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A Study on Agricultural Mechanization Status under Paddy and Wheat Crop Production in Central Region of Uttar Pradesh, India

Anand Chaudhari [a*] and Sheen C. Moses [a]

[a] *Department of Farm Machinery and Power Engineering, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj- 211007, Uttar Pradesh, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The technological progress in agricultural machinery since the mid-1960s has led to a revolutionary increase in crop yield in India. Northern states like Punjab, Haryana, Uttar Pradesh (especially the western and central region have experienced rapid growth in the adoption of mechanized farming practices. A study was conducted to evaluate the present state of farm mechanization in four districts of Uttar Pradesh. The average farm power accessible in this area was recorded at 2.05 $kWha^{-1}$, surpassing the national average (1.9 kW/ha). The lowest mechanization index in wheat crop was observed in plant protection operations (20.6%) whereas highest mechanization index was observed in harrowing operation (94.2%). Similarly, in paddy crop, the lowest mechanization index was observed in transplanting operations (0%) whereas highest mechanization index was observed in harrowing harrowing and puddling operations (99%).With the exception of tasks like transplanting paddy and ensuring pest control in rice and wheat cultivation, almost all stages of crop production employed tractor-driven machinery. The primary obstacle observed in farm mechanization in the region was the lack of timely access to farming equipment.

**Corresponding author: E-mail: znssbga@gmail.com;*

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1. INTRODUCTION

Following the introduction of the green revolution, Indian agriculture has undergone a swift transformation in terms of mechanized farming [1,2]. Over the past five decades, there has been a noteworthy increase in the average farm power accessible in India, escalating from approximately 0.30 $kWha^{-1}$ to roughly 1.9 $kWha^{-1}$ by 2020 [3]. This rapid shift towards mechanization in agriculture is primarily attributed to the scarcity of available human labor and the necessity for greater cropping intensity. The agricultural landscape in India encompasses diverse agro-ecological regions, resulting in substantial variations in cropping intensity and yield levels due to regional disparities [4]. In these distinct regions, there exists a notable discrepancy in the availability of farm power and the extent of mechanization within the agricultural practices. Notably progressive in terms of agro-ecology, the central region in the Uttar Pradesh state has embraced a comparable level of agricultural mechanization as observed in other high-yielding states such as Punjab and Haryana [1]. The primary goal of agricultural mechanization revolves around boosting the productivity of laborers, amplifying human exertion, minimizing the reliance on manual labor, and alleviating the physical strain that can detrimentally impact human cognitive abilities, resulting in mistakes, inaccuracies, and risks, ultimately diminishing effectiveness [5]. These aims drive the refinement of agricultural tools tailored to specific crops and the agro-climatic region they are utilized in.

Currently, the landscape of agricultural mechanization in advanced areas has shifted towards an increased utilization of powerful tractors and combine harvesters [6,7]. This shift has led to a notable rise in the availability of farm power. The incorporation of machinery into farming practices is progressively growing, driven by its capacity to generate cost savings and enhance net profits for farmers [3]. Some regions such as Punjab, Haryana, and the Terain area of Uttar Pradesh and Uttarakhand have achieved notable progress in the mechanization of agriculture. The utilization of agricultural machinery in India varies significantly across different geographical areas. The adoption of machinery in agriculture is heavily influenced by factors such as the agro-climatic conditions, crop patterns, intensity of cultivation, and soil types [8,9]. The challenges related to the maintenance and repair of farm machinery were being experienced by farmers [3]. Therefore, it becomes imperative to evaluate the current status of farm machinery usage in the state to facilitate the future development of agricultural equipment based on the requirements of the farmers.

2. MATERIALS AND METHODS

The study was carried out to assess the extent of mechanization and the availability of farm power in the four district of Uttar Pradesh viz Lakhimpur Kheri, Sitapur, Hardoi and Sahajhanpur. In February 2022, a total of 250 farmers from 59 villages representing various categories were engaged for the study. First of all, a detailed questionnaire was prepared to get the information about availability of prime movers, tractors and animal power sources available with farmers. Along with that the question related to availability of farm machinery and their usasge were also included in the questionnaire. The simple random sampling approached was adopted for conduction of survey. 50 farmers from different categories viz. large, medium, semi medium, small and marginal category were surveyd.

Data pertaining to diverse aspects of agricultural mechanization, including farm power utilization and machinery usage, was gathered through direct interviews with each chosen farmer, employing a predefined survey questionnaire. This questionnaire was meticulously designed to encompass comprehensive details regarding the resources and equipment owned by the farmers. The degree of mechanization in a specific area is typically gauged by factors such as the accessibility of farm power, the presence of agricultural tools, and a mechanization index. These metrics were computed to characterize the state of agricultural mechanization in the selected region of Uttar Pradesh.

2.1 Farm Power Availability

The primary determinant in agricultural mechanization is the presence of power supply. Within Indian farming, the diverse origins of farm power can be categorized as either mobile or stationary sources. Among mobile sources, there are human labor, draft animals, tractors, power tillers, and self-propelled machinery such as

reapers and combine harvesters. Stationary power sources comprise diesel engines and electric motors [10].

The calculation of farm power availability per hectare was accomplished using the t formula.

$$FPA = \frac{(No.of\ Agri.\ workers \times 0.05) + (No.of\ draft\ animals \times 0.3) + (Sum\ of\ RHP\ of\ tractor) + (Sum\ of\ RHP\ of\ power\ tillers) + (No.of\ electric\ motors \times RHP) + (No.of\ diesel\ engines \times RHP)}{Avaiable\ cultivable\ land, ha} \quad (1)$$

Where,

FPA= Farm power availability, $kWha^{-1}$

2.2 Farm Mechanization Index

The mechanization index reflects the proportion of tasks accomplished by machinery in comparison to the overall tasks completed by humans, draft animals, and machinery, expressed as a percentage. The calculation of the agricultural mechanization index followed the formula [3,11,12].

$$MI = \frac{LM}{LT} \times 100\% \quad (2)$$

Where,

MI= Mechanization index
LM=Average sum of all mechanical work of the machine, $MJha^{-1}$
LT = LM + LH + LA (3)

Where,

LH= Sum of work done by human, $MJha^{-1}$
LA= Sum of work done by draft animal, $MJha^{-1}$

Information regarding the collection of inventory data for all farm equipment, including handheld tools, tractor-operated machinery, and self-propelled equipment, was sourced from the farmers.

2.3 Availability of Farm Machinery

The details of inventory of all the farm equipment like hand tools, tractor operated and self-propelled equipment was obtained from farmers. The requirement of farm implements was calculated by the relationship [3].

Farm machinery demand supply gap= No of available machine- No. of required machine

$$Number\ of\ IR = \frac{UCA}{AFC \times No.of\ WD \times No.of\ WH} \quad (4)$$

Where,

No. of IR = No. of implement required
UCA = Uncovered cultivated area, ha
AFC = Actual filed capacity, ha/h
No. of WD = Number of available working days for the prescribed time window of the crop
No. of WH = Number of working hours per day, hd^{-1}

Working hours per day were taken as 8 hours. The time window used was based on the chart for different operations on wheat crop as validated for the selected region. Table 2 shows the time window for different unit operations in wheat crop production system of selected region. The time window does not have any mention for irrigation and fertilizer application and normally these operations are done by farmer as and when needed.

The farm machinery availability with a particular farmer was obtained by taking the difference between number of implements available with farmer and number of implement required [13,14]. An adequacy on availability of equipment was estimated taking a zero value indicating that the farmer has adequate number of equipment. A positive value indicates the farmer has more number of equipment than required and a negative value indicates that farmer does not have adequate number of equipment.

3. RESULTS AND DISCUSSION

The research was conducted to evaluate the degree of mechanization in the selected region of Uttar Pradesh. The farm power supply in the selected region was calculated to be 2.05 $kWha^{-1}$. Farmers falling under the large and medium categories in this area possess high-horsepower tractors and combine harvesters. Consequently, the farm power accessibility for these larger and medium-sized farmers stands apart from the remaining categories. [14,15] Moreover, the farm power availability in this region is on par with other high-yielding states in India, such as Punjab and Haryana.

Agricultural activities in the selected region of Uttar Pradesh are extensively automated with utilization of high-powered tractors and combine harvesters. Larger and medium-sized landholders possess multiple tractors and utilize

mechanized methods for nearly all tasks. The mechanization index for specific operations in wheat and paddy cultivation is displayed in Tables 3 and 4. The study revealed that even small and marginal farmers engage tractors from their larger counterparts to assist with tasks like seedbed preparation, plowing, and threshing. A similar trend was observed in the mechanization of paddy cultivation. Notably, a significant lack of mechanization was found in the transplanting of paddy, where the mechanization index reached zero [16,17]. Across all categories of farmers in the selected region of Uttar Pradesh, manual transplantation of the nursery was a common practice due to the substantial human labor is necessitated. It has been observed from Table 6 that in 80% of large, 83.3% of medium, 73.5% of semi medium, 40.5% of small and 12.5% of marginal farmers have more than required implements for seed bed preparation while 17.8% of large, 16.6% of medium, 26.5% of semi medium, 52.4% of small and 87.5% of marginal farmers do not have sufficient number of implements for seed bed preparation.

For sowing operation, 82.2% of large, 41.8% of medium, 14.3% of semi medium, 14.6% of small and 0% of the marginal farmers own more than sufficient implements while 17.8% of large, 59.2% of medium, 83.7% of semi medium, 85.4% of small and 100% of marginal farmers do not own sufficient implements for sowing. All marginal farmers and a large number of small and semi medium farmers also sow wheat crop through broadcasting therefore the percentage is high and even some cases the farmer who do not own a seed drill usually hires it at the time of sowing. Similarly, in plant protection, 75.6% of large, 62.5% of medium, 38.8% of semi medium, 52.4% of small and 7.3% of marginal farmers own more than sufficient implements while 22.2% of large, 37.5% of medium, 55.1% of semi medium, 40.5% of small and 92.7% of marginal farmers do not own sufficient implements for plant protection. Most of the marginal farmers hire the manually operated knapsack sprayer for application of agro-chemicals.

In harvesting and threshing operation, 11.1% of large, 6.3% of medium, 12.2% of semi medium, 11.9% of small and 0% of marginal farmers own more than sufficient equipments while 88.9% of large, 93.7% of medium, 12.2% of semi medium, 88.1% of small and 100% of marginal farmers do not own sufficient implements for harvesting and threshing operation. A large number of farmers in large, medium and small category opt for combine harvesting of wheat crop and therefore do not own any harvesting and threshing equipment.

Table 1. Distribution of farmers in the selected region

Particulars	Marginal (< 1ha)	Small (1-2 ha)	Semi medium (2-4 ha)	Medium (4-10 ha)	Large (< 10ha)
No. of farmers	63566	18277	14423	7155	528
Average land holding (ha)	0.67	1.57	3.16	6.26	21.84
Number of farmer surveyed	50	50	50	50	50

Table 2. Time window for different unit operations in wheat crop production

Unit operation	Month	Number of day available for operation
Seedbed Preparation	November	15
Sowing	November	15
Spraying	January	30
Harvesting	April	15

Table 3. Farm power availability ($kWha^{-1}$) in the selected region of Uttar Pradesh

Large	Medium	Semi Medium	Small	Marginal	Weighted Average
3.13	4.11	2.7	2.1	1.65	2.05

Table 4. Operation wise mechanization index in wheat crop production (%)

Harrowing	Planking	Sowing	Irrigation	Plant Protection	Harvesting and Threshing
94.2	93.8	62.6	58.2	20.6	88.8

Table 5. Operation wise mechanization index in paddy crop production (%)

Nursey Raising	Harrowing	Puddling	Transplanting	Irrigation	Plant Protection	Interculture operation	Harvesting and Threshing
87	99	99	0	62	29	0	99

Table 6. Availability of farm implements for wheat and paddy crop production

Particulars	Large (%)	Medium (%)	Semi Medium (%)	Small (%)	Marginal (%)
Seedbed Preparation	80	83.3	73.5	40.5	12.5
Sowing	82.2	41.8	14.3	11.9	0
Plant Protection	75.6	62.5	38.8	52.4	7.3
Harvesting & Threshing	11.1	6.3	12.2	11.9	0

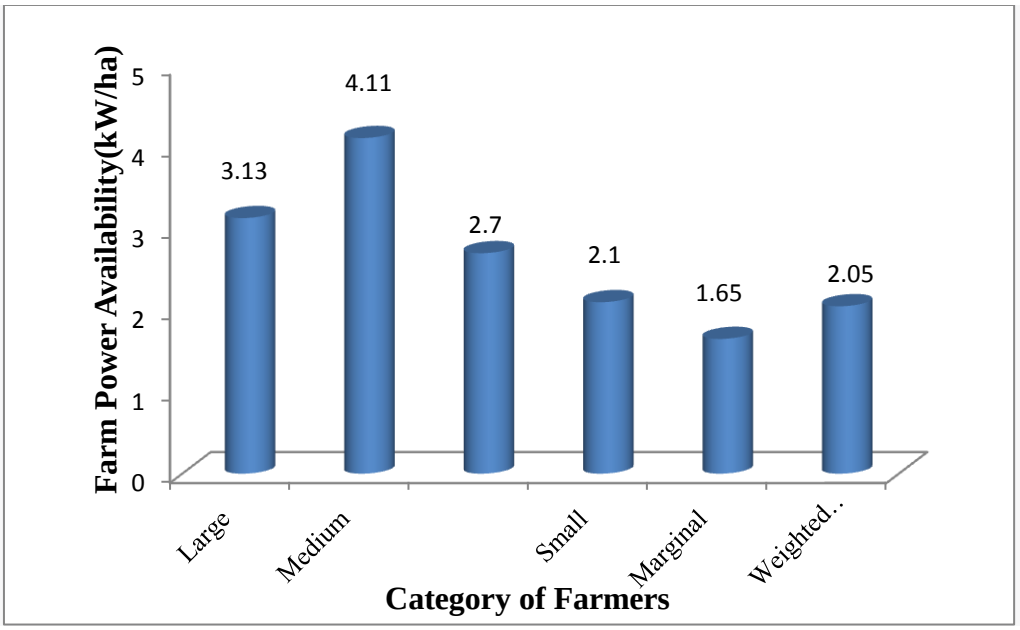

Fig. 1. Farm power availability of different category of farmers

Beyond the extent of mechanization, another challenge related to agricultural mechanization is the timely accessibility of farm equipment [18–22]. The research noted that farmers with larger land holdings possess sufficient tools for tasks like seedbed preparation, sowing, and plant protection. However, only 11 percent of the large-category farmers have adequate equipment for harvesting and threshing. The availability of farm implements for various farmer categories is outlined in Table 6 The study revealed that small and marginal farmers in the region lack adequate tools for crop cultivation, creating significant potential for the custom hiring of agricultural machinery. In this context, farmers with larger land holdings, who

possess more than enough machinery, often make their equipment available to smaller farmers.

4. CONCLUSION

Agricultural mechanization plays a crucial role in influencing both the cost of producing crops on time and the overall yield of crops. The rise in the degree of agricultural mechanization has led to higher crop value and increased frequency of cropping in the area. In the selected region of Uttar Pradesh, an average of 2.05 kW/ha of farm power was noted to be available. The majority of the steps involved in cultivating rice and wheat crops were observed to be extensively mechanized, with the exception of tasks like nursery transplanting and safeguarding plants. Despite the region displaying a significant level of mechanization, there is a shortage of sufficient farming tools and equipment. This might be due to the fact that most of the small and marginal category farmers do not own the machinery and they hire it from large and medium category farmers Based on the findings of the study, establishing a custom hiring bank in the area is strongly advised.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mandal S, Sharma RK. Application of Gasification Technology in Agriculture for Power Generation. In: Handbook of Energy Management in Agriculture. Springer Nature Singapore, Singapore. 2023;1–22
2. Sharma RK, Singh TP, Mandal S. et al. Chemical Treatments for Biochar Modification: Opportunities, Limitations and Advantages. In: Engineered Biochar. Springer Nature Singapore, Singapore. 2022;65–84
3. Sharma RK, Bhattacharya TK, Kumain A. et al. Energy use Pattern in Wheat Crop Production System among Different Farmer Groups of the Himalayan Tarai Region. Curr Sci. 2020;118:448. Available:https://doi.org/10.18520/cs/v118/i3/448-454
4. Mandal S, Sharma RK, Bhattacharya TK. et al. Charring of pine needles using a portable drum reactor. Chemical Papers. 2022;76:1239–1252. Available:https://doi.org/10.1007/s11696-021-01893-4
5. Alam A Future requirements of agricultural machines for mechanizing agriculture. Status of farm mechanization in India; 2006.
6. Jiang M, Hu X, Chunga J. et al. Does the popularization of agricultural mechanization improve energy-environment performance in China's agricultural sector? J Clean Prod. 2020; 276:124210. Available:https://doi.org/10.1016/J.JCLEPRO.2020.124210
7. Qian L, Lu H, Gao Q, Lu H. Household-owned farm machinery vs. outsourced machinery services: The impact of agricultural mechanization on the land leasing behavior of relatively large-scale farmers in China. Land use policy. 2022; 115:106008. Available:https://doi.org/10.1016/J.LANDUSEPOL.2022.106008
8. Tzanakakis VA, Chatzakis MK, Angelakis AN. Energetic environmental and economic assessment of three tree species and one herbaceous crop irrigated with primary treated sewage effluent. Biomass Bioenergy. 2012;47:115–124. Available:https://doi.org/10.1016/J.BIOMBIOE.2012.09.051
9. Das A, Layek J, Ramkrushna GI. et al. Effects of tillage and rice residue management practices on lentil root architecture, productivity and soil properties in India's Lower Himalayas. Soil Tillage Res. 2019;194:104313. Available:https://doi.org/10.1016/J.STILL.2019.104313
10. Mandal S, Roy S, Das A. et al. Energy efficiency and economics of rice cultivation systems under subtropical Eastern Himalaya. Energy for Sustainable Development. 2015;28:115–121. Available:https://doi.org/10.1016/J.ESD.2015.08.002
11. Albiero D, Pontin Garcia A, Kiyoshi Umezu C, Leme de, Paulo R. Swarm robots in mechanized agricultural operations: A review about challenges for research. Comput Electron Agric. 2022;193:106608. Available:https://doi.org/10.1016/J.COMPAG.2021.106608
12. Van Loon J, Woltering L, Krupnik TJ. et al. Scaling agricultural mechanization services in smallholder farming systems: Case studies from sub-Saharan Africa, South

Asia, and Latin America. Agric Syst. 2020;180:102792.
Available:https://doi.org/10.1016/J.AGSY.2020.102792

13. Ulusoy E. Agricultural Mechanization in Turkey. IERI Procedia. 2013;5:41–44.
Available:https://doi.org/10.1016/J.IERI.2013.11.067
14. Aryal JP, Rahut DB, Maharjan S, Erenstein O. Understanding factors associated with agricultural mechanization: A Bangladesh case. World Dev Perspect. 2019;13:1–9.
Available:https://doi.org/10.1016/J.WDP.2019.02.002
15. Belton B, Win MT, Zhang X, Filipski M. The rapid rise of agricultural mechanization in Myanmar. Food Policy. 2021;101:102095.
Available:https://doi.org/10.1016/J.FOODPOL.2021.102095
16. Daum T, Birner R. Agricultural mechanization in Africa: Myths, realities and an emerging research agenda. Glob Food Sec. 2020;26:100393.
Available:https://doi.org/10.1016/J.GFS.2020.100393
17. Pingali P. Chapter 54 Agricultural Mechanization: Adoption Patterns and Economic Impact. Handbook of Agricultural Economics. 2007;3:2779–2805.
Available:https://doi.org/10.1016/S1574-0072(06)03054-4
18. Diao X, Cossar F, Houssou N, Kolavalli S. Mechanization in Ghana: Emerging demand, and the search for alternative supply models. Food Policy. 2014;48:168–181.
Available:https://doi.org/10.1016/J.FOODPOL.2014.05.013
19. Su M, Heerink N, Oosterveer P, Feng S. Upscaling farming operations, agricultural mechanization and chemical pesticide usage: A macro-analysis of Jiangsu Province, China. J Clean Prod. 2022;380:135120.
Available:https://doi.org/10.1016/J.JCLEPRO.2022.135120
20. Li F, Feng S, Lu H. et al. How do non-farm employment and agricultural mechanization impact on large-scale farming? A spatial panel data analysis from Jiangsu Province, China. Land use policy. 2021;107:105517.
Available:https://doi.org/10.1016/J.LANDUSEPOL.2021.105517
21. Aryal JP, Rahut DB, Maharjan S, Erenstein O. Understanding factors associated with agricultural mechanization: A Bangladesh case. World Dev Perspect. 2019;13:1–9.
Available:https://doi.org/10.1016/J.WDP.2019.02.002
22. Takeshima H, Hatzenbuehler PL, Edeh HO. Effects of agricultural mechanization on economies of scope in crop production in Nigeria. Agric Syst. 2020;177:102691.
Available:https://doi.org/10.1016/J.AGSY.2019.102691

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