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MAKING INDIA

A Global Power House in the Farm Machinery Industry

Study Sponsored by

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January 2023

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National Council of Applied Economic Research
NCAER India Centre, 11 Indraprastha Estate, New Delhi 110 002, India.
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Foreword

With the ever-increasing production and demand for agricultural products and output, farm mechanisation is indispensable for achieving the desired output levels, efficient use of inputs and ensuring timeliness in the various farm operations. However, capital constraints and small land holdings are two major bottlenecks to the effective implementation of farm mechanisation. The necessity for promoting farm mechanisation as a special Mission was felt by the Government of India and the Sub-Mission on Agricultural Mechanisation and Farmer's Welfare (SMAM & FW) has been conceived as a vehicle for implementation during the XII Plan period. The present study by the National Council of Applied Economic Research (NCAER) aims to provide empirical evidence for recommending key strategic actions to be taken to foster the growth of the non-tractor farm machinery industry in India and make it into a global production hub.

NCAER has analysed the non-tractor farm machinery industry from both demand and supply side perspectives. NCAER brings out the challenges in the sector and recommends measures & reforms by benchmarking global practices in their white paper on 'Making India a Global Powerhouse in the Farm Machinery Industry'.

The key policy implication in this report is the urgent need for a vibrant R&D environment that encourages academia-industry collaboration to innovate & produce non-tractor farm machinery that caters to the needs of small & marginal farmers in India and has an external market.

My appreciation goes to the project team led by Dr Bornali Bhandari and Dr Laxmi Joshi, along with Mr Shish Pal Bansal, Senior Advisor and core team members comprising Mr Ajaya K. Sahu, Dr Saurabh Bandyopadhyay, Ms Vaishali Jain, Mr Devender Pratap, Dr Palash Baruah, and Ms Nishika Pal.

I join the NCAER team in expressing my appreciation for the insights and guidance received from officials of Mahindra & Mahindra at various stages of this study.

We genuinely hope that the study would be valuable and useful for policymakers and academics in due course.

Poonam Gupta
Director General
NCAER

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List of Abbreviations

AIDIS	All India Debt & Investment Survey
ASCI	The Agricultural Skills Council of India
ASI	Annual Survey of Industries
BUPL	Beri Udyog Pvt. Ltd.
CHC	Custom Hiring Centres
CSO	Central Statistics Office
DBT	Direct Benefits Transfer
DGFT	Directorate General of Foreign Trade
EMD	Earnest Money Deposit
FASAR	Food and Agriculture Strategic Advisory and Research
FDI	Foreign Direct Investment
FICCI	The Federation of Indian Chambers of Commerce & Industry
FLDs	Front-Line Demonstrations
FPA	Farm Power Availability
GAA	German Agribusiness Alliance
GL	Grubel-Lloyd Index
GOI	Government of India
GVA	Gross Value Added
GVCs	Global Value Chains
GVO	Gross Value of Output
HP	Horse Power
HS codes	Harmonized System codes
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICFA	Indian Council of Food and Agriculture
ITIs	Industrial Training Institutes
KCC	Kisan Credit Card
MENA	North Africa/Middle East
MoAFW	Ministry of Agriculture & Farmers Welfare
MOSPI	Ministry of Statistics and Programme Implementation
MSMEs	Micro, Small and Medium Enterprises
NABARD	National Bank for Agriculture and Rural Development
NCAER	National Council of Applied Economic Research
NER	North Eastern Region
NIC	National Industrial Classification
NPC	National Product Classification
NSO	National Statistical Office
NSSO	National Sample Survey Office
OECD	Organisation for Economic Co-operation and Development
PIB	Press Information Bureau
PPPs	Public-Private Partnerships
PSA	Principal Scientific Advisor
PwC	PricewaterhouseCoopers
R&D	Research & Development
RKVY	Rashtriya Krishi Vikas Yojna
RLI	Research-linked Incentive
SMAM	Sub-Mission on Agricultural Mechanisation
SSA	Sub-Saharan Africa
TTTOs	Technoparks and Technology Transfer Offices
TTOs	Technology Transfer Offices

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Executive Summary

Background and Objectives

Farm mechanisation in India is marked by 'tractor-isation'. India's farm equipment market is 7 per cent of the global market, with more than 80 per cent of the value contribution coming from tractors. The focus of this paper is on non-tractor farm machinery because India is already one of the global leaders in tractors. The twin objectives of this paper are to recommend to policymakers key strategic actions to be taken to foster the growth of the non-tractor farm machinery industry in India and make it into a global production hub, and to improve the match between the needs of Indian farmers and Indian farm machinery producers in terms of price, quality and efficiency of the machinery. This will make India a global powerhouse for farm machinery and enable farmers to improve crop yields, farm productivity and their overall lives.

Demand-side Challenges

Limited domestic demand

The Indian farm machinery sector is dominated by tractors. Plus, there is a mismatch between what the organised farm machinery sector produces and the needs of small and marginal Indian farmers. Although there is high State-level variation, in 2018–19 barely 4.4 per cent of farmer households in India owned a tractor, 2.4 per cent a power tiller and 5.3 per cent owned one of the four machinery items-tractor, power tiller/power-driven plough etc., crop harvester (power driven)/combined harvester thresher and other power-driven machinery and equipment.

> Farm machinery exports are driven by the tractors, and farm machinery imports are driven by non-tractor farm machinery imports. Further, the direction of trade is lopsided where 53 per cent of non-tractor farm machinery imports are coming from China, but the export markets are relatively more diversified.

The use of farm machinery in India is relatively low because of a number of reasons: large number of small & marginal farmers (though with state-level variations) with small and fragmented land holdings, the practice of subsistence agriculture, diverse soil conditions and cropping patterns, lack of access (especially timely access) to farm power, the cost of the equipment, the tedious process of acquiring farm equipment under a subsidy and farmers' credit constraints. Farmers also lack information and guidance on the machinery, so they waste money buying the wrong machinery. Government subsidies are able to reach small and marginal farmers in a limited fashion; therefore, they cannot buy farm machinery either for self-use or for leasing purposes. Credit constraints also limit their ability to rent equipment.

External Demand shows lop-sided patterns

Farm machinery exports are driven by the export of tractors, and farm machinery imports are driven by non-tractor farm machinery imports. Further, the direction of trade is lopsided where 53 per cent of non-tractor farm machinery imports are coming from China, but the export markets are relatively more diversified. India has a revealed comparative advantage (i.e., it can produce products at a relatively lower opportunity cost) in certain farm machinery such as ploughs, disc harrows, 'agricultural & horticultural machinery' and threshing machinery parts. Also, India's trade in this sector is characterised by high intra-industry trade, i.e., trade within the same industry group.

Supply-side Challenges

The Indian farm machinery industry is rendered uncompetitive in terms of scale, innovation and prices. The usual macro factors such as ease of doing business and inconsistent regulations make it a challenging environment for the industry. Further, it faces a shortage of skilled workers. There is little sustained collaboration between academia and industry, and in the academic institutes dedicated to farm mechanisation few of the new innovations/ inventions are commercialised. At the same time, micro, small & medium enterprises have no connection with the larger research world. Large firms are better placed in this regard, but they also have not been able to translate academic partnerships in a sustained collaboration.

In contrast, Chinese manufacturing firms in this industry are in a more advantageous position than India. China subsidises farmers to buy its own farm machinery (there was a mandate till 2019), the farm machinery industry is dominated by Chinese State-owned enterprises. The Chinese government sometimes funds the private sector directly and encourages public-private partnerships (Figure A). Further, Chinese imports are sold on Indian DBT portals to Indian farmers at a subsidised rate (Figure B).

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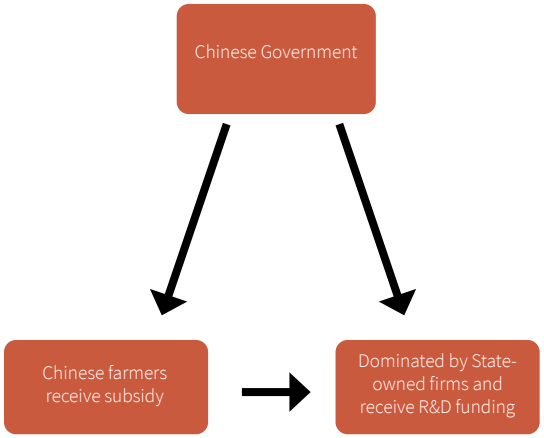
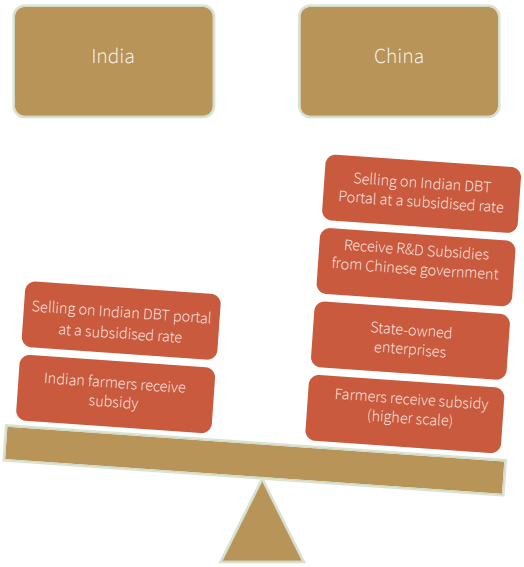
Figure A: Chinese Government Support for its Farm Machinery Industry



Source: NCAER conceptualisation.

Figure B: Advantages to Chinese vs. Indian Manufacturers in Farm Machinery Industry

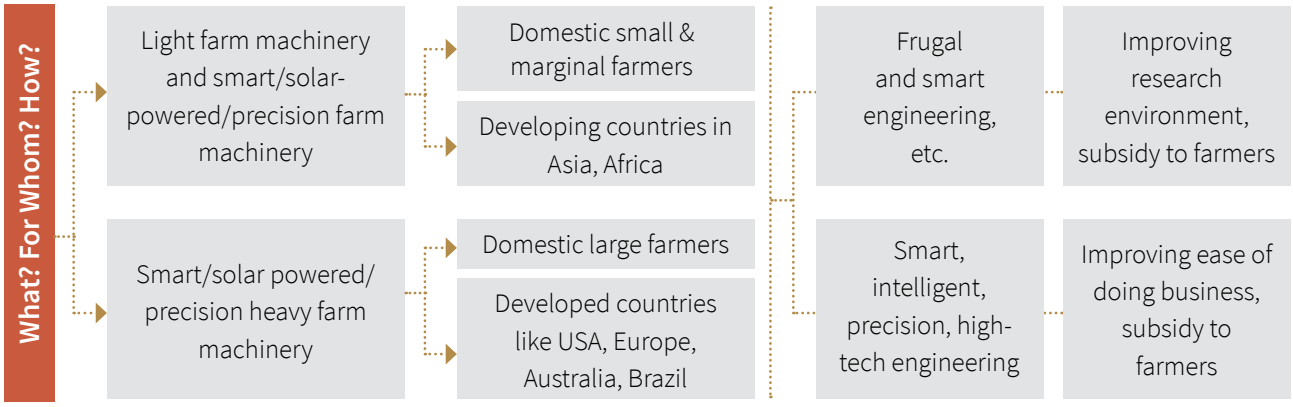


Policy Recommendations

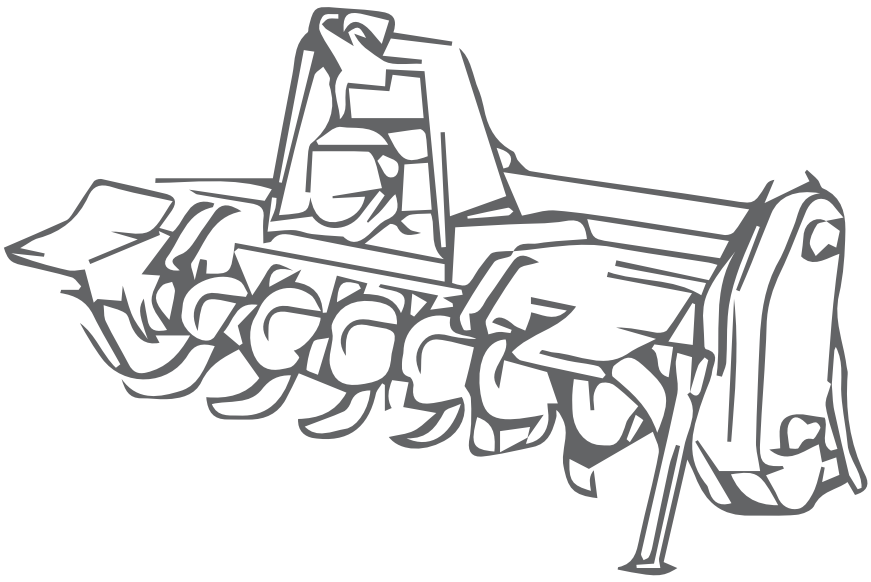
India is caught in a low-equilibrium trap. The main policy challenge is how to turn the current situation into a virtuous cycle where both the Indian non-tractor farm machinery industry and small & marginal farmers benefit. India needs a vision for the next 15 years to translate itself into a production and export hub for the non-tractor farm machinery. Policies should address current challenges and act as accelerators to convert India's dual farm machinery market into an advantage by producing a range of equipment that caters to all types of farmers around the world.

The non-tractor farm machinery industry is broadly divided into two types – tractor-mounted machinery and self-propelled/hand-driven mechanised/power farm machinery (Figure C). India can convert its dual farm machinery industry into an advantage. Since India has a comparative advantage in tractors; tractor-mounted machinery is a complementary good that has a domestic market among large farmers as well as in developed countries. Self-propelled/hand-driven mechanised farm machinery has a domestic market in small & marginal farmers and emerging & developing countries with similar socioeconomic structures such as Asia and Africa. This dual structure gives India a dual advantage. India should leverage it to become global suppliers of non-tractor farm machinery to the world while simultaneously uplifting small & marginal farmers around the world. How do we get there?

Figure C: What to Produce? For Whom to Produce? How to Produce?



Source: NCAER conceptualisation.



The Action Plan is divided into two sections – policies that address current challenges and policies that will act as accelerators to make India into a production hub. Both are designed around the above framework.

A. Addressing Current Challenges

i. Addressing Demand-side Challenges

Increasing demand for farm machinery at home may be done by improving the implementation of subsidy schemes by strengthening the Direct Benefit Transfers mechanism at the State-level (Odisha is the best case), improving farm machinery rental markets, improving access to credit, especially for small & marginal farmers and overhauling extension services. Banks need to be sensitised to the needs of small & marginal farmers. The programmes of Front-line Demonstration (FLD) of farm machinery should be strengthened. Handheld training to users of new-generation farm machinery may lead to and encourage increased adoption of the use of farm power. The Agricultural Skills Council of India needs to work through public & private partnerships to overcome the shortage of skilled workers, and Indian Council of Agricultural Research (ICAR) institutes can offer short-term training programmes. The shortage of agricultural engineers at the district level can be overcome if a Directorate of Agricultural Engineering is established at all blocks in all the States/UTs of India.

ii. Addressing Supply-side Challenges

- Encourage collaboration in R&D. At present, there is no platform for collaboration between academia, industry, government bodies to foster innovation in farm machinery. Technoparks and Technology Transfer Offices (TTOs) would offer a platform where institutions, private firms and individual faculty work together on specific research projects. R&D projects could be co-funded by universities and private partners. Commercialisation of new ideas can be financed through the Technology Development Board under the Department of Science & Technology.

- Improve ease of doing business. It is important to simplify clearance procedures and communicate that to all. There should be transparency and priority in the execution of procedures. Payments should be made on time.

- Encourage exports and FDI. While India already hosts multinationals in this arena, foreign multinationals should be encouraged to make India an export hub for South Asia and Southeast Asia. Foreign multinationals should be encouraged to include Indian manufacturing in Global Value Chains (GVCs), especially since India has a comparative advantage in machinery parts.

- Set up a level-playing field for Indian manufacturers. Given the unfair competition that Indian manufacturers face, it should be mandated that farm machinery that is sold under government subsidy on government DBT portals (both Central and State) follow the revised public procurement norms with regard to preference to 'Make in India' goods. Localisation should be promoted by simultaneously maintaining international quality standards. No other import restrictions or controls are recommended.

- Improve & maintain quality. Testing, specification standardization & performance requirements, and regulations should be developed such that they are in line with global benchmarks. The quality of non-tractor farm machinery can be improved by incentivising small-scale industries to employ Industrial Training Institute (ITI) trained personnel in manufacturing/production and diploma holders/graduates in agricultural engineering for supervisory roles.

- Address skill shortage. There is a shortage of skills in manufacturing. The District Industries Centre should work with local industrial clusters so that ITIs can provide the latest available technical knowledge and skills. This may include upgrading the syllabus & laboratory facilities, upskilling faculty, regular interaction of

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industry executives with faculty & students, and internships & job placements. Dual vocational skilling programmes will greatly benefit industrial clusters in Tier II & Tier III cities. MSMEs should also leverage the Apprentices Policy of the Government of India.

B. Accelerators

i. Encourage innovation in the non-tractor farm machinery sector, especially in the development of farm machinery and power units for the appropriate size of equipment for small, medium and semi-medium farmers, precision and protected agriculture, that is region-specific (hill agriculture, areas with nil or very poor penetration of mechanisation) and crop-specific (horticulture, cash and plantation crops), and the recovery & management of crop residues. Solar-powered farming equipment should be encouraged for sustainable farming and to reduce farmers' dependence on expensive fuel.

- Enact a law that enables universities, non-profit research institutions and small businesses to own, patent and commercialise inventions developed under government-funded research programmes within their organisations.
- Set up a non-tractor farm machinery Science & Technology Cluster under the aegis of the Principal Scientific Advisor Science & Technology (S&T) Cluster programme.
- Allow faculty to participate in projects subject to universities keeping part of their fee.
- In applied engineering, change the terms of tenure, promotions, salary increments and appraisals and make them dependent on how many inventions they were successfully able to commercialise.
- Research-linked incentive (RLI) is recommended for innovations in light farm machinery and futuristic precision farming for the next five years, where the firms invest 15 per cent of their

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- Encourage local innovation. Research and entrepreneurship eco-systems should be created and encouraged in ITIs; they may also partner with farm machinery firms. For help on patents, district-level patent offices need to be opened and strengthened and state agricultural universities' patent offices need to cater to the needs of local communities.

ii. Marketing and promoting exports. India has a comparative advantage in tractors, ploughs, disc harrows, etc. Better marketing and promotion of tractor-mounted equipment is needed in exports.

- Companies should sell economical packages of tractors with tractor-mounted equipment.
- MSMEs should be mentored and supported to participate in international trade fairs. They can be helped to produce YouTube videos of their equipment to promote them online.
- Technology transfer can be made part of bilateral trade agreements. The agreements can be leveraged to sell Indian non-tractor farm machinery products to developed countries.

iii. Achieving Scale. India has a current comparative advantage and there is a presence of intra-industry trade in sub-sectors with HS codes 84248200, 84328090 and 84331110. India should leverage this advantage by further scaling up and becoming part of GVCs by addressing current challenges. India can also try to achieve comparative advantage and scale in solar-powered equipment.

1 Introduction

> Farm mechanisation in India is marked by 'tractorisation'. India's farm equipment market is 7 per cent of the global market, with more than 80 per cent of the value contribution coming from tractors.

Farm mechanisation in India is marked by 'tractorisation' (ICFA, 2017). India's farm equipment market is 7 per cent of the global market, with more than 80 per cent of the value contribution coming from tractors (PwC and FICCI, 2019). The focus of this paper is on non-tractor farm machinery since India is already one of the global leaders in tractors. At the same time, tractors do not meet the needs of the majority of Indian farmers who are small & marginal and cannot afford to buy expensive farm equipment. The twin objectives of this paper are to recommend to policymakers key strategic actions to foster the growth of the non-tractor farm machinery industry in India and turn it into a global production hub, and to

improve the match between the needs of Indian farmers and Indian farm machinery producers in terms of the price, quality and efficiency of the machinery. This will make India a global powerhouse for farm machinery as well as enable farmers to improve crop yields, farm productivity and their overall lives.

The rest of the paper is divided into five parts. The second part describes the farm machinery industry. The third part contains the domestic demand for the non-tractors farm machinery industry and the fourth is the external demand. The fifth part presents policy recommendations on how the supply side can match those demand needs. The last section presents the conclusion.

What is the Farm Machinery Industry

The farm machinery industry operates at three levels. The industry is dominated by about 100,000 village-level craftsmen who are the source of supply, repair and maintenance of hand tools in villages.[1] At the next level are 2,500 small-scale manufacturers who produce improved farm equipment.[2] The organised farm machinery sector includes about 250 medium- to large-scale units that produce sophisticated machinery, provide after-sales service and innovate products and processes.[3]

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[1] *Village-level craftsmen produce, repair and maintain farm implements such as "spades, sickles, local ploughs, sowing devices, yokes, levellers, grinding wheels, hand mills, hand operated milk churning tools, sieves, wooden storage structures, bullock carts, and manual water lifting devices, etc." (Agriculture Today, 2018).*

[2] *Small-scale manufacturers produce "ploughs, cultivators, disc ploughs and harrows, seed drills, planters, plant protection equipment, reaper harvesters, combine harvesters, soil working tools, seeders, graders, mills, oil expellers, etc, and also manufacture equipment for tractor and power tiller manufacturers" (Agriculture Today, 2018).*

[3] *Large-scale manufacturers produce "diesel engines, electric motors, irrigation pumps, sprayers and dusters, land development machinery, tractors, power tillers, post-harvest and processing machinery and dairy machinery" (Agriculture Today, 2018).*

It is difficult to measure the size of the sector, so we adopt a statistical approach. Industries are identified by dedicated industrial classification (NIC) codes.[4] Unfortunately, there is no specific code for the farming machinery industry. Products associated with farming machineries are spread across multiple NIC codes, and they do not completely represent any NIC code. Therefore, we had to use 7-digit product classification codes (NPC), club the relevant codes together to form the industry. Annexure 1 reports the products, product classification code and their corresponding Harmonised System (HS) codes.

The Annual Survey of Industries (ASI) captures both NIC at the 5-digit and NPC at the 7-digit level.[5] We estimate the ex-factory values share within each NPC in each NIC codes.[6] Using these shares, we estimate various parameters (like workers, Gross Value of Output and Gross Value Added) in each NIC that can be attributed to farm machinery industries. However, the ASI only captures registered manufacturing. The unregistered manufacturing statistics are captured by enterprise surveys conducted by the NSO every five years. Unfortunately, the Enterprise Survey does not capture NPCs at that much disaggregated level which would allow us to estimate farm machinery industries by using the NPC.[7] For this, we used the share of organised (ASI) farm machinery industries in particular NICs to estimate the size of the unorganised farm machinery industry in those NICs. Further, enterprise survey data are available only for 2015–16. We then clubbed data from organised and unorganised farm machinery industries to compute the size of the farm machinery industry for 2015–16.

[4] *"The National Industrial Classification (NIC) is an essential Statistical Standard for developing and maintaining comparable database according to economic activities. Such classifications are frequently used in classifying the economically active population, statistics of industrial production and distribution, the different fields of labour statistics and other economic data such as national income. Comparability of statistics available from various sources, on different aspects of the economy, and usability of such data for economic analysis, are prerequisite for standardization of a system of classification" (CSO, 2008, p. 2).*

[5] *The ASI is conducted by the National Statistical Office (NSO) and is the principal source of industrial statistics in India (NSO Industrial Statistics website).*

[6] *Ex-factory value is ex-factory price multiplied by total quantity produced. Ex-factory price is the selling price of goods from the seller's factory.*

[7] *National Sample Survey Office, Ministry of Statistics and Programme Implementation (MOSPI), Government of India (GOI). India - Unincorporated Non-Agricultural Enterprises (Excluding Construction) - JULY 2015 - JUNE 2016, 73 round. http://microdata.gov.in/nada43/index.php/catalog/139/study-description.*

Table 1: Farm Machinery Industry, 2015–16

Industry	Workers	GVO	GVA
Share of farm machinery in overall manufacturing (%) in 2015–16			
Share of Farm Machinery	0.3	0.6	0.6
Share of Unorganised sector (%) in 2015–16			
Farm Machinery	60.9	7.9	13.1
Overall Manufacturing	72.5	9.4	17.9
Labour productivity (Rs per worker per annum) in 2015–16			
Organised (ASI)			
Farm Machinery		61,97,927	12,11,594
Overall Manufacturing		47,22,449	8,65,257
Unorganised (NSSO)			
Farm Machinery		3,43,269	1,17,085
Overall Manufacturing		1,86,440	71,762
Total			
Farm Machinery		26,33,607	5,45,256
Overall Manufacturing		14,35,812	2,90,318

Sources: NSO website and NSSO (2018).
Notes: 1. Farm machinery includes tractors and other industries. 2. Absolute size of workers is measured in numbers. 3. GVA & GVO are measured in current rupees.

Table 1 shows that the farm machinery industry forms 0.6 per cent of overall manufacturing. The share of the unorganised sector in terms of workers, GVO and GVA is smaller than overall manufacturing. Further, its labour productivity is also higher than overall manufacturing. In sum, the farm machinery sector is small but more productive than other manufacturing sectors.

III

Domestic Demand-side Analysis

While crop yields in India have gone up over time, international comparisons show that the country continues to lag behind (Ministry of Agriculture, 2016). One contributory factor to India's low yield is the low level of farm mechanisation in the country relative to the global average. The Indian farm mechanisation level is at 40–45 per cent compared to that of the United States (95 per cent), Brazil (75 per cent) and China (57 per cent) (NABARD, 2018).[8] A large literature shows that countries with higher levels of farm mechanisation are able to increase their productivity and therefore their yields. Further, higher mechanisation has a positive impact on employment (NCAER, 1973, 1974, 1980).

[8] *Yes Bank and GAA (2016) highlight the differences between Europe, USA and Japan, on the one hand and Sub-Saharan Africa (SSA) and North Africa/Middle East (MENA) on the other. The developed countries are highly mechanised. Europe prefers fewer but high-powered tractors and implements that cater to orchards. The US prefers very high horse-powered equipment and is moving towards the Internet of Things. Machines in Japan are small, sophisticated and specialised; Japan exports a lot of farm machinery. The level of farm mechanisation is low in SSA and it imports a lot from India and China. Mechanisation levels in MENA are higher than in SSA but varies country-wise.*

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Table 2 shows that certain farm operations such as harvesting & threshing and seedbed preparation & soil working are relatively more mechanised. While the state of farm mechanisation in India is marked by tractorisation, due to increased mechanisation in farm operations the demand for other farm machinery (such as threshers, rotavators, transplanters, reapers, zero-till drills, laser levellers and power weeders) is also increasing (ICFA, 2017).

Table 2: Penetration of Mechanisation across Farm Operations

Operation	Penetration of Mechanisation (%)
Seed Bed Preparation and Soil working	40
Seeding and Planting	29
Plant Protection	34
Harvesting and Threshing	60 -70 for wheat and rice but less than 5% for others

Source: India Agristat.

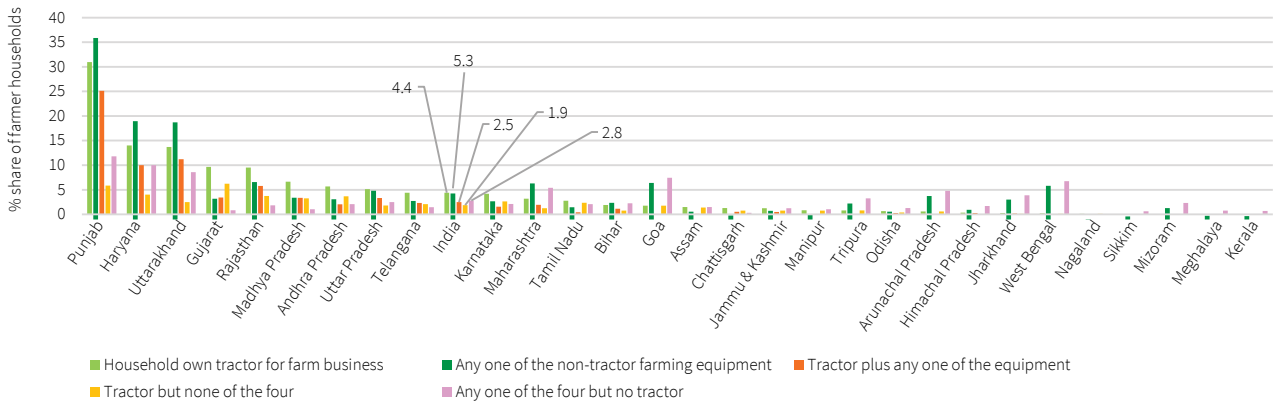
The average farm power availability (FPA) in India has risen from 1.1 kw/ha in 1995–96 to 2.02 kw/ha in 2017–18 (NABARD, 2018).[9] More recent research indicates that Indian FPA went up to 2.761 in 2020–21, but 59.4 per cent of this power comes from tractors (Singh & Singh, 2021). The target is to reach 4kw/ha by 2030 (NABARD, 2018). State-level variations in FPA is quite high and many states lag behind the national average. The level of FPA in the states varies from 0.287 kw/ ha (Meghalaya) to 4.398 kw/ha (Punjab) (MoAFW, 2018). Further, there are district-level variations within states. Although both Punjab and Haryana have achieved the national 2030 FPA target of 4.00 kw/hectare, the inter-district variation is between 0.335 – 9.541 kw/hectare and 1.885 – 8.098 kw/hectare for Punjab and Haryana, respectively (MoAFW, 2018). Such variations exist in all the states irrespective of the average FPA of the state.

Aggregate FPA measures may be overstated since it includes animal and human power. Ownership of power farm equipment in India is low, partially driven by ownership of tractors (Figure 1; Annexure 2). Usage is higher than indicated by ownership because, on aggregate, 63 per cent of farmers were renting equipment in 2018 (Table 3). There are two concerns with Table 3. One is that this statistic hides large state-level variations. Second, the reported statistic does not distinguish between power versus non-power farm machinery and therefore the aggregate number may be overstating the usage of modern powered farm machinery.[10] Lohan et al. (2015) show that the share of electrical and mechanical FPA increased in Punjab between 1960 and 2012–13 and the share of human and animal power declined.

[9] *Farm Power is an essential input in agriculture for timely field operations for operating different types of farm equipment and for stationary jobs such as operating irrigation equipment, threshers/ shellers/ cleaners/ graders and other post-harvest equipment. Sources of farm power include humans, animals, and machines such as tractors, power tillers, diesel engines and electric motors.*

[10] *The agricultural implements may include sickle, chaff cutter, axe, spade, chopper, plough, harrow, etc., power tiller, tractor, combine harvester-thresher, cane crusher, oil crusher, pump and other water-lifting equipment.*

Figure 1: Percentage share of Cultivator Households that owned Farm Machinery, as on June 2018



Source: Authors' computations from MoSPI (2021a).
Note: The AIDIS Survey 2019 probed farmer households about ownership of tractors as well as (a) power tillers/power-driven ploughs, (b) crop harvesters (power-driven)/combined harvesters, (c) threshers, other power-driven machinery and equipment, and (d) laser land leveller.

Table 3: Share of Farmers Spending on Repair & Maintenance and Hiring of Machinery & Equipment for Crop Production, as on June 2018

State/UT	% share of farmers spending on repair & maintenance of agricultural implements	% share of farmers hiring machinery & equipment for crop production	State/UT	% share of farmers spending on repair & maintenance of agricultural implements	% share of farmers hiring machinery & equipment for crop production
Jammu & Kashmir	30.2	48.8	West Bengal	26.7	65.5
Himachal Pradesh	44.5	38.5	Jharkhand	33.8	45.3
Punjab	34.4	52.5	Odisha	30.3	73.3
Chandigarh	48.2	32.1	Chhattisgarh	24.2	56.4
Uttarakhand	46.6	28.2	Madhya Pradesh	36.0	67.7
Haryana	34.6	58.3	Gujarat	19.4	59.6
Delhi	12.9	68.1	Daman & Diu	1.1	42.7
Rajasthan	27.8	80.5	D & N Haveli	1.1	54.9
Uttar Pradesh	36.6	70.5	Maharashtra	30.0	60.8
Bihar	30.5	73.3	Andhra Pradesh	14.2	62.5
Sikkim	20.5	1.1	Karnataka	20.0	57.4

(Contd.)

Table 3: Share of Farmers Spending on Repair & Maintenance and Hiring of Machinery & Equipment for Crop Production, as on June 2018 (Contd.)

State/UT	% share of farmers spending on repair & maintenance of agricultural implements	% share of farmers hiring machinery & equipment for crop production	State/UT	% share of farmers spending on repair & maintenance of agricultural implements	% share of farmers hiring machinery & equipment for crop production
Arunachal Pradesh	10.4	5.4	Goa	43.1	4.4
Nagaland	5.3	3.9	Lakshadweep	1.5	0.0
Manipur	3.4	40.4	Kerala	24.5	9.1
Mizoram	2.9	0.0	Tamil Nadu	10.0	39.6
Tripura	3.2	63.6	Puducherry	7.5	32.1
Meghalaya	3.9	4.0	A & N Islands	51.3	14.2
Assam	22.6	59.0	Telangana	41.1	83.7
India	29.4	63.5			

Source: Authors' computations from MoSPI (2021b).

III.1 What is Driving Farm Mechanisation in India?

Both Sarkar (2020) and Aryal et al. (2021) find that the probability of ownership of farm machinery increases with age and education of the household head, possession of a bank account by any one of the family members, bank transaction (bank account has been used) and possession of the Kisan Credit Card (KCC) (i.e., access to credit). Sarkar (2020) finds that geographical terrain plays a role in the adoption of farm machinery. Aryal et al. (2021) find that training in agriculture makes farmers aware of various farm machinery thereby encouraging ownership. While Sarkar (2020) finds that land area has a positive impact on mechanisation, Aryal et al. (2021) find that households with a higher number of farm plots have a higher probability of adopting farm machinery. Ghosh (2010) also found that size of land holdings had a positive impact on agricultural mechanisation in the case of Burdwan district in West Bengal. In addition, Aryal et al. (2021) find that the social capital of the household, the distance from the household to the market & extension services and an increase in agricultural wages play a role in the adoption of farm machinery. Also, Ghosh (2010) found that irrigation had a positive impact on agricultural mechanisation.

ICFA (2017) and PwC & FICCI (2019) have hypothesised other factors that may drive farm mechanisation:

- Feminisation of the workforce can enable farm mechanisation. However, it is difficult to disentangle the causality. Afridi et al. (2021) show that increased mechanised tilling led to a more than 22 per cent fall in women's agricultural labour in India from 1999 to 2011.
- Changing the rural aspirations of youth may cause their outmigration (Nandi et al. 2022), which, in turn, may cause farm labour shortages (ICFA, 2017). This may enable farm mechanisation, too.
- Increasing cropping intensity, contract farming and contingency farming can also encourage farm mechanisation (ICFA, 2017; PwC & FICCI, 2019).[11]

[11] *With de-notification of the labour laws, the impact of contract farming on mechanisation may be limited to a few crops in a few States.*

III.2 Government Policies

Multiple initiatives have been taken by the Government of India and state governments to increase farm mechanisation in the country. In this regard, India is not that different from the rest of the world (Box 1).

Box 1: International Comparisons of Demand-side Initiatives

Direct subsidy is given to small farmers across the world to buy farm equipment, e.g., China, Turkey, Brazil, Japan, Germany, France, and India. In Vietnam and Thailand, farmers are given subsidised loans to buy equipment.

The rental market is common across many countries. Barring Brazil, all countries had policies on hiring of farming equipment. Farmer awareness and training programmes are carried out in India and the US. In Thailand, farmers are provided low-cost machines, ensuring that the machinery is of good quality in terms of maintenance costs and price, and ensuring that the machinery is appropriate for use in rural areas. Low/liberal credit is given to all farmers, e.g., Brazil, France, Japan, Turkey, and India.

Sources: Loon et al. (2020), Oshiro (1985), Santana and Nascimento (2012), Shozo (2020), Usaborisut (2018), WTO (2012).

The Government of India has launched several schemes and policies to encourage farm mechanisation:

- Farm mechanisation is part and parcel of key schemes including Rashtriya Krishi Vikas Yojna (RKVY), Mission for Integrated Development of Horticulture, National Mission on Oilseeds and Oil Palm and National Food Security Mission (Agriculture Today, 2018).

- The Sub-Mission on Agricultural Mechanisation (SMAM) was introduced by the Central Government in 2014–15, under which subsidy was provided for the purchase of various types of agricultural implements and machinery used for tillage, sowing, planting, harvesting, reaping, threshing, plant protection, inter-cultivation and residue management. Until 2021–22, SMAM was the largest central government stand-alone scheme for farm mechanisation. It was merged with RKVY in 2022–23 (Union Budget website). In the five years between 2017–18 and 2021–22, the total Budget estimate has been ₹4,765.29 crore, while the actual total expenditure has remained ₹4,079.27 crore (86 per cent) (Jadhav, 2021). Annexure 3 shows details of the SMAM scheme.

- State governments such as Kerala, Madhya Pradesh and Tamil Nadu are providing farm machinery to farmers at a concessional rate through their Agricultural Departments, while some other States are providing subsidised farm machinery via Direct Benefit Transfers, Odisha stands out as a best practice (Kishore, Saini and Alvi, 2022; Directorate of Agriculture and Food Production, Odisha website).

- Custom Hiring Centres (CHCs) have been set up through a SMAM scheme, under which subsidy is provided at 40 per cent of the project cost to individual farmers up to a project cost of ₹60 lakh and 80 per cent to a group of farmers up to a project cost of ₹10 lakh (MoAFW, 2020).[12] A special consideration for farmers in the North Eastern Region (NER) is available; 95 per cent subsidy up to a project cost of ₹10 lakh is provided to a group of NER farmers to establish CHCs (MoAFW, 2020).

[12] *Anecdotal evidence from West Bengal suggests that non-availability of institutional loans is a hindrance for CHCs.*

- The government provides a subsidy of 50–80 per cent for crop residue management machinery. Farmer groups are being provided financial assistance at 80 per cent of the project cost to establish Farm Machinery Banks for custom hiring of crop residue management machinery (MoAFW, 2020).

- Under SMAM, 40 per cent subsidy is given on straw rake, straw baler, loader, etc. Through this, crop residue is collected and bundled into bales that can be easily transported to power generation plants.

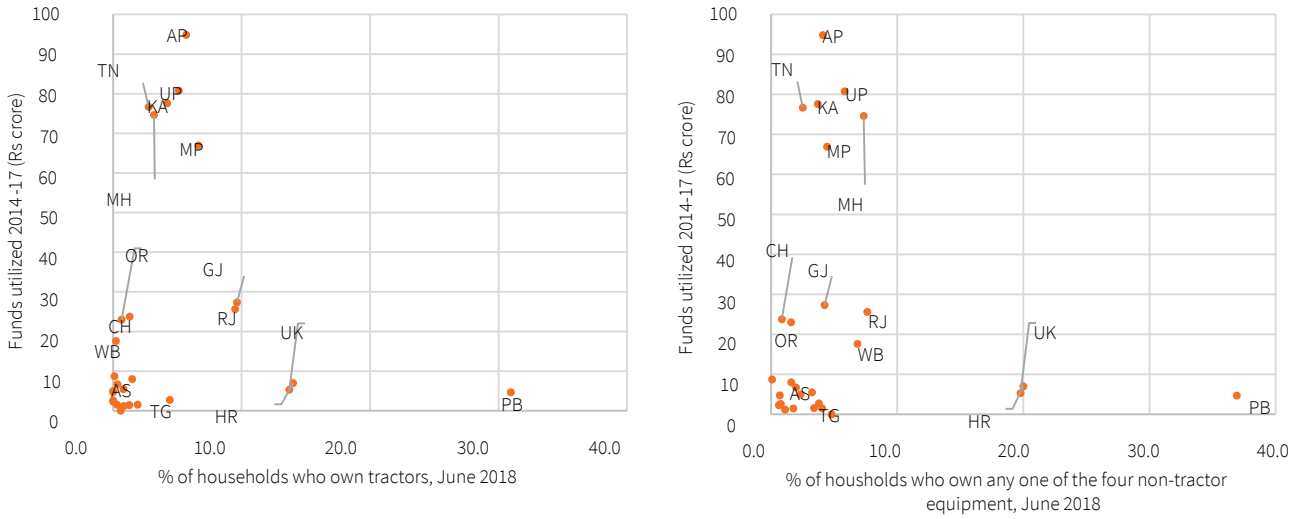
- A multilingual mobile app, CHC- Farm Machinery, helps farmers get rented farm machinery and implements through Custom Hiring Centres (CHCs) in their area (MoAFW, 2020).

- The Kisan Credit Card (KCC) Scheme enables farmers to purchase agricultural inputs and draw cash to satisfy their agricultural and consumption needs (MoAFW, 2020).

- An interest subvention scheme for short-term crop loans up to ₹3 lakh has been implemented. The scheme provides interest subvention of 2 per cent per annum to banks on the use of their resources. Besides, an additional 3 per cent incentive is given to farmers for prompt repayment of the loan, thereby reducing the effective rate of interest to 4 per cent.

Unfortunately, there is little macro evidence yet to show that subsidies encourage ownership of farm equipment (Figure 2), especially in the case of small & medium farmers (Kishore, Saini and Alvi, 2022; Srinivas et al. 2017). Anecdotal evidence suggests that increased subsidy does drive up farm mechanisation (MoAFW, 2021). The challenge is that farm mechanisation is going to remain low in India until the large majority of small & marginal farmers in India find it in their interest to mechanise.

Figure 2: Little macro evidence of a correlation between Central Subsidy under the Sub-mission on Agricultural Mechanisation and ownership of farm equipment



Sources: MoSPI (2021a); Ministry of Agriculture and Farmers Welfare (2018; Table 28).
Note: The AIDIS Survey 2019 probed farmer households about ownership of tractors as well as (a) power tillers/power-driven ploughs, (b) crop harvesters (power-driven)/combined harvesters, (c) threshers, other power-driven machinery and equipment, and (d) laser land leveller.

III.3 Projections for Farm Mechanisation for Domestic Demand

Total requirements of farm machineries are projected by bringing in all agricultural operations across crops and all areas across crops under mechanisation (Table 4). The following procedures are adopted to derive the projections for non-tractor farm machines:

- Season-wise area under various crops from secondary sources are used to compute the projections.
- Working capacity of equipment and annual operational period are used on the basis of secondary data.
- Annual working hours available for various farm operations calculated on the basis of estimated 8 working hours per day and Annual Operational Period.
- Annual operational capacity of the various equipment is calculated on the basis of the annual working capacity of equipment and annual working hours available for operations.
- Requirement of equipment for mechanisation on the basis of the annual operational capacity of equipment and total annual cropped area.
- Substitutability of various equipment (like harrow and rotavators) and allocation of the various equipment to various operations are also taken care of, keeping in mind agro-climatic regions and the suitability of this equipment. Along with this, mounting of equipment (like tractor mounting vs. power tiller mounting) is also taken care of, keeping in mind the land type and land size.

Table 4: Number of Equipment Required: Overall and Number per 1,000 hectares

Equipment	Total area under operation (lakh hectare)	Total no. of equipment required for total area	Total no. of equipment required for 1,000 ha area
Harrow (tractor operated) for 60% area/ 100% area	1241 (of 2068.3)	8,73,912	7
Cultivator (tractor operated)	1241	8,73,912	7
Rotavators (tractor operated)	620.5	6,33,140	10
Rotavators (power tiller operated)	206.8	76,60,222	370
Seed-cum-fertilizer drill (tractor operated)	899.4	3,94,468	4
Seed-cum-fertilizer drill (power tiller operated)	599.6	11,75,670	20
Sugarcane planter	48.3	80,500	17
Potato planter	16.9	28,200	17
Self-propelled eight-row paddy transplanter (Ride Type)	219.5	4,98,863	23
Self-propelled walk-behind type paddy transplanter	219.5	7,31,667	33
Cultivator (tractor operated)	1186.1	5,56,870	4.7
Power tiller operated cultivator /Power weeder	790.8	10,68,589	13.5
Knapsack sprayer-cum-duster (powered)	827.3	11,49,033	14

(Contd.)

Table 4: Number of equipment required: Overall and number per 1,000 hectares (Contd.)

Equipment	Total area under operation (lakh hectare)	Total no. of equipment required for total area	Total no. of equipment required for 1,000 ha area
Tractor-operated sprayer	1186.1	6,89,420	6
Sprayer self-powered high clearance (cotton, sugarcane)	65.2	27,175	4
Vertical conveyor reaper (power tiller operated)	412.5	3,43,758	8
Vertical conveyor reaper (tractor operated)	618.8	3,22,273	5
Multi-crop combine harvester for 60% area/100% area	607.8 (of 1012.9)	79,136/ 1,31,893	1.3
Multi-crop thresher (tractor PTO operated)	975.4	3,38,689	3.4
Paddy thresher	175.6	1,95,111	11
Maize thresher	92.1	76,750	8
Sugarcane harvester	48.3	67,083	14
Potato digger			
a) Tractor operated	11.8	17,312	15
b) Power tiller operated	7.8	46,165	59
Happy Seeder	158	1,97,550	12.5
Stubble shaver + Baler/ stubble shaver + Hay rack + Baler	105.4	1,09,750/ 87,800	10.4/8.3
Wheat straw combine	183.4	6,21,684	34

Source: NCAER calculations.
Notes: Assumptions made for projections are available upon request.

III.4 Demand-side Challenges of Farm Mechanisation in India

The demand-side challenges to the adoption of farm mechanisation are myriad (ICFA, 2017; NABARD, 2018):

- Small and fragmented land holdings
- The large number of small and marginal farmers, though with state-level variations[13]
- The practice of subsistence agriculture
- Diverse soil conditions and cropping patterns: This would require geographical and crop-based customisation of the machinery.
- Lack of access, especially timely access, to farm power
- Tedious procurement process: The process of acquiring farm equipment is tedious and cumbersome for a farmer. Kishore, Saini and Alvi (2022) compare the DBT experiences of Bihar and Odisha. The upfront capital cost of acquiring machinery is high, which is made

[13] *Small & marginal farmers account for around 85 per cent of all farmers, holding 44.3 per cent of agricultural land (Agricultural Census website). They are defined by the size of their land holdings. Marginal farmers' landholdings are less than 1 hectare and small farmers' landholdings are less than 2 hectares (but greater than 1).*

worse by delays in the transfer of the subsidy to farmers. Odisha stands out in terms of best practices. The entire process including application and subsidy transfer is digital in Odisha and farmers receive their subsidies within seven days of payment. In Bihar, some programmes require a farmer to have at least 1 acre of land, which effectively screens out 80 per cent of farmers in the State.[14]

- Cost of equipment: The equipment is unaffordable.[15]
- Quality of equipment: Most local and unorganised farm equipment manufacturers produce non-standardised equipment.
- Quality and after-sales service: Inadequate quantity and quality of service centres for proper maintenance.
- High cost of precision equipment: More sophisticated farm equipment such as potato harvester-cum-diggers, combine thresher-harvesters, paddy transplanters, sugarcane harvesters and laser-guided land levellers are expensive and require huge financial investments (Box 2).
- Credit constraints: Even if they qualify for subsidy, small and marginal farmers have to borrow money from dealers or moneylenders at high interest rates to make the upfront payment; they also face challenges in accessing institutional credit (Kishore, Saini and Alvi, 2022), thus making machine rental markets uncompetitive and inequitable (Box 2).
- Banks are, in general, reluctant to lend to farmers.
- Non-availability of institutional loans for CHCs: Most bankers are not aware of the CHC farm mechanisation scheme from their bank's head office at the State level.
- Poor selection of machinery: Due to inadequate information and guidance, farmers often select the wrong machinery, making it a wasted investment. There is lack of adequate information about the technology, its usefulness, and management of the machinery, which creates financial problems for farmers.

Box 2: Machinery Rental Market is not Inclusive of Small & Marginal Farmers

The farm machinery market (power and non-power machinery together) is pre-dominantly a rental market in India (Table 3). However, small & marginal farmers play a limited role in it as entrepreneurs for two reasons: first, they do not have access to institutional credit to set up CHCs, and second, the majority of CHCs carry only heavy machinery, such as tractors, laser land levellers, rotavators, cultivators, paddy transplanters, seed drills and threshers. Heavy machinery translates into expensive equipment, which creates entry barriers for small farmers who carry smaller farming machinery/implements to participate in the machinery rental market.

There can be three types of CHCs/service providers: farmers, entrepreneurs and society. However, 62 per cent of CHCs are owned by rural entrepreneurs and the others by society (MoAFW, 2018). Hence, there is a design flaw in the subsidy scheme, which discourages small & marginal farmers from participating in the machinery rental market (Kishore, Saini and Alvi, 2022).

Sources: Digital Platform for Farm Mechanisation & Technology website, MoAFW (2018), Kishore, Saini and Alvi (2022).

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[14] *Anecdotal evidence suggests that this is true in the case of West Bengal too where possession of 1.0 acre of land is mandatory to be eligible for DBT in farm machinery such as a power tiller.*

[15] *Anecdotal evidence from West Bengal suggests that the DBT portal price of products in many cases is higher by at least 10 per cent than the open market price on cash purchase.*

IV

External Demand Analysis

Farm machinery exports are driven by the export of tractors, but farm machinery imports are driven by non-farm machinery. Further, the direction of trade is lopsided where the majority of the imports come from China but the export markets are relatively more diversified. These key points are illustrated in Figures 3-5:

- India has a very high trade surplus in farm machinery (Figure 3a).
- In contrast, the trade surplus in non-tractor farm machinery is very small; if at all, there is a surplus (Figure 3b).
- Trade in non-tractor farm machinery forms less than one per cent of total merchandise trade (both exports and imports) (Figure 4a).
- Although India is both exporting and importing non-tractor farm machinery (Figure 4b), exports form a relatively small proportion of total farm machinery exports (though it has been increasing over the years) and imports form a relatively high proportion of total farm machinery imports (though the share has varied over the years).
- Figure 5 shows the direction of exports and imports over the last five years.

> Although India is both exporting and importing non-tractor farm machinery, exports form a relatively small proportion of total farm machinery exports (though it has been increasing over the years) and imports form a relatively high proportion of total farm machinery imports (though the share has varied over the years).

India has a revealed comparative advantage (i.e., it can produce products at a relatively lower opportunity cost) in ploughs, disc harrows, other machinery and parts of agricultural & horticultural machinery and threshing machinery (not elsewhere classified). See Annexure 4 for the detailed computations.

Figure 3: Exports and Imports of Total Farm Machinery and Non-tractor Farm Machinery

Figure 3a: Total Farm Machinery Exports and Imports

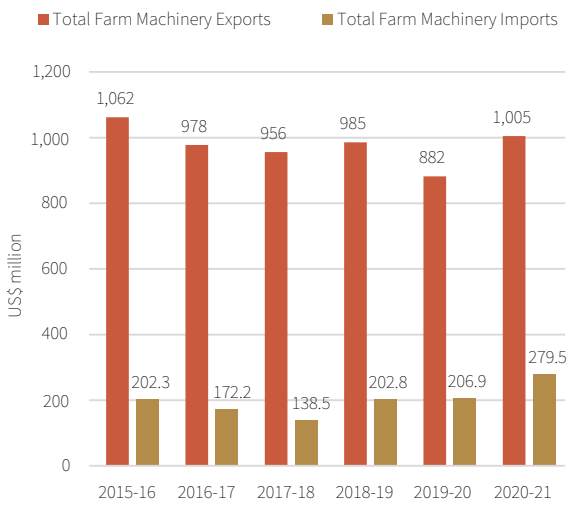
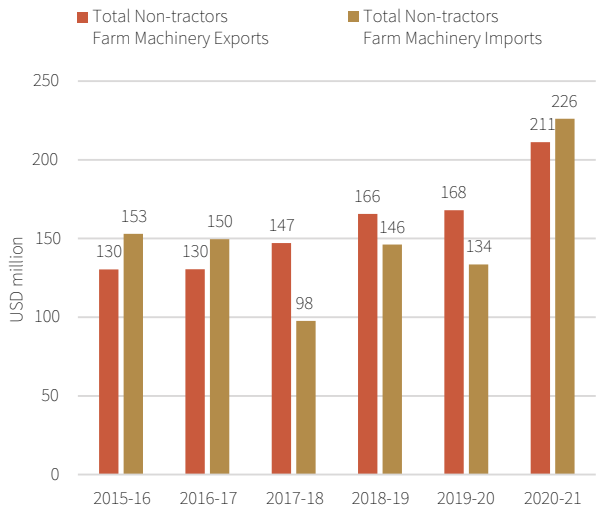


Figure 3b: Total non-tractor Farm Machinery Exports and Imports



Source: Ministry of Commerce.

Figure 4: Share of Non-tractor Farm Machinery in total Merchandise Trade and total Farm Merchandise Trade

Figure 4a: Share of non-tractor farm machinery trade in total merchandise trade

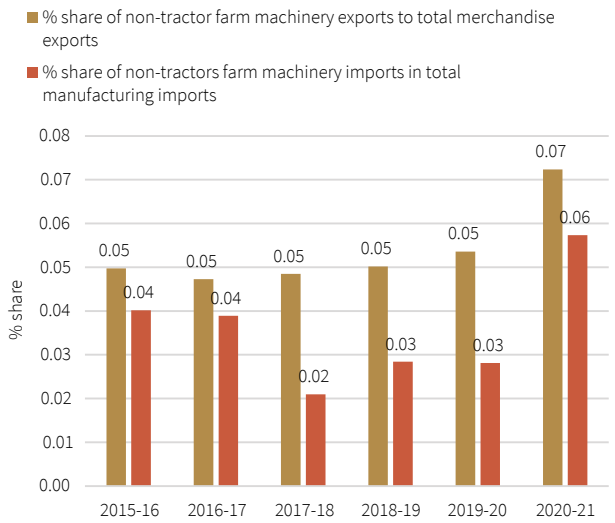
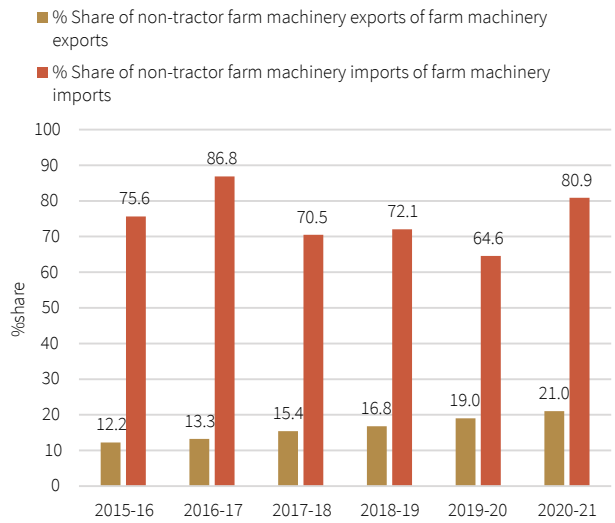
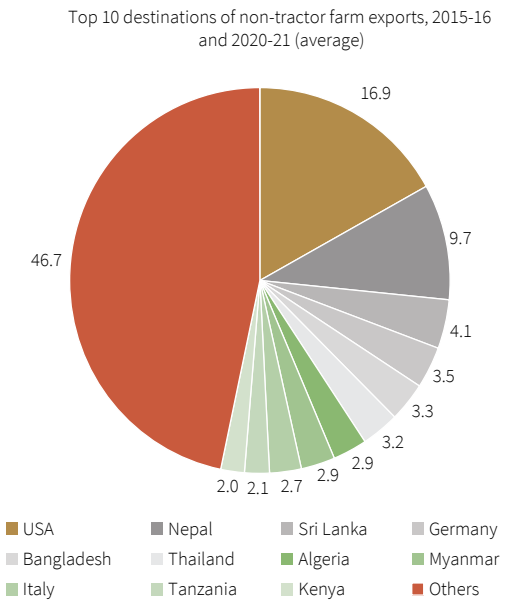


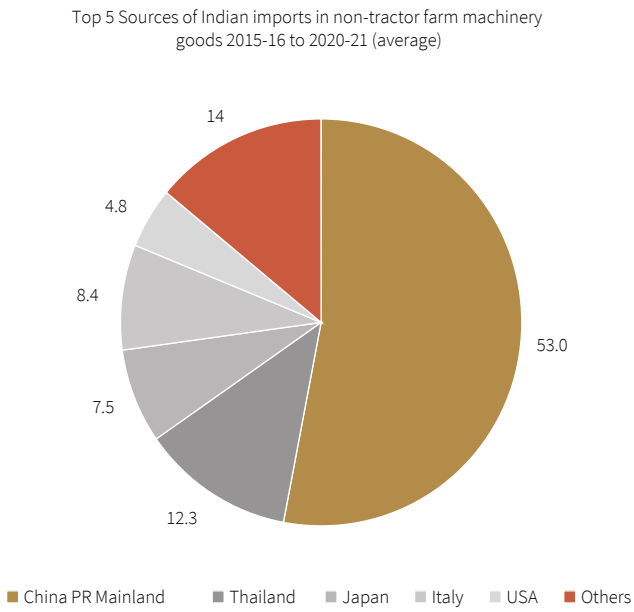
Figure 4b: Share of non-tractor farm machinery trade in total farm machinery trade



Source: Ministry of Commerce.

Figure 5: Destinations and Sources of Exports and Imports of Non-tractor Farm Machinery, 2015-16 to 2020-21



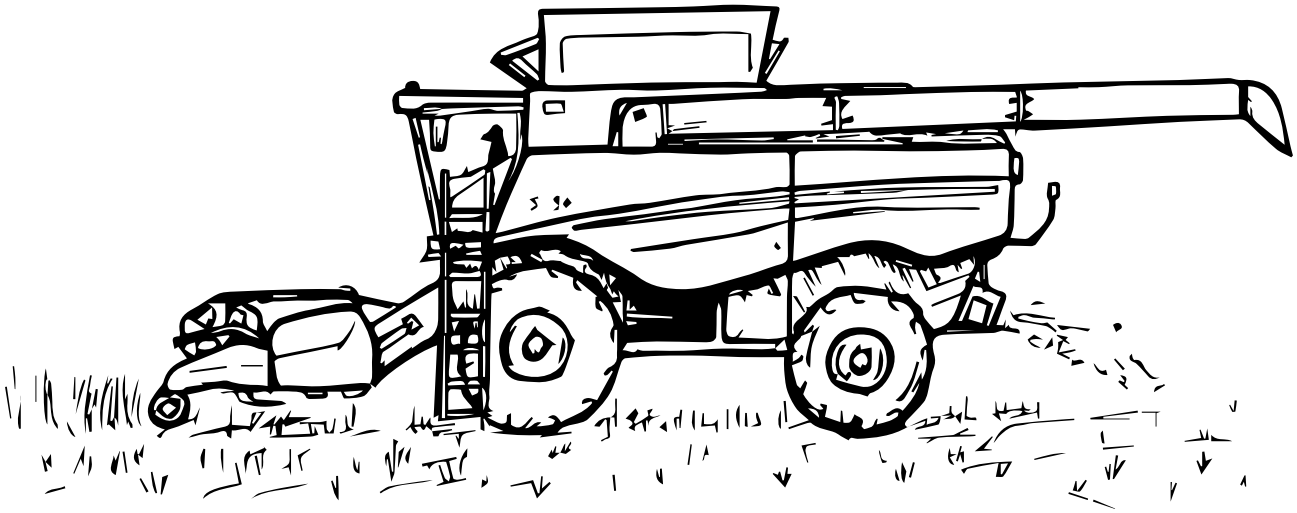


Source: Ministry of Commerce.

Note: Values in US$ million for HS codes 8432+8433.

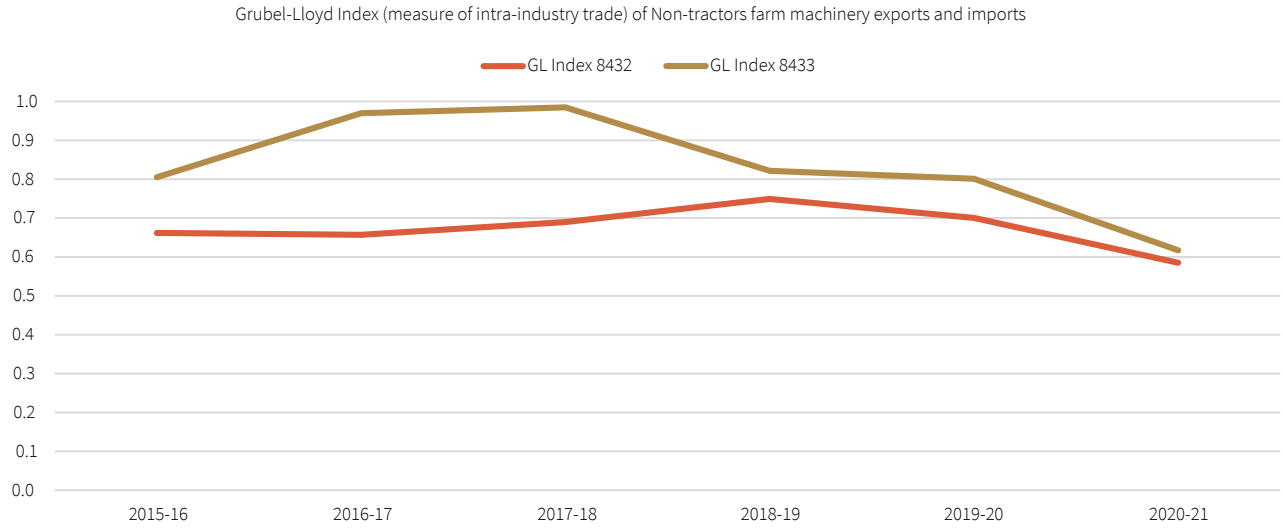
> The Indian non-tractor farm machinery trade is characterised by high intra-industry trade i.e., there is trade within the same industry group.

The Indian non-tractor farm machinery trade is characterised by high intra-industry trade i.e., there is trade within the same industry group (Figure 6). Intra-industry trade can be horizontal (differentiated varieties) or vertical (distinguished by quality and price) (OECD, 2005). In India, there is intra-industry trade in agricultural or horticultural machines (84248200), others (84322990; harrows, scarifiers, cultivators, weeders (imported) and hoes for use in agriculture, horticulture or forestry (excluding disc harrows); other soil machinery n.e.c. (84328090)[16]; parts of harvesting, threshing machinery (8433900); mowers for lawns, parks/sports grounds, power with 3 HP or more (84331110).



[16] *However, HS code 84328090 includes a variety of products (based on Google search of customs data). It can include cutter, power tiller model with accessories, tea pruning machine, manure spreader, rotary tiller, etc.*

Figure 6: High Intra-industry Trade



Source: Ministry of Commerce.

Notes: *1. Values in US$ million for HS codes 8432+8433.*

2. The Grubel-Lloyd index is computed both at the 4-digit level and at the eight-digit level to understand the dynamics of the non-farm machinery trade. Along with the basic index, various other intra-industry indices were computed based on Brülhart (1994). The results did not change.

3. GL indices higher than 0.33 indicate high intra-industry trade.

Intra-industry typically happens where there are economies of scale in differentiated products (Krugman, 1981). Differences in technology could also account for intra-industry trade (Davis, 1995).

The internal and external demand for non-tractor Indian farm machinery is relatively limited. If India is to become a production hub, it has to address both domestic supply and internal demand issues. This is not just about scale and capacity but about both matching the needs of the Indian farmers and farmers around the world. The next section discusses various policies that may catapult India into a production hub.

V

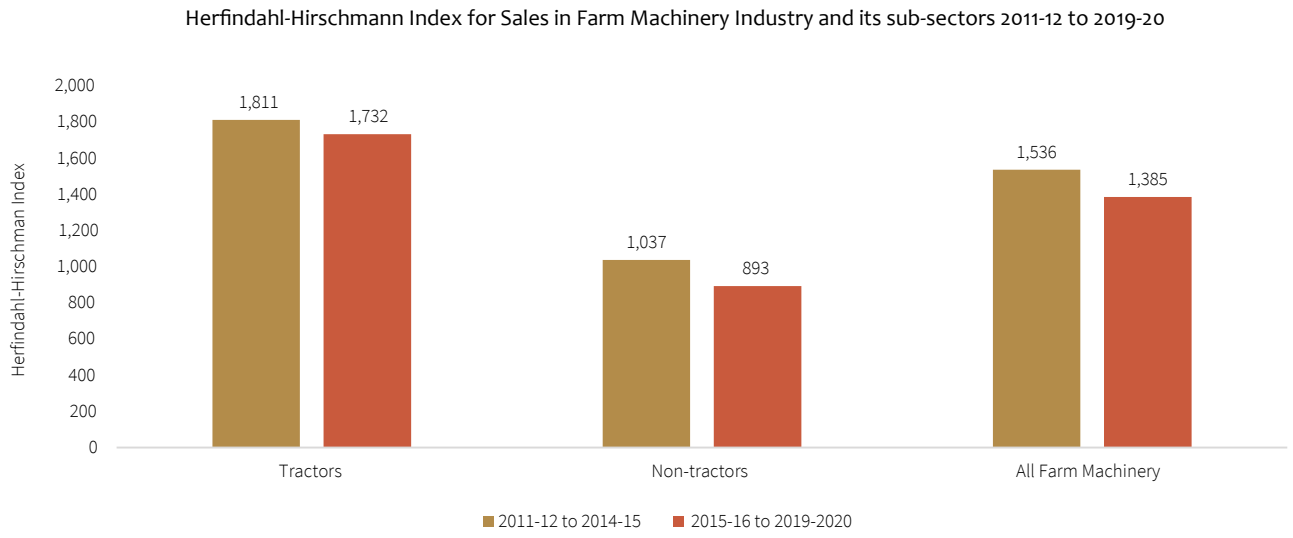
Supply-side Challenges

We summarise the supply-side challenges in this section.

V.1 Limited Research & Development (R&D) in Non-tractor Farm Machinery

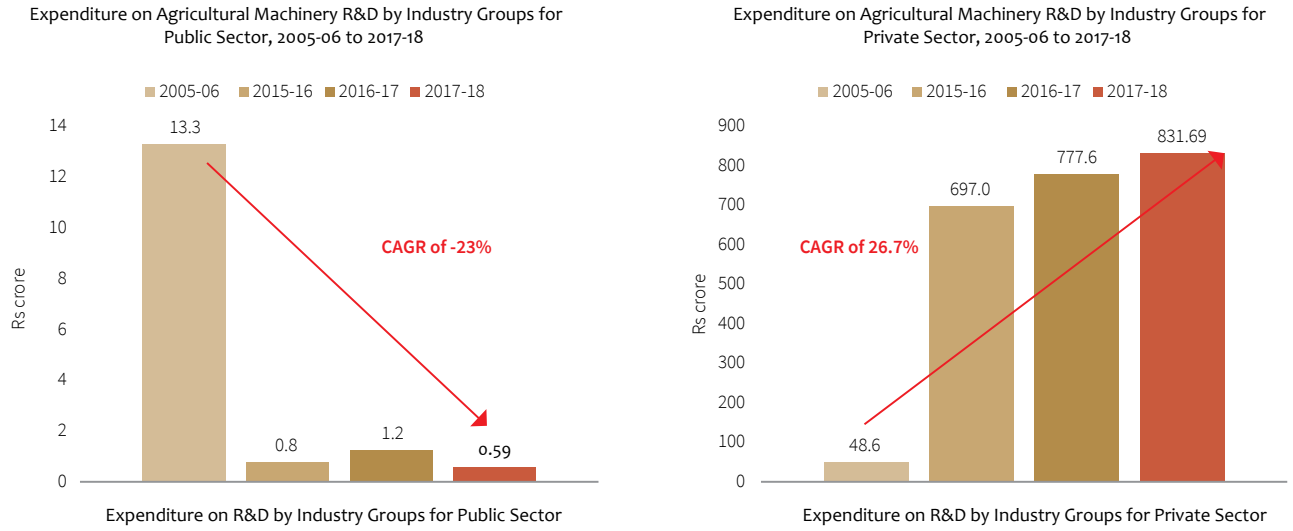
Despite the non-tractor farm machinery sector being a highly competitive industry (Figure 7), there is little incentive or appetite for R&D on the part of firms. Medium-to-large firms form a relatively small proportion of the overall industry and are the only ones that are likely to do R&D. Interviews with industry stakeholders suggest that the non-tractor farm machinery sector is dominated by small producers that survive by copying successful products cheaply or assembling cheap imports.

Figure 7: Tractors are Moderately Concentrated but Non-tractor Industry is highly Competitive



Source: Centre for Monitoring Indian Economy Prowess.

Figure 8: Total R&D has gone up but the Composition has shifted towards the Private Sector



Source: Ministry of Science & Technology (2020).

There is little interaction between medium & large firms and academia. While total R&D has gone up, the composition has shifted towards the private sector (Figure 8).[17] The number of patents filed in agricultural engineering is growing but the share is very small (Table 5). Proxy measures indicate that India's share in scientific publications in the field of engineering is lower than in the agricultural sciences (Table 6). We searched Google Scholar using specific terms and found how many publications (first author's affiliations) were coming out of India, China, Brazil and Turkey since 2021. India is doing R&D across a diverse set of machinery (Figure 9), but China is specialising in a few.

[17] *In contrast, the public sector plays a dominant role in China (OECD, 2018).*

The R&D programmes in India have so far mainly served the rice-wheat cropping system. The range of the equipment is not wide enough to facilitate diversification of agriculture. Equipment including tractors and prime movers for mechanisation of hill agriculture and production of fruits and vegetables is not commonly available. There is little innovation in these particular fields such as irrigation, plant growth and post-harvesting. Last but not least, there is little academic-industry collaboration.

Table 5: Agricultural Engineering Patents Filed and Granted in India, 2015–16 to 2019–20

	No. of patents filed in Agricultural Engineering	No. of patents granted in Agricultural Engineering	Share of patents filed in Agricultural Engineering	Share of patents granted in Agricultural Engineering	Patents granted out of total filed in Agricultural Engineering (%)	Total patents granted out of total filed (%)
2014–15	229	2	0.5	0.03	0.9	14.0
2015–16	268	2	0.6	0.03	0.7	13.5
2016–17	245	4	0.5	0.04	1.6	21.7
2017–18	338	24	0.7	0.18	7.1	27.3
2018–19	411	33	0.8	0.22	8.0	30.2
2019–20	13	54	0.0	0.22	415.4	44.3

Source: Intellectual Property of India (2021) and previous years.

Table 6: India's Publication Output and Share in World by Field of Science (Sci Database) 2011–16

Field of Science	India (number)	World (number)	% Share in World Output
Agricultural Sciences	15,941	241,321	6.6
Engineering	34,092	719,308	4.7

Source: Ministry of Science & Technology (2020).

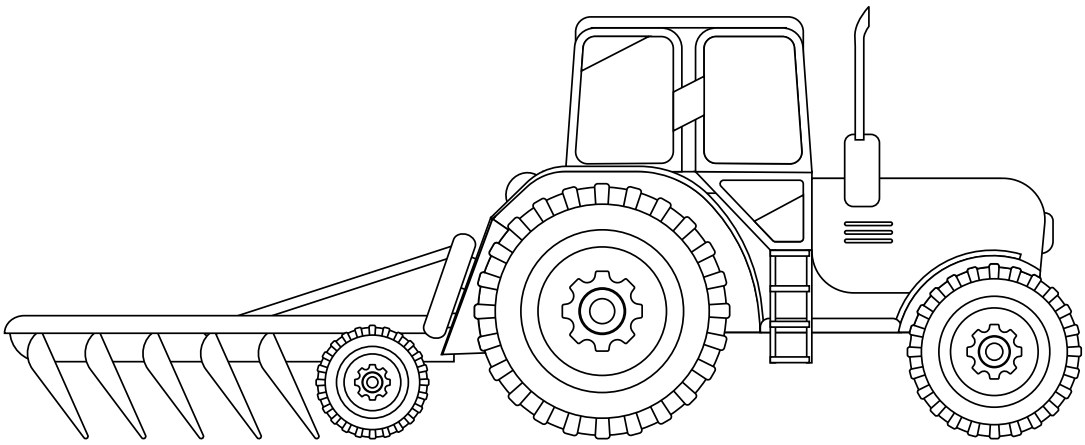
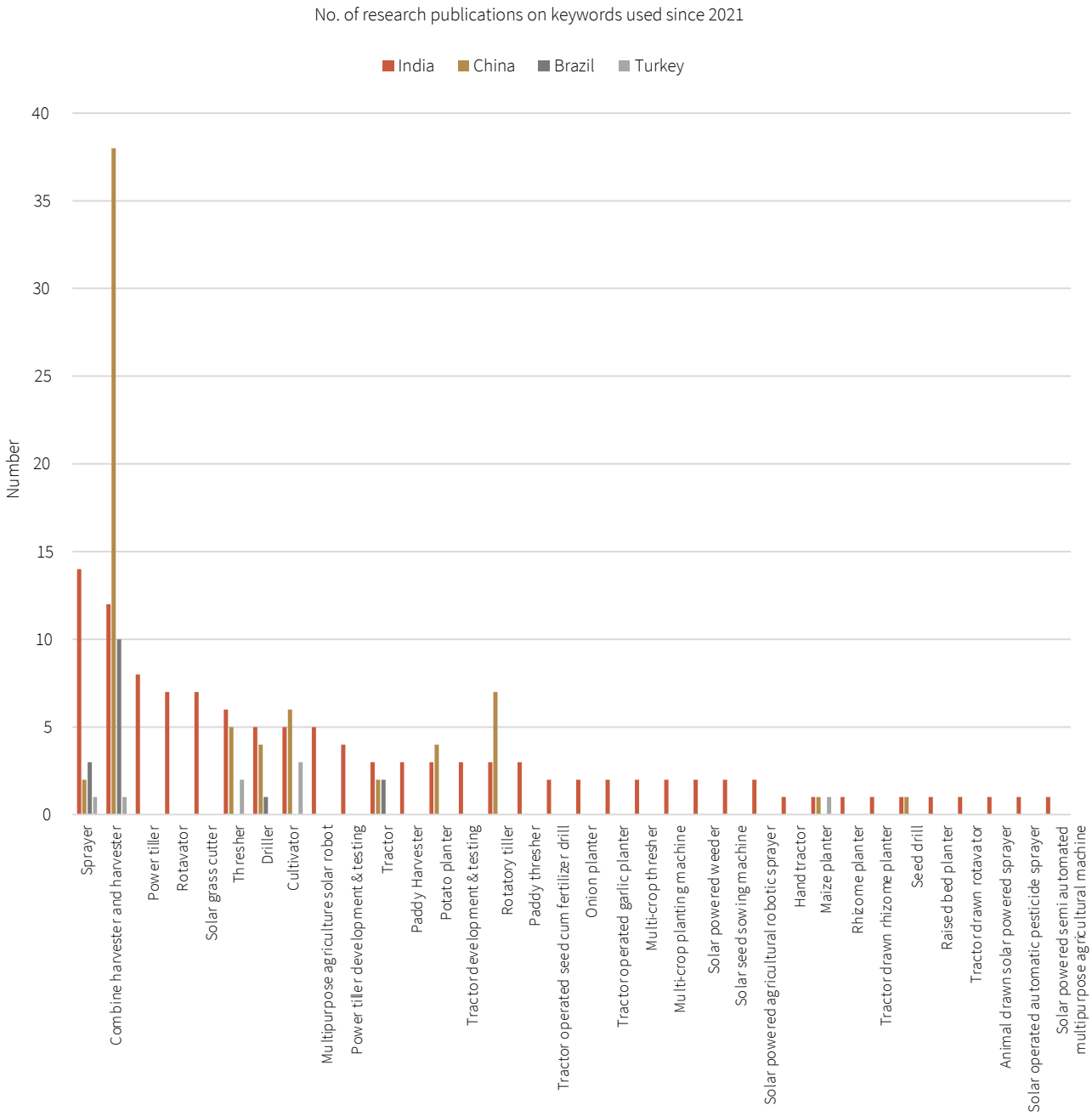


Figure 9: Research Publications on Farm Machinery from India, China, Brazil, and Turkey (since 2021)



Source: Compiled from Google Scholar; includes patents and citations.

India has no system for the exchange/transfer of new design or technology developed by research institutes with manufacturers/fabricators or feedback on market requirements from manufacturers to research institutes. In the absence of adequate interaction with research organisations and industries, R&D groups and industries in India are not able to incorporate new developments and improvements in their designs and products. Instead, manufacturers use their own wisdom for innovations based on market feedback. Thus, there is a need to develop links between research institutes and industry to facilitate the exchange of innovations and develop prototype equipment.

While academics in India are able to generate patents, they are unable to commercialise it.[18,19] In India, government reports discuss the farm machinery being produced, but none are available in the market. In one interview, a faculty at a public (government) university said that unable to find a partner to produce the machinery that he had invented, he went to a micro, small & medium enterprise (MSME) to manufacture the machine. However, the MSME had limited reach and the actual quality was not up to the mark.

OECD (2018) shows that India lags behind other countries in terms of R&D. We examined the R&D policies of Australia, Brazil, China, France, Finland, Germany, India, Japan, Thailand, Turkey, United States and Vietnam (Alston & Pardey, 2020; Chamsing and Singh, 2000; Fujibayashi, 2017; Hossen et al., 2020; Long, 2013; Mantovani et al., 2019; OECD, 2021). We found that all countries support R&D, i.e., investment in R&D and a machinery testing agency to check the quality of machinery produced. In Finland, most agro-tech businesses interact with local farmers while creating new goods and services (Agrotechnology in Finland). Turkey has built a relatively healthy eco-system for academia-industry collaboration (Box 3). Yet another mechanism is industrial doctorates where a private sector employee can work on the company's industrial problem while being registered at an academic institute.[20]

> "India has no system for the exchange/ transfer of new design or technology developed by research institutes with manufacturers/fabricators or feedback on market requirements from manufacturers to research institutes."

[18] *Yadav et al. (2021) is a case in point. The authors have innovated on a multipurpose mini tractor, which is a one-person machine at an affordable price. Will it make it to market?*

[19] *This problem is not peculiar to India but exists in the United States too (Caviggioli et al., 2020). In the US, "the Bayh-Dole Act is a federal (national) law enacted in 1980 that enables universities, non-profit research institutions and small businesses to own, patent and commercialize inventions developed under federally funded research programs within their organizations" (Ezell, 2019; Drexel University website).*

[20] *University of Strathclyde, Glasgow website.*

In order to enable and strengthen academia-industry linkages, the Principal Scientific Advisor has set up a programme to establish Science & Technology clusters around the country in 2020 (PSA website). These are formal umbrella structures for S&T organisations in cities that already have a critical mass of S&T. The idea is to have synergy and autonomy. While it is too early to assess them, six S&T clusters have been established around the country for different industries, but there are none for farm machinery.

Last but not least, can R&D incentives to firms help? We look to China for guidance where there is a history of significant R&D support. The empirical evidence is mixed about the impact of R&D incentives on firms (Jia and Ma, 2017; Tong et al., 2020).

Box 3: Turkey R&D Eco-system

Developed countries are key examples of how constructive industry-academia collaboration can be but they can be difficult to replicate. One emerging country that we can look at for motivation is Turkey, which has used a variety of methods to encourage this collaboration.

Some of the key mechanisms from Yalçintaş, Kaya and Kaya (2015) are :

- Revolving capital: Faculty are allowed to participate in projects subject to universities keeping a part of their fees. However, this was perceived to be not enough because faculty in Turkey run into the same problem as Indian ones, i.e., they are not allowed to contribute towards commercial activities.
- Techoparks: Faculty and institutions working in technoparks are exempt from a variety of taxes.
- Technology Transfer Offices: These act as an interface for academics and industrialists where both can seek help. Industrialists can approach TTOs for help and the TTOs try to match project needs to specific academics.
- R&D support programmes: R&D projects are co-funded by universities and private partners. This is especially beneficial for small and medium enterprises.
- Development Agencies in Turkey are local agencies that also call for participation in projects where academics can participate.
- Industries can use academic lab facilities (Temel and Glassman, 2013).

The first step is to create an atmosphere of trust and awareness between the stakeholders (Temel and Glassman, 2013) and enable various mechanisms that encourage industry-academic collaboration. Temel et al. (2013) also point out that industry-academic collaborations have to reach a scale for firms to benefit from it.

V.2 Disadvantage India

India mainly imports non-tractor farm machinery from China (Figure 5). In India, the central and state governments subsidise farmers' purchases of farm machinery via Direct Benefit Transfers (Kishore, Saini and Alvi, 2022). Chinese farm machinery are sold on India's DBT portals at par with Indian products. Thus, Chinese farm machinery manufacturers get support from both China

> India mainly imports non-tractor farm machinery from China. In India, the central and state governments subsidise farmers' purchases of farm machinery via Direct Benefit Transfers. Chinese farm machinery are sold on India's DBT portals at par with Indian ones. Thus, Chinese farm machinery manufacturers get support from both China and India, leaving the Indian manufacturers at a disadvantage.

and India, leaving the Indian manufacturers at a disadvantage. However, Tong et al. (2020) show the uneven impact of government subsidies on product quality in farm machinery in China. It is ambiguous whether the Indian and Chinese machinery are 1:1 substitutes. Compared to the world, Chinese non-tractor farm machinery necessarily does not enjoy comparative advantage (Annexure 4). In sum, the Chinese non-tractor farm machinery may or may not enjoy a quality advantage over India but it does enjoy a price advantage due to government subsidies.

Below, we compare government support models for the Brazilian and Chinese farm machinery sector.

V.2.1 Brazil

Brazil encourages local production of farm machinery products while ensuring quality. he Brazilian farm machinery sector is dominated by the local manufacturing and trading sector (Mantovini et al., 2019). Farmers are subsidised to buy local equipment. Government policies in Brazil have aimed for modernisation programmes that require 'a national content of 30 per cent, an accreditation index of 50 per cent and the remaining qualitative terms with 20 per cent (i.e. the technological content of the product, innovation effort, level of exports, technical qualification of the employees and added value).' The accreditation limits the value of import of readymade products without limiting the imports of parts and components. Further, while hi-tech components and parts are allowed to be imported, part of the assembly and manufacturing has to be done in Brazil. The machines are also acclimatised to local Brazilian conditions. There is a large literature on how Brazil is cooperating with individual African countries to encourage the use of Brazilian tractors and harvesters.

V.2.2 China

China has identified the farm machinery sector as part of its 'Made in China 2025' policy and it plans to consolidate the sector through the development of five globally competitive firms (Safdar and Gevelt, 2019). China is the only country that gives both

production and R&D subsidies in manufacturing, if not exactly in farm machinery (OECD 2018; Chapter 6)[21]. On the back of generous farm machinery subsidies for farmers, the farm machinery industry in China has grown at double-digit rates and the country has emerged as the largest global farm machinery manufacturer (Safdar and Gevelt, 2019). State-owned enterprises dominate the farm machinery industry in China. Domestic firms export low-power agricultural equipment to emerging and developing countries in Asia and Africa.

While the impact of subsidies on Chinese firms remains ambiguous, it does provide them with a cost advantage (Hsu, 2021) and Chinese subsidies have distorted global markets (Haley and Haley, 2013). The example of power tillers illustrates the conundrum faced by Indian policymakers (Box 4).

Box 4: Power Tillers

A power tiller is a farm machine that has a single axle and is used for soil preparation. It is self-powered, self-propelled and can pull a variety of attachments. Trade in power tillers is characterised by inter-industry trade where India has a comparative advantage in power tillers (HS code 843280; see Annexure 4). Trade in power tillers had a surplus between 2015–16 (US$ 4.8 million) and 2020–21 (US$ 33 million) (Ministry of Commerce website). Trade surplus was going up after 2018–19 and went up more sharply in 2020–21 (because of restrictions). While China is India's main importer, followed by Thailand, Japan and other developed countries, Sri Lanka, Brazil, Suriname, Bangladesh and Mauritiana were the top 5 export destinations.

Alagusundaram et al. (2017) showed that Chinese power tillers were being imported at ₹ 65,000 to 75,000 and the admissible subsidy on this was ₹ 60,000; yet farmers were being charged ₹ 1.25 lakh to ₹ 1.50 lakh. In contrast, the selling price of Indian power tillers ranged from ₹ 1.4 lakh to ₹ 2.15 lakh. Given the price differences, it is natural for the farmer to prefer the cheaper Chinese product. The authors did not have any data to comment on quality differences, if any, though the report said that Chinese imports were of inferior quality.

Despite a trade surplus, the DGFT (2020) placed restrictions on imports of power tillers and its components in 2020. A more nuanced policy would be to do research on how to make better quality and cheaper power tillers in India. Further, imposing localization conditions without import restrictions could contribute to this exercise and encourage Indian producers. Solar-powered mini power tillers may be particularly relevant for small & marginal Indian farmers and in hilly regions.

V.3 Ease of Doing Business

Our field interviews with firms suggest that constraints on the ease of doing business continue to plague firms. Firms do not get repayments on time, logistics is a constraint and policies on ground are implemented ineffectively. While these problems are not unique to this industry, given the nature of the products, i.e., heavy machinery, it affects the inventories and working capital of firms, which, in turn, affects small firms that are dependent on larger firms for business. Another

[21] *While there is evidence that China provides production subsidy for manufacturing firms, no paper has directly talked about subsidies in the farm machinery industry. Hsu (2021) reports that strategically important industries like steel, solar panel manufacturing, electric battery development, ship building, and oil production industries do receive subsidies. Even if farm machinery industries are not subsidised directly, many State-owned companies operate in this arena; they have access to ready capital and may not have been required to make a profit (Davis, Bailey, and Chudoba, 2010).*

> Firms incur large costs for the testing of equipment; the testing centres are located at a distance and transportation costs are high. In addition, there are problems with the results. Often, the same machine is repeatedly tested for several dimensions, and the validity of the test is for a relatively short duration.

related point is that firms have to enrol for different states' websites and pay an Earnest Money Deposit (EMD) for enrolment to supply machinery at subsidised rates.

Firms incur large costs for the testing of equipment; the testing centres are located at a distance and transportation costs are high. In addition, there are problems with the results. Often, the same machine is repeatedly tested for several dimensions, and the validity of the test is for a relatively short duration. Further, interviews with firms revealed that the testing reports can be faulty; these are binary reports that state whether the machinery has been accepted or rejected but the details are missing. Last but not least, there is a shortage of the skilled personnel needed for testing equipment.

V.4 Shortage of Skilled Workers

Fabrication of agricultural tools and machinery is often done by semi-skilled workers without proper tools. In the case of small-scale fabricators, there is no qualified supervisor to look after quality parameters.

In India, skilling courses are being offered in operating farm machinery especially in rural areas through the Agricultural Skill Council of India. In our field trip to Karnal, in a farm machinery cluster we found that the micro, small and medium enterprises (MSMEs) suffered from lack of skilled personnel. The Model ITI programme implemented by the Government of India asks for partnership between an industry partner and an ITI in a cluster (Bhandari et al., 2018), which was missing in this cluster.

V.5 Summary

The crux of the issue is that there is a mismatch between the needs of small & marginal Indian farmers and what the organised farm machinery sector is producing. The Indian farm machinery sector is dominated by tractors and the rental market is geared towards tractors, tractor-mounted equipment or other heavy farm machinery. There are large state-wise variations in farmers' ownership and usage of farm machinery. The overall usage of farm machinery remains low compared to international standards.

Overall, small & marginal farmers are left out of both the market due to the high costs of machinery and limited access to institutional credit. They cannot afford to buy even light farm machinery such as power tillers either for self-use or for leasing, and even their ability to rent equipment is constrained by lack of credit. As a result, they end up going

to village-level craftsmen. This non-tractors farm machinery industry is stuck in a low-level equilibrium trap.

Further, the Indian farm machine industry is plagued by Chinese imports that are sold on DBT portals to Indian farmers at a subsidised rate. At the same time, the Chinese farm machinery industry benefits, either directly or indirectly, from China's subsidies: China subsidises farmers to buy Chinese farm machinery (there was a mandate until 2019), the farm machinery industry is dominated by Chinese State-owned enterprises (Davis et al., 2010; Safdar and Gevelt, 2019), and Chinese manufacturing firms get R&D incentives (OECD, 2018) (Figure 10). Figure 11 provides a comparison of the subsidies in the Indian and Chinese farm machinery market.

Figure 10: Chinese Government Support for its Farm Machinery Industry

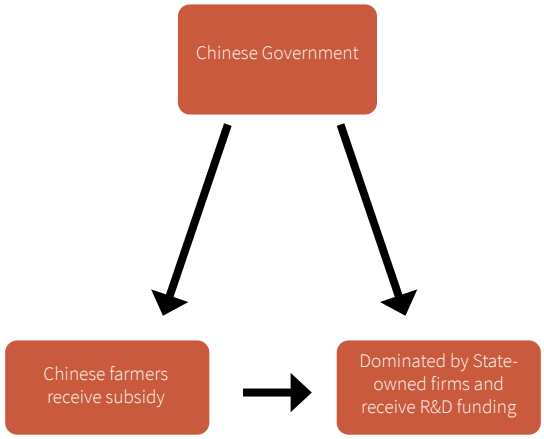
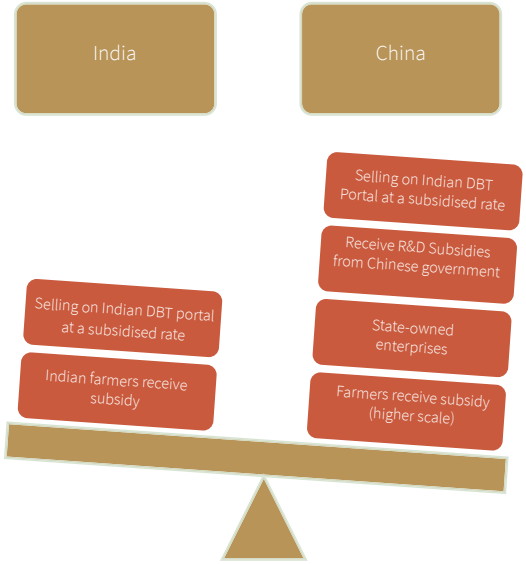


Figure 11: Advantages to Chinese vs. Indian Manufacturers in Farm Machinery Industry



Source: NCAER conceptualisation.

The usual macro factors such as ease of doing business and inconsistent regulations make it a challenging environment for the Indian farm machinery industry. It is rendered uncompetitive in terms of scale, innovation and prices. The industry faces a shortage of skilled workers and there is little sustained collaboration between academia and industry. Unfortunately, these have consequences for the largest share of farmers-the small & marginal farmer.

India is caught in a low-equilibrium trap. The main policy challenge is how to turn the current situation into a virtuous cycle that benefits both the Indian non-tractor farm machinery industry and small & marginal farmers.

VI

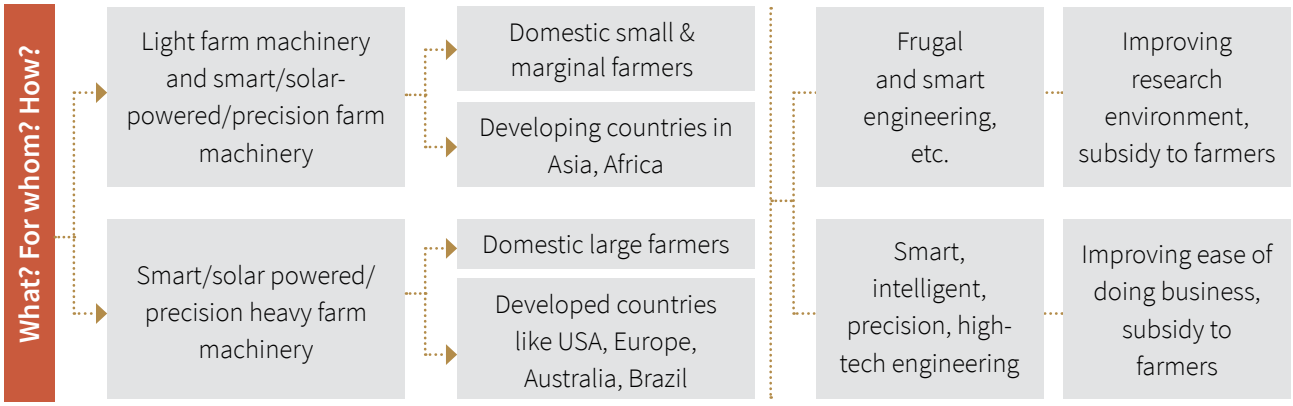
Policy Recommendations to Make India a Global Production Hub for Non-tractor Farm Machinery

VI.1 Framework

India needs a vision for the next 15 years to translate itself into a production and export hub for non-tractor farm machinery. Policies should address current challenges and act as accelerators to convert India's dual farm machinery market into an advantage by producing a range of equipment that caters to all types of farmers, both domestic and around the world.

The non-tractor farm machinery industry is broadly divided into two types – tractor-mounted machinery and self-propelled/hand-driven mechanised farm machinery. India can convert its dual farm machinery market into an advantage. It already has a comparative advantage in tractors. Tractor-mounted machinery is a complementary good that has a domestic market among large farmers as well as in developed countries. Self-propelled/hand-driven mechanised farm machinery has a domestic market in small & marginal farmers as well as in emerging & developing countries with similar socio-economic structures such as Asia and Africa (Figure 12). A dual structure gives India a dual advantage. India should leverage this to become a global supplier of non-tractor farm machinery to the world while simultaneously uplifting small & marginal farmers around the world. How do we get there? An Action Plan is delineated in the next section.

Figure 12: What to Produce? For Whom to Produce? How to Produce?



Source: NCAER conceptualisation.

VI.2 Action Plan

The Action Plan is divided into two sections – policies that address current challenges and policies that will act as accelerators to turn India into a production hub. Both are designed around the above framework (Figure 12).

VI.2.1 Addressing Current Challenges

1. Addressing Domestic Demand-side Constraints

A. Inconsistent subsidy policy formulation and implementation.

- Central and state governments may subsidise farmers on a consistent basis for the next 15 years for farmer mechanisation to reach desired levels. Small & marginal farmers need to be especially encouraged. Only farmers with annual income of less than Rs 2 lakh are eligible for SMAM under the revised guidelines in 2022–23. Women farmers with family income less than Rs 2 lakh are also eligible for this loan.

- Machine subsidy schemes and accompanying loans should be available throughout the year.

- Subsidy should be given not only for procurement but also for renting heavy farm machinery like harvesters and transplanters.

- Eligibility criteria for machine subsidy programmes requiring a farmer to have at least 1 acre of land (or any type of land ceiling or any other criteria) should be removed (Kishore, Saini and Alvi, 2022). This will ensure that small & marginal farmers can also participate in the rental market both as farmers and as entrepreneurs.

- Even small & marginal farmers should be able to rent out their machines. If a small farmer has one power tiller, he should be able to rent it out. Ceilings on land or type of machinery or quantity of machinery need to be removed.

- Make a uniform DBT model, i.e., choose one model of DBT, either as an in-kind subsidy or direct transfer of cash benefits to farmers.

- The process of applying for subsidy and receiving it should be streamlined, simplified and digitised as done in Odisha. The Odisha DBT portal is an example for the rest of the country (Kishore, Saini and Alvi, 2022).

- State governments should ensure that the DBT portal reflects the market prices of farming machinery.

B. Small & marginal farmers suffer from credit constraints.

- Farmers need to be provided with long-term credit to buy machinery.

- The suggestion by Kishore, Saini and Alvi (2022: p. 42) is re-emphasised: "Banks and the concerned state government can coordinate to offer loans to farmers against a farm implement once an application is approved. Dealers can also be made a part of the process where they put a small share of the cost of the implement as the first loan default guarantee (FLDG) cover to banks." This can help farmers reduce their upfront costs and ensure that they do not borrow from money lenders at high costs.

- Institutional loans should be provided to small & marginal farmers who qualify for a farm machinery subsidy. Kishore, Saini and Alvi (2022) suggest that it should be made part of the subsidy reforms.

- Bankers need to be sensitised to farmers, the various farm mechanisation schemes and CHCs. This needs to be done from the head office to the branch level, from induction programmes to other training sessions.

- The process of obtaining a bank guarantee and collateral security for CHCs needs to be simplified.

C. Extension programmes for farmers need to be strengthened.

- Region-specific strategies are needed. District-wise information on which crop is going to be harvested when, if publicly available, can help professionals plan out renting machines.

- Farm machinery dealers should be informed and sensitised before the onset of a farm mechanisation subsidy scheme. In many cases, dealers lack information as well as awareness of the spirit of the scheme.

- Since there is a large rental market for farm machinery, private CHCs need to be improved in terms of record maintenance, reporting, accounting and financial viability. State agro-industry corporations should provide CHC stations at the district/ tehsil level.

- Training & Demonstrations: State directors of Agricultural Engineering, State Agricultural Universities, State Agro-Industries Corporations, Farm Machinery Training and Testing Institutes and Indian Council of Agricultural Research (ICAR) institutes that have Tractor Training Centres, Krishi Vigyan Kendras and industry through their dealers should be made responsible for training and demonstrations to young farmers/owners/ operators on how to select, operate and service farm power units and machinery. They should also provide information on developments in mechanisation including the availability of new and better farm equipment for different applications. (b) The programmes of Front-Line Demonstrations (FLDs) of farm machinery should be strengthened. Handheld training to users of new generation farm machinery may encourage the extension and adoption of increased use of farm power.

- Skill shortages: On the demand-side, there are skill shortages in operation, repair & maintenance. The Agricultural Skills Council of India (ASCI) should work at the district level to address skilling shortages on the demand side; public-private partnerships

(PPPs) with CHCs may be especially useful. ICAR institutes can offer short courses that address skills shortage on the demand side and ITIs can be leveraged to address the skill gaps in repair & maintenance.

- Corporate linkages: There is increased participation by corporates in farming through contract farming agreements and the provision of specialised farm equipment and amenities to improve crop yield through new agricultural technologies. The continuation and growth of contract farming with more entities getting involved provides opportunities for expansion of the industry.

- Service centres at the regional and state levels may be promoted in the private and industry sector. This will alleviate the need for each farmer to own machinery and learn skills to operate the individual machines. Each centre can also rent out machines with the associated package of service (the equipment and skilled manpower to deploy the machine efficiently and effectively). Such service enterprises will also create jobs for skilled youth in that region.

2. Addressing Current Supply-side Challenges

A. Promote R&D in non-tractor farm machinery: There is no platform for collaboration between academia, industry and government bodies to foster innovation in farm machinery.

- Agricultural universities and ICAR institutes that have sufficient manpower and facilities for R&D in mechanisation should be identified and assigned the responsibility for R&D in different agro-economic zones.

- Technoparks can be established in the proposed Enterprise and Service Hubs or existing clusters where institutions, private firms and individual faculty can work together on specific research projects. Testing centres for farm equipment should also be established in existing and future clusters. Since a significant share of exports go to the East, especially Bangladesh, Nepal, etc., India should open a technopark in the eastern border region. A dedicated export promoting zone will help cater to both domestic and international demand.

- Interface for academics and industrialists through Technology Transfer Offices (TTOs) by the Department of Science and Technology.

- Industries can use academic lab facilities. This can be especially useful for MSMEs.

- R&D projects should be co-funded by universities and private partners.

- The Start-up India scheme should be implemented at ICAR institutes and universities. Incubation cells to encourage entrepreneurship should be developed in these institutes. This will also help universities and research institutes with additional sources of funding.

- Industries can collaborate with private universities to set up a strong academic-industry collaboration.

- Commercialisation of new ideas can be financed through the Technology Development Board under the Department of Science & Technology.

B. Improve Ease of Doing Business: Regulatory best practices need to be implemented. Payments need to be made on time. A clear and transparent communication strategy needs to be adopted. Logistics needs to be improved especially for transporting heavy machinery.

C. Encourage exports and FDI: While India already hosts multinationals in this arena, foreign multinationals should be encouraged to make India an export hub for South Asia and

Southeast Asia. Foreign multinationals should be encouraged to include Indian manufacturing in Global Value Chains (GVCs) especially since India has a comparative advantage in machinery parts.

D. Level-playing field for Indian manufacturers: Given the unfair competition that Indian manufacturers face, it is recommended that farm machinery sold under government subsidy on government DBT portals (both Central and State) should be compatible with Government of India's revised public procurement norms with a preference for 'Make in India' goods (Ministry of Commerce & Industry, 2020). No other import restrictions or controls are recommended.

E. Improving & Maintaining Quality: Testing, specification standardisation & performance requirements, and regulations should be developed such that they are in line with global benchmarks.

- Mandate and standardise performance characteristics and not technology/ specifications for meeting performance.
- Follow automobile models of testing such as establishing PPP models for testing and homologation, e.g., Automotive Research Association of India.
- Small-scale industries should be encouraged and incentivised to employ personnel trained at Industrial Training Institutes (ITIs) in manufacturing/ production and diploma holders/ graduates in agricultural engineering for supervisory roles.

F. Addressing Skilled Worker Shortages: There is a shortage of skills in the manufacturing sector, both in terms of quantity and quality.

- It is strongly recommended that District Industries Centre should work with local industrial clusters so that ITIs can provide these courses with the latest available technical knowledge and skills. This may include upskilling of faculty, interaction of industry executives with faculty & students on a regular basis, upgrading the syllabus and laboratory facilities, and internships & job placements (Bhandari, 2022). In the NCAER field research in Karnal, we found that the local farm machinery industrial association was in the process of acquiring the appropriate machinery to train youth and provide facilities to local firms.
- Dual vocational skilling programmes will greatly benefit industrial clusters located in Tier II and Tier III cities. MSMEs should also leverage the Apprentices Policy of the Government of India. This may be a win-win situation for youth. Opportunities for re-skilling and upskilling also need to be provided.

G. Improving governance: A Directorate of Agricultural Engineering should be established at the block level in each State (Mishra, 2022) to overcome shortage of agricultural engineers at the district level.

H. Data on farm machinery

- The National Statistical Organisation should recognise this as a separate industry; all the codes that are spread over several industries should be brought together in one place.
- The HS codes can signal two different products. It is recommended that the harmonized codes are cleaned up. This would be important if the sector is to be scaled up.

VI.2.2 Accelerators

India should have a 15-year vision plan to turn India into a farm machinery production hub for the world. This industrial sector is far too important since it has

implications for the agricultural sector. It already has a comparative advantage in the tractor industry. India needs to leverage that and use its advantages to now become a non-tractor farm machinery hub. While the current challenges are being resolved, India needs a strategic framework, which is given in Figure 12.

India needs scale to compete internationally in the case of tractor-mounted equipment and other heavy farm machinery. Unfortunately, it has a comparative advantage in a few limited products. Further, India needs to innovate on light farm machinery that small & marginal farmers can use at economical prices.

1. Encouraging innovations in the non-tractor farm machinery sector

    - Future R&D programmes should focus on the development of farm machinery and power units for the appropriate size of equipment for small, medium and semi-medium farmers, as well as precision and protected agriculture that is region-specific (hill agriculture and farm operations with nil/very poor penetration of mechanisation (Table 2)), crop-specific (horticulture, cash and plantation crop) and addresses the recovery and management of crop residues.

    - Although nascent, since India is doing R&D on solar-powered farming equipment, this can be encouraged specifically for R&D, production and marketing both at home and abroad. This will also encourage sustainable farming and reduce farmers' dependency on expensive fuel.

    - Enact a law that enables universities, non-profit research institutions and small businesses to own, patent and commercialise inventions developed under government-funded research programmes within their organisations.

    - In applied engineering, it is necessary to change the terms of tenure, promotions, salary increments and appraisals and make them dependent on how many inventions they are successfully able to commercialise.

    - Faculty should be allowed to participate in projects subject to universities keeping a part of their fees.

    - India can set up a non-tractor farm machinery Science & Technology Cluster under the Principal Scientific Advisor S&T Cluster programme.

    - Research-linked incentives (RLI) is recommended for innovations in light farm machinery, solar-powered equipment and smart/precision farming for the next five years, where the firms invest 15 per cent of their annual turnover in R&D (Das, 2022). The RLI should also be linked to quality parameters similar to Brazil.

    - Encourage local innovations

    o Both research and entrepreneurship eco-systems should be created and encouraged in ITIs. They may also partner with farm machinery firms to invent and innovate non-tractor farm machinery.

    o District-level patent offices need to be opened and strengthened or the patent offices of state agricultural universities need to cater to the needs of the local communities to enable patenting and commercialising of local innovations (Box 5).

Box 5: Farmer Innovators

A 71-year-old farmer in Maharashtra brought down the cost of weeding from Rs 40,000 to Rs 5,000 by inventing a weeding tool. As the tool caught the fancy of other farmers online, the farmer collaborated with a local workshop to produce and sell the tool. Another 34-year-old farmer in Maharashtra innovated a tiller using an old motorbike.

Both farmers had an ITI background, where they used their respective machinist and welding knowledge to solve their specific challenges. In the process they created efficiency inducing and cost-effective innovations, which can address the needs of small farmers.

Sources: Parmar (2022) and Rao (2021).

- Corporate partnerships can also help local innovations. Maruti Suzuki Innovation creates such a platform for start-ups; it allows entrepreneurs to collaborate with Maruti (Maruti Suzuki innovation website). The company funds entrepreneurs and provides mentorship and training to selected applicants.

- We need to create more farmer-engineers in India—farmers with engineering knowledge may be able to create wonders for small farmers and firms in India (Box 5). In the process, we will also encourage opportunity entrepreneurs.

2. Marketing and promoting exports

- India has a comparative advantage in tractors, ploughs, disc harrows, etc. (Annexure 4). Better marketing and promoting exports of tractor-mounted equipment is needed.

- Companies should try to sell economical packages of tractors with tractor-mounted equipment.

- MSMEs should be mentored and supported to participate in international trade fairs.

- MSMEs can be handheld to produce YouTube videos of their equipment to promote them online. Extension activities of promotion, branding and packaging may be provided to them.

- Since India is now again making bilateral trade agreements, technology transfers can be made part of those agreements to enable the transfer of technology. Further, bilateral trade agreements can be leveraged to sell Indian non-tractor farm machinery products abroad in advanced countries.

3. Achieving Scale

- India has a current comparative advantage and there is a presence of intra-industry trade in these sub-sectors: HS codes 84248200, 84328090 and 84331110. India should leverage this advantage by further scaling up and becoming a part of global value-chains by addressing current challenges. India can also try and achieve scale in solar-powered equipment.

VII Conclusions

This is an industry with myriad stakeholders. On the one hand, we have manufacturing firms, with a small number of large firms dominating the market. On the other hand, we have the small and marginal farmers who consume the products. The problem is that there is a mismatch between the aspirations of small and marginal farmers who rent out equipment, if at all, and producers who want to expand the market. While India has done well in the production and export of tractors, the market for non-tractor farm machinery is fairly limited, both on the supply and demand sides. The challenge is how to expand the market.

India needs a vision for the next 15 years to convert itself into production and export hub for non-tractor farm machinery. Policies should address current challenges and act as accelerators to convert India's dual farm machinery market into an advantage by producing a range of equipment that caters to all types of farmers around the world.

For that it needs to increase demand for farm machinery at home by addressing inconsistencies in subsidy policies, improve the implementation of subsidy, improve farm machinery rental markets, improve access to credit, especially for small & marginal farmers, and finally overhaul extension services.

On the supply side, it needs to address current challenges. Imports have an unfair advantage in India. It is recommended that it may be mandated that there should be 30-50 per cent of local value addition in all farm machinery that is sold under government subsidy. Testing, specification standardization & performance requirements, and regulations in line with global benchmarks should be improved. The

availability of quality farm machinery and skilled worker shortage should be addressed. Platforms for collaboration between academia, industry and government bodies to foster innovation in farm machinery should be encouraged.

For accelerators, we focus on research-linked incentives for light farm machinery, solar-powered machinery and precision equipment. Export promotion is strongly encouraged through a variety of initiatives. India should try and achieve scale in products in which it has a comparative advantage.

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Annexures

Annexure 1: Farm Machinery Industry

S. No.	Product Description	National Product Classification Code	HS code	HS code description	
Soil machinery (agricultural, horticultural or forestry machinery for soil preparation or cultivation; lawn or sports ground rollers)					
1.	Ploughs	4411100	84321010	Disc Ploughs	
2.			84321020	Tractor Ploughs	
3.			84321090	Other Ploughs	
4.	Cultivators	84322100	84322100	Disc Harrows	
5.	Harrows, Disc harrows	4411202	84322100		
6.	Weeders	4411205			
7.	Harrows, scarifiers, cultivators, weeders and hoes, n.e.c	4411299	84322990	Harrows, scarifiers, cultivators, weeders (imported) and hoes for use in agriculture, horticulture or forestry (excluding disc harrows)	
8.	Rotary hoes	4411299	84322910	Rotary hoes	
9.	Planters	4411301	84323000/ 84323100	No-till direct seeders, planters and transplanters	
10.	Seeders	4411302			
11.	Seeders, planters and transplanters, n.e.c	4411399	84323900	Other seeders, planters and transplanters	
12.	Fertilizer distributors	4411401	84324000/ 8432.42	84324100	Manure spreaders
13.	Manure spreaders and fertilizer distributors, n.e.c	4411499	84324000	84324200	Fertiliser distributors
14.	Other soil machinery	44119	84328010	Lawns or sports ground rollers	
15.	Parts of soil machinery	4411500	84329	84329010	Prts of agrcltrl mchnry fllng wthn hdg nos 843210, 843221, 843229, 843230 and 843240
16.				84329090	Parts of other agricultural and horticultural machinery of hdg no 843280
17.	Hand tractor (power tiller)	4411901	84328020	Power tiller (with or without rotary tiller)	
18.	Other soil machinery, n.e.c.	4411999	84328090	Others	
Harvester and threshers; machines for cleaning, sorting or grading agricultural products					
19.	Mowers for lawn, parks, sports ground not powered	4412102	84331110	Mowrs fr lawns,prks/sprts grnds, pwrd,wth 3 hp or more	

(Contd.)

Annexure 1: Farm Machinery Industry (Contd.)

S. No.	Product Description	National Product Classification Code	HS code	HS code description
20.	Mowers for lawns, parks or sportsgrounds	4412101	84331910	Non-powered mowers having width of 75 cm or more
21.	Mowers, n.e.c.	4412199	84331190	Parts
22.	Mowers for lawns parks or sports grounds: Others	44121	84331990	Other non-powered mowers
23.	Combine harvesters, threshers	4412201	84335100 /84335101	Combine harvesters, threshers
24.	Agriculture implements, n.e.c	4412299	84335100	
25.	Other mowers, including cutter bars for tractor mounting	4412300	84332000	Other mowers, including cutter bars for tractor mounting
26.	Bending machine agriculture	4412401	84333000	Other haymaking machinery
27.	Cutter and callipers agriculture	4412402	84333000	Other haymaking machinery
28.	Cutting machines agriculture	4412403		
29.	Other haymaking machinery, n.e.c	4412499		
	Other harvesting and threshing machinery, n.e.c.; parts for harvesting, threshing and grading			
30.	Harvesting machinery	4412901	84335900/ 84335200	Others
31.	Threshing machinery	4412902		
32.	Parts of harvesting machinery, threshing machinery, grading machinery, n.e.c.	4412999		
33.	Other harvesting and threshing machinery, n.e.c.; parts for harvesting, threshing and grading machinery	44129	84339000	Parts of harvesting, threshing machines etc.
	Agricultural Tractors			
34.	Pedestrian-controlled tractors	4414100	87011000	Single axle tractors
35.	Track-laying tractors, garden tractors	4414200	87013011	Garden Tractors of Engn Capacity <= 1800CC
			87013019	Other Garden tractors
			8709090	Other tractors
			87019100	Not exceeding 18 kw
36.	Other agricultural tractors	4414900	87019200	Exceeding 18 kw but not exceeding 37 kw
			87019300	Exceeding 37 kw but not exceeding 75 kw
			87019400	Exceeding 75 kw but not exceeding 130 kw
			87019500	Exceeding 130 kw
	Mechanical appliances for projecting, dispersing or spraying liquids or powders for agriculture or horticulture			
37.	Mechanical appliances for projecting, dispersing or spraying liquids or powders for agriculture or horticulture like spray guns for agriculture etc.	4415000	84248100/ 84248200	Appliances for horticultural and agricultural work

Sources: Ministry of Commerce, Annual Survey of Industries and United Nations Statistics Division.

Annexure 2: Percentage share of Cultivator Households that owned Farm Machinery, as on June 2018

	Percentage share of cultivator households that owned				
	Tractor for farm business	Any of the four*	Tractor + any of the four*	Tractor but none of the four*	Any of the four but no tractor*
Punjab	31.0	36.9	25.1	5.8	11.8
Chandigarh	22.7	44.7	22.7	0.0	22.0
Haryana	14.0	20.0	10.0	4.0	10.0
Uttarakhand	13.7	19.8	11.2	2.5	8.6
Daman & Diu	11.4	0.0	0.0	11.4	0.0
Gujarat	9.6	4.2	3.4	6.2	0.8
Rajasthan	9.5	7.6	5.8	3.7	1.9
Madhya Pradesh	6.6	4.4	3.4	3.3	1.1
Andhra Pradesh	5.7	4.1	2.0	3.7	2.1
Uttar Pradesh	5.1	5.8	3.3	1.8	2.5
Telangana	4.4	3.8	2.3	2.1	1.5
India	4.4	5.3	2.5	1.9	2.8
Karnataka	4.2	3.7	1.6	2.6	2.1
Maharashtra	3.2	7.3	1.9	1.2	5.4
Tamil Nadu	2.8	2.5	0.4	2.4	2.1
Bihar	1.9	3.4	1.1	0.8	2.3
Goa	1.8	7.4	0.0	1.8	7.4
Assam	1.5	1.6	0.1	1.4	1.5
Puducherry	1.4	1.6	1.2	0.2	0.4
Chhattisgarh	1.3	0.8	0.5	0.8	0.3
Jammu & Kashmir	1.3	1.8	0.5	0.8	1.3
Manipur	0.8	1.1	0.1	0.8	1.0
Tripura	0.8	3.2	0.0	0.8	3.2
Odisha	0.7	1.6	0.3	0.4	1.3
Arunachal Pradesh	0.6	4.8	0.0	0.6	4.8
Delhi	0.4	2.7	0.4	0.0	2.2
Himachal Pradesh	0.3	2.0	0.3	0.1	1.7
Jharkhand	0.3	4.0	0.2	0.1	3.9
West Bengal	0.2	6.8	0.1	0.1	6.8

(Contd.)

Annexure 2: Percentage share of Cultivator Households that owned Farm Machinery, as on June 2018 (Contd.)

	Percentage share of cultivator households that owned				
	Tractor for farm business	Any of the four*	Tractor + any of the four*	Tractor but none of the four*	Any of the four but no tractor*
Nagaland	0.1	0.1	0.0	0.1	0.1
Andaman & Nicobar Islands	0.0	0.0	0.0	0.0	0.0
Sikkim	0.0	0.6	0.0	0.0	0.6
Mizoram	0.0	2.3	0.0	0.0	2.3
Meghalaya	0.0	0.8	0.0	0.0	0.8
Dadra & Nagar Haveli	0.0	0.5	0.0	0.0	0.5
Lakshadweep	0.0	0.0	0.0	0.0	0.0
Kerala	0.0	0.7	0.0	0.0	0.7

Source: Authors' computations from MoSPI (2021a).

*Note: * The AIDIS Survey 2019 probed farmer households about ownership of tractors as well as (a) power tillers/power-driven ploughs, (b) crop harvesters (power-driven)/combined harvesters, (c) threshers, other power-driven machinery and equipment, and (d) laser land leveller.*

Annexure 3: Cost Norms and Pattern of Assistance Under Sub-Mission on Agricultural Mechanisation (SMAM) During 12th Plan Period

Components of SMAM

1. Promotion and Strengthening of Agricultural Mechanization through Training, Testing and Demonstration.
2. Demonstration, Training and Distribution of Post-Harvest Technology and Management (PHTM).
3. Financial Assistance for Procurement of Agriculture Machinery and Equipment.
4. Establish Farm Machinery Banks for Custom Hiring.
5. Establish Hi-Tech, High-Productive Equipment Hub for Custom Hiring.
6. Promotion of Farm Mechanisation in Selected Villages.
7. Financial Assistance for Promotion of Mechanized Operations/hectare carried out through Custom Hiring Centres.
8. Promotion of Farm Machinery and Equipment in North-Eastern Region.

Component	Budget Allocation		Sub-component	Pattern of Assistance	Implementing Agency
	Centre Share	State Share			
1. Promotion and Strengthening of Agricultural Mechanization through Demonstration, Training, and Testing	100	0	a) Demonstration b) Training c) Testing. Designated SAUs/ ICAR institutions/ govt. agencies to undertake testing of agriculture machinery	100% assistance @ ₹ 4,000 per hectare up to 100 ha per season. This includes: (i) Charges for hiring machines along with implements/ self-propelled machines – ₹ 2,000 per ha. (ii) Expenditure towards hands-on training – ₹ 1,500 per ha. Miscellaneous expenditure towards transport, labour, publicity and printing of technical literature etc – ₹ 500 per ha ₹ 4000/- per trainee per week, including board/lodging and transport One-time grant up to ₹ 1.5 crore	FMTTIs, state-identified institutions, ICAR institutions, ATMA institutions, PSUs of GOI, state governments

(Contd.)

Component	Budget Allocation		Sub-component	Pattern of Assistance	Implementing Agency
	Centre Share	State Share			
2. Demonstration, Training and Distribution of Post-Harvest Technology and Management (PHTM)	100	0	a) Establishment of PHT units b) Demonstration of developed/ appropriate Post-Harvest Technologies c) Training of farmers, entrepreneurs and scientists in areas related to Post-Harvest Technology	60% of cost of unit up to 1.50 lakh for SC, ST, small & marginal farmers, women and NE States beneficiary and 50% of cost of unit up to 1.25 lakh for other beneficiary 100% assistance @ ₹ 4,000 per ha up to 100 ha per season. This includes: (i) Charges towards hiring machines along with implements/ self-propelled machines – ₹ 2,000 per ha. (ii) Expenditure towards hands-on training – ₹ 1,500 per ha. Miscellaneous expenditure such as towards transport, labour, publicity and printing of technical literature– ₹ 500 per ha ₹ 4,000/per trainee per week, including board/lodging and transport	FMTTIs, state -identified institutions, ICAR institutions, ATMA institutions, PSUs of GOI, state governments
3. Financial Assistance for Procurement of Agriculture Machinery and Equipment	75	25		35% to 50% of cost of unit up to 0.50 to 1.25 lakh for SC, ST, small & marginal farmers, women and NE States beneficiary; 25% to 40% of cost of unit up to 0.40 t0 1.00 lakh for other beneficiary on purchase of tractor, power tiller and other equipment	State governments
4. Establish Farm Machinery Banks for Custom Hiring	75	25	a) Procurement subsidy to establish Custom Hiring Centre up to 10 lakh b) Procurement subsidy to Custom Hiring Centre up to 25 lakh c) Procurement subsidy to establish Custom Hiring Centre up to 40 lakh d) Procurement subsidy to establish Custom Hiring Centre up to 60 lakh	₹ 4.0 lakh @ 40% of project cost ₹ 10.0 lakh @ 40% of project cost ₹ 16.0 lakh @ 40% of project cost ₹ 24.0 lakh @ 40% of project cost	State governments

(Contd.)

Component	Budget Allocation		Sub-component	Pattern of Assistance	Implementing Agency
	Centre Share	State Share			
5. Establish Hi-Tech, High-Productive Equipment Hub for Custom Hiring	75	25	a) Procurement subsidy to establish Custom Hiring Centre up to 100 lakh b) Procurement subsidy to establish Custom Hiring Centre up to 150 lakh a) Procurement subsidy to establish Custom Hiring Centre up to 200 lakh b) Procurement subsidy to establish Custom Hiring Centre up to 250 lakh	₹ 40.0 lakh @ 40% of project cost ₹ 60.0 lakh @ 40% of project cost ₹ 80.0 lakh @ 40% of project cost ₹ 100.0 lakh @ 40% of project cost	State governments
6. Promotion of Farm Mechanisation in Selected Villages	75	25	Financial assistance for farm machinery banks with minimum 8 farmers per bank	80% of cost of machinery bank up to 10.00 lakh	State governments
7. Financial Assistance for Promotion of Mechanized Operations/ hectare carried out through Custom Hiring Centres	75	25	a) Hiring charges to farmer members of farm machinery banks set up under Component (6) b) Field Demo by CHCs	50% of the cost of operation/ha up to a maximum of 1 ha area as per following norms (i) For tractor/power-operated operations – ₹ 2,000/ha per farmer per year (ii) For animal-drawn mechanised operations- ₹ 1,000/ha per farmer per year For manual operations – ₹ 750/ ha per farmer per year ₹ 4,000/ha Minimum 120 ha/ season per Custom Hiring Centre	State governments
8. Promotion of Farm Machinery and Equipment in North-Eastern Region	75	25	a) Financial assistance for procurement of machinery/ implements b) Financial assistance for farm machinery banks for group of farmers	100% of cost of machinery/ implement/ equipment up to ₹ 1.25 lakhs per beneficiary 95% of cost of Farm Machinery Banks up to ₹10 lakh per Farm Machinery Bank	State governments of 8 North-Eastern States

Source: MoAFW (2014).

Annexure 4: Revealed Comparative Advantage

Revealed comparative advantage of all goods at the 6-digit HS level (mentioned in Annexure 1) have been computed. We used two alternative measures – one based on exports only and the other based on relative trade advantage i.e., the difference between revealed export advantage and revealed import advantage (Jagdambe 2019; Tripa, Cuc & Oana, 2016; Ukulu & Seymen, 2004). The results were broadly similar across the two measurements. India was compared against major farm machinery producers including both developed and emerging & developing countries. The results are reported below using HS codes at the six-digit. Eight-digit level could not be used as this is only available for India. The HS codes and their definitions are reported in Annexure 1.

Export Competitiveness Index 2016-17 to 2020-21

	842482	843210	843221	843229	843230	843239	843240	843280	843290
Australia	0.1	0.1	0.3	0.1	0.0	0.1	0.2	0.4	0.4
Brazil	0.5	1.0	4.2	0.3	2.0	0.1	0.5	0.5	1.3
China	0.5	0.3	0.1	1.7	0.3	0.3	0.1	0.5	0.7
France	0.9	4.7	2.6	1.9	1.9	2.7	2.5	1.1	2.0
Germany	0.4	2.7	4.3	1.9	2.9	3.7	2.3	1.3	1.9
India	0.5	1.6	1.1	0.2	0.1	0.0	0.0	1.5	1.1
Italy	2.7	1.5	0.8	3.6	2.6	3.1	1.7	6.3	4.0
Japan	0.0	0.0	0.0	0.1	2.4	1.5	0.1	0.7	0.4
Spain	3.5	1.0	0.3	0.7	0.9	0.6	0.3	1.2	1.6
Thailand	0.0	0.2	2.6	1.4	0.1	0.0	0.0	0.4	0.3
Turkey	3.3	3.3	2.3	1.5	1.8	4.0	1.7	0.3	1.3
United Kingdom	0.2	0.4	0.5	0.8	0.5	0.3	1.5	1.1	0.5
USA	3.2	0.5	0.6	0.6	1.2	0.9	0.9	0.8	1.0
Vietnam	0.0	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.2
Total	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Difference between Revealed Export Competitiveness and Revealed Import Competitiveness, 2016-17 to 2020-21

	842482	843210	843221	843229	843230	843239	843240	843280	843290
Australia	-3.1	-0.6	-1.4	-1.2	-2.1	-1.9	-2.9	-2.0	-0.8
Brazil	-0.4	0.9	4.2	-0.1	1.9	-0.1	0.3	0.2	0.2
China	0.4	0.0	0.1	1.6	0.1	0.1	-0.2	0.5	0.6
France	-0.7	3.5	-0.3	-1.1	1.0	0.5	0.4	-1.0	-0.9
Germany	-0.3	1.9	3.8	0.7	2.5	3.2	1.9	0.2	0.3
India	-1.3	1.1	1.1	-0.3	-0.1	0.0	0.0	0.5	0.9

Difference between Revealed Export Competitiveness and Revealed Import Competitiveness, 2016-17 to 2020-21									
	842482	843210	843221	843229	843230	843239	843240	843280	843290
Italy	1.6	1.1	0.3	2.5	2.4	2.7	1.2	5.4	2.8
Japan	-0.1	-0.2	-0.3	-0.3	2.2	1.2	-0.4	0.4	-0.1
Spain	0.7	0.3	-0.1	-0.3	0.5	-0.1	-0.2	0.4	0.5
Thailand	-0.3	0.1	2.5	1.2	0.0	0.0	0.0	0.3	-0.1
Turkey	2.3	3.3	2.3	1.3	1.6	3.6	1.5	0.3	1.1
United Kingdom	-0.1	-1.0	0.0	-0.5	0.0	-1.0	0.1	0.0	-0.4
USA	2.6	0.3	-0.3	-0.2	1.0	0.4	0.1	0.1	0.2
Vietnam	-0.2	-0.1	0.0	-0.4	-0.1	0.0	-0.1	-0.1	0.2
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.8

Source: Authors' computations from United Nations Comtrade.

Export Competitiveness Index							
	843311	843319	843320	843330	843340	843351	843352
Australia	0.1	0.3	0.0	0.0	0.3	0.0	0.1
Brazil	0.0	0.0	0.3	0.0	0.1	2.1	9.3
China	1.6	3.6	0.4	0.1	0.1	0.4	0.2
France	2.4	0.1	3.1	4.9	3.9	0.4	0.3
Germany	1.1	0.1	3.2	3.4	2.3	3.0	0.2
India	0.1	0.1	0.1	0.1	0.1	0.1	1.2
Italy	2.0	1.8	3.2	3.3	2.0	1.0	10.5
Japan	0.6	0.3	0.3	0.0	0.3	0.6	0.0
Spain	0.1	0.1	0.2	0.1	0.3	0.0	0.6
Thailand	0.0	0.1	0.1	0.0	0.0	4.7	0.3
Turkey	0.0	0.1	0.7	0.4	1.0	0.1	3.7
United Kingdom	2.0	2.2	1.3	0.4	1.0	0.4	0.8
USA	1.9	2.5	0.6	0.8	1.4	2.9	0.1
Vietnam	1.4	0.0	0.2	0.0	0.0	0.1	0.0
Total	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Difference between Revealed Export Competitiveness and Revealed Import Competitiveness							
	843311	843319	843320	843330	843340	843351	843352
Australia	-3.5	-4.1	-3.1	-2.2	-4.1	-3.8	-0.1
Brazil	-0.2	-0.1	-0.2	-0.3	-0.4	2.1	9.2
China	1.6	3.5	0.4	0.0	-0.3	0.3	0.2
France	-1.2	-1.7	1.1	1.8	1.5	-1.5	-0.6
Germany	-2.0	-0.4	2.0	1.4	1.3	2.5	0.1
India	0.0	0.0	0.0	0.0	-0.1	-0.2	1.1
Italy	0.9	1.2	2.2	1.8	0.9	0.5	10.4
Japan	0.4	-0.4	-0.4	-0.4	-0.1	0.5	0.0
Spain	-0.4	-1.0	-0.7	-0.6	-0.7	-0.4	0.4
Thailand	-0.1	-2.2	0.0	-0.1	-0.8	4.4	-0.3
Turkey	-0.1	-0.1	0.3	0.3	0.2	-1.0	3.5
United Kingdom	0.6	-2.4	0.0	-1.4	-0.7	-0.5	0.7
USA	1.0	1.7	-0.6	-0.2	0.9	2.7	-0.3
Vietnam	1.3	-0.9	-0.6	0.0	-0.2	-1.0	-0.1
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Authors' computations from United Nations Comtrade.

Export Competitiveness Index			
	843353	843359	843390
Australia	0.03	0.32	0.12
Brazil	0.07	6.36	1.67
China	0.02	0.45	0.67
France	0.90	2.05	1.46
Germany	7.15	4.44	1.71
India	0.01	0.45	0.20
Italy	0.78	1.78	1.73
Japan	0.05	0.12	0.30
Spain	0.59	0.62	0.39
Thailand	0.07	0.20	0.10
Turkey	0.45	0.52	0.47
United Kingdom	0.52	0.51	0.70
USA	0.47	1.18	1.52
Vietnam	0.00	0.02	0.05
Total	1.0	1.0	1.0

Difference between Revealed Export Competitiveness and Revealed Import Competitiveness			
	843353	843359	843390
Australia	-0.9	-2.5	-1.7
Brazil	-0.1	0.8	-0.9
China	-0.2	-0.4	0.5
France	-3.5	0.4	-0.9
Germany	6.6	4.0	0.2
India	0.0	0.3	0.0
Italy	0.6	0.9	0.6
Japan	-0.3	-0.2	0.0
Spain	0.2	0.0	-0.3
Thailand	0.1	-1.4	-0.1
Turkey	-1.0	-0.8	0.1
United Kingdom	-2.6	-0.3	-0.5
USA	0.3	0.1	0.2
Vietnam	-0.1	-0.1	-0.02
Total	0.0	0.0	0.0

Source: Authors' computations from United Nations Comtrade.

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