



Mechanization in Agriculture: Its Impact and Role of AICRP

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Agriculture in India has long been the backbone of rural livelihoods, food security, and economic growth. Yet, the sector has consistently grappled with structural challenges, ranging from high dependence on manual labour to fragmented landholdings and uneven productivity across regions. In this context, agricultural mechanization has emerged as a transformative pathway, offering not only efficiency and timeliness in farm operations but also long-term sustainability and competitiveness. Mechanization in its broadest sense refers to the application of tools, equipment, and machinery to agricultural practices. This includes everything from simple hand implements to highly advanced, digitally enabled machinery. Its purpose extends beyond mere substitution of human or animal labour, mechanization seeks to improve efficiency, reduce drudgery, ensure timeliness, and optimize the use of scarce resources such as water, soil, and energy.

Globally, mechanization has proven to be the cornerstone of agricultural modernization. Developed nations, where over ninety percent of agricultural tasks are mechanized, have achieved remarkable levels of efficiency and productivity. In India, however, the process has been gradual and uneven. Farm power availability, which was just 0.48 kW per hectare in the mid-1970s, rose to 2.49 kW per hectare by 2018-19, yet projections indicate that the country must nearly double this figure to meet food demands by 2030. Despite progress, the current mechanization level of around 40-45 percent lags far behind global standards. This gap reflects both structural constraints such as small and fragmented holdings, heterogeneity of cropping systems, and socio-economic disparities as well as the enormous potential for growth.

Recognizing the urgency of advancing mechanization, the Indian Council of Agricultural Research (ICAR) established the All India Coordinated Research Project (AICRP) on Farm Implements and Machinery in 1975. This initiative was envisioned not as a mere program of technology development but as a holistic, collaborative platform to address the diverse realities of Indian farming. Unlike industrialized nations where uniform mechanization strategies could be deployed, Indian agriculture required localized, crop-specific, and regionally adapted solutions. The AICRP framework, with its decentralized research centres spread across the country, enabled such innovations by combining national coordination with local responsiveness.

Over the years, AICRP has evolved into a robust institutional mechanism linking research institutions, universities, manufacturers, and farmers. Its mandate includes developing affordable implements, conducting multi-location testing, validating technologies through farmer participation, and facilitating commercialization through industry partnerships. This end-to-end approach from prototype design to field trials and eventual adoption has ensured that technologies are not only scientifically sound but also socially acceptable and economically viable. Notably, AICRP has developed a wide array of region-

specific implements, such as zero-till drills for the rice wheat cropping system, manually operated rice transplanters, animal-drawn planters, sugarcane sett cutter planters, and raised-bed planters. Each of these innovations addressed particular challenges, whether related to labour shortages, timeliness of operations, or resource conservation. For example, the tractor-operated zero-till seed-cum-fertilizer drill revolutionized wheat cultivation in rice-dominated regions by allowing direct sowing without tillage, resulting in savings of up to 50 percent in time and 40 percent in costs, while conserving soil and water resources.

The social and economic impacts of AICRP interventions have been equally noteworthy. Mechanization reduced drudgery, especially for labour-intensive operations such as sowing, transplanting, and harvesting, which are traditionally associated with high physical strain. Farmers adopting mechanized practices witnessed improvements in productivity and profitability, supported by cost and time savings. Environmental benefits were also significant, with technologies promoting conservation tillage, efficient water use, and reduced fuel consumption. Furthermore, AICRP emphasized the importance of accessibility through custom hiring services. Given that nearly 84 percent of Indian farmers are smallholders with limited capacity to own machinery, custom hiring centers and rental models enabled wider diffusion of technologies. By fostering rural entrepreneurship, these models also generated employment opportunities and strengthened rural economies, underscoring the project's inclusive approach.

Despite its achievements, mechanization in India continues to face persistent challenges. Structural issues such as fragmented landholdings and regional disparities in adoption remain significant. While states like Punjab and Haryana have reached high levels of mechanization, adoption is considerably lower in Eastern and North-Eastern regions due to smaller farm sizes, hilly terrains, and weaker infrastructure. Economic barriers also persist, as many smallholders find the upfront costs of machinery prohibitive, and institutional credit support is often inadequate. Dissemination bottlenecks further constrain adoption, with many farmers unaware of available technologies or lacking adequate training in their use and maintenance. Gender inequality adds another dimension to these challenges: women constitute a substantial share of the agricultural workforce but often face limited access to mechanized tools due to socio-cultural constraints and economic marginalization. These barriers highlight the need for not only technological innovation but also systemic reforms in financing, extension, and inclusive policy design.

Looking to the future, the trajectory of agricultural mechanization in India will need to embrace both inclusivity and sustainability. With continued land fragmentation, the demand for small, low-cost, and multifunctional implements tailored to marginal farmers is likely to grow. At the same time, the integration of advanced technologies such as drones, GPS-based machinery, robotics, and IoT-enabled sensors is set to redefine mechanization under the broader framework of precision agriculture. These technologies, while promising, will require adaptation to the Indian context, particularly in terms of affordability and ease of use. The role of AICRP will therefore remain central in piloting, standardizing, and disseminating these innovations in a manner that balances modernity with accessibility.

Sustainability concerns will also shape the future of mechanization. With growing awareness of soil degradation, water scarcity, and climate change, conservation agriculture practices such as zero-tillage, residue management, and resource-efficient machinery are expected to gain traction. Mechanization strategies will need to align with climate-resilient agricultural practices, ensuring that technological advancement does not compromise ecological stability. Policy frameworks must also evolve to support public-private partnerships, strengthen local manufacturing ecosystems, and integrate gender-sensitive approaches. The creation of robust extension systems, skill development programs, and innovative financing models will be essential to maximize the benefits of mechanization for all categories of farmers.

In conclusion, agricultural mechanization in India represents both a challenge and an opportunity. It has the potential to reduce labour drudgery, enhance productivity, and make

farming more resilient, but only if it is implemented in ways that are inclusive, regionally adaptable, and environmentally sustainable. The All India Coordinated Research Project on Farm Implements and Machinery has played a pivotal role in this journey, serving as an anchor institution that bridges the gap between research and practice. Its contributions in developing region-specific implements, fostering custom hiring models, and embedding sustainability in mechanization strategies underscore its enduring relevance. Yet, realizing the full promise of mechanization will require systemic reforms that address affordability, accessibility, and capacity-building, while also embracing digital innovations and climate-smart approaches. In this evolving landscape, AICRP remains indispensable not only as a research network but as a catalyst for empowering farmers, strengthening rural economies, and securing India's agricultural future.