सत्यमेव जयते

भाकृअनुप
ICAR

ASSESSMENT OF CROP RESIDUE MANAGEMENT MACHINERY FUNCTIONALITY AND UTILIZATION

Sponsored by

Mechanization & Technology Division
Department of Agriculture & Farmers Welfare (DA&FW)

ICAR-AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTE
ZONE-I, PAU CAMPUS, LUDHIANA-141004 PUNJAB

ASSESSMENT OF CROP RESIDUE MANAGEMENT MACHINERY FUNCTIONALITY AND UTILIZATION

Sponsored by

Mechanization & Technology Division

Department of Agriculture & Farmers Welfare (DA&FW)

ICAR-AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTE

ZONE-I, PAU CAMPUS, LUDHIANA-141004 PUNJAB

Guidance:
Dr. Rajbir Singh
Deputy Director General (Agricultural Extension)

Citation:
Sheoran, Parvender; Murai, Ashish Santosh; Bola, Simranpreet Singh; Meena, H.N.; Singh, Raghwendra and Mishra, J.P. (2026). Assessment of Crop Residue Management Machinery Functionality and Utilization. ICAR-Agricultural Technology Application Research Institute (ATARI), Zone-I, Ludhiana, Punjab. pp. 39

Editors:
Parvender Sheoran
Ashish Santosh Murai
Simranpreet Singh Bola
H N Meena
Raghwendra Singh
J P Mishra.

Published by:
Director, ICAR-ATARI, Zone-I,
PAU Campus, Ludhiana, Punjab, India.
Tel.:0161-2401018 Fax: 0161-2412719
Email: zcu1ldh@gmail.com
Website: https://atariz1.org.in/

ISBN: 978-81-983602-8-1

PME Ref. No.: ATARI1/Technical Bulletin/2026/20

Year of publication: 2026

Graphics Design & Page Setting: Cheena Vyas

CONTENTS

1

INTRODUCTION

Crop residue burning has emerged as one of the most pressing environmental challenges in India, particularly in agriculturally intensive states such as Punjab, Haryana, Uttar Pradesh, and NCT of Delhi. The widespread cultivation of paddy and wheat in these regions generates enormous quantities of crop residues within a short harvesting window. Due to limited time between crop cycles and high labour costs, farmers often resort to burning residues as a quick and low-cost solution for field clearance. However, this practice carries significant environmental, agronomic, and public health consequences.

The environmental impact of residue burning is substantial. Scientific estimates indicate that burning one ton of paddy straw releases approximately 3 kg of particulate matter (PM), 60 kg of carbon monoxide (CO), 1460 kg of carbon dioxide (CO_2), 199 kg of ash, and 2 kg of sulfur dioxide (SO_2). In addition, nitrous oxide and other trace gases are emitted, contributing to greenhouse gas accumulation. These emissions severely deteriorate ambient air quality, leading to dense smog episodes, particularly in the Indo-Gangetic Plains. Fine particulate matter (PM2.5 and PM10) penetrates deep into the respiratory system, increasing the risk of asthma, bronchitis, chronic obstructive pulmonary disease (COPD), and cardiovascular disorders. Seasonal spikes in air pollution during residue burning periods often overwhelm healthcare systems and reduce overall quality of life.

Beyond air pollution, crop residue burning results in significant nutrient loss and soil degradation. Paddy straw contains valuable nutrients such as nitrogen, phosphorus, potassium, and sulfur, which are lost during combustion. Instead of being recycled into the soil, these nutrients are converted into gaseous forms or ash, reducing soil fertility over time. The intense heat generated during burning also destroys beneficial soil microorganisms and diminishes soil organic carbon, adversely affecting soil structure, water-holding capacity, and long-term productivity. Repeated burning thus weakens soil health and increases dependency on chemical fertilizers, raising production costs for farmers. The climate implications are equally serious. Large-scale emissions of carbon dioxide and other greenhouse gases accelerate global warming and disrupt regional climatic patterns. This creates a vicious cycle in which agriculture both contributes to and suffers from climate variability, including erratic rainfall, heat stress, and declining yields.

Addressing crop residue burning requires a multi-pronged approach combining sustainable management practices and effective policy support. Ultimately, transitioning from residue burning to sustainable crop residue management is crucial for protecting air quality, restoring soil health, ensuring farmer profitability, and achieving climate resilience in Indian agriculture.

Crop Residue Management Project

Open-field burning of paddy straw is largely driven by the narrow turnaround time between rice harvesting and wheat sowing, combined with limited on-farm residue management options. In response to the urgency of crop residue burning, the Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, launched a Central Sector Scheme in 2018 titled "Promotion of Agricultural Mechanization for *In-situ* Management of Crop Residue." The scheme was aimed at supporting Punjab, Haryana, Uttar Pradesh, and the NCT of Delhi in mitigating air pollution through large-scale adoption of crop residue management machinery. With an initial allocation of ₹1,152 crore, the scheme was fully funded by the Central Government up to 2022-23 and later merged with the Sub-Mission on Agricultural Mechanization under the Rashtriya Krishi Vikas Yojana (RKVY) as a Centrally Sponsored Scheme with a 60:40 Centre-State funding pattern. The CRM project adopts a holistic, mechanization-driven approach aimed at mitigating air pollution, conserving soil health, and promoting sustainable agricultural practices.

CRM Options and Strategic Approach

Crop residue management interventions are broadly categorized into:

- ***In-situ* management,** involving retention, incorporation, or mulching of crop residues in the field using specialized machinery such as Happy Seeders, Super Seeders, Mulchers, Zero Till Drills, and Chopper-Spreaders, along with decomposition using microbial consortia.
- ***Ex-situ* management,** which involves collection, baling, transportation, storage, and utilization of paddy straw for industrial purposes such as biomass power generation, bio-CNG, bio-ethanol production, and co-firing in thermal power plants.

The CRM project envisages an optimal mix of these options through a cluster-based approach, ensuring efficient use of machinery, minimization of resource duplication, and establishment of a viable straw supply chain in proximity to straw-utilizing industries.

Paddy straw retention with Smart Seeder

***Ex-situ* management of paddy straw through baling**

Machinery Support and Financial Assistance

A central pillar of the CRM project is large-scale support for farm machinery through structured subsidy mechanisms. The project provides financial assistance under three major components:

1. Machinery Support to Individual Farmers

State Governments implement this component by identifying beneficiaries in a transparent manner, with priority to areas experiencing severe residue burning. Financial assistance is provided at **50 per cent of the cost of machinery**, subject to ceiling limits specified for each CRM implement. Preference is accorded to tractor-drawn machinery for farmers owning compatible tractors, ensuring operational feasibility. This support aims to enhance on-farm adoption of *in-situ* residue management technologies and reduce dependence on burning.

2. Establishment of Custom Hiring Centers (CHCs)

To address issues of affordability, scale, and access, the CRM project strongly promotes Custom Hiring Centers (CHCs) as a service delivery model. CHCs are established by rural entrepreneurs, farmer groups, co-operative societies, Farmer Producer Organizations (FPOs), and Panchayats.

Each CHC is designed as a comprehensive mechanization unit, equipped with a suitable mix of CRM machines selected from an approved list, along with a tractor of 60 HP or above. Financial assistance is provided in the form of **a credit-linked back-ended subsidy of 80 per cent of the project cost,** for projects costing up to ₹30 lakh, subject to a maximum subsidy ceiling of ₹24 lakh per CHC. This high subsidy support reflects the policy priority accorded to shared access models and large-scale service delivery.

CHCs play a pivotal role in extending CRM machinery access to small and marginal farmers, enabling timely operations during peak sowing windows and improving overall utilization efficiency.

3. Establishment of Paddy Straw Supply Chain (*Ex-situ* Management)

For *ex-situ* residue management, the CRM project supports the creation of an integrated straw supply chain encompassing baling, collection, densification, storage, and transportation. Financial assistance is provided on the capital cost of machinery such as high HP tractors, balers, rakers, loaders, grabbers, and telehandlers through **credit-linked back-ended subsidies**.

Projects may be implemented under **Public-Private Partnership (PPP)** or bilateral arrangements between beneficiaries and straw-utilizing industries. Under such arrangements, the Government provides up to **65 per cent** financial support, beneficiaries contribute at least 10 per cent, and the remaining cost is borne by industry partners. In non-PPP models, beneficiaries contribute 35 per cent of the project cost. The subsidy is routed through Direct Benefit Transfer (DBT) into the Subsidy Reserve Fund Account.

Institutional Framework and Monitoring

State Governments play a central role in planning, approval, and implementation through Annual Action Plans (AAPs), prepared under RKVY guidelines and approved by State Level Sanctioning Committees. The Department of Agriculture & Farmers Welfare (DA&FW) monitors implementation, while operational responsibility for supply chains rests with beneficiaries and partner industries. Project sanctioning committees evaluate proposals and oversee compliance with operational norms.

IEC, Demonstrations, and Capacity Building

Recognizing that machinery availability alone cannot ensure adoption, the CRM project allocates substantial emphasis to Information, Education and Communication (IEC) activities. State Governments, KVKs, ICAR institutions, SAUs, and PSUs conduct large-scale demonstrations of CRM machinery and bio-decomposer technologies on farmers' fields, supported by full machinery cost and contingency assistance. Demonstrations are geo-referenced, monitored, and documented to track adoption outcomes.

The CRM project actively undertakes a wide spectrum of IEC activities to create behavioural change and strengthen farmer awareness regarding sustainable crop residue management. These include farmer-scientist interactions, village-level awareness campaigns, Kisan Gosthis, field days, and choupal meetings to sensitize stakeholders about the environmental, agronomic, and economic implications of residue burning. Capacity-building programs and hands-on training sessions are organized for farmers, custom hiring centre operators, rural youth, and extension personnel to enhance technical skills in operating CRM machinery and adopting *in-situ* management practices. Capacity building programs are supported at ₹6,000 per trainee per week, enhancing farmers' technical skills and operational confidence.

Additionally, exposure visits to successful zero-burning villages, mobile advisory services, and social media outreach, radio talks, and print media coverage, distribution of pamphlets, posters, and technical literature in local languages further amplify outreach. School and college sensitization drives, pledge campaigns, and convergence meetings with Panchayati Raj Institutions and line departments also help build community-level commitment towards eliminating stubble burning and promoting sustainable residue management practices.

Conclusion

Overall, the CRM project represents a comprehensive, machinery-centric, and institutionally robust intervention to address crop residue burning. By combining high capital subsidies, shared access models, supply chain development, and intensive IEC efforts, the project seeks to transition farming systems towards sustainable residue management while safeguarding environmental quality, soil health, and rural livelihoods.


Stakeholders Consultation Meet
on
CROP RESIDUE MANAGEM T

2

Inclusive Mechanization through Machinery Support Systems

The Crop Residue Management (CRM) Scheme, implemented under the Rashtriya Krishi Vikas Yojana (RKVY), has been a key intervention for addressing crop residue burning through large-scale mechanization support and institutional strengthening. Between 2018-19 and 2025-26 (as on 12.12.2025), the Central Government released **₹4,090.84 crore** to participating states, facilitating the distribution of **over 3.5 lakh CRM machines** and the establishment of **more than 43,415 Custom Hiring Centres (CHCs)** (PIB, 4 December 2025).

State-wise Distribution of CRM Machinery (2018-19 to 2025-26)

During this period, a total of **3,50,077 CRM machines** were distributed across Punjab, Haryana, Uttar Pradesh, and the NCT of Delhi. Punjab emerged as the largest beneficiary with **1,60,296 machines (45.7%)**, reflecting the high intensity of residue burning and the state's rice-wheat cropping dominance. Haryana received **1,10,550 machines (31.5%)**, while Uttar Pradesh accounted for **76,135 machines (21.7%)**. The NCT of Delhi received a 247 machines consistent with its smaller agricultural area.

State/Agency	Number of Machines delivered to the Individual Farmers and CHCs								
	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	Total
Punjab	27747	23068	25811	13796	27250	13179	18352	11093	160296
Haryana	10627	14078	29020	19052	7153	11071	9666	9883	110550
Uttar Pradesh	23306	7054	13651	14057	7681	6227	2572	1587	76135
NCT of Delhi	0	111	51	85	0	0	0	0	247
Madhya Pradesh	0	0	0	0	0	0	0	2849	2849
Total	**61680**	**44311**	**68533**	**46990**	**42084**	**30477**	**30590**	**25412**	**350077**

Establishment of Custom Hiring Centres (2018-19 to 2025-26)

To ensure equitable access to CRM machinery, especially for small and marginal farmers, a total of **43,415 CHCs** were established during 2018-19 to 2025-26. Punjab alone accounted for **27,175**

State/Agency	Number of CHCs established								
	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	Total
Punjab	3888	5140	10808	3073	883	944	1380	1059	27175
Haryana	1194	1685	1345	2551	19	0	0	0	6794
Uttar Pradesh	2300	1650	1652	1904	1006	561	319	54	9446
NCT of Delhi	0	0	0	0	0	0	0	0	0
Madhya Pradesh	0	0	0	0	0	0	0	0	0
Total	**7382**	**8475**	**13805**	**7528**	**1908**	**1505**	**1699**	**1113**	**43415**

CHCs (62.5%), indicating strong adoption of the custom hiring model. Uttar Pradesh and Haryana established **9,446** and **6,794 CHCs**, respectively, with notable expansion during the initial years of the scheme.

Overall Assessment

The substantial financial investment and large-scale machinery support under the CRM scheme have significantly strengthened the mechanization infrastructure for crop residue management in major rice-growing states. However, the recent slowdown in asset creation highlights the need to priorities utilization efficiency, operational planning, and performance-based monitoring to fully realize the environmental and agronomic benefits of the CRM interventions.

3

Assessment of CRM Machinery Functionality & Utilization

The M&T Division, DA&FW, Government of India, entrusted the ICAR with the task of conducting a sample survey on CRM machinery. The assignment was undertaken in the context of large-scale public investment made under the CRM scheme for promoting mechanized *in-situ* and *ex-situ* residue management through individual farmers and Custom Hiring Centers (CHCs). While substantial numbers of machines had been distributed and CHCs established, there was a need for systematic, field-based evidence on the actual functional status and utilization efficiency of these assets. The survey was therefore conceived to bridge this information gap and to provide empirical inputs for policy refinement, program monitoring, and strategic planning.

Objectives

The specific objectives of the sample survey were to:

- Assess the functional status of CRM machines owned by individual farmers and operated through CHCs.
- Analyze the utilization pattern of different CRM machines in terms of area covered and actual use vis-à-vis their potential capacity.

Methodology

The study on the utilization of CRM machinery owned by individual farmers as well as CHCs was conducted during the year 2025-26 in CRM-implemented districts of Punjab, Haryana and Uttar Pradesh, using a structured Survey Proforma (Annexure-I) for Utilization of CRM Machinery. The survey was organized through the CRM Project implementing 60 Krishi Vigyan Kendras (KVKs) following a uniform and predefined sampling framework.

The Machine Utilization (%) (actual use out of potential) was calculated to assess the extent to which the available machinery capacity was utilized during the operational period. The total potential area coverage was first estimated based on the number of functional machines and their standard daily operational capacity. The theoretical potential area was computed by multiplying the number of functional machines by the potential area coverage per machine per day and the number of effective operational days (25 days) during the intervention window. The actual area covered was then expressed as a percentage of this estimated total potential area to determine the level of utilization.

Total Potential Area = No. of Machines × Capacity per Day × 25 days

Machine Utilization (%) = (Actual Area Covered / Total Potential Area) × 100

Where, 25 days reflects the effective mechanization window in the rice-wheat cropping system.

The potential area coverage (ha/day/machine) of CRM machinery was estimated using standardized per-day coverage norms derived from available literature and published operational benchmarks. These norms reflect average field performance under typical working conditions (8-10 operational hours per day) and standard field efficiency levels.

The following standardized coverage values were adopted for analysis:

CRM machine	Potential area coverage (ha/day/machine)	CRM machine	Potential area coverage (ha/day/machine)
Happy Seeder	2.8	Super Seeder	2.2
Smart Seeder	3.2	Surface Seeder	6.0
Zero Till Drill	4.0	Chopper/Mulcher	2.6
RMB/MB Plough	2.8	Straw Management System (SMS)	4.0
Cutter cum spreader/Shrub Master / Rotary Slasher	2.8	Baler	8.0

Study Domain and Sampling Framework

Each participating KVK covered four blocks within its operational district. From these selected blocks, a total of six CHCs were identified using purposive sampling to ensure adequate representation of different types of CRM machinery. Accordingly, the CHC sample size was fixed at 24 CHCs per district.

In addition, six farmers were also surveyed from the same four selected blocks so as to capture user-level information related to access, utilization, and performance of CRM machinery, resulting in an overall sample size of 24 farmers per district.

In this study, overall sample size for the study comprised 1,502 individual farmers and 1,328 CHCs, selected from the participating states. This combined sample provided a robust basis for assessing the access, utilization, and performance of CRM machinery across different operational contexts and user categories.

The state-wise distribution of the surveyed individual farmers and CHCs is presented below:

State	Individual farmer	CHCs
Punjab	532	528
Haryana	382	333
Uttar Pradesh	588	467
Total	**1502**	**1328**

4

RESULTS

The results of the CRM machinery assessment provide a comprehensive analysis of functionality, availability, and field-level utilization of machines deployed under the scheme. The findings highlight operational gaps, performance variations between individual and CHC models, and opportunities to enhance efficiency, optimize resource allocation, and strengthen in-situ residue management outcomes.

PUNJAB

CRM program in Punjab is a flagship initiative aimed at eliminating residue burning through the promotion of mechanized *in-situ* and *ex-situ* management practices, supported by Custom Hiring Centers (CHCs) and cooperative institutions. To assess the outreach, access, and performance of CRM interventions, a structured field survey was conducted covering individual farmers (532) and co-operative societies/CHCs (528).

Machine Use Efficiency at Individual Farmer's Level

The assessment of CRM machinery among individual farmers in Punjab shows that both *in-situ* and *ex-situ* residue management technologies are largely functional, with an overall functionality of 92.8% for *in-situ* implements. While availability and operational status of machines are satisfactory, their actual utilization varies widely across machine types. Super

Table 1: Functionality and Efficiency of CRM Machinery owned by Individual Farmers in Punjab (N=532)

Machine	Procured machines (No.)	Functional machines (No.)	Functionality (%)	Total Area Covered (ha)	Potential area coverage (ha)	Actual use of Potential (%)
***In-situ* Management**						
Happy Seeder	75	51	68.0	395	3570	11.0
Super Seeder	408	397	97.3	11793	21835	54.0
Smart Seeder	4	3	75.0	61	240	25.3
Surface Seeder	15	15	100.0	133	2250	5.9
Zero Till Drill	142	134	94.4	2381	13400	17.7
Cutter cum spreader/Shrub Master/ Rotary Slasher	21	21	100.0	1034	1470	70.3
Chopper/Mulcher	55	51	92.7	1006	3315	30.3
RMB/MB Plough	67	58	86.6	687	4060	16.9
SMS	4	4	100.0	98	400	24.5
Total/ Average	**791**	**734**	**92.8**	**17588**	**50540**	**34.8**
***Ex-situ* Management**						
Baler	55	55	100.0	8413	11000	76.4

Seeders, Cutter and Balers emerged as the most effectively used technologies in their respective categories. The findings point to a significant gap between potential and actual utilization for several in-situ CRM machines.

Key Findings

- Overall functionality of CRM machinery was high (above 90%), indicating strong operational readiness among individual farmers.
- Most *in-situ* machines recorded functionality above 85%, with some achieving 100%, yet their actual utilization remained moderate to low.
- **Average utilization of potential** for *in-situ* machinery was **only about one-third, reflecting a significant gap between capacity and actual use.**
- Super Seeder showed high functionality (above 95%) with relatively better utilization (above 50%) compared to other in-situ machines.
- The Baler (*ex-situ*) demonstrated 100% functionality and high utilization (above 75%), outperforming most *in-situ* machines in efficiency.

Machine Use Efficiency at CHCs Level

The analysis of CRM machinery indicates high availability and operational readiness of both *in-situ* and *ex-situ* technologies. Out of the procured *in-situ* machines, 91.7% were functional. Super Seeders, Mulchers, and Happy Seeders emerged as the most effectively utilized *in-situ* implements, though several machines remain underutilized despite high functionality. *Ex-situ* residue management through balers demonstrated exceptional performance, highlighting their critical role in straw removal and biomass utilization.

Key Findings

- Overall functionality of CRM machinery at CHCs remained high (above 90%), with most machines reporting more than 90% operational status.

Table 2: Functionality and Efficiency of CRM Machinery at CHCs Level in Punjab (N=528)

Machine	Procured machines (No.)	Functional machines (No.)	Functionality (%)	Total Area Covered (ha)	Potential area coverage (ha)	Actual use of Potential (%)
***In-situ* Management**						
Happy Seeder	161	120	74.5	3920	8400	46.7
Super Seeder	455	432	94.9	15022	23760	63.2
Smart Seeder	58	55	94.8	2071	4400	47.1
Surface Seeder	62	59	95.2	581	8850	6.6
Zero Till Drill	251	229	91.2	6989	22900	30.5
Cutter cum spreader/Shrub Master/ Rotary Slasher	54	53	98.1	325	3710	8.8
Chopper/ Mulcher	223	205	91.9	6230	13325	46.8
RMB/MB Plough	173	163	94.2	3879	11410	34.0
SMS 20	20	100.0	138	4	2000	
Total/ Average	**1457**	**1336**	**91.7**	**39155**	**98755**	**39.6**
***Ex-situ* Management**						
Baler	66	64	97.0	10379.2	12800	81.1

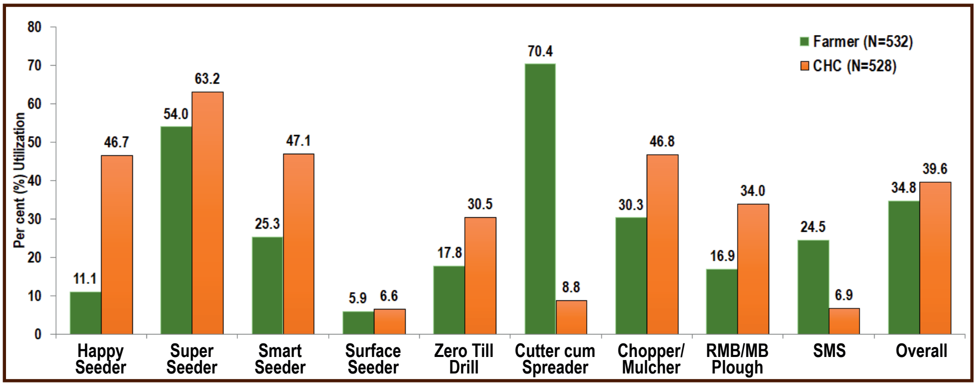

Fig 1. Comparison of Use efficiency of *In-situ* CRM Machinery at Individual Farmer's and CHCs levels in Punjab

- Super Seeder, Smart Seeder, RMB/MB Plough, and Chopper/Mulcher recorded functionality above 90%, with utilization levels ranging between roughly one-third and nearly two-thirds of their potential.
- Surface Seeder and SMS, despite functionality above 95% (including 100% for SMS), showed very low utilization, below 10% of their potential capacity.
- **Average utilization of *in-situ* machinery at CHCs was below 40%**, indicating a considerable gap between operational availability and actual use.

- The Baler (*ex-situ*) demonstrated high functionality (around 97%) and strong efficiency, utilizing over 80% of its potential, significantly higher than most *in-situ* machines.

The analysis of use efficiency, measured against the ideal benchmark of 100% potential utilization within the 25-day operational window, indicates **substantial underutilization of *in-situ* CRM machinery across both individual farmer and CHC systems in Punjab.** Even the relatively better-performing machines operated well below their full capacity, reflecting significant scope for improving operational efficiency without additional capital investment.

Super Seeder demonstrated comparatively higher efficiency, yet it still utilized only around two-thirds of its potential at best. Majority of CRM implements, including Happy Seeder, Zero Till Drill, Smart Seeder, RMB/MB Plough, and Chopper/Mulcher, operated at roughly one-third to half of their potential capacity. Certain machines such as Surface Seeder and SMS recorded utilization levels even below 10%, indicating serious inefficiencies in deployment.

Although overall efficiency was marginally better under the CHC system than at the individual farmer level, both systems remained far below optimal utilization. This clearly suggests that the primary challenge is not the availability of machinery, but the effective scheduling, aggregation of demand, logistics management, and service delivery within the critical operational period.

Therefore, policy emphasis should shift from additional procurement toward maximizing the efficiency of existing assets. Strengthening coordination mechanisms, improving booking systems, ensuring timely machine movement, promoting cluster-based operations, and enhancing managerial oversight at CHCs can substantially increase utilization rates. Optimizing current machinery use within the 25-day window would generate greater economic and environmental returns than further expansion of the machinery inventory.

Categorization of CHCs based on frequency of CRM Machines Ownership in Punjab

The distribution of CHCs based on CRM machine ownership in Punjab indicates that nearly two-thirds (around 63%) of centres operate with up to three machines. Only about one-fourth (approximately 26%) of CHCs possess four or more machines, and fewer than 10% operate with six or more machines. Centres owning ten or more machines account for only about 7%, indicating that high-capacity machinery hubs remain limited.

From a CRM perspective, this structure suggests that the majority of CHCs function with relatively low machinery density, which may constrain their ability to meet peak seasonal demand within the narrow 25-day operational window. Limited machine availability lead to scheduling bottlenecks, delayed service delivery, and sub-optimal area coverage. The small proportion of well-equipped

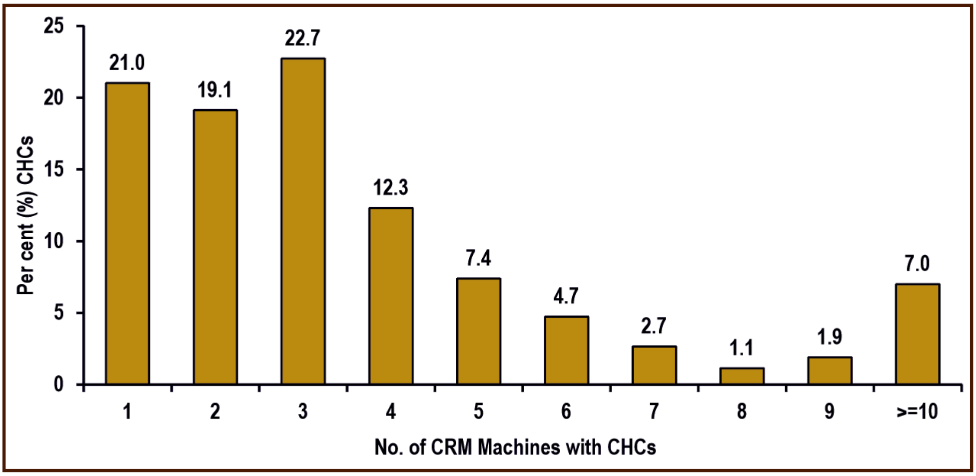

Fig 2. Number of CRM machines owned by CHCs (N=528)

CHCs highlights the need to strengthen operational efficiency, inter-CHC coordination, cluster-based deployment, and machine-sharing mechanisms.

Conclusion

The study reveals that Punjab has a strong base of functional CRM machinery under CHCs; however, the utilization of available capacity remains largely sub-optimal. Individual farmer-managed machinery exhibit particularly low use efficiency, while co-operative societies perform relatively better due to collective ownership and improved operational management. Despite this advantage, even co-operative CHCs operate well below their theoretical potential, indicating persistent operational and demand-side constraints. The findings suggest that enhancing institutional support, strengthening management practices, and promoting need-based, demand-driven use of machinery are critical for translating availability into effective field-level impact.

Way Forward

The analysis clearly indicates that enhancing the effectiveness of CHCs in Punjab demands a **strategic shift from an asset-centric focus towards a utilization-centric, demand-driven, and management-oriented approach.** While the state has achieved substantial coverage in terms of machinery availability, gaps in operational planning, management efficiency, and demand alignment continue to limit the realization of full mechanization benefits. Strengthening the managerial capacity of CHC operators, promoting co-operative and cluster-based ownership models, and aligning machinery deployment with local cropping systems are therefore critical. In this context, a structured and targeted way forward is essential to address the core constraints, improve utilization efficiency, and maximize the field-level impact of CRM interventions across Punjab.

- **Move from asset creation to utilisation efficiency:** Reorient CRM interventions to prioritise actual area coverage and use efficiency rather than mere procurement and machine counts.
- **Strengthen CHC management capacity:** Address managerial and operational gaps through structured training of CHC operators on planning, scheduling, demand forecasting, record keeping, and basic business management.
- **Promote co-operative and cluster-based CHC models:** Tackle fragmentation in ownership by encouraging aggregation of individual CHCs into co-operatives or clusters to improve machine circulation, outreach, and economies of scale.
- **Align machinery with local demand:** Resolve mismatch between machine availability and cropping systems through district-specific need assessments and demand-driven procurement, redistribution, or replacement of underutilised machines.
- **Introduce performance-linked incentives:** Shift policy support towards incentives linked to actual use of potential (%) and area coverage to motivate efficient deployment of machinery.
- **Target low-performing districts:** Implement location-specific interventions in persistently low-performing districts, including demonstrations, awareness campaigns, rationalisation of custom hiring rates, and improved last-mile connectivity.
- **Strengthen monitoring and feedback mechanisms:** Establish a robust monitoring framework focused on utilisation indicators to enable evidence-based corrections and adaptive planning.

HARYANA & DELHI

Crop Residue Management (CRM) is a key intervention aimed at minimizing residue burning through the promotion of mechanized *in-situ* and *ex-situ* residue management practices, supported by Custom Hiring Centres (CHCs) and cooperative institutions. To evaluate the outreach, accessibility, and performance of CRM interventions in Haryana & Delhi, a structured field survey was conducted covering individual farmers (N=382) and CHCs/co-operative societies (N=333).

Machine Use Efficiency at Individual Farmer's Level

The assessment of CRM machinery among individual farmers in Haryana & Delhi indicates that *in-situ* residue management technologies are largely operational, with an overall functionality of 98.8%. However, several machines exhibited low utilization despite good functionality, indicating underuse at the individual farmer level.

Table 3: Functionality and Efficiency of CRM Machinery owned by Individual Farmers in Haryana & Delhi (N=382)

Machine	Procured machines (No.)	Functional machines (No.)	Functionality (%)	Total Area Covered (ha)	Potential area coverage (ha)	Actual use of Potential (%)
***In-situ* Management**						
Happy Seeder	6	6	100.0	130	420	30.9
Super Seeder	284	284	100.0	15478	15620	99.0
Smart Seeder	27	27	100.0	277	2160	12.8
Zero Till Drill	44	43	97.7	2902	4300	67.4
Cutter cum spreader/Shrub Master/ Rotary Slasher	17	17	100.0	1050	1190	88.2
Chopper/Mulcher	9	8	88.9	434	520	83.4
RMB/MB Plough	22	19	86.4	1274	1330	95.7
Total/ Average	**409**	**404**	**98.8**	**21544**	**22540**	**84.3**
***Ex-situ* Management**						
Baler	29	12	41.4	911	2400	37.9

Key Findings

- Overall functionality of *in-situ* machinery was extremely high (nearly 99%), with most machines reporting 100% operational status.
- Average utilization of *in-situ* machinery reached over 84% of potential capacity, indicating highly efficient deployment within the operational window.
- Super Seeder (~99%), RMB/MB Plough (~96%), Cutter cum Spreader (~88%), Chopper/Mulcher (~83%), and Zero Till Drill (~67%) demonstrated strong efficiency levels.
- Smart Seeder (~13%) and Happy Seeder (~31%) showed comparatively lower utilization despite full functionality, indicating scope for improved operational planning.
- In contrast, the Baler (*ex-situ*) recorded low functionality (~41%) and moderate utilization (~38%), reflecting weaker efficiency compared to in-situ machinery.

Machine Use Efficiency at CHCs Level

The analysis of CRM machinery at the CHCs level reflects high availability and operational readiness of both *in-situ* and *ex-situ* technologies. Out of 670 *in-situ* machines procured, 566 were functional, resulting in an overall functionality of 84.5%. Among *in-situ* implements, Super Seeders achieved the highest area coverage with a utilization of potential capacity of 122.5%, indicating usage of the machine beyond 25-day window. Chopper-Spreaders, Cutter-cum-Spreaders, Mulchers and MB Ploughs recorded a high utilization of potential capacity, indicating efficient use under institutional management.

Table 4: Functionality and Efficiency of CRM Machinery at CHCs Level in Haryana & Delhi (N=333)

Machine	Procured machines (No.)	Functional machines (No.)	Functionality (%)	Total Area Covered (ha)	Potential area coverage (ha)	Actual use of Potential (%)
***In-situ* Management**						
Happy Seeder	17	3	17.6	44	210	21.0
Super Seeder	207	200	96.6	13479	11000	122.5
Zero Till Drill	155	135	87.1	4242	13500	31.4
Cutter cum spreader/Shrub Master/ Rotary Slasher	82	56	68.3	3787	3920	96.6
Chopper/Mulcher	128	103	80.5	5894	6695	88.0
RMB/MB Plough	81	69	85.2	4076	4830	84.4
Total/ Average	**670**	**566**	**84.5**	**31522**	**40155**	**78.5**
***Ex-situ* Management**						
Baler	40	24	60.0	2406.8	4800	50.1

Key Findings

- Overall functionality of in-situ machinery at CHCs stood at about 85%, with considerable variation across machine types.
- Super Seeder showed very high functionality (~97%) and exceeded potential utilization (> 120%), indicating intensive deployment beyond the standard operational window.
- Cutter cum Spreader (~97%), Chopper/Mulcher (~88%), and RMB/MB Plough (~84%) demonstrated strong efficiency levels, utilizing a large share of their potential capacity.
- Zero Till Drill showed moderate utilization (~31%), while Happy Seeder recorded very low functionality (~18%) and low utilization (~21%), indicating operational constraints.
- The Baler (*ex-situ*) reflected moderate functionality (~60%) and utilization (~50%), suggesting scope for improving efficiency in residue collection systems.

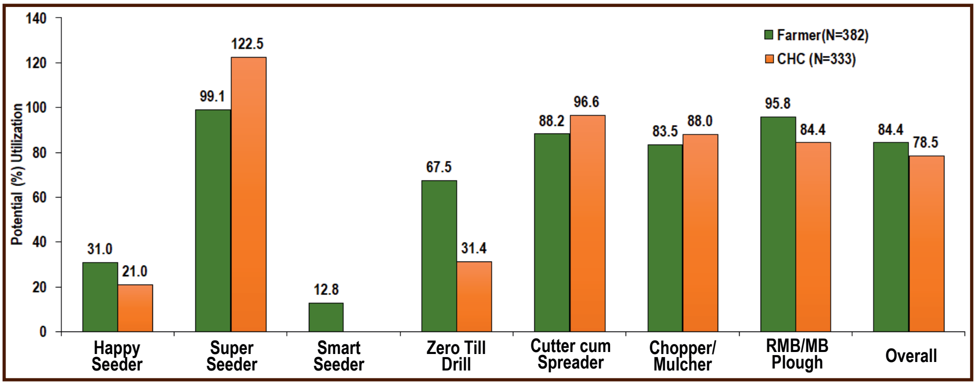

Fig. 3. Comparison of Use efficiency of *In-situ* CRM Machinery at Individual Farmer's and CHCs levels in Haryana and Delhi

The analysis of use efficiency (Fig. 3), indicates that *in-situ* CRM machinery in Haryana and Delhi is being utilized at relatively high levels overall, particularly at the individual farmer level (84.4%) and slightly lower at CHCs (78.5%). This suggests that, in general, the existing machinery base is capable of delivering substantial operational output when effectively managed.

The Super Seeder operated at approximately 99% at the farmer level and exceeded 120% at the CHC level, indicating highly intensive deployment and, in some cases, operation beyond the assumed 25-day benchmark. Similarly, Cutter cum Spreader (around 88% at farmer level and 97% at CHCs), Chopper/Mulcher (above 80% at both levels), and RMB/MB Plough (around 96% at farmer level and above 80% at CHCs) demonstrated strong efficiency, approaching optimal utilization.

However, not all machinery achieved desirable efficiency. Happy Seeder utilization remained low (around 31% at farmer level and 21% at CHCs), while Zero Till Drill showed moderate efficiency (around 68% at farmer level but only about 31% at CHCs). Smart Seeder at the farmer level operated at only about 13% of its potential, indicating substantial underutilization.

These findings clearly indicate that the core issue is not inadequate availability of machinery, but uneven and, in some cases, suboptimal utilization within the limited operational window. Before considering additional procurement, greater emphasis should be placed on improving scheduling, demand aggregation, logistical coordination, machine mobility, and service planning.

Categorization of CHCs based on frequency of CRM Machines Owned in Haryana & Delhi

The distribution of Custom Hiring Centres (CHCs) based on the number of CRM machines owned indicates a predominance of moderately equipped centres (Fig. 4). A substantial proportion of CHCs (44.72%) reported owning three CRM machines, followed by 19.11% with four machines. CHCs possessing one and two machines each accounted for 13.01%, indicating a noticeable presence of centres operating with limited machinery. About 9.35% of CHCs owned five machines, while ownership of six or seven machines was extremely rare (0.41% each).

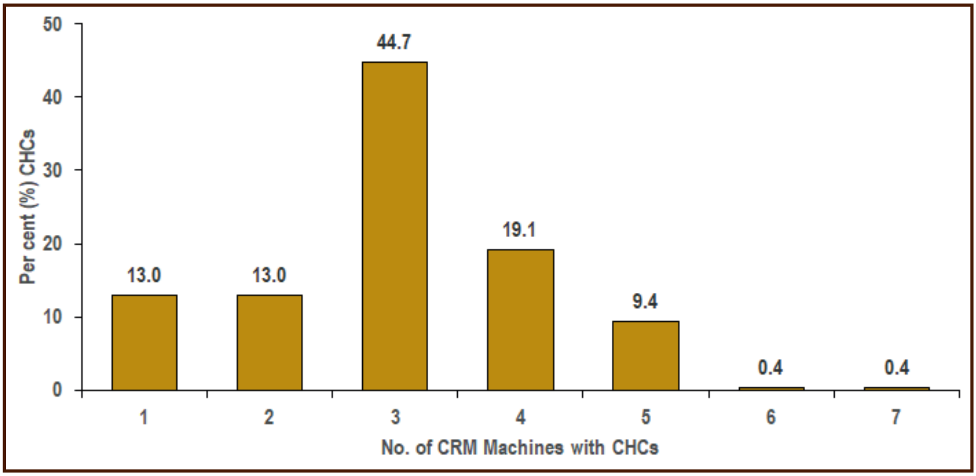

Fig 4. Number of CRM machines owned by CHCs (N=333)

Overall, the distribution suggests that a majority of CHCs operate with three or fewer machines, reflecting moderate operational capacity, while only a very small fraction of centres possess a higher number of machines, indicating limited presence of highly equipped CHCs. It may restrict their service coverage, turnaround time, and ability to meet peak-season demand. The near absence of large, well-equipped CHCs suggests a need for strategic strengthening of smaller centres through targeted support, machine aggregation, and convergence with cooperative institutions.

Conclusion

The study indicates that Haryana & Delhi have adequate availability and functionality of CRM machinery across individual farmers and Custom Hiring Centres (CHCs); however, utilization of available capacity remains uneven and machine-specific. Individual farmers recorded higher average utilisation of potential capacity compared to CHCs. Among *in-situ* technologies, Super Seeders dominated in terms of area coverage, reflecting their wide field-level acceptance, while Mulchers and Chopper-Spreaders achieved the highest utilisation of potential capacity among individual farmers. At the CHC level, Chopper-Spreaders, Cutter-cum-Spreaders, and Super Seeders showed relatively better utilisation, whereas MB Ploughs and Mulchers remained substantially underutilised despite wide availability. The findings underline that mere availability of machinery does not ensure effective utilisation. Variability in demand, small and fragmented CHC machine portfolios, and operational constraints continue to limit the field-level impact of CRM interventions.

Way Forward

The analysis clearly demonstrates that improving the effectiveness of CRM interventions in Haryana & Delhi requires a strategic transition from asset-focused expansion to utilization-driven and demand-responsive deployment. While substantial investments have strengthened machinery availability, operational planning, management efficiency, and institutional capacity remain key bottlenecks in achieving optimal field-level impact. A structured and targeted way forward is therefore essential to enhance utilization efficiency and maximize the benefits of mechanized crop residue management:

- **Enhance utilisation efficiency at CHCs:** Lower average utilisation at CHCs compared to individual farmers highlights the need for improved demand aggregation, advance scheduling, and coordinated machine deployment to reduce idle time during peak residue management periods.
- **Strengthen small CHCs through clustering and pooling:** As over two-thirds of CHCs operate with three or fewer machines, promoting cluster-based operations and inter-CHC machine sharing can improve service coverage, turnaround time, and operational viability.
- **Adopt a demand-driven machine mix:** Machines demonstrating consistent performance, such as Super Seeders and Chopper-Spreaders, should be prioritised, while procurement and placement of persistently underutilised machines (e.g., MB Ploughs at CHCs) should be guided by local cropping systems and field demand.
- **Align ownership models with utilisation patterns:** Machines showing low utilisation at the individual farmer level but better performance under institutional settings should be promoted primarily through CHCs rather than individual ownership.
- **Shift monitoring focus to utilisation outcomes:** Monitoring frameworks should emphasise machine-wise utilisation of potential capacity, area covered, and seasonal deployment patterns to enable evidence-based corrections and improve the overall effectiveness of CRM interventions.

UTTAR PRADESH

Crop Residue Management (CRM) in Uttar Pradesh is being promoted as a key intervention to mitigate residue burning through the adoption of mechanized *in-situ* and *ex-situ* residue management practices. The program is supported through Custom Hiring Centers (CHCs), cooperative societies, and individual farmers to enhance access to CRM machinery and encourage sustainable crop residue handling. To evaluate the outreach, availability, and performance of CRM interventions in the state, a structured field survey was conducted covering individual farmers (N=588) and CHCs/cooperative institutions (N=467).

Machine Use Efficiency at Individual Farmer's Level

The assessment of CRM machinery among individual farmers in Uttar Pradesh indicates that both *in-situ* and *ex-situ* residue management technologies are largely operational, though considerable variation exists in their actual utilization. Out of the total procured machines, 98.2% were functional. However, despite satisfactory availability and operational status, the utilization of potential capacity remained very low for several machine categories.

Key Findings

- Overall functionality of in-situ machinery was very high (above 98%), with most machines reporting 100% operational status.

Table 5: Functionality and Efficiency of CRM Machinery owned by Individual Farmers in Uttar Pradesh (N=588)

Machine	Procured machines (No.)	Functional machines (No.)	Functionality (%)	Total Area Covered (ha)	Potential area coverage (ha)	Actual use of Potential (%)
***In-situ* Management**						
Happy Seeder	50	50	100.0	466	3500	13.3
Super Seeder	234	228	97.4	4414	12540	35.2
Smart Seeder	12	12	100.0	275	960	28.6
Surface Seeder	3	3	100.0	209	450	46.4
Zero Till Drill	104	104	100.0	1483	10400	14.2
Cutter cum spreader/Shrub Master/ Rotary Slasher	147	146	99.3	1342	10220	13.1
Chopper/Mulcher	75	75	100.0	909	4875	18.6
RMB/MB Plough	81	75	92.6	1264	5250	24.0
SMS	3	3	100.0	68	300	22.6
Total/ Average	**709**	**696**	**98.2**	**10431**	**48495**	**21.5**
***Ex-situ* Management**						
Baler	19	19	100.0	639.4	3800	16.8

- Despite high functionality, average utilization of in-situ machinery was low (around 22%), indicating substantial underuse within the 25-day operational window.
- Surface Seeder showed relatively better efficiency (~46%), followed by Super Seeder (~35%) and Smart Seeder (~29%), while most other machines operated below 25% of potential.
- Happy Seeder, Zero Till Drill, and Cutter cum Spreader recorded particularly low utilization (around 13-14%), reflecting significant efficiency gaps.
- The Baler (ex-situ) also showed low utilization (~17%) despite full functionality, highlighting the need to improve deployment rather than expand machinery numbers.

Machine Use Efficiency at CHCs Level

The analysis of CRM machinery at the CHC level in Uttar Pradesh indicates high availability and strong operational readiness of both *in-situ* and *ex-situ* technologies. Out of total procured machines, 99.7% machines were found to be functional. However, the overall utilization of the machines was very poor.

Table 6: Functionality and Efficiency of CRM Machinery at CHCs Level in Uttar Pradesh (N=467)

Machine	Procured machines (No.)	Functional machines (No.)	Functionality (%)	Total Area Covered (ha)	Potential area coverage (ha)	Actual use of Potential (%)
***In-situ* Management**						
Happy Seeder	44	43	97.7	789	3010	26.2
Super Seeder	263	263	100.0	3904	14465	27.0
Smart Seeder	3	3	100.0	98	240	41.0
Surface Seeder	9	9	100.0	75	1350	5.6
Zero Till Drill	128	128	100.0	4113	12800	32.1
Cutter cum spreader/Shrub Master/ Rotary Slasher	182	1801	98.9	4841	12600	3.8
Chopper/Mulcher	138	138	100.0	3522	8970	39.3
RMB/MB Plough	163	163	100.0	9410	11410	82.5
Total/ Average	**930**	**2548**	**99.7**	**26753**	**64845**	**41.3**
***Ex-situ* Management**						
Baler	18	18	100.0	172.4	3600	4.8

Key Findings

- *In-situ* machinery at CHCs showed very high reported functionality (mostly near or at 100%), yet average utilization remained low (around 41.3%), indicating substantial underuse within the 25-day window.

- RMB/MB Plough demonstrated strong efficiency (~83%), while Chopper/Mulcher (~39%), Smart Seeder (~41%), and Zero Till Drill (~32%) showed moderate utilization levels.
- Happy Seeder and Super Seeder operated at only about one-fourth of their potential (~26-27%), reflecting limited operational intensity despite full functionality.
- Surface Seeder (~6%) and Cutter cum Spreader (~4%) recorded very low utilization, indicating serious efficiency gaps.
- The Baler (*ex-situ*) also showed minimal utilization (~5%) despite 100% functionality, emphasizing the need to improve deployment of existing machinery rather than expand inventory.

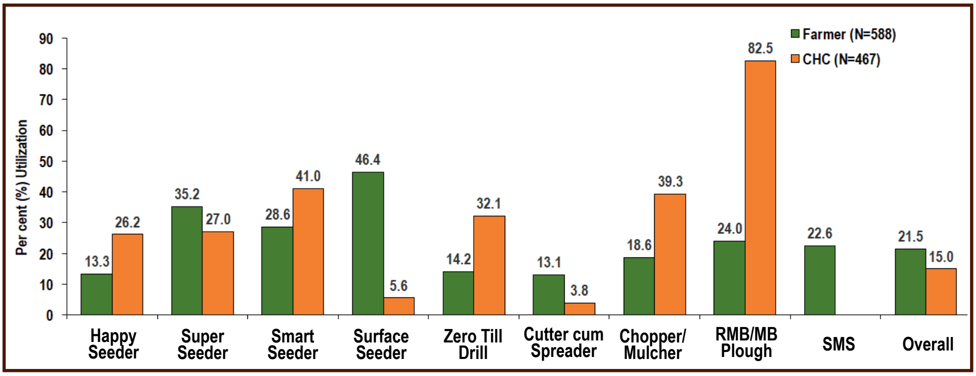

Fig 5. Comparison of Use efficiency of *In-situ* CRM Machinery at Individual Farmer's and CHCs levels in Uttar Pradesh

The assessment of use efficiency reveals substantial underutilization of in-situ CRM machinery in Uttar Pradesh at both individual farmer (21.5%) and CHC (41.3%) levels (Fig. 5). These figures indicate that a large proportion of the available operational capacity remains untapped during the critical residue management period.

Only a few machines demonstrated relatively higher efficiency. RMB/MB Plough at the CHC level operated at about 82.5% of its potential, reflecting strong deployment intensity. Surface Seeder at the farmer level (~46.5%) and Smart Seeder at the CHC level (~41.0%) also showed moderate efficiency. Chopper/Mulcher reached around 39.3% at CHCs, while Super Seeder utilization ranged between roughly 27-35%, indicating partial but far from optimal use.

Most other machinery types, including Happy Seeder, Zero Till Drill, Cutter cum Spreader, and SMS, operated largely below one-third of their potential capacity, with some performing below 41.3%. Such low utilization levels suggest inefficiencies in scheduling, aggregation of demand, machine mobility, and operational coordination within the limited 25-day window.

Overall, the evidence clearly indicates that the constraint lies not in machinery availability but in its effective deployment. Prioritizing improved planning, cluster-based operations, real-time booking systems, and better logistical coordination would significantly enhance efficiency. Strengthening the utilization of existing machinery assets is likely to yield greater economic and environmental returns than investing in additional procurement.

Categorization of CHCs based on frequency of CRM Machines Owned Uttar Pradesh

Figure 6 illustrates the distribution of Custom Hiring Centers (CHCs) based on the number of CRM machines owned. The results indicate that most CHCs operate with two to three machines, with 27.0% possessing two machines and 26.3% owning three machines, followed by 18.8% with one machine. A moderate proportion of CHCs (19.5%) operate with four machines, while 7.1% reported owning five machines. Ownership of six or more machines is extremely limited, each accounting for less than one percent of CHCs.

Overall, nearly three-fourths of CHCs operate with three or fewer machines, reflecting moderate mechanization capacity at most centers. The highly skewed distribution indicates that only a negligible proportion of CHCs possess larger machinery fleets, which may constrain their ability to meet peak seasonal demand and provide timely residue management services.

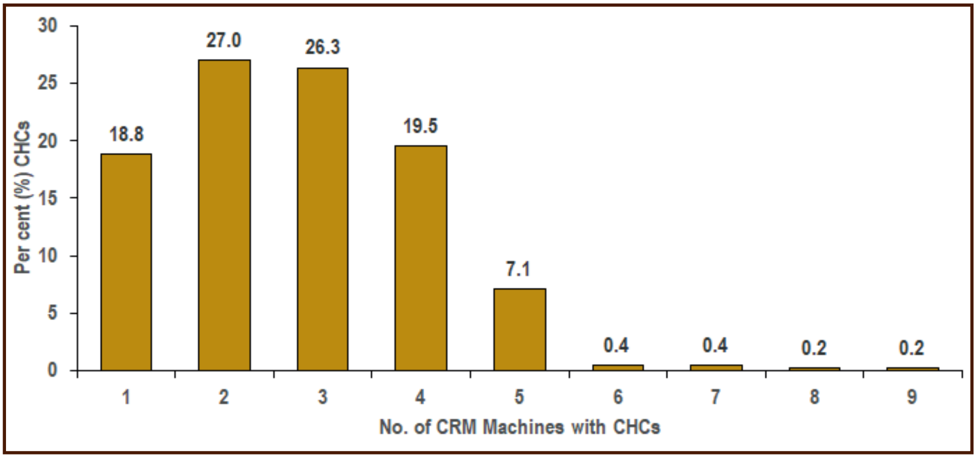

Fig 6. Number of CRM machines owned by CHCs (N=467)

The skewed distribution suggests that although CHCs are widely established across Uttar Pradesh, most centers are resource-constrained, with limited machinery availability to meet peak seasonal demand. Such constraints may affect service coverage, timeliness of operations, and overall efficiency of residue management during critical periods. The findings highlight the need for strategic strengthening of smaller CHCs through targeted financial support, machine aggregation, and convergence with cooperative and private service providers.

Conclusion

Uttar Pradesh has established a substantial base of functional CRM machinery across both CHCs and individual farmers. The overall utilization of available capacity remains uneven and generally sub-optimal. Among *in-situ* technologies, Super Seeders dominated in terms of adoption and area coverage at the farmer level. At the CHC level, Cutter-cum-Spreaders, Smart Seeders, Mulchers, MB Ploughs, and Zero Till Drills demonstrated relatively better utilization. Overall, the findings highlight a persistent gap between machinery availability and effective field utilization, driven by machine-specific demand patterns, small and fragmented CHC portfolios, and operational constraints during peak residue management periods.

Way Forward

Improving the effectiveness of CRM interventions require a clear transition from asset-centric expansion to utilization-focused and demand-responsive deployment. While machinery availability has expanded significantly, maximizing benefits will depend on addressing operational, institutional, and market-related constraints:

- **Consolidate and strengthen small CHCs:** Promoting inter-CHC pooling, block-level clustering, and shared operational planning is essential.
- **Prioritize deployment of high-utilization machines:** Scale up machines demonstrating consistently higher utilization under CHCs, while rationalizing procurement and placement of persistently under utilized implements.
- **Improve scheduling and seasonal mobility of machinery:** Introduce block-wise seasonal operation plans and coordinated machine movement to address uneven spatial and temporal demand, particularly for heavy-duty *in-situ* machinery requiring timely deployment.
- **Strengthen *ex-situ* residue utilization linkages:** Enhance the viability of balers by developing stronger linkages with fodder markets, biomass-based industries, and local aggregation points, enabling economic incentives for *ex-situ* residue removal.
- **Link monitoring and support to utilization outcomes:** Shift performance monitoring to indicators such as utilization of potential capacity, area covered, and seasonal deployment, with targeted corrective interventions in districts exhibiting persistently low utilization.

5

Constraints in Utilization of CRM Machinery

A structured and pre-tested questionnaire was used to collect primary data. A comprehensive list of potential constraints related to operational, demand-side, logistics and management, institutional/policy, and natural/field conditions was compiled based on literature review, expert consultations, and field interactions. Respondents were asked to rate the severity of each constraint using a Likert-type scale on a three-point continuum: Low severity, Moderate severity and High severity. The mean values were calculated to determine the relative importance of each constraint.

To statistically examine differences in the perceived severity of constraints, the Friedman test, a non-parametric test suitable for ranking related samples, was applied. The test assessed whether significant differences existed among the mean ranks of the identified constraints. The analysis was performed separately for both respondent groups to ensure consistency and robustness of the findings. The results were interpreted based on mean scores and rank orders to identify the most critical constraints affecting the effective utilization of CRM machinery in the study area.

PUNJAB

The results revealed a statistically significant difference in the mean ranks of the constraints perceived by respondents ($p < 0.05$), indicating that the constraints are not uniformly experienced and that certain factors pose substantially greater barriers to the effective utilization of CRM machinery.

Table 7 : Perceived Constraints in Utilization of CRM Machinery by Farmers (n=538) and CHCs (n= 527) in Punjab

S.No.		Constraints	Mean values	
			Farmers	CHCs
1.	Operational Constraints	Labour shortage	15.82	15.96
2.		Operator unavailability	16.83	17.04
3.		High fuel cost	22.77	23.55
4.		Machine breakdowns	22.44	23.04
5.		Lack of timely repairs/parts	13.58	13.87
6.		Low-skilled or untrained operators	14.07	14.49
7.		Delayed availability of spare parts	12.58	13.02
8.		Frequent clogging in heavy residue fields	20.35	21.03
9.		Poor machine calibration/maintenance	23.07	23.55
10.	Demand-Side Issues	Low farmer demand	21.13	21.66
11.		Use of alternative machines	8.59	8.69
12.		Preference for burning	16.46	16.62
13.		High rental cost perceived by farmers	21.78	22.32
14.		Mismatch between machine type and local cropping pattern	7.00	7.20
15.		Small and Fragmented holdings	23.07	23.55
16.		Delay in harvesting (late crop maturity)	8.07	8.23

S.No.		Constraints	Mean values	
			Farmers	CHCs
17.	Logistics & Management	Poor scheduling	12.44	12.84
18.		Limited awareness among farmers	15.98	16.20
19.		Inadequate field bunding or field readiness	13.98	14.42
20.		Lack of transport facility for machines	22.75	16.08
21.		Poor coordination among CHC staff	15.85	16.14
22.		Insufficient fuel or lubricant availability	12.37	12.80
23.		Delay in field allocation or booking	16.13	16.32
24.		Inadequate storage/shed for machines	12.41	12.84
25.	Institutional /Policy Related	Delay in subsidy reimbursement	16.14	16.70
26.		Insufficient financial resources for maintenance	22.77	16.70
27.		Non-functional machines from previous allocations	16.14	16.70
28.		Irregular monitoring or reporting requirements	16.14	16.70
29.	Natural /Field Conditions	High soil moisture during season	16.82	17.43
30.		Heavy straw load unsuitable for certain machines	16.82	17.43
31.		Stubble height too high/low	16.82	17.43
32.		Adverse weather (rain/fog) restricting operations	16.82	17.43

The results indicate that operational and economic constraints are the most critical factors affecting the utilization of CRM machinery in Punjab. Major operational challenges include poor machine calibration and maintenance, frequent machine breakdowns, clogging in heavy residue fields, and high fuel costs, which collectively reduce operational efficiency and increase the cost of machinery use. Demand-side barriers such as high rental charges and small, fragmented landholdings further limit the effective deployment of CRM machines, while the continued preference for residue burning reflects behavioral constraints. Logistical issues such as poor scheduling, limited farmer awareness, and delays in machine booking also hinder timely machinery access. Institutional factors including delayed subsidy reimbursement and limited financial resources for maintenance affect the sustainability of Custom Hiring Centers. Although environmental conditions such as high soil moisture and adverse weather influence machine operations, they are perceived as relatively less severe. Overall, the consistent responses across both respondent groups highlight that improving machine maintenance systems, reducing operational costs, strengthening CHC management, and enhancing farmer awareness are essential for promoting effective CRM machinery utilization.

Major Findings

- **Operational efficiency is a major bottleneck:** High mean scores for machine breakdowns, poor calibration/maintenance, and clogging in heavy residue fields indicates that technical efficiency and maintenance systems of CRM machinery require significant strengthening.

- **Economic barriers influence adoption:** High fuel costs and the perceived high rental charges of CRM machinery discourage farmers from opting for mechanized residue management, thereby affecting large-scale adoption.
- **Farm structure limits mechanization efficiency:** Small and fragmented landholdings significantly constrain the effective utilization of large CRM machines, reducing operational feasibility in many villages.
- **Capacity and skill gaps persist:** Moderate scores for operator unavailability and low-skilled operators suggest the need for improved technical training and skill development for machine operators and CHC staff.
- **Institutional management of CHCs needs strengthening:** Issues such as delayed subsidy reimbursement, inadequate financial resources for maintenance, and non-functional machines highlight administrative and institutional gaps in CRM program implementation.
- **Logistical coordination affects timely access:** Constraints related to poor scheduling, limited awareness, and delays in machine booking indicate that better management systems are needed to ensure timely access to machinery during the narrow window between harvesting and sowing.

HARYANA AND DELHI

The results indicated a statistically significant difference among the mean ranks of the constraints ($p < 0.05$), suggesting that respondents perceived certain constraints as significantly more severe than others. The similarity in mean values across both respondent groups further indicates a high level of consistency in the perception of the major challenges affecting CRM machinery utilization in the region.

Table 8: Perceived Constraints in Utilization of CRM Machinery by Farmers (n=553) and CHCs (n= 586) in Haryana and Delhi

S.No.		Constraints	Mean values	
			Farmers	CHCs
1.	Operational Constraints	Labor shortage	17.49	17.23
2.		Operator unavailability	17.58	17.44
3.		High fuel cost	19.44	19.95
4.		Machine breakdowns	15.96	16.55
5.		Lack of timely repairs/parts	16.30	16.27
6.		Low-skilled or untrained operators	15.44	15.53
7.		Delayed availability of spare parts	16.52	16.49
8.		Frequent clogging in heavy residue fields	17.55	17.44
9.		Poor machine calibration/maintenance	15.99	16.13
10.	Demand-Side Issues	Low farmer demand	15.15	15.17
11.		Use of alternative machines	16.39	16.35
12.		Preference for burning	13.73	13.80
13.		High rental cost perceived by farmers	18.96	19.23
14.		Mismatch between machine type and local cropping pattern	14.14	14.30
15.		Small and Fragmented holdings	20.07	19.79
16.		Delay in harvesting (late crop maturity)	17.23	17.12
17.	Logistics & Management	Poor scheduling	14.92	14.96
18.		Limited awareness among farmers	15.53	15.53
19.		Inadequate field bunding or field readiness	17.32	17.29
20.		Lack of transport facility for machines	16.00	15.68
21.		Poor coordination among CHC staff	13.80	13.63
22.		Insufficient fuel or lubricant availability	13.63	13.98
23.		Delay in field allocation or booking	15.02	14.83
24.		Inadequate storage/shed for machines	15.71	16.05
25.	Institutional /Policy Related	Delay in subsidy reimbursement	19.41	19.47
26.		Insufficient financial resources for maintenance	19.80	19.55
27.		Non-functional machines from previous allocations	14.44	14.32
28.		Irregular monitoring or reporting requirements	13.46	13.92
29.		High soil moisture during season	19.27	18.83
30.	Natural /Field Conditions	Heavy straw load unsuitable for certain machines	19.11	18.94
31.		Stubble height too high/low	16.23	16.15
32.		Adverse weather (rain/fog) restricting operations	16.41	16.08

The results reveal that economic, institutional, and structural constraints are the most significant barriers to the utilization of CRM machinery in Haryana and Delhi. High fuel costs, labor shortages, operator unavailability, and machine breakdowns were identified as key operational challenges affecting machinery performance and increasing operational costs. Structural issues such as small and fragmented landholdings and the perceived high rental cost of machines further limit farmers' demand for CRM machinery services. Institutional constraints, particularly insufficient financial resources for machine maintenance and delays in subsidy reimbursement, also affect the operational sustainability of CHCs. Additionally, logistical challenges related to field readiness, transport facilities, and machine scheduling influence timely machinery deployment. Environmental factors such as high soil moisture and heavy straw loads also reduce machine efficiency during peak residue management periods. Overall, the consistent perceptions of both farmers and CHC operators highlight the need for strengthening financial support, improving machine maintenance systems, and enhancing institutional and logistical mechanisms to promote effective CRM machinery utilization.

Major Findings

- **Farm structural limitations affect mechanization efficiency:** Small and fragmented landholdings emerged as one of the most critical constraints, indicating that conventional CRM machinery deployment becomes operationally inefficient in fragmented farm landscapes.
- **Economic viability influences CRM adoption:** High fuel costs and the perceived high rental charges of CRM machines significantly influence farmers' decisions to use mechanized residue management services.
- **Institutional financial constraints weaken CHC sustainability:** Insufficient financial resources for maintenance and delays in subsidy reimbursement affect the operational sustainability of Custom Hiring Centers and may lead to underutilization or poor maintenance of machinery.
- **Field conditions affect machine performance:** High soil moisture and heavy straw loads restrict the efficient functioning of certain CRM machines, indicating the need for location-specific mechanization strategies.
- **Skill and operational capacity gaps persist:** Issues such as labor shortages, operator unavailability, and the presence of low-skilled operators suggest the need for strengthening technical capacity and skilled manpower in CRM operations.
- **Moderate logistical constraints affect timely deployment:** Constraints related to field readiness, transport facilities, scheduling, and coordination within CHCs can reduce the efficiency of machine deployment during the short operational window between paddy harvesting and wheat sowing.
- **Consistency in perception across stakeholders:** The similarity in responses between farmers and CHC operators indicates that the identified constraints are systemic and widely experienced across the CRM implementation ecosystem.

UTTAR PRADESH

The results revealed a statistically significant difference among the mean ranks of the identified constraints ($p < 0.05$), indicating that respondents did not perceive all constraints equally. Instead, certain constraints were considered significantly more severe and influential in limiting the effective utilization of CRM machinery in the region.

Table 9: Perceived Constraints in Utilization of CRM Machinery by Farmers (n=586) and CHCs (n= 444) in Uttar Pradesh

S.No.		Constraints	Mean values	
			Farmers	CHCs
1.	Operational Constraints	Labor shortage	17.21	15.49
2.		Operator unavailability	16.63	15.15
3.		High fuel cost	18.60	16.43
4.		Machine breakdowns	15.62	15.18
5.		Lack of timely repairs/parts	16.85	15.25
6.		Low-skilled or untrained operators	15.81	15.96
7.		Delayed availability of spare parts	18.02	15.25
8.		Frequent clogging in heavy residue fields	16.47	15.08
9.		Poor machine calibration/maintenance	16.11	14.64
10.	Demand-Side Issues	Low farmer demand	16.17	15.30
11.		Use of alternative machines	16.27	15.35
12.		Preference for burning	15.18	14.75
13.		High rental cost perceived by farmers	16.98	15.76
14.		Mismatch between machine type and local cropping pattern	14.99	14.37
15.		Small and Fragmented holdings	17.35	17.14
16.		Delay in harvesting (late crop maturity)	17.71	16.16
17.	Logistics & Management	Poor scheduling	16.03	14.51
18.		Limited awareness among farmers	16.89	17.01
19.		Inadequate field bunding or field readiness	17.91	16.43
20.		Lack of transport facility for machines	16.06	15.22
21.		Poor coordination among CHC staff	14.74	14.10
22.		Insufficient fuel or lubricant availability	13.65	14.10
23.		Delay in field allocation or booking	14.55	13.90
24.		Inadequate storage/shed for machines	15.34	14.34
25.	Institutional /Policy Related	Delay in subsidy reimbursement	16.46	14.51
26.		Insufficient financial resources for maintenance	18.17	17.25
27.		Non-functional machines from previous allocations	16.67	17.04
28.		Irregular monitoring or reporting requirements	14.71	14.51
29.	Natural /Field Conditions	High soil moisture during season	19.00	19.14
30.		Heavy straw load unsuitable for certain machines	17.28	15.66
31.		Stubble height too high/low	15.53	15.49
32.		Adverse weather (rain/fog) restricting operations	19.02	15.15

The results indicate that natural and environmental factors, financial limitations, and structural farm characteristics are the major constraints affecting the utilization of CRM machinery in Uttar

Pradesh. High soil moisture and adverse weather conditions significantly restrict machinery operations during the narrow residue management window, while heavy straw loads further reduce machine efficiency. Operational challenges such as labor shortages, operator unavailability, delayed spare parts, and high fuel costs also affect machine deployment and increase operational expenses. Structural issues including small and fragmented landholdings and delays in harvesting limit the effective use of CRM machinery across fields. Institutional constraints such as insufficient financial resources for machine maintenance and the presence of non-functional machines also affect the operational sustainability of Custom Hiring Centers. Additionally, logistical issues related to field readiness and limited farmer awareness hinder efficient machine utilization. Overall, the results highlight the need for improved maintenance systems, enhanced financial support, stronger extension efforts, and location-specific mechanization strategies to promote effective CRM machinery utilization in the state.

Major Findings

- **Environmental conditions strongly influence CRM operations:** High soil moisture and adverse weather conditions (rain and fog) emerged as the most critical constraints, indicating that climatic variability significantly restricts the operational window for CRM machinery use in Uttar Pradesh.
- **Financial sustainability of CHCs is a key concern:** Insufficient financial resources for machine maintenance and the presence of non-functional machines suggest that many Custom Hiring Centers face challenges in maintaining operational efficiency.
- **Operational costs affect machine utilization:** High fuel costs and the perceived rental charges of CRM machinery influence farmers' willingness to adopt mechanized residue management practices.
- **Farm structure limits mechanization efficiency:** Small and fragmented landholdings restrict the efficient deployment of large CRM machines and increase operational complexity in many regions of Uttar Pradesh.
- **Field readiness affects machine performance:** Inadequate field bunding and poor field preparation reduce the efficiency of CRM machinery and increase the likelihood of operational difficulties.
- **Skill and service infrastructure gaps persist:** Labor shortages, operator unavailability, and delays in spare parts availability indicate the need for strengthening technical support systems and skilled manpower availability.
- **Awareness and extension gaps remain:** Limited awareness among farmers about CRM technologies suggests that extension outreach and knowledge dissemination need further strengthening.

IMPLICATIONS

- **Strengthening CRM machinery maintenance and service ecosystems is essential:** Establishing district-level repair and service hubs, ensuring timely availability of spare parts, and implementing preventive maintenance systems can significantly reduce machine downtime and improve operational efficiency of CRM machinery.
- **Capacity building and skill development of machine operators is critical:** Institutionalizing regular training and certification programs for CRM machine operators and CHC personnel through KVKs, agricultural universities, and extension agencies will enhance technical competency and improve machinery utilization.
- **Financial sustainability of Custom Hiring Centers (CHCs) needs policy support:** Providing maintenance grants, working capital assistance, operational subsidies, and ensuring timely reimbursement of subsidies can strengthen the operational viability and long-term sustainability of CHCs.
- **Cluster-based mechanization models can address structural farm constraints:** Promoting village-level or cluster-based machinery deployment and cooperative machine use can improve access to CRM machinery in areas characterized by small and fragmented landholdings.
- **Digital platforms can enhance logistical coordination and machine access:** ICT-based systems for machine booking, scheduling, monitoring, and real-time tracking can improve coordination between farmers and CHCs and ensure timely availability of machinery during peak seasons.
- **Extension and behavioral change interventions remain crucial:** Strengthening awareness campaigns and behavioral change communication through KVKs and extension networks can further promote the economic, agronomic, and environmental benefits of in-situ crop residue management and discourage residue burning.
- **Diversified and location-specific CRM machinery solutions are needed:** Encouraging CHCs to maintain a balanced portfolio of CRM machines and promoting the development of machines suitable for heavy residue loads, high soil moisture conditions, and diverse agro-ecological conditions of the Indo-Gangetic Plains can improve adaptability and efficiency.
- **Improved monitoring and institutional accountability can enhance program effectiveness:** Developing digital monitoring systems and transparent reporting mechanisms to track machine utilization, maintenance status, and field-level outcomes will strengthen governance and improve the impact of CRM interventions.

6

Summary & Way Forward

A comprehensive field survey was conducted across Punjab, Haryana (including Delhi), and Uttar Pradesh to assess the availability, functionality, and utilization of Crop Residue Management (CRM) machinery at individual farmer and Custom Hiring Centre (CHC)/cooperative levels. The total sample size comprised 1,502 individual farmers and 1,328 CHCs, selected through a uniform sampling framework wherein each participating KVK covered four representative blocks and surveyed six farmers and six CHCs per block. Across the three states, the survey revealed that while CRM machinery availability and functional status are largely satisfactory, the actual utilization of potential capacity remains uneven and generally sub-optimal, particularly at the individual farmer level. CHCs, on average, demonstrated better utilization efficiency than individual farmers, highlighting the relative advantage of shared-service and institutional ownership models. However, even at CHC level, utilization varied widely by machine type and state, with persistent gaps between potential and actual field use. The findings collectively point to a shift needed from asset-centric expansion towards utilization-focused, demand-driven, and better-managed deployment of CRM machinery to achieve the intended environmental and agronomic outcomes.

Major Highlights

- **High functionality, low-to-moderate utilization:** Most CRM machines across states were functional (>80-90%), but utilization of potential capacity often remained below optimal levels.
- **Institutional advantage of CHCs:** CHCs generally recorded relatively higher utilization efficiency than individual farmers, especially for heavy-duty and multipurpose machines.
- **Machine-specific performance patterns:**
  - ❖ Super Seeders consistently dominated in adoption and area coverage across all three states.
  - ❖ Mulchers, MB Ploughs, Zero Till Drills, and Smart Seeders showed moderate utilization, with better performance under CHC management.
  - ❖ Surface Seeders exhibited very low demand despite high functionality.
  - ❖ Balers performed exceptionally well in Punjab, but remained underutilized in Uttar Pradesh and at individual farmer level elsewhere.
- **Small and fragmented CHCs:** A majority of CHCs in all states operated with 1-3 machines, constraining service coverage and peak-season efficiency.

- **State-level contrasts:**
    - ❖ Punjab showed relatively higher utilization efficiency, especially under CHCs.
    - ❖ Haryana & Delhi displayed higher farmer-level utilization for select machines but lower average CHC utilization.
    - ❖ Uttar Pradesh exhibited the widest gap between availability and effective utilization, particularly at the individual farmer level.

KEY RECOMMENDATIONS AND WAY FORWARD

1. **Shift focus from asset creation to utilization efficiency:** Future CRM interventions should move beyond the distribution of machinery and prioritize performance-oriented indicators such as utilization of potential capacity, acreage covered, operational hours, and seasonal deployment efficiency. This shift will ensure that public investments translate into tangible field-level outcomes and reduce idle machinery capacity.
2. **Strengthen and consolidate Custom Hiring Centers (CHCs):** Promote cluster-based or block-level pooling of machinery and facilitate inter-CHC sharing arrangements to overcome fragmentation among smaller centers. Such consolidation can improve service continuity, enhance operational viability, and ensure wider access to CRM machinery, particularly in areas characterized by small and fragmented landholdings.
3. **Adopt a demand-driven and location-specific machinery portfolio:** Procurement and placement of CRM machinery should be aligned with demonstrated utilization patterns, residue loads, and agro-ecological conditions. Priority should be given to machines showing consistently higher utilization (e.g., Super Seeders, Mulchers, MB Ploughs, and Cutter-cum-Spreaders), while persistently underutilized implements should be rationalized or relocated to areas of higher demand.
4. **Align ownership models with performance outcomes:** CRM machines that demonstrate higher efficiency and utilization under institutional management should primarily be promoted through CHCs, whereas farmer-specific implements can be encouraged under individual ownership models. Such differentiation can improve machine accessibility, management efficiency, and overall utilization.
5. **Improve operational planning and logistical coordination:** Introduce block-wise seasonal operation plans, advance booking systems, and coordinated inter-district movement of machinery to address spatial and temporal mismatches in demand during the narrow residue management window between paddy harvesting and wheat sowing.
6. **Strengthen machine maintenance and service ecosystems:** Establish district-level service and repair hubs, ensure timely availability of spare parts, and implement preventive

maintenance protocols. Strengthening the service infrastructure will reduce machine downtime, enhance operational reliability, and improve the lifespan of CRM machinery.

7. **Enhance financial sustainability of CHCs:** Provide maintenance grants, working capital support, operational subsidies, and ensure timely reimbursement of subsidies to improve the financial viability and long-term sustainability of Custom Hiring Centers.

8. **Promote digital platforms for machine scheduling and monitoring (Uberization):** Develop unified ICT-based platforms for machine booking, real-time tracking, scheduling, and demand aggregation. Such digital systems can improve transparency, reduce idle time, and ensure timely access to CRM machinery for farmers.

9. **Strengthen capacity building and operator training:** Institutionalize regular training and certification programs for CRM machine operators and CHC personnel through KVKs, agricultural universities, and extension systems to improve technical competency and operational efficiency.

10. **Expand residue-based value chains and *ex-situ* utilization pathways:** Enhance the utilization of balers and other ex-situ technologies by strengthening linkages with fodder markets, biomass-based industries, and aggregation centers with assured off-take mechanisms.

11. **Intensify extension and behavioral change interventions:** Strengthen awareness campaigns and behavioral change communication through KVKs and extension networks to highlight the agronomic, environmental, and economic benefits of *in-situ* residue management and further discourage residue burning.

12. **Introduce performance-based incentives and monitoring systems:** Develop transparent monitoring mechanisms and performance-linked incentives for CHCs based on indicators such as acreage covered, machine utilization rate, reduction in burning incidents, and farmer satisfaction. Recognition of best-performing CHCs can promote accountability, operational efficiency, and healthy competition.

Annexure-I

Survey Performa

Assessment of Functionality and Utilization of CRM Machinery

A. Basic Information

1. Name of CHC / Farmer: ______________________________

2. District / Block / Village: ______________________________

3. Owner Type: ☐ Individual ☐ Cooperative ☐ Panchayat ☐ FPO/FPC

4. Year of Establishment of CHC: ______________________________

5. Contact Person & Mobile: ______________________________

B. Machinery Inventory & Utilization

S. No.	Machinery Name	Year of purchase	Total Units (No.)	Functional Units (No.)	Total Area Covered (acre) in current season 2025-26
1	Happy Seeder				
2	Super Seeder				
3	Surface Seeder				
4	Smart Seeder				
5	Zero Till Drill				
6	Baler				
7	Mulcher/Chopper				
8	Rotavator				
9	MB Plough				
10	Disc Harrow				
11	Any other 1				
12	Any other 2				

Perceived Constraints in Utilization of CRM Machinery

S.No.		Constraints	Low Severity	Moderate Severity	High Severity
1.	Operational Constraints	Labor shortage			
2.		Operator unavailability			
3.		High fuel cost			
4.		Machine breakdowns			
5.		Lack of timely repairs/parts			
6.		Low-skilled or untrained operators			
7.		Delayed availability of spare parts			
8.		Frequent clogging in heavy residue fields			
9.		Poor machine calibration/maintenance			
10.	Demand-Side Issues	Low farmer demand			
11.		Use of alternative machines			
12.		Preference for burning			
13.		High rental cost perceived by farmers			
14.		Mismatch between machine type and local cropping pattern			
15.		Small and Fragmented holdings			
16.		Delay in harvesting (late crop maturity)			
17.	Logistics & Management	Poor scheduling			
18.		Limited awareness among farmers			
19.		Inadequate field bunding or field readiness			
20.		Lack of transport facility for machines			
21.		Poor coordination among CHC staff			
22.		Insufficient fuel or lubricant availability			
23.		Delay in field allocation or booking			
24.		Inadequate storage/shed for machines			
25.	Institutional /Policy Related	Delay in subsidy reimbursement			
26.		Insufficient financial resources for maintenance			
27.		Non-functional machines from previous allocations			
28.		Irregular monitoring or reporting requirements			
29.	Natural /Field Conditions	High soil moisture during season			
30.		Heavy straw load unsuitable for certain machines			
31.		Stubble height too high/low			
32.		Adverse weather (rain/fog) restricting operations			

LIST OF CONTRIBUTORS

S. No.	KVK/ATARI	Contributors
		PUNJAB
1.	Amritsar	Raminder Kaur Hundal, Bikramjit Singh
2.	Bathinda	Tejbir Singh, Gurdeep Singh
3.	Faridkot	Rakesh Kumar
4.	Fatehgarh Sahib	Reet Verma, Hardeep Sabhikhi
5.	Ferozepur	B S Sekhon, Gurmail Singh Sandhu
6.	Gurdaspur	Ravinder Singh Chhina, Sarabjit Singh Aulakh
7.	Hoshiarpur	Ajaib Singh, Maninder Singh Bons
8.	Jalandhar	Prabhjit Kaur, Sanjeev Kumar Kataria
9.	Kapurthala	Bindu Marwaha, Harinder Singh
10.	Ludhiana	Amanpreet Singh, Vipan Kumar Rampal
11.	Mansa	Alok Gupta, Ajit Pal Singh Dhaliwal
12.	Moga	Manpreet Jaidka, Kamaldeep Singh Matharu
13.	Muktsar	Vivek Kumar, Karamjit Sharma
14.	Nawanshahr	Jaswinder Kumar, Pardeep Kumar
15.	Pathankot	Puneet Sharma, Ravinder Singh Chinna
16.	Patiala	Gurpreet Singh, Hardeep Sabhikhi
17.	Ropar	Aparna, Satbir Singh
18.	Sangrur	Sunil Kumar, Mandeep Singh
19.	Barnala	Suryendra Singh, Prahalad Singh Tanwar
20.	Mohali	Harmeet Kaur, Balbir Singh Khadda
21.	Tarn Taran	Navjot Singh Brar, Prabjeet Singh
22.	Fazilka	Kishan Kumar Patel, Arvind Kumar Ahlawat
		HARYANA
23.	Ambala	Rajena Singh, Amit
24.	Bhiwani	Krishma Nanda
25.	Delhi	Kailash
26.	Fatehabad	Santosh Kumar, Nirmal Singh
27.	Hisar	Narena Kumar, Pankaj
28.	Jhajjar	Rajesh Kumar
29.	Jind	Ravi, Pawan Kumar
30.	Kaithal	Gurnam Singh
31.	Karnal	Uttam Kumar, P K Saraswat
32.	Kurukshetra	Sarita Rani
33.	Panipat	Sunil Kumar, Satpal Singh
34.	Rohtak	Meenakshi Sangwan, Meena Siwach
35.	Sonipat	Kuldeep Singh
36.	Sirsa	Sunil Kumar
37.	Yamunanagar	Kapil, Sandeep Rawal
38.	ATARI, Jodhpur	Bheem Sen, Dinesh Dutt
		UTTAR PRADESH
39.	Azamgarh-II	L C Verma
40.	Bahraich-I	C P N Gautam, Nandan Singh
41.	Bahraich-II	Sandeep Kumar, Sunil Kumar
42.	Barabanki	Ashwani Kumar Singh, Bhaskar Pratap Singh
43.	Bareilly	H R Meena, Lakshya Yadav
44.	Bijnor	K K Singh
45.	Bulandshahr	Reshu Singh, Lalit Kumar
46.	Chandauli	Narendra Raghubansi, Chandan Singh
47.	Hapur	Arvind Kumar, Ashok Singh
48.	Etawah	M K Singh, Vijay Bahadur Jaiswal
49.	Hardoi-II	Pankaj Nautiyal, Traloki Singh
50.	Jaunpur - I	Suresh Kumar Kannaujiya, Rajeev Kumar Singh
51.	Jaunpur - II	RK Singh, Barun Kumar
52.	Kanpur Dehat	Ajay Kumar Singh, Khalil Khan
53.	Maharajganj	Dhirena Pratap Singh, Vijay Chana
54.	Mathura	Y K Sharma, Ravina Kumar Rajput
55.	Muzaffarnagar-II	Y P Singh, Reena
56.	Pilibhit	Shailena Singh Dhaka, Amarjeet Singh Rathi
57.	Raebareli-I	K K Singh, Deepak Mishra
58.	Shahjahanpur	N C Tripathi, Narena Prasad
59.	Saharanpur	I K Kushwaha, Ravina Tomar
60.	Siddharthnagar	Om Prakash, Shesh Narain Singh
61.	Varanasi	Naveen Kumar Singh, Amitesh Kumar Singh
62.	ATARI Kanpur	Ajay Kumar Singh, Anushi

सत्यमेव जयते

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

www.facebook.com/icaratari.ludhiana.5

twitter.com/atari1icar

www.youtube.com/@icar-atariludhianazone-i8059

atariz1.org.in

ICAR-AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTE
ZONE-I, PAU CAMPUS, LUDHIANA-141004 PUNJAB