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Assessment of agricultural mechanization parameters in Bundelkhand zone of Uttar Pradesh, India

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■ **ABSTRACT :** UP is the fifth largest state of India (24.1 million hectares) with a projected population of 220.7 million people (roughly 16.7 % of all-India population) in 2016. It is also one of the poorest states in India with 29.4 per cent of its population below the poverty line (Tendulkar Poverty Line, 2011-12). Agriculture forms an integral part of UP's economy and the lives of its people. Nearly 69 per cent of land in the state is under cultivation. The state is also divided into 9 agro-climatic zones. Agriculture in Bundelkhand zone was vastly rain-dependent, diverse, complex, under invested, risky and vulnerable mainly because of its geographical condition. A sizeable area of 84 per cent was allocated to food grain crops in this region. Unlike other regions pulses occupied large share *i.e.* 43 per cent in GCA. Among the cereals wheat was the important crop although its area remained static. This region is lagging far behind in the adoption of the improved varieties and application of fertilizer. The district selected from Bundelkhand agro-climatic zone of Uttar Pradesh was Jhansi and Chitrakoot. Primary data were collected from 100 farmers from 10 villages of 2 districts *i.e.* 50 farmers from each district. In India, there is a need to increase the availability of farm power from 2.02 kW per ha (2016-17) to 4.0 kW per ha by the end of 2030 to cope up with increasing demand of food grains. The average value of mechanization index, power availability, cropping intensity, irrigation intensity, annual farmer income, annual input cost, human energy, mechanical energy, total energy in Bundelkhand zone of Uttar Pradesh year 2018-19 were in 0.92, 1.61 kW/ha, 124.59 per cent, 124.59 per cent, Rs.119852, Rs.32463, 26.63 kWh/ha, 400.31 kWh/ha and 426.94 kWh/ha, respectively. Still the harvesting with harvesting worker is maximum mechanize *i.e.* 0.993 then cultivator as well as diesel engine both had almost same value of degree of mechanization *i.e.* 0.469 and 0.466, respectively.

■ **KEY WORDS :** Mechanization index, Farm power, Degree of mechanization, Cropping intensity, Human energy, Mechanical energy, Total energy

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UP is the fifth largest state of India (24.1 million hectares) with a projected population of 220.7 million people (roughly 16.7 % of all-India population) in 2016. It is also one of the poorest states in India with 29.4 per cent of its population below the poverty line (Tendulkar Poverty Line, 2011-12). Agriculture forms an integral part of UP's economy and the lives of its people. Nearly 69 perc ent of land in the state is under cultivation. UP accounted for 13.15 per cent (25.9 mha) of the gross cropped area in the country

in TE 2013-14, and 77.9 per cent of this was under irrigation (20.17 mha – roughly 21.6 % of gross irrigated area in the country in TE 2013-14). UP has more than 18 million agricultural households in the state and approximately 59 per cent of its workforce was dependent on agriculture for a livelihood in 2011 (as per NSS, 2012-13 and Census, 2011). Marginal (< 1 ha) and small (1 – 2 ha) farmers cultivate 92.5 per cent of all landholdings in UP which accounts for 64.8 per cent of the total area cultivated in UP. The state is also divided into 9 agro-climatic zones. Agriculture in Bundelkhand region was vastly rain-dependent, diverse, complex, underinvested, risky and vulnerable mainly because of its geographical condition. A sizeable area of 84 per cent was allocated to food grain crops in this region. Unlike other regions pulses occupied large share *i.e.* 43 per cent in GCA. Among the cereals wheat was the important crop although its area remained static. This region is lagging far behind in the adoption of the improved varieties and application of fertilizer.

The agro-climatic zone of Bundelkhand of Uttar Pradesh includes seven districts *viz.*, Jalaun, Jhansi, Chitrakoot, Lalitpur, Mahoba, Hamirpur and Banda districts. It receives about 900 mm of rainfall. The production of food grain is 14.58 q/ha and cover area 29.61 lakh hectare cultivated area. A little over 60 per cent of the area is cultivated, but compared to other parts of Uttar Pradesh; the sub-zone has less developed irrigation facilities. Only about 25 per cent of the cultivated area is irrigated as against a state average of nearly 60 per cent. Soil erosion is high and land productivity is low.

The mechanizing in crop farming is also much prevalent in Uttar Pradesh. The use of tractors, seed drill, rotavators, threshers, cultivators etc are very much common for agriculture and allied activities in Uttar Pradesh. Most of agricultural operations and activities are mostly performed by tractors in Uttar Pradesh. The diesel and electric tube-wells are being largely used across the state. The zero till multi crop planter and zero til-seed drill were very less in number in Uttar Pradesh upto 2014-15.

In modern era, agricultural mechanization draws a major controversy that it is considered as the application of mechanical power technology, particularly tractors. However, three main levels of mechanization technologies need consideration *i.e.* human power, animal power and mechanical power technologies, with varying degrees of sophistication within each level (Rijik, 1989), on the basis of capacity to do work, costs, and precision and effectiveness (Morris, 1985). Agricultural mechanization technology further varies from location to location and crop to crop. Thus, the quality of inputs of mechanization, and consequently land and labor productivity may differ considerably (Gifford and Rijik, 1980). So, mechanization planning requires the quantification of level of mechanization for each crop production. Several authors developed different methods to quantify the level of mechanization based on power or energy availability and its impact in agricultural and labour productivity.

Zangeneh *et al.* (2010) defined mechanization index (MI) and level of mechanization (LOM), to characterize farming system of potato in the Hamadan province of Iran. These indicators are defined mathematically as eq. (1) and (2), respectively. The MI elaborated here is an expression of the deviation of the actual amount of motorized farm work from the normal values at the regional level.

$$MI = \frac{1}{n}\sum_{i=1}^{n}\frac{M_{e(i)}}{M_{av}} * \frac{L_i}{TL_i} \quad ....(1)$$

where, MI = Mechanization index for the production unit 'a', $M_{e(i)}$ = Overall input energy due to machinery in the production unit 'a', M_{av} = Regional-average energy due to machinery, L_i =Land area cultivated in the production unit 'a', TL_i = Total farm land ownership of production unit 'a', n = Number of farms.

The MI index, proposed by Andrade and Jenkins (2003) is an indication of the amount of machinery a given farmer uses for farm work compared with the average in the region. The second term in Eq. (1) includes a ratio between the land area cultivated with wheat crop and the total land ownership. This term was introduced because it reflects the importance of land demand for cultivation. The LOM index is based on the premise that a mechanized farmer is the one that finds a way to utilize amounts of mechanical energy that are higher than the typical values using locally available technology.

$$LOM = \sum_{i=1}^{n}\frac{P_i * \eta}{L_i}$$

where, LOM = Level of mechanization, P_i= Power of tractors, η = Correction factor for utilized power (0.75).

Field capacity was multiplied by rated power so the

quantification of energy expenditure was made in work units (kWh). The regional normal will be obtained after compiling a full dataset of all respondents and then it would be defined the mode for the number of passes for each operation as well as the mode in tractor size and field capacity.

The level of mechanization is calculated by the following formula (Almasi *et al.*, 2000).

$$\text{Mechanization level (hp/ha)} = \frac{\text{Total power}}{\text{Cultivated area}} \quad \ldots(3)$$

The total power of existing tractors (hp) = Average nominal power of one tractor x Number of working tractors.

Total real power of tractors = Total power of existing tractors x Conversion co-efficient (0.75).

Animal energy (hp-h) = Total existing animal power x Annual functional hours.

Annual functional hours = Number of functional days x Mean functional hours during a day.

Total existing animal power (hp) = Produced power of animal x Number of animals.

Human energy (hp-h) =Total exiting human power x Annual functional hours.

Annul functional hours= Number of functional days x Mean functional hours during a day.

Total existing human power (hp) = Produced power of human x Number of humans.

METHODOLOGY

After selection of variables, a questionnaire was prepared to collect primary data from Bundelkhand agro-climatic zone of Uttar Pradesh. The district selected from Bundelkhand agro-climatic zone of Uttar Pradesh was Jhansi and Chitrakoot. A stratified multistage sampling design was applied considering district and village as strata. The villages were selected from two mentioned districts from of Bundelkhand agro-climatic zone of Uttar Pradesh using random sampling and 2 districts out of 7 districts of Bundelkhand zone were taken for the study. Then from each district, 5 villages and then from each villages, 10 farmers were selected using random sampling. Primary data were collected from 100 farmers from 10 villages of 2 districts *i.e.* 50 farmers from each district. As mechanization is a multi-dimensional concept, thus the following indices were evaluated to study the mechanization status in target region. To study the mechanization status of two districts of Bundelkhand zone of Uttar Pradesh The many variables were selected based on requirements to estimate degree of mechanization, level of mechanization (power availability), mechanization index, cropping intensity, irrigation intensity, input cost and farmers Income. The following variables were selected:

Degree of mechanization (MD):

It is one of the quantitative measure of mechanization, by which the degree of mechanization of different operations in a cropping system like land preparation, sowing, weeding, irrigation, spraying, harvesting, threshing, transportation of agri-cultural produce and etc. can be assessed. It is the ratio of mechanization area accomplished to the area to be mechanized (Almasi *et al.*, 2000). The degree of mechanization of particular implements used in a particular agricultural operation can be given as:

Degree of mechanization =Mechanized area/Area to be mechanized …(4)

In other words, the degree of mechanization can be used to evaluate the extent of different agricultural operations performed using machinery or improved implements to the operations performed by humans, animals or traditional implement *i.e.* Area under bullocks, cultivator, power tiller, disc plough, MB plough, deshi hal (local plough), seed cum fertilizer drill, diesel engine, electric pump, sprinkler, dripper, sprayer (manually operated), sprayer (tractor operated), manual harvesting, thresher and combine harvester.

Level of mechanization (power availability):

Farm power is an essential input in agricultural production system to operate different types of equipment for timely field completion of agricultural works to increase productivity and maintain sustainability of farm. The mobile power is used for different field jobs like land prepa-ration, sowing, weeding, spraying and harvesting etc., whereas stationary power is used for lifting water, operating irrigation equipment, threshing, cleaning and grading of agricultural produce. The main sources of mobile power are human, draught animal, tractors, power tiller and self-propelled machines (combines, dozers, reapers, sprayers and etc.) whereas the source of stationary power is oil engines and electric motors. In this study, power availability was also

evaluated for Bundelkhand zone of Uttar Pradesh. The main sources of mobile power were human, draught animal, tractors and combines whereas the sources of stationary power were oil engines, electric motors and threshers in the eastern region. The power availability was evaluated using formula given by Eq. 5.

Power availability (hp/ha) = Total power/ Net cultivated area ...(5)

where, Total power = Total mobile power + Total stationary power

Net cultivated area = Net cultivated area of target region villages wise number of tractor, combine harvester, bullocks, agricultural workers, power tiller, diesel engines and electric pump.

■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

The graphical representation of variation of mechanization index, degree of mechanization, cropping intensity, annual input cost, irrigation intensity, annual farmers' income, human energy, mechanical energy and total energy with net cultivated area for Bundelkhand zone are shown in Fig. 1 to 9. From Fig. 1, it is much cleared that the value of mechanization index is enhancing linearly with increase in net cultivated area in Bundelkhand zone of Uttar Pradesh. It was clearly shown that adoptability of machines was increasing with increase of net cultivated area in different farm unit operations. The average value of mechanization index in Bundelkhand zone was found 0.921. The value of 0.92 tells that 92 per cent agricultural farm work was performed with agricultural machines in Bundelkhnad

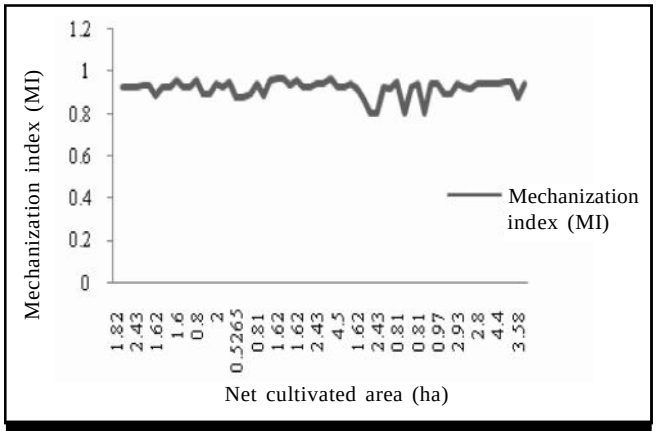

Fig. 1 : Variation in mechanization index with net cultivated area in Bundelkhand zone

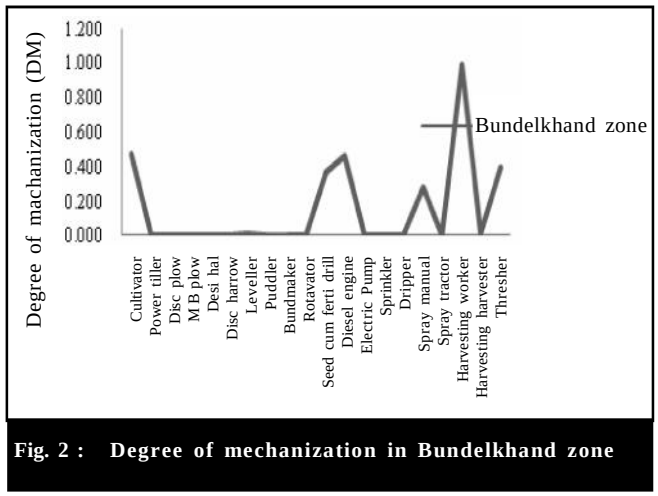

Fig. 2 : Degree of mechanization in Bundelkhand zone

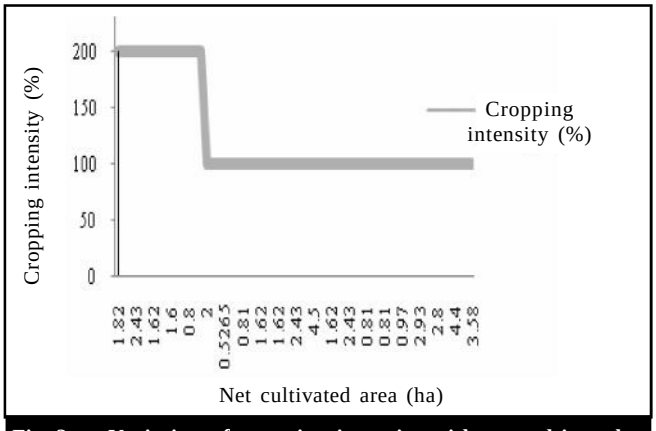

Fig. 3 : Variation of cropping intensity with net cultivated area in Bundelkhand zone

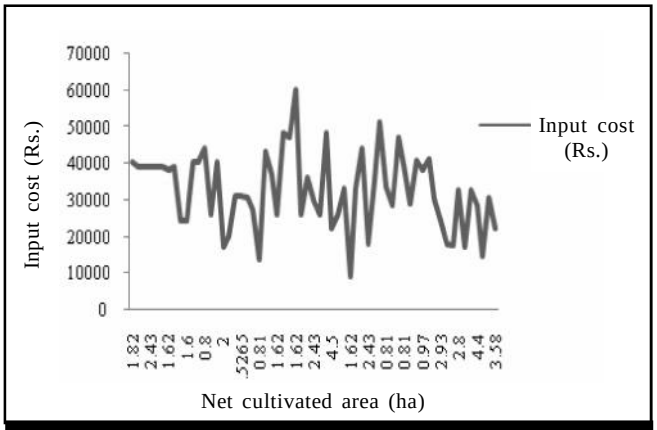

Fig. 4 : Variation of input cost with net cultivated area in Bundelkhand zone

zone. From the curve 2, it is found that maximum degree of mechanization was in harvesting unit operation with harvesting worker then land preparation unit operation with cultivator then irrigation unit operation with diesel engine Bundelkhand zone of Uttar Pradesh. The average degree of mechanization of harvesting worker, cultivator and diesel engine were 0.993, 0.469 and 0.464, respectively in Bundelkhand zone of Uttar Pradesh. It is cleared from the Fig. 3; the value of cropping intensity is not increasing with increase of net cultivated area. The average value of cropping intensity in Uttar Pradesh was 124.59 per cent as compared to national average value 142 per cent. From the Fig. 4, it is cleared that with increase in net cultivated area input cost is also increase. The average value of annual input cost in Bundelkhnad zone was found Rs. 32463. From the Fig. 5, it is shown that the irrigation intensity is also independent on net cultivated area in Bundelkhand zone of Uttar Pradesh. It is observed that the maximum income of farmer lies between 7 to 8 lakh for net cultivated area more than 4.05 hectare. The most of the farmers had income less than one and half lakh. The average value of annual farmer income was found Rs. 119852. The average value of irrigation intensity was also found 124.59 per cent in Bundelkhand zone of Uttar Pradesh. From the Fig. 7, it is found that with increase in net cultivated area, human energy decrease slowly in majority of cases when area is more than 1.5 hectare due to heavy use of farm machines in farm work. The average value of human energy in Budelkhand zone was 26.63 kWh/ha. It is clear from the Fig. 8, with increase in net cultivated area, the mechanical energy is also increasing very steeply. The

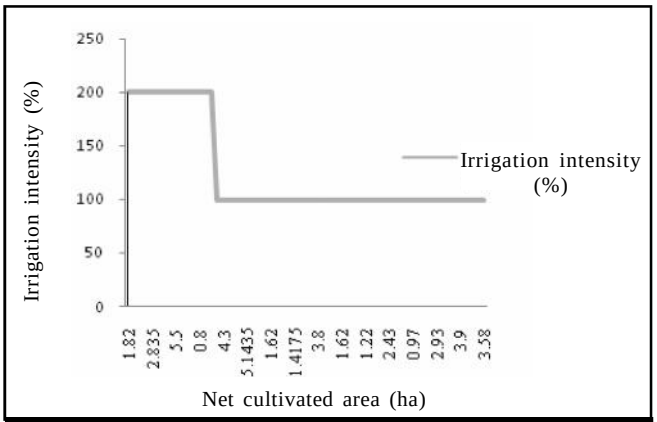

Fig. 5 : Variation of irrigation intensity with net cultivated area in Bundelkhand zone

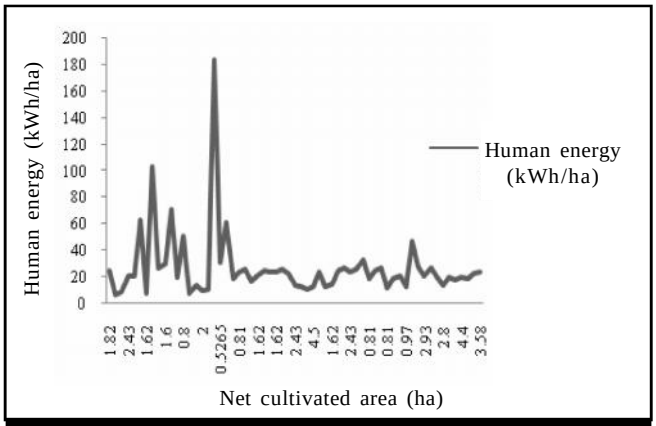

Fig. 7 : Variation of human energy with net cultivated area in Bundelkhand zone

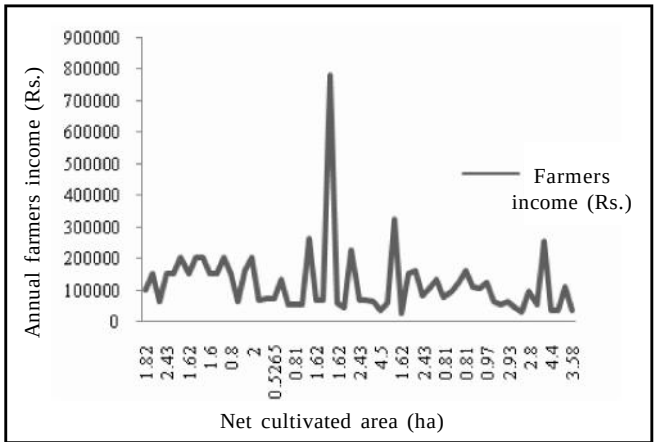

Fig. 6 : Variation of farmers income with net cultivated area in Bundelkhand zone

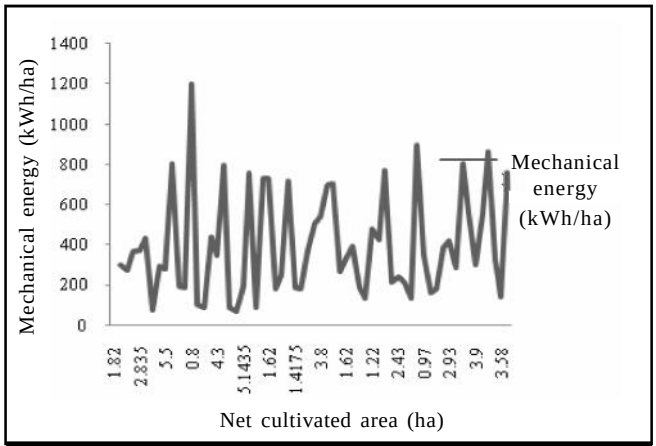

Fig. 8 : Variation of mechanical energy with net cultivated area in Bundelkhand zone

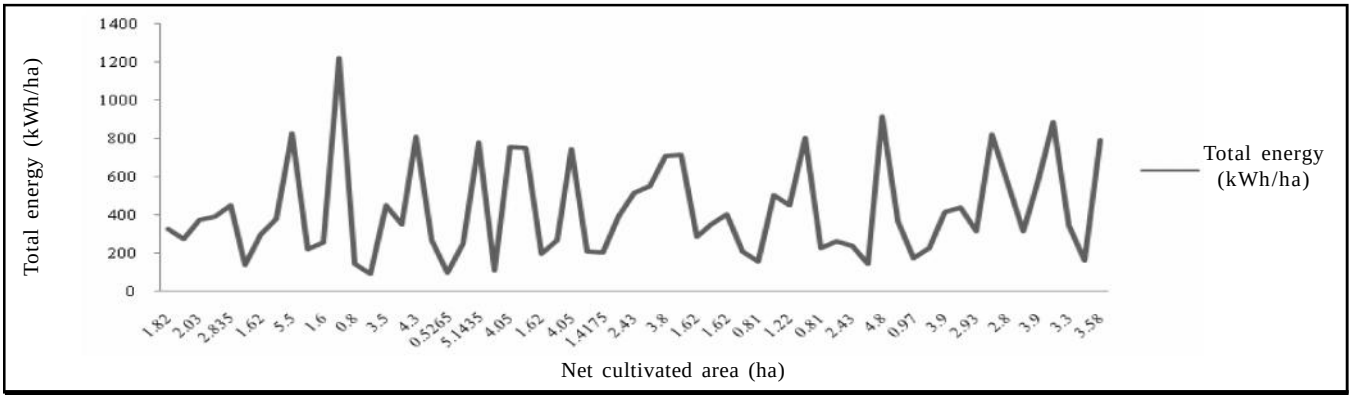

Fig. 9 : Variation of total energy with net cultivated area in Bundelkhand zone

minimum and maximum value of mechanical energy in Bundelkhand zone of UP were 89 kWh/ha and 2494 kWh/ha for 0.8 ha and 8 ha net cultivated area, respectively. The average value of mechanical energy was found 400.31 kWh/ha in Bundelkhand zone of Uttar Pradesh. As mechanical and human energy both are increasing with net cultivated area hence, total energy, which is sum of human and mechanical is also enhancing with net cultivated area. The maximum and minimum value of total energy in Bundelkhand zone of Uttar Pradesh were 2597 kWh/ha and 96 kWh/ha, respectively. The average value of total energy was found 426.94 kWh/ha. The average value of discussed parameters is also given in Table 1 and 2. The harvesting with harvesting worker is maximum mechanize *i.e.* 0.993 then cultivator as well as diesel engine both had almost same value of degree of mechanization *i.e.* 0.469 and 0.466, respectively.

Table 1: Mechanization status parameters of Bundelkhand zone in Uttar Pradesh

Sr. No.	Mechanization status parameters	Average values
1.	Mechanization index	0.921
2.	Farm power (kW/ha)	1.61
3.	Cropping intensity (%)	124.59
4.	Irrigation intensity (%)	124.59
5.	Annual farmers income (Rs.)	119852
6.	Annual input cost (Rs.)	32463
7.	Human energy (kWh/ha)	26.63
8.	Mechanical energy (kWh/ha)	400.31
9.	Total energy (kWh/ha)	426.94

Table 2: Degree of mechanization of different farm implements in Bundelkhand zone of UP

Degree of mechanization	Average values
Cultivator	0.469
Power tiller	0.001
Disc plow	0.002
M B plow	0.000
Desi hal	0.000
Disc harrow	0.005
Leveller	0.011
Puddler	0.000
Bundmaker	0.000
Rotavator	0.000
Seed cum ferti drill	0.364
Diesel engine	0.464
Electric Pump	0.000
Sprinkler	0.000
Dripper	0.000
Spray manual	0.284
Spray tractor	0.000
Harvesting worker	0.993
Harvesting harvester	0.007
Thresher	0.393

Conclusion:

The average value of mechanization index, power availability, cropping intensity, irrigation intensity, annual farmer income, annual input cost, human energy, mechanical energy, total energy in Bundelkhand zone of Uttar Pradesh were 0.92, 1.61 kW/ha,124.59 per cent, 124.59 per cent, Rs.119852, Rs.32463, 26.63 kWh/ha, 400.31 kWh/ha and 426.94 kWh/ha, respectively. The harvesting with harvesting worker is maximum mechanize *i.e.* 0.993 then cultivator as well as diesel engine both had almost same value of degree of mechanization *i.e.*

0.469 and 0.466, respectively.

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