The last category to be mechanized are those farm operations that require a high degree of control and varying levels of power inputs, e.g., transplanting, harvesting of fruits and vegetables, etc.

5.2. Farm Mechanization – World vis-a-vis India

Farm mechanization has been found to provide great benefits to farmers globally including in India. In 1905, the USA employed 40% of its population in agriculture. Essentially, four American farmers produced food for 10 Americans in 1905. Farm mechanization permitted the USA to release the majority of its agricultural labour force for more remunerative non-agricultural occupations. Essentially, farm mechanization led to productivity enhancement through higher labour efficiency, timeliness of operations, efficient input use, and application of sustainable production systems Now, one US farmer produces food for 166 persons living in the USA and abroad.

The level of mechanization has a significant positive impact on the cost, output value, income and return rate of all types of crops. For every 1% increase in the level of mechanization, the yields of all crops, grain crops and cash crops increase by 1.215, 1.594 and 0.435%, respectively (Peng et al, 2022). Singh and Singh, 2021 have presented the data for farm power availability (FPA) and grain productivity for Indian agriculture (1960-2020), suggesting a figure of 700 kg/ha per kW of FPA. While the GDP contribution of the agriculture sector and the workforce dependent on agriculture in India remain significantly higher; the level of mechanization remains very low in comparison to developed nations such as the US, Russia and Europe (Fig.2).

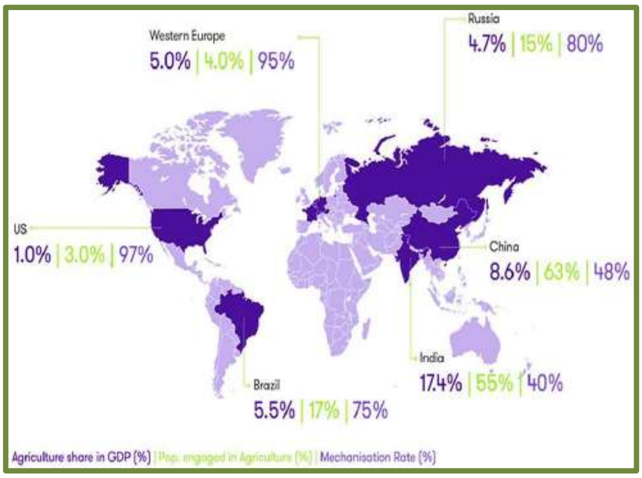

Figure 2. Agricultural GDP share, agricultural workforce percentage and agricultural mechanization rate across the world

Source: Grant Thornton and FICCI

The PWC and FICCI report 2019 suggested that the size of the global market for agricultural and farm machinery was around USD 200 billion in FY19, and it was predicted to grow at a compounded annual growth rate (CAGR) of 9% up to FY25. Globally, the major regions for the growth of the agricultural and farm machinery market are Asia-Pacific and North America. Europe holds about 30% of the market share globally. The Indian farm equipment market, worth USD 13 billion, is estimated to grow at a CAGR of 6% during FY19 - FY25. The composition of farm equipment in the world and India is as follows:

Exhibit 4. Farm Equipment share (percentage) in Global and Indian Market

S. No	Name	% Share in world market*	% Share in Indian market*	% Share in Indian market*	Analysis
1	Tractors	55	81.4	58	Tractors market is a bit higher than the world
2	Harvesting equipment	22	2.5	11	Very low in India. If only harvesters considered and not threshers and reapers the value is around 1%
3	Tillage equipment	8	5.1	7	Difference is less
4	Planting and fertilizing equipment	8	-	15	Maximum percentage are Fertilizer and Seed drills rather than any planters. Full mechanization such usage of rice transplanting and related planters is low at 3% only.
5	Haying and forage equipment	7	-	-	Meagre in India
6	Others		11	6	Sprayers, reapers, etc.

Source: Analysis by Study Team of ASCI and * PWC and FICCI, 2019 and **calculations based on data at Annexure-I from Demand and Supply Projections Towards 2033 by NITI Aayog, 2018

5.3. FARM POWER AVAILABILITY (FPA)

Indian farms have a variety of power sources that can be used for various agricultural operations of a mobile and stationary nature. Farm power, i.e., draught animals; humans; tractors/ tillers/ other self-propelled machinery; stationary engines (diesel/oil), and electric motors. The following Exhibit.5 and Figure. 3 give the details of the various power sources used on the farm for the last 7 decades. Among all the farm power sources, farm workers, and draft animal power are showing decreasing trends. The Tractors and other machinery and diesel & electric pump-sets are on the rise (Singh and Singh 2021).

Exhibit 5. Share of Different Sources in Farm Power Availability

Years	Sources in Sources in Farm Power Availability%						Net Sown Area Million/ Ha	Available Power Kw/ Ha	Productiv-ityT /Ha
	Farm Workers	Draft Animals	Tractor	Power Tiller	Diesel Engine	Electric Motor			
1961-62	16.09	75.26	2.37	0	3.91	2.36	135.4	0.301	0.709
1971-72	10.68	53.48	7.45	0.11	17.36	10.92	139.72	0.421	0.858
1981-82	9.11	34.24	17.06	0.12	23.33	16.15	141.93	0.572	1.032
1991-92	7.31	21.08	24.54	0.17	21.56	25.34	141.63	0.895	1.382
2001-02	6.12	11.29	36.79	0.36	19.11	26.33	140.73	1.358	1.734
2011-12	5.00	6.43	45.19	0.73	17.49	25.15	140.98	1.865	2.078
2020-21	2.97	3.03	59.37	1.02	14.03	19.58	140.00	2.761	2.390

Source: Singh S. P. and Singh Surendra, August 2021, Farm Power Availability and its Perspective in Indian Agriculture, RASSA Journal of Science for Society 3(2): 114-126

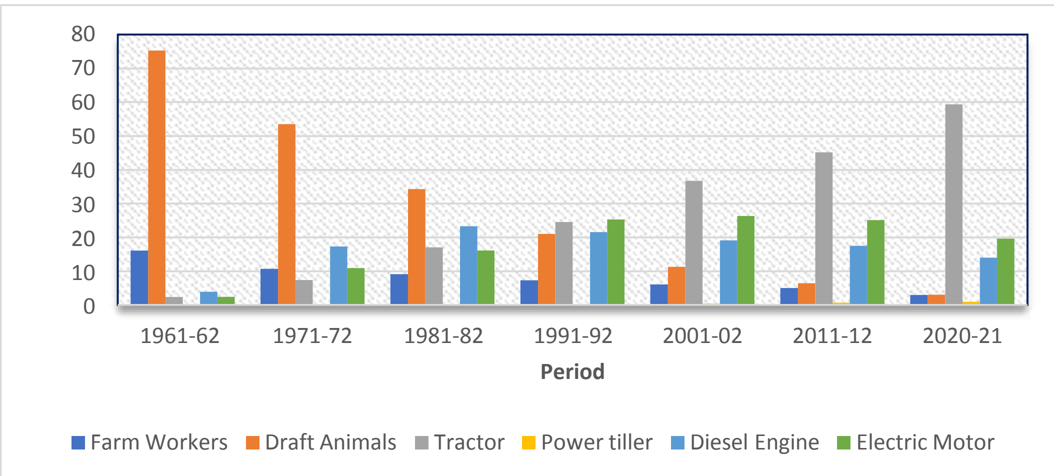

Figure 3. Share of Different Sources in Farm Power Availability

Data Source: Above Exhibit No.5

NITI Aayog report 2018 asserts that the shift in agricultural power use over the years has been towards mechanical and electrical sources. While about 93 per cent of farm power was derived from animate sources in 1960-61, the share of animate sources reduced to 12.6 percent in 2010-11. On the other hand, the share of mechanical and electrical power sources increased from 7.0 per cent to 87.4 per cent during the same time period. It is estimated that by 2032-33 the share of animate sources will get reduced to only about 4.0 per cent of total farm power (NITI Aayog, 2018).

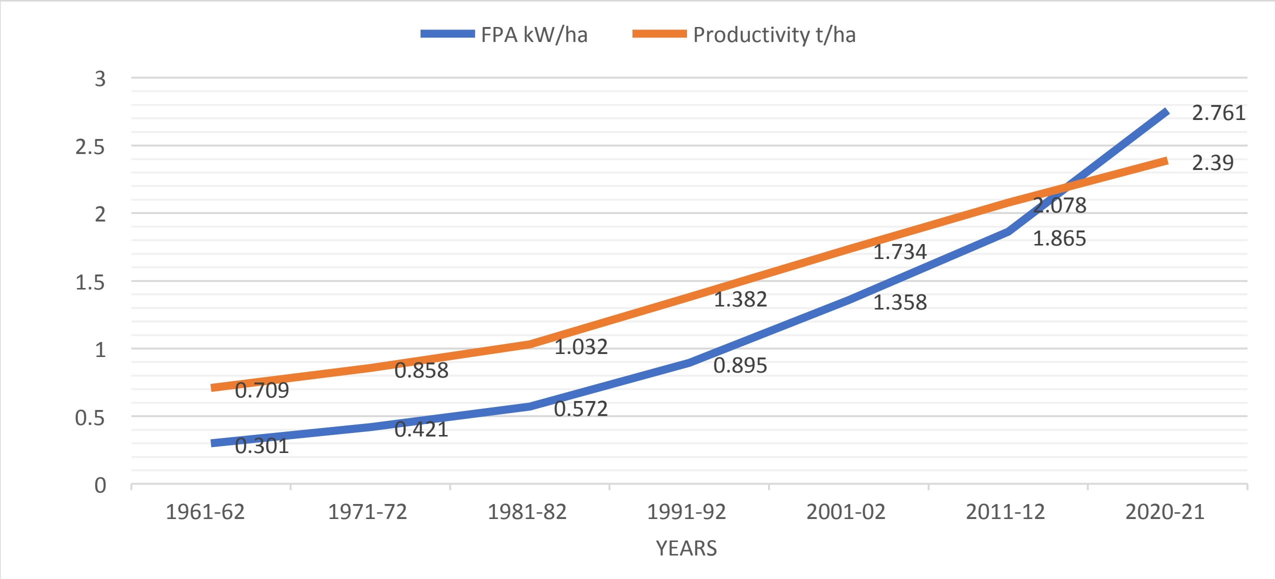

Figure 4. Farm power availability and productivity

Data Source: Exhibit No.5 above

The state-wise FPA is furnished in Fig. 5 and Exhibit 6. The farm power availability is expected to increase from 2.49 kW/ ha (2018-19) to 5.7 kW/ ha by the end of 2035 to cope with the increasing demand for food and other industrially important raw materials and to deal with the shortage of labour for agricultural purposes.

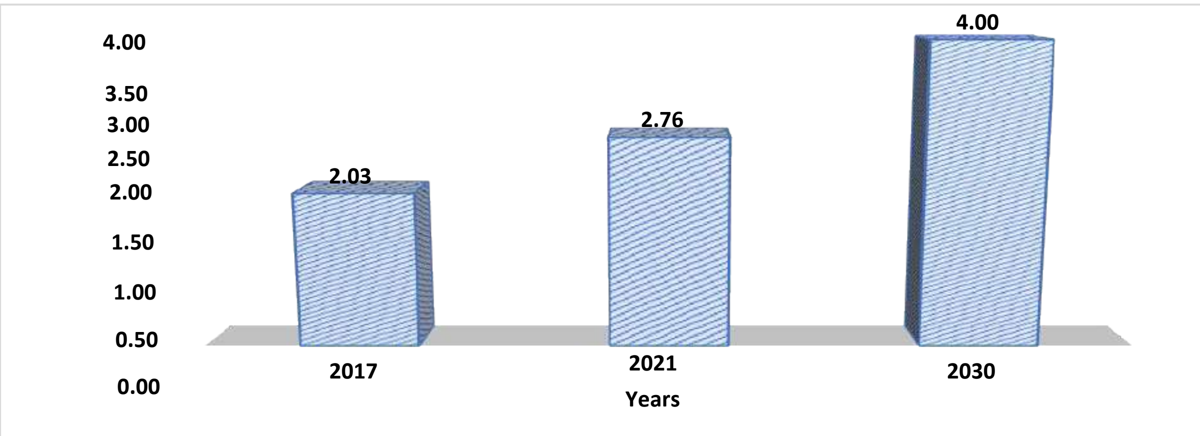

Figure 5. Farm power availability in India in 2016-17 and requirement of farm power by 2022 and 2030

Data Source: Monitoring, concurrent evaluation and impact assessment of Sub-Mission on Agricultural Mechanization, 2018, by WPCOS for MoAFW

The state-wise FPA (Exhibit 6) indicates that many states have FPA less than 1 kW/ha and those states are Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, and Sikkim. The states with 1 to 2 kW/ha FPA are West Bengal, Jharkhand, Himachal Pradesh, Jammu & Kashmir, Kerala, Maharashtra, Madhya Pradesh, Chhattisgarh, Odisha, Rajasthan and Tripura. The rest of the states, i.e., Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Punjab, Tamil Nadu, Telangana, Uttar Pradesh and Uttarakhand, have FPA of more than 2 kW/ha. Exhibit 6 also indicates the movement of states on a time scale from lower FPA to higher FPA; some states' movement is faster than that of others.

Exhibit 6. Farm power availability and requirement by 2022 and 2030

Year	Ranges of Farm Power per Hectare							
	0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0
2017 (All India Average 2.03)	Assam, Arunachal Pradesh, Manipur, Meghalaya Mizoram, Nagaland, Sikkim (7)	Tripura, West Bengal, Odisha, Rajasthan, Kerala, Maharashtra Madhya Pradesh, Chhattisgarh, Jharkhand, Himachal Pradesh, Jammu & Kashmir (11)	Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand Karnataka, Andhra Pradesh, Gujarat, Bihar (8)		Haryana, Punjab (2)			
2021 (All India Average 2.76)	Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim (6)	Tripura, Assam, Jharkhand, Himachal Pradesh, Jammu & Kashmir, Kerala, Maharashtra Madhya Pradesh, Chhattisgarh Odisha, Rajasthan (11)	Karnataka, Andhra Pradesh, West Bengal (3)	Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand, Bihar, Gujarat (6)	Haryana, Punjab (2)			
2030 (All India Average 4.0)	Meghalaya (1)	Assam, Nagaland, Sikkim, Arunachal Pradesh, Manipur (5)	Mizoram, Chhattisgarh Odisha, Rajasthan, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Kerala (8)	Tripura, West Bengal, Andhra Pradesh, Maharashtra, Madhya Pradesh (5)	Karnataka, Gujarat, Bihar (3)	Uttarakhand, Telangana, (2)	Uttar Pradesh, Tamil Nadu (2)	Haryana, Punjab (2)

Source: Evaluation report of SMAM by WAPCOS

5.2. Farm Mechanization Value Chain and Level of Farm Mechanization

Value chain of the farm mechanization is depicted below in **Exhibit.7.**

Exhibit 7. Farm Mechanization value chain and equipment usage

Field preparation	Sowing and planting	Weeding, inter-cultivation, plant	Harvesting and threshing	Post-harvest agro-processing
Tractors Levellers Plough Dozers	Drill Seeder Planter Dibbler	Harrow Tiller Sprayer Duster	Harvester Thresher Digger Reaper	Seed extractor Dehusker Huller Cleaner Grader/Sorter

Disc Harrow

Seeder

Combine Harvestor

Paddy Dehusker

Farm mechanization value chain includes seedbed preparation, sowing and planting, irrigation, weeding & plant protection, harvesting & threshing and post-harvest agricultural processing operations. In addition, stubble management/crop residue management for environmental protection (though in a few states at present) may be added to the value chain. Farm operation-wise mechanization is given below in Exhibit. 8. NITI Aayog working group report 2018 also indicates that the operation-wise farm mechanization in the country is about 40 per cent for tillage and seedbed preparation, 30 per cent for seeding/planting, 35-45 per cent for plant protection, 37% for irrigation, and 60-70 per cent for harvesting and threshing for rice and wheat and less than 5 per cent for other crops.

National Sectoral Paper (NABARD, 2018) makes a similar observation (Exhibit. 8). The level of mechanization varies greatly region-wise and crop-wise **(Exhibit. 9)**. Mechanization is significantly low in sowing/ planting of paddy and harvesting of cotton, sorghum, millets and oilseeds. Field or seedbed preparation across all the major crops is highly mechanized. States in the north (Punjab, Haryana and western Uttar Pradesh) have a high level of mechanization (70-80 per cent overall; 80-90 per cent for rice and wheat) due to highly productive land as well as declining labour availability and also support by state governments. The eastern and southern states have a lower level of mechanization (35-45 per cent) due to smaller and more scattered land holdings. In the north-eastern states, the level of farm mechanization is extremely low mainly due to hilly topography, high transportation cost of farm equipment and socio-economic conditions of the farmers.

Exhibit 8. Farm Operations and percentage mechanization

Field Operation	Tillage for seed bed preparation	Sowing and planting	Insect, pest, and disease control	Irrigation	Harvesting and Threshing
Level of mechanization (%)	40	29	34	37	60-70% for wheat and rice; and <5% for others

Source: Sectoral Paper on Farm Mechanization, NABARD, 2018

Exhibit 9. Crop-wise and operation-wise mechanization in percentage

Field operations	Paddy	Wheat	Potato	Cotton	Maize	Gram	Sorghum	Millets	Oilseeds
Seed bed preparation	85	90	90	90	90	90	80	80	80
Sowing/ planting/ transplanting	5	80	80	50	80	50	30	30	30
Weed and pest control	80	70	80	50	70	60	60	60	60
Harvesting	70	80	70	0	50	30	20	20	20

Source: FICCI and PWC, 2019

5.5. Usage of Agricultural Machinery and Equipment by Operational Land Holdings - Wise

The All India Report on Input Survey for various years 2006-07, 2011-12 and 2016-17, MoAFW has presented the data for operational land holdings-wise usage of agricultural machinery. The data from these reports have been analysed for agricultural machinery usage value chain-wise by operational holdings and the same is given below in Exhibits 10 to 15. The important highlights arising out of the overall value chain-wise data are as follows.

- The number of operational holdings increased and average land holding during the past two decades decreased due to fragmentation of land.
- The usage of agricultural machinery almost doubled every decade in the last two decades.
- The machinery usage is highest in soil preparation (90.7%) followed by harvesting (27.5%), sowing/planting (20.5%), weeding & plant protection (16%) and straw management (6.2%) in the year 2016-17.
- In the year 2016-17, the farmers utilized hired machines also, which was not observed/recorded in previous years of input surveys.

Though usages of tractors and power tillers continue to grow, there is an increasing trend for the usage of a new type of machines such as laser levellers; self-propelled harvesters, weeders and planters; straw combines, reapers and binders.

Exhibit 10. Usage of agriculture machinery by operational holdings

S. No.	Years	Total Number of operational holdings (in '000 units)	Average land holding in ha	% Operational holdings used machinery to total operational holdings				
				Soil preparation	Seeding and planting	Weeding and plant protection	Harvesting and threshing	Straw management
1	2021-22	150230	1.03	95.0	29.9	22.1	37.5	15.0
2	2016-17	146190	1.06	90.7	20.5	16.0	27.5	6.2
3	2011-12	138110	1.16	65.7	11.1	9.9	17.5	2.0
4	2006-07	100650	1.23	43.5	6.6	5.7	9.6	0.5

#Estimate

Source of data is All India Report on Input Survey for various years 2006-07, 2011-12 and 2016-17, MoAFW and analysis by ASCI Study team

Exhibit 11. Use of agricultural machinery for Soil bed preparation

Use of Agricultural Machinery for Soil Bed Preparation by Operational Holdings	Year		
	2006-07	2011-12	2016-17
Total Number of Operational Holdings	100650	138110	146190
Tractors	31279	61133	72293
Power Tillers	2895	7954	18878
Tractor Operated Cultivator	4918	11205	22302
Tractor Operated Leveler	4643	10425	17163
Laser Land Leveler	-	-	1922
Total Number of Operational Holdings Using Machines for Soil Bed Preparation	43735	90717	132558
% Holdings Using Machinery to Total Operational Holdings	43.5	65.7	90.7

Source of data is All India Report on Input Survey for various years 2006-07, 2011-12 and 2016-17, MoAFW and analysis by ASCI Study team

Exhibit 12. Use of agricultural machinery for Sowing and planting

No in '000 units

S. No.	Years	Total Number of operational holdings	Number of operational holdings using agricultural machinery for Sowing and planting												% Op holdings using machinery to total op holdings
			Tractor drawn planter	Tractor drawn potato digger	Raisedbed planter	Tractor drawn seed cum fertilizer drill	Zero till seed cum fertilizer drill	Tractorstrip drill	Tractor drawn sugarcane cutter and planter	Vegetable planter	Pneumatic planter	Self-propelled rice planter	Happy seeder	Total Number	
1	2016-17	146190	5570	2916	1124	16119	1366	578	355	333	444	359	824	29988	**20.5**
2	2011-12	138110	2069	1082	280	9375	385	132	263	1410	154	113		15263	**11.1**
3	2006-07	100650	1017	488		5131								6636	6.6

Source of data is All India Report on Input Survey for various years 2006-07, 2011-12 and 2016-17, MoAFW and analysis by ASCI Study team

Exhibit 13. Use of agricultural machinery for Weeding and Plant protection

S. No.	Years	Total Number of operational holdings	Number of operational holdings using agricultural machinery for Weeding and Plant protection			% Operational holdings using agri machinery to total Operational holdings
			Power sprayer	Self propelled Power weeder	Total Numbers	
1	2016-17	146190	22717	739	23456	16.0
2	2011-12	138110	13152	509	13661	9.9
3	2006-07	100650	5722		5722	5.7

Source of data is All India Report on Input Survey for various years 2006-07, 2011-12 and 2016-17, MoAFW and analysis by ASCI Study team

Exhibit 14. Use of agricultural machinery for Harvesting

S. No.	Years	Total Numberof operational holdings	Number of operational holdings using agricultural machinery for Harvesting								% Operational holdings used machinery to total operational holdings
			Tractor drawn Combine harvester	Self-propelled Combine Harvester	Sugar-cane harvester	Power thresher	Power Cane crusher	Maize sheller	Ground nut decorticator	Total Nos.	
1	2016-17	146190	7001	4502	640	23136	1715	2462	792	40248	27.5
2	2011-12	138110	2796	1900		17111	588	1465	299	24159	17.5
3	2006-07	100650	1022	638		6719	215	855	204	9653	9.6

Source of data is All India Report on Input Survey for various years 2006-07, 2011-12 and 2016-17, MoAFW and analysis by ASCI Study team

Exhibit 15. Use of agricultural machinery for Straw Management

S. No.	Years	Total Number of operational holdings	Number of operational holdings using agricultural machinery for Straw management						% Operational holdingsused machinery to total operational holdings
			Self-propelled reaper	Tractor mounted reaper	Straw combine	Straw baler	Reaper binder	Total Numbers	
1	2016-17	146190	2339	1681	1240	819	2938	9017	6.2
2	2011-12	138110	1263	911	522			2696	2.0
3	2006-07	100650	523					523	0.5

Source of data is All India Report on Input Survey for various years 2006-07, 2011-12 and 2016-17, MoAFW and analysis by ASCI Study team

5.6. FARM MACHINERY MARKET

Equipment manufacturers: There are about 250 medium to large scale units, 2500 small scale industries, 15,000 tiny industries, and 1,00,000 village level artisans for agriculture tools, implements, and equipment manufacturing in India (Singh and Babu, 2018). Equipment-wise number of manufacturers is provided in **Exhibit .16.**

Exhibit 16. Number of Agricultural Equipment Manufacturers in India

Equipment Manufacturers	No. of units
Agricultural tractors	21
Power tillers	7
Irrigation pumps	600
Plant protection equipment	300
Combine Harvester	48
Reapers	60
Threshers	6000
Seed Drills and planters	2500
Diesel oil engines	200
Plough, cultivators, harrows	5000
Chaff cutter	50
Rural artisans (hand tools)	>1 million

Source: Singh and Babu, 2018

5.6.2. Annual Market for major farm machinery used in India

Indian tractor industry, largest in the world, accounts for one-third of the total global production. The industry, including tractors, power tillers, combine harvesters and other agricultural machinery, was estimated to be worth USD 13 billion in 2019 (PWC and FICCI report). Annual tractor and power tiller sales are given below in Fig. 6. The tractor sales were 5,32,210 and 9,88,000 in the year 2011-12 and 2020-21, respectively. The power tillers sales were 47,000 and 54,200 in the year 2012-13 and 2020-21 (Economic survey 2021-22).

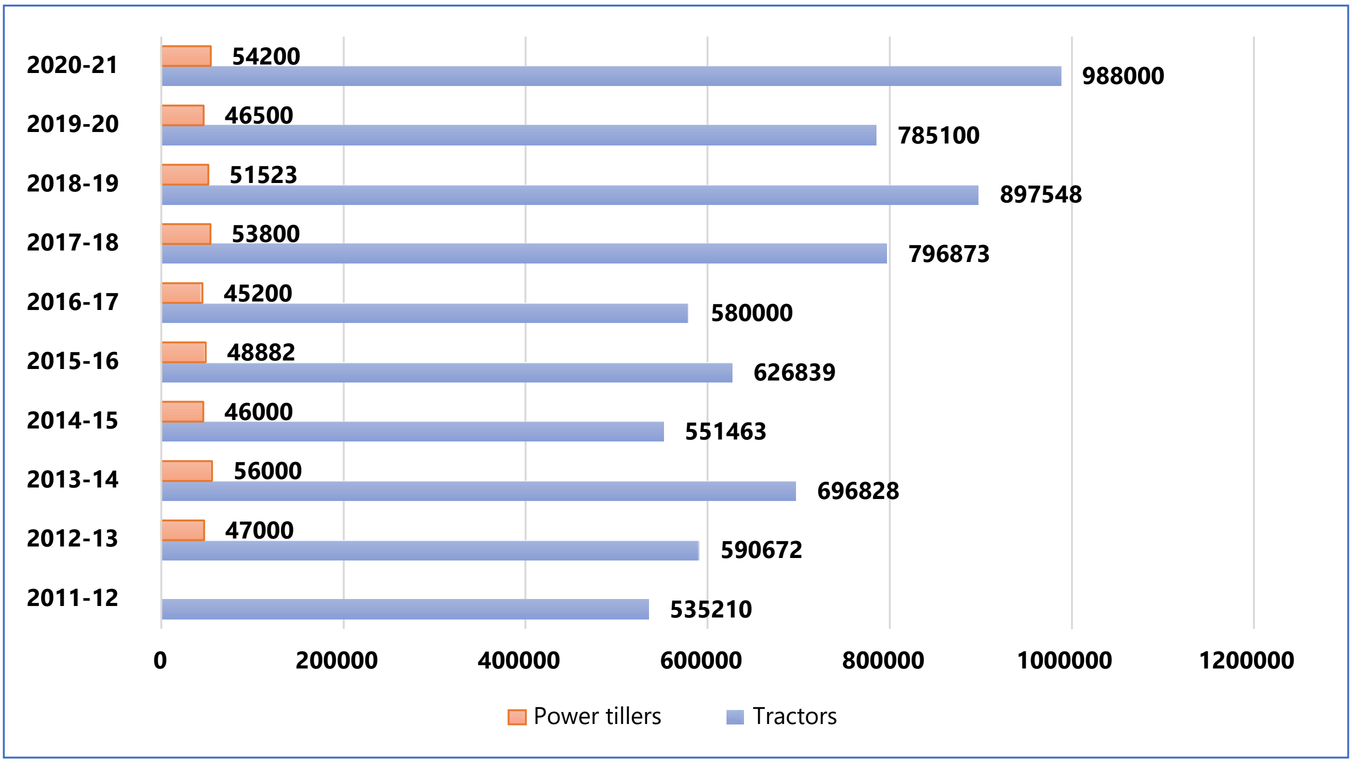

Figure 6.Year-wise sale of Tractors and Power-tillers in India

Source: Data source - Economic survey 2021-22 and analysis by ASCI Study team

As per Agriculture Machinery Manufacturers Association (AMMA), sales of major farm machinery/ equipment apart from tractors and power tillers in the year 2015 in India (Singh and Babu, 2018) are given below in **Exhibit .17.** The expected annual growth rate in the sales is 5% CAGR.

Exhibit 17. Annual market of major farm machinery used in India

Item	Numbers	Item	Numbers
Combine harvesters	3,500	Reapers	10,000
Cultivators	1,50,000	Rice transplanter	3,000
Harrows	1,20,000	Rotary hoes	20,000
Laser land levelers	2,500	Rotary tiller	1,00,000
MB Plough	50,000	Seed-fertilizer drills	60,000
Planters	15,000	Sprayers (TD)	10,000
Potato diggers	25,000	Threshers	60,000
Power weeders	35,000	Trailers	1,50,000

Source: Singh S and Babu B. Agriculture Machinery Industry in India 2018

PWC and FICCI reports indicate that domestic tractor sales increased from 3 lakh units to 7.8 lakh units from FY09 to FY19 with a CAGR of 6%. The sales of tractors and the consequent rise in farm power availability (FPA) in the recent past are also indicative of increased adoption rates of farm equipment. In addition to the impressive domestic tractor sales, India has also been exporting tractors (92,095 units of tractors in FY 2019) and other equipment. The engineering expo 'Farm mech 2021' reported that the Indian exports stood (Exhibit.18) at USD 1.3 billion with a positive trade balance.

Exhibit 18. India's Trade Trend in Agriculture Machinery Sector

Agricultural Machinery Group	India's Exports		India's Imports	
	2018-19	2019-20	2018-19	2019-20
Agricultural hand tools	33.58	31.94	4.29	4.87
Balers, dryers and cleaning machines	16.44	9.46	22.02	26.49
Harvesters and threshers	49.59	45.84	72.77	62.97
Machinery for soil preparation or cultivation	108.98	115.26	68.42	70.86
Mowers	7.55	7.34	5.12	6.85
Poultry or bee keeping machinery including germination plant fitted equipment	41	11.79	28.95	38.79
Sprayers	5.55	8.04	21.35	16.28
Tractors and parts	978.18	739.3	55.98	61.98
Trailers	46.52	55.61	33.80	27.20
Grand Total	1287.39	1024.58	312.70	316.29
India's Engineering Trade	80955.50	76275.50	110095.20	100550.70
Share % of Agricultural Machinery	1.6%	1.3%	0.3%	0.3%

Source: https://farmmech-eepc.expoplatform.com/indias-trade-trend

Market data suggest that the top five tractor manufacturers constituting more than 80% of total sales of tractors are M/s Mahindra & Mahindra group, TAFE group, Escorts, Sonalika and John Deere. As indicated by the Centre for Sustainable Agricultural Mechanization (CSAM) working paper on Mechanization of Agriculture and Market Dynamics, the market structure of tractor and agricultural machinery in India is open. There exists a country-wide network of all medium and large-scale manufacturers of combine harvesters, tractors, power tillers, and agricultural machinery. Farmers/users can select the machines of their own brands. Farm machinery dealers can also arrange finance for the purchase; the interest is generally 2-3 per cent higher than that of commercial banks.

It has been learnt that a range of stakeholders is involved in the farm power and machinery supply chains in India. This supply chain involves manufacturers and importers through dealers, hire service providers, repairers and farmers. Large and medium-scale manufacturers have their well-organized country-wide network of distributors and dealers to undertake product promotion and advertising, conduct product awareness training programs for prospective customers, and provide after-sales- services to the customers including free services, repair and maintenance, and supply of parts in their respective territories. However, in the case of small-scale industries, the market size is limited and there is a lack of arrangements, facilities, and services like those for the bigger and medium manufacturers. Besides, there is an absence of standardization of parts and components in the case of small-scale industries.

Self-Propelled Hydrauric Machine for Orchard Management

Open Roof Greenhouse

FARM MECHANIZATION IN INDIA - GROWTH DRIVERS AND CHALLENGES

6. FARM MECHANIZATION IN INDIA - GROWTH DRIVERS AND CHALLENGES

6.1. Growth Drivers

India has been witnessing a growth in the sales and usage of farm machinery and, simultaneously, a downward trend in the usage of animate power (section 5.3). Further, it has been realized that the push for farm productivity enhancement could not be achieved without mechanization (para 5.3). Other drivers of farm mechanization in India include migration-based continuously reducing labor availability, the need for efficiency and timeliness of agriculture operations, increasing labor wages and greater involvement of women. On the whole, the growth drivers can be classified under 3 categories namely, social, agricultural, and economic drivers which are as follows:



Exhibit 19. Growth Drivers for Farm Mechanization in India

Category	Growth Driver	Details
Social growth drivers	Increased participation of women in agriculture	In recent times, the migration of men from rural to urban areas for livelihood has rendered farming a responsibility of women. The strenuous agricultural operations such as transplanting, weeding, dibbling, harvesting, etc. are labour intensive and these are performed by female labourers across the country. Thus, mechanization has become necessary for reducing drudgery.
	Mechanization reduces the drudgery of farm activities	Farm activities are considered to be highly physical-strength demanding jobs where in labourers exert continuously in awkward a nd stressful postures leading to discomfort, pain, and diseases. Hence, the farm workers do not prefer farm activities. Thus, drudgery in farm operations encourages mechanization in farm operations. Since there is a small window of time available for conducting field operations, the need for timeliness of farm activities makes the task more complex.
	As per ILO, the agriculture sector must be a priority area for the elimination of child labour and increasing mechanization is one of the options for elimination of child labour	In India, child labour is involved in tea plantations, cotton cultivation; especially, plucking, and other crops. The majority of children work on their parents' farms, especially, consisting of small land holdings, as unpaid family labour. They get involved in land preparation, seedlings transport and planting, weeding, application of fertilizers as well pesticides, harvesting, and value addition. The children get exposed to sharp tools and dangerous machinery, possibilities of injuries and snakebites, and extreme environmental conditions. Hence, mechanization plays an important role in the reduction of child labour in farm operations.
Economic growth drivers	Increased population and Increases demand for food, fiber and fuel	World population is expected to reach some 9.7 billion people and the population in India will reach 1.6 billion by 2050 which translates into increased demand for agricultural commodities. The recent developments such as COVID, wars, natural calamities, and others also cause shortages of food and raw materials supply.

	Shift of workforce away from agriculture, increased growth of service	There is a declining ratio of agricultural to the total workforce in India from 59.1% in 1991 to 41.49% in 2020. The ratio is expected to decline to 25.7 % by 2030, leading to a severe farm labour deficit.
	Manufacturing sector, increased cost of labour, labour migration to urban areas in search of employment	Service/manufacturing sector GDP growth rates in the country have been higher as compared to that of agriculture over the years. Higher income and growth opportunities in the services and manufacturing sectors are leading to the migration of the workforce away from agriculture. Besides, there is relatively lower wage growth in the agricultural sector as compared to the manufacturing and service sectors. Labour wages account for more than half of the total variable cost of crop production. It is in recent years that agricultural wages have witnessed high growth from Rs. 78 in 2007-08 to Rs. 232 in 2013-14 and Rs.289 in 2021. Hence, increased mechanization is needed to tackle these workforces related challenges.
	Savings in Cost and time leading to efficiency	Mechanization of the agricultural operations makes farming more profitable because of savings in time and cost. Timeliness of farm operations, achieved through mechanization, leads to better and sustainable profits/ farm income.
	Increased FPA increases farm productivity	The land available for farming is more or less stagnant and hence increasing cropping intensity and farm productivity are the ways for higher production. Cropping intensity reduces the time available between two crops. Mechanization of farm operations permits the farmers to carry out farming operations in a short duration or a suitable time space, minimizing weather risks, and optimal utilization of resources.
	Enabling contract farming	Corporates are educating farmers in farming inputs' management, farm mechanization, and precision farming through contract farming agreements, through their dealers and, live demonstrations (ex. M&M and TAFE).

Agricultural and Technological growth drivers	Precision agriculture, wide adoption of System of Rice Intensification (SRI) and Zero Tillage	Mechanization levels in allied sectors such as dairying, fisheries, plantation crops and horticulture, etc. are low. Mechanization can be used at various production stages, e.g., grass harvesting, milking parlour, spreading slurry, silage making, fishing operations, cage culture, aquatic weeding, pesticide spraying, plucking and weeding in plantation crops, and protected cultivation. These practices are picking up slowly and gradually.
	Reducing stubble burning	GoI has launched the Scheme "Promotion of Agricultural mechanization for in-situ management of Crop residue". Various machines/ equipment, e.g., super straw management system (SMS) attachments to the Happy Seeder and combine harvester, Rotary Slasher, Straw Chopper, Rotavator, etc., have been introduced. Due to demonstrations by government agencies,their usage has increased especially in Punjab and Haryana.

Source: Analysis by ASCI Team from the Discussions with Stakeholders; FAO, 2017, and ILO, 2006

6.2. Challenges:

The major challenges identified by the ASCI Team out of discussions held with Development agencies, Scientists, Industries and other stakeholders (stakeholder discussions) in the promotion of farm mechanization in the country are as follows:

- **Fragmented land holdings:** Small size (less than one hectare) and scattered land holdings are not suitable for the use of machinery. Ownership of agricultural machinery individually for small and non-contiguous farms is not commercially viable.

- **Diverse soil conditions, many agro-climatic zones, a wide variety of topography and weather conditions and cropping patterns:** The cultivable land experiences different weather patterns because it is spread across various Agro-ecological zones, soil types, and topographical regions. Differing cropping patterns are the results of these Agro-ecological zones and the soil conditions. For optimal utilization of farm machinery, there is a need to customize the machinery packages for these varying conditions.

- **Supply-demand mismatch:** The utilization of the equipment remains low since the demand is disaggregated and there is minimal synapse with supply points (ex. implements/ machinery owners to those of actual multiple users).

- **Dismal FPA in many states (Exhibit.6 and Fig.5):** The reasons include (i) lack of awareness amongst the farmers, (ii) limited access to information such as the impact of using other equipment and techniques on agricultural yield, (iii) cost-benefit analysis of such equipment, especially, for smaller land holdings, operational realities, minimal CHCs and hiring opportunities, etc.

- **Skewed market towards Tractors:** Indian farm machinery market has been skewed toward tractors and the rest of the farm equipment (sowing devices, planters, seeders, tillers, harvesters, etc.) contributes to less than 50% of the market share (exhibit.4 and para 5.6.2).

- **Quality and serviceability:** Low-income farmers are price sensitive when purchasing farm equipment and opt for locally available equipment from local manufacturers with a lower quality product. While the capital cost is low, the usage of low-quality equipment results in higher operational costs, longer downtime, and poor yields. Additionally, spare parts availability is poor for such locally manufactured equipment. Hence, the cost of servicing customers in rural areas by these manufacturers is usually high and not sustainable.

- **Financial constraints such as the high cost of precision equipment, a subsidy-boosted market, and poor access to finance:** Significant capital investments are needed for acquiring machines such as harvesters (grain combines, sugarcane, cotton, potato), paddy transplanters, and laser-guided land levellers.

- **Capacity-building constraints:** Capacity building is more akin to awareness creation rather than skill development. Lack of skilled manpower is a serious constraint ineffective usage of heavy farm machinery as well as repairs and maintenance services within practical reach.

- **No access on one side and under-utilization on the other side:** Ms. Mallika Srinivasan, TAFE CEO, opined that while, on one hand, a significant fraction of farmers have no or limited access to farm mechanization, about 4.5 million tractors are significantly underutilized on the other. Therefore, as part of their CSR initiative, TAFE is attempting to empower the farmers to contact each other directly for farm mechanization services through a digital initiative (Rising mechanization-will boost-tractor-market, The Hindu Business line dated 16th October 2018).

- **NITI Aayog (2018):** Reported that some of the major challenges to the mechanisation of Indian agriculture are small and scattered land holdings, poor quality of equipment available in the market, the high capital cost of equipment, and non-availability of high-tech precision equipment, and poor after sales services. These challenges hinder faster farm mechanisation growth. It has suggested the following.

  - ✓ There is a need to increase the number of custom hiring centres substantially, especially, in areas with a concentration of small and marginal land holdings.
  - ✓ There is a need to strengthen human resource development; research and development; and testing and standardization in support of agricultural mechanisation.
  - ✓ There is a greater need for research and development efforts toward hill agriculture and horticulture.

- **Skill development** should be taken up in the areas of operation, repair, and maintenance of farm machines.



POLICY/INTERVENTIONS AND SUPPORT FROM GOVERNMENT FOR FARM MECHANIZATION SECTOR

7. POLICY/INTERVENTIONS AND SUPPORT FROM GOVERNMENT FOR FARM MECHANIZATION SECTOR

The historical perspective of the development of the usage of farm machinery in India is furnished in para no.5.1. As mentioned in para 5.1, the spectacular development of farm machinery production and usage has been driven by proactive policies of national as well as regional governments. Important policies include "Industrial Development and Regulation Act, 1951, treating tractor industry as core sector in 1951, and allowing import of farm machineries such as tractors and power tillers and banning of imports of fully built tractors (1973) emphasizing on indigenous production of tractors (Bhattarai, et al, 2018).

The requirements of Government approval and licensing for the manufacturing sector were abolished in 1992, benefitting farm mechanization and the overall economy. India had become an exporter of tractors by this time. A major shift came in 2010 with the introduction of Custom hiring service centres in Karnataka and Punjab by Farmers' cooperatives. Later, SMAM (2014) and diversification of agriculture from cereal-based cropping to high value crops such as fruits, flowers, vegetables, etc. were encouraged. Further, the year 2015 was the beginning of heavy penalties for straw/stubble burning in Punjab and other states, providing an incentive for environmental safety, conservation agriculture and zero-tillage machinery/straw management machinery.

The Automotive mission plan 2016-26 envisages the next 10 years growth trajectory of vehicles, auto-components and tractor industries in terms of size, global footprint, technological maturity and competitiveness, contribution to India's development (12% of GDP), and institutional structure and capabilities.

There are various schemes under implementation at present which give support to the expansion of farm mechanization as indicated in **Exhibit.20.** State governments or various organizations can avail funds for skilling programmes from various schemes such as SMAM, PMKVY, DDUGKY, RKVY, NRLM, allied sector schemes like NLM, MIDH, fisheries, etc. belonging to various ministries. State governments are also spending their budgeted amount on skilling the needy in association with ASCI.

Exhibit 20. National Schemes for Infrastructure under Farm Mechanization

S. No	Name of Scheme	Source of Scheme	Eligible activities	Loan/ Grant	Remarks
1	RIDF	NABARD	Infrastructure in agriculture and rural development	Loan	Proposals routed through finance department of government
2	NIDA	NABARD	Infrastructure in agriculture and rural development (relevant to sub themes on Agricultural extension and rural education institutes)	Loan	To be submitted to concerned regional office of NABARD
3	RKVY	Government of India	For Infrastructure creation. Ex. Madhya Pradesh has availed assistance for setting up of SDCs exclusively for Farm mechanization	Grant	To state governments only
4	Sub-mission on Agricultural Mechanization (SMAM)	Government of India	Infrastructure (Creation and Promotion of CHS, Develop Hi- tech hubs), Testing and demonstration of Agri-machinery	Loan cum grants	State governments as well as the individuals, can avail the benefits through different channels
5	National Food Security Mission	Government of India	Promotion of farm machineries or implements in cultivation of target crops for improved production efficiency	Loan	Gram Panchayats is responsible for the selection of beneficiary farmers
6	Agricultural Mechanization Promotion Scheme	Government of India	Infrastructure in In-situ crop residue management machinery, financial assistance Farmers Societies, Farmer Producer Organization Scheme (FPOS), Self-Help Groups, Women Farmer Groups	Loan	State Governments will identify the need to establish FMB (farm machinery bank), For individual CHC, documents need to be submitted in the concerned district office
7	Pradhan Mantri Krishi Sinchai Yojana	Government of India	Infrastructure to reduce wastage and increase the availability of farm water	Grants	State govt need to apply for PMKSY funds with the District Irrigation Plans (DIP) and State Irrigation Plan (SIP)
8	PM Kisan Tractor Scheme (Yojana)	Government of India	Tractor subsidies	Loan	Farmers can avail of this on the purchase of only 1 tractor with necessary documents in the nearest CSC (Common service centers) center

Sources: nabard.org and https://agricoop.nic.in/en/ministry-major-schemes

Tractor cut section at SDC Bhopal

Tractor repairing workshop at SDC Bhopal in collaboration with John Deere

EXISTING PRACTICES AND TECHNOLOGICAL ADVANCES IN FARM MECHANIZATION

8. EXISTING PRACTICES AND TECHNOLOGICAL ADVANCES IN FARM MECHANIZATION

India has moved forward from severe food shortages in the 1960s to exporter of many agricultural and food commodities at present in spite of the availability of more or less the same cultivated land area. The improvement in availability and usage of farm power and decline in drought power indicates positive trends over the recent past. Further, it has been learnt that the farm operations generally the first to be mechanized are those that require high power inputs with low skill/control such as tillage, transport, water pumping, milling, threshing, etc. Such power intensive activities can normally be done faster and at a lower cost. The next category to be mechanized next is that of operations requiring medium power and skill/control such as seeding, spraying, inter-row operations, etc. However, the last category to be mechanized is those operations that require a high degree of skill/ control and varying levels of power inputs such as transplanting, planting of vegetables, harvesting and grading of fruits and vegetables, etc. The growth in agricultural mechanization in India has also followed this general pattern **(Exhibit. 21).**

Exhibit 21. Stage-wise Farm Mechanization in India

Operation	First Stage	Second Stage	Third Stage
Type	High power, low skill/ control	Medium power, medium skill	Variable power, high skill / control
Stationary	Grinding, milling, crushing, pumping, threshing	Grinding by size,cleaning	Grinding by quality
Mobile	Land preparation, transport	Seeding of grain, harvesting of grain	Transplanting, harvesting of fruits and vegetables, Sugarcane, cotton

Source: Singh G, Agriculture Mechanization development in India, Ind. Jn. of Agri. Econ.Vol.70, No.1, Jan. March 2015.

The existing practices of farm mechanization, technological advances and upcoming and future requirements as analyzed by the ASCI study team are provided in **Exhibit.22.** It gives a fair idea about where the Indian farmers and industry stand in farm mechanization.

Exhibit 22. Existing practices in the farm machinery and future requirements / technological advanced in farm mechanization

Existing practice	Recent Developments and trends	Future Development
A. Soil working /Seed bed / Land preparation		
The farm machinery /equipment used are Tractors, levellers, ploughs, dozers, and scrapers. Tractors have a share (page 15) in the farm equipment market in India. The cumulative share of the remaining farm equipment (sowing machines, tillers, harvesters, etc.) is limited to less than 50% (page15). Medium and large farmers create high concentration of tractors and farm equipment in a specific geography or a zone.	Shift towards high power tractors Shift towards set of tractors along with related equipment Small and marginal farmers alsousing farm machinery through custom hiring centers (CHC) onrent basis Happy seeder/zero till drill encouraged by Govt. schemes	Big data-based mechanization technologies, Internet of Things (IoT), Farming as a Service (FAAS), and AI based mechanization technologies. The technologies can be applied on the model of UBER/OLA to maximize utilization of farm machinery, timely availability at lower costs. TAFE is doing similarly for renting of agricultural machinery. Environment friendly technologies, such as electric tractors and farm machinery State and crop specific strategy as the type of crop production varies from state to state End-to-End crop-wise farm mechanization to boost productivity and farm income
B. Sowing and Planting		
Farm machinery used are drills, seeders, planters, dibblers, and transplanters. Trained human resources are accessed from select states such as Punjab and Haryana Concentration in only few crops like paddy	Shift from manual drills, seeders to power or machine operated ones. Usage of transplanters /planters (Potato, sugarcane etc.) in crops other than paddy is increasing. Skilling through SDCs in MP. Increasing establishment of CHC	Specialized machinery for different crops. Precise placement of seed, seedling, and nutrients. AI based automation with remote monitoring
C. Weeding, inter-cultivation, plant protection		
Farm machinery used are shovels, ploughs, harrows, tillers, sprayers and dusters.	Shift from manually operated sprayer to power operated or tractor mounted sprayers/aero blast sprayers	Image-based real time monitoring of weeds, pests, and diseases. Deployment of mechanical / chemical control measures.

Mostly manually operated by small and marginal farmers.		Usage of drones in plant protection operations Use of data base of plant diseases, Machine learning and AI in identification of plant diseases remotely when farmer submits the live photos/videos of plant diseases
D. Harvesting & threshing		
Farm machinery used are harvesters, threshers, diggers, reapers, shellers, and sickles	Usage of Cotton pickers Harvesters, shellers in maize, and diggers in potato are on the rise There is increasing usage of tractor-operated forage harvester, high hp tractors in silage preparation, and power-operated chaff-cutter Mechanical Harvesting in other than paddy and wheat is on the rise.	Availability of specialized smart machinery for harvesting and threshing of various commodities including cereals, millets, pulses, oilseeds, cotton, sugarcane, vegetables and fruits
E. Post-harvest		
Equipment or machinery used at present are seed extractor, de-husker, dehuller, de-seeder, huller, cleaner, grader, dryer, mill, turmeric boiler, washing and polishing machine, cold chain	Larger and mechanized machines for higher capacity and timely completion of jobs. Specialized and motorized machinery for higher recovery and better quality. Reduction of quantitative and qualitative losses through the development of value chains for different commodities	Process optimization and automation Real-time monitoring and process control By-product value addition and utilization
F. Irrigation		
Micro irrigation (Drip and Sprinkler) pump sets	Fertigation, application of fertilizers/pesticides through irrigation system	Sensor based irrigation systems Detection of sensor based operational problems and taking up of remedial measures
G. Stubble Management		
Straw management system attachments to the happy seeder, combine harvester, rotary slasher, straw chopper, baler, block making machine, and rotavator are presently being used by a few	The scheme is now being actively promoted by governments and many more farmers are coming forward	Value addition to the harvested and / or processed biomass; Biomass briquetting, thermal power generation, production of liquid fuels, structural materials

farmers of Punjab, Haryana, surroundings of Delhi under the centrally sponsored scheme, launched in FY19, on promotion of agricultural mechanization for in- situ management of crop residues in the states of Punjab, Haryana, UP and NCR of Delhi		
H. Farm Machinery/Equipment Market(s)		
India is also one of the largest manufacturers of such equipment as tractors, harvesters, and tillers. Domestic sales of tractors registered a phenomenal CAGR of 10 %. In the year 2019, tractors held the largest share (80%) of India's farm machinery market, followed by rotavator (3.7%), threshers (2.5%), power tillers (1.5%), and others (12.3%). India majorly imports machinery with regard to seeders, planters and transplanters	Growth rate is high in seeders, planters, transplanters, and Number of CHCs	Greater inputs of automation and smart controls. Encourage more of CHCs, and farm equipment banks. Demand for other than tractors, threshers, power tillers, is on the rise

Source: Analysis by the ASCI study team from the data collected and discussions with farm mechanization stake-holders

Today, farm mechanization is a technology that has been recognized as essential for the sustainable growth of agriculture in India. Custom Hiring Centres (CHC) under the Sub-Mission on Agricultural Mechanization (SMAM) scheme of the Government of India (http://www.agricoop.nic.in/) needs to be established in every village. The CHCs and rental services present a powerful mechanism for bringing the benefits of mechanization to small farmers, overall knowledge dissemination, and retaining youth in agriculture. Farm mechanization is well based on science, it has been demonstrated to be beneficial in economic terms, and there is strong policy support for the promotion of farm mechanization. However, the horizontal and vertical growth of farm mechanization at present is constrained by the non-availability of adequate skills.

The farm industry is also contributing to improving Indian agriculture. There is a growing shift in marketing strategy by input and equipment suppliers. In order to enable the farmers to achieve the desired usage of the acquired technology, businesses that were merely selling tractors, seeds, micro-irrigation equipment, Agrochemicals, etc. are now providing packages of practices and related services also. With greater awareness about food quality and to ensure that the best quality raw materials are made available for the food processing industry, there is increasing importance for improving farming practices and farm management. Thus, specialized skills are needed to guarantee the carrying out of the right practices and assuring traceability. Private companies and foundations such as Mahindra and Mahindra, John Deere, TAFE, Tata Kisan Centres (TKS), and Syngenta are contributing towards skill development through their CSR models.

Higher efficiency in agriculture and increased cropping intensity is achieved through farm mechanization and innovative use of such new technologies as precision farming, GIS, remote sensing, robotics, use of drones, bioinformatics, and artificial intelligence. Like para-medics, the availability of skilled human resources at village cluster levels needs to be ensured to cover the whole basket of services. These services cover a wide canvas and include knowledge share, input supply, market links, machine hire and/or use, care of farm machinery, maintenance of horticultural nurseries, and technology support to the livestock, poultry and fisheries enterprises.

Precision farming, involving hi-tech mechanization, is the next higher level of agriculture that requires the farmers and farm workers to possess advanced skills for customized field applications to meet local needs, operation and maintenance, and education/training of future farmers. Precision agriculture means "doing the right thing in the right place at the right time" for maximizing the gains. It requires harnessing modern tools, technologies and innovations, including some or all of the drones, sensors, robots, genetically enriched seeds, nanotechnology, artificial intelligence (AI), etc. Other attributes include reducing production costs, the drudgery of agricultural workers, and attracting youth to achieve environmentally sustainable agricultural production and productivity. Micro irrigation is a proven precision technology to achieve more crops per drop. There is a potential to double the area under micro-irrigation in the next decade because only 7.7 m ha out of a total of 64.7 m ha irrigated area has only been brought under micro-irrigation so far.

Protected cultivation, envisaging the use of a cascade of low-cost technologies and structures, has the potential of increasing productivity and income by several times and can encourage youth (including women) to become entrepreneurs. Protected cultivation in a specific situation needs the application of one or more plastic mulch, low tunnel, walk in tunnel, naturally ventilated poly houses, net houses, and environment-controlled greenhouses. The area under protected cultivation in India is currently estimated to be just about 50,000 ha and there is scope for the area expansion up to 500,000 ha in the near future. China has more than 5 million ha under protected cultivation.

In addition to the production of agriculture, economic and employment security are further strengthened through good post-production value addition, robust entrepreneurship initiatives, and the establishment of agro-processing industries in rural areas besides attracting youth to agriculture-food systems. It would then be possible to substantially enhance farmers' income and reduce wide social inequalities (farmers' average income being one-fourth of that of non-farmers).

There are new employment opportunities for youth in technology driven agriculture in on-farm and off-farm activities. Entrepreneurship in agriculture is getting accepted by people even from non-agricultural streams. IT professionals are helping farmers by bringing artificial intelligence to solve specific agricultural issues. Such knowledge and technology empowered entrepreneurs can make a huge difference in the way agriculture has been perceived so far. In fact, there is an emergence of the agricultural service sector. Farm mechanization services for completing various farm operations in time, in the form of custom hiring centres, have been gaining momentum. Similarly, agricultural machinery service centres provide repair and maintenance support to individual farmers as well as custom hiring centres. There is a huge scope for services in post-harvest processing and logistics sub-sectors.

However, the need for skills to use these modern technologies is very different from those necessary for subsistence traditional agriculture. Thus, policy framework and institutional support are required to make appropriate skills and vocational training available to people engaged in agricultural production and value addition.

Solar Pump

LABOUR AND EMPLOYMENT ASPECTS AND AGRICULTURAL WORKFORCE

9. LABOUR AND EMPLOYMENT ASPECTS AND AGRICULTURAL WORKFORCE

9.1. Labour and Employment Aspects

The Labour force consists of the people who are usually employed or willing to be employed. At any given instant, the whole population cannot be engaged in economically productive activities. A potential labour force of a country consists of those men and women who can produce goods and services. Therefore, the potential labour force does not include those that are physically or mentally challenged, the very young, and the very old. Besides, also excluded are those that are not willing to work and/ or are engaged otherwise (such as in household activities). The workforce includes only those that are actually engaged in economically productive activities. The unemployed labour force, thus, is the difference between the labour force and the workforce. In other words, the employed labour force has termed the workforce. Subtracting the number of unemployed people from the labour force gives the number of actual workers (workforce). These workers are further categorized as persons who are engaged in any activity as self-employed or regular wage/salaried and casual labour **(Exhibit.23).**

Exhibit 23. Number (millions) of workers employed in various occupation types for the year 2019-20

Sector	Self-Employed	Regular Wage/Salary	Casual Labour	Total
Non-Agriculture	100.8	113.3	64.9	279.0
Agriculture	173.3	4.1	56.0	233.4
Total	274.1	117.3	120.9	512.4

Source: Chand R and Singh J. Discussion Paper on Workforce changes, NITI Aayog, 2022

Overall, as per PLFS survey 2019-20, persons of 15-59 years age group undertaking formal as well as informal vocational/technical training comes to 14% only and persons receiving Formal vocational training are less than 5% **(Exhibit.24).**

Exhibit 24. Persons receiving Vocational and Technical Training in Total workforce

Age group in years	No of persons	Persons receiving Vocational and technical training (formal + other than formal)	% Persons receiving Vocational and technical training (formal + other than formal)	Persons receiving Vocational and technical training (formal only)	% Persons receiving Vocational and technical training (formal only)
15-29	30,06,20,000	3,59,33,200	12	1,22,10,200	4.06
15-59	71,80,02,000	9,98,11,100	14	2,30,39,500	3.21

Source: PLFS 2019-20

Estimates derived from the Periodic Labour Force Survey (PLFS) 2019–20 show that 86.2 million agriculture workers were females and 147.1 million were males (total agricultural workers are 233.4 million). The PLFS data also show that three fourths of agriculture workers were self-employed as cultivators and this share remains more or less stable. The survey results show that the primary sector, i.e., agriculture, forestry and fishing sector, is the major employer in the country. Out of total workers, the percentage distribution of workers in agriculture in all India during the PLFS survey 2017-18, 2018-19 and 2019-20 is 45.6, 42.5 and 44.1% (Figure.7), respectively, on the Usual Principal Status basis.

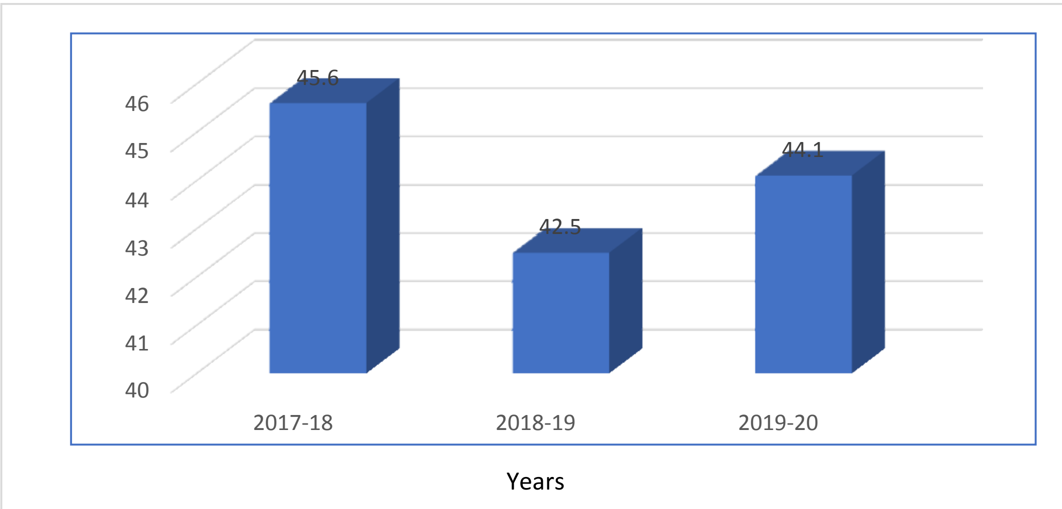

Figure 7. Percentage share of agricultural workers in total workforce in India

Labour Force Participation Rate (LFPR) is estimated to be 52.5 per cent under the Usual Principal Status (UPS) approach at the all India level. The Worker Population Ratio (WPR) is estimated to be 50.9 per cent at the all India level. In comparison, LFPR is reported to be nearly 74 per cent in China, 67 per cent in Canada, 64 percent in the United States of America, 62 per cent in the United Kingdom and 60 per cent in Japan. LFPR and worker population ratio in percent for different categories is as follows in **Exhibit .25:**

Exhibit 25. All India worker population ratio and labour force participation rate (LFPR) in percent for different categories in 15 years and above age group

Sector	Labour Force Participation Rate (LFPR)			Worker population ratio		
	Male	Female	Person	Male	Female	Person
Rural	74. 7	29.1	54.7	74.4	32.2	53.3
Urban	73.8	18.5	47.2	69.9	21.3	45.8
Rural + Urban	74.4	25.8	52.5	73.0	28.7	50.9

Source: PLFS survey 2019-20

A vast majority of the Indian workforce consists of those that are employed in informal or unorganized sectors. The informal economy encompasses more than 90 per cent of the workforce and about 50 per cent of the national product. Informal economic activities absorb a high proportion of the socially and economically underprivileged workforce. Indian agriculture at present engages far too many people for its workforce in relation to its contribution to the national economy. In fact, the country needs to shift a large proportion of its workforce from farming to more remunerative and meaningful employment in allied and non-farm sectors. Besides, traditional farming needs to be transformed into modern, more efficient, sustainable, and productive farming.

India has a great opportunity waiting to take shape. Two-thirds of the population is in the 15–69 years bracket, forming the labour force. The country gains immensely by transforming this human resource into a labour force to the extent possible. While the current labour force participation rate (LFPR) in the country is around 52.5%, the dilemma today is whether the LFPR could be raised to 60% or more.

At the current growth rate, India's population would grow to more than 1.5 billion by 2030, i.e., about 100 million more than that in 2022. Keeping the labour force participation rate constant, India would have 60 million more people entering the labour force, under this demographic scenario, and seeking employment by 2030. During 2012-18, there were 3.7 million workers annually who moved out of agriculture. At this rate, India's farm employment would reduce from the 2018-19 figure of 44 percent of the total to about 30 per cent in 2029-30. Thus, during 2022-30, at least 90 million new non-farm jobs are required to be created.

9.2. Agricultural work force dynamics

The sustainability of agricultural and rural developments requires them to be ecologically sound, economically viable, culturally appropriate, humane, socially just, and based on a holistic scientific approach. There were about 173 million self-employed people in Indian agriculture in 2019-20. These are essentially the land owners, fishermen, cattle farmers, poultry farmers, etc. Besides, there are about 60 million regular and casual wage earners assisting these self-employed people. Although the data suggest that the agricultural workforce is shrinking on account of small farmers leaving the land, the number of waged agricultural workers is increasing in absolute and relative terms. The majority of the agricultural workforce in India is neither educated nor skilled. Lack of skills has impeded the rate of new technology absorption in agriculture and, subsequently, the growth rate.

First electric tractor tested early this year (2021) at FMTTI, Budhni, Madhya Pradesh

Agricultural labour productivity continues to be dismally low on account of a large variety of inputs, levels of technology, and output market constraints. It is, therefore, not surprising that young people are disinterested to perform low-paying and hard farm work. One of the strategies is to accelerate productivity-enhancing investment in agriculture in conjunction with the movement of workers off the farm elsewhere. Agricultural production is required to be increased with fewer farm workers to facilitate the movement of workers off the farm. This would reduce the disparity between the wages of farm and non-farm workers.

Integrated solutions that overcome several constraints causing low farm productivity are needed. Inclusive value chain development (iVCD) links farmers with buyers in contracting arrangements to offer access to credit and inputs, and higher (less volatile) prices for a consistent volume of high-quality produce. The development of iVCD is expected to benefit the poor by raising the smallholder incomes. One can also foresee through consumption linkages that jobs off the farm, in the value chains and beyond would be created.

What is needed now is to ensure the use of labour-saving technologies for agricultural development while workers move away from the farm. For raising agricultural labour productivity while making sure that those leaving can access the new jobs, it is critical to invest in people. This investment for skilling will pave the way for the people to find remunerative employment in the agriculture-food system as well as other non-farm sectors. Then the rising economic aspirations of rural youth would be met. Clearly, what is needed is the continued investment in quality rural education. As a result of pulling about 30 million workers out of agriculture and getting them absorbed in the manufacturing and services sectors, the net labour force in agriculture in 2030 would be only about 175 million.

SKILL DEVELOPMENT IN FARM MECHANIZATION – CURRENT INFRASTRUCTURE, SKILLING PROGRAMMES AND GAPS

10. SKILL DEVELOPMENT IN FARM MECHANIZATION – CURRENT INFRASTRUCTURE, SKILLING PROGRAMMES AND GAPS

The share of the skilled labour force to the total labour force in India as per HDR 2020 is at 21.2% only as compared to the highly skilled labour force in advanced countries such as Germany (87.3%), Norway (84.3%), United Kingdom (84.4%), Belgium (86.6%), the USA (96.5%), Singapore (84%), Australia (78.9%), Japan (99.9%), etc. As per the National Skill Development Policy (2015), it was projected that 109.93 million additional workers would be needed by 2022 in 24 sectors. It should, however, be kept in view that about 93% of workers are engaged in the informal sector.

There is a need for designing non-traditional skill-building programs in conjunction with effective agricultural extension programs for creating human capital, especially, in those areas where the traditional approaches have failed. Every day is witnessing the infusion of advanced technologies in the seed-to-plate value chain. One of the objectives of high-end technologies, such as robotics, is to reduce human dependence on improving not only the work efficiency but also the end product's quality. Farmers may venture into those production activities that require reduced human effort. There is, on the other hand, a trend from more affluent clientele for niche products, e.g., fresh, locally-grown fruits and vegetables, organic and environmentally friendly produce, using fair trade and possibly better labour practices. Such demands from a specific section of society seek to increase labour demands compared to field crops where automation would be more advanced.

An advanced agricultural and food system would certainly need people skilled in the application of high-tech machines and practices. There is increasing input of information technology in agricultural production and value addition operations. In such a scenario, the relevance of uneducated/ unskilled workers would vanish sooner than later. Therefore, the existing agricultural workforce needs to either get skilled or move out to other sections of the national economy for their survival. A prosperous farm sector needs a policy framework necessitating skilled farm entrepreneurs and workers. Larger, wealthier and better-educated farming entrepreneurs are in a far better position to adopt new technologies. The future farm workforce is going to be younger and better educated/skilled than the current workforce. It should, however, be realized that there are likely to be some phase lags among human capital formation, technological interventions, and new employment opportunities, leading to short-term adjustment issues.

10.1. Current Skill Training Infrastructure in Farm Mechanization Sector

The promotion of sustainable agricultural mechanization requires both, technical expertise as well as skills in field applications. The stakeholders in the creation of human resources through technical education and research are ICAR and its institutes such as IARI, CIAE, CIPHET, AICRPs on Farm implements and machinery, and state agriculture universities (numbering 63), IITs and other agricultural engineering colleges (233) including private colleges. These human resources serve to occupy management and highly technical jobs in the industry, teaching and research faculty, state governments, and so on.

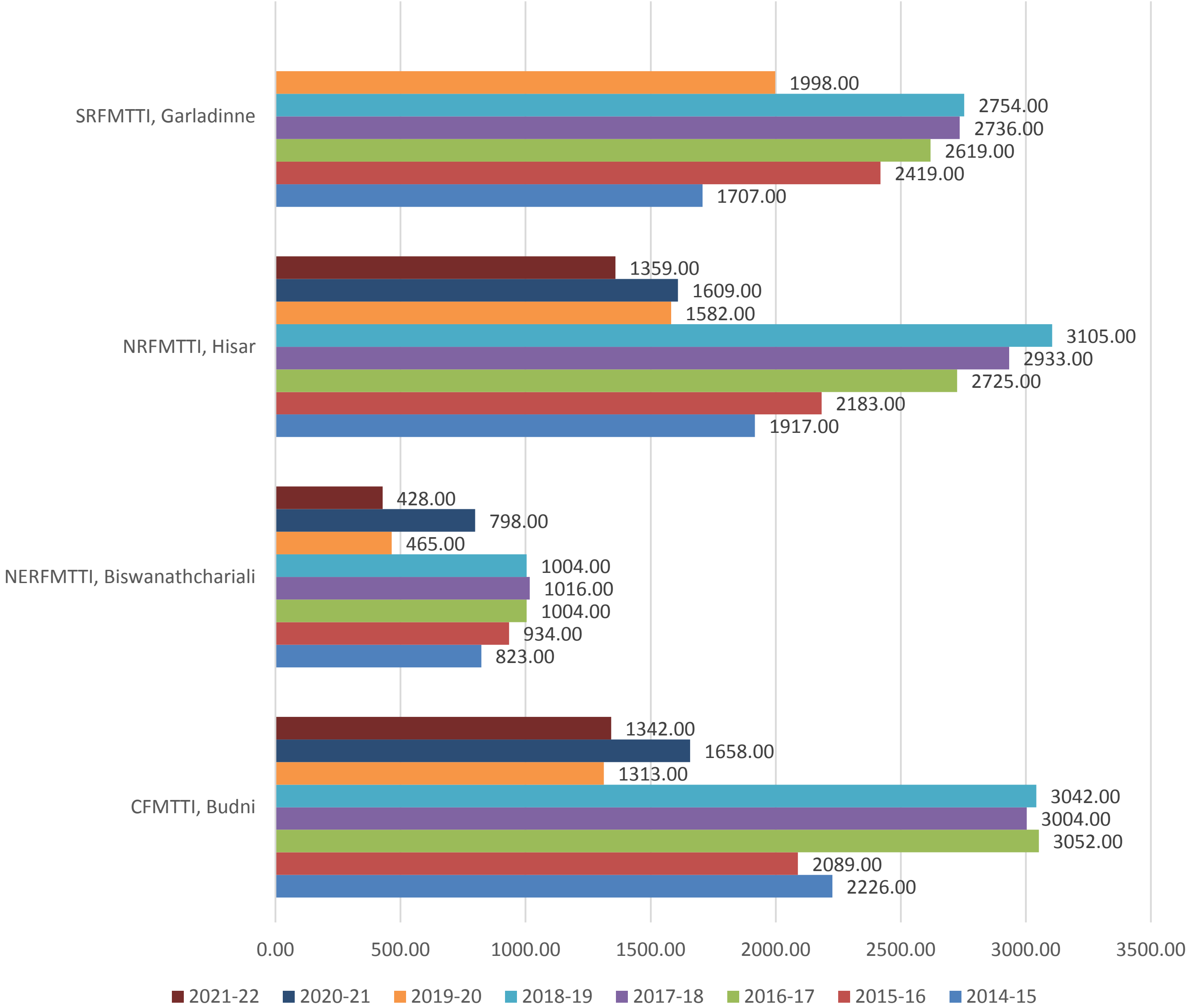

Figure 8. Training programmes conducted by FMTTIs in Farm Mechanization

Source: Data from agrimachinery.nic.in and analysis by ASCI team

10.2. Trainings conducted and types of trainings

The government of India through its Sub-mission on agricultural mechanization (Government of India website on agricultural machinery) set the target to train 1,48,000 persons in order to create skilled manpower in the farm mechanization sector and conduct 19,000 demonstrations on farmers' fields in 5 years starting from 2014-15.

The promotion of sustainable agricultural mechanization requires both, technical expertise as well as skills in field applications. The stakeholders in the creation of human resources through technical education and research are ICAR and its institutes such as IARI, CIAE, CIPHET, AICRPs on Farm implements and machinery, and state agriculture universities (numbering 63), IITs and other agricultural engineering colleges (233) including private colleges. These human resources serve to occupy management and highly technical jobs in the industry, teaching and research faculty, state governments, and so on.

In respect of skilling programmes, various stakeholders such as FMTTIs (4 in number) of MoAFW, KVKs under ICAR institutes, SAUs/ recognized universities by ICAR, agricultural engineering colleges, Government Agriculture/agricultural engineering departments through Skill development centres (SDCs), developmental agencies and manufacturers provide training programmes of a wide variety, i.e., demos, exposure visits, awareness programmes, hands-on skilling, etc. Although there are 725 KVKS, at least one in each district, they don't have mandatory agricultural engineering faculty. As a result, only a few farm mechanization programmes are conducted by KVKs. The state governments conduct programmes through their training centres, Skill development centres (SDCs) under various schemes such as SMAM, and RKVY, and their budgets. Department of Agricultural Engineering, Madhya Pradesh 23 has established 5 exclusive skill development training centres for farm mechanization at divisional headquarters, namely, Bhopal, Jabalpur, Sagar, Satna and Gwalior in PPP mode under the Rashtriya Krishi Vikas Yojana (RKVY). The private partners are leading tractor manufacturers of the country, e.g., Mahindra and Mahindra Ltd., CNH India Pvt, Ltd. (Formerly known as New Holland Fiat India Pvt. Ltd.) and John Deere India Pvt. Ltd.

The total trainees from 2014-15 to 2021-22 were 55,844. The total number in the year 2019-20 and subsequent years was reduced due to COVID (Figure.8). The monitoring and evaluation report of SMAM, 2020 assessed the course-wise details of trainees under different FMT&TIs during 2017- 19 and indicated that the shares of different courses, i.e., user-level (1-6 weeks), technician level (3-6 weeks), academic level (for students 4 weeks or as per the sponsor), need-based, management level (one week), National Skills Qualification Framework (NSQF), and Apprenticeship were 23.9, 6.2, 19.6, 39.1, 7.3, 3.5 and 0.4%, respectively. A few interesting facts reported in this report are as follows.

- The majority of the trainees were with higher Secondary education.
- The trainees belonged to families with income less than Rs. 2,00,000.
- The trainees had prior experience of using agricultural machines, possibly learnt locally.

With respect to KVKs, less than 10% of KVKs have agricultural engineering faculty, usually, just one in each KVK. Hence, the training/skilling programmes on agricultural mechanization conducted at KVKs are few. The states of Madhya Pradesh and Punjab have been running SDCs successfully by associating suitable private players in PPP mode. As per the Directorate of Skill Development, Madhya Pradesh report, SDCs are established in either PPP or private sector in Madhya Pradesh. In the case of Madhya Pradesh, after the selection under SMAM/CHCs scheme, the candidates are sent for a mandatory week-long technical training at either one of the SDCs, FMTTI (Budhni), or CIAE (Bhopal) as a condition to qualify for the bank loan. Also, the applicant is required to acquire a set of essentially minimum equipment needed for farm activities from ploughing to harvesting in his/ her zone of operation.

Further, training through diploma courses in agricultural and farm machinery is available at a very few ITIs and general courses are available. The ASCI study team observed that the percentage of ITI/diploma holder students along with those attending the SDC skilling programmes seeking employment /establishing their own unit garage/repair centre varied from batch to batch, i.e., 30-40% (Exhibit.26). This observation is corroborated by Skill report of CII, 2021 which indicates that the employable talent of ITI students was 44% in 2015 and got reduced to 29.46% in 2018.

The study team observed (during discussions) that the majority of the skilled trainees, undergoing farm mechanization skill development training, were farmers' children from rural areas and belong to the poor category (Exhibit 26). Almost all of them indicated that the batch size was 25 - 30. Out of a batch, around 6-8 trainees were with Polytechnic Diploma/ITI background and were getting jobs in good companies such as M&M, John Deere, Subros, Kalyani Auto Parts, Eicher tractors, Tata, etc. Around 5-6 trainees were joining the local tractor and other agricultural machinery dealers. A few (5-6) of the trainees were operating their own machinery on their own land as well as on rent. The remaining trainees were working as operators or mechanics at the local level.

The skilled trainees expressed that there was a problem in availing loans and establishing their own unit (CHC / service/garage) due to margin money and security issues as they belong to poor families. Further, out of 17 candidates with whom the discussions were held, 3 told that the training was not directly useful for them in getting jobs since they got the jobs based on their graduation qualification (B.Sc – computers and B.A). It can, however, be said that these trainees added value to their qualifications and the added value may become more useful in future. One candidate established CHC, employing 12 part-time and 4 full-time persons (3 are skilled in tractor and harvester), and facing difficulty in getting skilled employees. A few candidates (25%) expressed that they would like to establish their own CHC/garage/service centre after gaining experience and around 25% of the candidates indicated that they would like to learn /attend advanced courses or learn other upcoming machinery.

Exhibit 26. Discussion Outcome with Skilled Trainees

(In Nos.)

S. No	Parameters	Yes	No
1	Belongs to Rural areas	16	1
2	Parent's income less than 2 lakh	17	3
3	Parents Occupation is agriculture	13	4
4	Skill training in Tractor	14	-
5	Skill training in Harvester	4	-
6	Skill training in Tractor and harvester	3	-
7	Skill training helped in getting job or own unit	14	3
8	Would like to go for Advanced training in FM	5	12
9	Would like to establish their own garage /service centers after gaining experience	5	12
10	Established own unit (CHC)	1	-

Source: Study team discussion with Skilled trainees and analysis

10.3. Skill Gaps

The stakeholders, in general, asserted that there was certainly a strong need for skilling in farm mechanization. The responses of the stakeholders to specific questions on areas where the gaps existed are summarized in **Exhibit.27.** All have indicated that there is a skill gap existing in the areas of "operation of all farm machinery and especially tractors with implements, repair and maintenance at operators and mechanic levels". The respondents (40-50%) expressed the willingness to have skilling programmes in advanced repair and maintenance, advanced technologies and new and innovative technologies. About one-third of respondents wanted to skill in entrepreneurship and about half of the respondents wanted a special focus on women. About 20% opined that crop-wise mechanization from soil preparation to threshing would give good results since a few of the machines can be operated only for a limited time of the year. The approach allows the human resource to get full time employment, and increased efficiency in farm operations for all farmers, even small-farmers.

Exhibit 27 Gaps identified in Farm Mechanization skill development by various stakeholders

S. No.	Category of institutions	Skill gaps identified - In numbers who said yes (Y) for a skill gap										
		Operation of farm machines along with implements	Repair and Maintenance – Technician level	Repair and Maintenance – Mechanic level	Advanced repair and maintenance	Skilling in advanced technologies	CHCs economics, profitability and management	New / Innovative technologies for SAUs, Depts. etc	Apprenticeship / Industrial training for ITI / Agri Eng. students	Crop-wise mechanization training from soil prep to threshing	EDP training	Special skilling programme for women candidates
A	Central & State* Govt. Department	1	1	1		1	1	1	1	1		
B	State Agricultural Universities (SAU)	8	8	8	2	7	7	8	3	2	6	8
C	ICAR Institutions in farm mechanization	2	2	2	1	2	1	2	1		1	1
D	Farm Machinery Training & Testing Institutions (FMTTI)	4	4	4	1	1	2	1	4			2
E	Industry / Corporates	5	5	5	2		2		2	1		
F	Training Centre – Agri Machinery manufacturers	4	4	4	3		2		4	1		
G	Industry Association	1	1	1	1	1	1		1		1	1
H	Development Institutions	2	2	2	2	2	2	1			1	1
	Total	**27**	**27**	**27**	**12**	**14**	**18**	**13**	**16**	**5**	**9**	**13**
	In %	**93**	**93**	**93**	**41**	**52**	**67**	**48**	**56**	**19**	**33**	**48**

*Officials of ICAR and MoFWA opined that overall skilling is required in farm mechanization and hence not counted under specific query.

Source: Stakeholder interaction and analysis by ASCI Team

The state specific needs as indicated by stakeholders are furnished in **Exhibit.28.** The major needs identified are "non-availability of operators/mechanics for harvesters and planters within the state and sourcing from other states", "machinery varies with region/topography" and "changing cropping pattern changes the type of farm machinery". There are special needs in some places such as aquatic weeding and related issues, CHC management and profitability, women focused training, etc.

Exhibit 28. Some state-specific skilling needs indicated by Stakeholders

S. No.	State-Specific needs	States
1	Faced problems in harvesting and transplanting of crops due to Covid travel restrictions as operators came from Punjab and Haryana. Tamil Nadu operators were going to Kerala and other, neighboring states.	MP, Orissa, Bihar, Kerala, AP, and Telangana
2	End-to-end crop-wise solutions for farm mechanization	Madhya Pradesh
3	Small land holdings and hence required small tractors, tillers, harvesters, etc. small equipment suitable for small holdings. And need training/skilling accordingly	UP, Karnataka, and Kerala
4	Level and the type of farm mechanization are different in different regions due to topography, i.e., coast, hills, low lying areas, areas below mean sea level and plains and have a variety of crops as millets, plantation crops, horticultural crops, exotic crops	Karnataka, Kerala, Tamil Nadu, Uttarakhand
5	In the Saurashtra region, the cropping patterns changed from groundnut to cotton. In many states cropping patterns changed to vegetables and horticultural crops, high value exotic crops and hence need suitable machinery for those crops and skilling to be done accordingly.	Gujarat, Rajasthan, Tamil Nadu, Karnataka, Uttarakhand
6	Aquatic weeding and other machines and skilling in those operations	Kerala
7	CHCs/FMBs/Hitech hubs – management, economics and profitability, accounting, management of books,	Punjab, Haryana, and all other states
8	EDP training in establishment of enterprises such as CHCs/FMBs, individual hiring units, etc.	AP, Telangana, Haryana, Orissa, Bihar, Karnataka, Kerala, MP, and Gujarat
9	Transportation of fuel (diesel, petrol), machinery and crops are difficult in hilly terrain and hence need smaller machines	All states with hilly areas
10	Due to labour migration, especially male members, and also for the reduction of drudgery of women, women should be trained in farm machinery operations and upkeep	Uttarakhand, Bihar, Rajasthan, UP, etc.
11	CHCs – operation, repairs and maintenance and advanced training in Farm mechanization	All states
12	Women focused on Skill training to reduce drudgery and focus on other productive activities	All states
13	General awareness module on farm mechanization and agricultural profitability with sustainability	All states, all stakeholders of agriculture and food sector
14	Solar pumps	All states and all stakeholders

SKILL GAP ESTIMATES

11. SKILL GAP ESTIMATES

Skills need to be developed for use in manufacturing, marketing, servicing, repair, operation, and management of farm machines for their convenient access and application. Estimation of skill requirement, of course, would depend on the existing status of farm mechanization in the country. On the basis of the foregoing discussion, an effort is being made in this section to arrive at some credible numbers representing skill requirements.

11.1. Manufacturing of Agricultural Machinery

Agricultural machinery here is represented by a very diverse range of prime movers, tools, implements, machines, and gadgets that are used for accomplishing timely mobile and stationary operations for agricultural production, value addition, by-products utilization, and resource management. Manufacturing of farm machinery of such diverse proportions is carried out at different locations in the country in formal as well as informal sectors.

11.1.1. Geographic locations of Agri Machinery Manufacturing in India

The major manufacturing and assembly plants in respect of agricultural machinery in India are provided in the Exhibit 29 given below. However, there are many medium and smaller plants which are also located in these states. The states of Punjab, Haryana, Uttarakhand, UP, Himachal Pradesh, Tamil Nadu, Maharashtra, Madhya Pradesh, Karnataka, and Rajasthan are recognized as the major agricultural machinery manufacturing hubs.

Skill training at SDC, Madhya Pradesh

Exhibit 29. Agri Machinery Manufacturing hubs in India

S. No.	Name of Major Manufacturer	Place	State
1	Mahindra group (Mahindra and Swaraj)	Mumbai, Nagpur	Maharashtra
		Mohali	Punjab
		Jaipur	Rajasthan
		Rudrapur	Uttarakhand
		Zahirabad	Telangana
		Rajkot, Vadodara, Amreli	Gujarat
2	Sonalika	Hoshiarpur	Punjab
3	John Deere	Pune	Maharashtra
		Dewas	Madhya Pradesh
4	Eicher Ltd. (TAFE acquired it in 2005)	Alwar	Rajasthan
		Mandideep	Madhya Pradesh
		Parwanoo	Himachal Pradesh
5	TAFE	Doddaballapur, Bangalore	Karnataka
		Chennai, Kalladipatti, Madurai	Tamil Nadu Tamil Nadu
6	New Holland	Greater Noida	UP
		Pune	Maharashtra
		Pithampur (near Indore)	Madhya Pradesh
7	Escorts, Power trac, Farmtrac	Rudrapur	Uttarakhand
		Doddaballapur, Bangalore	Karnataka
		Faridabad	Haryana
8	Force motors	Akurdi and Chakan	Maharashtra
		Pithampur (near Indore)	Madhya Pradesh
		Chennai	Tamil Nadu
9	Kubota	Pune	Maharashtra
		Chennai	Tamil Nadu
10	VST	Hosur, Mysore and Malur	Karnataka
11	CLASS	Morinda, Chandigarh	Punjab

Source: ASCI Study Team

11.1.2. Workforce Distribution and Incremental Manpower Requirement

As per the Annual Industries survey, an average of 9000 workers and 2900 other-than-workers (managerial level and other employees) were added annually during 2018-19 **(Exhibit.30).** These were the net additions and therefore, the considerations of retirement, attrition and death rate were assumed to be included. The year-on-year growth rate of the total number of persons was seen to be varying heavily **(Exhibit.30)** due to such factors as COVID, inflation, geopolitical issues, etc. Hence, the growth rate per annum had been conservatively assumed to be 15%. The breakup considered for incremental skilling at various levels, i.e., workers and managerial level is given at **Exhibit.31** and the assumptions are as follows:

- Using Annual Industry survey data, the net additions of persons in factories derived for the year 2018-19 and, with 15% growth rate, the personnel added for the year 2020-21 is calculated. In 2020-21, 11865 workers and 3839 managerial personnel were added.

- Of these (11865 workers and 3839 managerial personnel) 75% of skilling is met from employment ready freshers as well as training given to freshers at the time of joining by farm machinery industries. Hence, only 25% of the new workforce is considered for skilling purposes which works out to 2966 rounded off to 3000 and 960 rounded off to 1000, respectively for the year 2020-21.

- Of these (3000 workers), 50% (1500 workers) to be skilled as mechanics /technicians and rest 50% (1500 workers) as advanced mechanics/ technicians with additional and latest skills. Similarly, of 1000 managerial personnel, 50% (500 persons) are proposed to be skilled as managers and the rest 50% (500 persons) as advanced managers.

- Estimates of Skilling needs in subsequent years, i.e., from **2022-23 to 2026-27** assume the growth rate of 15% per annum, i.e., personnel in the current year = (1.15) x personnel in the previous year.

- The estimated incremental skilling requirement for factory personnel for the years from **2022-23 to 2026-27** with base year as 2021-22 is furnished in **Exhibit.31.**

Exhibit 30. Data on manpower in manufacture of agricultural machinery

S. No.	Particulars	2016-17	2017-18	2018-19	Growth rate in %		Additions / Year 2018-19	Additions /Year 2019-20	Additions /Year 2020-21
					2016-17 to 2017-18	2017-18 to 2018-19			
1	No. of Factories	797	1052	915	31.99	-13.02			
2	Total no of persons engaged	60829	80343	92218	32.08	14.78			
3	Workers (no)	45350	58620	67592	38.42	15.31	8972	10318	11865
	1.1 Directly employed	27730	42459	42883	53.12	1.00			
	Men	26799	41156	41491	53.57	0.81			
	Women	931	1303	1392	39.96	6.83			
	1.2 Employed through contractors	17620	16161	24709	-8.28	52.89			
	2. Employees other than workers	15479	21723	24626	40.33	13.36	2903	3338	3839
	2.1 Supervisory and Managerial	7639	9366	9614	22.61	2.65			
	2.2 Other employees	7840	12357	15012	57.61	21.48			

Source: Data from Annual Survey of Industries, 2016-17, 2017-18 and 2018-19 and analysis by ASCI Team

Exhibit 31. Estimated Incremental Skilling requirement for factory personnel/ manufacturing

(Number of persons per annum)

S. No.	Factory personnel	Job role	2021-22 (base year)	2022-23	2023-24	2024-25	2025-26	2026-27	Total Incremental from 2022-23 to 2026-27
A	Workers	Mechanics /Technicians	1500	1725	1984	2281	2624	3017	11631
		Advanced Mechanics/ Technicians	1500	1725	1984	2281	2624	3017	11631
B	Other than workers-managerial	Managers	500	575	661	760	875	1006	3877
		Advanced Technologies for managers	500	575	661	760	875	1006	3877
C (A+B)	Factory personnel	Total /year	4000	4600	5290	6082	6998	8046	31016

Source: Analysis by ASCI Team from data from Exhibit 30

11.2. Dealerships and Services

Dealership is an essential link in the farm machinery supply chain. Dealers represent the manufacturers in terms of demonstrations, sales, after-sale services, and any other support that may be deemed necessary and agreed mutually between the vendor and the vendee. The dealers employ certain people with appropriate farm machinery skills.

11.2.1. Organization Design of Dealerships

Generally, the dealerships have the following structure and the numbers may vary. Hence, ranges are given for various positions.

Exhibit 32. Organization Design of Dealerships

Exhibit 32. Organization Design of Dealerships

General Manager					
Sales Department	Service Department	Parts	Accounts	Customer Relationship	Machinery Insurance
⇩					
1 Sales Manager (Graduation)	1 Service Manager (Diploma and 5 years of Experience)	1 Mechanic (ITI or Diploma)	1 Accountant (CA)	1 Customer-care executive (Graduation)	1 Insurance executive
⇩					
7-10 Sales Men/Women (12th pass to Graduation)	3-5 Mechanics (ITI or Diploma), 1 Helper and 1 Field assistant			1 Tele caller (12th pass to Graduation) 1 -Service adviser/Mechanic (ITI or Diploma)	1- Machinery Inspection mechanic (ITI or Diploma), 1- Documentation person (graduation)

Source: Discussions with Stakeholders and Analysis by ASCI Team

11.2.2. Geographical Distribution of Dealerships

Manufacturing of agricultural machinery is concentrated in a few states whereas the dealerships are spread across the country. The dealerships provide sales, services and spare parts. Certain dealerships are associated with relevant demo units, help in initial operations of machinery, and crop advisory. For example, M & M dealerships have been found to be associated with these types of services. The agricultural machinery dealerships are located more in rural and semi urban/II and III tier towns rather than metros/big cities. Each dealer is involved in multiple products and not just tractors. Hence, the figures given below in the exhibits are used for estimation of manpower associated with dealerships (total dealerships numbering 7569) in the country. The state-wise numbers of dealerships are given below in Exhibit.33 and the brand-wise numbers are at **Exhibit.34.** Each brand sells all types of the products related to agricultural machinery/equipment.

Exhibit 33. Tractor and other farm machinery dealers in various states

State	No. of dealers	State	No. of dealers
Uttar Pradesh	1308	Jharkhand	136
Madhya Pradesh	898	Assam	70
Maharashtra	767	Jammu & Kashmir	64
Rajasthan	564	Himachal Pradesh	39
Karnataka	538	Uttarakhand	33
Bihar	506	Kerala	26
Gujarat	507	Manipur	8
Haryana	386	Delhi	5
Tamil Nadu	314	Mizoram	3
Punjab	285	Goa	3
Orissa	262	Arunachal	2
Chhattisgarh	238	Tripura	2
Telangana	231	Nagaland	2
Andhra Pradesh	220	Pondicherry	1
West Bengal	150	Andaman	1

Source: Collected data from tractorjunction.com/find-tractor-dealer

Exhibit 34. Brand-wise Dealerships of Agricultural Machinery Manufacturers

Name of the Company	No. of Dealers	Name of theCompany	No. of Dealers
Mahindra	1011	Force motors	285
Swaraj	948	Kubota	284
Sonalika	869	VST	253
John Deere	795	Escorts	197
Eicher	715	Solis tractors	93
Massey Fergusson	647	Captain	7
New Holland	552	Same Deutz Fahr tractors	7
Power trac	451	Preet	5
Farm trac	442	Indofarm	3

Source: Collected data from tractorjunction.com/find-tractor-dealer

11.2.3. Employment Scenario/Workforce Distribution and Incremental Human Resource Requirement

As indicated above, the total number of tractor and agricultural machinery dealerships are 7569 in the country. The workforce designations related to mechanical services and parts have been adopted for workforce estimation. The incremental workforce estimate norms are given below.

- Estimated incremental workforce = Number of incremental persons employed per annum per dealership x number of dealerships

- The growth rate is assumed as 5% (as taken for various machinery in para 5.6.2).

- In general, dealers are recruiting the ITI, Diploma holders and trainees from skill development training centers. Past trends suggest that about 30% of the employment needs in this sector could be met through the output of the existing ITIs and Diploma programmes. The remaining 70% of the Estimated incremental workforce would require the skilling intervention.

- The corresponding ASCI job roles are Agriculture Machinery Repair and Maintenance Service Provider, Farm Workshop Foreman/ Supervisor, Farm Workshop Service Manager, Service and Maintenance Technician -Farm Machinery.

The estimation of year-wise workforce and skill needs from 2022-23 to 2026-27 is given at **Exhbit.35.**

Exhibit 35. Estimated workforce Distribution, Incremental Workforce and Estimated Incremental Skilling needs per Annum for the Farm Machinery Dealerships

S. No.	Type of Skill	No. of Persons per dealer	EWF 2021-22	Estimated incremental workforce (EIWF)					Estimated Incremental Skill Need Estimate (SNE)					
	Particulars		Number of persons per dealer x 7569	2022-23	2023-24	2024-25	2025-26	2026-27	2022-23	2023-24	2024-25	2025-26	2026-27	Total SNE from 2022-23 to 2026-27
1	Service Manager	1	7569	378	397	417	438	459	265	278	292	306	322	1463
2	Mechanics in Service Department (persons/ dealer)	3	22707	1135	1192	1251	1314	1380	795	834	876	920	966	
		5	37845	1892	1987	2086	2190	2300	1324	1391	1460	1533	1610	
	Average	4	30276	1514	1590	1669	1752	1840	1060	1113	1168	1227	1288	5855
3	Mechanics in Parts inventory mgmt. Customer-care/ Tele services Departments (persons/ dealer)	3	22707	1135	1192	1251	1314	1380	795	834	876	920	966	
		6	45414	2271	2385	2504	2629	2760	1590	1669	1753	1840	1932	
	Average	4.5	34061	1703	1789	1878	1972	2070	1193	1252	1315	1380	1449	6589
4	Total (s.no.1 + average of s.no.2 +average of s.no.3)		71906	3595	3776	3964	4162	4369	2516	2642	2774	2913	3058	13903

Estimated workforce (EWF), Estimated incremental workforce (EIWF) and Skill Gap Estimate (SGE)
Estimated workforce in 2021-22 = No of persons per dealer x no of dealers, i.e., 7569
Estimated incremental workforce in 2022-23 = 5% of the workforce in 2021-22 and EIWF for sub-sequent years with a growth rate @ 5% on EIWF in previous year
Estimated Incremental Skill Need Estimate (SNE) is @ 70% of the EIWF in each year

Source: Analysis by ASCI Team

11.3. Key Skill Sets – Importance of Skills/Jobs Roles, Additional Skill Sets Required for Existing Job Roles, New Job/Skill Sets Required

As mentioned in chapters 5.5 and 8 and as per analysis of ASCI team, there is gradual change in the usage pattern of machinery for various agricultural operations such as soil preparation, sowing/planting, crop protection, harvesting, post-harvest processing and straw management operations. As of now there is no danger of losing/endangering existing skill sets except for a few hand-operated tools and lower-level machinery /equipment. There is now a shift from tractor or power-tiller operated machinery to self-propelled, and even autonomous, machinery. Tractor operated/ mounted implements and additional coverage of other crops under mechanization are creating skilling opportunities for these agricultural machines. This became apparent during COVID lockdown period, i.e., for want of operators for transplanters and harvesters, the machines stood still in many states of the country.

Big data-based mechanization technologies, Internet of Things (IoT), Farming as a Service (FAAS), and AI based mechanization technologies are already taking roots in the Indian agricultural system. These technologies can be made available on the model of UBER/OLA to maximize the utilization of farm machinery and timely availability at reasonable costs. TAFE is following a similar strategy for renting agricultural machinery. The requirement will be growing in these sectors. In very near future, environment friendly technologies such as electric tractors and farm machinery; state and crop specific mechanization strategies; image-based real time monitoring of weeds, pests, and diseases; deployment of mechanical / chemical control measures; usage of drones in plant protection operations; greater inputs of automation and smart controls, etc. will invite greater acceptability and usage. New job-roles need to be created in these areas and the existing job-roles will need to be upgraded. On the manufacturing side also, involvement of AI and robots, new machinery and technologies encourage the manufacturers to seek skill upgradation of their managerial staff and workers.

11.4. Skill Gap Estimate – Field Level

Farm mechanization applications, not limited to crop production only, extend to dairy, animal husbandry, poultry, and fishery. Besides, farm mechanization applications also extend to value addition, by-products utilization, and energy management. Sustainability calls for circular agricultural and food economy. Therefore, farm mechanization must synchronize with the concepts and practices of circular agri-food economy.

11.4.1 Manpower required for various machines for operation and maintenance/repairs at field level *(Mechanics/technicians at village level and operators at farmer level for various agricultural machinery)*

Data sources for annual market of various machinery are as follows:

Exhibit 36. Data sources for annual market of various machinery

S. No.	Technology	Source
1	Tractors and power tillers	Chapter 7, Agriculture and Food Management, Economic Survey 2021-22
2	Planters	CSAM Agri mech 2018 ppt
3	Powered machines (weeders, threshers, sprayers, and laser levelers) and polyhouses	NITI Aayog demand supply report page 118 and CASM ppt
4	Micro-irrigation	https://agrionline.nic.in/dash/dash.html;
5	Harvesters	https://www.researchandmarkets.com/reports/5012239/india-combine-harvester-market-growth-trends
6	Solar pump sets	https://mnre.gov.in/solar/current-status
7	Custom Hiring Centers	Agrimechinery.nic.in

The data for all categories of the machines and technologies have been extrapolated based on previous growth rates and to make projections for the year 2021 and beyond (**Exhibit.38).** Wherever the growth rates have been high (tractors, harvesters, etc.), there has been an effort to moderate them by taking a realistic view on account of COVID, inflation, world geopolitical impact on economy, etc. For example, the growth rate for tractors during the last 3 years was @ 8.5% per annum; however, the future growth has been assumed as 5% only.

Ministry of Renewable Energy (GoI) under Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM KUSUM) scheme in off-grid areas, i.e., where grid supply is not available, is supporting individual farmers for the replacement of existing diesel agricultural pumps / irrigation systems of up to 7.5 hp capacity by stand-alone solar agriculture pumps. Installation of new pumps will also be permitted under this scheme, except in dark zone areas. Target is 1.75 million pumps by 2022. Obviously, there is a need to develop a skilled and employable workforce catering to the needs of Solar PV industries to install, operate, repair & maintain the solar systems. The Ministry of Renewable Energy has been conducting such programmes but there is a shortfall in the achievement of the targets. Since around 80000 to 1 lakh solar pumps are expected to be installed every year, there is a need for manpower to operate and service these pumps. The required human resource is assumed @ 1 skilled person for every 30 solar pumps and, therefore, the requirement will be to skill 2000 to 3000 persons annually (agricultural irrigation pumps data at iea.org).

The number of Custom hiring centers (CHC), Hitech Hubs and Farm Machinery Banks (FMBs), established initially in 2014, was 1113 and it grew to 9017 gradually in 2020 with an average growth rate of 13.26% since inception **(Exhibit 37).** The year on year growth rate is varying considerably. Hence, the growth rate is assumed @15% on conservative side, in view of the present macro-economic situations, to estimate the skilled persons requirement. There is a general need for 2 mechanics and technicians per CHC; some have just one and a few do not have any mechanics (Report of SMAM monitoring and evaluation).

Exhibit 37. CHCs, Hitech Hubs and FMBs data

S. No.	Year	Custom Hiring Centers (CHCs)	Hi-Tech Hubs	Farm Machinery banks	Total	Growth rate per year in %
1	2014	663	14	436	1113	
2	2015	268	13	218	499	-55.17
3	2016	1458	13	1877	3348	570.94
4	2017	1851	47	1852	3750	12.01
5	2018	3614	106	1469	5189	38.37
6	2019	2155	60	1964	4179	-19.46
7	2020	3938	55	5024	9017	115.77
8	**Average growth rate since inception**					**13.26**

Source: Data from Agrimechinery.nic.in and Analysis by ASCI Team

Exhibit 38. Year-wise sales/estimated sales, growth rates and considered growth rates of Agricultural machinery and equipment

S. No.	Year	Tractors	Power tillers	Planters	Harvesters	Power weeders	Laser # land Levelers	Seed cum fertile -izer drills	Poly houses	Power threshers	Power reapers	Power sprayers	Micro-irrigation (Drip+ Sprinkler)	Solar pump sets installed per year
1	2011-12	535210												
2	2012-13	590672	47000										573438	
3	2013-14	696828	56000	15000									431503	
4	2014-15	551463	46000	15341	6000								425535	7875
5	2015-16	626839	48882	15689	6420	35000	3500	57000	4000	75000	15000	10000	572980	18043
6	2016-17	580000	45200	16045	6869	35700	3675	60000	4275	78750	15750	10500	839964	31472
7	2017-18	796873	53800	16409	7350	37485	3859	63000	4500	82688	16538	11025	1048934	53044
8	2018-19	897548	51523	16782	7865	39359	4052	66150	4725	86822	17364	11576	1158519	56350
9	2019-20	785100	46500	17163	8415	41327	4254	69458	5209	91163	18233	12155	1170051	65892
10	2020-21	988000	54200	17552	9004	43394	4467	72930	5500	95721	19144	12763	937761	35036
11	CAGR Growth rate % based on past figures	8.5%	1.7%	2.1%	7.0%	2.0%	5.0%	5.0%	5.0%				3.0%	
12	Considered growth rate	5.0%	1.5%	2	5.0%	2.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	3.0%	
13	Number of newly added machines/ year at 50% of the sales/year*	Of the 494000, 75% are for agricultural and 25% for other purposes. Thus, for agriculture the number is 370500	27100	8776	4502	21697	2233	36465	5500	47861	9572	6381	468881	80000 to 100000 and average 90000@

**Of the total, 50% is replacement and 50% new. Therefore, the new additions are considered @50% for all the machines, except polyhouses which are just picking up. Among the tractors, out of the new additions of tractors, 75% are for agricultural purposes and 25% for other purposes.*
 # Tractor drawn levelers are not included here as they are included in Tractors with implements.
@ Every year 80000 to 1 lakh (average 90000) solar pump sets to be established (target) by MNRE and hence the same figure has been taken for calculation

Source of Data: *Tractors – Chapter 7, Agriculture and Food Management, Economic Survey 2021-22; Planters - Data from CSAM Agri mech 2018 ppt and calculated based on NITI Aayog demand Supply; Power weeders power threshers, power sprayers, Laser levelers, Polyhouses: NITI Aayog demand supply report and CASM ppt; Micro-irrigation data: https://agrionline.nic.in/dash/dash.html;*
Harvesters - https://www.researchandmarkets.com/reports/5012239/india-combine-harvester-market-growth-trends and Solar pump sets - https://mnre.gov.in/solar/current-status/

Exhibit 39. Skilled manpower required per unit and per 100 units of the machines at Field level

S. No.	Skilled Manpower Requirement for Farm Machines	Operators / Unit	Mechanics & Technicians / 100 Units	Farmers Skilling	Agronomic Services	Entrepreneurs/ Managers
1	Tractors with equipment	1	2			
2	Power tillers, weeders, drills, etc.	1	2			
3	Planters	1	2			
4	Harvesters	3	2			
5	Power weeders	1	2			
6	Laser levelers	1	2			
7	Seed cum fertilizer drills	1	2			
8	Polyhouses	1	2	1	1/100 units	
9	Power threshers	1	2			
10	Power reapers	1	2			
11	Power sprayers	1	2			
12	Micro-irrigation equipment including installation	1	1	20% of the farmers	1 / 100 units	
13	Solar pump-sets – installation, repairs and maintenance	1	1 for every 30 solar pumps			
14	Custom Hiring Centres (CHCs)	1	2			1
15	Kisan drones Advanced equipment and technologies @1/5000 ha	1	1			1

Source: Assumptions and Analysis by ASCI Team

ASCI job role-wise estimation of incremental skilling needs is given below for 5 years for various agricultural machinery operated at farm level including kisan drones and CHCs/FMBs/Hitech Hubs in rural and sub-rural areas which include operation, repair and maintenance related jobs such as operations, mechanics and technicians.

Exhibit 40. Estimation of Incremental Skilling Needs of Manpower in Farm Mechanization at Field Level (Mechanics/Technicians at Village Level and Operators at Farmer Level)

S. No.	ASCI Job Role	Job Roles For Skill Estimation	2021-22 (base)*	2022-23	2023-24	2024-25	2025-26	2026-27	Total from 2022-23 to 2026-27
1	Tractor Mechanic And Tractor Operator	Operators	370500	389025	408476	428900	450345	472862	2149609
		Mechanics/ Technicians	7410	7781	8170	8578	9007	9457	42992
2	Power Tiller Operator	Operators	27100	27507	28882	30326	31842	33434	151991
		Mechanics/ Technicians	542	550	578	607	637	669	3040
3	Rice Transplanter Machine Operator Cum Mechanic	Planters – Operators	8776	8952	9399	9869	10363	10881	49463
		Mechanics / Technicians	174	177	186	196	205	216	981
4	Harvesting Machine Operator	Harvesters Operators	13506	14181	14890	15635	16417	17237	78361
		Mechanics / Technicians	90	95	99	104	109	115	522
5	Agri Machinery Mechanic	Power Weeders Operators	21697	22131	23237	24399	25619	26900	122287
		Power Weeders Mechanics/Technicians	434	456	478	502	528	554	2518
6	Agri Machinery Mechanic	Laser Levellers -Operators	2233	2345	2462	2585	2714	2850	12956
		Laser Levellers – Mechanics and Technicians	45	47	50	52	55	57	261
7	Pesticide And Fertilizer Applicator,	Seed Cum Fertilizer Drills Operators	36465	38288	40203	42213	44323	46540	211567
		Seed Cum Fertilizer Drills Mechanics and Technicians	729	765	804	844	886	930	4230
		Power Sprayers Operators	6381	6700	7035	7387	7756	8144	37022
		Power Sprayers Mechanics and Technicians	128	134	141	148	156	163	743
8	Green House Fitter And Operator	Operators	5500	5775	6064	6367	6685	7020	31911
		Mechanics And Technicians	110	116	121	127	134	140	638
9	Operator - Reaper, Thresher & Crop Residue Machinery	Operators, Mechanics/ Technicians For Power Threshers And Reapers.	58581	61511	64586	67815	71205	74766	339881
10	Micro-irrigation Service Technician	Micro-irrigation Operator, Mechanic/Technician	98490	101445	106517	111843	117435	123307	560546
11	Solar Pump Technician	Operator	90000	94500	99225	104186	109396	114865	522172
		Mechanic/Technician	3000	3150	3308	3473	3647	3829	17406
	Sub-total		**751891**	**785631**	**824911**	**866156**	**909464**	**954936**	**4341098**
12	Kisan Drone	Technicians and Operators	9000	11250	14063	17578	21972	27466	92329
	Sub-total		9000	11250	14063	17578	21972	27466	92329
13	**Custom Hiring Centers**								
a	Custom Hiring Service Provider	CHC Operators	9017	10189	11514	13011	14702	16613	66029
		CHC Mechanics/ Technicians	18034	20378	23028	26021	29404	33226	132057
b	Farm Workshop Foreman/ Supervisor And Farm Workshop Service Manager	CHC-Entrepreneurs	9017	10189	11514	13011	14702	16613	66029
	Sub-total		**36068**	**40756**	**46056**	**52043**	**58808**	**66452**	**264115**
14	**Total In FM At Field Level**		**796959**	**837637**	**885030**	**935777**	**990244**	**1048854**	**4697541**

**Estimate of base year* = *Machinery Figure at s.no. 13 of Exhibit.38 x no of operators or mechanics/technicians in Exhibit.39*
Growth rates as per the s.no. 11 of Exhibit.38 applied to the base figures and derived data for year 2022-23 and similarly for subsequent years.
***Kisan drones** @1/1500 ha works out to 90000 drones and of these 10% are considered for skilling in 2021-22. Applied growth rate of 25% from 2021-22 to estimate skill requirement in subsequent years.*
Data on Number of CHCs established is provided in Exhibit.37.
Source: Analysis by ASCI Team

Drone is a new technology for agriculture promising multiple applications in terms of input use and surveillance. Government of India is encouraging the use of drones on farms including accreditation of centers for skill development. The cost of drones, limited availability of technically trained pilots, and an enabling policy are the major constraints in expansion of drone applications in India. Government of India unveiled a certification programme for agricultural drones in January, 2022. The government has offered the Farm Machinery Training and Testing Institutes, ICAR Institutes, KVKs, and State Agriculture Universities 100 % subsidy up to March 2023, to encourage the use of drones for agricultural purposes.

The global drone market within agriculture is projected to grow at 35.9% CAGR and would reach $5.7 billion by 2025. M/s Blue Weave Consulting have conducted a study of drone market for Indian agriculture, forecasting a four-fold increase in drone deployment by 2028, with a projected CAGR of more than 25% during 2022 – 2028. One of the manufacturers of drones is Chennai-based Garuda Aerospace, a home-grown startup who plan to manufacture 100,000 drones in the next 2 years.

Command area of a drone varies with its size and the application. The next decade is the period of exponential growth in drone population for agriculture. Taking a conservative figure of 1500 ha coverage of cropped area by one drone, Indian agriculture would need 90,000 drones. Agricultural drones will have to be offered through custom hiring centers.

11.4.3. Skilling in Other Agriculture and Allied Services / Activities:

As indicated earlier, farm mechanization is generally taken as meeting the mechanization needs of traditional crop production, harvesting, and threshing. However, the domain of farm mechanization extends to new and innovative applications for production, i.e., protected cultivation; value addition; and by-products utilization activities pertaining to crops, dairy, animal husbandry, poultry, and fishery. At present, protected cultivation (controlling crop micro-climate and nutrition); Primary agro-processing covering cleaning, grading, drying, sorting, dehusking, dehulling, packaging and reaching to warehouse, etc.; biomass management (biomass collection, processing and value addition); and drainage and tube-well equipment are attracting youth for entrepreneurship because of higher income generation and other benefits. These activities, beyond traditional crop production, are essential in order to reduce post-harvest losses, maintain quality of the product, boost exports, preserve/protect environment, and generate additional employment. An effort has been made to project the skilling needs in these areas **(Exhibit.41).** The Testing and quality assurance services, and consulting / advisory / insurance services are also needed by farmers in the field. These services are provided by many of the state governments through agriculture departments at a nominal charge. For all these services, the NSQF packs are yet to be developed and skilling would be provided upon development of these.

Further, it is emphasized that the mechanization inputs are going to be important in sectors such as livestock, fishery and poultry for such activities as the operation of Machines and maintenance related to housing, micro-climate, feeding, byproduct and product management. However, the needs of these sectors are being taken care by respective skill gap assessment studies and hence they are not being projected here under skilling estimates in respect of the agricultural farm mechanization.

Exhibit 41. Incremental Skill Requirement in Other Agricultural Activities

S. No.	Focus Area	Key Activities of Focus Areas	Unit Skill Requirement	Total Require-ment	2022-23	2023-24	2024-25	2025-26	2026-27	Total Incremental From 2022-23 To 2026-27
1	Controlled Environment Agriculture in 500,000 ha	Protected cultivation structures, hydroponics, aeroponics, controlled environment systems, operation and management of facilities	Technicians @ 1/ha	500000	50000	52500	55125	57881	60775	276281
			System manufacture @ 1/10 ha	50000	5000	5250	5513	5788	6078	27629
2	Primary Agro-processing centers @ 1/village, i.e., 700,000 units	Machine operators and Technicians	Operators and Technicians @1	700000	70000	73500	77175	81034	85085	386794
3	Biomass management @1/200 ha	Operators and Mechanics/Technicians- Biomass collection, processing	Operators and Technicians @1	750000	75000	78750	82688	86822	91163	414423
4	Drainage and tube-well equipment operation and services @ 1/2000 ha	Equipment management, operation and services	Operators and Technicians @ 1	150000	15000	15750	16538	17364	18233	82885
	Total			**2150000**	**215000**	**225750**	**237039**	**248889**	**261334**	**1188012**

Exhibit 42. Incremental Skill Requirement in Other Agricultural Services

1	Testing and quality assurance services 100,000 centers	Soil, water, raw materials and product quality	Lab technicians @ 1	100000	10000	10500	11025	11576	12155	55256
2	Consulting / advisory / insurance 100000 units	DPR, procurement, supervision, financial management, insurance products	Consultants @1	100000	10000	10500	11025	11576	12155	55256
	Sub Total			**200000**	**20000**	**21000**	**22050**	**23152**	**24310**	**110512**

 # It is assumed that the total work force requirements would take a 10-year period for the skilling to achieve the adequate levels.
Skilling requirement in 2022 is @10 % of Total requirement
Annual growth rate of 5% per annum over previous year for all in rest of the years
Source: Analysis by ASCI Team

11.4.4. Students:

There are 233 Agricultural Engineering Colleges and 34 Diploma colleges in India with around 11000 seats. Internship is mandatory for B. Tech /B. E and apprenticeship is mandatory for Diploma students. About 25 %, i.e., **2750 / annum** can be tapped for skill courses at CoE-FM. Further ITI students can also be tapped for skilling programmes in farm mechanization. There are 13,353 ITIs and the annual student intake is 19.4 lakh. About 15000/ annum of these students can be trained and skilled in agricultural machinery related focus areas.

11.4.5 Faculty:

For advanced technologies, 1000 faculty members of these agricultural engineering and diploma colleges (@ 4-5/college (4 or 5 x 233)) need to be trained annually.

11.4.6. Agri Engineering Officials:

Agricultural engineers are employed in different central and state government agencies. These agricultural engineers need to be kept up to date with the changing scenario of farm mechanization locally as well globally. It is projected that 1000 officers from all over India are trained annually.

Skill Training at SDC Madhya Pradesh

11.5. Summary of Skill Requirement / Needs in Farm Mechanization Sector

Year-wise and job role-wise summary of the total incremental skill requirements/needs in farm mechanization sector is presented in the Exhibit.43. The total requirement for ASCI job role-wise skilling of operators, mechanics and technicians needed for dealerships, at field level for various agricultural equipment and machinery, CHCs, solar pumps, micro-irrigation and Kisan drones is 47.11 lakhs and factory personnel is 0.31 lakhs for a period of 5 years. During the same 5 years period, there is a need for skilling 98,750 persons from academia, students, and government officials.

In addition, there would be a need for about 12.98 lakh skilled workers annually **(Exhibit 41),** not included in the current estimates of skilling needs in farm mechanization, for such activities as controlled environment agriculture, agricultural processing, biomass management, drainage equipment, testing and quality assurance services, and consulting / advisory / insurance.

All these estimations bring home the fact that skill requirements and gaps in farm mechanization are varied and very high. Mechanisms would need to be developed for achieving these skilling milestones.

Exhibit 43. Total Estimation of Incremental Skilling Needs for Various Activities of Farm Mechanization

S. No.	Focus Area	ASCI / Non-ASCI Job Roles	Year-wise Incremental Skilling need in person numbers per annum						
			2020-21 (Base)	2022-23	2023-24	2024-25	2025-26	2026-27	Total from 2022-23 to 2026-27
A	ASCI Notified Job Roles								
1	Dealerships level (Service Manager, Mechanics/ Technicians)	Agriculture Machinery Repair and Maintenance Service Provider, Farm Workshop Foreman/ Supervisor, Farm Workshop Service Manager, Service and Maintenance Technician -Farm Machinery	-	2516	2642	2774	2913	3058	13903
2	At field level ((mechanics technicians at village level and operators at farmer/village level) which includes operators and Mechanics/Technicians for various farm machinery, Poly house/ Greenhouse, Micro-irrigation and Solar pump sets, Kisan drones and CHCs	Operators, Mechanics/Technicians, and Demonstrator for all agri-machinery, Micro-Irrigation Service Technician and Solar Pump Technician, Poly-houses,	751891	785631	824911	866156	909464	954936	4341098
		Kisan drones	9000	11250	14063	17578	21972	27466	92329
		Custom Hiring Services	36068	40756	46056	52043	58808	66452	264115
	Sub Total			**840153**	**887672**	**938551**	**993157**	**1051912**	**4711444**
B	ASCI Yet to be Notified Job Roles								
3	Manufacture of agricultural and forestry machinery	Mechanics /Technicians Advanced Mechanics/ Technicians Managers, Advanced Technologies for Managers	4000	4600	5290	6082	6998	8046	31016
4	Officials and Academia	Officials, Faculty and Internship for Students of Graduation & 3-year Diploma Apprenticeship ITI		19750	19750	19750	19750	19750	98750
	Sub Total			**24350**	**25040**	**25832**	**26748**	**27796**	**129766**
C	**Grand Total**			**864503**	**912712**	**964383**	**1019905**	**1079708**	**4841210**

KEY ACTIVITIES AND SKILLS/JOB ROLES RECOMMENDED

12. KEY ACTIVITIES AND SKILLS/JOB ROLES RECOMMENDED

ASCI has notified skill development programmes in the area of farm machinery that have been aligned to NSQF. These job roles include Tractor Operator, Harvesting Machine Operator, Agriculture Machinery Operator, Agriculture Machinery Repair and Maintenance Service Provider, Custom Hiring Service Provider, Irrigation Service Technician, Service and Maintenance Technician- Farm Machinery, Agriculture Machinery Demonstrator, Tractor Mechanic, Farm Workshop Foreman/Supervisor, Farm Workshop Service Manager, Solar Pump Technician, Rice Transplanter Machine operator, Operator - Reaper, Thresher & Crop Residue Machinery, Combine Harvester Machine Operator, Power Tiller operator, Micro - Irrigation Service Technician.

In alignment with the above job roles and as analyzed by the ASCI study team, along with the valuable inputs from various stakeholders, the following major areas including the new technologies require immediate attention in order to strengthen Indian agriculture through farm mechanization for higher land productivity and profitability **(Exhibit 44).**

Exhibit 44. Value chain-wise Key Areas and Activities

Key Area and Activity	Justification/Need for the skilling
A. Seed bed preparation	
Operation of Tractors with implements	Many farmers and drivers/operators driving tractor without proper training, leading to accidents, inefficiency of machinery and higher cost of operation. The operators must understand the role of depth control and forward speed regulation and know the methods to achieve them practically.
Skilling in repair and maintenanceof tractors with implements to establish rural, satellite or mobile workshops	Repairs and maintenance are available in towns or cities and taking the heavy machinery to the cities or towns is difficult. Hence, the skilling in repairs and maintenance is necessary to make such facilities available locally.
Usage of tractor implements for better productivity	Proper usage of implements as per crop, soil and terrain needs to be made.

Key Area and Activity	Justification/Need for the skilling
B. Sowing, planting, and transplanting	
Calibration and operation of seed drills and planters	Depth control and precise metering for placement of seeds directly affects the cost of the operation and the crop growth
Operation of transplanter including growing of nursery	Different states like Odisha and Madhya Pradesh depend on skilled human resource from Punjab and Haryana, creating difficulties in those states during Covid-like emergencies, and peak demand for transplanting (limited period) for these operators leading to increased operational costs. Concentration of usage of transplanters is in only a few crops like paddy. Hence, transplanter usage needs to be increased in other crops such as sugarcane, cotton, and horticultural crops for better productivity and to tackle labour shortage.
Repair and maintenance of transplanters	Different states like Odisha and Madhya Pradesh depend on skilled human resource from Punjab and Haryana and the services are available mostly with dealers or district head quarters
C. Irrigation and drainage	
Pump installation and operation	Correct installation of irrigation pump sets for efficient operation is essential. Besides, the pumps need to be operated with the maximum water output and minimum specific energy input.
Operation and maintenance of micro-irrigation systems	Drip and sprinkler irrigation systems can provide irrigation to the maximum number of plans/trees if maintained properly and operated in accordance with the recommended practices.
Design and installation of micro-irrigation systems	The technicians must be able to take into account all the site and equipment related parameters to arrive at the most suitable design specifications. Besides, the micro-irrigation systems, so designed, must be installed so as to achieve long operational life while maintaining the operational efficiency
D. Weeding & plant protection	
Operation, repair and maintenance of power operated or tractor mounted sprayers/ Aero-blast sprayers	Since shifting from manual sprayers to power operated sprayers, it is needed that the operators are skilled to ensure precise application of the agricultural chemicals while minimizing the drift and other losses.
Usage of advanced technology such as drones and other forms of artificial intelligence	Advanced and futuristic technologies to cover large areas in shorter time efficiently need to be learnt and practiced by the prospective operators.
E. Harvesting & threshing	
Operation and repairs of Combine harvesters, crop specific harvesters	Different states like Odisha and Madhya Pradesh depend on skilled human resource from Punjab and Haryana, creating difficulties in those states during Covid-like emergencies. Therefore, a pool of skilled operators should be available in each of the user states. Other than wheat and paddy, usage of harvesters is increasing in maize, potato, cotton, sugarcane, pulses, oilseeds, and forage crops.
Operation and repairs of threshers	Down-time for threshers needs to be minimized to complete the operation in the available short window of time. Therefore, the operation, maintenance, and repair skills need to be available locally.
Usage of cotton pickers	To reduce shortage of adult labour, eliminate child labour and facilitate clean picking, mechanical and power operated cotton- picking devices need to be used
Operation of Orchard management machines	There is going to be increasing adoption of machines for fruit orchards like sprayers, pruners, and harvesters. Skills in safe and efficient operations of these machines would need to be imparted to prospective operators

F. On farm post-harvest value addition operations	
Operation, maintenance and repairs of threshing, dehulling, and milling machines	Usually, threshing is popular in paddy and wheat but it is to be popularized for other crops for higher and better quality product/ crop output. Hence awareness, operation, repairs and maintenance of these machines are essential
Cleaning, de-stoning, sorting,	In order to create higher quality produce, better market and price
Grading, and packaging	Operations like cleaning, de-stoning, sorting, grading and packaging can be carried out on farm using mechanized equipment. farmers/cooperatives/FPOs can add value to their produce and market it on their own. Hence, skilling in such activities will lead to better income to farmers.
G. Stubble management/crop residue management for environmental protection	
Straw management system (SMS) attachments to the existing machines in addition to the stand- alone systems	It is needed to manage stubble for environment protection and reduction of pollution. Especially, there is demand for operation of balers and block making machines in those states where stubble is needed to be managed.
H. CHCs/FMBs/Hitech hubs	
Awareness programmes or advisory services for selection of crop-wise, region-wise machinery to keep at these centers	All machinery is not suitable for every area and crop. CHC entrepreneurs need to know the criteria for the selection of machinery for specific crop, soil, region and climate for high performance and revenue.
Crop-wise end-to-end farm mechanization solutions	Industry discussions indicated that from soil preparation to harvesting and threshing of a crop, e.g., paddy or potato, by using machinery at all levels increases productivity by 25 to 30% and reduces cost by around 20% and total profitability doubles. Hence, farmers, CHCs etc. should be trained to use such solutions as efficiently as possible
Economics, profitability, account keeping and other management practices	To improve profitability of mechanization, these issues are necessary and hence adequate skills are needed.
I. New Areas	
Farm machinery applications in livestock and fishery sectors	Farm mechanization is expected to expand in the production and post-harvest operations related to livestock and fishery sectors. Therefore, skills would be needed for operation, repair and upkeep of relevant equipment and machinery.
Renewable energy gadgets:operation and maintenance	Farm mechanization in the very near future will be making use of renewable energy gadgets for greater sustainability of agriculture. Proactive action on skilling of operators and maintenance personnel is needed now in collaboration with the manufacturers.

The above summary of key skilling activities is not exhaustive. There are many skills related to farm mechanization that have not been reflected in the summary for brevity. However, as the activity keeps expanding, such skilling requirements would become apparent. A moot question at this stage is why a person should undergo skilling and how it could be materialized.

WHY SHOULD ONE GET SKILLED?

WHY SHOULD ONE GET SKILLED?

A person knows that the acquisition of adequate skills in a chosen domain adds value to the person's capabilities in terms of efficient execution of work in that domain and, therefore, justifies preferential employment and/ or higher wages. But it has been observed that skill acquisition does not necessarily lead to higher wages for the skilled person unless the effect of skilling is reflected tangibly in the overall value chain. Agriculture and agricultural employment are mainly in the informal sector. Therefore, it is not easy to focus on skilling and skilled human resources, especially in farm mechanization, from an employment perspective.

Unskilled or partially skilled machinery operators are available in the informal domain at lower wages and, thus, get employed easily. The skilled people feel that their skilling efforts are wasted. The question, therefore, arises about the utility of skilling. Although skilling and skilled human resources are well recognized in the domain of formal farm mechanization, the same is not quite visible in the informal domain. In this scenario, how to promote skilling?

Initially, prospective employers need to be aware of the benefits of skilling. Clearly, farmers and farming entrepreneurs must be exposed to the basics of farm mechanization and how the mechanization leads to improved production, value addition, and utilization of by-products for the generation of employment and income. The presence of such enlightened farmers and entrepreneurs is a prerequisite for promoting farm mechanization and skilling activities. Skilling should lead to preferential hiring, i.e., the skilled worker should get preference over the one who is unskilled. All skilled persons should be certified by accredited bodies. All schemes of farm mechanization promotion must build skill acquisition as the essential eligibility condition for availing of the scheme benefits.

In order to put the farm mechanization skilling in the right perspective, it is essential to have a well-illustrated and professionally produced audio-visual module in regional languages to provide a basic understanding of farm mechanization, governmental infrastructure and programmes for farm mechanization promotion, success stories, and enabling skill development programmes. This two-to-four-hour foundation module on farm mechanization will create a fertile mindset for accepting farm mechanization and allied programmes. This foundation module can be conveniently delivered by KVKs.

OVERVIEW AND RECOMMENDATIONS

13. OVERVIEW AND RECOMMENDATIONS

India is poised to be the World's second or third largest economy by 2050 and the country would have 1.6 billion people by that time. Almost 50% of the estimated population in 2050 (800 million) would live in cities. The workforce in agriculture (part-time and full-time) would get down to about 10% of the total workforce. Many of the agricultural workers would have additional non-agricultural sources of income to meet their needs. The share of agriculture in the national GDP would be about 5% in the year 2050.

A typical farmer in 2050 would be a well-informed and tech-savvy professional in network with other fellow farmers who would have real-time information on natural resources available, including weather data, to precisely plan the production and value addition activities by utilizing the modern machinery in a sustainable manner. He/she would have market intelligence to ensure immediate disposal of the produce, thereby, reducing losses and maximizing returns. A significant portion of production activity whether crops, livestock or fishery, would be in the form of protected production technology as part of urban farming.

Although people would own their small farms, they would become a part of some sort of cooperative plan, e.g., FPO. Such people would generally be working in cities and maintaining their links with the cooperatives utilizing their farm holdings. Techno-economic feasibility of speciality agriculture such as vertical farming, hydroponics, soilless agriculture, ocean farming, cultivation in problematic soils, etc. would greatly improve.

Developments of inefficient and feasible energy storage devices (particularly for electricity) would govern their use for mobile energy demands in agriculture.

Machines would be redesigned to suit alternative energy sources such as bio-diesel, fuel cells, solar chips, portable energy sources and multi-fuel options. Agricultural mechanization tomorrow would utilize green energy generated from newer and renewable sources. The overall goal would be to balance the energy from agriculture and energy from agriculture for sustainability.

An effort has been made in this report to create a scenario of future Indian agriculture and the role that farm mechanization would play to realize the intended goals. The introduction of mechanization in Indian agriculture has picked up pace recently. Horizontal and vertical growth of farm mechanization in the country, of course, depends upon the enlightenment of the farmers and farm entrepreneurs about farm mechanization and the availability of the skilled human resource. The report has attempted to visualize various drivers of growth in farm mechanization and focus on the need for skill development to achieve the growth targets. The recommendations emerging out of this effort are as follows.

Recommendations:

It has been observed that there is a huge annual skilling requirement if the full advantage of farm mechanization is intended to be derived, i.e., 2.8 million at present, rising to 3.6 million in the year 2030. The recommendations for better implementation and assimilation of farm mechanization skilling programmes are Categorized as related to policy, linkages among academia, industry, and ASCI.

Policy Related:

- The majority of skill seekers are likely to come from farming and rural background. In fact, all farm mechanization skill seekers must receive a foundation module on farm mechanization and its role in enhancing employment, income, and sustainability of agriculture. Any farm mechanization related financial support should be linked to the proof of having completed the foundation module and another suitable skill module.

- An appropriate training/ skill must be mandatory for the establishment of CHCs/FMB/Hitech hubs in order to run these enterprises efficiently and profitably.

- The majority of the skill trainees at SDCs and ASCI associated programmes belong to poor families. They are unable to pay the fees. Hence, provision should be made for financial assistance to all those who wish to be skilled in farm mechanization and certified in order to get employment or establish self-employment.

- The employability and skills of students coming out of agricultural engineering colleges/ITIs are not matching with the expectations of the industry/workplace and hence, industries have established their own skilling centres as per their standards and requirements. It would be advantageous if apprenticeship/internships and associated certification are carried out through the NSQF skilling framework and promoted for all engineering/ITI students related to the farm mechanization sector to enhance their employability.

Linkages among Academia, Industry, and ASCI:

❖ Work under PPP mode for skilling initiatives by ASCI and government skilling initiatives

❖ Convince the industry to utilize CSR funds for skilling in farm mechanization

❖ Academia, Industry and ASCI should collaborate with each other to keep pace with emerging technological trends which, in turn, are changing the job roles and skills. There should be mechanisms for collaboration in research, development, and skill requirements to address the evolving needs.

ASCI:

❖ Addition of relevant NSQF/National Occupational Standards and updating the existing standards to suit the emerging market needs.

❖ Design and develop the curriculum and contents in order to adopt new/upcoming technologies.

❖ Dealership services are in the unorganized segment with respect to employment and, hence, getting skilled workers is difficult. Therefore, ASCI can partner with them for skilling their existing workforce and employment enhancement for skill trainees.

❖ ASCI/ CoE can identify and map the skilling requirements of the local mechanics and operators in villages/rural areas to bridge the skill gaps, i.e., required skill minus existing skills, for enhanced employability.

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ANNEXURE. I.

Annual market of major farm machines used in India

<table>
<tr><th>S. No.</th><th>Name of Farm Machinery</th><th>Annual market range in numbers</th><th>Number considered for calculation</th><th>Value chain-wise total in numbers</th><th>Value chain- wise %</th></tr>
<tr><td>1.</td><td>Tractors</td><td>450000 – 500000</td><td>500000</td><td>500000</td><td>57.67</td></tr>
<tr><td>2.</td><td>Power tillers</td><td>50000 - 60000</td><td>60000</td><td>60000</td><td>6.92</td></tr>
<tr><td>3.</td><td>Planters& rice planters</td><td>17000 – 28000</td><td>28000</td><td rowspan="3">133000</td><td rowspan="3">15.34</td></tr>
<tr><td>4.</td><td>Seed-cum-fertilizerdrills</td><td>60000 – 75000</td><td>75000</td></tr>
<tr><td>5.</td><td>Potato diggers</td><td>25000 - 30000</td><td>30000</td></tr>
<tr><td>6.</td><td>Power weeders</td><td>35000 - 40000</td><td>40000</td><td>40000</td><td>4.61</td></tr>
<tr><td>7.</td><td>Reapers</td><td>10000 - 15000</td><td>15000</td><td rowspan="3">94000</td><td rowspan="3">10.84</td></tr>
<tr><td>8.</td><td>Threshers</td><td>60000 - 75000</td><td>75000</td></tr>
<tr><td>9.</td><td>Combine harvesters</td><td>3500 - 4000</td><td>4000</td></tr>
<tr><td>10.</td><td>Sprayers (tractor drawn)</td><td>10000- 15000</td><td>15000</td><td rowspan="2">40000</td><td rowspan="2">4.61</td></tr>
<tr><td>11.</td><td>Power weeders</td><td>20000 - 25000</td><td>25000</td></tr>
<tr><td colspan="3">Total</td><td>867000</td><td></td><td></td></tr>
</table>

Source: NITI Aayog report Demand & Supply Projections


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