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Agricultural Mechanization Policy in Bangladesh

An Assessment of the Phase III Support Program and Recommendations for Reform

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ACRONYMS AND ABBREVIATIONS

AEZ	agroecological zone
AIT	Advance Income Tax
AT	Advance Tax
ATET	average treatment effect on the treated
ATI	agricultural training institute
BADC	Bangladesh Agricultural Development Corporation
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BDRS	Bangladesh Disaster-Related Statistics
BDT	Bangladeshi taka
BIHS	Bangladesh Integrated Household Survey
BRRI	Bangladesh Rice Research Institute
CD	Customs Duty
CH	combine harvester
CI	confidence interval
CIMMYT	International Wheat and Maize Improvement Center
CSISA-MEA	Cereal Systems Initiative for South Asia – Mechanization Extension Activity
DAE	Department of Agricultural Extension
DTW	deep tubewell
FGD	focus group discussion
GoB	Government of Bangladesh
HH	household
HP	horsepower
HYV	high-yielding variety
IDI	in-depth interview
IFPRI	International Food Policy Research Institute
Kg	kilogram
KII	key informant interview
LGED	Local Government Engineering Department
LLP	low-lift pump

MFI	microfinance institution
MICS	Multiple Indicator Cluster Survey
MSP	Machinery Service Provider
MT	metric ton
NAMP	National Agricultural Mechanization Policy
NBR	National Board of Revenue
NGO	non-governmental organization
DiD	difference-in-differences
LASSO	least absolute shrinkage and selection operator
PCA	principal component analysis
PSU	primary sampling unit
PT	power tiller
PTOS	power tiller-operated seeder
RD	Regulatory Duty
RT	rice transplanter
SPIA	CGIAR Standing Panel on Impact Assessment
TTI	total tax incidence
USD	United States dollar
VAT	Value Added Tax

EXECUTIVE SUMMARY

This report assesses Bangladesh's Phase III agricultural mechanization support program (2020–2024), examining the distribution, impacts, and governance of subsidies for agricultural machines—particularly combine harvesters (CHs). We analyze program effectiveness and identify critical implementation gaps using mixed-methods research combining administrative data analysis; a representative survey of 979 Machinery Service Providers (MSPs), including 400 CH MSPs sampled across 10 districts representing Bangladesh's major agroecological zones and mechanization intensity; panel data from over 2,000 nationally representative Boro rice–producing households; and 128 qualitative interviews to analyze program effectiveness and pinpoint critical implementation gaps.

Key findings

Substantial program reach: The government of Bangladesh distributed 35,347 subsidized machines between 2020 and the second quarter of 2023, including 8,912 CHs, representing BDT 1,595 crore (USD 163 million) in subsidies. This is nearly half of the total budget of the Phase III agricultural mechanization support program. CHs accounted for 84% of the value of subsidized machines distributed.

Strong productivity impacts: Causal statistical analysis using a difference-in-differences approach shows that areas with high levels of CH allocation experienced a 17-percentage point increase in mechanized harvesting adoption, 12.2% yield gains (703 kg/hectare), a 38% reduction in labor costs (BDT 10,357/hectare), and 16.6% increase in farm revenue (BDT 17,560/hectare), relative to areas with fewer CHs.

Profitable combine harvester service provision businesses: Each MSP serves an average of 216 farmers and covers 84 hectares per year, mainly in the winter boro rice production season. MSP enterprises are generally profitable, earning an average annual operating profit of BDT 489,530 (equivalent to a 48% margin). Based on observed financials, CHs purchased with a 70% subsidy can be paid off in full within an average of 31 months, while those purchased with a 50% subsidy would require 42 months to pay off in full.

Issues with geographic targeting of the subsidy program: Our statistical analysis of the geographic distribution of subsidized CHs reveals that districts in the Northwest and Center of the country with high potential demand for CHs remain underserved, while many areas with characteristics indicative of low demand received disproportionately high levels of support.

Excessive pricing and capture of subsidies: Analysis of import versus retail prices reveals wide variation in markups among CH brands, ranging from 27% for Kubota to 113% for Marksan. This spread suggests that some importers may have engaged in opportunistic pricing practices by inflating retail prices in anticipation of government subsidies, effectively capturing subsidy value and reducing program cost-effectiveness for end-users.

Governance challenges and implementation gaps: Field verification of the Department of Agricultural Extension (DAE)'s machinery allocation records during our survey of MSPs revealed apparent discrepancies. We attempted to trace 552 CHs recorded as distributed by DAE: 28% could not be located, and the listed recipients could not produce ownership evidence. Moreover, snowball sampling uncovered 57 additional CHs (14% of our sample) absent from DAE's official list, suggesting that their registrations were done elsewhere. A further 27% of machines were registered in the name of someone other than the owner, enabling some MSPs to obtain more than one subsidized machine. Additionally, 14% of surveyed applicants reported paying unofficial fees—averaging BDT 59,000—to local officials to secure approval or expedite allocation.

Restrictive ownership and movement rules: Ownership rules imposed by the subsidy program prevented banks from accepting CHs as collateral, effectively excluding smallholder farmers or small rural entrepreneurial businesses from ownership. Recipients of subsidized CHs are required to request permission from local DAE officers to take their machines outside of the upazila or district where they are registered. This restriction may create inefficiencies by limiting the potential land area and number of farmers that could be supported with harvesting services, both of which are associated with increased time to break even on investment in CHs.

After-sales service, training, and credit access gaps: Only 37% of MSPs received warranty documents, and 21% received training on how to operate their CH. Of the total, 97% experienced machine downtime averaging 12 days annually, equivalent to 17% of their total service days. While most CHs are used during the boro season, downtime is common across all seasons and is likely driven by service bottlenecks like lack of spare parts or mechanics. 68% of MSPs had taken at least one loan to finance a CH purchase or to pay for repair and maintenance costs. Among them, only 6% accessed bank financing, while nearly half relied on informal sources such as moneylenders or acquaintances, with an average annual interest rate of 22%, with a high variance.

Policy recommendations

Reduce import barriers and support local manufacturing: Removing current import tariffs could decrease CH prices by at least 25%, offering a cost-effective alternative to direct subsidies while eliminating the administrative burden and governance risks associated with beneficiary selection, geographic targeting, and machinery quality assessments. Similar approaches have been successfully used in the past to support the diffusion of other agricultural machines such as two-wheeled tractors. In addition, imported spare parts for CHs are typically charged full tariffs. A reduction in spare part tariff costs is a logical extension of the suggestion to consider reducing current import tariffs. Additionally, supporting the local manufacturing sector to set up assembly lines and acquiring capital machinery through low-cost financing schemes may be considered.

Reform allocation approach – evidence-based targeting versus market mechanisms: Two alternative approaches merit consideration for future machinery distribution:

- ▷ **Option 1: Market-driven allocation.** Eliminate geographic targeting entirely and allow market forces to determine machine distribution patterns. This approach could involve removing or significantly reducing both import tariffs and direct subsidies, thereby reducing administrative costs, eliminating targeting distortions, and enabling machinery suppliers and MSPs to respond directly to local market demand signals. Any geographical targeting for mechanization (e.g., in areas with climate vulnerabilities/early harvest requirements, such as haor regions) can be achieved through geographically targeted special credit rates and tailored financial products rather than direct subsidies.

- ▷ **Option 2: Evidence-based geographic targeting.** If centralized allocation continues, implement transparent, data-driven frameworks—such as combining LASSO regression to select the most predictive need indicators (e.g., climate vulnerability, labor shortages, irrigation coverage, yield gaps) with principal component analysis (PCA) to reduce dimensionality and score districts on a composite “mechanization need” index. This approach replaces ad hoc decisions with clear, repeatable rankings of priority areas. By updating the model annually with fresh data, policymakers can adjust allocations as conditions evolve, ensuring that support reaches districts where it has the greatest impact.

Standardize subsidy rates: Consider the establishment of uniform base subsidies across regions to eliminate cross-district fraud incentives created by the current 50% versus 70% differential rates (with higher rates currently applied in Haor and coastal areas versus inland regions).

Mandate comprehensive after-sales infrastructure: Importers could be required to establish district-level service centers staffed with certified mechanics, maintain 90-day inventories of ready-to-use quality spare parts, and provide warranty documentation along with Bangla-language manuals as conditions for import approval. This approach could be extended to mandating pre- and in-season machinery maintenance services to reduce the risk of breakdowns and unproductive downtime.

Develop specialized financial products: Create government-supported hire-purchase schemes bypassing ownership restrictions, seasonal credit lines aligned with harvest cycles, and MSP working capital facilities through specialized agricultural finance windows.

Strengthen governance and monitoring: Begin by digitizing the subsidy application and allocation process to replace the current paper-based system, creating a secure, verifiable database that reduces manipulation and prevents untraceable allocations. Layer in GPS-enabled registration for each machine, enabling remote asset tracking—and even conditional disabling for lenders—to support both transparency and innovative asset-based financing models (as piloted by some companies such as ACI). Finally, institute independent third-party verification of allocations and empower community-based monitoring committees with frequent reporting to ensure ongoing accountability.

CHAPTER 1. INTRODUCTION

1.1 Policy context and motivation

Bangladesh's agricultural sector faces a confluence of structural challenges that threaten its long-term sustainability and food security objectives. Wages in agriculture increased by 30% in real terms between 2011 and 2018 (Karim et al. 2024), while seasonal labor shortages during peak harvesting periods have intensified due to rural-urban migration and competing employment opportunities in the non-farm sector. Labor market dynamics, combined with the imperative to feed a growing population, have positioned agricultural mechanization as a critical policy priority for Bangladesh.

The Government of Bangladesh (GoB) launched Phase III of its mechanization support program in 2020, building on almost two decades of subsidy-driven policies to promote agricultural mechanization. This latest phase, with a budget of BDT 3,105 crore (USD 341 million), represents the country's most fiscally ambitious attempt to modernize agriculture through technology adoption. The program offered 50-70% purchase incentives for agricultural equipment ranging from small (seeders/bed-planters, threshers, diggers, and sprayers, among others) to large (combine harvesters).

In this phase, the GoB prioritized harvesting mechanization, recognizing it as the most labor-intensive agricultural operation and a critical bottleneck in the production cycle. This focus responded to acute labor shortages and high labor wages during harvest seasons, particularly in Haor and coastal regions vulnerable to flash floods and climatic extremes. According to administrative data from the Department of Agricultural Extension (DAE), the program distributed over 35,000 subsidized machines by mid-2023, including nearly 9,000 combine harvesters, representing a fiscal investment exceeding BDT 1,595 crore (approximately USD 163 million). This was 85% of the machinery purchase budget and nearly half the total project budget.

The efficacy of agricultural mechanization programs depends critically on multiple interconnected factors: geographic targeting that aligns with agroecological conditions, cropping patterns and labor market characteristics; local infrastructure quality that enables machine mobility and maintenance; market structure and competition among service providers; and institutional governance mechanisms that ensure accountability throughout the implementation process. While early studies (Biggs and Justice 2015; Mandal 2017b; Mottaleb, Krupnik, and Erenstein 2016; Rahman et al. 2021) examined various dimensions of mechanization policies in Bangladesh, a comprehensive assessment of the current program's design, implementation, and impacts remains absent from the literature.

This report addresses critical knowledge gaps through a detailed assessment of the third phase of Bangladesh’s mechanization program and policies. Given the significant government investment in combine harvesters (CHs) and and their strategic importance in addressing labor shortages in Bangladesh's agriculture, we focus most of our analysis on this technology. Our assessment examines three critical dimensions: the efficacy of geographic targeting, the market constraints that shape service delivery, and the governance challenges that affect implementation quality. To rigorously assess program effectiveness, we estimate the causal impacts of CH distribution on agricultural productivity, labor allocation, and farm profitability. Our mixed-methods approach integrates quantitative impact evaluation with qualitative insights drawn from 128 interviews spanning the entire mechanization value chain—from farmers and service providers to policymakers and market actors.

1.2 Objectives and scope of the report

This report provides evidence-based analysis to inform policy refinements for Bangladesh's mechanization subsidy program through six interconnected objectives.

We begin by providing a comprehensive overview of rice mechanization in Bangladesh, examining the evolving patterns of machine usage and ownership. This analysis also explores the policy linkages that have influenced these changes over time.

Second, we analyze optimal subsidy design through comprehensive cost-benefit simulations. Using primary data from 400 CH machinery service providers (MSPs), we model break-even periods under alternative subsidy scenarios (0%, 15%, 25%, 33%, 50%, and 70%), and examine how maintenance costs, downtime, and financing constraints affect the minimum efficient scale for sustainable service provision.

Third, we characterize the operational viability of the MSP model by examining ownership profiles, financing sources, service quality, and profitability drivers. This analysis identifies binding constraints—from spare parts availability to credit access—that determine whether subsidized machines translate to sustainable rural enterprises.

Fourth, we estimate causal program impacts using difference-in-differences methodology on data from more than 2,000 rice-farming households from a nationally representative panel of rural households. By comparing high- and low-allocation areas before and after intervention, we quantify effects of mechanized harvesting on yields, labor costs, production efficiency, and farm revenues.

Fifth, we assess geographic targeting efficiency by developing a data-driven framework using least absolute shrinkage and selection operator (LASSO) regression and principal component analysis (PCA). This approach identifies priority districts based on mechanization need indicators, including cropping intensity, labor availability, infrastructure, and climate vulnerability, and compares these rankings with actual machinery distributions to quantify misallocation.

Lastly, we diagnose institutional and governance challenges through qualitative analysis of implementation processes. Drawing on interviews with farmers, service providers, officials, and market actors, we document gaps between policy design and field reality, including informal fees, ownership manipulation, and accountability failures.

1.3 Summary of the report structure

This report is organized into nine chapters. Following this introductory chapter, Chapter 2 details our mixed-methods research design, combining administrative data analysis, household panel surveys, a survey of MSPs, and qualitative interviews. Chapter 3 traces the evolution of agricultural mechanization in Bangladesh, documenting ownership trends, rental market growth, and the design of successive government interventions.

Chapter 4 presents findings from the IFPRI Bangladesh Machinery Service Provider Survey, 2024/25, revealing critical gaps in training, warranty support, and after-sales service that undermine operational sustainability. Chapter 5 develops a financial model of MSP viability, demonstrating how subsidy levels, maintenance costs, and downtime interact to determine profitability thresholds.

Chapter 6 provides rigorous impact estimates, showing substantial productivity and income gains in treatment areas while raising questions about labor reallocation. Chapter 7 introduces our geographic targeting framework, which reveals systematic mismatches between empirical need and actual allocation patterns.

Chapter 8 examines market failures and governance challenges, from information asymmetries enabling low-quality imports to rent-seeking in machine distribution. Chapter 9 synthesizes findings into actionable policy recommendations spanning subsidy design, service delivery, financial access, and institutional reform.

CHAPTER 2. DATA

We employed a mixed-methods approach to assess Bangladesh's mechanization subsidy and support program, integrating quantitative tracking of machine allocation with qualitative insights into implementation challenges. The quantitative component involves analyzing multiple data sources to track the allocation and distribution of agricultural machinery alongside agricultural production trends. These include machinery allocation data from DAE for 2020–2023, which provides insights into geographic and demographic distribution patterns; a structured survey of MSPs; and several rounds of IFPRI's Bangladesh Integrated Household Survey (BIHS). We use the difference-in-differences (DiD) impact evaluation method to measure the causal benefits of the program in implemented areas, and statistical techniques such as LASSO and PCA for our geographical targeting analysis.[1]

Qualitative data complements the quantitative analysis by providing deeper insights into the program's contextual aspects, capturing stakeholder experiences, challenges, and perspectives that may not emerge from numerical data alone. This approach identifies factors influencing implementation and enhances understanding of program dynamics through 50 in-depth interviews (IDIs) and focus group discussions (FGDs) with beneficiaries (namely, MSPs, farmers, and farmer cooperatives), and 25 key informant interviews (KIIs) with program implementers (upazila DAE officials and project personnel), importers and local manufacturers, spare parts producers, researchers and academics, and bank and non-bank financial institutions. Stakeholder interviews are central to this process, with participants selected based on their involvement and ability to provide relevant insights. Data collection methods are tailored to each stakeholder group, ensuring a comprehensive exploration of various dimensions of the program's implementation and its operational effectiveness (see Appendix Table A1 for details of the number of stakeholders of each type interviewed).

2.1 IFPRI Bangladesh Machinery Service Provider Survey 2024/25

The research team designed and conducted the IFPRI Bangladesh Machinery Service Provider (MSP) Survey 2024/25 between December 2024 and January 2025.[2] The survey interviewed 979 MSPs across 21 upazilas within 10 purposively selected districts, employing a three-stage design to ensure representation across Bangladesh's major agroecological zones (AEZs) and mechanization contexts.

Stage 1: District selection. Ten districts were selected to represent key rice-producing AEZs, including Haor basins (Kishoreganj and Sunamganj), coastal areas (Barguna and Cox's Bazar), northern highlands (Dinajpur and Thakurgaon), and high-cropping-intensity regions (Bogura, Chuadanga, Faridpur, and Mymensingh). Districts were chosen based on rice production prominence, mechanization intensity, and the presence of government subsidy programs.[3]

Stage 2: Upazila selection. Two upazilas were selected per sampled district—the first being the "sadar" upazila (district headquarters), and the other chosen based on cropping patterns, mechanization concentration, and the availability of DAE records on subsidy beneficiaries. Phone surveys with block-level extension officers provided estimates of machine numbers and operational MSPs in each area.

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[1] We provide a detailed description of these methods in Chapters 6 and 7.

[2] Ethical approval for this survey was provided by the Institutional Review Board (IRB) at IFPRI (IRB #00007490).

[3] We used data from the Yearbook of Agricultural Statistics and Agricultural Censuses of the Bangladesh Bureau of Statistics (BBS), as well as administrative data on machinery distribution from DAE.

Stage 3: MSP selection and verification. For the target sample of 400 combine harvester MSPs, all individuals from DAE's official beneficiary lists in selected upazilas were contacted (for a total of 552 contacted MSPs). A spot verification process confirmed machine operability and active service provision. Only MSPs who had provided harvesting services in the preceding agricultural year (boro 2023 to aman 2024) were included in the final sample. For other machinery types, simple random sampling was employed to achieve the total target of approximately 1,000 MSPs.

The final sample achieved a 76% response rate, with 400 CH operators forming the core analysis sample for this report. These MSPs provided services for major crops, including aman, boro, and aus paddy, as well as wheat, maize, and potato. Figure 1 summarizes the survey methodology.

Figure 1: Overview of the IFPRI Bangladesh Machinery Service Provider (MSP) Survey, 2024/25

District selection

- 10 districts selected for the survey in total
- Combination of cropping patterns, AEZs, geographical contexts, and the crop of interest considered for district selection
- Selected districts: Barguna, Bogura, Chuadanga, Cox's Bazar, Dinajpur, Faridpur, Kishoreganj, Mymensingh, Sunamganj, and Thakurgaon

Upazila selection

- From the 10 districts, 21 upazilas selected for the survey in total
- Two upazilas selected from each district - the "sadar" upazila, and the other based on crop of interest
- One additional upazila from Bogura selected for potato

Respondent selection

- Phone survey with block level extension officers from each upazila to identify different machines available in the block and the number of MSPs in October 2024
- Used probability proportional to size (PPS) sampling to select unions based on the number of MSPs
- Listing of MSPs in selected unions and random selection for survey
- Survey conducted with a total of 979 MSPs who owned a tractor, power tiller / seeder / bed-planter, maize sheller, thresher, or harvester
- 400 CH MSPs surveyed out of 979 MSPs
- In each upazila, 20 CH MSPs surveyed from DAE's list, conditional on actively providing services and spot verification of harvesters
- Survey ran from December 2024 until January 2025

Source: Authors.

2.2 Bangladesh Integrated Household Survey (BIHS)

The Bangladesh Integrated Household Survey (BIHS), conducted by IFPRI in 2011/12, 2015, 2018/19, and 2024,[4] provides nationally representative panel data critical for causal analysis of agricultural mechanization at the farm level. Covering 6,503 households across 325 villages (which

[4] The 2024 "round" is in fact the CGIAR Standing Panel on Impact Assessment (SPIA)'s Survey, which followed BIHS households. This survey covered 275 villages across seven divisions, with adjusted sampling weights based on the 2022 Bangladesh Population and Housing Census.

were the primary sampling units, PSUs) in all 64 districts, the survey maintained less than 6.4% attrition between rounds (2018 and 2024) , with sampling weights updated using 2022 census data to ensure representativeness (Stevenson 2025). Nearly half the sample was engaged in agriculture, and over 2,000 households were boro rice producers. The agriculture module collected detailed plot-level data on household production, including input use (labor, machinery, agrochemicals, and irrigation) and associated costs. The timing of the BIHS/SPIA rounds before and after Phase III of the mechanization subsidy program enables tracking of pre/post-mechanization changes in productivity, labor costs, and profitability for boro rice cultivation—Bangladesh's most mechanized crop—allowing us to measure the impact of this phase of the subsidy program.

2.3 Other data sources

To contextualize district-level mechanization needs, we integrated multiple secondary datasets. Agricultural output and area figures including total rice production, harvested area, net cropped area, cropping intensity, share of irrigated land, and mean daily agricultural wage were extracted from the latest Yearbook of Agricultural Statistics (2023). District-level counts of farm holdings, agricultural labor households, and total machine ownership data at the district level were taken from the Agricultural Census 2019 and 2008, ensuring precise enumeration of production units and mechanization stock. Road density (kilometers of rural road per square kilometer) is obtained from the 2024 Road and Market Database maintained by the Local Government Engineering Department, using the 2019 inventory. The share of households without access to grid, generator, or solar electricity is taken from the Multiple Indicator Cluster Survey (MICS) 2019. To capture climate vulnerabilities, we used the Bangladesh Disaster-Related Statistics (BDRS 2021) with six proportional indicators of households affected by drought, floods, cyclones, storm surges, erosion, and salinity—critical for identifying high-risk districts in targeting analysis. Finally, we compute a land fragmentation index for each district using plot-level data from the IFPRI Bangladesh Integrated Household Survey’s third round (2018/19), following the Januszewski (1968) formulation.

CHAPTER 3. EVOLUTION OF AGRICULTURAL MECHANIZATION IN BANGLADESH

3.1 Overview of Bangladesh's Phase III mechanization subsidy program (2020–24)

The Government of Bangladesh has been implementing a three-phase development assistance program targeted towards agricultural mechanization since 2005 (see Table 1). **Phase I (2005–2012)** saw the introduction of a 30% subsidy on the acquisition of various types of agricultural machinery for farmers, covering 112 sub-districts in 56 districts. The primary objective during this phase was to enhance irrigation efficiency for farmers (Ministry of Planning 2014).

Phase II (2012–2019) continued this initiative with an increased subsidy rate of 50-70%, extending its geographic coverage to 300 sub-districts across all 64 districts. The overarching goal of this phase was to encourage the adoption of suitable farm machinery among farmers, farmer groups, and MSPs. This phase aimed to reduce crop production costs, enhance cropping intensity, minimize crop loss, sustain crop production, and build stakeholder capacity (Alam 2022). Notably, the government targeted climate-vulnerable areas such as the Haor (North-East) and coastal (South-West) regions for a higher level of subsidy (70%), while other areas received a lower subsidy rate (50%). The Haor basin, a low-lying floodplain area, is highly suitable for dry-season rice (that is, boro rice) production due to its water retention characteristics, which provide a stable environment for rice cultivation during the dry season. This significant contribution underscores the region's strategic importance in ensuring food security for Bangladesh, especially given the country's high dependence on rice as its primary staple. On the other hand, aman rice is a key crop for coastal areas during the monsoon season (July to December), when fields are rainfed. Coastal districts such as Satkhira, Khulna, and Barishal are important aman-producing zones, contributing significantly to local food security.

Phase III (2020–2024) of the subsidy program built on earlier phases by introducing new types of machinery and expanding the geographic coverage of the subsidy program (Alam 2022; Hossen et al. 2020), and was worth BDT 3,105 crore (approximately USD 341 million).[5] As a strategic policy measure to support this phase, the government introduced the National Agricultural Mechanization Policy (NAMP) 2020 and the Mechanization Plan of Action 2023. These two policy documents outline the strategic priorities for agricultural mechanization and set forth a timeline of milestone targets extending to 2041.

Phase III of the mechanization support program opened a call for applications twice every year, during the boro and aman seasons. Applicants were required to submit a simple application form, accompanied by their national identity card, farmer identity card, or any local level authorization certificate. In the application, they had to declare the type and brand of machinery they wished to purchase, with the option to change their preference later. The Upazila Agriculture Committee, consisting of five members, evaluated the applicants' profiles and recommended beneficiaries to the central selection committee headed by DAE. The project office then allocated machines based on their targets and the number of applications received. Generally, the entire process took approximately one month to complete. The beneficiary had to sign a formal agreement with the upazila DAE Office stipulating that they would not be able to transfer ownership of the machine within three years.

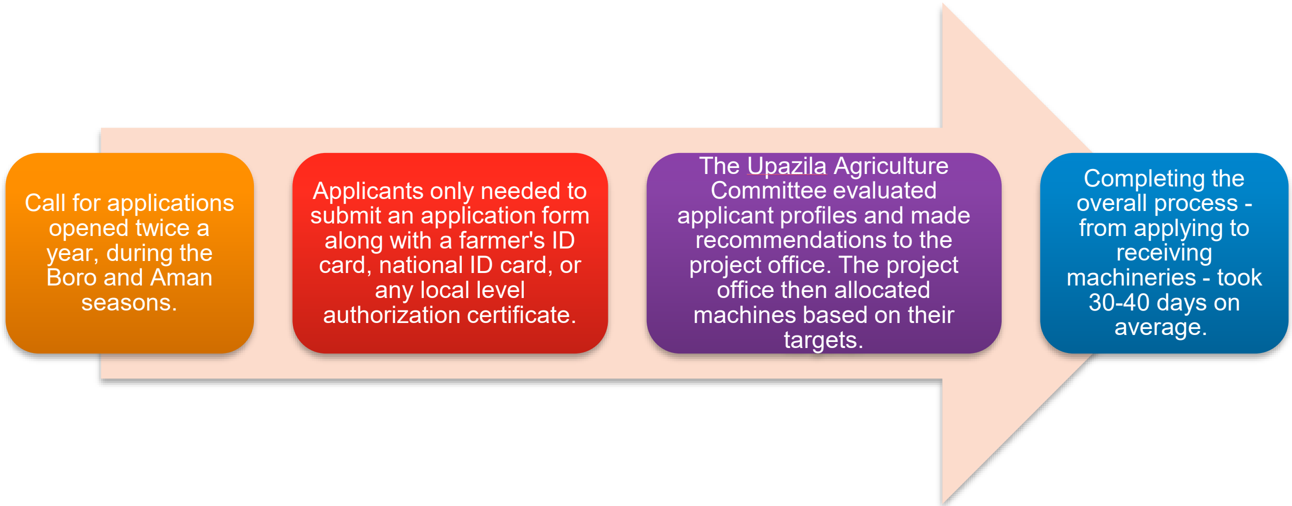
[5] The Phase III mechanization subsidy program was approved in 2020. Given the significant fluctuations in the exchange rate between 2020 and 2024, we use an average exchange rate of USD 1 = BDT 98 to represent the prevailing rate over this period.

Table 1: Evolution of government support for agricultural mechanization, 2005–2024

Phase I (2005–2012)	Phase II (2012–2019)	Phase III (2020–2024)
30% incentive for purchasing:	**50-70% incentive for purchasing:**	**50-70% incentive for purchasing:**
Power threshers	Power threshers	Power threshers
Reapers	Reapers	Reapers
Sprayers	Sprayers (foot pumps)	Sprayers (power)
Power tillers	Combine harvesters	Combine harvesters
Seeders/bed-planters	Rice transplanters	Rice transplanters
Weeders		Seeders/bed-planters
Dryers		Power weeders
Power winnowers		Dryers
Sprinkler irrigation sets		Maize shellers
		Potato diggers
		Potato chip makers
		Carrot washers

Source: Evaluation report by the Bangladesh Ministry of Planning (2014, 2018); Ministry of Agriculture and Project Documents.

Figure 2: Machinery allocation process



Source: Authors.

Until Q2 2023, DAE had allocated a total of 35,347 agricultural machines to farmers, including 8,912 CHs, 12,059 seeders/bed-planters, and 9,057 power threshers (see Table 2). CHs were the highest expenditure, accounting for approximately 50% of the total program budget and 84.2% of the value of subsidized machines distributed at BDT 1,595 crore (approximately USD 163 million), followed by seeders/bed-planters at BDT 136.66 crore (about USD 14 million and 7.2% of the value of subsidized machines distributed), and power threshers at BDT 100.61 crore (USD 10.3 million and 5.3%). In terms of the number of machines distributed, power tiller-operated seeders (PTOSs) and bed-planters comprised the largest share (3%), followed by threshers (26%), and combine harvesters (25%). Around 60% of all machines were allocated under the 70% subsidy rate, although the project had originally aimed to provide only 26% of all machines (13,450 out of 51,300) at this rate (see Appendix Table A2).

Most machines, including power tillers (PTs), CHs, rice transplanters (RTs), and reapers, were imported mainly from China by key distributors such as ACI, Metal, and Abedin.[6] Geographically, harvesters are predominantly allocated to Haor and coastal areas, while local markets for seeders, power threshers, and maize shellers are dominated by the Bangladesh Agricultural Research Institute (BARI) and Bangladesh Rice Research Institute (BRRI) designs, highlighting a balance between imported and domestically developed technologies.

Data from DAE's machinery allocation database highlights that mechanization in rice harvesting has been a central focus of government investment. Figure 3 shows that the majority of CHs were allocated to Haor areas. Qualitative interviews with key stakeholders suggest that the government prioritized Haor areas due to concerns of early flash floods, labor scarcity during harvesting periods, and increasing labor costs.

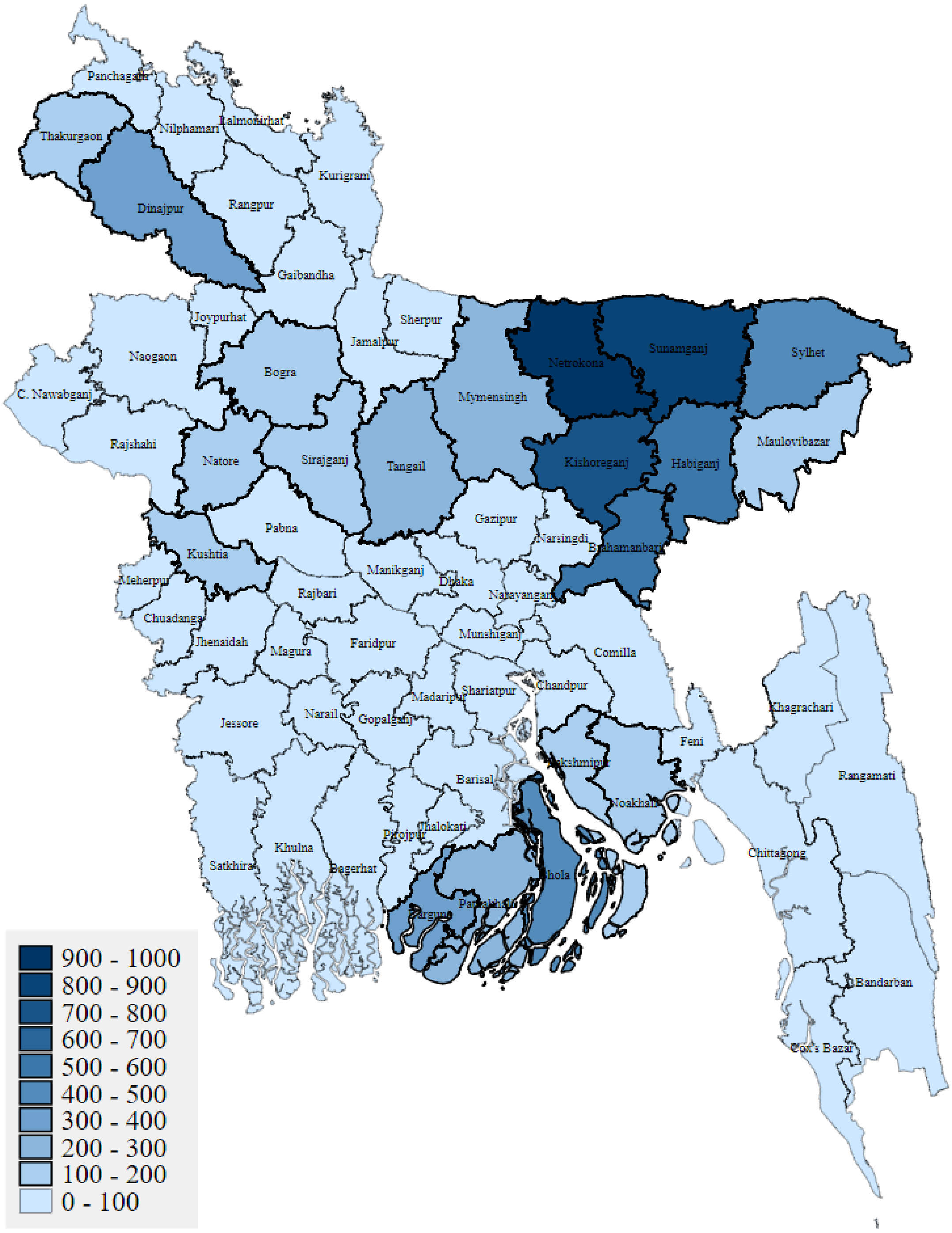
Table 2: Latest available machinery allocation statistics (2020 – Q2, 2023)

Machine type	Quantity	BDT (in crore)	% of Quantity	% of Expenditure
Combine harvesters	8,912	1,594.78	25.21	84.19
Seeders/bed-planters	12,059	136.66	34.12	7.21
Power threshers	9,057	100.61	25.62	5.31
Reapers	2,327	28.14	6.58	1.49
Maize shellers	1,309	8.97	3.70	0.47
Dryers	33	0.62	0.09	0.03
Potato diggers	1,076	11.04	3.04	0.58
Power sprayers	164	0.23	0.46	0.01
Power weeders	39	0.08	0.11	0.00
Rice transplanters	371	13.06	1.05	0.69
Total	**35,347**	**1,892**	**-**	**-**

Source: Department of Agricultural Extension (DAE) machinery allocation database.

[6] While Japanese companies Yanmar and Kubota maintain strong brand presence in the combine harvester market, their machines are manufactured in facilities across Japan, Thailand, or China, depending on model and cost considerations. FM World combine harvesters—imported by Metal—are produced by Jiangsu World Agriculture Machinery Co., Ltd. in China.

Figure 3: Geographical distribution of combine harvesters (2020–2023)



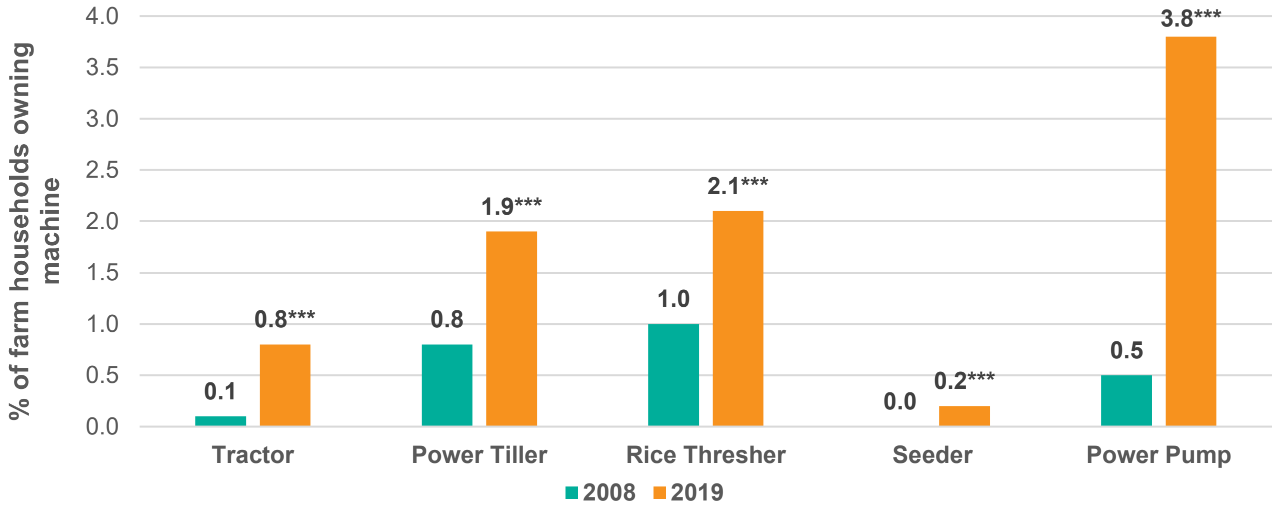
Source: Authors' calculations using DAE's machinery allocation data.

Note: Figures in the legend reflect the number of CHs distributed.

3.2 Trends in machine ownership and rental markets (2008 and 2019 agricultural censuses; BIHS data)

We analyze the evolution of agricultural machinery ownership using nationally representative data from the 2008 and 2019 Agricultural Censuses conducted by the Bangladesh Bureau of Statistics (BBS). Despite starting from a low baseline, the data reveals statistically significant increases in the proportion of households owning key agricultural machinery over this eleven-year period (Figure 4). Tractor ownership among households, for example, increased from 0.1% to 0.8%, while power tiller ownership rose from 0.8% to 1.9%. Similarly, rice thresher, seeder, and power pump ownership all showed significant upward trends (all changes significant at the 1% level).

Figure 4: Share of farmers owning machines by type of machine, 2008 and 2019 (%)

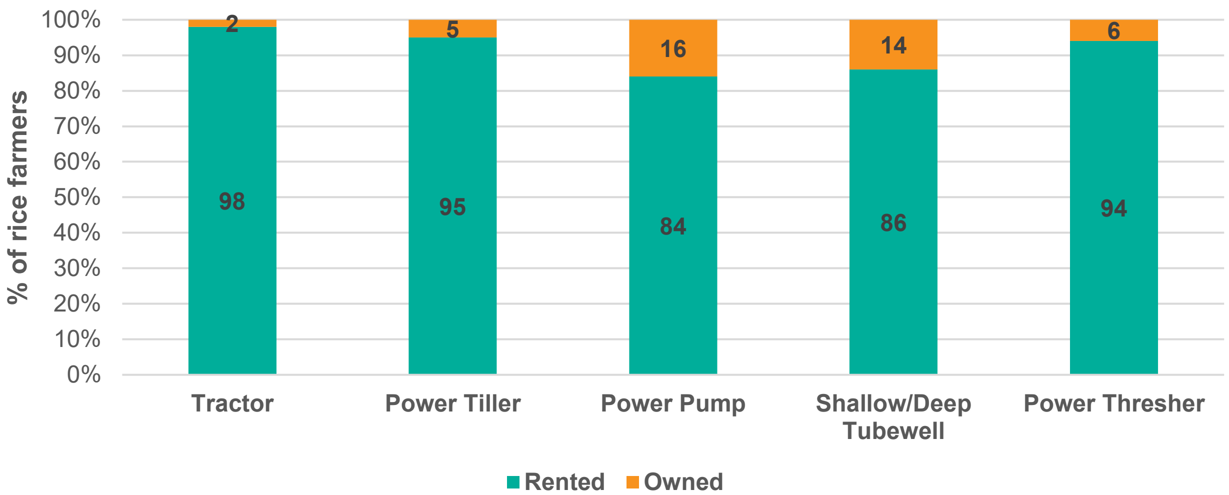


Source: Authors' calculations using data from the 2008 and 2019 National Agricultural Censuses.

Note: The results are significant at the 1% level (denoted by ***) for all types of agricultural machinery ownership between 2008 and 2019. "Power pump" refers to motorized pumps, typically used for irrigation, as per standard BBS classification.

However, absolute ownership levels remain modest even after this growth, suggesting that increased machinery use, documented later in this chapter, primarily reflects expansion of rental markets rather than individual ownership. Indeed, data from the nationally representative BIHS point to a growing reliance on rental rather than ownership models for machinery access. Figure 5 underscores this dynamic: the vast majority of tractors (98%) and power tillers (95%) in use are rented. The pattern is similar for irrigation and post-harvest equipment, with 84% of power pumps, 86% of shallow and deep tubewells, and 94% of power threshers accessed through custom hiring services.

Figure 5: Percent of rice farmers renting or owning machines by task, 2018



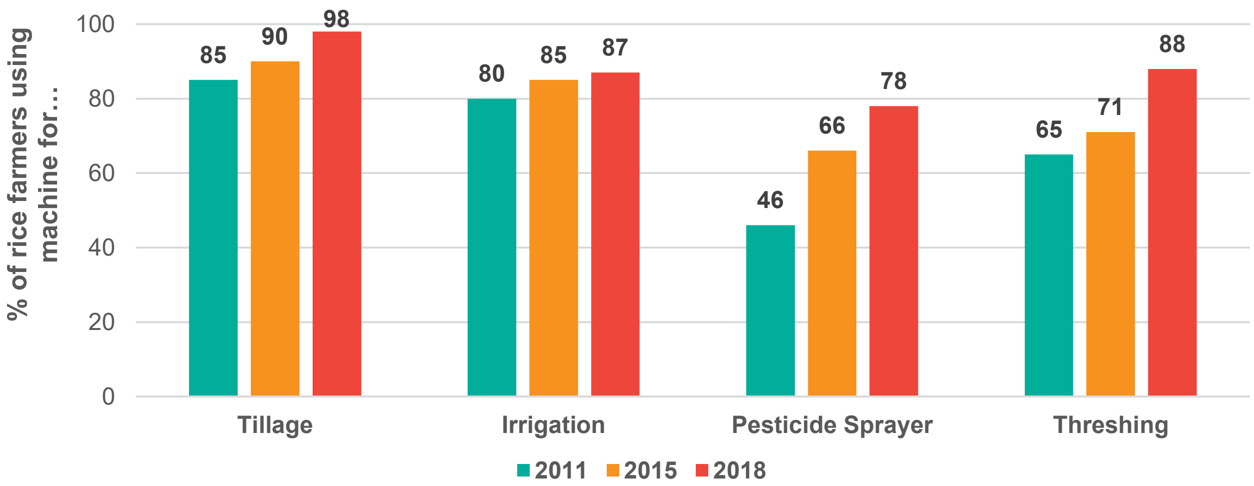
Source: Authors' calculations using BIHS 2018/19 data.
Note: Percentages reflect only rice farmers who used each machine; values are conditional on use.

3.3 Trends in mechanization across different agricultural tasks

To analyze trends in mechanization across different agricultural tasks, we focus on boro rice—Bangladesh's largest crop by area (42% of total rice hectarage) and production (19.8 million MT in 2022-23). BIHS data from 2011 to 2018 reveals significant improvements in machinery adoption for boro cultivation, particularly for spraying and threshing (Figure 6). While mechanized tillage, irrigation, spraying, and threshing increased substantially over this period, planting and harvesting remained largely manual operations as of 2018 (see Figure 6 and Figure 7).

Low-cost Chinese power tillers (also known as two-wheel tractors) are affordable and easy to move during field operations. In 2018, 87% of farmers used power tillers for land preparation (Karim et al. 2024). Government support through the Bangladesh Agricultural Development Corporation (BADC) including rental distribution of low-lift pumps (LLPs) and deep tubewells (DTWs) at subsidized rates from the 1970s coincided with a rapid increase in private pump ownership, enabling farmers to adopt mechanized irrigation services (Mandal 2017a). Knapsack sprayers[7] are also widely used by farmers due to their low cost and ease of handling. Figure 6 illustrates a rapid increase (by 32 percentage points, from 46 % in 2011 to 78% in 2018) in mechanized spraying for pesticides from 2011 to 2018. We also observe an increase of 23-percentage points (from 65% in 2011 to 88% in 2018) in mechanized threshing.

Figure 6: Share of boro rice farmers using agricultural machinery by task (2011–2018)



Source: Authors' calculations using BIHS 2011/12, 2015, and 2018/19 data.

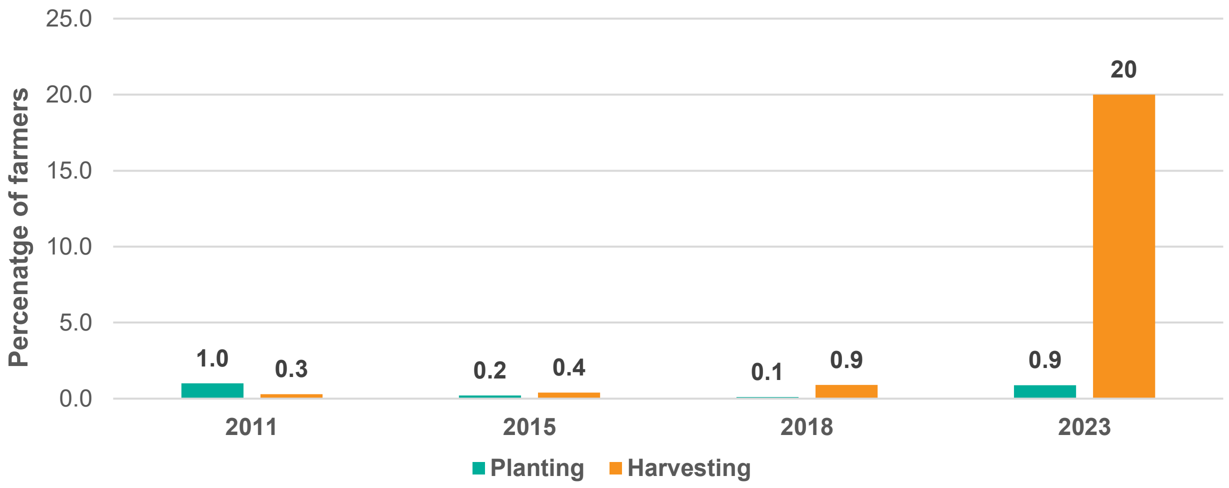
Several factors contributed to the expansion of mechanized agricultural tasks. Between 2005 and 2019, the government operated a continuous subsidy program targeting small-scale machinery, offering 30-50% purchased incentives for equipment such as power tillers, seeders, pumps, and threshers. While the program continued beyond 2019, its focus gradually shifted toward larger machinery such as combine harvesters.[8] Simultaneously, local research institutions particularly BARI and BRRI developed context-appropriate machinery designs that local manufacturers could produce in a cost-effective manner. These innovations reduced import dependency on these types of small machines and made mechanization more accessible to smallholder farmers.

[7] A knapsack sprayer is a manually operated or battery-powered device used to apply liquid pesticides, herbicides, or fertilizers in agricultural fields. It consists of a tank worn on the back like a backpack, with a hand-operated or motorized pump and a spray nozzle.

[8] A detailed overview of the earlier phases of the mechanization subsidy program is provided in Section 3.1.

Figure 7 illustrates the evolution of mechanized planting and harvesting in boro rice production between 2011 and 2023. While mechanized planting remained below 1% throughout this period, mechanized harvesting increased markedly—from 1% in 2018 to approximately 20% in 2023. This rapid increase in mechanized harvesting can be attributed to the Phase III subsidy program's strategic prioritization of CHs, with approximately 9,000 units distributed nationally between 2020 and 2023.

Figure 7: Trends in mechanized planting and harvesting among boro rice farmers (2011–2023)



Source: Authors' calculations using BIHS 2011/12, 2015, 2018/19, and BIHS/SPIA 2024 data.

Note: Percentages reflect households that used mechanized planting or harvesting on at least one plot.

CHAPTER 4. CHARACTERISTICS OF COMBINE HARVESTERS AND MACHINERY SERVICE PROVIDERS

This chapter presents detailed findings from the IFPRI Bangladesh Machinery Service Provider Survey conducted between December 2024 and January 2025, examining the operational characteristics, financial constraints, and service delivery challenges faced by CH service providers. Our analysis draws on primary data from 400 CH operators across 10 strategically selected districts in Bangladesh with an aim to capture Bangladesh's agroecological and socioeconomic diversity: Barguna and Cox's Bazar (coastal belt); Kishoreganj and Sunamganj (Haor region); Dinajpur and Thakurgaon (northern highlands); and Bogura, Chuadanga, Faridpur, and Mymensingh (central plains). While the survey covered multiple machinery types, this analysis focuses on the 400 CH operators, reflecting the government's prioritization of harvesting mechanization, which accounts for 50% of the total program expenditure and 84% of the value of subsidized machines distributed.

The survey employed a multi-stage sampling design: first, selecting districts based on mechanization intensity and subsidy allocation patterns; then, randomly selecting upazilas and unions within each district; and finally, identifying MSPs through systematic listing. Data collection utilized structured questionnaires administered through face-to-face interviews, complemented by direct observation of machine conditions and operational practices. The survey instrument captured detailed data across six domains: ownership and financing patterns, operational performance metrics, cost structures, maintenance practices, service quality indicators, and market dynamics.

4.1 Basic characteristics of combine harvesters and major importers

The technological and brand composition of Bangladesh's CH fleet reveals important implications for productivity and market segmentation. A large majority (72.5%) of these machines are full-feed harvesters,[9] which typically offer greater processing capacity, with an average horsepower (HP) of 88. The remaining 27.5% are head-feed harvesters,[10] which are relatively less powerful, averaging 66 HP with almost all of these having a caterpillar type wheel (see Appendix Table A3 for details). This distribution reflects a market preference for higher-capacity, full-feed systems despite their limitations in straw preservation—a critical consideration given the economic value of rice straw for livestock feed in Bangladesh's integrated crop-livestock systems.

In terms of brand distribution, FM World leads with 24.8% of all harvesters, followed closely by Yanmar (23.5%), and Kubota (20.3%). Other notable brands include Lovol (8.5%), Zoomlion (8.0%), and Marksan (6.0%). The average HP varies across brands, ranging from 70 (Yanmar) to 96 (Lovol), indicating heterogeneity in machine capabilities across different suppliers. The average market price of a combine harvester was BDT 3,137,539. Under the 50% subsidy scheme, the price paid for a CH by MSPs was on average BDT 1,629,332. With a 70% subsidy, the average price born by the purchaser was significantly lower, at BDT 1,205,699 (see Appendix Table A4 for price details by brands and subsidy levels).

[9] Full-feed combine harvesters process the entire plant—straw, panicles, and all—into the threshing and separating unit. This design typically offers faster harvesting speeds and higher throughput, making it suitable for large, uniform fields. However, full-feed machines require more power, consume more fuel, and often leave the straw chopped, limiting its reuse for fodder or other purposes.

[10] Head-feed harvesters process only the grain-bearing portion of the plant (the panicle), leaving most of the straw standing. This approach is better suited for small, fragmented fields and helps preserve straw quality, which is valuable for livestock feed. Head-feed machines are generally lighter, consume less fuel, and cause less soil compaction—an advantage in rainfed or waterlogged conditions.

The import market structure exhibits even greater concentration than brand distribution. ACI's dominant position (with a 31.8% market share) reflects its established distribution networks and preferential relationships with major manufacturers, particularly Yanmar and Lovol. The top four importers—ACI, Metal (24.8%), Abedin (20.3%), and SQ Trading (12.3%)—control 89% of the market (see Appendix Figure A1).

4.2 Ownership profiles, demographics, and financing sources

The socioeconomic profile of CH owners reveals important structural characteristics of Bangladesh's emerging mechanization service market. Our analysis of 400 CH operators demonstrates that ownership remains highly concentrated among larger landholders, with 83% owning at least 3 hectares—well above the national average farm size of 0.5 hectares.[11] Additionally, 16% of CH owners are non-farm entrepreneurs, indicating growing interest from outside the farming community. CH owners are typically middle-aged men with modest levels of education (with an average of 8 years of education). All MSPs offer harvesting services to other farmers. The majority (91%) operate within their own upazila, while 14% extend services to other upazilas in the same district. Notably, 61% provide services to districts beyond their own home district.

While our survey targeted combine harvester operators, the data reveals that 82.8% of respondents operated machines they personally owned. An additional 10.8% operated machines owned by relatives or friends, with joint ownership accounting for 6.6%. Only a small fraction operated machines owned by non-family members. This ownership pattern confirms that most operators are also the machine owners, validating our subsequent analysis of ownership-related variables such as financing, purchase decisions, and investment planning.

Gender representation remains negligible, with women comprising 0.8% of CH owners, reflecting broader structural barriers to women's participation in agricultural mechanization service provision. Approximately 67% of owners operate additional agricultural machinery, primarily PTs and irrigation pumps, suggesting economies of scope in service provision and established client networks that facilitate CH service adoption. Half the CHs in our sample were purchased in 2022, a period of intensified government support.

Subsidies played a major role in CH acquisition—58% of owners received a 70% subsidy and 41% received a 50% subsidy—bringing down purchase costs from BDT 32 lakh to between BDT 12 and 16 lakh on average. As indicated previously, full-feed machines (73%) dominate the market. Yanmar, Kubota, and FM World account for 70% of machines in use. Most units are imported from China and Thailand, and just four importers—ACI, Metal, Abedin, and Banglamark—supply 84% of all machines.

The financing ecosystem for agricultural mechanization reveals persistent gaps in formal credit markets.

Across the board, 68% of MSPs reported borrowing for at least one machine-related purpose. Downpayments were the most common (50%), followed by repair costs (37%) and dealer payments (28%). Loans for downpayments and dealer payments had the highest average size (BDT 241,600 and BDT 228,600, respectively), reflecting their critical role in machine acquisition. Loans for repairs were smaller but differed substantially in terms of interest rates and repayment periods.

Of the 68% of MSPs who took out loans for at least one machine-related purpose, nearly half (48%) borrowed for more than one purpose, meaning they secured loans for two or more of the following:

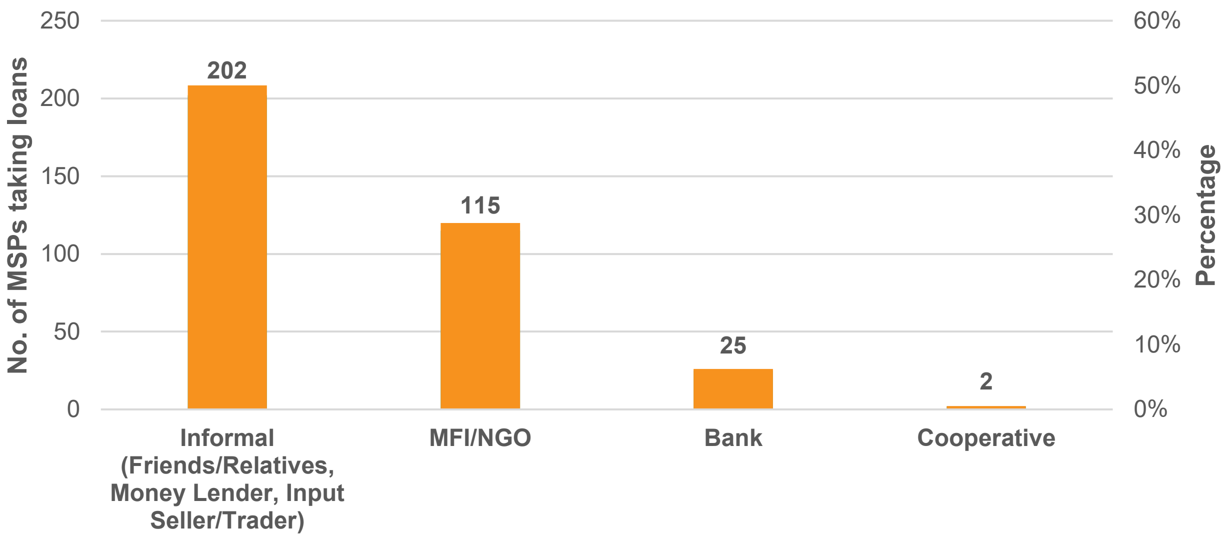
[11] According to BBS's 2019 Agricultural Census, the average farm size was 0.5 hectares (1.29 acres); in 2008, the average size was 0.6 hectares (1.47 acres).

downpayment, dealer payment, or repair payment. This overlapping borrowing pattern likely contributes to the relatively high average overall loan amount of BDT 336,428, as many MSPs accumulated debt from multiple sources or loan types. It is important to note that these loans were taken at any point between the time of machine purchase and the time of the survey, and in several cases, MSPs reported taking more than one loan for the same category, such as repeated loans to pay the high downpayment amount or to cover successive dealer payments.

Table 3 disaggregates the financing arrangements underpinning CH acquisition and operation, revealing a troubling dependence on high-cost informal credit. Survey data show that MSPs use credit to fund three aspects of machine operations and purchase—initial downpayments, dealer balance payments, and ongoing repairs—each with distinct cost structures and repayment features. Despite the capital-intensive nature of CH operations, formal banking channels provide credit to only 6% of MSPs for any purpose.

Half of the MSPs surveyed relied on informal lenders—such as friends, relatives, input sellers, and moneylenders—for machine-related expenses, particularly for downpayments and repairs. This was followed by 29% who borrowed from microfinance institutions (MFIs) or non-governmental organizations (NGOs). A negligible proportion (1%) of MSPs take loans from cooperatives.

Figure 8: Sources of loans taken by MSPs for any purpose



Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Note: Loans were taken by MSPs to finance machine downpayments, pay dealers, or cover repair-related expenses.

Across the board, 68% of MSPs reported borrowing for at least one machine-related purpose. Downpayments were the most common (50%), followed by repair costs (37%) and dealer payments (28%). Loans for downpayments and dealer payments had the highest average size (BDT 241,600 and BDT 228,600, respectively), reflecting their critical role in machine acquisition. Loans for repairs were smaller but differed substantially in terms of interest rates and repayment periods.

Of the 68% of MSPs who took out loans for at least one machine-related purpose, nearly half (48%) borrowed for more than one purpose, meaning they secured loans for two or more of the following: downpayment, dealer payment, or repair payment. This overlapping borrowing pattern likely contributes to the relatively high average overall loan amount of BDT 336,428, as many MSPs accumulated debt from multiple sources or loan types. It is important to note that these loans were taken at any point between the time of machine purchase and the time of the survey, and in several cases, MSPs reported taking more than one loan for the same category, such as repeated loans to pay the high downpayment amount or to cover successive dealer payments.

Table 3: MSPs' use of finance for machine purchases and repairs

	Downpay-ment	Dealer payment	Repair payment	Overall
% of MSPs who took loans for…	50%	28%	37%	68%
Avg. loan size (BDT)	241,600	228,600	150,880	336,428
Avg. interest rate (%)	15	16	31	20
Avg. repayment period (months)	10	9	7	9
Loan source = Informal (%)	30	14	27	51
Loan source = MFI/NGO (%)	18	13	9	29
Loan source = Bank (%)	4	1	2	6

Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Note: All figures in this table are based on the full sample of 400 MSPs surveyed. Percentages under each loan category represent the share of all MSPs who reported borrowing for that specific purpose. Loan source shares (informal, MFI/NGO, bank) indicate the proportion of all MSPs who reported using each source. The "Overall" column includes MSPs who took loans for at least one machine-related reason, and some MSPs reported borrowing for more than one purpose.

The financing data also reveal several patterns. First, repair loans carry interest rates averaging 31% annually, nearly double the rates for acquisition financing. Second, the compressed repayment period for repair loans (7 months) is noteworthy. Third, the predominance of informal financing (27% for repairs) indicates steep market bottlenecks in formal agricultural credit for operational expenses.

Spare parts constraints emerge as a critical pressure point for MSPs, both in terms of availability and financing. On average, MSPs borrow BDT 150,880 for repairs, an amount that must be repaid within 7 months. The annual interest paid, averaging BDT 22,663, amounts to roughly 15% of the loan principal. Moreover, the average cost of the top three spare parts over a year (BDT 159,184) slightly exceeds the average loan amount, suggesting that even small-scale repairs often demand significant resources.

4.3 Warranty, training, and after-sales service

The after-sales service ecosystem plays a vital role in sustaining mechanization, yet our findings point to persistent gaps in warranty provision, technical training, and service support. Table 4 summarizes the warranty coverage and documentation practices associated with different brands. While dealers typically offer free service for up to 480 operational hours, many MSPs report gaps in other critical forms of support. Notably, 62% of MSPs did not receive a warranty card, and nearly a quarter were not given a maintenance manual, which can lead to confusion and disputes over service entitlements.

Among prominent brands, Field King offers the highest average warranty coverage at 602 hours, but only 20% of MSPs reported receiving a warranty card from this company, suggesting poor documentation despite generous service support. Lovol and Yanmar (both brands imported by ACI) also offer high warranty hours—590 and 572, respectively—with moderate rates of card distribution (47% and 34%). By contrast, Kubota provides a relatively low average of 386 warranty hours but has the highest percentage of MSPs receiving a warranty card (48%). FM World shows a more balanced performance with 508 warranty hours and 38% card receipt. On the other hand, brands such as Zoomlion, Marksan, and those grouped as “others” demonstrate both low warranty hours and low card issuance rates, pointing to weaker after-sales service support.

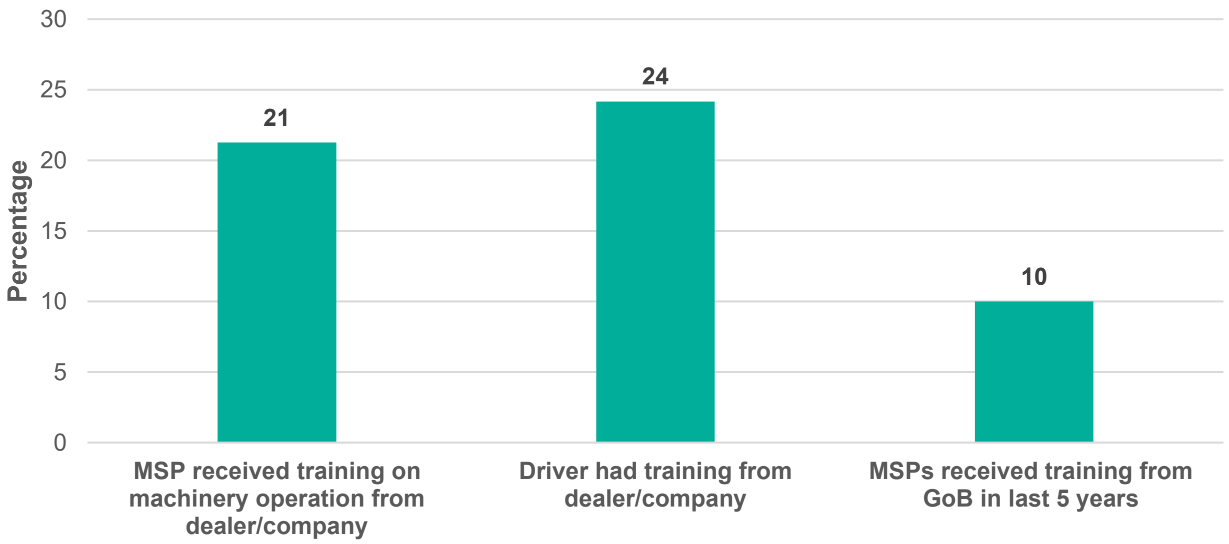
Table 4: Warranty schemes provided by different brands

Brand	Average warranty hours offered for free servicing at the time of purchase	% of MSPs received warranty card from the dealer/company	% of MSPs received maintenance manual from the dealer/company
Kubota	386	48	88
Lovol	590	47	91
FM World	508	38	79
Yanmar	572	34	78
Others	325	29	57
Zoomlion	380	22	62
Marksan	378	21	42
Field King	602	20	53
Total	**481**	**37**	**75**

Source: Authors’ calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

The training landscape reveals human capital deficiencies for CH operators (see Figure 9). With only 21% of MSPs and 24% of drivers/operators receiving any formal training, the sector operates largely on trial-and-error learning, likely resulting in suboptimal performance and safety hazards. The government's failure to deliver its promised 21-day training program, reaching only 10% of CH owners, also undermined the mechanization initiative.

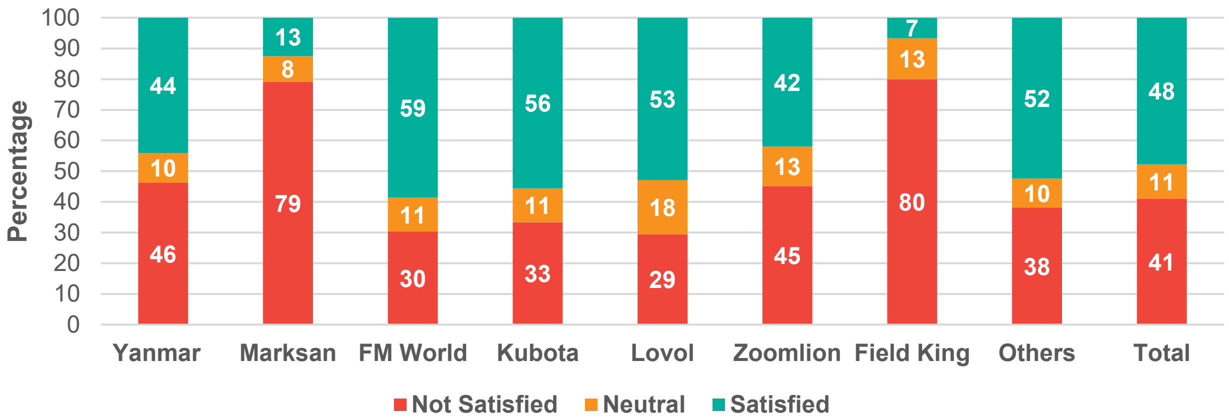
Figure 9: Issues with machinery-related training



Source: Authors’ calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

After-sales service is crucial for customer satisfaction. Harvesters frequently break down and require urgent repair support. Availability of parts and skilled mechanics can determine whether a machine stays operational during peak season. Figure 10 presents the distribution of user satisfaction levels across various harvester brands, based on survey responses. The findings reveal notable heterogeneity in satisfaction levels. Brands such as FM World, Kubota, and Lovol demonstrate relatively high satisfaction rates, with 59%, 56%, and 53% of users, respectively, reporting satisfaction. By contrast, Field King and Marksan exhibit markedly low satisfaction levels, with 80% and 79% of respondents, respectively, indicating dissatisfaction. The proportion of respondents reporting neutral opinions is generally modest across brands, ranging from 8% (Marksan) to 18% (Lovol). The overall distribution across all brands indicates that 48% of respondents were satisfied with their machines, 11% were neutral, and 41% were not satisfied.

Figure 10: Level of satisfaction with after-sales services for different brands

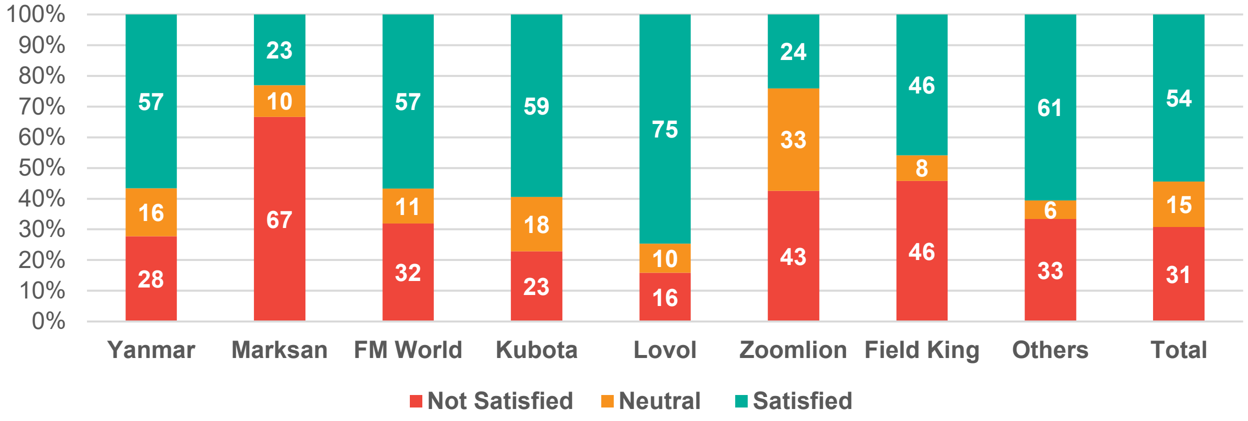


Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Figure 11 illustrates the overall level of satisfaction among MSPs with different agricultural machinery brands. The results reveal notable variation in user satisfaction across brands, highlighting differences in perceived performance, reliability, and service delivery. Among all brands, Lovol demonstrates the highest level of user satisfaction, with 75% of Lovol harvester users reporting a positive experience and only 16% indicating dissatisfaction. Similarly, Yanmar, Kubota, and FM World users also exhibit strong performance in terms of satisfaction. These results suggest that these brands are generally well received by users and may be associated with higher product quality or better after-sales support. By contrast, 67% of Marksan users reported the highest level of dissatisfaction with their harvesters. This suggests a significant gap in user expectations versus actual experience,[12] potentially pointing to issues in product durability, performance, or support services. Zoomlion and Field King also showed comparatively lower satisfaction levels.

[12] Qualitative interviews with users who reported higher levels of dissatisfaction revealed a recurring pattern of persuasive marketing tactics. The suppliers of some of these ill-reviewed brands seemed to target individuals with limited or no prior experience in operating agricultural machinery, often presenting misleading investment-return projections to encourage purchase decisions. This led to a higher level of dissatisfaction among MSPs when the realized return on investment was lower from these machines.

Figure 11: Overall level of satisfaction with different CH brands



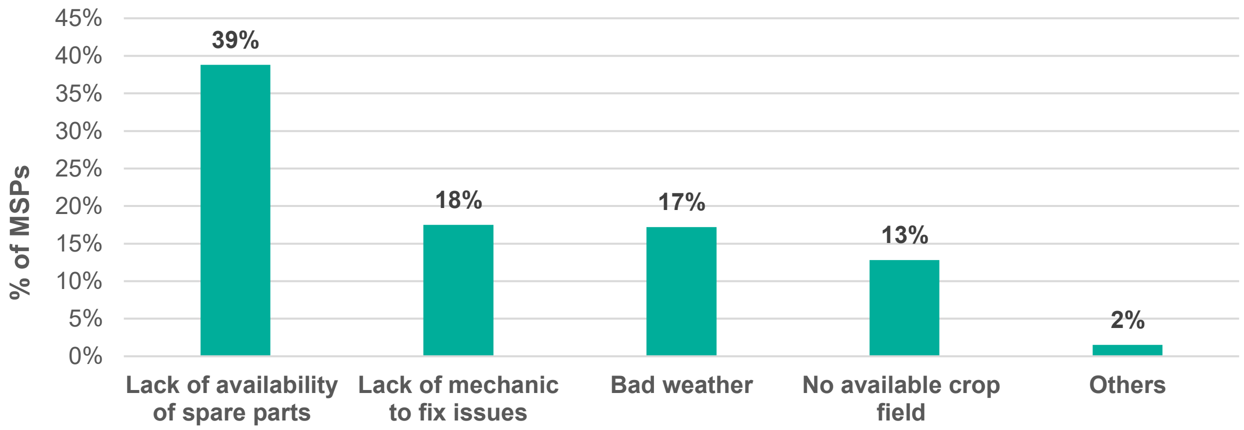
Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Note: The satisfaction levels presented correspond to 385 MSPs during the boro season (covering paddy and wheat) and 264 MSPs during the aman season.

4.4 Downtime drivers and spare-parts constraints

Figure 12 shows that 97% of MSPs reported experiencing downtime in machine operation. MSPs experience an average of 12 days of downtime annually, during which they are unable to operate despite demand. Given that they currently operate for an average of 58 days per year, this suggests a total potential of 70 operating days annually. The downtime therefore accounts for approximately 17% of their total potential service days, indicating a substantial loss in productive capacity. Nearly 40% of MSPs identified the lack of spare parts as the leading cause of machinery downtime, by far the most frequently reported constraint. This was followed by the unavailability of skilled mechanics (18%) and weather disruptions (17%), both of which contributed significantly to operational delays. Seasonal factors such as the absence of crop-ready fields (13%) were less frequently cited, suggesting that some technical and logistical bottlenecks, rather than agronomic cycles, are the primary drivers of machine idle time. This suggests some shortcomings in machinery dealer-led after-sales service systems and underscores the pressing need to strengthen spare parts supply chains and access to repair support—topics of importance which the Cereal Systems Initiative for South Asia – Mechanization Extension Activity (CSISA-MEA) project sought to address.

Figure 12: Reasons for machinery downtime



Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

CHAPTER 5. COST-BENEFIT ANALYSIS AND OPTIMAL SUBSIDY RATE DESIGN

5.1 MSP cost and revenue profiles

In Table 5, we present the unit economics of MSP operations for different seasons. Seasonal figures are based on MSP-reported data spanning from the 2023 Aman season through the 2024 Aus season, with operating days and outcomes reported within each seasonal window. Boro is the most important operating period for CH MSPs, with 97% of service providers active over the course of the season. On average, MSPs can operate for 39 days during the boro season, serving 153 farmers and covering 60 hectares, far more than in other seasons. The season also has the highest share (53%) of MSPs providing services outside their own district. Despite high operational (BDT 305,795) and repair costs (BDT 92,623), boro yields the highest total revenue (BDT 765,508) and a gross margin (total annual revenue minus all costs of operating the machine, including expenses for operations and repairs) of 48%.

Table 5: Seasonal performance and financial summary of MSPs across different seasons

	Boro	Aman	Aus	All
% of MSPs operating	97	66	15	100
Days of operation	39	24	24	58
Days unable to operate	8	5	5	12
Number of farmers served by MSPs	153	82	71	216
Area covered (hectares)	60	32	25	84
Area per farmer served (hectares)	0.4	0.4	0.3	0.4
Share of MSPs providing services outside district (%)	53	36	20	45
Total revenue (BDT)	765,508	364,803	291,444	1,029,033
Operational cost (BDT)	305,795	190,011	129,714	404,241
Repair cost (BDT)	92,623	62,112	28,567	135,263
Gross margin (BDT)	367,090	112,681	133,163	489,530
Gross margin (%)	48	31	46	48

Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Note: Gross margins shown in this table reflect the difference between total revenue and the sum of operational and repair costs. Interest payments on loans were not included in the calculation of gross margins because financing information was collected only on an annual basis, and seasonal disaggregation of interest paid specifically for machine-related loans was not available. As a result, the gross margin estimates do not capture the financial cost of borrowing, which may vary across MSPs and seasons.

By comparison, the aman season engages 66% of CH MSPs, who operate for 24 days and serve 82 farmers across 32 hectares on average. Although costs are lower, at BDT 190,011 for operations and BDT 62,112 for repairs, the gross margin drops to 31%, constrained by fewer days of operation and limited cross-district service (36%).

Only 15% of MSPs operate during the aus season, reflecting low demand and limited opportunity. MSPs can operate for 24 days, serving just 71 farmers and covering 25 hectares on average. However, MSPs operating during the aus season had a gross margin of 46%, and also notably low costs (BDT 129,714 operational, BDT 28,567 repair).

Overall, the annual average gross margin per MSP stands at BDT 489,530, with a gross margin rate of 48%. These findings underscore the financial importance of ensuring machine availability and access during the boro season, while also revealing opportunities[13] to improve service efficiency and outreach during the aman season. They also highlight the strategic role of seasonal diversification to smoothen revenue and sustain MSP operations throughout the year.

5.2 Break-even analysis: Observed and simulated scenarios

To estimate the time required for MSPs to recover their investment in a CH, a structured approach was used, beginning with a detailed calculation of annual gross profits. Gross profit is defined as the difference between the annual revenue and all associated costs of machine operation, including operational expenses, repair and maintenance costs, and the interest burden from loans taken to finance the purchase.

Annual revenue was determined by first calculating the gross service income, obtained by multiplying the total number of hectares serviced in a year by the average service fee charged per hectare. From this amount, the total annual commission paid to brokers who facilitate access to clients was subtracted to arrive at the net revenue. This adjustment reflects the fact that brokers often receive a share of the earnings for connecting MSPs to farmers and arranging service engagements. In summary, revenue was calculated using the formula:

$$Net\ Revenue = (Hectares\ \ Serviced \times Service\ Fee\ per\ Hectare) - Total\ Broker\ Commission \quad (1)$$

The cost structure comprised three main categories. The first was **operational costs**, which included expenditure on fuel, operator wages, and other routine running costs. These were aggregated on an annual basis to reflect the total outlay required to keep the machine functional throughout the harvest season. The second cost component was **repair and maintenance expenses**, which covered the annual cost of servicing, parts replacement, and mechanical repairs expenses that tend to increase as machines age (see Appendix Figure A2).

The third and more nuanced component was **interest payments on loans**, as most MSPs do not pay the full purchase price upfront. Financing is often segmented across three types of loans: one for the initial downpayment, another for the dealer balance (the remaining portion of the purchase price paid in installments), and in some cases, loans taken for repairs. With all cost elements specified, the gross profit was computed using the formula:

$$Gross\ Profit = Net\ Revenue - Operational\ Cost - Repair\ Cost - Total\ Interest\ Payments \quad (2)$$

The final step involved estimating the **time to break even**, which was defined as the period required to recover the machine's effective purchase price using the annual gross profit. The effective price varied by subsidy level. For a 0% subsidy, the full market price[14] of the CH was used (see Appendix Table A4 for a full list of price details). For subsidized scenarios, the purchase price was adjusted to

[13] MSPs face significant challenges during the aman paddy season. Waterlogging is a major constraint, making it difficult for harvesters to operate efficiently. Additionally, farmers place high value on aman straw, which is commonly used as cattle feed and often considered more valuable than the paddy itself. Unlike the boro season, which includes both wheat and paddy crops, the aman season is rice intensive. As a result, the overall demand for CHs during aman is substantially lower than in the boro season. Our qualitative interviews reveal that head-feed CHs are in high demand during aman, but there are not enough such harvesters available to meet this demand. Data shows that nearly 73% of CHs are of the full-feed variety (see Appendix Table A3).

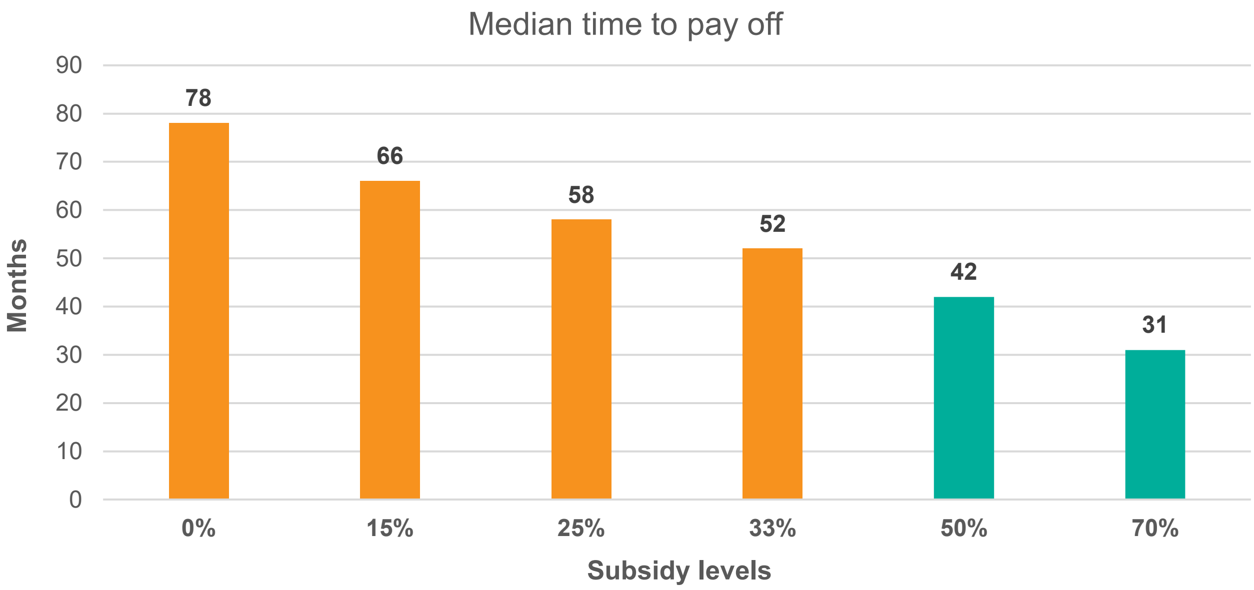
[14] Market price information is based on data collected through the IFPRI Bangladesh MSP Survey 2024/25.

reflect the actual financial burden on the MSP—for example, a 50% subsidy implied that the MSP paid only half the market price. The formula used was:

$$Breakeven\ time\ (in\ months) = (Effective\ Purchase\ Price \div Gross\ Profit) \times 12 \qquad (3)$$

For each scenario, the median break-even time across all MSPs was reported to provide a robust measure that reduces the influence of extreme values. MSPs who operated for 7 days or fewer were excluded to keep the results meaningful.

Figure 13: Break-even period by subsidy level



Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

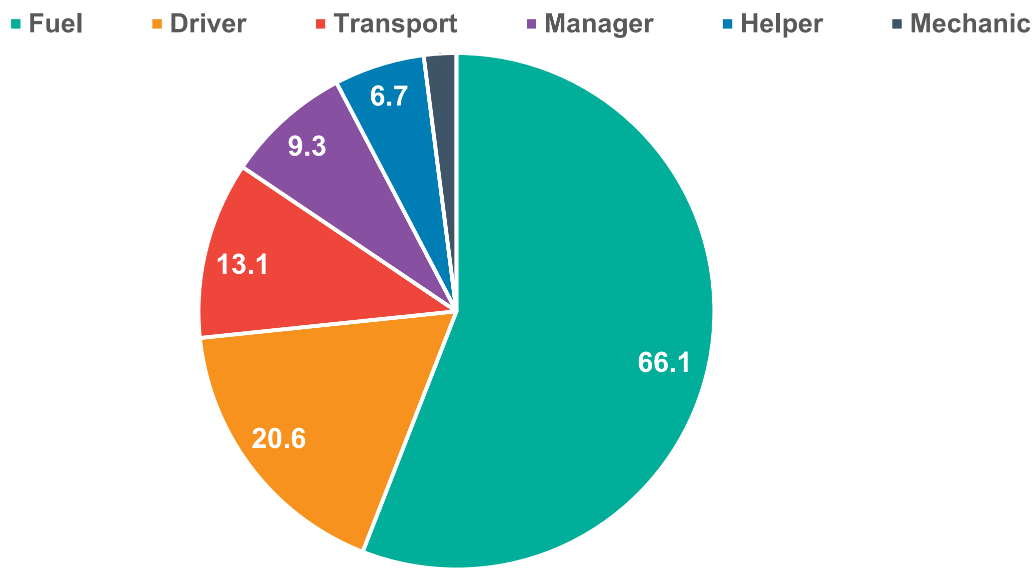
Note: The orange bars represent policy simulations.

Building on this framework, the analysis of median break-even periods under varying subsidy levels is presented in Figure 13. The graph illustrates a clear inverse relationship between the subsidy rate and the time required for MSPs to recover their investment. Without any subsidy support (0%), the median time to pay off the cost of a combine harvester is 78 months, or six and a half years. As subsidy support increases, this period declines significantly. The most substantial reductions occur under higher subsidy rates: a 50% subsidy reduces the median payback time to 42 months, while at 70%, the payback period falls sharply to just 31 months, or a little over two and a half years. The orange bars in the figure reflect policy simulations rather than observed outcomes, offering projections of how various subsidy scenarios could affect the financial viability of MSP operations.

5.3 Sensitivity to maintenance costs and downtime

The cost structure of annual operations reveals a high sensitivity to maintenance-related expenses, with fuel alone accounting for 66% of total operational costs—by far the largest share. Driver wages (21%) and transport (13%) follow, while manager and helper costs remain relatively modest. Interestingly, mechanic costs, closely tied to breakdowns and downtime, make up a small share (2%). This is perhaps because sellers typically waive mechanic costs during the initial years of machine use, and exempt any service charges incurred for spare parts repairs beyond the warranty period. On average, MSPs had spent BDT 140,000 annually on repair and maintenance for CHs. We ran an ordinary least squares regression of repair and maintenance cost on time (months) in operation. We found that on average the cost increased by BDT 19,000 with each additional year of machine operation, which is statistically significant (see Appendix Figure A2). These rising costs, when viewed alongside reported challenges like spare parts shortages and limited after-sales support, may indicate areas of financial strain for some MSPs and highlight the potential value of strengthening support systems to help manage machine upkeep and reduce unexpected downtime.

Figure 14: Breakdown of annual operation and maintenance costs for MSPs



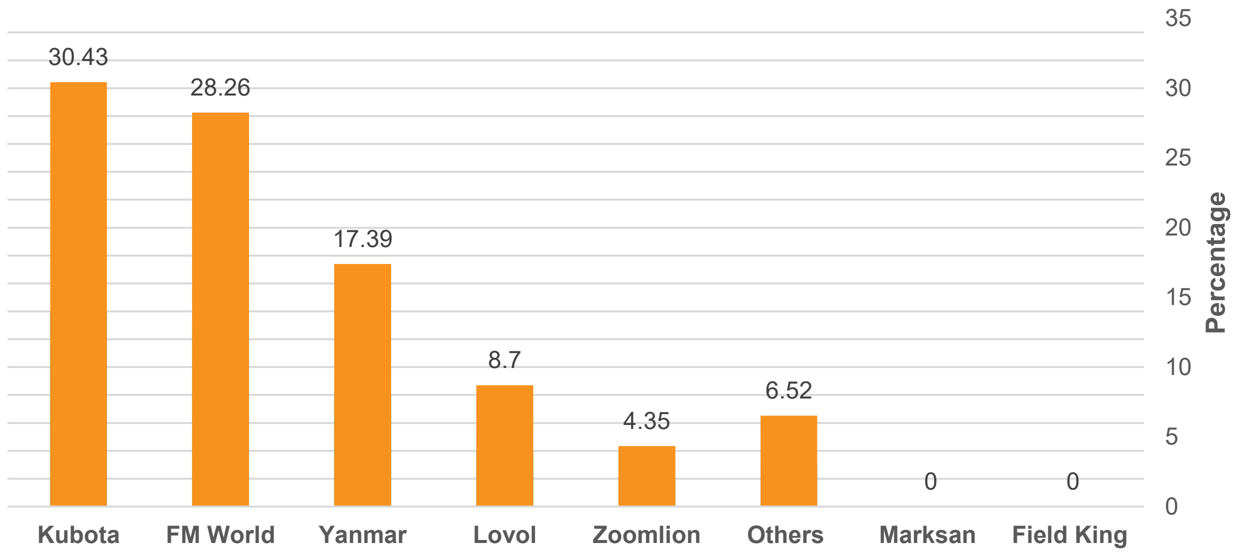
Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

This pattern is also clearly reflected in Appendix Figure A2, which is a scatter plot depicting the relationship between machine age and total repair cost. Each dot represents an MSP-owned machine, and the fitted line reveals a steady upward trend: as machines age, the associated repair costs increase. The positive and significant relationship suggests that older machines systematically demand higher upkeep. Even though the distribution of costs varies across individual cases, the overall trend is positive—repair costs rise with age (see Appendix Figure A2), reinforcing the need for well-timed maintenance interventions or replacement planning to ease the cumulative financial stress on MSPs.

5.4 Preference for future investments in combine harvesters

We asked CH MSPs about the prospects of their future investment in machinery within the next two years. Among the 400 surveyed MSPs, 345 (approximately 86%) were willing to do so. Of these 345 MSPs, 204 (60%) were willing to purchase a CH within the next two years and reported greater demand for full-feed harvesters. These 204 MSPs were then asked whether they would be willing to purchase any type of CH without a subsidy, and only 22.5% (46 out of 204 MSPs) responded affirmatively. We next inquired about brand preferences and their reasons for choosing a particular brand.

Figure 15: Unsubsidized harvester brand preference



Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Note: This figure is conditional on MSPs being willing to purchase combine harvesters. 204 MSPs revealed their preference for purchasing a harvester within the next two years. Of them, only 46 were willing to do so without any subsidy. None of the MSPs reported preferring to buy Marksan or Field King harvesters.

Understanding the preferences of MSPs in the procurement of CHs is critical for evaluating long-term sustainability and market behavior—particularly in contexts where machines are acquired without government subsidies. While the subsidy program plays a central role in initial adoption, MSPs' choices in unsubsidized purchases offer insights into brand perceptions, service quality, and machine reliability—factors that will become increasingly important as the private market matures.

Figure 15: Unsubsidized harvester brand preference reveals that Kubota and FM World are the two most popular brands among MSPs who may be interested in purchasing a harvester. This likely reflects these brands' superior networks,[15] greater perceived durability or resale value, and stronger market trust.

These patterns are reinforced by the responses summarized in Table 6. Among MSPs willing to purchase CHs without a subsidy, the most cited reason for the selection of any brand was machine quality (42% of respondents). This was followed by 31% who cited "good service offered by the company", highlighting the importance of maintenance and support infrastructure in driving purchase decisions. Price, though still relevant, was cited by only 7% of MSPs, suggesting that long-term performance and reliability outweigh upfront cost considerations for many buyers (particularly at relatively low/subsidized price levels). Other sources of influence—such as advice from dealers, friends, or online forums—account for relatively small shares of decision-making, and no MSPs reported following recommendations from agricultural officers.

Overall, these findings indicate that as the market for agricultural machinery evolves, sustained adoption and diffusion of CHs will depend not only on pricing and subsidy design but also on the availability of high-quality machines backed by strong after-sales service. Supporting the development of such networks will be essential for deepening mechanization in a commercially viable and durable manner.

[15] In Section 4.3, we show that MSPs are more satisfied with the after-sales service and seasonal use performance of Kubota, Yanmar and FM World harvesters.

Table 6: Stated reasons for selecting machines

	Frequency	%
Quality is good	45	42
Service offered by the company is good	33	31
Price is low	8	7
Following suggestions of friends/relatives	7	7
Following suggestions of dealers/agents	6	6
Following suggestions online	6	6
Others	2	2
Following suggestions of agricultural officers	0	0

Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

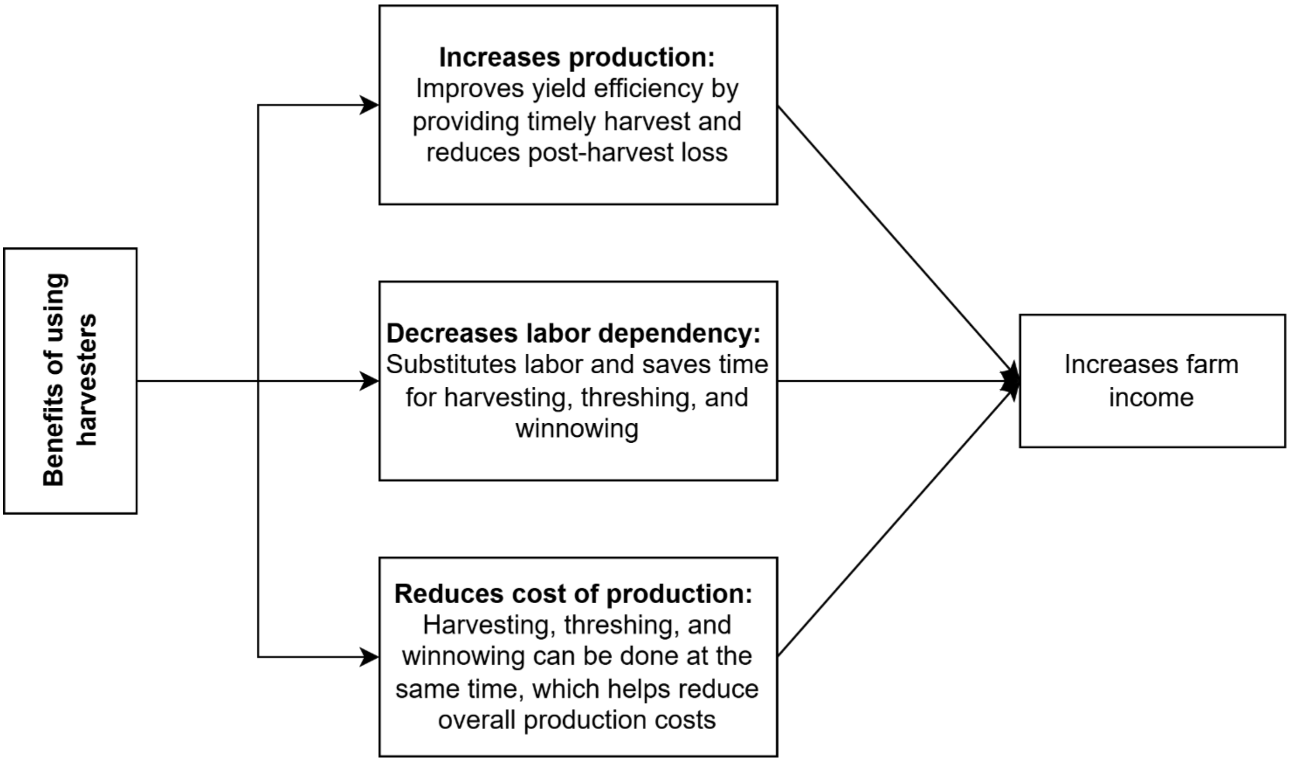
Note: This is a multiple response answer and conditional on MSPs being willing to buy CHs without a subsidy.

CHAPTER 6. CAUSAL IMPACT OF THE SUBSIDY ON FARMING OUTCOMES

6.1 Causal estimates of combine harvester allocation

We assess the causal relationship between government-subsidized CH allocations and farming outcomes in Bangladesh in this chapter. Evidence-based policymaking requires an understanding of the efficacy of such extensive initiatives, particularly for informing future subsidy program design. To estimate the impact of CH allocation, we use the difference-in-differences (DiD) method. DiD is an econometric technique widely used in policy analysis to estimate the causal impacts of policy interventions by comparing changes in outcomes over time between treatment (those who received support) and control (those who did not receive any intervention or were treated less compared to the treatment group) groups.

Figure 16: Causal paths for benefits of using combine harvesters



Source: Authors.

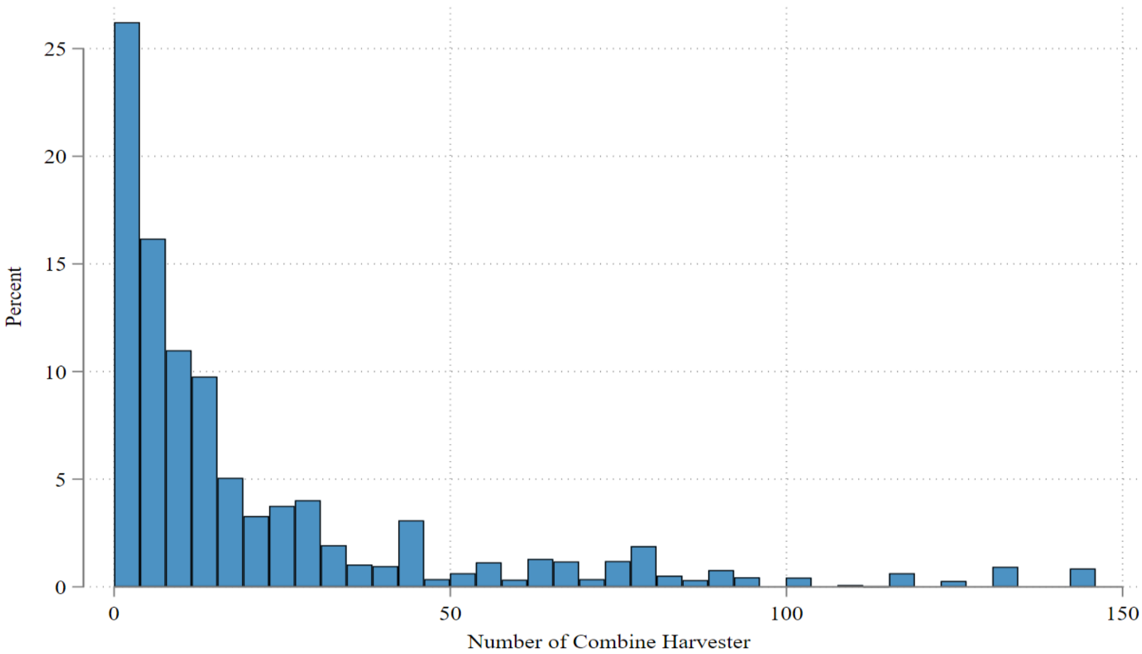
We merge government records on sub-district (upazila) level CH allocations from 2020 to 2023 with farm data on mechanization from BIHS. DAE's official list includes information on 460 upazilas where CHs were distributed under the mechanization support program. Matching administrative data with the BIHS sample (233 upazila) allows the linking of information on farm households from the matched sub-districts. BIHS has information on 233 upazilas across 64 districts. Since our treatment variable is CH allocation at the 75th percentile, there are 60 "treatment" and 173 "control" upazilas. Figure 17: Distribution of combine harvester allocation in selected BIHS upazilas presents the distribution of combine harvester allocation across BIHS sampled sub-districts in Bangladesh based on administrative data compiled through 2023. The histogram reveals a highly right-skewed distribution, suggesting that most sub-districts received a relatively small number of harvesters, while a few received disproportionately large allocations.

On average, 21 CHs were allocated to our BIHS sampled upazilas, whereas the median value is only 8. At the 75th percentile of upazila-level distribution, we find that 26 harvesters have been allocated. As such, we define the "treatment" group as upazilas at or above the 75th percentile in terms of harvester machine allocation, that is, upazilas with 26 or more harvesters. Upazilas with fewer than 26 harvesters are classified as the "control" group. The intervention year is set as 2020, with BIHS 2018/19 serving as the baseline and BIHS/SPIA 2024 as the endline.[16] We also trial different "treatments" by changing the arbitrary cutoff—from the 75th percentile to the 50th, and then up to the 99th percentile. Regardless of the treatment level, we find that the main results remain robust.

$$Y_{ist} = \alpha_i + \beta_1\, Treatment_i + \beta_2\, Post_t + \beta_3\,(Treatment_i \times Post_t) + \beta_4\, Year_t + \beta_5\, X_{ist} + \beta_6\, Upz_i + \varepsilon_{ist} \quad (4)$$

Here, Y_{ist} denotes the outcome variable of interest for individual i, in upazila s, at time t. Outcome variables include paddy yield, hired labor and machine rental costs, farm's status with regard to mechanized harvesting, total production cost, and revenue. X_{ist} represents a vector of farm-level characteristics, such as the gender, education and age of the household head, household size, sharecropping status, and the type of paddy variety used (hybrid or high-yielding).[17] We include year fixed effects ($Year_t$) to control for time-specific unobserved shocks common across all upazilas, and upazila fixed effects (Upz_i) to account for time-invariant characteristics at the sub-district level.

Figure 17: Distribution of combine harvester allocation in selected BIHS upazilas



Source: Authors' calculations using DAE's administrative data.

Note: On average, 21 CHs have been allocated to our sampled upazilas (sub-districts), well above the median value of 8 harvesters. At the 75th percentile, 26 harvesters have been allocated.

First, we present DiD estimates of the impact of the harvester allocation program on key outcome variables without controlling farm-level time-varying observed characteristics (see Appendix Table A6). Then, we estimate the impact by controlling key farm-level characteristics where results remain

[16] This is a panel dataset of more than 2,000 farming households in Bangladesh. For details on BIHS/SPIA, see Chapter 2.2. We consider the 2018 and 2023 boro paddy seasons as our reference periods for the baseline and endline, respectively.

[17] See Appendix Table A5 for a detailed description of the control and outcome variables.

similar as in Appendix Table A6. Table 7 presents the results, controlling for key farm-level characteristics, including household size, household head's gender, age, education level, type of paddy variety, sharecropping status, and farm size. The coefficient on the interaction term (Post × Treat) identifies the average treatment effect on the treated (ATET).

As expected, we observe an increase in mechanized harvesting in the treatment areas post-intervention. The probability of adopting mechanized harvesting increased by 17 percentage points in treated areas compared to control areas. Mechanized harvesting reduced losses during harvesting and resulted in a net gain of 703 kg/hectare, representing a 12.2% gain over the control group mean. Labor costs declined by BDT 10,357/hectare, amounting to a 38% reduction, suggesting a major substitution of manual labor with mechanized harvesting. We see a positive but statistically insignificant effect on the cost of machine rental. This suggests that, on average, machine rental costs remained similar across both treatment and control areas.[18] Total production costs fell by BDT 9,833/hectare (12.2%), indicating that labor cost savings more than offset the marginal rise in machine costs. On the revenue side, we see the effects of yield increase and cost reductions. Farms in "treatment" upazilas earned BDT 17,560/hectare more than those in "control" upazilas, an increase of 16.6%. These results confirm that the introduction of CHs improved both technical (yield) and economic (cost savings and profitability) efficiency.

Table 7: Impact of mechanization (controlling farm-level characteristics)

	(1)	(2)	(3)	(4)	(5)	(6)
	Yield	**Labor cost**	**Mechanized harvesting**	**Machine cost**	**Production cost**	**Revenue**
Post*Treat	703.41**	-10,356.99**	0.17**	378.29	-9,833.20*	17,559.70*
	(269.58)	(3,435.17)	(0.06)	(2,010.86)	(4,621.42)	(7,460.47)
Control mean	5,807.61	26,765.75	0.00	24,464.50	80,393.09	106,357.19
% change	12.2	-38.7	-	-	-12.2	16.6
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Upazila fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors' calculations using BIHS 2018/19 and BIHS/SPIA 2024 data, and administrative data from DAE.

Note: Robust standard errors are in parentheses. * p<0.05, ** p<0.01, *** p<0.001. BIHS has information on 233 upazilas across 64 districts. Since our treatment variable is CH allocation at the 75th percentile, there are 60 "treatment" and 173 "control" upazilas. Paddy yield (kg/hectare), labor cost, machine cost, production cost, and revenue are expressed in BDT/hectare. Here, $Treatment_i$ is a binary indicator, equaling 1 if the upazila is in the 75th percentile for harvester allocation (that is, in the treatment group), and 0 otherwise. $Post_t$ is a binary indicator, equaling 1 for observations in the post-treatment period, and 0 otherwise. The vector of control variables included household size, the household head's gender, age, level of education, the type of paddy variety used in cultivation, sharecropping status, and farm size.

The increase in paddy yield can be attributed to two main factors. First, mechanized harvesting led to efficiency gains by reducing system losses typically associated with manual harvesting. Previous research suggests that mechanized harvesting can improve efficiency by reducing losses at the

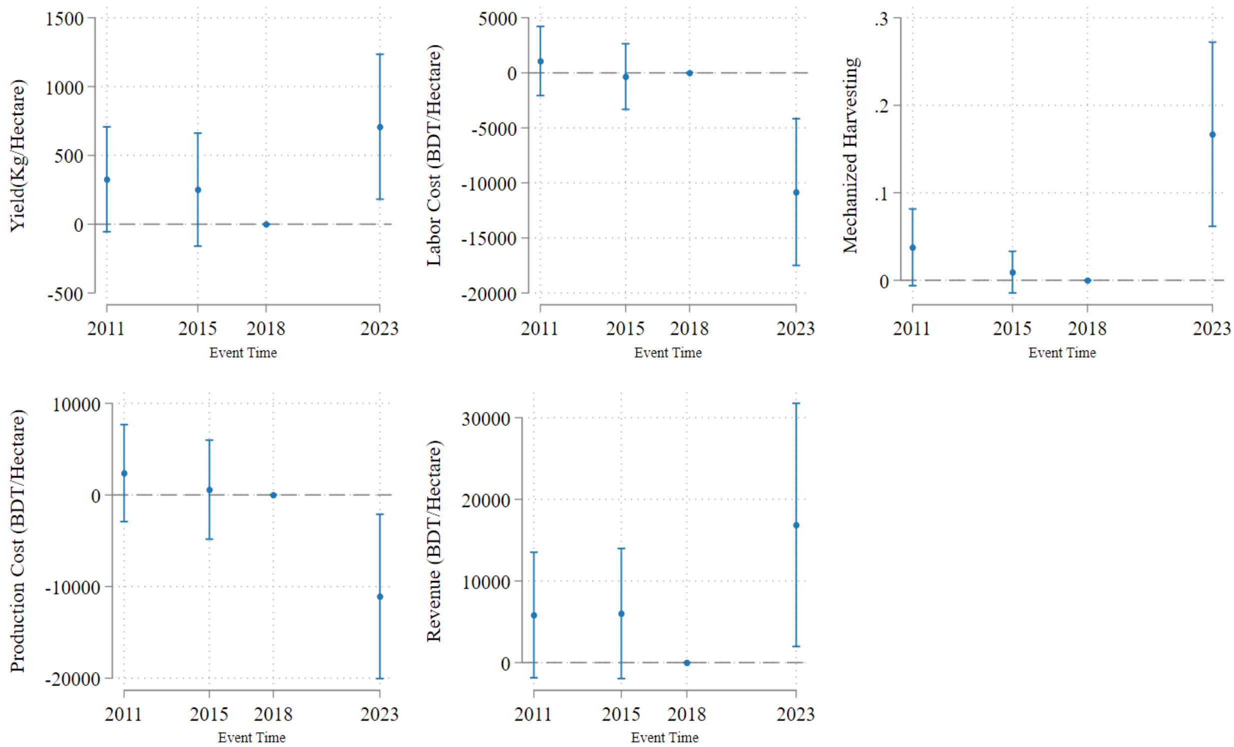
[18] Machine rental prices likely remained stable due to market structure and operational constraints. MSPs operate in highly competitive, seasonal markets with limited pricing flexibility—rapid price increases risk losing customers to competitors from within and outside the upazila. Additionally, MSPs often provide flexible "pay-later" arrangements to maintain long-term farmer relationships, and many offer multiple services (for example, tillage, irrigation, and harvesting), requiring consistent pricing across operations and seasons.

time of harvest by between 4.5% and 5%, depending on harvester size and type (Hasan et al. 2021; Khan et al. 2024). The availability of CHs allowed farmers to complete harvesting operations earlier than usual, helping avoid losses caused by adverse weather conditions such as flash floods.

One of the key assumptions for the validity of a DiD causal estimate is the parallel trends assumption. This requires that, in the absence of the intervention, the outcome variables for the treatment and control groups would have followed similar trends. In other words, there should be no significant pre-intervention differences in outcome trends between the two groups.

Figure 18 provides empirical support for this identification assumption in our DiD specification. Using 2018 as the reference year, we plot the coefficients from interactions between the treatment group and year dummies. The results show that, prior to 2019, the estimated coefficients are statistically indistinguishable from zero, indicating no differential trends between treatment and control groups before the intervention. A statistically significant divergence appears only in 2023, supporting the validity of our DiD framework.

Figure 18: Event study plot for outcome variables relative to intervention year



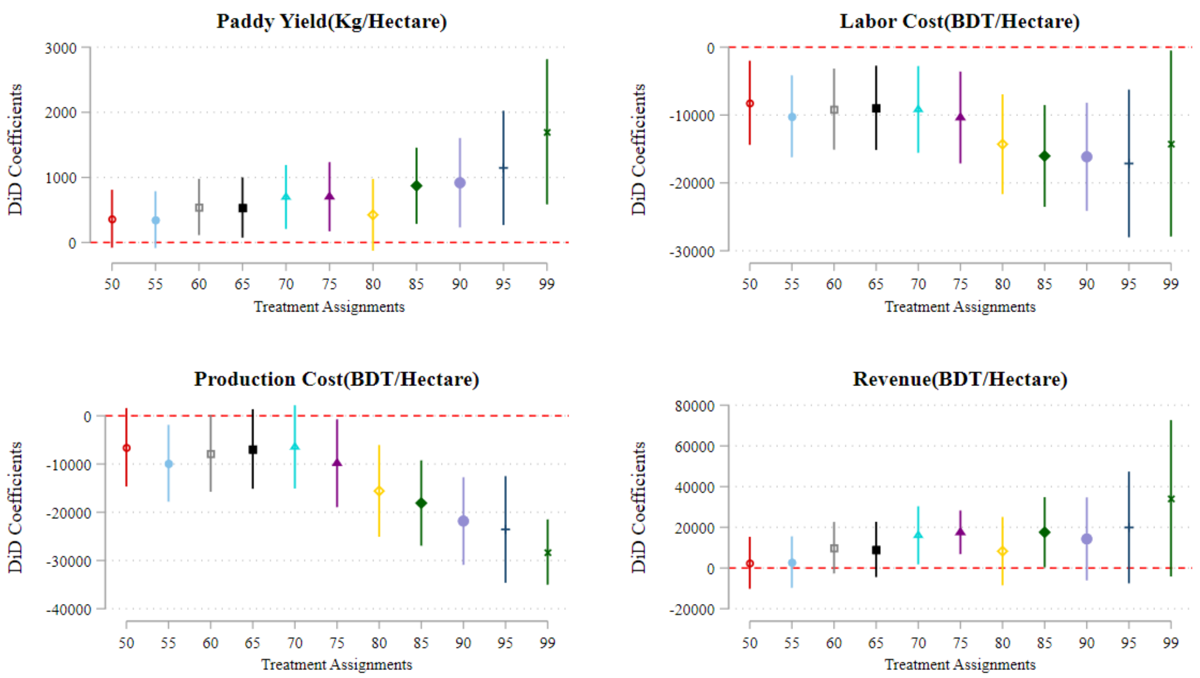
Source: Authors' calculations BIHS 2018/19 and BIHS/SPIA 2024 data, and DAE's administrative data.

Note: The coefficients are reported with 95% confidence intervals (CIs). The event study analysis shows no significant changes in the outcome variables before the intervention in 2019, confirming the parallel trends assumption. Also note that 2018 is the excluded category with which the comparison for other years is being made.

We initially selected the 75th percentile as the cutoff for treatment assignment. However, it is important to test the robustness of our findings by varying this threshold. Figure 19 presents results from sensitivity analyses, where the treatment cutoff is adjusted from the 50th to the 90th percentile in 5-percentage-point increments.

The results show a consistent pattern: as the cutoff increases, the estimated impact on paddy yield becomes larger, while the effects on hired labor and total production costs decrease. This trend suggests that upazilas receiving a higher concentration of combine harvesters experience stronger impacts on key outcome variables, reinforcing the main findings of the analysis.

Figure 19: Heterogeneity analysis with different levels of treatment assignment



Source: Authors' calculations using BIHS 2018/19 and BIHS/SPIA 2024, and DAE's administrative data.

6.2 Future research on welfare analysis

One overarching question remains: does the adoption of CHs lead to an overall gain in social welfare? Our analysis shows clear benefits in terms of increased agricultural production, reduced labor costs, and higher revenue. However, we lack data on how the labor time displaced by mechanization is being reallocated. If the labor saved from harvesting is redirected toward other productive activities, this would suggest a net gain in social welfare. Further research is needed to understand how this labor substitution is being absorbed—whether through shifts to non-farm employment, household enterprises, or other forms of time use—to fully assess the broader economic implications of mechanization.

CHAPTER 7. TARGETING MECHANIZATION SUPPORT: A GEOSPATIAL APPROACH TO DISTRIBUTING COMBINE HARVESTERS

Historically, Bangladesh has pursued agricultural intensification and mechanization to mitigate labor shortages and build resilience against climate-related vulnerabilities (Mainuddin and Kirby 2015). Despite these efforts, the geographical targeting of mechanization subsidies has predominantly followed ad hoc administrative decisions rather than systematic, evidence-based criteria. Consequently, machinery distribution has become uneven, with some districts receiving disproportionately high support, whereas others with considerable potential for productivity gains remain underserved. This chapter addresses this imbalance by proposing an evidence-driven approach to geographical targeting, demonstrating how systematically prioritizing districts can enhance both agricultural productivity and equitable access to mechanization.

7.1 Empirical predictors of rice yield and mechanization need

Least absolute shrinkage and selection operator (LASSO) is a regression analysis method that simultaneously performs variable selection and regularization to enhance predictive accuracy (Tibshirani 1996). Particularly useful in settings characterized by many predictors relative to observations, or when predictors exhibit multicollinearity, LASSO applies a penalty to shrink the absolute size of regression coefficients. This technique effectively simplifies the model by retaining only the most informative predictors, thus reducing complexity and improving interpretability.

LASSO regression was applied to a set of 17 district-wise candidate yield determinants (see Appendix Table A7 for a full list of variables), enabling the identification of those predictors that exert the strongest influence on yield variability. These 17 variables were selected to capture the full spectrum of factors driving rice yield, including socioeconomic conditions (farm and agricultural labor holdings, average wage), mechanization intensity (total machine stock), cropping characteristics (net cropped area, share of irrigated area), infrastructure proxies (road density and electricity availability), and environmental vulnerability (proportions of households affected by drought, flood, salinity, cyclones, storm-tidal surges, river/coastal erosion, fragmentation index, and the number of transboundary rivers).

Building on the results of our LASSO regression analysis, six key predictors of rice yield were identified to assess mechanization need. These predictors encompass cropping intensity, agricultural labor holdings, average annual wages, and infrastructure measured by road density (km of road per sq km area). Additionally, environmental risks such as the proportion of households impacted by drought, and river and coastal erosion, were included as essential determinants. Prior to conducting principal component analysis (PCA), all variables were standardized to ensure comparability across different metrics. Collectively, these variables provide a comprehensive understanding of mechanization demand by capturing labor market dynamics, agricultural productivity potential, infrastructural constraints, and district-level climate vulnerabilities.

7.2 LASSO-PCA ranking of districts for priority allocation

PCA reduces complex datasets with multiple correlated variables into fewer uncorrelated dimensions (principal components), capturing most of the variability (Hotelling 1933; Wold, Esbensen, and Geladi 1987). After selecting the nine most significant yield predictors[19] through LASSO regression,

[19] We provide details of the variables used in the LASSO model in Appendix Table A7.

cropping intensity, agricultural labor holdings, average annual wage, drought exposure, river and coastal erosion exposure, road density, transboundary rivers, storm-tidal surge exposure, and salinity exposure, each variable was standardized to ensure equal contribution to the PCA (Jolliffe 2002). Standardization involved rescaling each indicator on a range from 0 to 1 to avoid dominance by variables with larger numerical scales.

Components with eigenvalues greater than one were retained, distilling the variables into a composite mechanization-priority score for each district (Braeken and Van Assen 2017). Districts were subsequently ranked into five tiers, with higher-ranked districts prioritized for targeted mechanization subsidies.

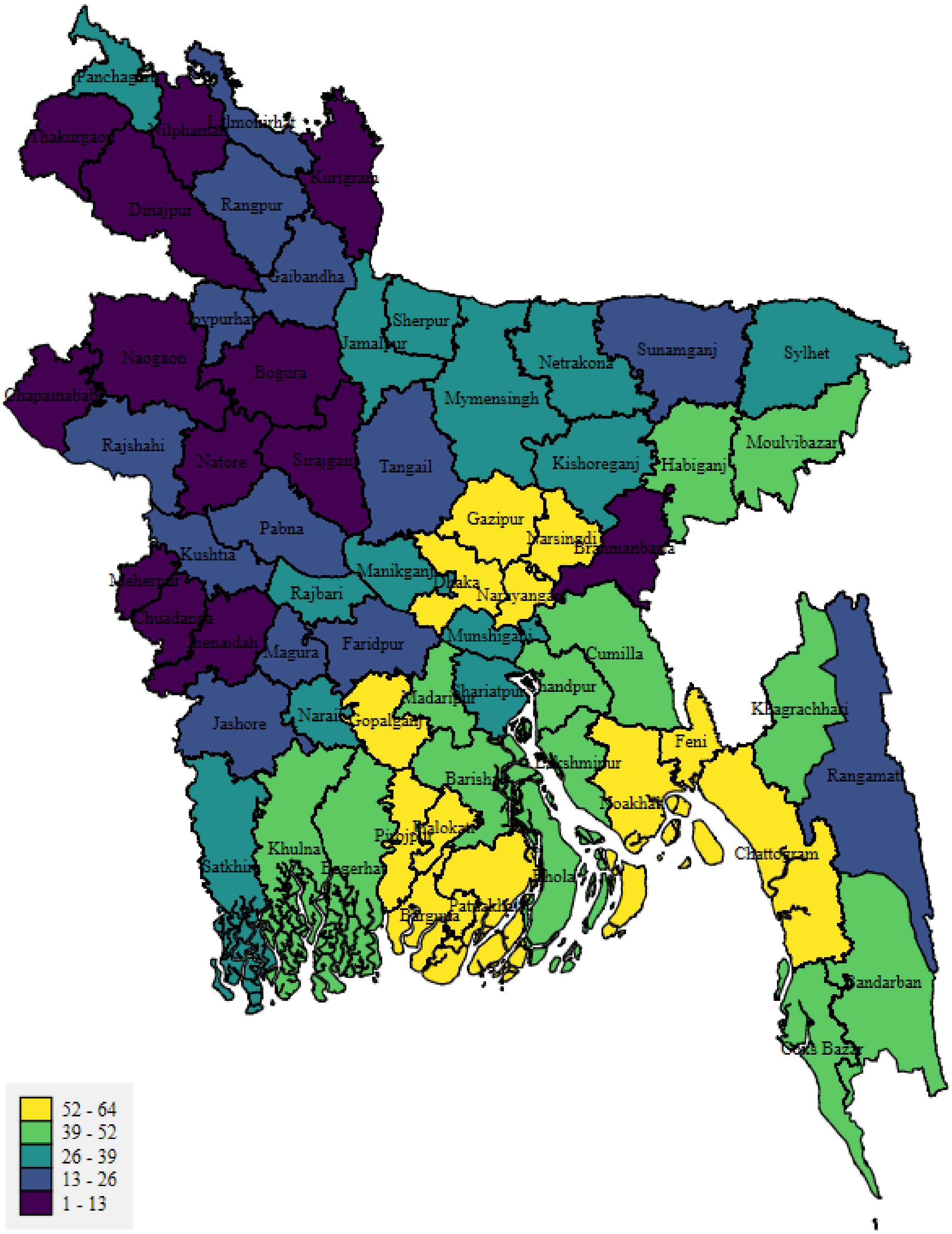
The PCA was conducted using a set of key predictors selected through LASSO regression, including cropping intensity, agricultural labor holdings, average annual wage, drought exposure, river and coastal erosion, and road density. The PCA produced a composite mechanization-priority score for each of Bangladesh's 64 districts, offering an integrated index that accounts for the correlations among variables and reduces redundancy in assessing mechanization need. Figure 20: Rankings of districts based on principal component analysis presents the district rankings by dividing the districts into five major categories. The approach we took is based on static and limited data—this could be updated with progressive data collection every year and can include more variables. Given the data constraints, the results should be interpreted carefully.

The analysis identified several districts in the northwest and western regions, such as Dinajpur, Naogaon, Chuadanga, Jhenaidah, Meherpur, and Chapai Nawabganj, as priority areas for mechanization support due to their high cropping intensity and large share of farm households, yet relatively low CH distribution between 2020 and 2023. Additionally, districts such as Sirajganj and Kurigram, located in the north-central and northern floodplains, also emerged as high-need areas, likely due to periodic labor shortages and vulnerability to climate shocks. By contrast, eastern districts such as Sylhet, Moulvibazar, and Sunamganj, which received high allocations of combine harvesters, were not identified as priority zones through the targeting analysis.

When the PCA-based priority rankings were compared with CH distribution data from DAE for 2020–2023, some misalignments between areas of need and actual allocation became evident. Several high-priority districts, particularly those in vulnerable coastal regions such as Barguna, Bhola, and Patuakhali, as well as centrally located districts such as Shariatpur and Madaripur, were among the top 20% in terms of mechanization need yet received lower priority in the actual distribution of subsidized machines than the model suggested. Conversely, a number of districts ranked in the bottom 20% by PCA, such as Gazipur, Narayanganj, Rajshahi, and Naogaon, received relatively larger shares of subsidized machinery. These areas typically have better infrastructure and pre-existing mechanization levels, which may have inadvertently influenced allocation decisions in their favor. Nontheless, a few districts, including Satkhira, Bagerhat, Khulna, and Cumilla, showed encouraging alignment between priority rankings and actual disbursement. These cases suggest that data-informed distribution can lead to more efficient and equitable outcomes when properly applied. Overall, these findings reinforce the need for a more systematic, evidence-based targeting strategy to guide future mechanization subsidy programs.

While Principal Component Analysis provides a useful framework for synthesizing multiple indicators of mechanization need, we acknowledge its limitations as a targeting tool. The composite scores generated through PCA should be interpreted as one input among several in allocation decisions, not as definitive rankings. Local knowledge, administrative capacity, and political economy considerations inevitably—and perhaps appropriately—influence distribution patterns. Our analysis reveals systematic mismatches between PCA-derived priorities and actual allocations, but perfect alignment with statistical models may neither be feasible nor desirable in practice. Instead, we propose using this framework to identify cases of extreme misallocation and to promote more transparent discussions about trade-offs in geographic targeting.

Figure 20: Rankings of districts based on principal component analysis



Source: Authors' calculations using district level national data from Agricultural Census 2019, Yearbook of Agricultural Statistics, 2023, BBS, Road and Market Database, 2024, Local Government Engineering Department (LGED), Bangladesh Disaster-Related Statistics (BDRS) 2021 (BBS), Nishat et al. (2014), and the Bangladesh Integrated Household Survey 2018/19.

CHAPTER 8. GOVERNANCE, MARKET CONSTRAINTS, AND INSTITUTIONAL CHALLENGES

This chapter explores the systemic challenges that hinder the effective implementation of mechanization support programs in Bangladesh. Drawing on insights from qualitative interviews with key stakeholders, we examine governance bottlenecks, market inefficiencies, and institutional gaps that constrain the potential outcomes of policy interventions.

8.1 Missing machines, informal fees, and profile manipulation

While the official application process for subsidized machinery distribution is clearly outlined, beginning with a call from DAE, followed by applicant screening, approval, and machine handover, the reality on the ground reveals notable deviations. Although the procedure prescribes documentation checks, evaluation by the Upazila Agriculture Committee, and a structured handover involving DAE offices and importers, survey evidence suggests the process is not uniformly implemented.

As mentioned in Chapter 2, to complete our survey of 400 CH MSPs, we reached out to 552 CH owners as listed by DAE on account of being unable to perform a spot verification of harvesters. Of these, 28% could not be physically located, with recipients unable to provide evidence of machine ownership or use. Another 6% of machines were found to be no longer operational. Moreover, 57 additional CHs (14% of the final sample) were identified through snowball sampling that were not part of DAE's official list, suggesting that these machines were registered elsewhere, or that secondary market transactions took place.

There is also evidence of manipulation in the registration process. While 73% of machines were officially registered in the MSP's own name, the remaining 27% were listed under a relative's name or in joint ownership, potentially to circumvent eligibility criteria or the three-year ownership restrictions. Additionally, 14% of surveyed applicants reported paying unofficial fees, averaging BDT 59,000, to local officials to secure approval or expedite allocation.

These findings point to significant implementation and monitoring gaps. The current 50–70% regional subsidy differential creates incentives for applicants from lower-subsidy regions to apply using addresses in higher-subsidy regions (Haor and coastal areas). Local DAE offices then lack the capacity to thoroughly verify applicant credentials, enabling such circumvention. Combined with the documented cases of missing machines and informal payments, these governance weaknesses undermine both program integrity and equitable access to mechanization support.

8.2 Market failure and political economy of allocation

Information asymmetries and market quality issues: The CH market exhibits classic "lemon market" characteristics (Akerlof 1978), where information imbalances between sellers and inexperienced MSPs have enabled machines of varying quality to enter the market. Many MSPs made purchasing decisions based on sellers' optimistic projections without independent quality assessment. Survey evidence shows MSP preferences for established brands (Kubota, Yanmar, and FM World) over others, particularly Banglamark, which entered the market following the subsidy program's establishment using aggressive marketing tactics. This pattern echoes earlier experiences with Chinese PTs in the 1980s, where quality improved only after increased competition and market maturation (Mandal 2017a).

Payment disputes and service failures: MSPs frequently delay installment payments to machinery suppliers despite reporting substantial revenues. Interviews reveal this reflects strategic behavior: MSPs use payment delays as leverage to secure better after-sales service, effectively treating withheld payments as informal insurance against inadequate warranty support. With suppliers obligated to provide two years of after-sales support but MSPs reporting consistent dissatisfaction with service quality and spare parts availability, delayed payments become a mechanism to compel continued supplier engagement beyond warranty periods.

8.3 Price mark-ups

Table 8 reveals significant variation in pricing practices across machinery brands, raising concerns about potential distortions in the subsidy program. While the average markup across brands is 47%, some brands apply considerably higher margins. In particular, Marksan exhibits a striking 113% markup, selling machines at more than double their import price.[20] By contrast, well-established brands such as Kubota and Field King maintain relatively moderate markups of 27% and 31%, respectively. These disparities suggest that certain importers may be inflating prices in anticipation of government subsidies, potentially undermining the cost-effectiveness of the program and reducing the real value of the subsidy for end-users. Greater transparency in price-setting and stricter oversight may be needed to curb excessive markups and ensure equitable access.

Table 8: Markups on imported combine harvesters by brand—evidence of pricing distortions in the subsidy program

Brand	Import Price	Sales price (before subsidy)	Markup (BDT)	Markup (%)
Yanmar	2,500,000	3,418,571	918,571	37
Marksan	1,532,495	3,265,000	1,732,505	113
FM World	2,034,806	2,833,876	799,070	40
Kubota	2,717,000	3,441,610	724,610	27
Field King	2,377,000	3,106,667	729,667	31
Average	2,190,361	3,213,145	1,022,784	47

Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25, and the National Board of Revenue (NBR)'s machinery import data from 2020 to 2024.

Note: We use NBR's machinery import data from 2020–2024 to calculate the imported price of machines. The import price includes all relevant tariffs (CD, RD, SD, AT, AIT and VAT). The total tax incidence (TTI) is 26.2% and has remained constant between 2020 and 2024. Sales prices are calculated from the IFPRI Bangladesh MSP Survey 2024/25.

8.4 Financing barriers

Financing barriers constrain mechanization access, particularly for farmers requiring capital-intensive equipment. Currently, no specialized loan schemes exist for CH purchases. The government's three-year ownership transfer restriction prevents banks from using machinery as collateral and

[20] The import and selling price analysis for Marksan combine harvesters presented methodological challenges due to substantial price variations across shipments and models. To ensure accuracy, we analyzed three models included in the subsidy program: BM 608 (72 HP), MS700 4LZ 1.6Z (70 HP), and MS700 4LZ 5Z (120 HP). National Board of Revenue (NBR) data reveals that unit prices fluctuate significantly based on shipment volumes, necessitating weighted averages for each model. We then calculated an overall weighted average across all three models to derive representative import prices. These pricing irregularities have attracted media attention, with Channel 24 reporting markups as high as 300% over import costs. Report link: https://www.youtube.com/watch?v=MEBriD2cZJ0.

most MSPs (68%) use informal financing at high interest rates (averaging 20–31% annually). This restriction, intended to ensure equipment commitment, inadvertently creates financing bottlenecks for both farmers and importers.

Addressing these constraints requires innovative financing models such as government-backed loan guarantees, seasonal repayment schedules aligned with agricultural cash flows, or hire-purchase schemes that bypass ownership restrictions.

CHAPTER 9. CONCLUSIONS AND POLICY RECOMMENDATIONS

Our assessment of Bangladesh's agricultural mechanization initiatives highlights a story of mixed outcomes - one where real progress has been made but key gaps still remain. The program has expanded access to harvesting services and has helped farmers in program-intensive areas, such as the Haor areas, to reduce their reliance on manual labor during peak seasons as well as to combat the risk of early flash floods. Consequently, we see meaningful improvements: a 12.2% yield increase, which likely reflects both reduced field losses and the ability to harvest at optimal timing before weather-related damage. Additionally, labor costs have come down, and farmers have made more money. These are no small achievements.

But this success has not been universal. We show how critical governance, market and value chain coordination, and institutional challenges undermine the effectiveness of the program. Field evidence reveals substantial deviation from the formal application process for machinery subsidies, with 28% of listed machines untraceable and 14% of applicants reporting unofficial payments. Survey data suggest that manipulation of eligibility criteria and registration under relatives' names reflects pervasive rent-seeking behavior and weak oversight. MSPs appear to have at times purchased low-quality machines based on exaggerated revenue projections from sellers, leading to frequent breakdowns and dissatisfaction with after-sales service. Our evidence suggests that price markups across brands are significant, with some exceeding 100%, reducing the real benefit of subsidies.

Financing constraints further limit access to mechanization. Restrictions on machine transferability appear to hinder collateral use, discouraging formal lending for machinery from banks and other financial services providers. MSPs consequently rely on high-interest informal loans, which likely exacerbate their financial vulnerability. Cooperative-based mechanization and synchronized farming initiatives—while useful in principle—have faced issues of trust and poor coordination among farmers, logistical complexity, and inequitable input distribution. Our qualitative analysis suggests that this may particularly disadvantage smallholders.

Together, issues ranging from weak implementation and market inefficiencies to poor coordination highlight the need for better regulatory oversight, transparent allocation mechanisms, improved financial instruments, careful matching of regulations, subsidies, government-led extension activities with the agronomic challenges farmers face, and socially inclusive program design to realize the full potential of mechanization in enhancing agricultural productivity and equity in Bangladesh. In particular, little focus has been placed on addressing machinery breakdowns or the availability of quality spare parts. While there are initiatives in Bangladesh that do address these issues, more focus is required from Government to support these efforts.

Is the program worth continuing? Yes—but substantial reforms are needed. The evidence demonstrates that mechanization generates significant productivity and income gains where implemented effectively. However, realizing the program's full potential requires moving beyond simple machine distribution toward building sustainable, inclusive mechanization systems. Efforts are also needed to examine the broader welfare effects of mechanization to fine-tune efforts and avoid unintended negative consequences—particularly on rural welfare and labor markets.

Future efforts should prioritize building inclusive service markets that reach smallholder farmers, creating financing mechanisms tailored to seasonal agricultural cash flows, establishing transparent governance systems from application through after-sales support, and affordable and timely access to spare parts combined with training of machinery operators to diagnose and overcome breakdowns. Success depends on designing policies around the lived realities of small farmers, machine operators, and rural entrepreneurs rather than administrative convenience.

With evidence-based targeting, innovative financing, and strengthened local capacity, mechanization can contribute meaningfully to more productive, resilient, and equitable food systems in Bangladesh. The following sections outline specific reform priorities to achieve these objectives.

9.1 Removing import tariffs on agricultural machines and promoting local industry

The NAMP 2020 and the Mechanization Action Plan 2023 underscored the need to lower tariffs on agricultural machinery to boost farm productivity and affordability. The 2023 Action Plan specifically targeted a reduction to a 1% tariff on harvester imports and spare parts production by 2025. However, progress on these commitments has been stagnant. Minimizing the current import tariffs can reduce combine harvester prices by at least 25%, offering a cost-effective alternative to subsidies and enabling broader access to modern equipment for improved agricultural efficiency. Additionally, spare parts for harvesters remain costly, and have import tariffs ranging from 26–37%. Supporting the local assembly and manufacturing sector through measures such as reducing tariffs on raw materials and spare parts, providing low-cost financing for capital machinery purchases to establish assembly lines, implementing proper standardization guidelines for spare part quality, and strengthening manufacturers' capacity through regular training will be instrumental in driving the sector's growth.

9.2 Reform allocation approach: Evidence-based targeting vs. market mechanism

The current differential subsidy rates—70% for Haor and coastal areas versus 50% elsewhere—reflect legitimate policy priorities given these regions' vulnerability to flash floods and climate extremes. However, the system has created some unintended distortions in machine distribution. While these climate-vulnerable regions merit support, our analysis reveals that high-productivity areas in Rajshahi and Rangpur divisions—with intensive rice cultivation and acute labor shortages—remain underserved.

Two primary pathways could address these allocation inefficiencies:

Option 1: Market-driven allocation with tariff reform. Phase out geographic targeting and direct subsidies while eliminating/reducing the current import tariff on agricultural machinery. This tariff removal would effectively provide a universal 25% price reduction—comparable to moderate subsidies but without administrative costs or targeting distortions. Market forces would then direct machines to areas of highest demand and profitability. Climate-vulnerable regions could still receive support through geographically-targeted concessional credit rates rather than equipment subsidies, maintaining policy flexibility while reducing market distortions.

Option 2: Evidence-based geographic targeting. If centralized allocation continues, replace current ad hoc decisions with transparent, data-driven frameworks. The preliminary LASSO-PCA approach demonstrated in Chapter 7—while requiring further refinement—illustrates how statistical methods can identify priority districts based on mechanization need indicators including labor availability, cropping intensity, climate vulnerability, and infrastructure quality. This framework should be updated annually with fresh data and expanded to consider differential needs across machinery types (e.g., some districts may require power tillers more than combine harvesters).[21] This would replace the current *ad hoc* system with a transparent and regularly updatable targeting framework aligned with changing agroecological and economic conditions. Also, rather than a "one size fits all" strategy, the respective needs of a district or region should be considered when prioritizing stages of operation, or which machines should be included in the subsidy program. A particular district may have greater need for PTs than CHs, and the program should be responsive to such differential priorities.

A hybrid approach could also combine reduced universal subsidies with targeted support in data-guided high-need areas, balancing market efficiency with strategic intervention where market failures persist. The choice among these options depends on whether policymakers prioritize immediate mechanization expansion through subsidies or longer-term market development through tariff reform and institutional strengthening.

9.3 Standardize subsidy rate and design

If centralized allocation continues rather than shifting to market-based distribution, reforming the current subsidy structure becomes critical. While differential rates serve important policy goals, they have inadvertently created opportunities for misuse, with applicants from 50% subsidy regions reportedly using dummy applicants on their behalf in 70% subsidy areas to access higher benefits. Field verification found 28% of machines missing from registered locations, suggesting some combination of fictitious allocations and cross-district applications seeking higher subsidy rates.

Should the government maintain a subsidy-based approach, it could establish a moderate uniform base rate supplemented by transparent, need-based top-ups for data-guided high-priority areas. International experience offers important lessons for any continued subsidy program. South Korea's mechanization subsidies led to machine oversupply, particularly of power tillers and harvesters (Kim 2009). To avoid similar outcomes, the government could implement demand assessment procedures to calibrate subsidized machines to actual need.

If subsidies remain the primary policy tool, strengthening governance through digital systems becomes essential:

- **Digital application platforms** with geotagging and national ID integration to reduce fraudulent applications
- **GPS-enabled machine registration** for tracking machine locations and utilization patterns
- **Regular third-party audits** of machine allocation and usage to identify discrepancies
- **Transparent online dashboards** showing district-wise allocations and application status

These measures would improve program integrity while maintaining flexibility for MSPs to operate across districts according to business opportunities, regardless of which allocation approach is ultimately chosen.

9.4 Strengthening after-sales service, training, and quality standards

Our interviews with MSPs reveal high levels of dissatisfaction with after-sales service. In addition, poor build quality and frequent machinery breakdown, lack of knowledge regarding machine opera-

[21] Before the results from LASSO or PCA as presented in this report are utilized, more nuanced analysis that includes a wider range of variables related to rice harvesting should be included through further research.

tion and maintenance, and the unavailability and high cost of spare parts remain major factors contributing to downtime during the harvest season. To address these challenges, ensuring machinery reliability and serviceability is crucial.

Quality standards and certification: Establishing stringent quality standards and certification processes for both imported and locally manufactured machinery would safeguard consumer interests and promote market integrity. Reviving the National Agricultural Machinery Standardization Committee could be a major priority. Additionally, user feedback metrics could be developed to evaluate the performance of specific brands and models. A consumer protection policy could also be developed for ensuring after-sales service. The GoB could conduct periodic inspections of agricultural machinery to assess their eligibility for continued financial support.

Capacity building for MSPs: Comprehensive training programs for MSPs should focus on technical skills, business management, and financial literacy. Additionally, transparent information sharing regarding costs, benefits, and risks associated with different machinery options would empower MSPs to make informed decisions. Additionally, manuals for training and maintenance should be developed in Bangla, and local institutions such as BARI, BRRI, and private sector actors can be engaged to jointly develop such resources.

Specialized training programs: Investing in specialized training programs for rural mechanics—for example, as the CSISA-MEA project has focused on—would enhance their skills and enable them to provide effective after-sales service and repair services.

Empowering extension services: District agricultural engineers need be empowered to play a more proactive role in promoting mechanization. Following their training to ensure capabilities relevant to CHs, they could provide technical guidance, troubleshoot problems, and facilitate access to credit and insurance. At the same time, upazila-level extension officers should receive targeted capacity-building support to equip them with the knowledge and skills necessary for guiding farmers and MSPs in machinery selection, usage, and maintenance. By enhancing the technical competence of field-level extension personnel, the government can foster a more informed, responsive, and trusted support system that bridges the gap between machinery suppliers, policymakers, and end-users. Significant progress towards these aims has been made by the CSISA-MEA project, though further efforts are needed.

Revisiting agricultural training institutes (ATIs): ATIs in Bangladesh are crucial to advancing mechanization by equipping farmers and extension service providers with essential skills for operating and maintaining agricultural machinery. Through hands-on training, ATIs can potentially introduce diverse machinery and effective techniques for crop production, while also providing instruction on maintenance and basic repairs to minimize equipment downtime and prolong machinery lifespan.

9.5 Enhancing access to finance

Specialized agricultural financing schemes are essential to support local machinery manufacturers, spare parts producers, and importers—all key players in advancing mechanization in agriculture. Although the current mechanization policy, mechanization road map, and agricultural financing policies highlight the importance of providing dedicated credit schemes, the directives for their implementation lack specificity, leading to challenges in practical application. For instance, although the Mechanization Plan of Action 2023 proposed providing loans at a 4% interest rate to purchase machinery and support local manufacturing, no significant progress has been made in implementing this provision.

Both the agricultural credit and small and medium enterprise credit policies underscore the need for loans targeted at agricultural entrepreneurs and the spare parts manufacturing sector. However, these guidelines remain insufficiently articulated, creating ambiguity around eligibility and prioritization. Due to limited access to low-cost financing, local manufacturers struggle to invest in essential capital machinery required for producing high-quality agricultural equipment.

Facilitating affordable credit for these manufacturers would enable critical investments in capital assets, enhancing their capacity to produce quality machinery and ultimately contributing to sustainable mechanization efforts in the sector. Countries that serve as good mechanization examples, such as Thailand, Vietnam, and South Korea, provide support for machinery financing, either in the form of subsidies or lowered interest rates. Thailand provides loans at 4–6% interest rates for purchasing machines, while Vietnam provides zero-interest financing on the purchase of big machines and setting up new entrepreneurships (Hossen et al. 2020). South Korea provides subsidies in the form of loans (Kim 2009).

Finally, the lack of customized financial products—such as seasonal credit or hire-purchase schemes—[22] excludes MSPs and farmers. Innovative financing instruments, including government-backed loan guarantees and flexible repayment structures, are essential to lower entry barriers for small-scale service providers.

9.6 Monitoring and evaluation feedback loops, and digitizing applications

We observe that a significant gap persists in program monitoring, evaluation and feedback. As per project guidelines, Upazila Agriculture Offices are responsible for nominating beneficiaries, monitoring machinery, and holding beneficiaries accountable for misuse. However, we observe no proper monitoring mechanism in practice. A dedicated national monitoring body should be established to oversee the program's implementation, ensuring transparency, accountability, and adherence to allocation policies. Since DAE has other ongoing projects offering machines to farmers at low or no cost, coordination across these projects should be maintained.

To enhance allocation integrity, the government should implement the digital systems discussed in Section 9.2—including GPS-enabled machine registration and transparent online dashboards showing district-wise allocations. Post-distribution audits and community validation mechanisms can verify that machines reach intended beneficiaries. Regular third-party verification, as mentioned in our governance findings, could help address the 28% of machines that could not be located during field visits.

A transparent and equitable beneficiary selection process, based on objective criteria and community involvement, can ensure that the program reaches the most vulnerable and marginalized farmers. To promote fair participation, subsidies should avoid repeated allocations to the same households within short timeframes. Distributing machinery to the same family within three years restricts

[22] Belton et al. (2021) studied the evolution of mechanization in Myanmar and found that the hire-purchase scheme is an effective tool for machinery financing. Hire-purchase is a financing model that enables farmers to acquire agricultural machinery through installment payments, with ownership transferred upon completion. In Myanmar, it exists in two forms: direct loans from machinery dealers and hire-purchase arrangements via banks partnered with retailers. Given that banking regulations typically limit credit based on fixed assets, direct lending by banks for high-cost machinery (for example, CHs or four-wheel tractors) remains limited. The involvement of machinery dealers as intermediaries in bank-backed hire purchase schemes helps to overcome these regulatory constraints and the problem of information asymmetry between lenders and borrowers. Retailers play a crucial role by screening clients and acting as guarantors, thereby lowering the risk of default for financial institutions. This partnership-based model improves credit flow, especially in rural areas with weak formal credit penetration. Overall, hire-purchase expands access to mechanization, facilitates capital investment, and supports productivity-enhancing technology adoption in agriculture.

program access for other eligible participants. From a welfare perspective, such practices risk concentrating public resources among wealthier farmers, limiting smallholder access to mechanization.

Finally, as noted in Chapter 6, the mechanization program should be complemented by research and monitoring initiatives to assess how displaced agricultural labor is being reallocated. Understanding labor substitution patterns will help evaluate the broader welfare impacts of mechanization and inform the design of complementary policies if needed.

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APPENDIX 1. ADDITIONAL TABLES

Table A1: Distribution of qualitative interviews conducted

Stakeholders	Methods	Number of interviews
Farmers and cooperatives	IDIs, FGDs	50
Machinery service providers and cooperatives	IDIs, FGDs	40
Mechanics	IDIs	10
Machinery suppliers (importers and manufacturers)	IDIs	5
Local spare parts producers	KIIs	3
Upazila DAE officials	KIIs	7
Project personnel	KIIs	2
Academics and researchers	KIIs	5
Other development organizations	KIIs	2
Financial institutions	KIIs	4
Total	**-**	**128**

Source: Authors.

Note: The qualitative interviews captured a broad spectrum of mechanization-related issues, extending beyond CHs to encompass the overall dynamics of agricultural mechanization in Bangladesh. Discussions with stakeholders addressed topics such as access to machinery, service delivery models, maintenance and spare parts availability, institutional support, financing mechanisms, and the enabling policy environment. This comprehensive approach allowed for a deeper understanding of the challenges, opportunities, and interlinkages shaping the mechanization ecosystem at various levels.

Table A2: Number of machineries allocated at different subsidy rates, 2020–2024

Machine type	Number of machines distributed at 50% rate	Number of machines distributed at 70% rate	Total number of machines distributed
Seeders/bed-planters	8,100	3,959	**12,059**
Rice transplanters	167	204	**371**
Power sprayers	148	17	**165**
Power weeders	32	7	**39**
Potato diggers	768	308	**1,076**
Maize shellers	1,002	307	**1,309**
Reapers	1,556	771	**2,327**
Combine harvesters	3,560	5,352	**8,912**
Power threshers	5,979	3,077	**9,057**
Dryers	9	24	**33**
Total machines distributed	**21,321**	**14,026**	**35,347**
Machine allocation (in %)	**60**	**40**	**100**

Source: Authors' calculations using data from DAE's machinery allocation database.

Table A3: Basic characteristics of combine harvesters (CHs)

Type of harvester			
	(N)	(Percent)	(Horsepower)
Head Feed	110	27.50	66
Full Feed	290	72.50	88
Total	**400**	**-**	**-**
CH brands			
	(N)	**(Percent)**	**(Horsepower)**
Lovol	34	8.50	96
Zoomlion	32	8.00	95
Others	21	5.25	88
FM World	99	24.75	86
Field King	15	3.75	85
Marksan	24	6.00	78
Kubota	81	20.25	71
Yanmar	94	23.50	70

Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Table A4: Average price of combine harvesters with and without subsidy by brand

Brand	Full market price (BDT)	Price after 50% subsidy (BDT)	Price after 70% subsidy (BDT)
Yanmar	3,351,429	1,788,235	1,438,880
Marksan	3,265,000	1,560,000	1,039,211
FM World	2,829,495	1,482,896	926,895
Kubota	3,409,727	1,885,455	1,440,491
Lovol	3,122,059	1,628,571	1,031,500
Zoomlion	2,787,586	1,506,250	945,300
Field King	3,106,667	1,561,111	906,000
Others	3,007,895	1,537,500	1,152,400
Overall	**3,137,539**	**1,629,332**	**1,205,699**

Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Table A5: Description of variables used for causal estimation

Variable name	Measurement unit	Description
Control variables		
Household (HH) head age	Years	
HH head gender	Dummy	=1 if HH head is male
HH head education	Years	HH head years of schooling
HH workforce size	Persons	Number of family members above 15≥ years of age, not including migrant members
Hybrid variety	Dummy	=1 if HH used HYV or hybrid rice varieties
High yielding varieties (HYV)	Dummy	=1 if HH used HYV rice varieties
Farm size	Total operable area in hectares	Total operated land = (Owned + Leased in) – Leased out
Sharecropper	Dummy	=1 if farm is a share crop
Outcome variables		
Harvesting	Dummy	=1 if HH used mechanized harvesting
Paddy yield	kg/hectare	Measured as total paddy production divided by cultivated area
Labor cost	BDT/hectare	All hired labor costs from land preparation to threshing
Machine cost	BDT/hectare	Cost of hiring/using own machine from land preparation (including irrigation) to threshing
Production cost	BDT/hectare	This includes all types of production costs – seed and seedlings, fertilizers, agrochemicals, hired labor, and machine costs.
Revenue	BDT/hectare	Market value of total paddy output using village-level median paddy price

Source: Authors.

Table A6: Impact of mechanization (without controlling for farm-level characteristics)

	(1)	(2)	(3)	(4)	(5)	(6)
	Yield	**Labor cost**	**Mechanized harvesting**	**Machine cost**	**Production cost**	**Revenue**
Post*Treat	746.02**	-10,529.78**	0.17**	332.80	-10,531.50*	18,814.32*
	(278.40)	(3,474.37)	(0.06)	(1,919.17)	(4,648.17)	(7,878.91)
Control mean	5,807.61	26,765.75	0.00	24,464.50	80,393.09	106,357.19
% change	12.8	-39.3	-	1.4	-13.1	17.7
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Upazila fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	No	No

Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25, and the 2018/19 and 2024 BIHS/SPIA rounds.

Note: Robust standard errors are in parentheses. * p<0.05, ** p<0.01, *** p<0.001. BIHS has information on 233 upazilas across 64 districts. Since our treatment variable is CH allocation at the 75th percentile, there are 60 "treatment" and 173 "control" upazilas. Paddy yield (kg/hectare), labor cost, machine cost, production cost, and revenue are expressed in BDT/hectare. Here, $Treatment_i$ is a binary indicator, equaling 1 if the upazila is in the 75th percentile for harvester allocation (that is, in the treatment group), and 0 otherwise. $Post_t$ is a binary indicator, equaling 1 for observations in the post-treatment period, and 0 otherwise.

Table A7: Variables used for least absolute shrinkage and selection operator (LASSO) regression

No.	Variable	Definition	Source
1	Rice yield	Total rice production divided by total area under rice production	Yearbook of Agricultural Statistics, 2023, Bangladesh Bureau of Statistics (BBS)
2	Number of farm holdings	Number of agricultural production units having cultivated land equal to or more than 0.05 acres (approximately 0.02 hectares)	Agricultural Census 2019
3	Agricultural labor holdings	Households whose major source of income during the preceding year was obtained by working as agriculture labor	Agricultural Census 2019
4	Average wage	Mean of the twelve-monthly average daily wage rates paid to hired agricultural laborers for crop-related operations	Yearbook of Agricultural Statistics, 2023, BBS
5	Total number of machines	Agricultural machineries owned	Agricultural Census 2019
6	Net cropped area	Total area of land cultivated with one or more crops during the year, excluding periods when the land remains fallow	Yearbook of Agricultural Statistics, 2023, BBS
7	Cropping intensity	Number of crops a farmer grows in a given agricultural year on the same field	Yearbook of Agricultural Statistics, 2023, BBS
8	Share of irrigated area in gross cropped area	Shares of irrigated area in gross cropped area and reported as percentages	Yearbook of Agricultural Statistics, 2023, BBS
9	Road density per square km	Total length of rural roads (including earthen and paved) divided by total area of the district (km road per sq km area)	Road and Market Database, 2024, Local Government Engineering Department (LGED)
10	Lack of electricity	Percentage of households without access to electricity (interconnected grid, generator, solar panel, etc.)	Multiple Indicator Cluster Survey (MICS), 2019
11	Proportion of storm and tidal surges	Share of households in a district hit by abnormal sea-level rises during storms	Bangladesh Disaster-Related Statistics (BDRS), 2021, BBS
12	Proportion of river and coastal erosion	Share of households in a district suffering land loss along riverbanks or coastlines due to erosive forces	BDRS, 2021, BBS
13	Number of trans-boundary rivers	Number of rivers shared by the border of each district	BDRS, 2021, BBS
14	Proportion of drought-affected households	Share of households in a district experiencing insufficient precipitation	BDRS, 2021, BBS
15	Proportion of flood-affected households	Share of households in a district affected inundated by overflowing water	BDRS, 2021, BBS
16	Proportion of salinity-affected households	Share of households in a district affected by seawater penetrating freshwater aquifers	BDRS, 2021, BBS

No.	Variable	Definition	Source
17	Proportion of cyclone-affected households	Share of households in a district impacted by rotating windstorms (cyclones)	BDRS, 2021, BBS
18	Fragmentation Index	Calculated for each farm as the ratio of the square root of total farm area to the sum of the square roots of each individual plot's area, yielding a value between 0 and 1 (higher values indicating less fragmentation)	Bangladesh Integrated Household Survey (BIHS), 2018/19

Source: Authors.

Table A8: Rankings of all 64 districts based on principal component analysis (PCA)

District	Ranking
Dinajpur	1
Jhenaidah	2
Chapai Nawabganj	3
Chuadanga	4
Natore	5
Naogaon	6
Kurigram	7
Sirajganj	8
Nilphamari	9
Meherpur	10
Brahmanbaria	11
Bogura	12
Thakurgaon	13
Gaibandha	14
Lalmonirhat	15
Rangpur	16
Faridpur	17
Rajshahi	18
Joypurhat	19
Pabna	20
Tangail	21
Jashore	22
Rangamati	23
Kushtia	24
Magura	25
Sunamganj	26
Rajbari	27
Narial	28
Panchagarh	29
Satkhira	30
Mymensingh	31

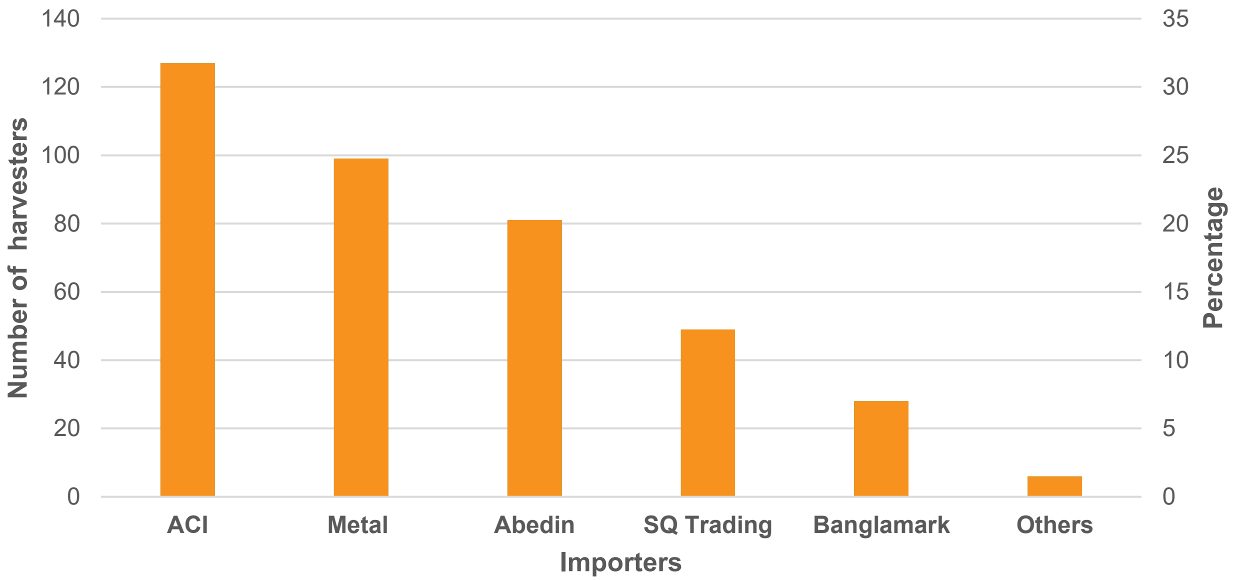
District	Ranking
Jamalpur	32
Sherpur	33
Netrakona	34
Manikganj	35
Sylhet	36
Shariatpur	37
Munshiganj	38
Kishoreganj	39
Chandpur	40
Khagrachhari	41
Lakshmipur	42
Cox's Bazar	43
Moulvibazar	44
Habiganj	45
Bandarban	46
Khulna	47
Cumilla	48
Madaripur	49
Bhola	50
Barishal	51
Bagerhat	52
Gopalganj	53
Patuakhali	54
Noakhali	55
Narayanganj	56
Chattogram	57
Narsingdi	58
Feni	59
Pirojpur	60
Barguna	61
Dhaka	62
Gazipur	63

District	Ranking
Jhalokati	64

Source: Authors.

APPENDIX 2. ADDITIONAL FIGURES

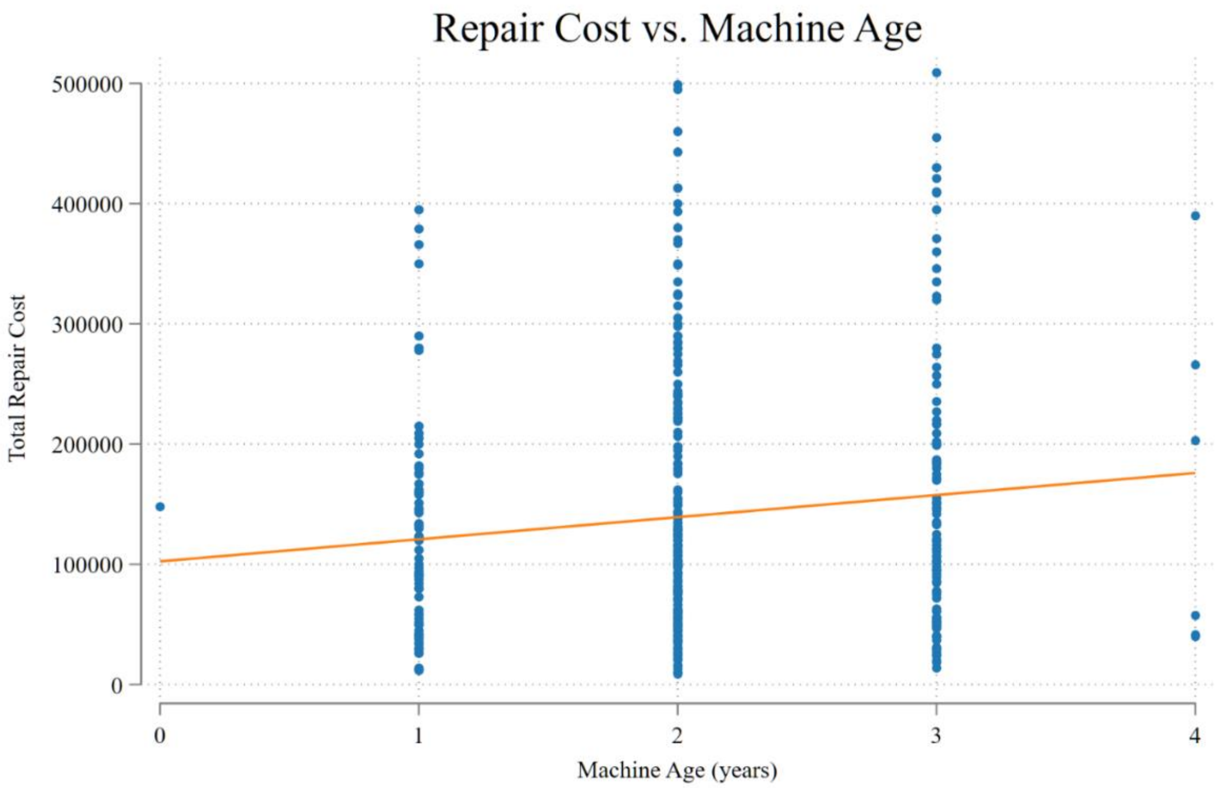
Figure A1: Distribution of combine harvesters by different importers



Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

Note: Some importers import several different brands. ACI imports Yanmar, Lovol, and Lulin. Banglamark imports Masy Ferguson and Marksan. In the Figure above, "Others" includes importers such as Uttaran and Alim Industries.

Figure A2: Scatter plot with linear fit: Relationship between machine age and repair costs



Source: Authors' calculations using data from the IFPRI Bangladesh MSP Survey 2024/25.

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