Women empowerment through agricultural mechanization in India

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Based on the 2011 census, 37% of the total number of agricultural workers in the country are women and by 2020, this figure is expected to be about 45%. The increased participation of women in agriculture will demand more emphasis on the development of gender-friendly tools, equipment as well as work places. Women have different ergonomical characteristics. It is necessary to give due consideration to their ergonomical characteristics while designing various farm tools and equipment. An effort has been made in this study to analyse various issues related to women and suggest ways to empower women workers through use of modern farm tools and machines. This study also highlights the need to organize demonstrations and trainings for farm women on proper operation of various modern tools/equipment. It is also necessary to find a way to ensure supply of these improved tools and equipment at the village level.

Keywords: Agricultural mechanization, empowerment, farm equipment, hand tools, women workers.

IN India, about 60% of the population is dependent on agriculture. The cultivated area of about 140 million ha is scattered in 138 million landholdings. From the 2011 census, the population of India was 1210 million and the total workforce was 482 million, and about 263 million (55%) work in agriculture[1,2]. Of these, a women work force of 37%, i.e. about 97 million participate in different crop production and processing operations. Considering various factors such as past growth rate and changing socio-economic factors, it is estimated that the ratio of agricultural workers to total workers will reduce to 41% by 2020, and the number of workers would remain around 230 million. Of these, about 45% will be women workers as against 37% in 2011 (ref. 3).

Traditional agriculture mainly used human and animal power sources. However, due to modernization, mechanical and electrical power sources are now being used extensively for various farm operations. There are about 120 million agricultural machines/implements operated by various farm power sources such as tractors, power-tillers, electric motors, diesel engines, animals or human workforce. The number of agricultural hand tools in use is about 400 million. At present, majority of agricultural workers in the country are used for their muscular power. However, in future, most farms will involve manually guided self-propelled machines. It is estimated that as of today, about 20% of male workers act as controllers of machines and 80% as a source of power. In case of women workers, the corresponding figures are 1% and 99%. This situation will change in future. It is projected that by 2020, about 30% of male workers will work as controllers of machines with 70% as a source of power. The corresponding projections for female workers are 5% as controllers of machines and 95% as a source of power.

About 85% of farm holdings in India are less than 2 ha in size. Also, women dominate farm activities on these farms as men migrate to cities for jobs in industries/services sector. Therefore, use of women-friendly tools and equipment will help in small farm mechanization to a great extent. Suitable design of power operated/self-propelled machines as well as skill upgradation of these workers for operating these machines will help in increasing efficiency of farm operations as well as productivity on farms.

Though agriculture in India is changing at a fast rate, the work being done by women has not changed much. Higher participation of the female workforce and the changing scenario of farm technologies demand more emphasis on development of gender-friendly tools, equipments as well as work places. Men and women differ in their ergonomical characteristics and therefore, it is necessary to give due consideration to these characteristics while developing farm equipment suitable to them. Also, skill upgradation of women workers is necessary to enable them to operate the machines.

Figures 1 and 2 show the change in population of agricultural workers during 2001–2011 in relation to tractor density in different states, which indicates that the present farm mechanization is not gender-neutral, but, heavily biased towards male workers. The growth rate of women agricultural labourers was less than their male counterparts in states having higher tractor density. However, for states in hilly areas, the growth rate of women agricultural labourers was more than male agricultural labourers. The low growth rate of women agricultural labourers is because of the fact that when a machine is introduced for some operation (which may be women-dominated), it is generally operated by male workers, reducing opportunities for women workers. Therefore, it is necessary to correct this approach, to utilize the full potential of women workers and to facilitate 5% of them to work as controllers of machines by 2020.

Ergonomics is defined as the scientific study of the relationship between a person and his/her working environment. The term environment includes ambient conditions, tools and materials, methods of work and organization of work. Major ergonomical parameters suitable for the design of farm equipment and work places are briefly discussed below.

Anthropometric data are the data on various body dimensions. Seventy-nine body dimensions have been

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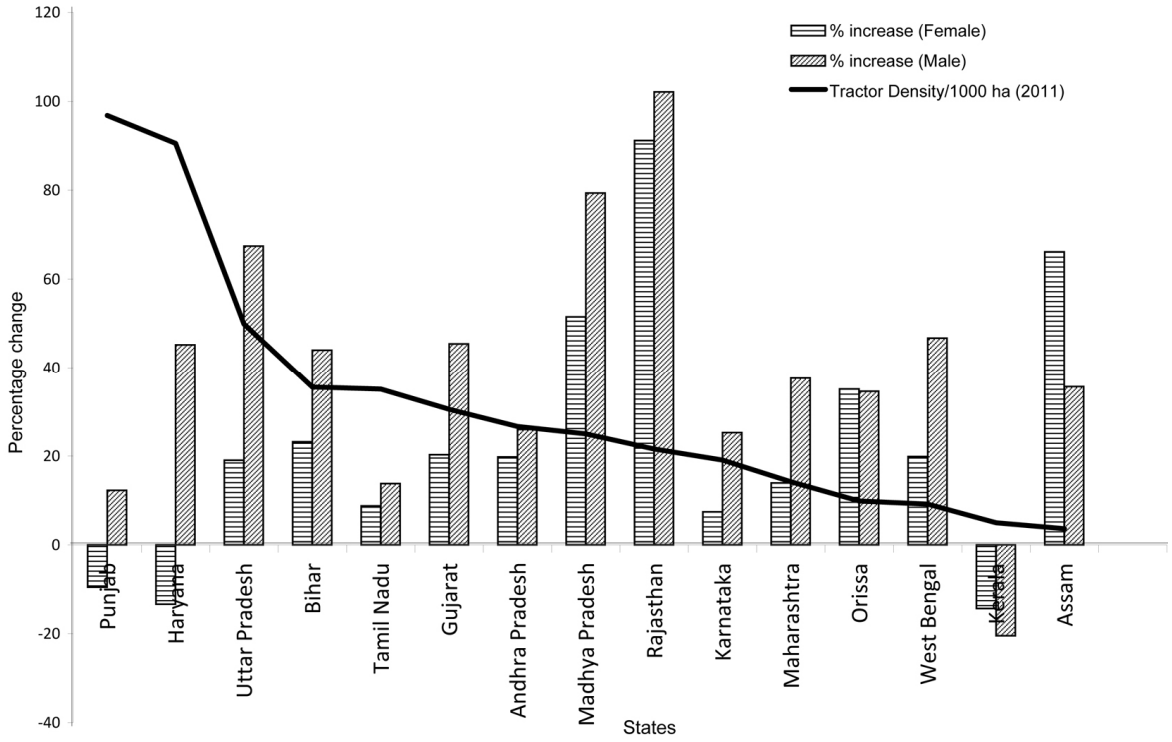

Figure 1. Percentage change in population of male and female agricultural labourers in 2011 as compared to 2001 superimposed with tractor density for states in plain areas.

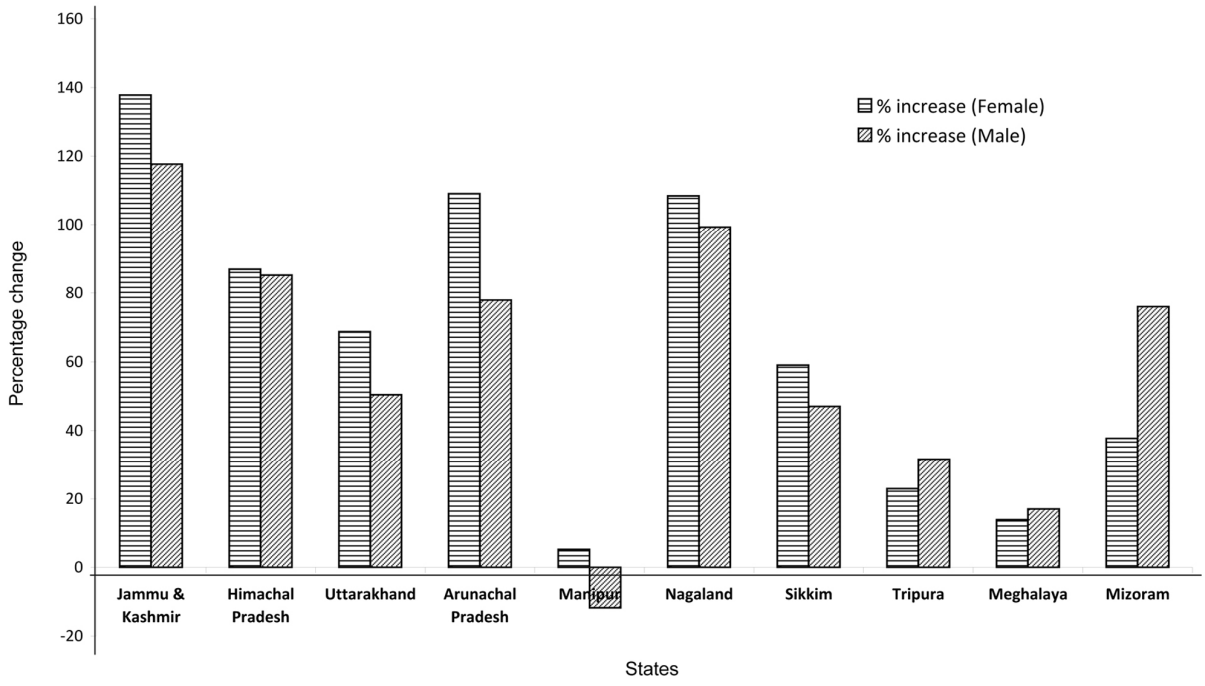

Figure 2. Percentage change in population of male and female agricultural labourers in 2011 as compared to 2001 for states in hilly areas.

identified as useful for farm equipment design. The mean values of height and weight of Indian women agricultural workers have been reported as 151.5 cm and 46.3 kg as against 163.3 cm and 54.7 kg for male workers[4]. This indicates that women have different anthropometric characteristics than men, which need to be given due consideration while designing safe and efficient farm equipment.

Sixteen strength parameters have been identified as useful in agricultural machinery design. These are push and pull strength with both hands in standing posture, push and pull strength with right/left hand in sitting posture, hand grip strength, torque strength of preferred hand as well as of both hands in standing posture, hand grip torque, and leg strength in sitting posture. In general, a woman has about 2/3 strength as that of a man. The mean push strength with both hands in standing posture has been reported as 224 N and 143 N for male and female workers respectively[4].

The aerobic capacity (maximum oxygen consumption rate) sets the limit for maximum physical work capacity of a person. For women, generally, this value is considered as 75% that of men. According to the data available for Indian workers, this value for women workers is about 1.5 l/min (ref. 5).

Physiological cost of any activity can be expressed in terms of heart rate and oxygen consumption rate of the worker. For women workers, a work load demanding oxygen at a rate of 0.6 l/min (40% of aerobic capacity) is considered as the maximum limit for acceptable work load for day long work (8 h duration). The heart rate for such a work load will be about 110 to 120 beats/min.

A good working posture is considered as one which requires minimum static muscular effort to maintain that posture. For long duration jobs, a standing posture is preferred instead of bending or squatting posture. Also, a sitting posture is always better than a standing posture, if the work can be done in that posture.

The body pain arising out of working posture and/or excessive stress on muscles due to the effort involved in the activity is reflected as discomfort. In agricultural activities, though the work may be well within physiological limits, body discomfort may restrict the work duration depending on the static load component involved in it. Therefore, the static loading of muscles needs to be kept minimum as far as possible.

Many agricultural operations involve load-carrying activity. Maiti and Ray[6] concluded that the load to be carried by an adult woman worker should not exceed 15.0 kg (about 40% of body weight). The load-carrying mode should be such that static loading of hands and arms is avoided.

Benefits of improved farm tools and equipment include reduced drudgery, increased utilization efficiency of inputs, timeliness in farm operations and reduced turnaround time for next crop, increased productivity of the worker-machine system, conservation of energy, improved quality of work and produce, and better quality of work-life of agricultural workers.

Many ICAR and other organizations, Central Institute of Agricultural Engineering (CIAE), Bhopal; Central Institute for Women in Agriculture, Bhubaneswar; centres of AICRP on Ergonomics and Safety in Agriculture (ESA); and AICRP on Home Science and State Agricultural Universities (SAUs) carried out ergonomical evaluation of hand tools/equipments developed by various research organizations in the country and found some of them to be suitable for women workers. The design of a sitting type groundnut decorticator based on ergonomic characteristics of women workers is given below[7]. The data used in the design are given in Table 1. Efforts are being made to manufacture these tools (Table 2, Figure 3) and make them available to farm women for reducing drudgery and enhancing output.

In the sitting type groundnut decorticator, the workers apply push/pull force in sitting posture with arm fully extended/flexed (Figure 3). Generally, the force needed at start of the operation is greater and it keeps decreasing as the decortication progresses for the batch of 1–2 kg.

The groundnut decorticator is a portable equipment and needs to be carried from place to place. Therefore, it is desirable to have the weight of the equipment less than 15 kg (40% of the 10th percentile body weight of female workers).

As the equipment is to be operated by female workers in sitting posture, its total height (up to the top of the handle) should be less than 811 mm (5th percentile acromial height sitting (470 mm) + 5th percentile popliteal height sitting (341 mm)).

Based on ergonomical guidelines, the lateral distance between feet for comfortable sitting should not exceed 500 mm. Considering 95th percentile value of heel breadth of female workers which is 70 mm, the machine width should not exceed 430 mm.

The distance between the seat and the centre of the handle will depend on shoulder grip length. The worker sits on the stool kept on the platform on which the decorticator is fitted. Ideally this distance (seat reference point to centre of handle) should be equal to or less than 5th percentile shoulder grip length which is 570 mm.

It is desirable to have the length of the handle movement less than 5th percentile shoulder grip length which is 570 mm.

Table 1. Important anthropometric and strength data of Indian female agricultural workers for groundnut decorticator design[7] (values in mm unless otherwise stated)

Dimensions	Mean	Percentile	
		5th	95th
Weight (kg)	47.8	35.0	65.0
Stature	1521	1420	1634
Sitting acromion height	532	470	599
Shoulder grip length	667	570	750
Heel breadth	55	42	70
Middle finger-palm grip diameter	25	20	32
Popliteal height sitting	393	341	447
Hand breadth at metacarpal-III	73	61	85
Hip breadth sitting	309	250	371
Push strength (N)	143	84	230
Pull strength (N)	159	101	240

Table 2. Improved tools/equipment/energy gadgets for reducing drudgery of women in agriculture

Operation	Traditional practice and details	Improved tools/equipment and details
Seed treatment	Done with bare hands. Non-uniform application, possible seed damage, health hazards–chemicals in direct contact with hands.	*Seed treatment drum* Cost – Rs 2500, capacity – 200 kg/h, contact with chemical avoided, uniform application, no seed damage.
Ridge making	With spade in bending posture. Output – 80 m^2/h, discomfort due to bending posture.	*Hand ridger* Cost – Rs 700, capacity – 330 m^2/h, bending posture is avoided; discomfort is reduced during operation, 67% saving of cardiac cost of worker per unit area.
Fertilizer broadcasting	Broadcasting by hand. Output – 0.31 ha/h, non-uniform distribution, problem due to direct contact of fertilizer with hands.	*Fertilizer broadcaster* Cost – Rs 3000, capacity – 1.15 ha/h, uniform application, no direct contact of fertilizer with hands, about 6% saving of cardiac cost of worker per unit area.
Sowing	Broadcasting seeds by hand or by putting the seeds manually in row after opening the furrow with hand hoe. Output – 20 m^2/h.	*Manual seed drill* Cost – Rs 7000, capacity – 430 m^2/h, row sowing possible, about 87% saving of cardiac cost of worker per unit area.
Dibbling	By hand in bending posture. Output – 120 m^2/h.	*Naveen dibbler* Cost – Rs 700, capacity – 150 m^2/h, bending is avoided, about 13% saving of cardiac cost of worker per unit area. *Rotary dibbler* Cost – Rs 2300, capacity – 1000 m^2/h.
Rice transplanting	By hand in bending posture. Output – 34 m^2/h	*Three row rice transplanter* Cost – Rs 8500, capacity – 170 m^2/h, bending avoided.
Rice seeding	Broadcasting by hand. Non-uniform sowing, difficulty in weeding.	*Four row paddy drum seeder* Cost – Rs 4000, capacity – 920 m^2/h, uniform seeding in rows.
Weeding in dry land	Hand hoe. Capacity – 45 m^2/hin squatting posture.	*Wheel hoe* Cost – Rs 800, capacity – 150 m^2/h, squatting and bending avoided, 45% saving of cardiac cost of worker per unit area.
Weeding in wet land	By hand in bending posture, capacity –30 m^2/h.	*Cono-weeder* Cost – Rs 1500, capacity – 280 m^2/h, bending is avoided.
Harvesting	Local sickle Capacity – 150 m^2/h for wheat, weight – 0.350 kg, higher fatigue.	*Improved sickle* Cost – Rs 60, capacity – 150 m^2/h for wheat, weight 0.180 kg, less fatigue due to low weight and serrated edge, 15% saving of cardiac cost of worker per unit area.
Groundnut stripping	By hand beating on rods, damage to pods.	*Groundnut stripper* Cost – Rs 2500, capacity – 11 kg/h/person, four persons can work at a time, muscular discomfort is reduced.
Paddy threshing	By hand beating in bending posture.	*Pedal operated paddy thresher* Cost – Rs 7000, capacity – 40 kg/h, discomfort is reduced as work is done in standing posture.
Paddy winnowing	By taking the winnowing basket above shoulder level and taking help of natural air to blow off the chaff and dust.	*Paddy winnower* Cost – Rs 6000, capacity – 170 kg/h, drudgery is reduced. Dependence on natural air is eliminated

(*Contd*)

Table 2. (*Contd*)

Operation	Traditional practice and details	Improved tools/equipment and details
Maize shelling	Local sickle, capacity – 17 kg/h, possibility of injury to fingers.	*Tubular maize sheller* Cost – Rs 60, capacity – 27 kg/h, safe operation in sitting posture, less discomfort, about 15% saving of cardiac cost of worker per unit output. *Rotary maize sheller* Cost – Rs 8000, capacity – 77 kg/h, operation in standing posture.
Grain cleaning	By hand with supa, capacity – 25 kg/h	*Hanging type grain cleaner* Cost – Rs 5700, capacity – 225 kg/h, about 63% saving of cardiac cost of worker per unit area.
Groundnut decortication	By hand, capacity – 1 kg/h, abrasion and injury to fingers.	*Sitting type groundnut decorticator* Cost – Rs 2400, capacity – 26 kg/h, work done in sitting posture, less discomfort, about 79% saving of cardiac cost of worker per unit output.
Fruit harvesting	By hand picking, possibility of accidents and injury.	*Fruit harvester* Cost – Rs 600, capacity – 420 fruits/h *Bamboo ladder for harvesting of apples* Height – 1200 mm, weight – 10.5 kg, more output per person using ladder.
Cotton stalk uprooting	By hand pulling in bending posture.	*Cotton stalk puller* Cost – Rs 1200, capacity – 280 m^2/h, discomfort and probability of back injury are reduced as work is done in standing posture.
Coconut dehusking	By hand using knife. Finger and hand injuries are common, postural discomfort is experienced.	*Coconut dehusker* Cost – Rs 800, capacity – 200 nuts/h, chances of injuries are eliminated. Postural discomfort is reduced.

For deciding the length of the handle grip, 95th percentile value of hand breadth is taken which is 102 mm. Therefore, the length of handle grip is taken as 105 mm. To arrive at the grip diameter, 5th and 95th percentile values of middle finger to palm grip diameter may be taken into consideration and these values are 20 and 32 mm respectively.

Height of the seat should be less than 5th percentile popliteal sitting height of female workers which is 341 mm. While operating this equipment, the stool is placed on a platform which is 20 mm thick. Therefore, the height of the stool should be less than 321 mm. Considering the 95th percentile value of hip breadth in the sitting position, the width of stool top should be 371 mm.

Based on the all India strength data, the 5th percentile values of push strength and pull strength with both hands are 84 N and 101 N respectively. Taking 50% as the limit, the force required in the operation of the decorticator should not exceed 42 N in push and 51 N in pull modes. The 5th percentile values of push and pull force in sitting posture by right/left hand are 30 N and 42 N respectively. Therefore, it is desirable to have the force required at the handle grip less than 30 N in push mode and 42 N in pull mode so that the equipment is suitable for 95% of female workers.

It is necessary that the improved tools and equipment are made available in villages so that farm women can procure and use such equipment based on their requirement. The ICAR-CIAE (Bhopal) is making efforts to make these tools/equipment available to users in various states through its prototype production centre and licensed manufacturers. The state agricultural departments need to take a lead role in this activity as they have functionaries at the village level.

Technology development needs to be followed by awareness creation, commercialization and infrastructural support. When technology involves tools and equipment, training on operation, repair and maintenance is very important. Due to socio-cultural bindings in rural areas, women farm workers seldom come forward to operate mechanical equipment in the field. They have reservations even in handling simple hand tools. Therefore, it is necessary to have infrastructure and facilities for training women at places within their reach. This may be accomplished either by training them in their own environment or by bringing them to training centres located in close

Figure 3. Improved tools/equipment for reducing drudgery of women in agriculture.

proximity. Farm women need to be given greater access to various farm tools and equipment to carry out their work more efficiently and with minimal drudgery. Moreover, they have little access to informal education and training. It is a known fact that agricultural extension services are mainly composed of male subject matter specialists who tend to channelize knowledge and training on improved technology mainly to male farmers/workers only. The infrastructural facilities related to accommodation, transport and technical training of women workers are poor in the country. The central/state government departments, research and development institutions and non-government organizations (NGOs) should come forward to promote improved technology to enhance labour productivity and reduce drudgery of women workers. They should also recruit women extension staff for effective transfer of technologies to farm women. The ICAR-CIAE is providing necessary training on various tools and equipment to women facilitators from different states. These facilitators can act as resource persons for their own state to propagate the technologies[8].

It is estimated that participation of women in agriculture will increase to 45% by 2020 (estimated population of about 110 million) mainly because male workers get involved in other non-farm activities or migrate to towns and cities for other jobs. Therefore, women will play a major role in agriculture in future. To empower them, the following steps need to be taken: (1) Design tools/equipment keeping in view the anthropometric data of women workers. (2) Organize demonstrations and trainings for rural women on various modern tools/equipment for proper and safe operation. (3) Encourage manufacturers/entrepreneurs to fabricate improved tools and equipment and make them available in rural areas for purchase by users. (4) Assist farm women to obtain loans from banks/other organizations to procure various tools/equipment. (5) Link with central/state departments, NGOs, banks and other stakeholders to promote these improved tools and equipment.

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Last 42 ky sediment chemistry of oxygen deficient coastal region of the Bay of Bengal: implications for terrigenous input and monsoon variability

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The discharge of terrigenous clastics by seasonal peninsular rivers is known to reach the upper slope of the eastern margin of India, which is presently impinged by the monsoon-sensitive intense oxygen minimum zone (OMZ); however, their mutual behaviour in response to changes in the intensity of past Indian summer monsoons (ISM) is not clear. The $\delta^{18}O_{G.sacculifer}$ time-series of a sediment core from the upper slope off Chennai exhibits distinct enrichment (~0.4‰) during the last glacial period (30–18 kiloyears BP: ka), and depletion (~−2.2‰) during the Holocene, suggesting a significant shift in ISM intensity. The monotonously increased terrigenous elements (Al, Ti and Mg) content and depleted $\delta^{18}O_{G.sacculifer}$ during the Holocene suggest tight-coupling between ISM and terrigenous sediment input. Highly depleted redox-sensitive Mn (<0.04%) (lesser than the source sediment content of 0.07%) throughout the last 42 kyr suggests well-sustained intense OMZ irrespective of ISM variation.

Keywords: Bay of Bengal sediment, geochemistry, Holocene-LGM, OMZ, monsoon.

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