Impact of Agricultural Engineering Technology on India's Agricultural Growth

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Introduction

The growth story of Indian agriculture from a paltry 51 million ton (1950-51) of food-grain production to massive 330 million ton (2023-24) is nothing short of a miracle. This stupendous feat gathers sustained appreciation for the fact that this country accounts for not more than 2.4% of the world geographical area and 4% of fresh water, while it's share in global population is 17.7% (2025) a substantial increase of 3.5% since independence, also the workforce engaged in agriculture is decreasing by about 1% annually (Fig. 1). Undeniably, agriculture has remained a cornerstone of Indian economy since eternity. However, there are multifaceted challenges that this sector has to counter amidst the evolving global dynamics in terms of change in land use pattern, soil quality, water availability, climate change, government policies, and most importantly a burgeoning global population that is expected to reach 10 billion by 2050. This scenario makes up a typical case for modernisation of Indian agriculture. Mechanization has immense proven potential to increase productivity, diminish drudgery, reduce cost of operation and alleviate climate risks; it sees opportunity for all the foreseen challenges. Agricultural

mechanization per se has reduced human labour, thus, saving onto the vital calories and time, especially for women. National Food Security Mission (NFSM) made provisions for assistance (up to 50 % the cost of machinery) to be provided for adoption of farm machinery such as pump sets, tractor mounted sprayers, seed drills, zero till seed drill, etc. to secure its food security mission with enhanced wheat, rice and pulses production. Availability of mechanized options promotes restoration of crop diversity which has wide ranging potential from economic to nutritional security of rural households. The case for mechanization is further emboldened by a simple comparative; in a highly mechanized agricultural eco-system like USA, a maize farmer can harvest 1470 kg in an hour, while a farmer in Kenya can only harvest 1.2 kg by the same time; or a US farmer supplied food for 26 people in 1960,

Particulars	2001	2011	2020	2047
India population (million)	1029	1211	1323	1612
Total no. of workers (million)	402	482	566	693
No. of workers as % of population	39.0	39.8	42.8	43.0
No. of agricultural workers (million)	234	263	230	202
% of agricultural workers to total workers	58.2	54.6	40.6	26.0
No. of male agricultural workers (million)	143.0	165.7	126.5	81.0
No. of female agricultural workers (million)	91.0	97.31	103.5	121.0
% of females in agricultural work force	39.0	37.2	45.0	60.0

Fig. 1 Changing face of agricultural work force during the first half of 21st century.

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whereas now he can do the same for 144 people. Indian agriculture is presently 47% mechanized with an average farm power availability of 3.05 kW/ha, the country is witnessing a rapid increase in farm power availability over the last few decades which is marked by an increased use of tractors for various farm operations. There is also an inundation of newer trends for mechanization of Indian agriculture which is leveraging the power of emerging technologies like artificial intelligence (AI) and machine learning (ML). Precision agriculture goals are being attempted to be addressed by robotics, unmanned vehicles, drones, etc. Embracing these cutting-edge technologies shall help Indian agriculture towards resilience and prosperity and enable it scale newer heights.

Challenges and attainments

While the country is setting a template of agricultural mechanization initiatives to attain a 75% mechanization and 7.5 kW/ha farm power availability by the 2047, there remains a challenge of equitable distribution of the geographical spread of such milestones. Today while the country has succeeded in attaining an average farm power availability is 5 - 6 kW/ha in states like Punjab and Haryana, the same is a dismal 0.2 kW/ha in the north-eastern states. Overcoming such discrepancies is a challenge of high degree; given that mechanization has resulted in input savings, reducing seed requirement by 15-20%, fertilizer requirement by 15-20% and improves cropping intensity by 5-20%. Challenge is also meted out by unequal level of mechanization across different agricultural commodities, with cereal crops like wheat and rice stand at about 50–60% mechanization, while horticultural crops languish at much lower level of mechanisation. Mechanization overall helps in reducing time of an agricultural operation by 15-20%. Postharvest mechanization interventions have been successful in handling the losses to a great extent over the years, they prevent the quantitative as well the qualitative losses across all the agricultural commodities and are ready to elicit food uses out of coarse cereals, soybean and millets. With a quarter of the water and fertilizer being used for growing crops not reaching the consumer's table, mechanized post-harvest solutions hold the key for a food secured and hunger free world. Water saving aspects are being taken care by adopting fully automated micro-irrigation options targeted to increase the spatial spread from the present 15 to 50 Mha in the coming two decades. During the same period of time is foreseen that mechanization intervention will continue to play a pivotal role in enhancing the renewable energy use in pre and post-production agriculture from 5 to 50%; while increasing the energy production to 2000 MW from the present level of 450 MW.

Mechanization interventions have also addressed some key social issues plaguing the Indian agriculture which is marked by demographical changes in the farming community. The participation of workforce in agriculture which was at 60% at the start of this century shall be a meagre 26% by the middle of it. Bringing women and youth to agriculture is a challenge and a major driver of agricultural mechanization. While, mechanization has introduced tools, machines and gadgets to reduce the drudgery associated with agriculture; it has also been able to make agricultural operations gender neutral as well.

Digitalizing agriculture, is one option to make agriculture women friendly and shall prove to be an able tool to retain youth in agriculture. The now famous, "Drone Didi" is one such path breaking measure to promote digital agriculture for women. This is a fair and square attempt to involve more women in agriculture given that their participation in agriculture is going to increase by more than 30% in the next two decades. Digitalizing farm mechanization will intervene in operations right from field preparation to harvest to post-harvest and then storage of the agricultural produce (Fig. 2). Key cogs in the wheel will be agro-chemical application by drone, yield estimation by drones and other digital tools, reflectance-based stress identifications, smart tools for food quality check and storage, etc. All this will support multiple goals like, reducing drudgery and workloads, converting uncultivable land into agricultural land, make farming safe and encourage youth to join agriculture.

A study was conducted for impact assessment of selected 19 ICAR-Central Institute of Agricultural Engineering technologies commercialized through licensing to manufacturers and their production and supply to end-users during 2012-2021. Five technologies namely tractor operated inclined plate planter, animal drawn seed-cum-fertilizer drill, manual cono-weeder, paddy drum seeder and power operated cleaner-cum-grader have been well adopted by the users and popular in number of states. It was estimated that there was a producers' surplus, consumers' surplus and total surplus generated of Rs. 14071 crore/annum from these 19 technologies in the year 2021. Impact is based on the number of units of technologies recorded only from those manufacturers who have signed MoA for manufacturing of the CIAE developed technologies while actual number of units may be several times more than the recorded numbers. The rapid adoption of the CIAE technologies is a right step forward in doubling farmers' income as envisaged by Hon'ble Prime Minister.

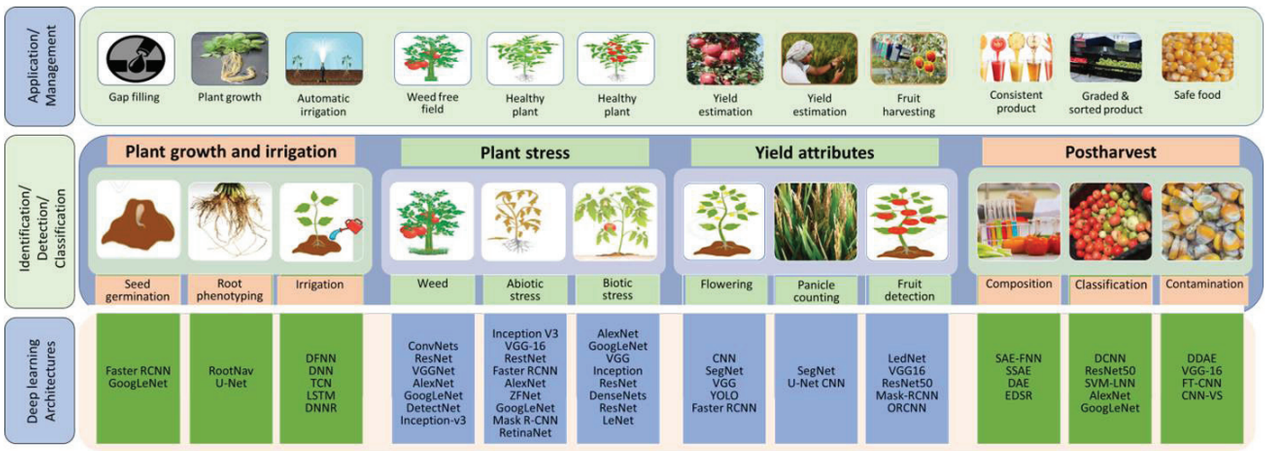

Fig. 2 The broad scope of application of digital agriculture approaches for pre and postharvest operations

WAY FORWARD

In the times to come, farm mechanization innovations will have to cater to well-informed farmers who will be tech savvy professional stakeholders who will demand for comfortable and safe working environment and resources for real time information on weather data, market data for precise planning for pre and post-production activities. Understandably, the hardwares for the future will require a digital interface so that they can be remotely controlled, intelligently handled, easy to maintain and above all, affordable.

Farmers of the future shall be informed and considerate towards climate initiatives, this will possibly lead to a threefold increase in area under conservation agriculture by 2047, resulting in an enhanced soil health and quality. Innovations for the future shall not only need to provide customized solutions in mechanized multi or special purpose field operations and postharvest solutions but will also be required to be made from light, strong and environmentally friendly materials for fabrication of machinery. There will be demand for custom designed gender-neutral machines, these machines should be able to reduce fatalities in agriculture related work from the current 180 to 100 per million workers per year. The agricultural machinery manufacturing sector needs to be ready with newer methods like 3D printing for machine prototyping.

Mechanization initiatives will have to counter some pressing challenges like fragmented landholdings, unavailability of matching equipment, lack of sufficient capital and lack of required skills which hinder the growth of mechanization in India. Also, the initiatives need to be ready for an eco-system of corporate and contract farming.

Therefore, a multi-pronged approach encompassing interventions related to field operations, institutions, training and capacity building, awareness generation, research and development is essential. State will have to formulate policies of growth of farm mechanization so that they are able to remove the social in-equalities in terms of gender, opportunity and access, successfully.