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AGRICULTURAL MECHANIZATION FOR SUSTAINABLE AGRICULTURAL AND RURAL DEVELOPMENT IN EASTERN UP - A REVIEW

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ABSTRACT

Agricultural mechanization is an important input to agriculture for performing timely farm operations; reducing the cost of operation; maximizing the utilization efficiency of costly inputs (seeds, fertilizer, plant protection chemicals, water and agricultural machinery); improving the quality of produce; reducing drudgery in farm operations; improving the productivity of land & labour and for improving the dignity of labour. The strategy for mechanization in different regions will be different depending on the conditions and resources of that region. The agricultural mechanization strategy for eastern U.P. region is suggested keeping in view the land holding pattern, the available resources in the region, the population depending on agriculture, the important cropping systems being followed in this region, farm power availability and the infrastructural facilities available for promotion of agricultural mechanization and agro-processing programmes.

Keywords:

Agriculture, Eastern U.P., Mechanization, Rural development, Sustainable

INTRODUCTION

Farm Mechanization in the country is set to enter a new phase. It is felt that there is need tore-look' and 'reengineer' the process of farm mechanization so that it effectively includes small and marginal farmers (Aggrawal, 1983). Farm mechanization programmes in the country have been guided by the ICAR system with the aim of optimum utilization of available farm power resources and augmenting the farm power availability (Singh, 1999). To meet the growing demand for food grains and other food and non-food commodities, expansion of farm mechanization is becoming inevitable (Srivastava, 1999). The projected reduction in the number of draught animals has underlined the need of suitably reframing the farm mechanization strategy. Modernization of Agriculture is a felt need of the day. Mechanization has been well received the world over as one of the important elements of modernization of agriculture (Vatsa, 2013). Availability of mechanical power and improved tools and equipment has enabled States like Punjab, Haryana and western part of Uttar Pradesh to achieve high levels of land productivity. The same trend should shift to other states also. There is a close relationship between farm power availability and productivity (Singh, 2001).

Increased agricultural production is most often brought about by the introduction of improved crop varieties and by creating an optimal environment such that the plants and animals can develop to their full potential (Singh, 2000a). Planting, tending and harvesting a crop requires both a significant amount of power and a suitable range of tools and equipment (Pandey, 2000). Mechanization of farming has allowed an increase to the area that can be planted and has contributed towards increased yields, mainly due to the precision with which the crop husbandry tasks can be accomplished (Gajri *et al.*, 2002). In fact, most farmers in developing countries experience a greater annual expenditure on farm power inputs than on fertilizer, seeds or agrochemicals (Gite, 2003).

Mechanization helps in sustainable agriculture

Agricultural productivity has soared due to new technologies, mechanization, chemical use, specialization and government policies that favored maximization of production (Peter, 1983). Though these changes have many positive effects but also resulted into topsoil degradation, ground water depletion and contamination, decline of living and working conditions of farm workers, higher cost of production and the disintegration of economic and social conditions in rural communities (Aggrawal, 1983; Sindhu and Grewal, 1991; Singh, 2001). Such agricultural practices are now being questioned and the farming community and other rural population want to have sustainable agriculture to address these environmental and social concerns and have

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innovative and economically viable opportunities for farmers, agricultural workers, consumers, policy makers and other stakeholders in the entire agricultural production system (Srivastava, 1999; Karmakar *et al.,* 2001; Vasta, 2013).

The ideas, practices and policies that would define the concept of sustainable agriculture are still evolving (Rijk, 1989; Joshi, 1998; Srivastava, 2002). It integrates three main goals namely; environmental health, economic profitability and social & economic equity (FAO, 1997a; MOA, 1998). Sustainability rests on the future generations must meet the need of the present without compromising the ability of future generations to meet their own needs (Singh, 1999; Singh, 2000a). Therefore, stewardship of both natural and human resources is of prime importance. Stewardship of human resources include consideration of social responsibilities such as working and living condition of farm workers, needs of rural communities and consumers health & safety, both in the present and the future. Stewardship of land and other natural resources involved maintaining or enhancing this vital resources base for the long term (Singh, 2001). A system perspective is essential to understand sustainability. It involves individual farm, local eco-system and communities that get affected by this farming system, both, locally and globally (Karmakar *et al.,* 2001). A system approach gives us the tool to explore the inter connections between farming and other aspects of environment. It also implies inter-disciplinary efforts in research and education from researchers, farmers, farm workers, consumer, policy makers and others those are involved in agricultural pre and post production system. Making the transition to sustainable agriculture is a process involving a series of small but realistic steps (Brar, 1998; Joshi, 1998; Mandal *et al*., 1999; Velayutham, *et al*., 1999). Realization of the goal of sustainable agriculture is the responsibility of all participants in the system, including farmer, farm workers, policy makers, researchers, retailers, consumer and other stakeholders (Karmakar *et al.,* 2001). Each group has its own part to play to strengthen the sustainable agriculture. Agricultural mechanization is an important link for sustainable agriculture and rural development (Vatsa, 2013).

Eastern U. P. having three sub-Agro Climatic Zones

1. North Eastern Plain Zone
2. Eastern Plain Zone
3. Vindhyan Zone

North Eastern Plains Zone of Uttar Pradesh

This sub-zone covers the districts of Baharaich, Gonda, Balrampur, Basti, Gorakhpur, Sidharth Nagar, Maharajgunj, Kushinagar and Deoria. Rainfall is quite high at about 1210 mm, the climate is moist sub-humid to dry sub-humid. 73 per cent of the land area is cultivated and about half of the cultivated land is irrigated. Tube wells are the major source of irrigation (DAS, 2012).

Eastern Plain Zone of Uttar Pradesh

Azamgarh, Mau, Balia, Faizabad, Ghazipur, Jaunpur, Sant Ravidas Nagar and Varanasi districts fall under this sub-zone. Rainfall is adequate with a normal of 1025 mm. The climate is dry sub-humid to moist sub-humid. Over 70 per cent of this land is cultivated and more than 80% of the cultivated area is irrigated (Velayutham *et al.,* 1999).

Vindhyan Zone of Uttar Pradesh

Mirzapur and Sonbhadra districts of Uttar Pradesh are the Vindhyan sub-zone of the Middle Gangetic Plain zone (ZPD, 2012). Rainfall is adequate at about 1134 mm; the climate is similar to the other parts of the eastern plains of Uttar Pradesh. However, the region has a very high forest cover of about 40 per cent of the land. Less than one-third of this land is cultivated and only a third of this is irrigated (KVK, 2013).

Topography of the zone

The land topography is of plain land, fairly leveled to very gently sloping with slopes ranging from 0–3% (DAS, 2012). Soils are deep and water table is high. Shallow tube wells, open wells and tank irrigation are common for supplemental irrigation. Canal irrigation is also available in some parts of this region (Mandal *et al.,* 1999). Agriculture is the main occupation of the rural people. Land is fertile and can give good yields with proper management. Many of the farmers take two crops a year, and some with assured irrigation also take third crop during summer (Velayutham *et al.,* 1999; DAS, 2012).

Operational land holding pattern in Eastern U.P.

The average operational land holdings in Eastern Uttar Pradesh during 2009-2010 were 0.75 and 0.86 ha respectively against the national average of 1.41 ha. The ratios of marginal, small, semi-medium, medium and large category of farmers were 75.43, 14.56, 7.36, 2.47 and 0.18% respectively in Eastern Uttar Pradesh. About 90% farmers are under marginal and small categories with an overall average between 0.456 and 0.555 ha. Predominance of such small farms poses serious problems in mechanization and use of costly machinery on individual ownership basis for self-use only is not economically viable (DAS, 2012).

Important soil types and crops grown in Eastern U.P.

The soils in this region are alluvium-derived soils mostly khaddar (recent alluvium) and hangar (old alluvium). In some area the soil is highly calcareous. The soils are deep, loamy and high in organic matter content (Mandal *et al*., 1999). Rice, maize, pigeon pea, moong bean crops are common in *kharif* season. In post-rainy (*rabi*) season wheat, lentil, bengal gram, pea, and sesame and at some places groundnut is grown on residual soil moisture with one or two supplemental irrigation (DAS, 2012). The important cash crops of the region are sugarcane, potato, chillies, turmeric and coriander with supplemental irrigation. Rice–wheat cropping system is more predominant (Velayutham *et al*., 1999). Mostly cultivated crops such as mango, guava, litchi, banana and citrus, potato, tomato, cauliflower and cabbage are important. Average consumption of fertilizer in 2009–10

in Eastern Uttar Pradesh 130.44 kg/ha against the national average of 90.12 kg/ha. (KVK, 2013).

Climate and annual rainfall in Eastern U.P.

Hot, wet summer and cool dry winter characterize the climate of the region. The region receives an annual rainfall of 1,050–1,300 mm, 80% of which is received during the months of June to September. The area experiences a small seasonal water deficit of 400–500 mm during February to May (ZPD, 2012). The growing period ranges from 180–210 days in a year. The soil moisture control section (SMCS) either as a whole or in parts remains dry from middle of January till May, about 120–150 cumulative days.

Brief scenario of agriculture sector in Eastern U.P.

Agriculture sector is the backbone of economy of this region. About 79.22% of the total population of Eastern Uttar Pradesh in 2010 was living in rural areas and depending on agriculture and allied sector for their livelihood. Due to our social structure in which land belonging to a person gets divided into their children, the land holdings are getting smaller and smaller. In Uttar Pradesh, the average operational holding size got reduced from 0.86 ha to 0.68 ha during the 1995-96 to 2009-2010. This is going to be reduced further to about ha 0.57 in Uttar Pradesh by 2020, unless the Govt. either takes some drastic measures to change the land tenancy rules or create enough jobs in non-agricultural sector. On one hand the number of people dependent on agriculture for their livelihood is increasing every year, the share of agricultural and allied sector in the State GDP is going down.

While it was more than 60% in 1950, 27.1% in Eastern Uttar Pradesh during 2009–10 (DAS, 2012). In the rural areas, on an average there are 5 persons in a family. Since the average operational holdings of about 75.42% of the population under marginal and 14.56% in small categories in Eastern Uttar Pradesh were only about 0.39 ha and 1.41 ha respectively in 1995–96 with overall average of these two categories as 0.555 ha in Eastern Uttar Pradesh. The per capita availability of land in the two combined categories was only between 0.091–0.111 ha. Most of the people below the poverty line in rural areas (32% in Eastern Uttar Pradesh) in these categories of farmers (DAS, 2012).

Irrigated area and source of irrigation

About 64.9% area under food grains in Eastern Uttar Pradesh was irrigated in 2009–10. About 89.5% area in Eastern Uttar Pradesh under the sugarcane crop was irrigated in 2009–10. The irrigated area under other crops was low. Amongst the sources of irrigation, the area under tube well irrigation was high (58–74%) followed by canal irrigation..

Infrastructural facilities available

Important markets for farm implements and machinery

All big manufacturers of tractors and pump sets have their show rooms/dealers in big towns like Gorakhpur, Faizabad and Varanasi in Eastern UP. Almost in every town there are a few manufacturers making different types of implements and machinery, but there are bigger markets for manufacture and sale of farm machinery located in Gorakhpur, Faizabad and Varanasi in Eastern UP (DAS, 2012; KVK, 2013). Specialized equipment is bought from other part of states and other states. In spite of good manufacturing base for production of different types of agricultural machinery, their availability in many of the districts is not very satisfactory. The quality of implements being manufactured by majority of the manufacturers of the region is not very good and needs improvement (ZPD, 2012).

Facilities available for extension and training

In this region, there are a number of ICAR Institutes, their Regional Stations, Agricultural Universities, Institute of Agricultural Sciences (Banaras Hindu University, Varanasi) and Krishi Vigyan Kendras (ICAR, 2011). Some facilities for training of farmers, farmwomen, mechanics, and school dropouts are available in these organizations and at Farmer's Training Centers run by the Central/State Governments. But all these trainings are not at all adequate. Training facilities related to operation, maintenance and repair of different types of agricultural machinery is almost missing and need to be strengthened substantially as the population of power-operated machinery is increasing at a fast rate (DAS, 2012).

Subsidies available for agricultural implements

Subsidies on different types of agricultural machinery are available for different categories of farmers under centrally sponsored scheme. These subsidies are provided to the farmers under the Micro-management scheme of the State Governments (DAS, 2012).

Monitoring of agricultural engineering programmes

The infrastructure for execution and monitoring of the agricultural engineering programmes in country and state is very poor (Peter, 1993). There are a few positions of agricultural engineers in the Directorate of Agriculture but those are highly inadequate and practically there is very little activity in this Directorate on front line demonstration, training, promotion and monitoring of agricultural mechanization programmes in the region. The budget allocation for this type of activities is also very meager.

Implements being used by the farmers in the region

Majority of the farmers are using animal drawn equipment (Singh, 2001; Srivastava, 2002). During the last 10 years, the population of tractors in this region has increased substantially and use of power machinery is now becoming popular (Singh, 2000a, Singh, 2000b; Singh, 2004). The average annual sale of tractors and power tillers in Eastern Uttar Pradesh was more than 60,000 tractors and 500 power tillers (Mandal and Maity, 2013; Sarkar, 2013). Custom hiring of tractors, threshers and other power machinery is becoming popular (Nair, 2002).

Agricultural mechanization strategies

For preparing long term strategies for agricultural mechanization till 2020, it is important to visualize the scenario prevailing at that time and the challenges which are to be overcome to meet the aspirations from agriculture

sector. It is visualized that with the annual growth rate of about 1.8%, the population of Eastern Uttar Pradesh in 2020 will be approximately 230.81 millions. To be self sufficient in food grain production to have enough food for the entire population of the state @ about 200 kg/head and to have surplus for sale to deficient states or for export, the annual production of food grains in Eastern Uttar Pradesh will have to be increased to about 70 million tonnes. This will call for increasing the productivity levels from 21.57 q/ha to about 35.00 q/ha in Eastern Uttar Pradesh by 2020. Production of other items will also have to be increased in the same proportions (DAS, 2012).

Strategies for farm power

This region, although highly populated, should progressively adopt to power farming for timely and precise field operations at reduced costs and to maximize utilization efficiencies of costly inputs (seed, fertilizer, plant protection chemicals, water, machinery etc.) and for conservation of natural resources-soil water and environment (Rijk, 1989; Joshi, 1998; Srivatstava, 2002). Availability of adequate farm power for mobile and stationary farm operations should be increased from the present level of about 1.75 to 3.0 kW/ha in Eastern Uttar Pradesh by 2020. For stationary operations like water lifting, threshing, chaff cutting, cane crushing, cleaning, grading and other agro-processing and value addition activities, adequate electrical energy should be provided. For this it should be ensured that the farmers get at least 16–20 hours uninterrupted electrical power supply every day. If grid power availability is not assured, decentralized power generation using locally available materials should be encouraged in rural areas (De, 1998; De, 2000)

Improved agricultural implements and machinery

Annual yield potentiality of rice–wheat cropping system of this region has been assessed, by the rice–wheat consortium, between 16.5 to 17.5 tonn/ha (Bhatia, 1990). Top priorities should be given to these crops by adopting improved varieties, high doses of fertilizers and precision equipment for proper placement of inputs (APO, 1983; Gajri *et al.,* 2002). This will boost up the production of the whole region. Sub-soilers and equipment for deep tillage for breaking hardpan and other perennial weeds should be introduced. For timely farm operations, reduction in cost of operations and saving energy in tillage and sowing /planting/ transplanting operations, conservation tillage technologies (promotion of zero till drills, strip till drills, roto-drills, till-plant machines, raised bed planters, ridger seeder etc.) and promotion of precision drills, planters for all crops should be promoted and given high priorities (Peter, 1993).

Presently, mechanization of rice transplanting and planting of sugarcane and many other crops is at very low level (Singh and Singh, 2002). Suitable machines will have to be introduced and popularized. Check row planters for cotton and other crops will have to be introduced. Electronic devices for identifying gaps and counting seeds/seedlings in planters/transplanters will be required to be introduced and popularized (Singh and Bhardwaj, 1985; Singh, 1999).

In order to make efficient use of available human and animal energy, improved, efficient and ergonomically designed hand tools and matching animal operated equipment for different operations like seed bed preparation, sowing/planting, weeding/intercultural operations etc. should be promoted and popularized (Vatsa, 2013).

Farm tools and equipment

Farm tools and equipment are needed for timely completion of various agricultural operations and precise application of inputs to have higher productivity and profitability and also to reduce the drudgery of farm workers including women (Balishter *et al.,* 1991). 80% of farm holdings in India are less than one hectare and source-wise, current power use is 65% mechanical, 21% electrical, 8% animal and 65% human, respectively (De, 2000). Appropriate and selective mechanization is needed for production agriculture, post-harvest management and value addition using a proper blend of conventional and renewable energy sources to achieve higher income (Mittal and Bhatia, 1988). While mechanization would augment the agricultural production by 10-15%, post harvest management could add 5-10% more by reducing losses (Singh, 2000a). The potential for value addition to agro-produce including byproducts is immense, 25-400%, depending upon the commodity and the level of processing (Singh, 2004). Few important farm tools and equipment for mechanization of agricultural production operations are as given in Tabel-1 (Pangotra, 1983; Sindhu and Grewal, 1991; Gajri *et al.,* 2002).

Mechanization of Horticulture Crops

Whole set of equipment for mechanization of orchard crops-pit making, transplanting of saplings, pruning, spraying in tall crops, harvesting of fruits etc. need to be identified/imported/designed, introduced and popularized (Dhillon and Sindhu, 1987; Brar, 1998; Pandey, 2000). Vegetable crop production has to be mechanized for which full set of equipment from seed bed preparation, planting, transplanting of seedlings, inter culture, irrigation, spraying harvesting, picking/digging has to be identified/designed and introduced (Ozmeri and Barut, 1998).Different types of manually operated and power operated garden tools will have to be introduced and popularized for promotion of raising of seedlings for growing of fruits, vegetables and flowers and for work in the gardens (Aggrwal, 1983). Use of plastic mulch reduces water requirement and checks weed growth. Equipment for laying plastic mulch, low plastic tunnels for cultivation of vegetables, cut flowers etc. will be required to be introduced and popularized (Prasad and Srivastava, 1993). Green house technology has good scope in India for growing, seedlings, flowers, high value off-season vegetables and some fruit crops. This technology needs greater promotion. Equipment for mechanization of cultivation in green houses will be required (Patil and Sirohi, 1987).

Table-1: Important farm tools and equipment for mechanization of agriculture

Tools and equipment	Description
Rotavator	Rotavator is used for seedbed preparation, weed control, mixing of soil with crop residue and fertilizer and puddling of the soil. It saves times (30-35%), water (30%) and cost of operation (20-25%) as compared to tillage by cultivator and harrow.
Sub-soiler	It breaks soil hard pan up to a depth of 60 cm and is used for rain water retention and suitable for dryland farming areas. Use of this implement results in increased yield by up to 30% and the cost of operation is ` 1000/ha.
Zero-Tillage Machine	Use of ZTM for direct sowing of wheat after rice saves time (50%) and cost (40%) as compared to the conventional practice of seedbed preparation and sowing. It costs ` 18,000-22,000 depending upon the size of the drill and the cost of operation is about ` 1,500/ha.
Happy Seeder	It combines two units, one for straw management and the other one is for sowing wheat after paddy. Machine cost is ` 60,000 and the cost of operation is ` 1,750-2,000/ha. Green gram can also be sown in summer after wheat in standing stubble which helps in moisture conservation and soil temperature regulation.
Raised Bed Former	This equipment has been developed to facilitate Furrow Irrigated Raised Bed (FIRB) cropping system for wheat after soybean or maize. It reduces tillage requirement and the subsequent crop can be sown directly on the beds without field preparation. The benefits of the machine are saving of cost of operation (20-30%), seeds (25%), fertilizer (25%) and irrigation water (20-30%). The cost of the machine is ` 45,000.
Ridger Seeder	The ridger seeder is suitable for dryland farming. It forms ridges and furrows and does sowing on the ridge or at side of the ridge or in the furrows, as desired. For *Kharif* crops seeding is done on the ridges in paired – row system and for *rabi* crops seeding is done in furrows. It is suitable for planting maize, ragi, gram, pearl millet, etc. There is increase of about 15% in the yield compared to conventional method of sowing. It costs ` 20,000 and cost of operation is ` 1,050/ha.
Sugarcane Cutter Planter	It is suitable for cutting and planting sugarcane setts and application of granular fertilizer in single operation. The machine accepts whole cane. This implement costs ` 55,000 and the cost of operation is `1,800/ha as compared to ` 3,000/ha by conventional method. The labour requirement and time of operation are reduces by 78% and 50%, respectively.
Automatic Potato Planter	It is a two-rows or three rows equipment to plant potato tubers of 20-40 mm size at 250-400 mm plant spacing. It can also be used for intercultural and earthing operation. Its field capacity is 0.40 ha/hr, cost is ` 25,000 – 30,000 and the cost of operation is ` 1,050/ha.
Self propelled vertical conveyor reaper	It is suitable for harvesting and windrowing cereals and oilseeds crops. This machine costs ` 60,000 and the cost of operation is ` 1,500/ha compared to ` 2000/ha by conventional methods. It saves 50% labour and cost of operation and 75% operating time. The equipment gives negligible losses for paddy crop and within permissible limit for wheat.
Wheat Straw combine	This machine cuts and gathers the left over straw from the combine harvested field and chops it into fine straw and blows it into a trailer. The capacity of the machine varies from 0.4 – 0.5 ha/hr and it recovers 55-60% of straw in addition to 75-100 kg of grains / ha resulting into an average net saving of ` 1,750/ha.
High capacity multi-crop thresher	It is suitable for threshing wheat, maize, sorghum, gram, pigeon pea, soybean, sunflower and other crops. It costs ` 75,000 and cost of operation is ` 5/q. Output capcity is 550 – 2890 kg/ ha depending on the crop being threshed. It saves 50% labour and time of operation.
Pressurized Irrigation System (Sprinkler & Drip)	It consisting of sprinkler and drip systems help to increase yield by 40-50% and also achieve water saving of 30 – 70% depending upon the crop. Sprinkler irrigation can be adopted for almost all crops (except rice and jute) and in various soils and topographic conditions. Drip irrigation is more effective in horticultural crops, cotton and sugarcane.

CONCLUSION

Engineering interventions in the form of appropriate tools and technology facilitate in maximizing agricultural productivity and profitability on sustainable basis and with a minimum drudgery to farm workers, especially to women. There is a need for forgoing partnership among various stakeholders like farmers, extension workers, researchers, financial institutes, agribusiness companies, policy makers and consumers for greater synergy in farm production, value addition and marketing. Knowledge centers in rural areas are needed for an effective utilization of available agricultural technologies and experiences by the farmers, to derive benefits. The existing extension systems needs to be reoriented to address the entire value chain from production to consumption for quick delivery of improved technologies and judicious harnessing their potential for enhancing net monetary return per unit of area, time, input and energy.

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