STRATEGY PAPER

18

Drudgery Reduction in Agriculture through Improved Farm Machinery

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Preface

Agriculture, a vital occupation for our very survival, is labor-intensive. Agricultural operations require persistent labor, which in turn demands physical energy and laborious postures. Lack of access to appropriate farm machinery and decision support systems at affordable cost further add to long hours of stressful work, forcing workers to adopt static and neo-neutral postures and unsupported positions. Excess dependence on muscular force and strength makes farm work even more laborious and energy intensive.

In India, agriculture employs 230 million workers to cover 142 million (M) hectares of total cultivated area. An average of roughly 44% of farmers use farm machinery, mainly tractors, diesel engines, pump sets, and power tillers. The remaining 56% depend on animal-drawn / manual implements, machines, and hand tools. Total hand tools and animal-drawn machines used in Indian agriculture are only 520 M and 124.1 M, respectively, which not only increase struggle but also lower the efficiency of agricultural work.

Keeping these in view, a brainstorming session was organized by the NAAS in hybrid mode on September 15, 2021 to deliberate on “Drudgery Reduction in Agriculture through Improved Farm Machinery”. Nearly thirty experts, including those from the ICAR institutes/projects and AUs and the engineering manufacturers participated in the deliberations. Various models were discussed, and the experts provided valuable inputs to suggest technical and policy interventions, as elaborated in this Strategy Paper, which I hope will be useful in defining action points, policies and programs for labour-efficient and drudgery-free agriculture in the country.

I take this opportunity to thank Dr K.P. Singh, the Convenor and Dr Naresh Chhuneja, the Co-convenor all eminent participants, and the reviewers for bringing out this strategy paper. I also sincerely thank the editors of NAAS, Dr P.S. Birthal and Dr Malavika Dadlani, for their editorial support.

(Trilochan Mohapatra)
President

December, 2022
New Delhi

Drudgery Reduction in Agriculture through Improved Farm Machinery

Agricultural operations require persistent labor, which demands physical energy and proper posture. Most of the operations are very tiring, time-consuming, and stress- causing due to a lack of access to appropriate agricultural machines and decision support systems. Working conditions of agriculture workers lack essential facilities, which force them to adopt static and neo-neutral postures, and unsupported positions, besides dependence on muscular force and strength that reduce the comfort index. Drudgery in agricultural operations is a major cause of accidents and injuries, both visible and hidden. The accidents associated with the use of tractor (overturning, falling from the tractor, etc.) are the highest (36.2%), followed chaff cutter (17.4%), electric motor and pump set (9.3%), animal drawn equipment (7.2%), sprayer/ duster (7%), thresher (6.5%), Power tiller (4.0%), self-propelled machines (3.6%) and sugarcane crusher (2.2%)(Anon, 2021). Hand tools related injuries (8% of the totalaccidents) are non-fatal. Drudgery in agricultural operations can be reduced significantly by using appropriate farm mechanization and digital platforms.

1.0 DRUDGERY

Drudgery is defined as dull, repetitive, time-consuming, irritating and fatigue-causing work. Major cause of drudgery in agriculture is in the form of excess labor, improper working posture, and time consumption in work. However, drudgery may also occur with the use of machines and due to improper workplace and man-machine interface. Drudgery can be quantified in many ways.Human Physical Drudgery Index (HPDI) is commonly used for agricultural practices (Kundu et al., 2021; Joshi et al., 2015), and calculated as,

$$HPDI = \left(\frac{TS + TPS + DSA + BPA + FPC + PDS + LS}{7}\right) \times 100$$

where TS = Time spent; TPS = Task performance score; DSA = Difficulty score of activity; BPA = Body posture adopted; FPC = Frequency of postural change; PDS = Postural discomfort score; LS = Load score.

HPDI value is quantified and assessed for various crop cultivation practices such as land preparation, intercultural operation, harvesting, threshing and load carrying, and for post-harvest management. For ergonomics, three most drudgery prone activities in wheat production system are identified as threshing (47.81), load carrying (47.23) and harvesting (46.48). Similarly, the maximum HPDI values in paddy cultivation correspond to transplanting (51.54), threshing (47.81), harvesting (46.48), and weeding (37.31) (Joshi et al., 2015).

Based on severity and energy demand, different agricultural activitiescan be classified as heavy, moderate, and light (Nag and Nag, 2004): ***Heavy work severity*** (25-28 kJ/min) is a characteristic of such operations as ploughing (country plough, MB plough), using paddy seeder, uprooting seeding by hand, load carrying on head, pounding grain, manual paddy transplanting, etc.; ***Moderate work severity*** (23-25 kJ/min) pertains to tractor empty trailer on bitumen road, powered paddy transplanter, self-propelled paddy harvester, irrigation work etc.; ***Light work severity*** (10-16 kJ/min) is attributed to sowing by machine, weeding using hand tools, fertilizer application, winnowing, harvesting using combine/ reaper etc. Workload classifications based on energy expenditure rate, studied by many researchers, have been given in Table 1.

2.0 MAJOR CAUSES OF DRUDGERY IN INDIAN AGRICULTURE

2.1 Low power availability

Available information shows that per hectare power availability on Indian farms is 2.49 kW/ha with a total of 5.39M tractors used in agriculture [about 70% of total tractors (7.7 M) available in India are being used in agricultures activities, other 30% tractors are used for the purpose of construction and industry], 0.05 M power tillers, 0.05 M combine harvesters, 11.50 M diesel engines, 7.50 M electric motors, 2.62 M levellers, 1.2 Mrotavators, 1.83 M seed drills, 0.103 M planters, 0.952 M sprayers and 0.9432 M threshers. If the total tractor power available in the country is used only for agricultural purposes, then power availability would increase to 2.54 kW/ha (Mehta and Badegaonkar, 2021). The average power of agricultural workers and draught animals are 0.05 and 0.38 kW, respectively. Currently India's per hectare farm power availability is

Table 1. Workload classification based on energy expenditure rate

Category of work	Energy expenditure, kJ/min						
	Christensen (1953)	Malhotra *et al.* (1966)	Ramanathan et al. (1967)	Sen (1969)	Sen and Nag (1975)	Nag *et al.* (1980)	Varghese *et al.* (1994)
Sedentary/ very light	11	4.5	4.2	< 7.3	-	-	< 5.0
Light	11-21	4.5-10.5	4.2-10.5	7.3-14.6	7.5-15.0	< 9.1	5.1-7.5
Moderate	21-31	10.5-21	10.5-16.7	14.6-22.0	15.0-22.0	9.1-18.2	7.6-10.0
Heavy	31-41	21-31	16.7-25	22.0-29.3	22.0-29.0	18.2-27.2	10.1-12.5
Very heavy	41-51	31-41	25-33	29.3-36.6	29.0-36.0	>27.2	12.6-15.0
Extremely heavy	51	41	33	> 36.6	36.0	-	>15.0

much lower than countries like Japan (8.75 kW/ha) and China (5.7 kW/ha) (Fig. 1). Past trends and projections reveal that power requirement would be 4 kW/ha to meet the growing food demand by 2030 (Tiwari et al., 2019). Thus, inadequate power availability increases manual operations and hence, more drudgery.

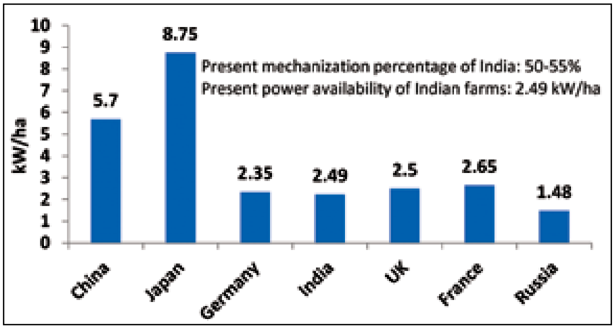

Fig. 1: Farm power availability of different countries

2.2 Underutilization of available farm power at Indian farms

The introduction of tractors in Indian agriculture contributed significantly to the increase in farm power availability in India, reducing farmers' drudgery and retaining the interest of youth in agriculture. India is the world's largest tractor-producing country, followed by the United States and China. In 2021, India produced 10.29 lakh tractors (Fig. 2), of which 1.249 lakh were exported to other countries. However, tractor use is not optimized in India. To achieve optimum tractor use efficiency, a tractor should operate at least 1000 hours in a year, whereas, presently the maximum tractor use is only 500 to 600 hours per year (Gulati and Juneja, 2020). The underutilization of tractor power also causes an additional burden on farmers.

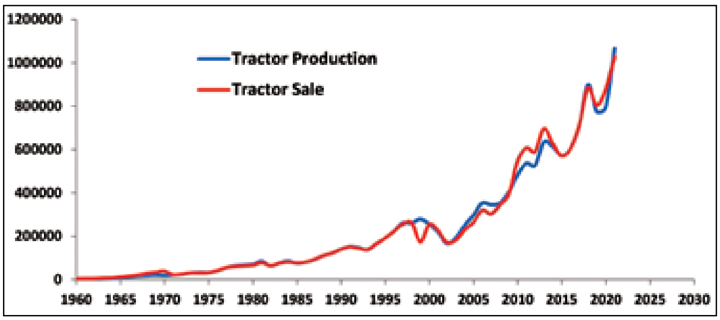

Fig. 2: Tractor production and sale in India

2.3 Migration of agricultural laborers

In a population of nearly 1400 million in India, the share of agricultural workers is about 16% (230 million). The observation from the recent past shows that as agricultural workers are getting better employment in the non-agriculture sector, the share of workers in agriculture is decreasing steadily. On the other hand, for meeting the food needs of a growing population, there is a need to increase productivity and cropping intensity, which would require more intensive agricultural activity. Therefore, immediate attention is needed on reversing the decreasing trend of agricultural male workers. Around 30 to 40 million of the male agricultural workers who are leaving agriculture, are migrated to urban areas and providing services to other sectors. To compensate for the shortage of male workers the number of female workers are increasing in agriculture (Fig. 3). Since majority of the agricultural machines are designed as per the requirements of male workers, the women workers find it hard to run these machines, and thus experiencing more drudgery. There is a need to design gender neutral agricultural machines to reduce drudgery of female farm workers.

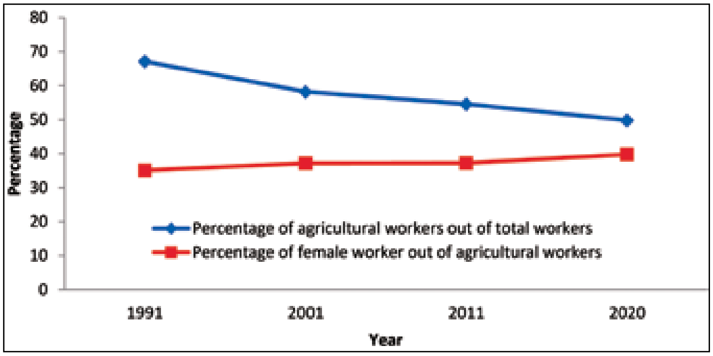

Fig. 3: Women workers engaged in Indian agriculture

2.4 Improper utilization of natural resources

As per UN report, 500 million people of the world live in areas that experienced desertification between 1980 and 2000. India is also vulnerable, as during 2011-13, 29% cultivable land in the country underwent desertification and degradation. Expansion of real estate activities is one of the major causes for the reduction in the area of cultivable and fertile land in the country. Arable land per person has declined from 0.34 ha in 1961 to 0.12 ha in 2015, mandating higher production from lesser area. This intensification of cultivation is causing greater drudgery for the farm workers and also putting excess pressure on natural resources like soil and water. In India, at present total water available from all resources is 1121 BCM (Billion Cubic Meter), whereas the per capita water availability is decreasing steadily indicating stress levels (Fig. 4). Lesser availability and inefficient use of water may become a major cause of drudgery in agriculture.

Further, Indian agriculture depends mostly on irrigation from surface water and groundwater. Subsidized electricity has led to extensive extraction of groundwater. It is stated that India is the largest consumer of groundwater in the world extracting about 150 cubic km of water annually. According to data from the World Bank, areas irrigated by groundwater have increased by 500% since 1960 and the total number of tube wells in India has increased to 20 million. Reforms are

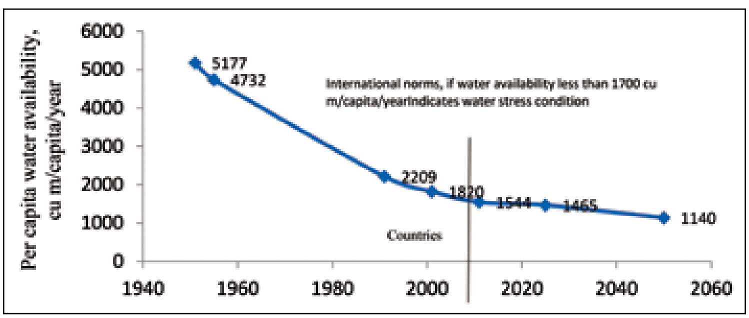

Fig. 4: Per capita water availability in India

Source: National Water Mission 2011

needed in subsidies on electricity for agriculture. Besides, linking of bore/tube wells to solar pumping, sensors and micro-irrigation system is essential for sustainable water use as well as drudgery reduction in future.

3.0 WAY FORWARD FOR REDUCING DRUDGERY IN AGRICULTURE

3.1 Entrepreneurship in the development of Custom Hiring Centres (CHC) for agricultural machinery

The average size of operational land holding in India has declined to 1.08 ha in 2015-16 as compared to 1.15 hectares in 2010-11. The small and marginal holdings (<2 ha) now constitute 86%, while the large holdings (>10ha) are merely 0.57% of the total land holdings. Farm power availability in India has increased from about 0.30 kW/ha in 1960-61 to about 2.49 kW/ha in 2021. To make available various farm machinery/ equipment to small and marginal farmers, the Indian government is promoting Custom Hiring Centres (CHCs), which has helped the farmers increase their level of mechanization and profitability. There are 78,117 CHCs and 4.15 Lakh farm equipments owned by the CHCs. Recently, the Government of India has introduced a "CHC Farm Machinery Mobile App" to provide farmers' access to farm equipment and machinery available within 50 km of their agricultural land. As of October 2021, 70,382 custom hiring service providers (farmers, entrepreneurs, and societies) have been registered on this app, and more than 164,000 farm equipments are available for rent, which need further scaling up across the country. Implementing the Sub-mission on Agricultural Mechanization (SMAM) Program by the Ministry of Agriculture is a step towards ensuring the availability of farm machinery to farmers with small and marginal land holdings.

However, in the peak period of farming activities, the availability of tractors and farm machines becomes a major challenge and causes drudgery for the smallholders. ***Using digital platforms for 'Uberization' of farm machinery and custom hiring services will facilitate all stakeholders, especially the smallholders, in accessing farm mechanization services at their doorsteps.*** Big farmers owning tractors and big equipment will get better utilization of their assets and increased revenues through servicing more farmers in a day. The number of CHCs has to increase in order to cover all regions of the country and for making machinery services available throughout the year. Youth including women are to be encouraged to become entrepreneurs with financial and policy support from the government and establish CHCs so that agricultural operations including those during post-harvest stage are carried out efficiently in time, thereby addressing drudgery.

3.2 Automation for Reduction/Elimination of Drudgery in Indian Agriculture

Large-scale industries are fully automated to reduce the cost of production and reduce/ eliminate drudgery. Automation can also help reduce losses during post-harvest, transport, and storage, enhance the opportunities for local employment and also skill development. Many pre-harvest operations including irrigation, fertigation, sowing, spraying, weeding, inter-culture etc. can also be automated bringing thereby much needed efficiency, and cost-saving for small and marginal farmers. Automation is needed in the local marketplace for fruit and vegetable sorting and grading. Logistics for storage of fruits & vegetables for a few weeks and availability of transport containers for processed products like tomato pulp will reduce wastages and human drudgery. FPOs and NGOs should be equipped with good technical and industrial skills, material handling kits like forklifts, and automatic climate information systems like temperature/humidity logging systems and warning systems. In the areas of processing and packing, extractors and pre-processors, automation in pulp, paste-making equipment, juice-making equipment, customized dryers, sustainable automatic packaging machines, labeling, marking machines are required. Waste processing is another area with value-addition processes for solid and liquid wastes. Periodic monitoring and evaluation of the digital data available to all is the way to succeed. ***Promotion of automation in Indian agriculture would need higher investment and supportive policies of the government so that private sector is encouraged for deeper engagement.***

3.3 Use of renewable energy in agriculture

In the coming years, diminishing availability of petroleum-based energy is likely to become a big constraint and cause more drudgery in agriculture. At some point of time, fossil fuels are going to be either unavailable or become too expensive to be economical. Restricted supply of petroleum-operating tractors, power tillers, combine harvesters and engines is going to pose a big challenge and cause drudgery in Indian Agriculture. It is a fact that the proven petroleum reserves of India, Japan, and Germany are less as compared to the USA, China, UK, Australia, etc. (Fig 5).

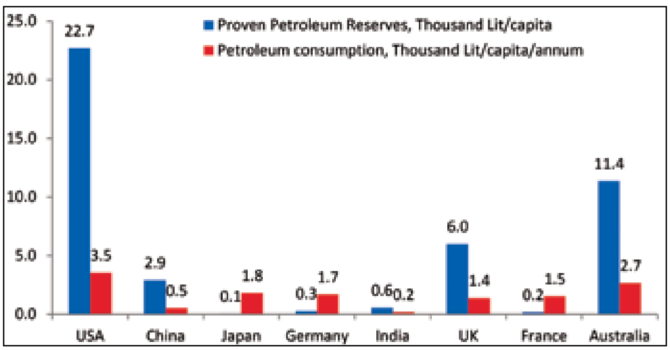

Fig. 5: Proven reserve and consumption of petroleum in India and other countries

Countries like Japan and Germany have compensated the deficit of petroleum reserves by excess use of electrical energy. Use of electrical/renewable energy in agriculture shall be an alternate option in any adverse situation when the import of petroleum is restricted.

There is a global need for clean and renewable energy sources as fossil fuels are non-renewable finite resources, which are dwindling, expensive, and environmentally damaging. The solar energy has been used since the days of yore by mankind for meeting day-to-day needs; however, with the change in lifestyle, development of technology, and end-user applications, the mode of usage of solar energy has also changed. Solar energy has started playing a vital role in agricultural operations ranging from tilling to processing of agricultural produce. For example, solar cold storage, solar dryers, solar space heating system, solar water heaters, solar cooking systems, solar steam generation for processing operations, solar water pumps for irrigation and solar power generators for providing electricity for decentralized operations have become very common with commercial viability.

Rural areas in the country are well endowed with natural resources such as biomass, solar, and wind energy, which can be tapped for generating localized sustainable energy and, thereby, reducing the dependence on fossil fuels. Efforts in the non-governmental sector have shown that decentralized off-grid energy generation through biomass-based energy system, i.e., bio-energy, which is carbon neutral, offers a viable and sustainable solution to rural energy availability. ***The aim should be to develop an integrated system of Energy Technologies, which would be able to meet the energy requirements of villages including on-farm as well as off-farm operations for drudgery-free sustainable agriculture by using resources that are available locally in a reliable and cost-effective way. At the same time, it is essential to prevent the increasing degradation of the environment caused by unchecked consumption of "non-commercial" energy resources including biomass, biogas, solar, wind, micro-hydro and animal power.***

3.4 Use of micro irrigation system (MIS) equipped with digital platform

Water is an integral part of agriculture. If irrigation water is not easily available, then long transportation of water for irrigation purposes shall be needed. Therefore, it may be a major cause of drudgery in future. Recognizing the importance of agricultural productivity in the country's economic development, the government introduced several promotional schemes such as providing subsidized electricity charges, centralized subsidy scheme on micro-irrigation through PMKSY etc. to bring more area under irrigation.

Efficient use of available water using modern techniques and digital platforms can reduce the possibility of drudgery. Micro-irrigation system is highly compatible with groundwater, and saves water and fertilizer due to controlled application. It can be made more efficient and compatible with the digital technological disruption through the use of IoT, sensors and big data analytics as well as artificial intelligence and machine learning. The use of digital technologies in micro-irrigation systems is limited due to non-availability of infrastructure, affordability, awareness, and regulatory issues. ***Digitally enabled, remote controlled and solar powered micro-irrigation along with a decision support system needs to be popularized among various stakeholders. Technology demonstration is required at block and tehsil level in the country with the active participation of state department of agriculture and private sector. There should be extension and capacity building of various stakeholders dealing with micro-irrigation technology.***

3.5 Drudgery reduction of women in agriculture

Risk factors associated with work that cause drudgery are machine factors, i.e. old, unrepaired, and inappropriately designed; environmental factors such as heat, noise, humidity, dust and light; and human factors such as lack of knowledge, skill, job satisfaction, feeling, attitude and awareness. These factors lead to occupational health hazards. Agricultural tasks which women are performing are not only repetitive in nature, but as the machineries are mostly made keeping in view male physical abilities, women have to operate in discomfort that leads to musculo-skeletal problems. Due to this, efficiency of workers decreases leading to poor goal-achievement, frustration, and drudgery.

Should there be separate technologies for women? There are two schools of thoughts: the first is of biological scientists, who believe that all technologies should be made gender-neutral, and hence there is no need for designing separate technologies for women. The second view, that of the social scientists, proposes that whatever technologies are being developed, the inter and intra-household relations, needs and asset distribution for male and female are to be considered.

3.5.1 National level strategy

- A national task force on technological empowerment for farm women should be constituted.
- Easy to follow video films on operation of farm equipment and tools for reducing drudgery need to be prepared and provided to extension agencies for creating awareness among farm women.
- Large scale demonstration programs on proven equipment and tools, which will reduce drudgery and empower women workers with technical skills should be promoted by the central and state governments.
- Ministry of health should set up a special cell on farm women' occupational health
- For newly developed equipment and tools, agencies and prototype workshop centers are to be identified and given responsibility to multiply the prototypes.

3.5.2 State-level strategy

- The state governments need to fix targets for popularizing equipment and tools amongst women workers. The industries may be incentivized to manufacture and sell such equipments at affordable prices.
- State departments of agriculture, agricultural engineering, horticulture, animal husbandry, fisheries, rural and tribal development, etc should coordinate and create activities directed towards reducing drudgery of farm women and for economic empowerment of rural women through entrepreneurship development.

- Technologies that are reducing drudgery of women need to be publicized through different media, as an extension activity.
- Women entrepreneurs should also be encouraged to provide custom servicing of agricultural machines.

3.5.3 Role of SAU/ICAR

- Modifying available small tools and implements to suit the ergonomic needs of women, testing them in different locations, and producing them in bulk are required urgently.
- There is a need to build a constant link between technology generation and transfer through assessment and refinement.
- Multilocation testing and evaluation of proven tools in different regions followed by refinements need to be based on the feedback of farm women.
- Training-cum-production units to be created at all centers of AICRP on FIM (All India Coordinated Research Project on Farm Implements and Machinery) involving local people, for operation by rural women.
- All KVKs should be provided with a set of proven technology to be operated by the rural women in a planned manner for creating awareness through actual demonstration in resource centers.

3.6 Strategies for drudgery reduction in hill farms

- There is need to establish an apex body to implement a national policy on hill farm mechanization, which would provide a basis for industries to plan their capacities, sale and servicing of equipments.
- The state governments in the hilly region of the country should proactively open adequate training centers in hills for building capacities of engineers, mechanics, technicians, operators and users regarding proper selection, operation, maintenance and repair of farm machinery. Adequate number of testing, evaluation and repairing centers for farm machinery have to be created in the hill region.
- An Agriculture Engineering Extension wing needs to be established in the Agriculture department of each concerned state to keep farmers up-dated on various aspects of application of engineering to agriculture.
- The landless hill workers need skill improvement and financial assistance to own small tools to improve their earnings.
- Post-harvest technology needs special attention for the functioning of the state processing centers located in hills.
- Custom-hiring system is required to be encouraged in hilly areas.

3.7 Policy interventions

i) The industry should be a partner in research projects so that they become stakeholders in promoting the technology and contribute towards its commercialization. Appropriate changes in policy / commercialization guidelines for exclusive licensing of technology are to be made, ii) Presently the manufacturers of farm machinery sell the same items at very different rates as the states demand different amounts of bank guarantee. Uniform bank guarantees all over the country may be considered. iii) Another issue is that for qualifying in the subsidy program; there is a testing board of the implements in every state. A centrally approved board acceptable by all states would greatly facilitate the industry. Manufacturers have to take the responsibility for the performance of their machines.

3.8 Role of MSMEs

As the micro, small amd medium enterprises (MSMEs) are producing about 95% of farm machinery in the country, certain supportive interventions are expected from the Government of India. Development of a better understanding and liaison between research organizations and manufacturing agencies can promote the MSMEs in the country. Since many MSMEs are located in small towns, and are easily approachable by the farmers, these can promote information dissemination regarding new developments in the field of farm machinery and facilitate their availability. MSMEs need inputs from researchers regarding designing of efficient farm machines and tools. Hence, they need to be invited to the State Agricultural Universities and Research stations for demonstration of newly developed prototypes. The capacity of testing centers should be strengthed so that test reports can be obtained by the manufacturers in time. The time frame for GST refund to the agriculture machinery manufacturers should be followed strictly.

3.9 Promotion of digital and disruptive technologies

Digital technology (DT) includes electronic tools, systems, devices, and resources to generate goods and processes efficiently. Digital agriculture can be used to integrate man and advanced technologies into one system in order to enable farmers and other stakeholders to improve food production more efficiently with lesser drudgery. The resulting combined data are analyzed and interpreted so that the farmers can make more informed and appropriate decisions. Real-time monitoring of farm productivity, combining the periodic satellite and weather-based uptake will enable decision-makers to derive sustainable tool types on standing crops. If digitalization of agriculture is introduced in our country, technologies such as artificial intelligence, cloud computing, machine learning, satellite imaginary, and advanced analytic tools will empower smallholder farmers to increase their income through higher cropping intensity and more price.

Strategy points for the promotion of digital and disruptive technology in the agriculture sector in India are:-

- Custom hiring centers (CHCs) are to be well-equipped for promoting such technology.
- Lowering the cost of hardware and technology can make these more affordable to small and marginal farmers. The technologies, which are portable, plug and play type, have a better chance of success in India. These can be achieved through support to the start-ups.
- Interactive digital platforms need to be established to allow farmers full access to information on technology and decision support system, skill development, machinery management and financial assistance.
- The private sector is required to be involved for increased application of digital/ precision technologies for drudgery-free agriculture.
- App based aggregation platform to be promoted for bridging the demand-supply gap in machinery use by connecting owners of the technology with the end users.

REFERENCES

Anonymous (2011) National Water Mission under National action Plan on Climate Change, New Delhi.

Anonymous (2019) https://www.indiawaterportal.org/

Anonymous (2021) Project Coordinator Report, AICRP on ESA, ICAR-CIAE, Bhopal.

Gulati, A. and Juneja R. (2020) Farm Mechanization in Indian Agriculture with focus on Tractors, ZEF-Discussion Paper on development policy no 297, pp 30.

Joshi, P., Jethi, R., Chandra C., Roy, M.L., Kharbikar, H.L., and Atheequlla, G.A. (2015) Ergonomics assessment of post harvest finger millet threshing for reducing women drudgery, Indian Research Journal of Extension Education 15(1): 25-30.

Kundu, T., Kumar, M., Joshi, P., Bharadwaj, A., Marwaha S. and Pal, S (2021) Development and validation of mobile based decision support system for Human Physical Drudgery Index, Indian Journal of Agricultural Sciences 91 (8): 61-63.

Mehta, C.R. and Badegaonkar, U.R. (2021) Farm Mechanization in India: a Perspective, Agricultural Research Journal 58(6): 1142-1146.

Nag, P.K. and Nag, A. (2004) Drudgery, accidents and injuries in Indian Agriculture, Industrial Health 42: 149-162.

Singh, S. (2016) Data book on agricultural mechanization in India, pp93.

Tiwari, P.S., Singh, K.K., Sahni, R.K. and Kumar, V. (2019) Farm mechanization – trends and policy for its promotion in India, Indian Journal of Agricultural Sciences 89(10): 3-10.

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Note: The designations and affiliations of the participants are as on the date of BSS.

NAAS DOCUMENTS ON POLICY ISSUES

Policy Papers

65.	Climate Resilient Agriculture in India	2013
66.	Role of Millets in Nutritional Security of India	2013
67.	Urban and Peri-Urban Agriculture	2013
68.	Efficient Utilization of Phosphorus	2014
69.	Carbon Economy in Indian Agriculture	2014
70.	MOOC for Capacity Building in Indian Agriculture: Opportunities and Challenges	2014
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