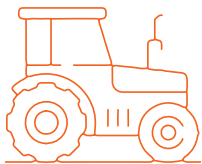


National Sectoral Paper **Farm Mechanisation**

Farm Sector Development Department
National Bank for Agriculture and Rural Development
Mumbai





NABARD's Vision

Development Bank of the
Nation for fostering rural
prosperity

NABARD's Mission

Promote sustainable and equitable
agriculture and rural development
through participative financial
and non-financial interventions,
innovations, technology and
institutional development for
securing prosperity

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Foreword

India's agricultural landscape is undergoing a significant transformation, with mechanisation emerging as a key driver of productivity, efficiency, and climate resilience. This National Sectoral Paper on Farm Mechanisation 2025 provides a comprehensive overview of the trends, opportunities, and challenges shaping India's journey towards a modern and inclusive farm economy.

The Government of India, through flagship initiatives such as the Sub-Mission on Agricultural Mechanization (SMAM), Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), National Food Security & Nutrition Mission (NFSNM) [erstwhile National Food Security Mission (NFSM)], and the visionary Namo Drone Didi scheme, has laid a strong foundation for accelerating adoption of mechanisation - especially among small and marginal farmers. These efforts aim not just to reduce drudgery and costs, but to also promote precision agriculture, sustainable practices, and enhanced income generation.

Despite being the largest tractor manufacturer in the world, India still faces substantial mechanisation gaps across regions and crop operations. The fragmented landholding pattern, high cost of machinery, inadequate custom hiring models, and dependency on imports for non-tractor machinery remain key challenges. In this context, the paper's insights on region-

specific strategies, institutional credit flows, emerging technologies like robotics, AI, and IoT, as well as the vital roles of Farmer Producer Organisations (FPOs) and Custom Hiring Centers (CHCs), are particularly relevant.

This paper encourages a shift from 'tractorisation' to holistic mechanisation - tailored for India's diverse agro-climatic zones and farming demographics. With the sector poised to grow at a Compound Annual Growth Rate (CAGR) of 8.5%, surpassing global trends, there is a unique opportunity to foster innovation, indigenisation, and entrepreneurship through collaborative action.

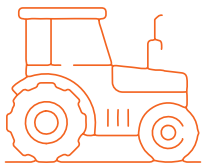
I commend the dedicated team behind this document for their in-depth analysis and actionable insights. I am confident that this paper will serve as a crucial resource for policymakers, financial institutions, entrepreneurs, and development practitioners committed to building a resilient and mechanised future for Indian agriculture.

Shaji KV

Chairman

**National Bank for Agriculture and Rural
Development Mumbai**

August 2025



Message

Since the mid-1960s, India's agriculture sector has witnessed remarkable gains in food grain production, largely driven by scientific interventions and policy support. However, the spread of mechanisation—a key enabler of modern, efficient, and resilient farming—has been uneven across regions and farmer categories. This unevenness is particularly distinct for small and marginal farmers, who constitute nearly 85% of India's farming households and often lack access to suitable machinery and finance.

The use of appropriate mechanised tools and equipment has the potential to enhance productivity by up to 30% and reduce cultivation costs by around 20%. Recognising this, the Government of India launched the Sub-Mission on Agricultural Mechanisation (SMAM) way back in 2014–15, a transformative initiative to improve access and affordability of farm machinery. The mission promotes not just procurement, but also training, testing, and demonstration; the establishment of Farm Machinery and Equipment Banks and Custom Hiring Centres (CHCs); and awareness building around Post-Harvest Technology and Management (PHTM). More recently, forward-looking interventions such as NAMO Drone Didi reflect a shift towards digital and precision agriculture with gender empowerment and inclusive growth at the core.

The credit requirement for the farm mechanisation sector for FY 2024–25 is projected at ₹1,09,838 crore, accounting for nearly 4% of the total agricultural Ground Level Credit (GLC) flow. NABARD remains committed to this

cause by extending refinance support to banks, cooperatives, and other financial institutions, facilitating the adoption of mechanised practices by farmers at scale.

This National Sectoral Paper offers a holistic view of India's mechanisation ecosystem—covering status, institutional credit, trade dynamics, government schemes, issues, emerging technologies, and most critically, strategies for smallholder-centric mechanisation. It provides actionable insights on promoting scale-neutral and climate-resilient equipment, fostering innovations through indigenisation, and building ecosystems that encourage FPOs, women, and youth-led service models like Farming-as-a-Service (FaaS).

I commend the Farm Sector Development Department and the Technical Advisory Group for their diligent efforts in preparing this paper. I am confident that this document will serve as a strategic resource for policymakers, lenders, entrepreneurs, and practitioners in shaping inclusive and sustainable mechanisation strategies. I welcome feedback and suggestions to further strengthen this initiative and deepen its impact on ground.

Dr A K Sood

Deputy Managing Director

National bank for Agriculture and Rural Development

Mumbai

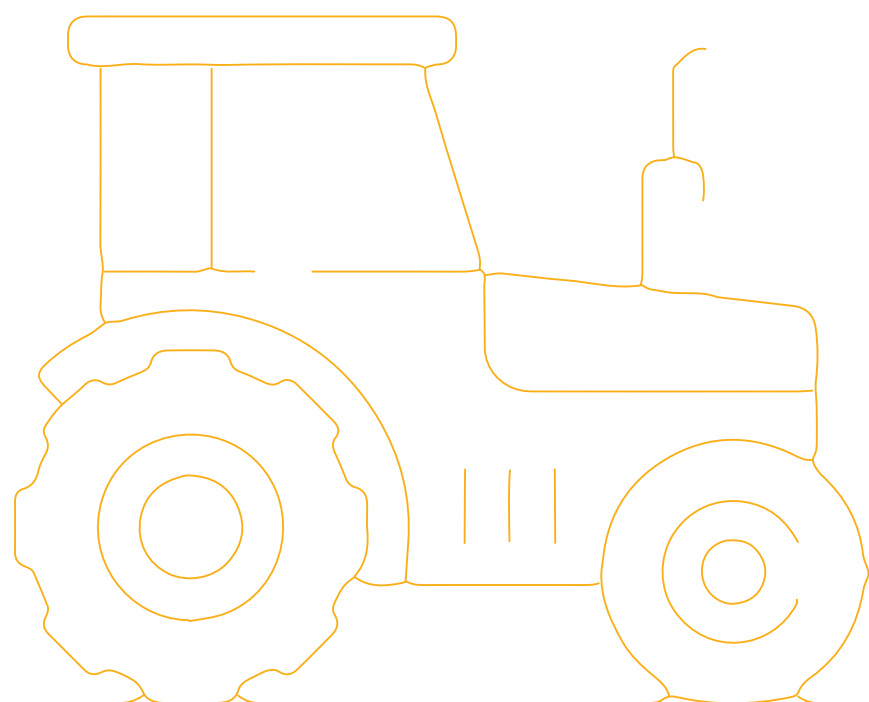
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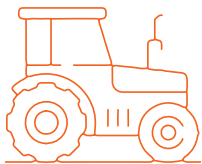
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01 Introduction



Introduction

1.1 Overview of Farm Mechanization

Farm mechanization refers to the application of machinery, tools, and technology in agricultural practices to enhance productivity, reduce manual labor, and optimize the utilization of resources such as water, seeds, and fertilizers. It is one of the key drivers of modern agricultural transformation, playing a pivotal role in improving the efficiency and profitability of farming operations. Mechanization includes a wide range of activities, from land preparation (tillage, sowing, and planting) to post-harvest processing (threshing, milling, and packaging). The adoption of mechanization has the potential to not only increase agricultural output but also address issues such as labor shortages, low farm productivity, and post-harvest losses, which have long plagued the sector.

1.2 Historical Development of Farm Mechanization in India

Farm mechanization in India began during the Green Revolution of the

1960s and 1970s, which aimed to boost agricultural productivity through the introduction of high-yield variety seeds, chemical fertilizers, and modern irrigation systems. The increased use of tractors and irrigation pumps during this period marked the beginning of a gradual shift towards mechanized farming.

Despite these advances, the growth of farm mechanization in India has been uneven, with significant variations across regions and farm sizes. States like Punjab and Haryana, which were at the forefront of the Green Revolution, experienced rapid mechanization, while states in the northeastern and hilly regions lagged behind due to topographical challenges, small farm sizes, and limited financial capacity.

1.3 Scope of Farm Mechanization in India

Mechanization plays a crucial role in addressing some of the critical challenges faced by Indian agriculture, including:

- i. **Labor Shortages:** Due to urbanization and industrialization, there has been a gradual shift of rural

labor to non-farm sectors, leading to labor shortages in agriculture. Mechanization helps mitigate this by automating labor-intensive tasks like plowing, sowing, and harvesting.

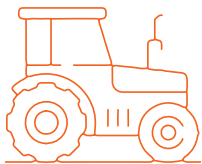
- ii. Low Productivity:** Mechanization significantly boosts the productivity of farms by ensuring timely and efficient execution of various agricultural tasks. Studies have shown that mechanized farms achieve higher yields compared to those relying solely on manual labor.
- iii. Reduction of Drudgery:** Agricultural mechanization reduces the physical burden on farmers by replacing labor-intensive activities with machine-operated processes. This not only improves the quality of life for farmers but also makes farming a more attractive occupation.
- iv. Resource Optimization:** Mechanized farming helps in the efficient use of inputs such as water, fertilizers, and seeds. Precision farming techniques, which use advanced machinery and tools, allow for better resource management, thus reducing wastage and improving sustainability.

1.4 Current Status of Farm Mechanization in India

Farm mechanization in India has advanced significantly in recent years, with current levels estimated between 40% and 50%. This contrasts sharply with industrialized nations, where

mechanization rates often exceed 90%. The Government of India recognizes the urgent need for enhanced mechanization due to diminishing land holdings and a growing population driven by urbanization, labor migration, and the demand for timely agricultural operations. To address this, the government launched the Sub Mission on Agricultural Mechanization (SMAM) in 2014-15, providing financial assistance covering 40% to 50% of agricultural machinery costs, with higher subsidies in northeastern states. This initiative has established over 40,900 Custom Hiring Centres (CHCs) and Farm Machinery Banks (FMBs), improving access to machinery for small and marginal farmers.

Despite notable progress, there is considerable regional disparity in mechanization levels. Operations such as seedbed preparation have achieved over 70% mechanization for major crops like wheat and rice, while harvesting and threshing remain under-mechanized at rates below 32%. The average farm power availability has increased from 0.48 kW/ha in 1975-76 to about 2.49 kW/ha in 2018-19, but it needs to reach 4.0 kW/ha by 2030 to meet rising food demands. While tractors are widely used in states like Punjab, Haryana, and Uttar Pradesh, smallholder farmers in eastern and northeastern states still rely heavily on manual labor. India, the world's largest tractor manufacturer, producing over 900,000 units annually, still has significant



potential for improvement in sowing, weeding, and harvesting operations. The government is also promoting drone technology in agriculture, which further aims to enhance efficiency and commercial viability. Sustained efforts are crucial to elevate mechanization levels, particularly for smallholders, ensuring sustainable agricultural growth and productivity.

1.5 Government Initiatives to Promote Mechanization

Recognizing the importance of mechanization in transforming agriculture, the Government of India has launched several schemes and initiatives aimed at promoting the use of modern equipment and technology on farms. Some of the key initiatives include:

- i. **Sub-Mission on Agricultural Mechanization (SMAM):** Launched in 2014, SMAM focuses on promoting mechanization among small and marginal farmers, particularly in regions with low mechanization levels. The scheme provides subsidies for the purchase of farm machinery, establishment of Custom Hiring Centers (CHCs), and training programs for farmers.
- ii. **Custom Hiring Centers (CHCs):** To address the financial barriers faced by smallholder farmers in purchasing machinery, CHCs allow farmers to rent farm equipment at affordable rates. This initiative has been particularly successful in promoting mechanization among small and

marginal farmers.

- iii. **Rashtriya Krishi Vikas Yojana (RKVY):** Under RKVY, states are provided financial support to enhance farm mechanization. The scheme encourages states to allocate funds towards the purchase of farm equipment and the establishment of CHCs.
- iv. **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY):** This initiative aims to improve irrigation efficiency, and mechanization plays a crucial role in the implementation of micro-irrigation techniques like drip and sprinkler systems, which are essential for water conservation in agriculture.

1.6 Challenges in Farm Mechanization

- i. **High Cost of Machinery:** The cost of acquiring modern farm machinery, such as combine harvesters and tractors, remains prohibitively high for smallholder farmers, who constitute a majority of India's farming community. While subsidies and financial schemes are available, they often fall short of bridging the affordability gap.
- ii. **Fragmented Landholdings:** India's highly fragmented landholding pattern poses a significant challenge to the effective utilization of large-scale farm machinery. Small and fragmented plots make it difficult for farmers to adopt mechanized solutions designed for larger tracts of land.

iii. Lack of Technical Knowledge:

Many farmers, particularly in remote and less-developed regions, lack the technical know-how to operate modern machinery. There is a pressing need for skill development programs to equip farmers with the knowledge required to maintain and use farm machinery efficiently.

iv. Infrastructure Deficiencies:

Poor rural infrastructure, such as inadequate transportation facilities and lack of access to reliable electricity, hampers the full-scale adoption of mechanization. Efficient transport is necessary to move machinery across farms, while electricity is crucial for operating many types of equipment.

1.7 Mechanization in allied sectors

Mechanization in allied sectors of agriculture, such as dairy farming, poultry, fisheries, and horticulture, plays a crucial role in enhancing productivity and efficiency. In dairy farming, mechanized milking machines, automated feeding systems, and cooling equipment have significantly reduced labor costs and improved milk quality. Poultry farming benefits from automated egg collection, feeding, and climate control systems, ensuring better health and higher yields. In fisheries, mechanized boats, nets, and processing units streamline operations, increasing catch efficiency

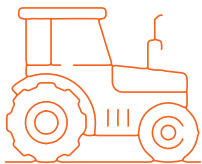
and reducing post-harvest losses. Horticulture has seen advancements with the use of mechanized planting, pruning, and harvesting equipment, which not only save time but also improve the quality of produce. Overall, adopting mechanization in these allied sectors reduces manual labor, enhances operational efficiency, and ensures better quality and higher productivity, contributing to the agricultural industry's overall growth and sustainability.

1.8 Future Prospects and Policy Directions

As India aspires to modernize its agricultural sector, farm mechanization will remain a cornerstone of this transformation. To achieve this, the government and private sector need to collaborate closely to address existing challenges and promote the use of technology in agriculture. Some of the key focus areas for future policy interventions include:

i. Innovation in Mechanization for

Small Farmers: There is a need to develop affordable, low-cost machinery tailored to the needs of small and marginal farmers. Encouraging innovation in farm equipment that is suited to small and fragmented landholdings will ensure that mechanization benefits all segments of the farming population.



ii. Sustainability and Climate-Resilient

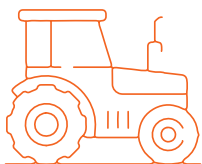
Mechanization: The future of farm mechanization will need to integrate sustainability and climate resilience. Machines that promote conservation agriculture, reduce greenhouse gas emissions, and optimize resource use will play a crucial role in addressing the environmental challenges facing agriculture.

iii. Digital Integration and Smart

Farming: The integration of digital technologies such as Artificial Intelligence (AI), drones, and precision agriculture tools will further enhance the effectiveness of mechanization. These technologies enable farmers to make data-driven decisions, improving yields and reducing input costs.



02 Status of Farm Mechanisation



The agriculture sector in India has witnessed a considerable decline in the use of animal and human power in agriculture related activities. The trend has paved the way for a range of agricultural tools. A large number of these are driven by fossil fuel operated vehicles such as tractors and diesel engines. This has resulted in a shift from the traditional agriculture process to a more mechanized process.

2.1 Availability of Farm Power

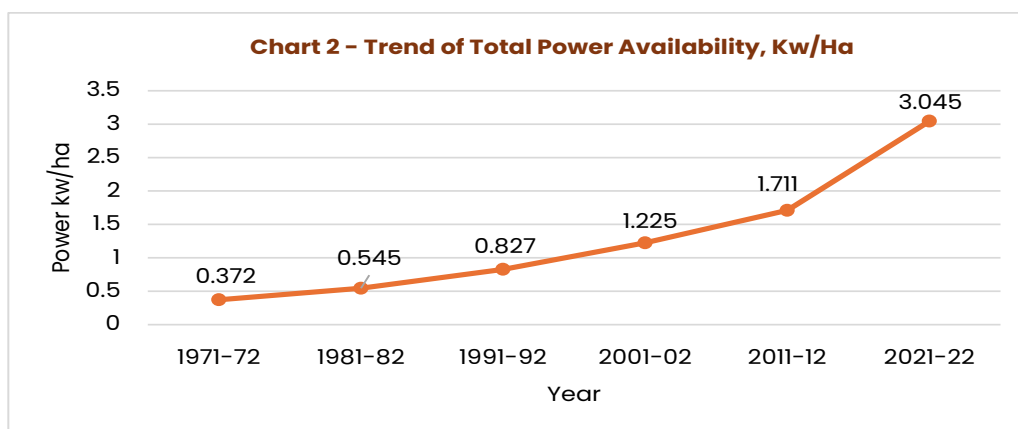
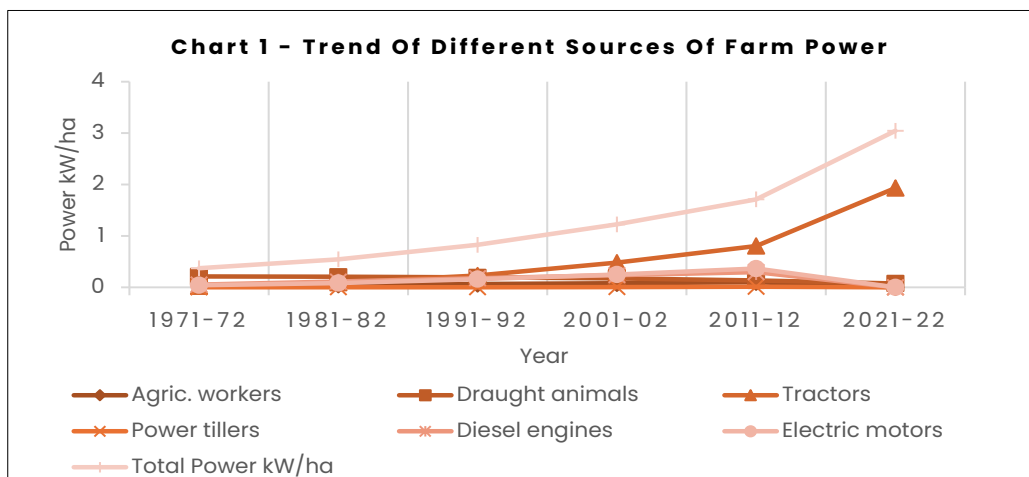
The use of farm machinery depends upon the farm power sources available in the country for various tractive and stationary operations. The sources of power available in Indian farms for various farm operations include mobile sources viz. human (men, women), draught animals (bullocks, camels, horses, ponies, mules and donkeys), tractors, power tillers and self-propelled machinery (combines, reapers, sprayers etc.); and stationary sources viz. diesel/oil engines and electric motors for pump sets, threshers, sprayers, etc.

The available farm power in kilowatt per hectare in Indian agriculture from different power sources along with total farm power is presented in Table 1.

Table 1: Farm power availability from different sources in India

Year	Power, kW/ha						Total power, kW/ha
	Agric. workers	Draught animals	Tractors	Power tillers	Diesel engines	Electric motors	
1971-72	0.045	0.212	0.02	0.001	0.053	0.041	0.372
1981-82	0.051	0.206	0.09	0.002	0.112	0.084	0.545
1991-92	0.065	0.193	0.23	0.003	0.177	0.159	0.827
2001-02	0.079	0.172	0.48	0.006	0.238	0.25	1.225
2011-12	0.1	0.134	0.804	0.012	0.295	0.366	1.711
2021-22	0.082*	0.075	1.932	0.020*	0.368*	0.568*	3.045

Source: Agricultural Mechanization in Asia, Africa, And Latin America 2023 Vol.54 No.2



It indicates that during the last 50 years, there has been a considerable change in the relative proportion of various sources of power available for agricultural operations. The total power availability on Indian farms has increased at a Compound Annual Growth Rate (CAGR) of 4.3% from 0.372 in 1971-72 to 3.045 kW/ ha in 2021-22. The availability of draught animal power has come down from 0.212 kW/ha in 1971-72 to 0.075 kW/ha in 2021-22, whereas the power available from agriculture workers, tractors, power tillers, diesel engines and electric motors has increased from 0.045 to 0.082, 0.02 to 1.932, 0.001 to 0.020, 0.053 to 0.368 and 0.041 to 0.568 kW/ha, respectively during the same period.

2.2. Cropping intensity and power availability on Indian farms

During 1975-76, the cropping intensity was 120% with a power availability of 0.43 kW/ ha. By 2021-22, cropping intensity increased to 141.6%, accompanied by a rise in power availability to 3.045 kW/ha (see Table 2). This indicates that the increase in power availability resulted in higher cropping intensity in Indian agriculture. Over the last forty-six years, the power availability per unit of food-grain production has risen from 0.46 kW/t to 1.34 kW/t (see Table 2). Conversely, the net sown area per tractor showed a reverse trend during the same period, decreasing from 487 hectares per tractor in 1975-76 to 15 hectares per tractor in 2021-22.

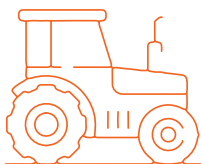


Table 2 : Data on Cropping Intensity, Food grain productivity and Power per unit production

Year	Cropping intensity (%)	Food grain productivity, t/ha	Power available, kW/HA	Power per unit production, kW/T	Net sown area per tractor, ha
1975-76	120.00	0.94	0.43	0.46	487.00
1985-86	127.00	1.18	0.65	0.55	174.00
1995-96	131.00	1.50	0.98	0.65	84.00
2005-06	132.00	1.65	1.54	0.93	47.00
2015-16	141.00	1.80	2.34	1.30	22.00
2021-22	141.60	2.27	3.05	1.34	15.00

2.3 Share of farm mechanization in farming operations

The penetration of powered machines in various farm activities is assessed in the range of 40 to 45 per cent. Share of mechanization of field activities in 2023 is represented in the following Table 3.

Table 3 : Penetration of Mechanisation across major Farm Operations

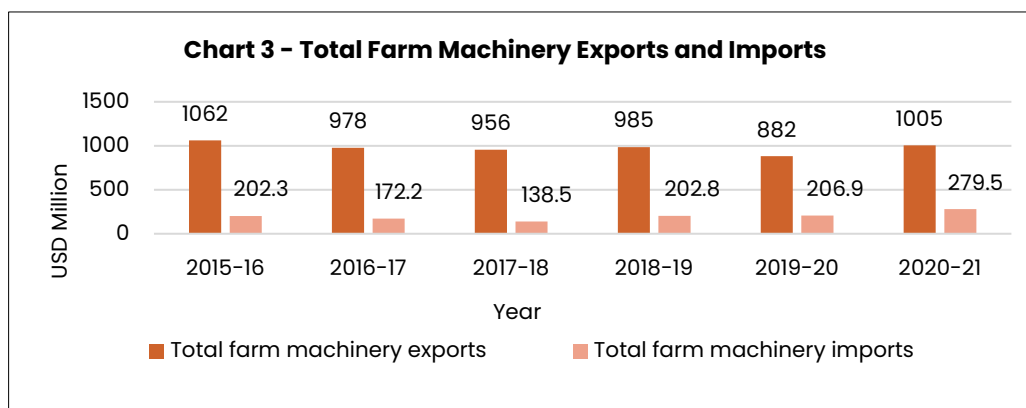
S. No	Operation	Penetration of Mechanisation (%)
1	Seed Bed Preparation and Soil working	40
2	Seeding and Planting	29
3	Plant Protection	34
4	Harvesting and Threshing	60-70 for wheat and rice but less than 5% for others

Source: NCAER

2.4 Exports and Imports of Total Farm Machinery and Non-tractor Farm Machinery

The non-tractor farm machinery sector is broadly categorized into two types: tractor-mounted machinery and self-propelled or hand-driven mechanized power equipment. India exhibits a comparative advantage in certain types of machinery, such as ploughs, disc harrows, agricultural and horticultural machinery, and threshing machinery parts, meaning it can produce these items at a significantly lower opportunity cost.

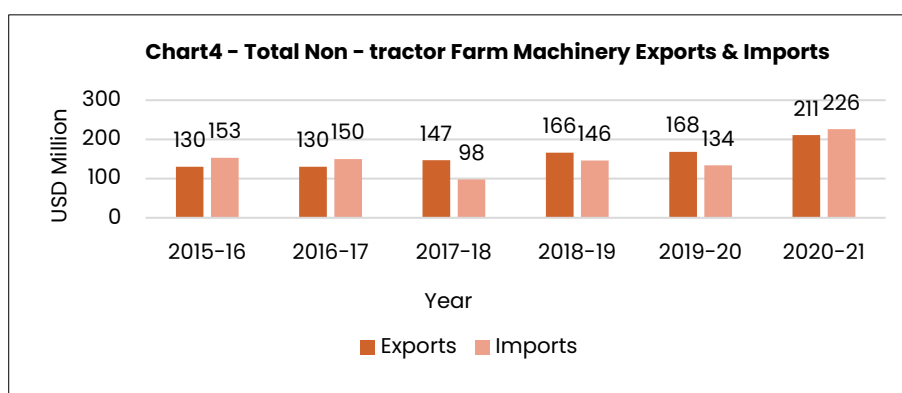
As shown in the chart below, tractor exports primarily drive the overall farm machinery exports, while non-tractor farm machinery imports are the main contributors to total farm machinery imports. Trade patterns are asymmetrical: 53% of non-tractor agricultural machinery imports come from China, whereas the export markets are more varied.



Source: National Council of Applied Economic Research (NCAER)

India maintains a substantial trade surplus in the total farm machinery sector. Despite this, non-tractor farm machinery exports make up a relatively

small portion of total farm machinery exports, while imports of non-tractor farm machinery account for a larger share of total farm machinery imports.



Source: National Council of Applied Economic Research (NCAER)



03 Status of Institutional Credit

Credit flow to farm mechanization plays a crucial role in enhancing agricultural productivity and efficiency. Access to affordable credit is essential for farmers to invest in modern equipment and technology. Farm mechanization increases crop yields and ensures timely farming operations. Banks and other financial institutions are providing credit for adopting farm mechanisation by farmers. Banks and other financial institutions are also providing for the establishment of Custom Hiring Centres so that farm machinery is available to farmers on hire at affordable rates.

3.1. Potential Linked Credit Plans

NABARD prepares district wise Potential Linked Credit Plan which includes the credit potential for farm machinery. The total credit potential for farm machinery for FY2024-25 across all states is estimated at Rs. 1,09,838.63 crore crore underscoring the significant financial resources required to boost farm machinery activities. The State wise credit projections for FY 2024-25 are presented in Table 4

Table 4 PLP Projection for the FY 2024-25

State	Amount (In Rs. Lakh)
Andaman and Nicobar	1380
Andhra Pradesh	557406
Arunachal Pradesh	1465
Assam	90481
Bihar	616021
Chhattisgarh	336432
Goa	7026
Gujarat	838485
Haryana	329777
Himachal Pradesh	40226
Jammu and Kashmir	47893
Jharkhand	118674
Karnataka	645999
Kerala	181025
Ladakh	460
Madhya Pradesh	1597709
Maharashtra	653554
Manipur	3164
Meghalaya	3541
Mizoram	3258
Nagaland	990
ODISHA	494206
Punjab	578362
Rajasthan	703891
Sikkim	230
Tamil Nadu	1128254
Telangana	509878
Tripura	4758.95
Uttar Pradesh	997202
Uttarakhand	58469
West Bengal	433645
Total	10983863

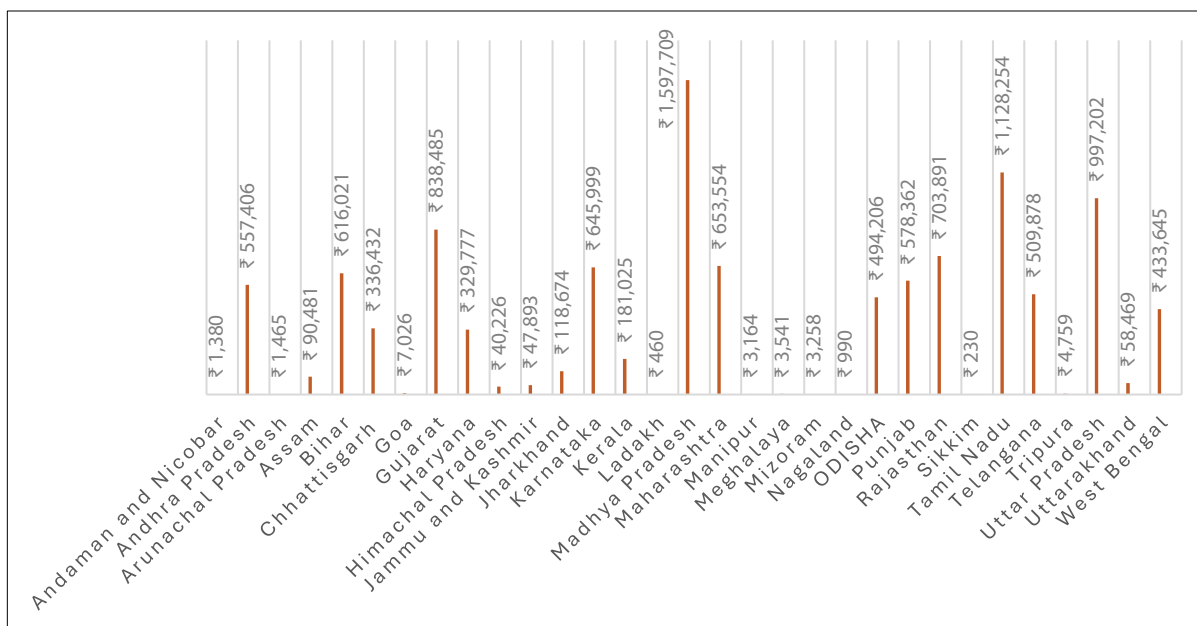
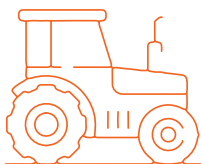


Chart5 – PLP Projection for the FY 2024 – 25

The credit potential data indicates that Madhya Pradesh leads with a potential of Rs. 15,977.09 crore, indicating a strong emphasis on improving agricultural practices and infrastructure. This could involve investments in irrigation systems, mechanization, and post-harvest technologies. Tamil Nadu (Rs. 11,282.54 crore) and Uttar Pradesh (Rs. 9,972.02 crore) also exhibit high credit potential, suggesting robust agricultural sectors that require modern engineering solutions to optimize production. Gujarat (Rs. 8,384.85 crore) and Bihar (Rs. 6,160.21 crore) are significant contributors, highlighting their needs for advanced agricultural technologies and infrastructure improvements.

3.2. NABARD Refinance for Farm Mechanisation Sector

NABARD provides Long term refinance to Commercial Banks, Small Finance Banks, RRBs, StCBs, DCCBs, NBFCs, NBFC-MFIs

and NABARD Subsidiaries for enabling them to finance for farm machinery activities. The data on refinance for farm mechanization over the past 10 years is presented in Table 5

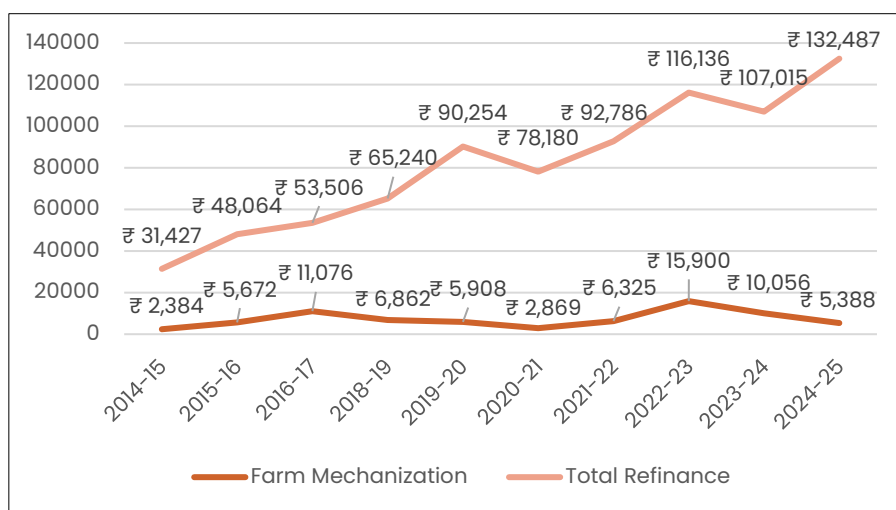
Table 5 Refinance Given in Past 10 years

Amt. in Rs. Crore

Years	Farm Mechanization	Total Refinance	% Refinance for FM
2014-15	2384	31427	8
2015-16	5672	48064	12
2016-17	11076	53506	21
2017-18	6862	65240	11
2018-19	5908	90,254	7
2019-20	2869	78180	4
2020-21	6325	92786	7
2021-22	15900	116136	14
2022-23	10056	107015	9
2023-24	5388	132487	4
CAGR	8 %	15 %	-6 %

The CAGR for farm mechanization refinance for the last 10 years stands at 8%, while the total refinance CAGR is 15%. The negative CAGR of -6% for the percentage of refinance for farm mechanization indicates that, despite overall growth in refinance, the relative emphasis on farm mechanization has decreased over time.

Chart 6 – Trend of CAGR of Total Refinance vis-à-vis Refinance to Farm Mechanisation





04 Tractor & Farm Machinery Trade of India

4.1 Global Scenario:

Asia-Pacific Region has the highest share of more than 45% in the World Farm Machinery market and of that Tractors have the lion share of more than 55%. The global agriculture machinery market which is estimated to be valued to be about USD 151.55 billion in 2024 is expected to reach USD 197.19 billion in the year 2029 at a Compounded Annual Growth rate of 5.40%³. While the Tractor market currently valued at USD 84.80 billion is expected to reach USD 114.5 billion by 2029 at a CAGR of 5.90%. This expected growth levels can be attributed to increase in farmers' income, shortage of farm labour, need to enhance farm productivity, increase in extent of farm mechanization and the need for sustainable agricultural practices. The growth of agriculture production in China, India and other South Asian countries is also expected to drive this growth.

4.2 Indian Scenario:

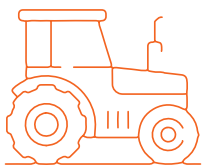
The agricultural machinery industry is operating at three tiers, one being village craftsmen who supply, maintain and repair hand tools in villages and then there are about 2500 small scale producers of enhanced farm equipments and 250 medium to large scale industries producing advanced farm machinery.⁴

NCAER has estimated the total requirement of different farm machinery & implements in India, as given in the table below:

Sl. No	Equipment	Total no. of equipment required for total area
1	Harrow (tractor operated) for 60% area/ 100% area	8,73,912
2	Cultivator (tractor operated)	8,73,912
3	Rotavators (tractor operated)	6,33,140
4	Rotavators (power tiller operated)	76,60,222
5	Seed-cum-fertilizer drill (tractor operated)	3,94,468
6	Seed-cum-fertilizer drill (power tiller operated)	11,75,670
7	Sugarcane planter	80,500
8	Potato planter	28,200
9	Self-propelled eight-row paddy transplanter (Ride Type)	4,98,863
10	Self-propelled walk-behind type paddy transplanter	7,31,667
11	Cultivator (tractor operated)	5,56,870
12	Power tiller operated cultivator / Power weeder	10,68,589
13	Knapsack sprayer-cum-duster (powered)	11,49,033
14	Tractor-operated sprayer	6,89,420
15	Sprayer self-powered high clearance (cotton, sugarcane)	27,175
16	Vertical conveyor reaper (power tiller operated)	3,43,758
17	Vertical conveyor reaper (tractor operated)	3,22,273
18	Multi-crop combine harvester for 60% area/100% area	79,136/ 1,31,893
19	Multi-crop thresher (tractor PTO operated)	3,38,689
20	Paddy thresher	1,95,111
21	Maize thresher	76,750
22	Sugarcane harvester	67,083
23	Potato digger – a) Tractor operated	17,312
	b) Power tiller operated	46,165
24	Happy Seeder	1,97,550
25	Stubble shaver + Baler/ stubble shaver + Hay rack + Baler	1,09,750/ 87,800
26	Wheat straw combine	6,21,684

³ Mordor Intelligence

⁴ NCAER



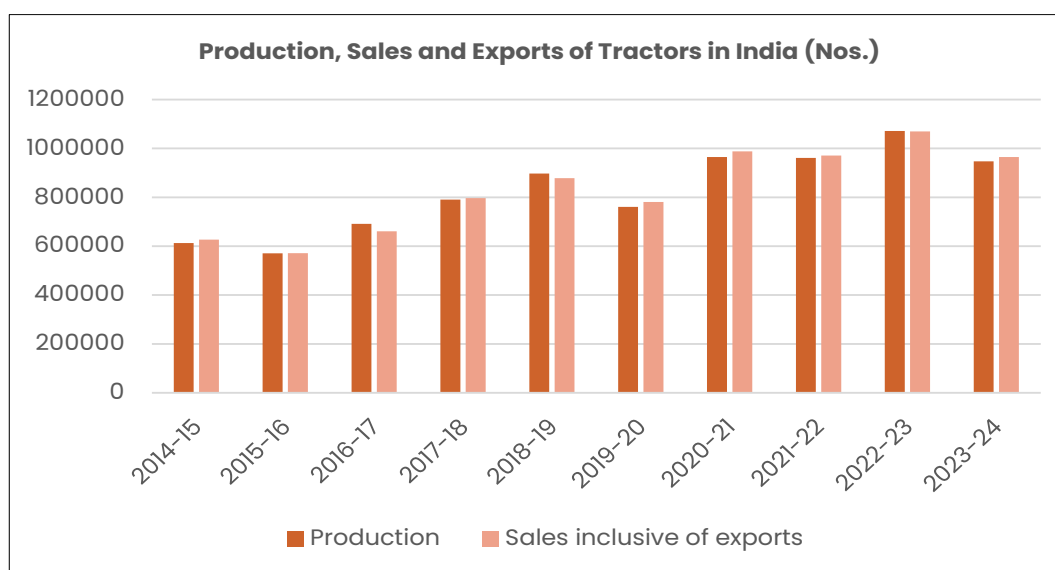
The agriculture machinery market of India currently estimated to be valued to be about USD 16.73 billion is expected to reach USD 25.15 billion in the year 2029 at a significantly at a higher CAGR of 8.50% in comparison to the global scenario. On the contrary, the Indian Tractor market currently valued at USD 7.42 billion is expected to reach USD 10.28 billion by 2029 at a CAGR of 6.70%.⁵

While the CAGR of agricultural machinery & tractor market at global level seems to be on par, the sizeable difference in CAGR levels at the Indian market scenario, indicates higher growth of agricultural machinery market vis-à-vis Tractors, thereby hinting adoption of non-tractor farm machineries such as power tillers, planters, fertilizer applicators, seeders, harvesters to meet the farm power requirements of small & marginal farmers.

India is the largest manufacturer of Tractors in the world. The tremendous increase in tractor production experienced by India during the last few years has turned the country into a net exporter of tractors. The trends in production, sales inclusive of tractors from India is indicated in the chart above⁶

4.3. Export and Imports of Tractors and Farm Machinery by India

As the Indian farm machinery market is highly dominated by tractors, farm mechanisation in the country is often referred to as 'tractorisation' instead. This is mainly on account on establishment and thriving of major tractor producing companies on account of green revolution, favourable government support and policy environment. This has now lead to India becoming the largest tractor manufacturing country in the world.

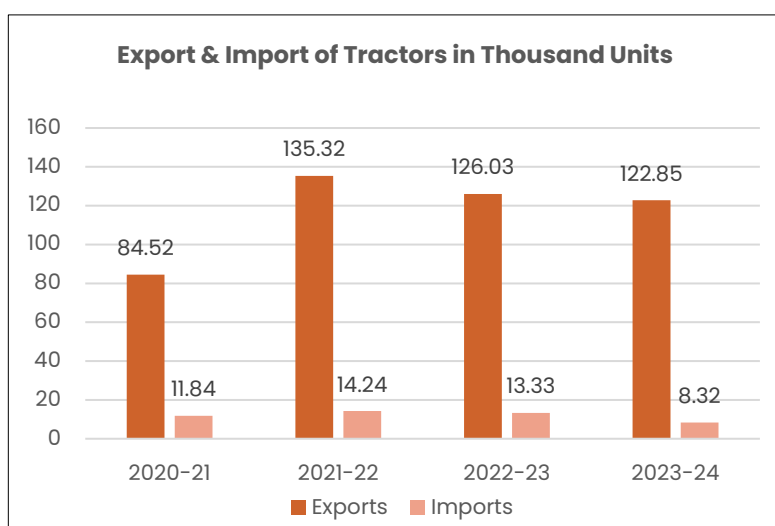


⁵Mordor Intelligence

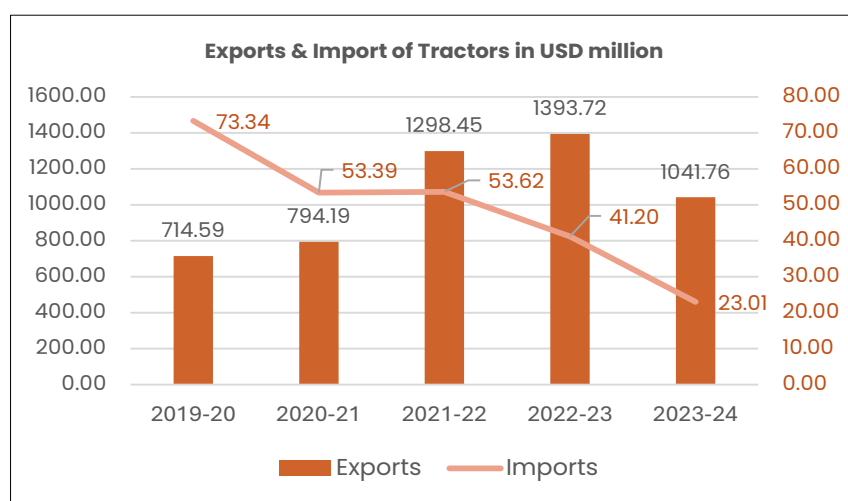
⁶CMIE

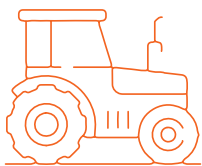
The agriculture machinery market comprises of two major segments, tractors and non-tractors agriculture machinery. While farm machinery exports of India are driven by tractors, the import of farm machinery is dominated by non-tractor agriculture machinery especially power tillers and other small farm machinery.

While India's export of tractors is distributed across different countries, more than 50% of its non-tractor agriculture machinery imports are coming from China. However, there has been perceptible shift in export trade of India in Tractors & Farm Machinery segment in the past 5-7 years, with United States becoming the major export market for India in Tractors & Farm Machinery. The charts given below shows the trends in export and import of tractors from India both in numbers and value.

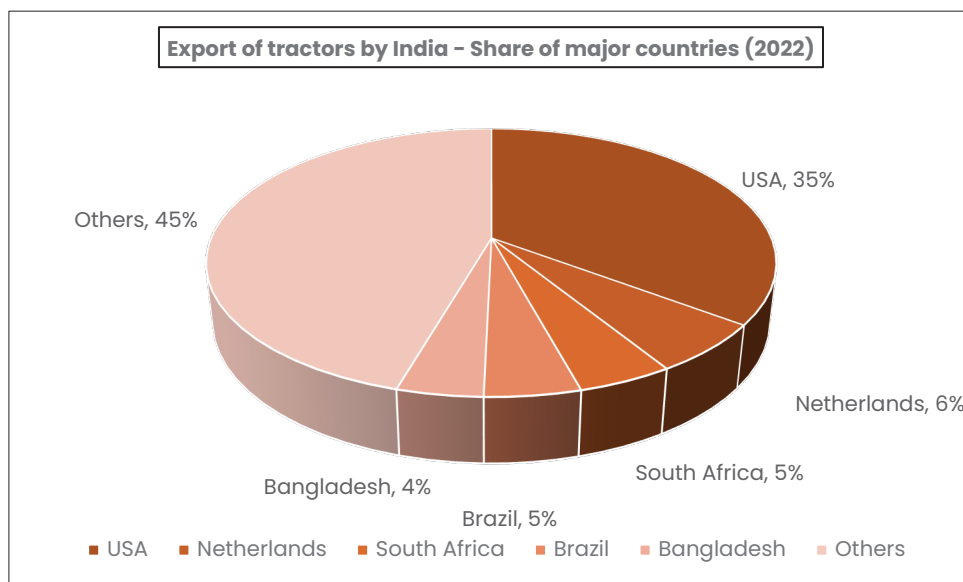


The exports of Tractors from India grew from USD 714.59 million in 2019-20 to USD 1041.76 million in 2023-24 at a CAGR of 7.83% with reaching peak level of USD 1393.72 million in 2022-23 and the imports dropped from USD 73.34 million USD in 2019-20 to USD 23.01 million in 2023-24 thereby registering a negative CAGR of -20.69%, clearly establishing the net exporter status of India in Tractors



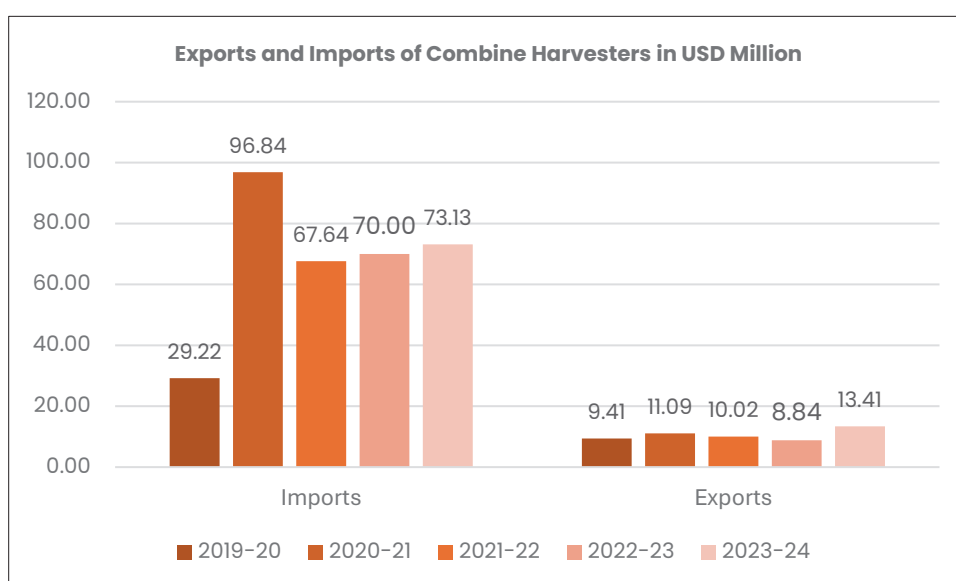


The destination of tractor exports from India is shown in the chart below⁷, which clearly indicates USA emerging as a major export destination for tractors for India



4.4. Export & Import of Combine Harvesters

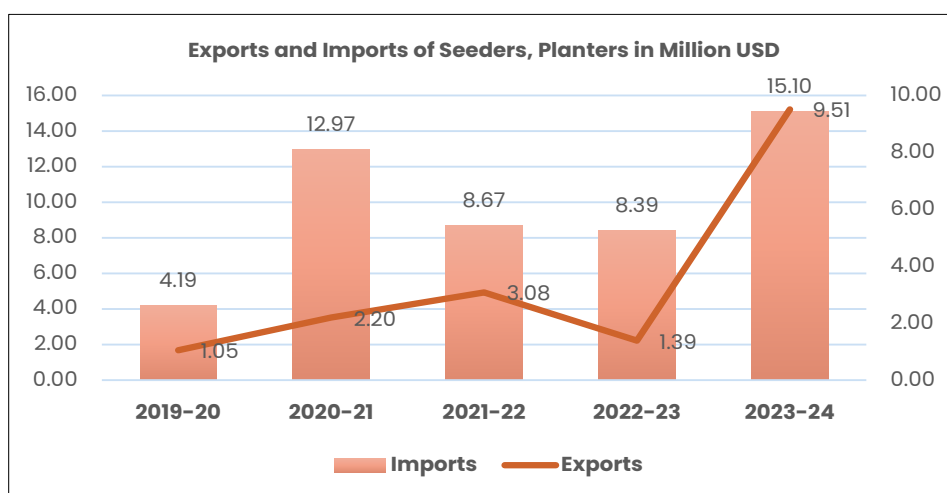
While the exports of Combine Harvesters grew from USD 9.41 million in 2019-20 to USD 13.41 million in 2023-24 at a CAGR of 7.34%, the imports of Combine Harvesters grew from USD 29.22 million in 2019-20 to USD 73.13 million in 2022 at a CAGR of 20.14%. India is a net importer of harvesters. Share of export of harvesters to USA has steadily increased from about 10% five years back to about third of the total exports now. Thailand and China together constituted major share of more than 70% in import of Harvesters by India.



⁷OEC

4.5. Export & Import of Seeders, Planters & Transplanters

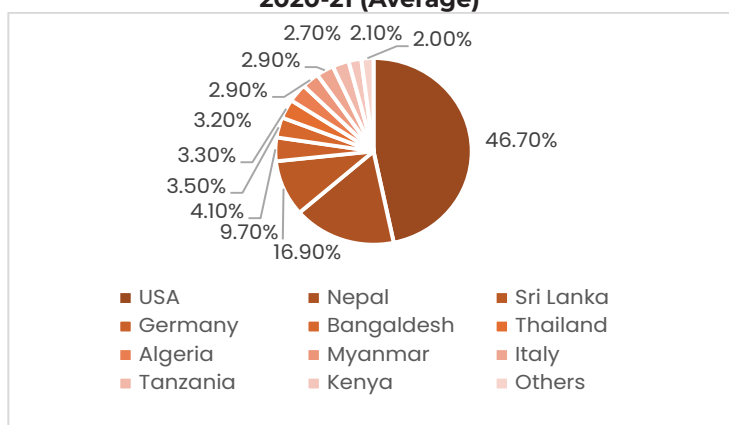
The export of seeders / planters / transplanters grew from USD 1.05 million in 2019-20 to USD 9.51 million in 2023-24 at a CAGR of 55.38% and imports grew from USD 4.19 million to USD 15.10 million during the same period at a CAGR of 29.23%, which clearly that India is a net importer under this segment⁸. However, the growth levels have been fluctuating across the years. The export market for India for seeders/ planters/ transplanters has been predominantly African countries followed by Asia, South & North America. The share of China in import of seeders/ planters/ transplanters by India has increased beyond 75% clearly indicating lopsided dependence of India on China for import of this farm machinery.



4.6. Export and Import of Non-tractor Farm Machinery by Source and Destinations⁹

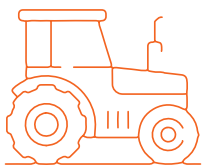
The share destinations and sources of Non-Tractor Farm Machinery of India are indicated in the Charts below.

Top Destinations for non-tractor farm exports, 2015-16 and 2020-21 (Average)

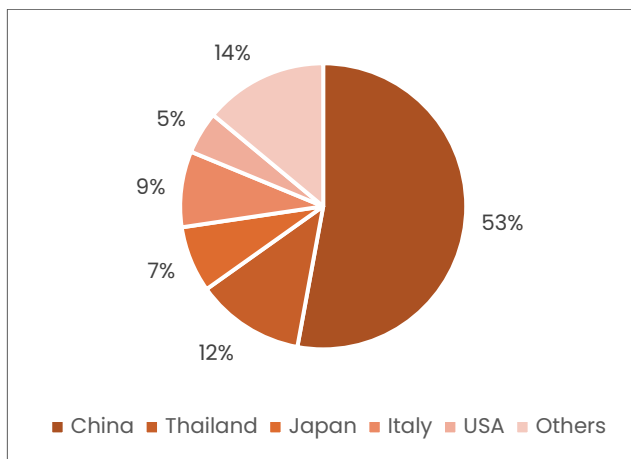


⁸Ministry of Commerce

⁹NCAER



Top Sources for non-tractor farm imports, 2015-16 and 2020-21 (Average)

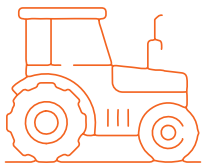


4.7. Major factors contributing to Production, Sales, Export & Import of Tractors & other Farm Machinery

- 1.1. Economic growth of India coupled with enhancement in Farmer's Income and the need for enhancing productivity to meet the growing population of the country is driving the enhanced adoption of farm machinery in different aspects of farming practices. Earlier farm mechanization was limited to land preparation, after which sowing & harvesting also necessitated adopted of farm machinery
- 1.2. With current generation opting out of farming and urban migration resulting in decreasing levels of farm labour availability, mechanization of agriculture is becoming increasingly necessary
- 1.3. With the need for sustainable farming practices getting more pronounced as the natural resources are dwindling, there is renewed push for mechanization of farming operations
- 1.4. With around 85% of farmers being Small & Marginal farmers, there is a need for focussed push for design & development of small farm machinery in India itself through enhanced funds to R & D, direct subsidy and policy support thereby reducing our dependence on China.



05 Schemes of Government of India supporting Farm Mechanisation



Mechanization is crucial in the context of the growing commercialization of agriculture. The application of farm machineries is increasing continuously in Indian Agriculture as it contributed to the increase in productivity due to timeliness of operations and increased precision in input application. The Government of India has introduced several schemes to promote farm mechanization, aiming to make modern agricultural equipment accessible and affordable for farmers.

The details of the schemes are indicated below :

1. Sub-Mission on Agriculture Mechanisation (SMAM)
2. Support for farm machinery under Rashtriya Krishi Vikas Yojana (RKVY)
 - a) RKVY-RAFTAAR (Infrastructure & Assets)
 - b) Bringing Green Revolution in Eastern India (BGREI)
 - c) Crop Residue Management
3. Support for farm machinery under National Food Security Mission (NFSM)
4. Support for farm mechanization under Pradhan Mantri Krishi Sinchai Yojana (PMKSY)
5. NAMO Drone Didi
6. Support for farm machinery under MIDH

Of the above, the Sub-Mission on Agriculture Mechanisation (SMAM) is the major and exclusive scheme by the Govt of India for promotion of farm mechanization. The other schemes have

some components of farm mechanization as part of the major scheme.

The details of individual schemes are as under:

5.1. Sub-Mission on Agriculture Mechanisation (SMAM):

To boost the farm mechanization in the country, a special dedicated scheme 'Sub Mission on Agricultural Mechanization (SMAM)' has been introduced by Government of India in 2014-15. The scheme aims at 'reaching the unreached' by making farm machines accessible and affordable for the small and marginal farmers (SMFs) through establishment of Custom Hiring Centres (CHCs), creating Hubs for hi-tech & high value farm equipment and Farm Machinery Banks.

5.1.1 Objectives:

To reach small and marginal farmers by making farm machines accessible and affordable.

5.1.2 Components:

- i. **Promotion and Strengthening of Agricultural Mechanization**

through Training, Testing and Demonstration: Aims to ensure performance testing of agricultural machinery and equipment, capacity building of farmers and end users and promoting farm mechanization through demonstrations.

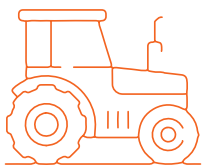
- ii. **Demonstration, Training and Distribution of Post-Harvest Technology and Management (PHTM):** Aims at popularizing technology for primary processing, value addition, low-cost scientific storage/transport and the crop by-product management through demonstrations, capacity building of farmers and end users. Provides financial assistance for establishing PHT units.
- iii. **Financial Assistance for Procurement of Agriculture Machinery and Equipment:** Promotes ownership of various agricultural machinery & equipments as per norms of assistance.
- iv. **Establish Farm Machinery Banks for Custom Hiring:** Provides suitable financial assistance to establish Farm Machinery Banks for Custom Hiring for appropriate locations and crops.
- v. **Establish Hi-Tech, High Productive Equipment Hub for Custom Hiring:** Provides financial assistance to set up hi-tech machinery hubs for high value crops like sugarcane, cotton etc.
- vi. **Promotion of Farm Mechanization in Selected Villages:** Provides financial assistance to promote appropriate technologies and to set up Farm Machinery Banks in identified villages in low mechanized

states.

- vii. **Financial Assistance for Promotion of Mechanized Operations/hectare Carried out Through Custom Hiring Centers:** Provides financial assistance on per hectare basis to the beneficiaries hiring machinery/equipments from custom hiring centers in low mechanized areas.
- viii. **Promotion of Farm Machinery and Equipment in North-Eastern Region:** Extends financial assistance to beneficiaries in high potential but low mechanized states of northeast.
- ix. **Promotion of Drone Technology:** Extends financial assistance for purchasing agricultural drones to beneficiaries like FPOs 75 % cost of Drone up to a maximum Rs. 7.5 Lakh , for individuals Framers like SC, ST, Small, Marginal, Women and NE state Farmers 50 % cost of Drone up to a maximum Rs. 5 Lakh and for other individual farmers 40 % cost of Drone up to a maximum Rs. 4 Lakh

5.2 Support for farm machinery under Rashtriya (RKVY)

Rashtriya Krishi Vikas Yojana was initiated in 2007 as an umbrella scheme for ensuring holistic development of agriculture and allied sectors by allowing states to choose their own agriculture and allied sector development activities as per the district/state agriculture plan. RKVY guidelines have been revamped as RKVY – RAFTAAR - Remunerative Approaches for Agriculture and Allied sector Rejuvenation to enhance efficiency, efficacy and inclusiveness of the programme



5.2.1 Objectives

The scheme aims at making farming a remunerative economic activity through strengthening the farmers effort, risk mitigation and promoting agri-business entrepreneurship. The main objectives of the scheme are

- i. To strengthen the farmers efforts through creation of required pre- and post-harvest Agri-infrastructure that increases access to quality inputs, storage, market facilities etc. and enables farmers to make informed choices.
- ii. To provide autonomy, flexibility to States to plan and execute schemes as per local/ farmers needs.
- iii. To promote value chain addition linked production models that will help farmers increase their income as well as encourage production/ productivity.
- iv. To mitigate risk of farmers with focus on additional income generation activities - like integrated farming, mushroom cultivation, bee keeping, aromatic plant cultivation, floriculture etc.
- v. To attend national priorities through several sub-schemes.
- vi. To empower youth through skill development, innovation and Agri entrepreneurship-based agribusiness models that attract them to agriculture.

5.2.a Support under RKVY (Infrastructure & Assets)

Under Agriculture Mechanization, support is provided under the scheme for Custom Hiring Centers for Agricultural Equipment, Agriculture Machines Testing Centers, Establishment of Hi-tech

hubs for Custom Hiring, Establishment of Post-Harvest Technology Units for Primary Processing and Value Addition, Use of Solar Energy in Agriculture i.e. Solar pump sets, Solar dryers, solar energy in green house etc. Support is also available for Development of Modern Farms of agricultural mechanization at Govt./SAUs level for demonstration Training, Demonstration, Distribution of agricultural machinery and establishment of custom hiring centers for Straw Management etc.

5.2.b Bringing Green Revolution in Eastern India (BGREI)

Support is available under the scheme through asset building Intervention which include assistance for farm machineries & implements like cono weeder, manual/power sprayer, drum seeder, seed drill/zero-till seed drill, power weeder, self-propelled paddy transplanter, rotavator, multi crop thresher, laser land leveller, pump set and for any other farm machine suitable for cultivation of rice.

5.2.c Crop residue Management (CRM):

5.2.c.1 Objectives:

- i. Environmental Protection: Preventing air pollution and protecting soil health by reducing the burning of crop residues.
- ii. Nutrient Conservation: Retaining essential nutrients and soil microorganisms that would otherwise be lost due to burning.
- iii. Sustainable Practices: Promoting the incorporation of crop residues into the soil and establishing supply chains for their utilization.
- iv. Awareness and Education:

Creating awareness among farmers and stakeholders through demonstrations, capacity-building activities, and information campaigns.

These objectives aim to promote sustainable agricultural practices and improve overall environmental health.

5.2.c.2 Components:

- i. Financial assistance to farmers for procurement of crop residue management machines on individual ownership basis:** The rate of financial will 50% of the cost of machinery.
- ii. Establishment of Custom Hiring Centres of Crop Residue Management Machines:** Financial assistance 80% of the project cost for the projects of Custom Hiring Centres (CHCs) costing up to Rs. 15 lakhs will be available to Rural Entrepreneurs (Rural youth and farmer as an entrepreneur), Cooperative Societies of Farmers, Self Help Groups (SHGs), Registered Farmers Societies, Farmer Producer Organizations (FPOs) and Panchayats. The maximum permissible assistance per machine under the CHC project will be the amount arrived by multiplying the maximum permissible assistance for each machine. The maximum permissible assistance for each project should not exceed Rs. 12.00 lakhs per project.
- iii. Establishment of crop residue/paddy straw supply chain:** The project proposal based financial assistance will be provided only on the capital cost of machinery and equipment like Higher HP Tractor, Cutters, Tedder, Medium to Large

Balers, Rakers, Loaders, Grabbers, and Telehandlers. The capital subsidy will be released into the bank Escrow account of beneficiary through Direct Benefit Transfer (DBT).

- iv. Information, Education and Communication (IEC) for awareness on crop residue management:** The machines to be demonstrated shall be identified by the implementing agencies. The implementing agencies will be provided full cost of machines to be procured and a contingency expenditure Rs. 6000/- per hectare will also be provided for taking up demonstrations on the farmers' fields

5.3 Support for farm machinery under National Food Security Mission (NFSM):

The National Food Security Mission (NFSM) provides support for farm mechanization to enhance agricultural productivity and efficiency.

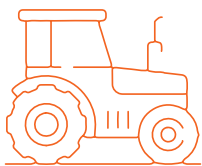
5.3.1 Objectives:

To increase the production of rice, wheat, pulses, coarse cereals, and commercial crops.

5.3.2 Components:

Only the components which support farm machinery / farm mechanization under NFSM are indicated below

- i. Subsidies for Farm Machinery:** The NFSM offers subsidies on various farm machinery, including tractors, harvesters, seeders, and threshers. These subsidies reduce the upfront cost of purchasing machinery, making it more accessible to farmers. The subsidy amounts vary depending



on the type of machinery and the specific state's guidelines.

- ii. **Custom Hiring Centers (CHCs):** The NFSM supports the establishment of CHCs, which provide farmers with access to modern farm machinery on a rental basis. This is particularly beneficial for small and marginal farmers who may not be able to afford their own machinery. CHCs help in timely completion of farm operations, leading to increased productivity and reduced post-harvest losses.
- iii. **Training and Capacity Building:** The NFSM provides training programs to farmers on the proper use and maintenance of farm machinery. This helps in maximizing the benefits of mechanization and ensuring efficient operation.

5.4 Support for farm mechanization under Pradhan Mantri Krishi Sinchai Yojana (PMKSY):

The Pradhan Mantri Krishi Sinchai Yojana (PMKSY) is a flagship scheme of the Government of India aimed at enhancing agricultural productivity and increasing farmers' incomes. Under this scheme, several initiatives have been taken to promote farm mechanization.

5.4.1 Objectives:

The scheme aims to improve agricultural productivity and farmers' incomes by expanding irrigation facilities, enhancing water use efficiency, reducing dependence on rainfall, promoting sustainable agriculture practices, and increasing crop yields and quality.

5.4.2 Components:

Only the components which support farm machinery / farm mechanization under PMKSY are indicated below

- i. **Expansion of irrigation facilities:** The PMKSY primarily aims to provide irrigation facilities to all farmlands. By promoting modern irrigation systems like drip and sprinkler irrigation, water use efficiency is being improved.
- ii. **Subsidies on agricultural machinery:** The scheme provides subsidies to farmers on various agricultural machinery such as tractors, combine harvesters, rice planting machines, etc. This makes it easier for farmers to purchase agricultural machinery.
- iii. **Custom hiring centers:** Custom hiring centers are being established under the scheme. Through these centers, farmers can rent agricultural machinery. This benefits small and marginal farmers who cannot afford to own their own agricultural machinery.
- iv. **Training programs:** Farmers are provided training on the use and maintenance of agricultural machinery. This enables farmers to make the most of agricultural machinery.

5.5 NAMO Drone Didi:

It is a Central Sector Scheme designed to harness the collaborative efforts of key government departments, including the Department of Agriculture & Farmers Welfare (DA&FW), Department of Rural Development (DoRD), and Department of Fertilizers (DoF). The initiative aims to promote the utilization of drones in

agriculture for the precise spraying of Nano fertilizers and pesticides with the emphasis on women's engagement and their sustained participation in mainstream agriculture.

5.5.1 Objectives:

Its primary objectives are:

- **Empowering Women:** The scheme aims to create job opportunities for rural women by training them to operate drones. This empowers them economically and socially.
- **Promoting Agricultural Development:** Drones equipped with advanced cameras and sensors can be used for various agricultural tasks such as crop monitoring, pest control, and precision farming. This can significantly boost agricultural productivity and income for farmers.
- **Disaster Management:** Drones can be deployed for rapid assessment and response during natural disasters like floods, droughts, and landslides. This can help save lives and property.
- **Rural Development:** The scheme can contribute to rural development by providing access to modern technology and creating new economic opportunities.
- **Bridging the Digital Divide:** By training rural women to operate drones, the scheme can help bridge the digital divide and improve connectivity in rural areas.

The components of the Drone Didi scheme are as follows:

- **Training:** The scheme provides training to women on how to operate drones and use them for agricultural

applications.

- **Drones:** The scheme provides drones to the participating women.
- **Insurance:** The scheme provides insurance coverage for the drones and the drone pilots.
- **Support:** The scheme provides support to the participating women in terms of technical assistance, marketing, and finance.

The Drone Didi scheme is expected to benefit women in rural areas by providing them with new skills and employment opportunities. It is also expected to benefit farmers by improving the efficiency and effectiveness of agricultural operations.

5.6 Support for farm machinery under MIDH:

Mission for Integrated Development of Horticulture (MIDH) is a Centrally Sponsored Scheme for the holistic growth of the horticulture sector covering fruits, vegetables, root & tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa and bamboo. Assistance under the scheme is being provided for activities such as procurement of power operated machines & tools, besides import of new machines. Assistance for horticulture mechanization is to be also available to grower associations, farmer groups, Self Help Groups, women farmer groups, who are engaged in cultivation of horticultural crops, provided balance 60% of the cost of machines and tools is borne by such groups.

06 Farm
Mechanization –
Issues, Benefits
and Suggestions

6.1. Farm Mechanization - Issues

- i. **High cost:** Farm equipment, especially energy-efficient options, is capital intensive and is a significant investment for most of the farmers in India. A majority of them belong to the low-income bracket.
- ii. **Economies of operation:** To ensure attractive return on investment in farm mechanization, area under operation and usage of different machinery should be high/ optimal, which has been challenging. The small size of landholdings makes it difficult to use modern farming machinery. Increase in gross cropped area also has limitation due to non-availability of assured irrigation facility and favourable climatic conditions.
- iii. **Credit process:** Availing agriculture term loan is more cumbersome than availing production credit, primarily due to poor projectization, uncertain cashflow, inadequate appraisal skill set with some of the bank personnel.
- iv. **Rate of interest:** Under interest subvention scheme for crop loan (production credit), farmers receive short term credit at 7% p.a. rate of interest, with an upper limit of Rs 3.00 lakh on the principal amount. Additional interest rebate of 3% is being provided to farmers on prompt repayment. Also, many of the State Govt. are providing interest subvention for farmers availing crop loan through cooperative banks, which further lowers the effective rate of interest for crop loans. Similar incentive structure on rate of interest on loans is not available for farm mechanization activities.

v. Subsidy through budget allocation:

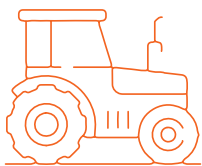
Farm mechanization requires substantial investment. To assist farmers, to withstand the burden of loan repayment and interest pay out, Central Govt. and various State Govts. have been providing subsidies for Individual/ Group of farmers/ Cooperatives to invest. These subsidies are available based on the budget allocation made by Central/ State Govt. It is quite inadequate compared to the requirement.

vi. Inadequate technical know-how/ awareness:

Farm mechanization is still perceived as only using tractors, power tillers, combine harvesters and threshers. There are many other self-propelled machinery and equipment, which are suitable for small land holdings and can be used by even individual farmers. Farmers are not much aware about these kinds of machineries and implements, their utility value/economics and methods of use.

6.2. Benefits of farm mechanization

- i. **Input savings:** Studies have shown a direct relationship between farm mechanization (farm power availability) and farm yield. Farm mechanization could help in savings in seeds (approx. 15-20 percent), fertilizers (approx. 15-20 percent).
- ii. **Increase in efficiency:** Farm machinery helps in increasing the efficiency of farm labour and reducing drudgery and workloads. It is estimated that farm mechanization can help reduce time by approx. 15-20 percent. Additionally, it helps in



improving the harvest and reducing the post-harvest losses. These benefits and the savings in inputs help in the reduction of production costs and allow farmers to earn more income.

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

- a. Helps in conversion of uncultivable land to agricultural land through advanced tilling techniques.
- b. Decrease in workload on women as a direct consequence of the improved efficiency of labour.
- c. Improvement in the safety of farm practices.
- d. Helps in encouraging the youth to join farming and attract more people to work and live in rural areas.
- e. Farm mechanization offers an alternative to deal with the increasing cost of labour.

6.3. Suggestions

6.3.1. Individual farm equipment for Small & Marginal farmers

Tractor penetration has increased from 34 per '000 ha in FY 2015 to 52 per '000 ha in FY 2021. However, such an increase in penetration has not been seen in other segments of farm equipment. As per-capita land holding is decreasing, small farm machinery/ implements (individually operated) need to be promoted keeping in view the versatility of various crops, cropping pattern and agriculture operations. The 'Make in India' initiative launched by the Government can be used to support the manufacture of inputs and farm implements currently being imported. This would help in

reducing the overall capital cost.

6.3.2. Ease of financing

Procedure to avail term loan may be simplified with minimum documentation. Capacity building of bank staff dealing with agriculture term loan products would be of help. Credit guarantee products covering farm mechanisation activities would help the sector.

6.3.3. Lower rate of interest

The subsidy support could be re-routed to ensure that the interest on financing farm mechanization purposes is brought to a lower rate and that payback periods/ moratoriums are aligned with cash flow.

6.3.4. Demonstration and awareness

To create awareness about type and use of new farm machineries and implements, organizing demonstrations at field level for farmers should be the part of marketing policy of manufacturers. The demonstrations may be arranged in collaboration with Agriculture Universities, Krishi Vigyan Kendra's, Agriculture Institutes etc. at regular intervals.

6.3.5. Value addition and Marketing

Keeping long term perspective to make agriculture sustainable and a lucrative activity, value addition and marketing should be strengthened at farmers' level with assured forward linkages. It will boost confidence of farmers to invest in farm mechanization.

6.3.6. Ergonomics

There is a large female workforce employed in farming and off-farm activities. Ergonomically designed tools

and equipment for reducing drudgery, enhancing safety, and comfort of women workers, and meeting the needs of women workers would help in better acceptance of technology in agriculture.

6.3.7 Farm Mechanization and Recommendations of Committee on Doubling Farmers' Income (Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare)

- i. Considering the preponderance of small & marginal holdings in the country, R&D should aim at developing and designing scale-neutral machinery. Further, machinery that can suit different terrain of the geography deserves priority attention.
- ii. Agriculture Machineries can become part of 'Farming as a Service' (FaaS), which means that farmers should have easy access to mechanization and related services on rent in preference to owning the same. This can be facilitated by promoting:
 - a. 'Custom Hiring Centres' (CHCs) at the rate of a minimum of 1 (one) per village (when large) and 1 (one) per Gram Panchayat comprising in cluster of small villages. These should be able to meet the demand for all basic services and would therefore be expected to possess low duty machinery.
 - b. 'Agriculture Machinery Banks' (AMBs) at the district/subdistrict level, possessing heavy duty machinery like combine harvester, laser land leveller etc.
- iii. 'State/Regional Services' possessing

more sophisticated and heavier machinery that can service larger areas to meet certain specific demands; and possess ICT/ GIS/ Space technology-based services.

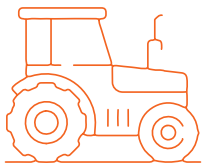
- iv. These centres at different levels should be supported to broaden their technologies to include modern systems like drones, sensor-based applications, etc. and also those needed in the sub-sectors of animal husbandry, fisheries, etc.

6.3.7.1 Promotion modes: The above types of services can be promoted by adopting one or more of the approaches below:

- i. Enterprise mode – the youth can be specifically trained and financially supported (credit linked back-end subsidy) to set up CHCs. In order to make such enterprises viable, other agricultural services can also be integrated to offer 'One Stop Shop'. Some of the services deliverables are pesticide, fertilizer & seed retailship, I.T. based extension services etc.
- ii. SHG/FPO/Trust/PACS based CHCs.
- iii. NGO/CSR (Corporate Social Responsibility) based CHCs and AMBs.

6.3.7.2 Shared utility or Uberization:

Aggregation platforms have proved highly successful in city transport services. On similar lines, uberization is feasible in agricultural mechanization. Hence networking of individual owners, CHCs, AMBs and Regional/State Service Centres can happen by onboarding a common platform and meet the demand in real time and cost effectively. Professional Service Providers with large investments and capable of establishing a brand name



can opt to promote franchise model for quick scale up across the region/state. The youth can grow up professionally as franchise-based entrepreneurs. Since agricultural operations are seasonal and time bound, the farmer in need of a service cannot afford to wait and would benefit only if response to his call is positive with nil/least time lag.

Further, transaction cost will need to be rational, and therefore, the machinery will need to be sent to the farmer's work site from the nearest location. Uberization is the most optimal solution to such demands. This brings an advantage of enhancing the use-time of the machinery purchased, and therefore, the realization of a positive RoI (Return on Investment).

6.3.7.3 Service facilities

It is important to ensure the availability of repair and service facilities in proximity so that operation & maintenance issues are addressed. Mobile service centres can also be promoted to cater to minor repair demands. This requirement also generates scope for enterprise creation.

The concept of FaaS goes beyond providing machinery on hire. It encompasses a number of services including offering labour, managing actual field operations in respect of not only agricultural machinery, but also other agricultural operations. For example, harvesting of coconut, arecanut and the like is a specialized function,

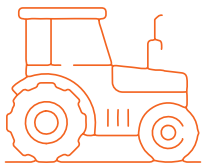
and the traditional tree climber may not always be available these days. A 'FaaS' entrepreneur can meet such a service demand.

In sugarcane belts, it is common to see labour contractors undertaking harvesting, and labour groups travelling long distances, even across the states. Mechanized services through FaaS can become effective at lesser social cost, that migration brings in movement/migration of labour.

6.3.7.4 Machinery for waste management

In the Indo-Gangetic Plains (IGP), where rice-wheat is the dominant cropping system, burning of rice straw to meet the deadline of wheat sowing time is a common practice. This is not only unsound ecologically but also causes a loss of opportunity to capture the value that lies in the paddy straw. This wasteful practice describes most agricultural activities. In the strategy for doubling farmers' income, gainful use of all biological products, and not just the grain or fruit, is necessary to generate additional farm incomes. Hence, agricultural mechanization plans must include farm waste management machines and devices and make residue management a productive activity.

07 Mechanisation
for Small and
Marginal Farmers



India is the most populous country in the world recently surpassing China with an estimated population of 145.4 crores. India's population has reached the current levels from a level of 36.1 crore with initial growth rate of 2.21% and thereafter tapering off to a current growth rate of 0.92%. In 2021, the estimated total number of households in India was 30.24 crore with average household size of 4.44 persons. Of these, 65% were rural households and remaining being urban households. Of the above, 9.31 crore are from farming households with total number of cultivators estimated to be approximately 11.89 crore. As per the agriculture census 2015-16, there were 14.65 crore operational farm holdings of these nearly 86% belong to marginal farmers i.e. farmers having landholdings lesser than 1 ha.

As per the latest estimates for 2023-24, the total food grain production is projected to be around 332.3 million tonnes. India has achieved phenomenal growth in food grain production from about 50 million tonnes in 1950 on account of green revolution, advancements in agricultural practices, adoption of technologies, increased mechanisation of farm operations, focused Govt. support to achieve self-sufficiency in food production to the burgeoning population of the country. The contribution of all categories of farmers is worth mentioning.

One of the critical factors that has resulted in such resounding performance in food grain production is the increase

in farm power availability over the years, enhanced mechanisation of farm operations and the country rising to the level of world's leading tractor manufacturers. Farm Mechanisation's main purposes are to reduce drudgery in farm operations, reduce dependence of farm labour and facilitate precision agriculture i.e. application of **right input** at **right location** with **right amount** at **right time** and from **right source**.

Farm mechanisation trends since 1950s indicate the adoption of tractors initially for land preparation and thereafter the mechanisation spread to harvesting, seeding/ planting, weeding, so on and so forth. Also, in terms of crops, the mechanisation initially picked up in cultivation of paddy/ wheat and thereafter to other cereals, pulses, cash crops like sugarcane, etc.

In south Asian countries which has similar farmer demographic profiles as India, the adoption of tractors/ power tillers as the prime mover for farm operations have been distributed as per the proportion of small, marginal and other farmers, for e.g., in Vietnam, Philippines etc. However, in India, adoption of tractors has been spearheading the mechanisation of farm operations and farm mechanisation in India is often called as 'Tractorisation'. As of year 2018, around 4.5% of farming households possessed tractors indicating that nearly 96% of farming households majority of which constitute small & marginal farmers cannot afford to possess tractors & associated farm machinery on account of following reasons:

1. High cost of tractors & farm machinery
2. Lack of credit facilities
3. Lack of capability to manage tractors & farm machinery
4. Quantum of subsidy and coverage under SMAM and other similar schemes
5. Lack of collateral security for availing loans

Of the total cultivable area in the country nearly 56% of the area is unirrigated and dependent on rainfall for source of irrigation. Dependence on rainfall provides a truncated & unpredictable window/ time frame for execution of different farm operations thereby making precision agriculture all the more important and relevant to unirrigated farmlands. Use of tractors/ power tillers are central to precision agriculture in food grain production.

Factoring the field capacities, it can be easily concluded that tractors would be a larger farm power source for marginal farmers and even to small farmers and power tiller and power tiller operated implements are more suited to the needs of the small & marginal farmers of the country. However, the tremendous growth of tractor industry and importance it established for itself in the Indian agriculture environment has proved to be a dampening for the growth of small tractor, power tiller and power tiller-based farm machinery & equipment which are more suited to the needs of the small and marginal farmers.

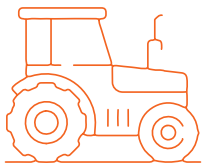
It can be seen from export & import of

tractors & farm machinery figures of the country, that India's farm machinery exports are dominated by Tractors, the farm machinery imports are dominated by non-tractor farm machinery. While our farm machinery exports are more diversified in terms of countries to which they are exported, our imports are more concentrated from China which has a share of more than 50%.

The overt tractorisation of the Indian agriculture has given less room for R & D and creation of production facilities for power tiller and its associated farm equipment. This has led to a situation for the creation of number of custom hiring centres through schemes of both central & state governments, setting up of such CHC units by PACS or FPOs. However, the establishment of such CHCs has not necessarily helped the cause of Small & Marginal Farmers as even rental markets are going beyond the reach of these farmers.

With their land holdings being minimal, the overall policy environment with regards to farm mechanisation needs to be re-oriented to the needs and requirements of Small & Marginal farmers of the country. A differentiated policy approach is required to be adopted for high and low mechanized areas. While small & marginal farmers do possess minimal land holdings, additional collateral in the form of land need not be insisted by banks for financing tractors/ power tillers.

Based on the proportion of different categories of farmers in the district, credit



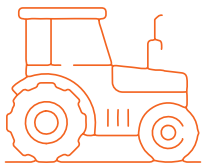
planning needs to be done separately for SF/MF & other farmers. While imports of farm machinery are of non-tractor in nature and sourced mostly from China, there has always been concern of quality products entering Indian market and availability of sales and service for such imported equipment is a matter of concern.

Apart from reducing drudgery in farm operations, reducing dependence & cost of farm labour, farm mechanisation also leads to reduction in farm inputs to

upto 20% which can lead to considerable savings and enhanced net farm income or net surplus. In order to give impetus to indigenous development of power tiller, small tractor and associated small farm machinery or equipments, Govt. of India may consider introducing PLI scheme for production of power tillers and other small farm machinery in the country itself thereby reducing dependence on imports and production of farm machinery suited to different farming practices of India.



08 Emerging Trends in Farm Mechanisation



Rapid technological advancements are shaping the future of farm mechanization. From autonomous tractors to drones and robotic harvesters, the agriculture sector is undergoing a transformation that aims to boost productivity, reduce costs, and promote sustainability. As these technologies become more affordable and accessible, farming would be more precise, efficient, and environment friendly¹⁰.

8.1. Precision Agriculture

Precision agriculture utilizes Global Positioning System (GPS), Geographic Information System (GIS), sensors, drones, data analytics, etc. to optimize field-level crop management, which could include applying precise amounts of inputs like water, fertilizers, and pesticides, thus increasing yields and reducing wastage¹¹.

- GPS enables farmers to pinpoint their exact location in a field, allowing for precise mapping of crop yields, soil types, and other variables.
- GIS integrates various data layers (e.g., soil, crop, weather) to create detailed maps that help in decision-making.
- Remote Sensing, Drones and Unmanned Aerial Vehicles (UAVs)
 - Satellite or drone imagery is used to monitor crop health, soil conditions (through Normalized Difference Vegetation Index (NDVI) maps, etc.) and weather patterns. This data helps in identifying issues like pest infestations or nutrient deficiencies early on.
 - Aerial surveys of fields help in gathering high-resolution

images and data. Drones can cover large areas quickly and provide detailed information on crop conditions, detailed vegetation maps with images from multispectral cameras.

- Variable Rate Technology (VRT) allows farmers to adjust the application rates of inputs like seeds, fertilizers, and pesticides based on the specific needs of different areas of a field. This technology uses data from GPS, remote sensors, and soil sampling to identify variations in field conditions and adjust application rates accordingly. This could be Variable rate seeding, Variable rate fertilizer application or Variable rate irrigation.
- Soil Sensors / Smart Irrigation & Fertigation Systems help in measuring soil moisture, temperature, and nutrient levels in real-time. This data helps in optimizing irrigation and fertilizer application schedules.
- Data Analytics and Machine Learning - Advanced algorithms and Machine learning models help in predicting crop yields, optimizing planting schedules, and identifying potential issues. Predictive models use historical data to forecast crop performance under different conditions.

8.2. Autonomous Machinery

Autonomous machinery, including tractors, harvesters, and drones, is revolutionizing farm operations. These machines can operate independently

¹⁰ Frontu. (2022). Farm Machinery and Ag Equipment Trends

¹¹ MDPI. (2018). Advances in Agriculture Mechanization

or with minimal human intervention, improving efficiency and reducing labour costs. For instance, autonomous tractors equipped with GPS and sensors can perform tasks such as ploughing, planting, and harvesting with high precision¹².

These autonomous machineries use technology/ies like:

- **GPS and Telematics :** These provide precise location data, enabling autonomous machinery to navigate fields accurately, and allow remote monitoring and control of machinery, providing real-time data on machine performance and field conditions. For example, GPS-guided autonomous tractors can follow predefined paths for planting, fertilizing, and harvesting.
- **Sensors and Cameras :** LiDAR, Radar, and Cameras provide real-time data about the environment, helping machines to detect and avoid obstacles, identify crops, and perform tasks with high precision. For example, autonomous harvesters use LiDAR and cameras to identify ripe fruits and vegetables, ensuring accurate and efficient harvesting.
- **Robotic Arms and Actuators** in machinery perform tasks such as planting, weeding, and harvesting with high precision. For example, robotic weeders can identify and remove weeds without damaging crops.
- **Internet of Things (IoT)** connects autonomous machinery to a central system, allowing for real-time data exchange and remote control. IoT-enabled irrigation systems can adjust water levels based on real-

time soil moisture data, optimizing water usage.

- **Artificial Intelligence (AI) and Machine Learning** with AI Algorithms enable machines to perceive their surroundings, recognize objects, and make decisions. These continuously improve the performance of equipment by learning from past experiences and data. For example, autonomous tractors can use AI algorithm and analyse sensor data to navigate fields, avoid obstacles, and optimize routes.

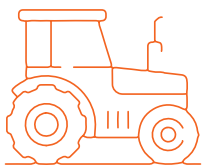
8.3. Robotics and Artificial Intelligence (AI)

Robotics and AI are being integrated into various farm equipments for performing repetitive tasks such as planting, weeding, and harvesting with data driven decision-making.¹³

- Weeding robots can identify and remove weeds without harming crops.
- Robotic Harvesters can identify and pick ripe fruits with high accuracy, addressing labour shortages and reducing costs.
- Autonomous Weeding Robots use AI to distinguish between crops and weeds, removing the later without harming the former.
- AI-Powered Decision Support Systems analyse data from various sources (e.g., weather, soil, crop health) to provide actionable insights for farmers. AI algorithms that predict optimal planting times and irrigation schedules based on historical and real-time data.
- Robotic Milking Systems automate

¹² McKinsey & Company. (2022). Trends driving automation on the farm

¹³ Agritech Tomorrow. (2021). Recent Innovations in Farm Equipment Allow for Increased Versatility



the milking process, ensuring consistency and improving animal welfare.

8.4. Sustainable Mechanization

Sustainable mechanization focuses on reducing/ minimizing the environmental impact of farming practices. This could be a system that uses renewable energy sources such as solar-powered irrigation systems, equipment designed to minimize soil compaction and erosion or alike.¹⁴

Key Aspects of Sustainable Mechanization:

- **Technological Integration/ Efficient Machinery:** Using advanced machinery that is efficient and reduces/ minimises emissions.
- **Environmental Sustainability/ Conservation Agriculture:** Practices that protect the soil, conserve water, and use inputs more efficiently. No-till farming could be one option.
- **Economic/ Financial Viability/ Cost-effective Solutions:** Ensuring that mechanization is affordable for small and large-scale farmers alike. Cooperative ownership/ rental models could help.
- **Social and Cultural Considerations: Labour Efficiency:** Reducing the physical burden on farmers and addressing labour shortages, e.g. mechanized planting and harvesting equipments that reduce the need for manual labour.
- **Resource Optimization / Precision Agriculture:** Using technology to apply inputs like water, fertilizers, and pesticides precisely where needed, e.g. smart irrigation systems that

adjust water levels based on real-time soil moisture data.

8.5. Internet of Things (IoT)

The Internet of Things (IoT) connects various devices and sensors on the farm, enabling real-time monitoring and control of agricultural operations. IoT applications in agriculture can include soil moisture sensors, weather stations, livestock monitoring systems, etc. These technologies help farmers make informed decisions, optimize resource use, and improve overall farm management. These could include:

- **Sensors and Actuators :** Sensors collect data on various parameters such as soil moisture, temperature, humidity, and crop health. Actuators then use this data to perform actions like adjusting irrigation levels or applying fertilizers. Soil moisture sensors that monitor soil conditions and trigger irrigation systems when moisture levels drop below a certain threshold.
- **Connectivity and Communication Networks :** IoT devices communicate with each other and central systems through various networks such as Wi-Fi, cellular, and low-power wide-area networks (LPWAN). LPWAN technologies like LoRaWAN enable long-range communication between sensors and central systems, even in remote agricultural areas.
- **Data Analytics and Cloud Computing :** Data collected by IoT devices is transmitted to cloud-based platforms where it is analysed to provide actionable insights. Cloud platforms can help in analysing data from multiple sensors to optimize

¹⁴PwC. (2019). Farm mechanisation: Ensuring a sustainable rise in farm productivity and income

irrigation schedules, predict crop yields, etc.

- **Automation and Control Systems:** Automated systems use data from IoT devices to control farm machinery and processes, reducing the need for manual intervention, e.g. automated tractors that adjust their operations based on real-time data from field sensors.

8.6. Farm Management Software

Farm management software integrates various aspects of farm operations, including crop planning, inventory management, and financial tracking. These platforms provide farmers with tools to analyse data, forecast yields, and manage resources effectively. The

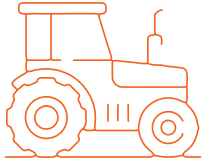
adoption of farm management software is increasing as farmers seek to streamline operations and improve profitability.

Conclusion

The emerging trends in farm mechanization are transforming agriculture, making it more efficient, sustainable, and resilient. By leveraging technologies such as precision agriculture, autonomous machinery, robotics, AI, IoT, and advanced irrigation systems, farmers can address the challenges to modern agriculture, have better farm returns and meet the growing demand for food. Continued innovation and investment in farm mechanization are essential for the future of agriculture.

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- 4: Frontu. (2022). Farm Machinery and Ag Equipment Trends.
- 5: Agritech Tomorrow. (2021). Recent Innovations in Farm Equipment Allow for Increased Versatility.



i. **Notes**

the *Journal of the American Medical Association* (JAMA) and the *New England Journal of Medicine* (NEJM).

These journals are the most widely read and cited in the field of medicine. They are also the most expensive, with subscription rates for institutions ranging from \$10,000 to \$20,000 per year.

The *Journal of the American Medical Association* (JAMA) is the largest of the three, with a circulation of over 100,000 copies per year. It is published weekly and covers a wide range of medical topics.

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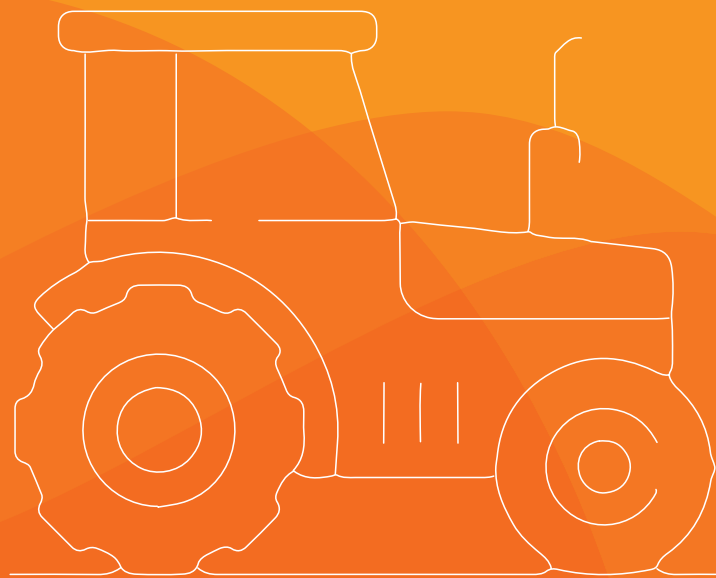
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Farm Mechanisation



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