SYNTHESIS REPORT

Promoting Electric Tractor for Developing a Sustainable Agriculture Ecosystem

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#2501

Synthesis Report

Promoting Electric Tractor for Developing a Sustainable Agriculture Ecosystem

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Authors:
Sanobar Imam; Research Associate, and
Akash Sharma; Associate Fellow, CUTS International
Priyadarshini Alok; Programme Manager, Shakti Sustainable Energy Foundation

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Table of contents

Overview **4**
Introduction **4**
Emission Standards for Tractors in India 5
Emission Levels Norms in India, the U.S., and the EU 6
Policy Gap *7*
About the study **8**
Study Area and Survey Details 8
Objectives 8
Schemes Promoting the Adoption of Tractors **9**
Agricultural Tractor Subsidies **11**
Key Findings from the Farm Survey **12**
Impact of Fuel Cost on Overall Operational Costs 13
Impact of Cost of Tractor on Buying Decision 14
Impact of Resale Value of Tractor on Buying Decision 14
Key Findings from the Non-Farm Survey **15**
Impact of Fuel Cost on Overall Operational Costs 16
Impact of Cost of Tractor on Buying Decision 16
Impact of Resale Value on Tractor Buying Decisions 17
Findings from the Perception Survey **18**
Other Relevant Aspects **19**
Cost Benefit Analysis **20**
Recommendations for the Central Government **22**
Conclusion **25**
References **26**

Overview

Addressing the environmental concerns linked to conventional tractors is vital for reducing emissions in the agriculture sector. Electric tractors (e-tractors) present a sustainable alternative, enhancing energy security and advancing India's net-zero aspirations. By integrating renewable energy into rural and agricultural communities, e-tractors can help build a sustainable agricultural ecosystem and drive economic growth in rural areas.

However, the adoption of e-tractors faces several challenges, including high upfront costs, limited awareness, insufficient policy support, inadequate charging infrastructure, and a lack of EV-supporting facilities, among others.

Building on the aforementioned background and context, this initiative seeks to address these challenges through research-driven advocacy and strategic collaboration with stakeholders. The goal is to facilitate necessary reforms that will promote the adoption and growth of e-tractors in the Indian market, a critical step toward establishing a sustainable agricultural ecosystem. These efforts are intended to ensure an effective and timely transition from diesel-powered tractors to e-tractors.

Introduction

India is the world's largest manufacturer of tractors, producing over one million units in 2021 and exporting 125,000 units in the same year. Tractor exports contribute significantly to the industry's revenue, accounting for 10 percent and valued at over USD 1 billion. However, the environmental impact of diesel-powered tractors remains a critical concern, particularly emissions of particulate matter (PM) and nitrogen oxides (NOx). Notably, approximately 78 percent of tractors sold in India are powered by engines in the 19 kW to 37 kW range, which are exempt from BS-IV emission standards regulations (Bhatt & Shao, 2022).

Table 1: Compiled Data for Tractor Production, Sale and Exports

Tractor Compiled Data			
Month	**Total Production**	**Total Sales (Including Exports)**	**Exports**
Jan-24	74,895	62,774	7,185
Feb-24	71,607	51,764	8,487
Mar-24	72,128	74,549	10,794
Apr-24	77,464	84,404	7,459
May-24	89,154	91,757	8,809
June-24	95,010	110,348	8,367
July-24	96,380	67,952	8,423
Aug-24	93,176	58,733	8,599
Sep-24	93,121	108,030	7,488
Oct-24	94,771	151,772	7,097
Nov-24	74,854	78,263	6,963
Dec-24	49,586	59,067	8,074
Total	982,146	999,403	97,745

Source: Tractor and Mechanization Association

Emission Standards for Tractors in India

India has implemented several measures to reduce pollutant emissions from tractors. The evolution of emission standards in the country is summarised in Table 2.

Table 2: History of the Evolution of Emissions Standards in India

Year	Emission Norms	Key Features
1999	Bharat (Trem) Stage I	Introduced emission norms for agricultural tractors aimed at reducing carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx).
2003	Bharat (Trem) Stage II	Further reduced permissible levels of CO, HC, and NOx emissions.
2005	Bharat (Trem) Stage III	Set limits on CO, HC+NOx, and particulate matter (PM).
2010–2011	Bharat (Trem) Stage III A	Established emission limits based on tractor power output, further refining standards for tractors with different operational capacities.
2020	Separation of CEV and Trem Norms	Emission norms for construction equipment vehicles (CEV) and agricultural machinery (Trem) were differentiated.
2023	Trem Stage IV	Aligned agricultural tractor emission standards with Bharat Stage IV (BS IV) norms, emphasising significant reductions in all key pollutants.

Source: Lubrizol360, and Tractor Karvan

Table 2 illustrates the evolution of emission standards for tractors and on-road vehicles. Significant progress has been made in reducing emissions of CO, HC, and NOx. However, when compared to other modes of transport, such as buses—whose emissions are comparable to those of tractors—buses have transitioned to BS VI standards and comply with stricter emission regulations than tractors.

Emission Levels Norms in India, the U.S. and the EU

India's agriculture sector consumes approximately 13 percent of the country's diesel, with tractors responsible for 7.4 percent of that consumption, making a significant contribution to air pollution. In 2020, Indian tractors were estimated to emit around 25 kilotonnes of particulate matter (PM) and nearly 300 kilotonnes of nitrogen oxides (NOx). While the implementation of BS-IV standards for agricultural machinery in October 2022 marked a step forward, these standards exclude many tractors powered by lower-kW engines (Shao, 2022).

European Union: In the EU, the exemption for engines below 37 kW is not a major concern, as most tractors have engines exceeding 37 kW and are therefore subject to BS-IV regulations. However, in India, many tractors fall within the 19–37 kW range and are excluded from these standards, posing a significant challenge (Dallmann, 2017).

United States: The US Tier 4 emission standards, phased in between 2008 and 2015, introduced significant reductions in NOx (for capacities above 56 kW) and PM (for capacities above 19 kW), along with more stringent limits on HC emissions. CO emission limits remained unchanged from the Tier 2-3 stage.

In the EU, around 90 percent of tractors sold have capacities exceeding 37 kW, and the US has enforced stricter Tier 4 standards for agricultural machinery. However, in India, most tractors fall within the 19–37 kW range, which is not covered by Trem Stage IV emission norms. This gap creates a major challenge, as Indian tractors do not meet the stricter emission standards applied to other vehicles, such as buses. As a result, these gaps hinder the effectiveness of emission control measures in India's agricultural sector, contributing to air pollution.

Policy Gap

Tractors in India consume 7.4 percent of the country's diesel, similar to buses (9.6 percent), but unlike buses, which have adopted BS VI emission norms and electrification, tractors lack fuel efficiency standards and face no incentives for electrification. E-tractors are excluded from subsidy schemes like the Sub-Mission on Agricultural Mechanisation, which supports diesel tractors.

Additionally, BS-IV standards, based on EU Stage IV regulations, do not cover tractors with engines between 19 and 37 kW, leaving most Indian tractors outside emission control measures. To address these issues, policy reforms are needed to incentivise e-tractor adoption, enhance infrastructure, and raise awareness among farmers.

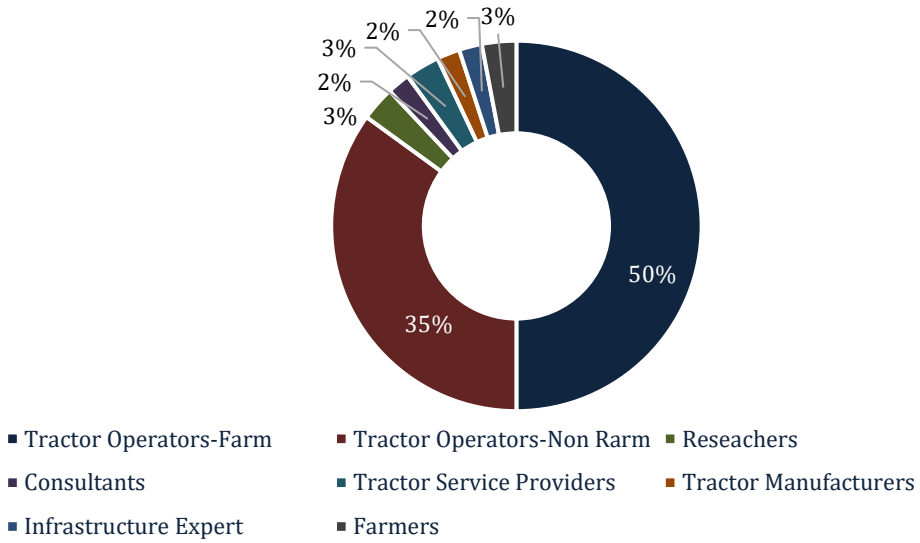
This synthesis report will outline the key interventions needed by central agencies to establish a market for e-tractors through targeted policy and regulatory reforms in the agricultural sector.

About the Study

Study Area and Survey Details

A total of 200 surveys were conducted in Rajasthan, with 100 focusing on tractor operators in the agricultural sector and 70 targeting those in the non-agricultural sector. The distribution of these surveys was based on data from the Ministry of Road Transport and Highways' Vahan dashboard, covering multiple districts. Additionally, perception surveys were conducted with 30 stakeholders, including researchers, consultants, tractor service providers, manufacturers, infrastructure experts, and farmers, to assess various aspects of e-tractors.

Figure 1: Survey Distribution



Objectives

The initiative aimed to define the key interventions needed by central agencies to develop a market for e-tractors through the introduction of policy and regulatory reforms in the agriculture sector. It also seeks to create an enabling environment for e-tractor adoption by addressing barriers and promoting the technology's benefits among farmers. The specific goals included:

- Engaging with farmers to document the costs associated with diesel tractors and conduct a cost-benefit analysis comparing e-tractors to diesel tractors.
- Conducting a value chain analysis of the tractor market to identify opportunities for e-tractors in the non-farm sector.

- Organising an exhibition of e-tractors and electric farm machinery to address consumer barriers and raise awareness among farmers about the socio-economic benefits of e-tractors.
- Advocating for policy measures to central policymakers aimed at developing the market for e-tractors in India.

Schemes Promoting the Adoption of Tractors

As shown below in Table 3, several countries have introduced various schemes and reforms to encourage the purchase of conventional tractors, aiming to strengthen their agricultural sectors. A summary of these reforms is presented in the table.

Table 3: Schemes/Reforms to Promote the Purchase of Diesel Tractors in Different Countries

Country	Policies/Reforms	Subsidy	Eligibility
India	**Sub-Mission on Agriculture Mechanisation (SMAM)**[1]	• This scheme comprises both centrally sponsored and central sector components. • For centrally sponsored components, the Government of India covers 60 percent of the costs, while states contribute the remaining 40 percent. In northeastern and Himalayan states, however, the funding ratio is 90:10, with the Government of India providing 90 percent. • In Union Territories, the central government funds 100 percent of the costs.	• The scheme is open to all landholding farmers' families, Self-Help Groups (SHGs), User Groups, Cooperative Societies, Farmer Producer Organisations (FPOs), and Entrepreneurs, provided the farmer is a native of India.
India	**NABARD Agricultural Equipment Subsidy**[2]	• This scheme offers a 30 percent subsidy on tractor purchases and a 100 percent subsidy for other transportation machinery.	Eligible for all
Pakistan	**Chief Minister Green Tractor**	• The scheme provides a subsidy of 1 million Pakistani Rupees (PKR) per tractor.	The scheme is applicable to landowners with holdings of up to 50

1 https://www.myscheme.gov.in/schemes/smam

2 https://tractornews.in/articles/exploring-india-s-latest-tractor-subsidy-schemes-2023/#:~:text=National%20Bank%20for%20Agriculture%20and%20Rural%20Development%20%28NABARD%29,invest%20in%20equipment%20that%20advances%20their%20crop%20cultivation

Country	Policies/Reforms	Subsidy	Eligibility
	Scheme 2024[3]		acres.
Vietnam	**Under Agricultural Mechanisation**[4]	• Under this scheme, 30 provinces in Vietnam offer policies to support farmers in purchasing agricultural machinery, including tractors. • Farmers can avail of loans covering 70-80 percent of the cost at low-interest rates, with a repayment period of up to three years.	The scheme is open to all farmers across 30 provinces in Vietnam.
Cambodia	**Supporting Policies on Agricultural Mechanisation**[5]	• This scheme offers low-interest loans to farmers. • Loan amounts range from 40 to 80 percent of the cost, with interest rates between 0 and 2 percent per month. The repayment period varies from 3 months to 5 years.	Not Defined
Nigeria	**Government Tractor Subsidy programmes**[6]	• In this subsidy programme, both federal and state governments procure and distribute tractors, offering varying subsidy rates. • For example, in Kaduna state, a 40 percent subsidy was provided in 2010, with 25 percent funded by the federal government and 15 percent by the state.	Eligibility may vary depending on the criteria established by state and federal programmes.
Kyrgyz Republic		• The Kyrgyz Republic has a lower number of tractors per hectare compared to other similar countries, with a projected deficit of 40 percent.[7] • To address this issue, the Kyrgyz Republic reduced the cost of tractor registration.[8]	

3 https://agripunjab.pk/chief-minister-green-tractor-scheme-2024/
4 https://un-csam.org/sites/default/files/2021-01/vn_0.pdf
5 https://un-csam.org/sites/default/files/2020-12/KH-2_0.pdf
6 https://www.researchgate.net/publication/276279409_Characteristics_of_Private-Sector_Tractor_Service_Provisions_Insights_from_Nigeria
7 https://openknowledge.worldbank.org/entities/publication/b5cb5044-1b49-5c47-adf0-7be2b82af317
8 https://www.worldbank.org/en/news/press-release/2019/10/21/47-countries-make-67-reforms-to-help-farmers-grow-their-business

Agricultural Tractor Subsidies

Subsidies, along with commodity prices, profitability, and other factors, are key drivers of agricultural machinery and technology sales. Based on AGCUMEN data from January 2022 to September 2024, the table below highlights the countries most active in offering subsidies, including tax incentives, subsidised loans, guarantees, and grants. While the total subsidy amounts are not specified, this overview provides a clear picture of where subsidies play a significant role.

Table 4: Provision of Agricultural Machinery/Technology-related Subsidies (Including e.g. Grants, Subsidised Loans, and Tax Incentives) January 01, 2022-September 06, 2024

Country	Subsidy (in %)
Russia	13.29
Germany	8.58
United States	8.50
United Kingdom	6.41
Italy	4.40
Ukraine	3.94
France	3.71
Netherlands	3.55
Spain	3.55
Australia	3.01
Canada	3.01
Belarus	2.70
Brazil	2.40
China	2.24
India	2.09
Poland	1.93
Denmark	1.47
Kazakhstan	1.39

Country	Subsidy (in %)
Sweden	1.24
Czech Republic	1.08

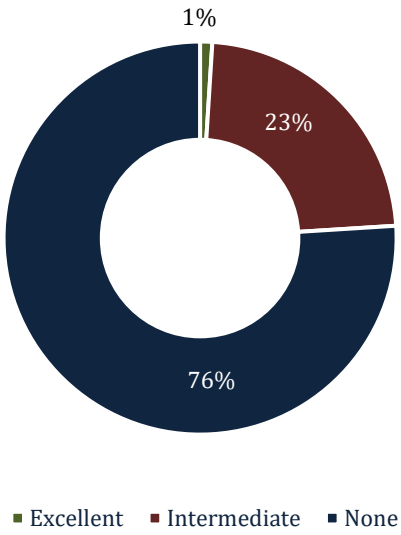
Source: Farm Table (2024)

Table 4 highlights that, compared to countries like Russia and Germany, India offers significantly lower subsidies for agricultural machinery. However, e-tractors, which currently have a high upfront cost, require targeted incentives and subsidies to enhance their accessibility for farmers and tractor owners.

Key Findings from the Farm Survey

In Rajasthan, 100 surveys were conducted among small, large, and marginal farmers who own tractors in the agricultural sector to assess the impact of fuel costs on overall operational expenses. The findings revealed that 76 percent of respondents were unaware of e-tractors.

Figure 2: Awareness of E-tractors in the Farm Sector

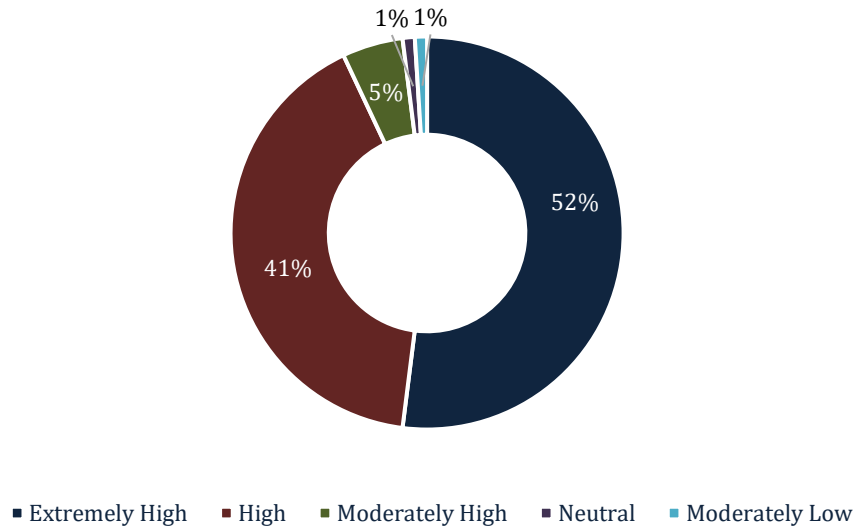


Source: Farm Survey

Impact of Fuel Cost on Overall Operational Costs

The farm survey across Rajasthan found that 52 percent of the surveyed farmers rated the contribution of fuel costs to their overall agricultural expenses as "extremely high" on a Likert scale.

Figure 3: Contribution of Fuel Costs to The Overall Operational Costs



Source: Farm Survey

In addition to fuel expenses, overall operational costs also encompass servicing, maintenance, and repair costs. A study titled "Repair and Maintenance Costs Estimation as Affected by Hours of Use and Age of Agricultural Tractor in New Halfa Area — Sudan" highlights that repair and maintenance (R&M) costs are key components of machine operating expenses, influenced by the tractor's usage and age. These costs are typically estimated to account for 10–20 percent of the total operating costs.

Table 5: The Scale Used to Assess the Impact of Fuel Costs on Overall Agricultural and Operational Expenses

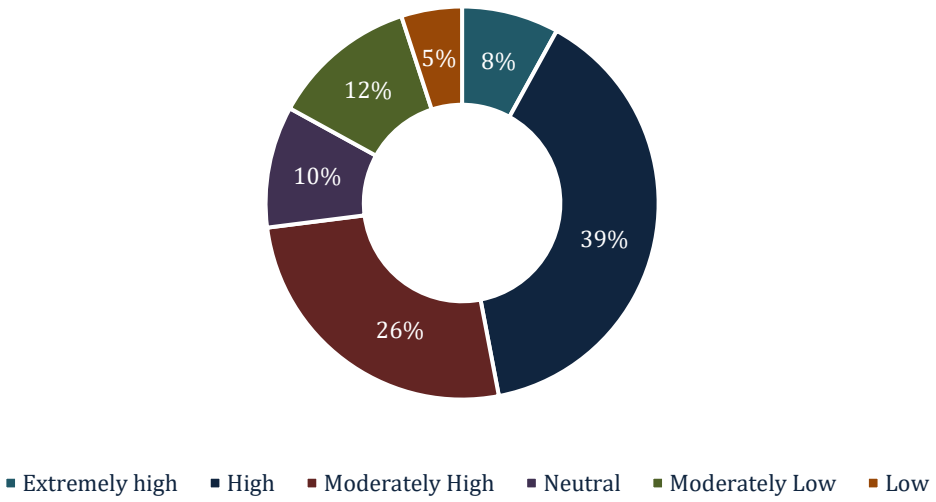
Annual Expenditure on Fuel (INR)	Scale
3 lakhs and more	Extremely High
2 lakhs - 3 lakhs	High
1 lakh - 2 lakh	Moderately High
50 thousand - 1 lakh	Neutral

Annual Expenditure on Fuel (INR)	Scale
25 thousand - 50 thousand	Moderately Low
15 thousand - 25 thousand	Low
Less than 15 thousand	Extremely Low

Impact of Cost of Tractor on Buying Decision

In the farm segment, tractor costs had a limited impact on purchasing decisions, with only 8% of farmers considering the cost as "extremely high" in their decision-making. Respondents highlighted that resale value and brand played a more significant role in their choices.

Figure 4: Impact of Cost of Tractor on Buying Decision

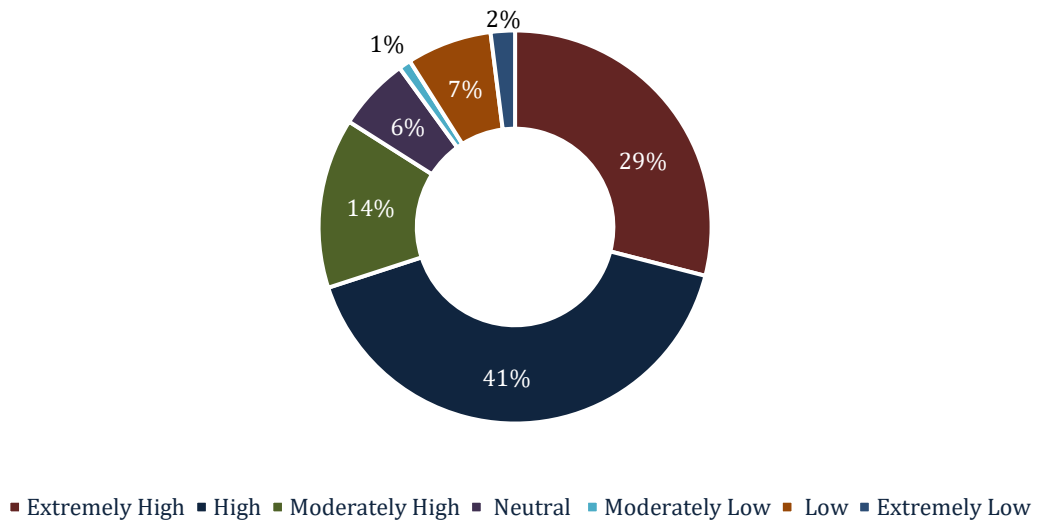


Source: Farm Survey

Impact of Resale Value of Tractor on Buying Decision in the Farm Sector

Of the surveyed tractor operators, 29 percent of respondents rated the impact of resale value as "extremely high." The study found that resale value has a particularly strong influence in the farm sector, as tractors generally have a long lifespan of 25 to 30 years.

Figure 5: Impact of The Resale Value of Tractor on Buying Decision

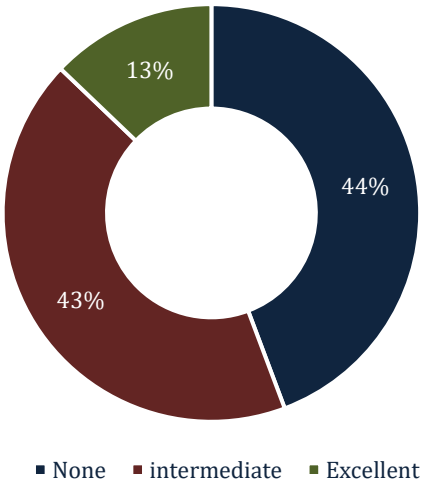


Source: Farm Survey

Key Findings from the Non-Farm Survey

Seventy surveys were conducted across Rajasthan targeting tractors used in the non-farm sector, which includes construction, loading, and water supply. In contrast to the farm segment, where only 1 percent of respondents demonstrated an excellent awareness of e-tractors, the non-farm segment showed a significantly higher level of awareness, with 13 percent indicating excellent knowledge of e-tractors.

Figure 6: Awareness of E Tractor

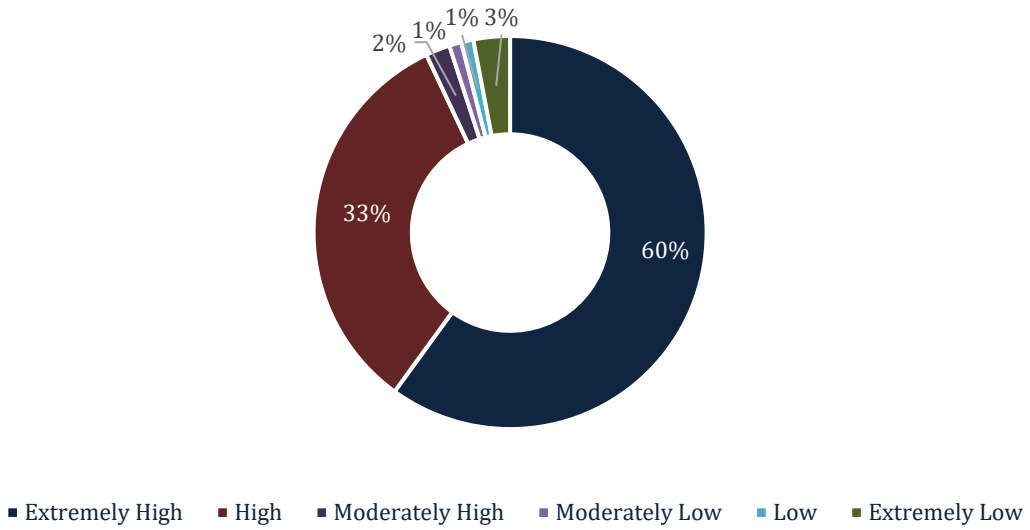


Source: Non-farm Survey

Impact of Fuel Cost on Overall Operational Costs

60 percent of respondents in the non-farm segment rated fuel costs as "extremely high" on the Likert scale in relation to their overall operational expenses.

Figure 7: Contribution of Fuel Cost to The Overall Operational Costs

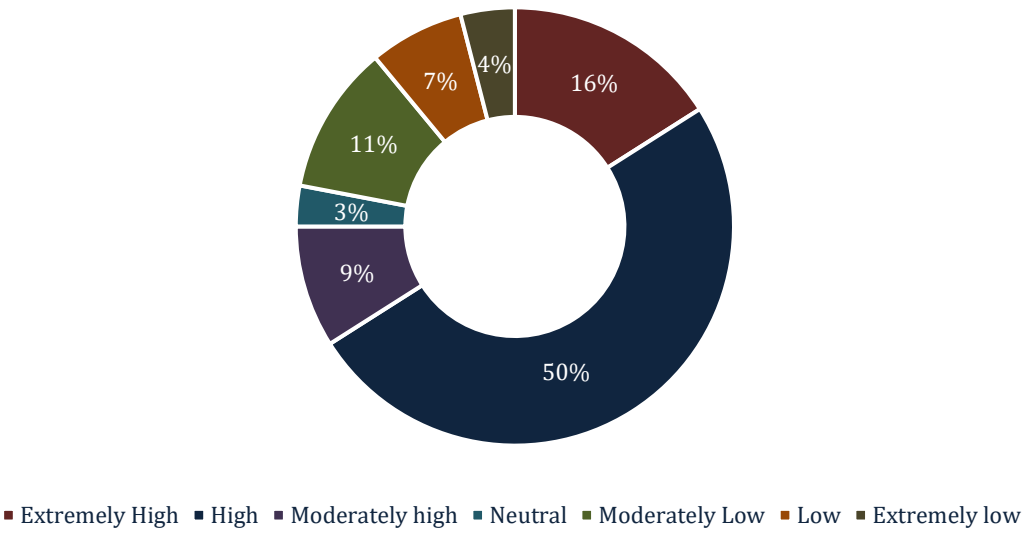


Source: Non-farm Survey

Impact of Cost of Tractor on Buying Decision

In the non-farm segment, only 16% of tractor owners indicated that the cost of the tractor had an "extremely high" impact on their purchasing decision. This suggests that, for non-farm users, factors such as functionality, brand reputation, and resale value may play a more significant role in influencing their choice of tractor, rather than the initial cost alone.

Figure 8: Impact of Cost of tractor on buying decision

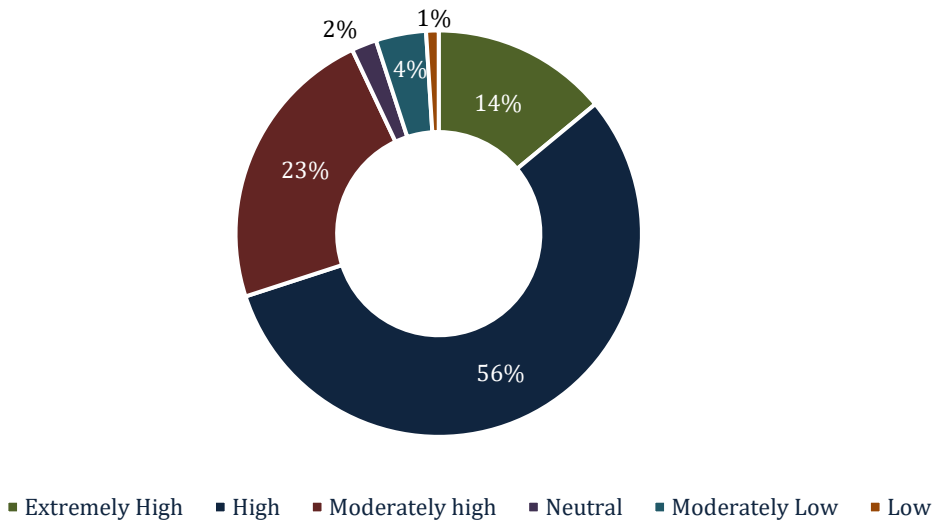


Source: Non-farm Survey

Impact of Resale Value on Tractor Buying Decisions

In the non-farm sector, 14% of tractor users rated the impact of resale value as "extremely high." The study found that resale value holds more significance in the farm sector, where tractors generally have a lifespan of 25 to 30 years, compared to the non-farm sector, where tractors typically last around 5 to 6 years.

Figure 9: Impact of Resale Value of Tractor on Buying Decision



Source: Non-farm Survey

Findings from the Perception Survey

Perception surveys were conducted with 30 stakeholders, including tractor service providers, manufacturers, researchers, consultants, infrastructure experts, and agriculture universities. The aim was to evaluate various aspects of e-tractors, focusing on their cost, durability, and operational efficiency, while also identifying key areas for improvement.

Load Carrying Capacity

A notable 43% of respondents rated the impact of load-carrying capacity on tractor operational efficiency as "high" on the Likert scale. This highlights the critical role of robust performance, especially in heavy-duty applications, where reliability is paramount.

Charging Infrastructure

Similarly, 43% of respondents rated inadequate charging infrastructure as having a "high" impact on shaping a positive perception of e-tractors. This emphasises the crucial need for sufficient infrastructure to support the widespread adoption of e-tractors.

Future Fuel Cost Trends

Notably, 47 percent of respondents rated “high” about the potential disruptions in future fuel cost trends due to innovative and alternative fuel technologies. This reflected a growing awareness among respondents about how technological advancements could reshape the agricultural landscape.

Resale Value

Regarding resale value's influence on purchasing decisions, 30 percent of respondents rated it as "high," while 37 percent rated it as "extremely high." This indicates that resale value plays a crucial role for farmers in evaluating their tractor investment, as they aim to maximise their return.

OEM Preference

Brand value also had a significant influence on buyers' decisions, with 50 percent rating it as "high" and an additional 30 percent rating it as "extremely high." This suggests that established OEMs enjoy a considerable advantage in shaping consumer choices, likely driven by trust and reputation.

Potential of Growth of the E-Tractor Market in Low-Emission Zones

40 percent of respondents rated the potential for growth in the electric tractor market—driven by the establishment of low-emission zones in certain areas—as "high." This indicates that environmental regulations could play a pivotal role in driving future demand for e-tractors.

Other Relevant Aspects

- The Goods and Services Tax (GST) on e-tractors is set at 12 percent, whereas other electric vehicles (EVs) are taxed at a lower rate of 5 percent.
- E-tractors are excluded from central and state subsidy schemes, such as the Sub-Mission on Agricultural Mechanisation, which provides financial support for diesel tractors.
- In the farm sector, tractors are often used for extended periods, with some remaining operational for over 40 years. In contrast, tractors in the non-farm sector are typically

resold after 5 to 6 years, primarily due to their higher load capacities (7-12 tonnes), which lead to faster wear and tear.

Cost Benefit Analysis

The cost-benefit analysis compared 40HP diesel tractors used in both farm and non-farm operations with electric tractors. The total cost of ownership (TCO) for diesel tractors in the farm and non-farm segments was calculated using survey data, while the TCO for electric tractors was derived from an EVReporter study[9]. This analysis spans a 10-year period, providing a comprehensive comparison of the two technologies.

The analysis took into account several parameters for both diesel and electric tractors. For diesel tractors, factors such as loan repayment instalments, diesel consumption (6 litres per hour for 15 days per month), monthly maintenance and repair costs, and miscellaneous expenses were considered. For electric tractors (30 kW), the parameters included loan repayment instalments, battery charging costs (25 units per day for 15 days per month), monthly maintenance and repair costs, battery replacement cost (estimated at ₹4.2 lakhs), and other miscellaneous expenses.

Table 6 presents a comparison of the Total Cost of Ownership (TCO) over 10 years for a 40HP diesel tractor used in both farm and non-farm segments, alongside a 30kW electric tractor.

Table 6: TCO calculation for Electric and Diesel Tractors (Farm and Non-Farm Segment)

Parameters	Cost (INR) for a 40 HP Diesel Tractor in the Farm segment	Cost (INR) for a 40 HP Diesel Tractor in the Non-Farm sector	Cost (INR) for a 30 kW Electric Tractor
Cost for Tractor	700,000	700,000	15,00,000
Down Payment	150,000	150,000	300,000
EMI	7,250	7,250	15,820
Diesel @ 6 litre /hour/15 days/month	20,000	25,000	-

[9] https://evreporter.com/tractor-industry-in-india-ripe-for-electrification/

Parameters	Cost (INR) for a 40 HP Diesel Tractor in the Farm segment	Cost (INR) for a 40 HP Diesel Tractor in the Non-Farm sector	Cost (INR) for a 30 kW Electric Tractor
Battery charging @ 25 units/day/15 days/month	-	-	2,625
Maintenance and Repair/month	4,000	5,000	1,500
Battery Replacement cost/month (cost of the battery is 4.2 lakhs)	-		4,166
Miscellaneous costs	1,000	1,000	1,000
Total Cost Per Month (EMI+Diesel/ Battery Charging+ Maintenance+Battery replacement+ Misc Costs)	32,250	38,250	25,111
Cost Per Year	387,000	459,000	301,332
TCO over 10 years	**38,70,000**	**45,90,000**	**30,13,320**

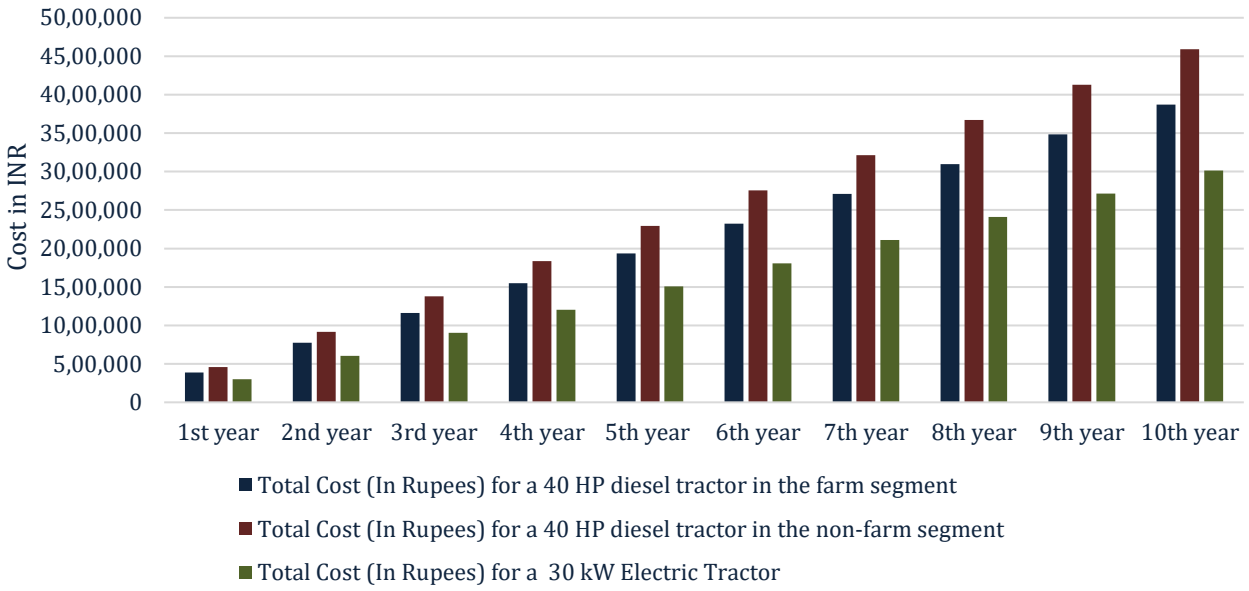
Source: EVReporter for Electric Tractor Calculations/ Survey

Table 7: TCO Comparison Over Individual Years For 10 Years for Diesel Tractors in Farm and Non-Farm Segment & E-Tractor

Year	Total Cost in a year (In Rupees) for a 40 HP diesel tractor in the farm segment	Total Cost (In Rupees) for a 40 HP diesel tractor in the non-farm segment	Total Cost (In Rupees) for 30 kW Electric Tractor
1st year	387,000	459,000	301,332
2nd year	774,000	918,000	602,664
3rd year	11,61,000	13,77,000	903,996
4th year	15,48,000	18,36,000	12,05,328
5th year	19,35,000	22,95,000	15,06,660
6th year	23,22,000	27,54,000	18,07,992
7th year	27,09,000	32,13,000	21,09,324

8th year	30,96,000	36,72,000	24,10,656
9th year	34,83,000	41,31,000	27,11,988
10th year	38,70,000	45,90,000	30,13,320

Figure 10: Total Cost of Ownership Over 10 Years for A Diesel Tractor (Farm and Non-Farm Segment) and E-Tractor



Recommendations for the Central Government

- **Lowering upfront Cost of electric tractors**

One of the primary barriers to the adoption of electric tractors is their high upfront cost. To encourage widespread adoption, a targeted subsidy scheme offering at least 50 percent off the purchase price of electric tractors is essential. Additionally, promoting an in-house supply chain for electric tractors could help balance out the costs of subsidies and contribute positively to national revenues.

Haryana's Electric vehicle Policy offers a purchase incentive of 50 percent or up to ₹5 lakh for first 1,000 e-tractors. Other states like Karnataka and Uttar Pradesh are in the process of preparing subsidy schemes and tax waivers for electric tractors, while the Yantra Lakshmi Scheme in Telangana provides similar financial support for diesel tractors. A nation-wide incentive scheme can be introduced to ensure uniform access to subsidised e-tractors.

- **Adopting battery as a service model for electric tractor**

Although an industry-driven initiative, central policymakers can develop a regulatory framework to promote the Battery-as-a-Service (BaaS) model in the e-tractor market. This approach will significantly alleviate the upfront cost burden for both the farm and non-farm sectors, making electric tractors more accessible and financially viable for farmers and operators. By encouraging the adoption of BaaS, a seamless transition to electric tractors can be facilitated.

- **Inclusion of electric tractors in custom hiring centres for agriculture machinery**

Under the Sub-Mission on Agricultural Mechanisation, the Department of Agriculture supports the establishment of Custom Hiring Centres (CHCs) to provide farmers access to various types of farm machinery, including conventional tractors. Integrating electric tractors into these CHCs can serve as pilot projects to evaluate their operational feasibility and address consumer concerns regarding performance.

Additionally, CHCs can play a crucial role in managing and disseminating technical know-how related to electric tractors, such as charging and servicing procedures, thereby enhancing farmers' awareness and confidence in adopting this emerging technology.

- **Integration of renewable energy into the charging infrastructure for e-tractors**

The current power supply scenario in rural areas is insufficient to support the widespread adoption of electric tractors. Integrating renewable energy systems into rural power supply networks can help address concerns about inadequate charging infrastructure. This renewable energy push can be facilitated through central schemes like PM-KUSUM or state-specific initiatives. Additionally, electric tractors have the potential to contribute to rural energy resilience by acting as mobile power banks, providing backup power during extreme events that damage transmission infrastructure, thereby offering a dual benefit of advancing agricultural mechanisation and enhancing energy security.

- **Awareness campaigns**

The numerous advantages of electric tractors, such as lower operational and maintenance costs, often go unnoticed due to limited awareness among farmers. Targeted awareness campaigns highlighting the long-term savings from reduced fuel and maintenance expenses can play a crucial role in educating farmers about the benefits of transitioning to electric

tractors. Allocating funds for a comprehensive multimedia campaign—including radio, television, and social media—can ensure that these benefits reach a broader audience, thereby fostering greater adoption of electric tractors across farm and non-farm segments.

- **Financial incentives for OEMs to strengthen supply side ecosystem**

Ther farmers' survey revealed that tractor operators tend to prefer well-established OEMs when making purchase decisions. However, the current e-tractor market is primarily dominated by emerging start-ups offering customised agricultural solutions. To address this challenge and build confidence in the e-tractor ecosystem, incentive-driven schemes such as the Production Linked Incentive (PLI) Scheme and Scheme for Investment Promotion (SIP) can be leveraged. Additionally, tax rebates and other fiscal incentives can be introduced to attract investments, advancing the development of a robust supply-side ecosystem for e-tractors. These measures will help bridge the gap between market expectations and the evolving e-tractor industry.

- **Reform in Emission Norms**

Expand TREM IV emission regulations to encompass more stringent standards across all categories of tractors, with the aim of accelerating the transition to cleaner technologies. By implementing regulations that mandate all newly sold tractors to meet specific emissions standards after a designated date, the government can create a powerful incentive for manufacturers to shift toward producing more electric tractors. These regulations would not only reduce the environmental footprint of agricultural operations but also drive innovation within the industry. Manufacturers would be compelled to invest in and develop cleaner technologies, including electric tractors, to comply with the evolving standards. Additionally, this move could help create a market-driven push for e-tractors, as farmers and agricultural businesses seek to align with the regulatory requirements, making sustainability a central focus of the agricultural machinery sector.

- **Research and Development Support**

Allocate substantial funding for research and development (R&D) initiatives aimed at advancing electric tractor technology and enhancing battery efficiency. Establishing strategic partnerships with agricultural universities, research institutions, and technology companies can serve as a catalyst for innovation. These collaborations should focus on

developing cutting-edge battery technologies that not only extend the operational range of e-tractors but also reduce production and operational costs. Such advancements will play a pivotal role in making electric tractors more accessible and efficient, ultimately contributing to the widespread adoption of sustainable agricultural practices.

Conclusion

In conclusion, advancing the adoption of electric tractors in India requires a multifaceted approach that addresses both the demand and supply-side challenges. Key initiatives, such as reducing the upfront cost through targeted subsidies and incentivising the development of local supply chains, are crucial to making electric tractors more accessible. The Battery-as-a-Service model holds significant potential for easing the financial burden on farmers, while integrating electric tractors into Custom Hiring Centres will enhance their adoption and operational efficiency.

Further, the integration of renewable energy into charging infrastructure will ensure that the necessary power is available, even in rural areas. Raising awareness through comprehensive campaigns will educate farmers about the long-term savings and environmental benefits of electric tractors. Financial incentives for original equipment manufacturers (OEMs) can strengthen the supply-side ecosystem, while stricter emission norms will encourage the production of cleaner technologies.

Lastly, substantial investment in research and development will drive innovations in battery efficiency, extending the operational range and reducing costs, making electric tractors a viable alternative for a larger segment of farmers. Through these combined efforts, India can pave the way for a more sustainable and technologically advanced agricultural future.

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CUTS International

D-217, Bhaskar Marg, Bani Park, Jaipur 302 016, India
Ph: 91.141.228 2821, Fax: 91.141.228 2485
Email: cuts1@cuts.org, Website: www.cuts-international.org

Also at Delhi, Kolkata and Chittorgarh (India); Lusaka (Zambia); Nairobi (Kenya); Accra (Ghana); Hanoi (Vietnam); Geneva (Switzerland) and Washington DC (USA).