**Assessing the Dynamics and Scope of Farm Mechanization in Karnataka, India**

**ABSTRACT**

Agriculture plays an important and significant role in the development of a country. The Indian economy has undergone a tremendous change from agriculture dominance to non-agriculture dominance, as it is reflected in the decline in the share of agriculture in total income from 55 per cent in 1950-51 to 18.30 per cent in 2022-23. Farm mechanization holds substantial scope and importance in an agricultural landscape. It involves the integration of modern machinery and technology into various farming processes, ranging from initial soil preparation to the final harvest. In this regard, the study aimed to conduct research on the dynamics of nature and extent of farm mechanization across zones and crop-wise over the years and to understand the extent of farm mechanization in different operations of various crops.

This study was based on the secondary data obtained from the Comprehensive Scheme for studying the Cost of Cultivation of Principal Crops of Karnataka. Data from 2011-12 to 2020-21 for 18 major crops were analysed using descriptive statistics, CAGR, and mechanization index. Here, data analysis was done using analytical tools such as Descriptive statistics, Mechanization Index (MI) and Compound Annual Growth Rate (CAGR) analysis were used. The results revealed that the North East Transition Zone (6.73%) and Hill Zone (6.03%) have positive growth in farm mechanization. In 2020-21, North Eastern Dry Zone (41.76%) and Northern Dry Zone (36.65%) and Southern Transition Zone (28.80%) showed high mechanization, while Coastal Zone (16.18%), North Transition Zone (17.77%) and Southern Dry Zone (23.19%) have low mechanization. Overall, mechanization was 27 per cent in Karnataka, with a CAGR of 2 per cent. In paddy, redgram and greengram, the highest growth in mechanization was observed. The intercrop comparison revealed that paddy (41.81%) and greengram (35.69%) cultivation was more mechanized, while chilli (14.97%) was low mechanized. The share of machine labour cost was highest in paddy (18.67%). Operations such as preparatory tillage (49%), irrigation (41%) and harvesting/picking (41%) are more mechanized. Inter-zonal and inter-crop disparity in the adoption of farm mechanization is reported in this study. This can be overcome by improving the availability of farm power and farm machinery and equipment through expanding new custom hiring centres and developing suitable and affordable farm machinery and equipment engineered to specific crop and regional characteristics.Hence, enhancing farm machinery availability and encouraging private investments in rental services is crucial for expanding mechanization in the Karnataka state.

**Keywords:** *farm mechanization, agricultural development, farm machinery, Inter-zonal and inter-crop*

**1. INTRODUCTION**

In developing countries, overall economic development is mainly articulated by agricultural development. Agriculture plays an important and significant role in the development of a country. According to figures from the World Bank, the agriculture sector made about one-third of the global gross domestic product (GDP) in the year 2014. Agriculture continues to be the primary source of livelihood for most people in developing economies, supporting 60.0 per cent of the world's population (Kumar & Manshi, 2023). During the year 2022-23, the share of GVA of agriculture and allied sectors in the Indian economy is 18.30 per cent and is growing at a rate of 3.30 per cent annually (Anon, 2023a). As of 2021, around 65 per cent of the Indian population lives in rural areas, and 47 per cent of the population is dependent on agriculture for livelihood (Anon, 2023b). However, the Indian economy has undergone a tremendous change from agriculture dominance to non-agriculture dominance, as reflected in the decline in the share of agriculture in total income from 55 per cent in 1950-51 to 18.30 per cent in 2022-23 (Anon, 2023a).

The backbone of any agricultural revolution is the access and use of modern agricultural inputs. The resources or inputs include a variety of improved seeds, fertilizers, plant protection chemicals, machinery, irrigation and knowledge. In agriculture, labour is one of the most important components of the four factors of agriculture production, i.e., land, labour, capital and organisation (Pathania *et al.,* 2020). As a country moves from underdeveloped to developing and to developed, labour starts moving from the agriculture sector as opportunities increase in high productivity sectors. In India, a similar trend has been seen in recent years. Agricultural mechanization is an innovation that is rapidly gaining momentum in the world and is high on the agenda for policy in developing countries (Yasar et al., 2024). Sustainable agricultural mechanization is a key strategy to achieve long-term growth of agricultural production in all aspects, including reducing the coolie of small-scale farmers, improving the timeliness of agricultural operations and improving the efficiency of input and use (Devlet, 2021).

* 1. **Scope and importance of farm mechanization**

Farm mechanization holds substantial scope and importance in the agricultural landscape. It involves the integration of modern machinery and technology into various farming processes, ranging from initial soil preparation to the final harvest. By mechanizing these tasks, the efficiency of agricultural operations will be significantly improved. It takes an average of 12 hours to prepare an acre of land using draft animals, whereas land preparation using a four-wheel tractor takes about one hour per acre (Soe and Kyaw, 2019). Operations such as ploughing, sowing, weeding, spraying, harvesting and threshing can be executed more quickly and with reduced labour input.

The motivation behind mechanization in agriculture is primarily driven by the desire to enhance family income, ensure food security and improve overall quality of life (Nikhade and Gunaki, 2020). By employing mechanized inputs, farmers can access numerous economic and social advantages. Economically, these benefits encompass lowering input costs, enhancing the efficiency of labour, expanding the cultivated area, performing timely operations, increasing farm output, following crop diversification and generating income through farm power services for others. Additionally, mechanization minimizes weather-related risks and reduces post-harvest losses. Farmers who used a tractor were less likely to report any pre- or post-harvest crop losses than those using only draft animals, suggesting that mechanization may help to moderate these risks resulting from weather-related yield losses (Belton *et al.,* 2021). Simultaneously, mechanization yields social benefits such as reduced workloads and drudgery, particularly for women workers, improved safety measures and the encouragement of younger generations and innovative individuals to remain in rural areas and engage in agricultural work.

**1.2. Regional disparity in farm mechanization**

India's agricultural landscape is marked by significant regional disparities in farm mechanization, reflecting diverse socio-economic characteristics (education, awareness, income, access to credit, land holdings and occupational diversification), geographic (topography, cropping pattern, climate, and market access) and infrastructural challenges across different states and regions. While some states have embraced advanced agricultural technologies, others continue to rely heavily on traditional and manual farming methods. These disparities stem from varying levels of government support, access to credit and awareness about modern farming practices.

The level of mechanization (farm power availability) in India during 2018-19 was 2.49 kW per hectare, wherein Punjab has the highest level of mechanization with around 6 kW per hectare, followed by Haryana and Bihar with 5.50 and 3.50 kW/ha, respectively. It is lowest in Meghalaya (0.37 kW/ha), Arunachal Pradesh (0.58 kW/ha) and Nagaland (0.61 kW/ha) states. For the same year, the level of mechanization in Karnataka was 2.44 kW per hectare.

The extent of mechanization varies greatly from region to region. Northern states such as Punjab, Haryana and Western Uttar Pradesh have higher mechanization due to high productive land as well as a declining number of agriculture workers and through various state-specific policies. The Eastern and Southern states have lower mechanization due to smaller and scattered land holdings. In the Northeastern states, the mechanization is extremely low mainly due to hilly topography, high transportation cost. Although the overall mechanization in India is 47 per cent, it is still low as compared to other countries such as the U.S. (95 %), Brazil (75 %) and China (57 %). It has been observed that unless machines appropriate for small holdings are made available or substantial farm land consolidation takes place, small farmers will find it difficult to purchase their own machinery. According to the estimates of the Department of Agricultural Research and Education, it would take about 25 years from 2022 for the country to achieve 75-80 per cent mechanization.

In this regard, the study made an attempt to study the dynamics of nature and extent of farm mechanization across zones and crops over the years and to understand the extent of farm mechanization in different operations of various crops.

**2. METHODOLOGY**

**2.1. Study area and selection of farmers**

This study is based on secondary data. The main data required has been collected from the Comprehensive Scheme for studying the Cost of Cultivation of Principal Crops of Karnataka (CSCCPC) from the year 2011-12 to 2020-21. The plot-level data from the CSCCPC was used in this study. The plot-level data refers to the detailed crop production information collected periodically at each plot of the selected farmer by using the cost accounting method as prescribed by the Commission on Cost and Prices (CACP).

The data was aggregated at the zonal level by using the farmers’ code in order to ensure a true reflection of the farm mechanization at different agro-ecological zones of the state. The crop wise data on labour usage (human, machine and animal), production, cost and returns were used for 18 crops viz. bengalgram, blackgram, chilli, coconut, cotton, finger millet, greengram, groundnut, maize, onion, paddy, pearl millet, redgram, sorghum, soyabean, sugarcane, sunflower and wheat. Other than these data sets, other secondary data sources from the Directorate of Economics and Statistics, Government of Karnataka, were utilized in order to arrive at meaningful conclusions.

**2.2. Data arrangement, management and cleaning**

Before analyzing, the data cleaning was undertaken in order to minimize the effect of outlier and address the issues of missing data. The following measures were employed for the data cleaning and arrangement.

* Those crops which have less than ten observations were dropped from the analysis
* The mechanization of the coconut crop was not considered for the analysis of the mechanization index. Capturing the mechanization of perennial crops was difficult due to the non-availability of the historical data of coconut crops. However, the income from the coconut crop and the level of mechanization in that particular year were considered in order to study the impact of mechanization on farm income.
* Outliers and missing values were identified and replaced by using *Z*-score and percentile method,
	1. **Z-score method:**

It is a statistical technique which measures how many standard deviations a data point is away from the mean of the dataset. The *Z*-score for a data point *X* is calculated using the formula in equation 1.

$Z= \frac{(X-μ)}{σ }$ ……………………… (1)

Where,

Z = Z-score of the observation X

X = Value of the observation

$μ$ = Mean

$σ$ = Standard deviation

By examining *Z*-scores, observation values with Z-scores beyond the threshold (1 standard deviation) were considered outliers and replaced with mean values.

1. **Percentile method:**

This involves using specific percentiles to identify and handle outliers in a data set. Here, outliers above the 50th percentile with larger values were replaced with 50th percentile values, while outliers with very small or zero values were replaced with the mean values.

By employing the above procedure, the total sample size selected for the study was 445, and the data was subjected to further analysis using the tools mentioned in the following section.

**Analytical tools used**

Descriptive statistics

Mechanization Index (MI)

Compound Annual Growth Rate (CAGR) analysis

**2.3. Descriptive statistics**

In order to assist the interpretation of findings, descriptive statistical measures like percentages, averages and ratios were worked out wherever necessary. Tabular analysis facilitates easy interpretation and comparison and was used to present mechanization status, extent of farm mechanization over the years, crops and different operations of the crop.

**2.3.1. Mechanization Index (MI)**

A mechanization index based on the matrix of using human, animate and mechanized energy inputs could be given by incorporating cost factors as indicated in equation 2.

$$I\_{mi}= \frac{C\_{Emi}}{C\_{EHi}+C\_{EAi}+C\_{Emi}} x 100 ……………………… (2)$$

Where,

Imi is the mechanization index of the ith crop

CEMi  is the cost of use of machinery in the ith crop

CEHi is the cost of human labour in the ith crop

CEAi  is the cost of animal labour in the ith crop

**2.3.2. Compound Annual Growth Rate (CAGR) Analysis**

The growth rate of mechanization over the years in Karnataka was estimated using the following procedure (equation 3):

$$MI\_{tc}=ab^{t}e^{u} …….……………….. (3)$$

Where,

MI= Mechanization index in year ‘t’ for crop ‘C’

a= Intercept (constant)

b=Regression coefficient

t= Years / time period (1, 2,………,n)

eu = Error term

Equation 3 was transformed into log linear form as in eq. 4,

$lnMI\_{tc}=lna+t lnb+u$ ……………………… (4)

Log a and Log b were obtained by using the Ordinary Least Squares (OLS) procedures, and the R2 was computed for the goodness of fit.

Then, the compound annual growth rate in percentage terms was estimated as follows (equation 5):

g = (Antilog b – 1) \*100 ……………………… (5)

Where,

g = Compound growth rate in per cent per annum

b = Coefficient

The significance of the growth rates was tested using a t-test. Compound Annual Growth Rate was estimated for 12 crops which were grown in all the years from 2011-12 to 2020-21.

**3. RESULTS AND DISCUSSION**

**3.1. Dynamics of farm mechanization**

Farm mechanization plays an important role in the effective utilization of inputs, which ultimately increases the productivity of land and labour by reducing the labour in farm operations in agriculture. There has been substantial progress of farm mechanization in India; however, its spread has been in the most uneven manner. To assess the extent of farm mechanization, a mechanization index was used, which gives the relative share of the cost of machine labour to the total cost of labour (i.e., sum of total cost of human labour, machine labour and animal labour).

The zone-wise mechanization index was calculated for the past ten years, and the results are presented in Table 1. To know the growth rate of mechanization, the CAGR was estimated for ten years, and results revealed that there was significant growth in agro-ecological zones such as NETZ, NDZ, HZ and as well for the Karnataka state. However, the growth rate was found to be maximum in NETZ (6.73 %) and HZ (6.03 %), which was significant and positive. This is due to changing cropping patterns, rising labour wages and increased area under the crop production.

**Table 1: Dynamics of farm mechanization in Karnataka (2011-12 to 2020-21)**

|  |  |
| --- | --- |
| **Zone** | **Mechanization Index (%)** |
| **2011-12** | **2012-13** | **2013-14** | **2014-15** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** | **CAGR (%)** |
| **NETZ** | 12.94 | 19.76 | 21.26 | 17.47 | 13.86 | 19.32 | 23.66 | 24.11 | 29.33 | 25.50 | 6.73\*\*\* |
| **NEDZ** | 25.59 | 26.80 | 28.70 | 16.28 | 24.00 | 17.23 | 19.88 | 29.60 | 33.80 | 41.76 | 3.99 |
| **NDZ** | 26.29 | 25.13 | 26.26 | 20.04 | 24.73 | 24.92 | 25.89 | 30.82 | 32.45 | 36.65 | 3.93\*\* |
| **CDZ** | 17.31 | 18.72 | 18.66 | 16.21 | 15.82 | 17.64 | 15.74 | 19.11 | 18.92 | 24.31 | 2.00 |
| **EDZ** | 16.25 | 24.32 | 19.44 | 10.83 | 13.91 | 21.07 | 26.79 | 24.93 | 24.19 | 25.20 | 5.15 |
| **SDZ** | 12.71 | 14.66 | 13.19 | 16.03 | 15.72 | 12.67 | 17.08 | 15.16 | 12.24 | 23.19 | 2.96 |
| **STZ** | 25.42 | 28.70 | 31.84 | 18.39 | 18.22 | 15.12 | 20.31 | 29.13 | 33.09 | 33.40 | 1.91 |
| **NTZ** | 19.27 | 20.05 | 20.08 | 16.04 | 17.95 | 21.00 | 27.39 | 26.41 | 22.47 | 17.77 | 1.96 |
| **CZ** | 12.19 | 17.98 | 18.03 | 10.18 | 19.19 | 5.92 | 8.67 | 5.16 | 15.93 | 16.18 | -3.70 |
| **HZ** | 14.45 | 16.69 | 22.64 | 27.91 | 23.56 | 25.59 | 28.27 | 26.70 | 23.90 | 28.80 | 6.03\*\*\* |
| **KA** | 20.66 | 21.63 | 22.72 | 17.29 | 19.96 | 19.92 | 22.30 | 25.67 | 22.73 | 26.87 | 2.51\* |

Note: \*\*\*, \*\* & \* indicates significance at one, five and ten per cent level of significance

Zone wise mechanization index particularly for the year 2020-21 is presented in fig. 1 and it was observed that, the MI was highest for NEDZ (41.76 %) followed by NDZ (36.65 %) and STZ (28.80 %) and was lowest in CZ (16.18 %), NTZ (17.77 %) and SDZ (23.19 %) for the year 2020-21. The zones NEDZ and NDZ have a larger area under crop production and have a maximum area under cereals and pulses. Similar findings reported that the level of mechanization is lower in coastal zones compared to arid zones (Sarkar, 2020).

**Fig. 1: Zone-wise mechanization in Karnataka during the year 2020-21**

The trend in farm mechanization in Karnataka from 2011-12 to 2021-22 is depicted in fig.2. There is an increasing trend in the extent of farm mechanization over the years in Karnataka. Mechanization has increased from 20.66 per cent in 2011-12 to 26.87 per cent in 2020-21. It was noticed that mechanization decreased from 2014 to 2017 due to the occurrence of drought. The growth rate in farm mechanization in Karnataka was found to be 2.51 per cent, which was significant. Thus, mechanization has been increasing gradually in Karnataka. The results are in line with the study conducted by Adarsh and Sivasubramanian (2023).

**Fig. 2: Trend in farm mechanization in Karnataka (2011-12 to 2020-21)**

The crop-wise extent of mechanization in Karnataka during the year 2011-12 is shown in Table 2. The results revealed that there is positive and significant growth in mechanization over the years for crops like paddy, redgram, greengram, maize and finger millet, whereas negative growth was reported in the sugarcane crop. The highest growth of mechanization was observed in paddy, redgram and greengram crops with 7.70, 6.88 and 6.76 per cent, respectively. This is due to the rising use of combine harvester in harvesting of paddy and redgram and greengram majorly this machinery was used on rent. Though the positive growth of use of machinery was reported in cotton and wheat but it was not statistically significant. It is interesting to note that in the majority of the crops, mechanization has decreased during the years, i.e., 2014-15 to 2016-17, as a consequence of drought in the state.

The extent of mechanization in Karnataka varied among crops and is presented in Table 3.

**Table 2: Growth of crop-wise farm mechanization in Karnataka (2011-12 to 2020-21)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Crop** | **Mechanization Index (%)** | **CAGR (%)** |
| **2011-12** | **2012-13** | **2013-14** | **2014-15** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** |
| 1. | Bengalgram | 26.62 | 19.94 | 19.83 | 13.22 | 18.33 | 21.17 | 27.11 | 27.11 | 23.05 | 23.15 | 2.22 |
| 2. | Cotton | 14.96 | 14.76 | 15.02 | 12.41 | 15.68 | 17.60 | 16.63 | 15.19 | 12.24 | 16.24 | 0.29 |
| 3. | Greengram | 19.30 | 23.63 | 18.05 | 27.77 | 18.99 | 17.32 | 28.62 | 27.73 | 36.91 | 35.69 | 6.76\*\* |
| 4. | Groundnut | 18.70 | 17.64 | 12.37 | 10.35 | 10.44 | 14.91 | 17.32 | 26.74 | 12.20 | 21.01 | 2.59 |
| 5. | Fingermillet | 10.52 | 13.79 | 13.90 | 15.80 | 12.77 | 18.16 | 16.56 | 20.22 | 18.22 | 17.98 | 5.70\*\*\* |
| 6. | Maize | 19.90 | 21.73 | 21.59 | 18.46 | 24.62 | 22.45 | 21.43 | 26.16 | 28.20 | 27.54 | 3.75\*\*\* |
| 7. | Paddy | 17.50 | 22.32 | 24.80 | 28.70 | 23.60 | 21.30 | 25.03 | 32.89 | 36.78 | 41.81 | 7.70\*\*\* |
| 8. | Redgram | 15.38 | 25.21 | 20.95 | 11.34 | 15.22 | 20.04 | 26.53 | 31.91 | 24.83 | 30.51 | 6.88\*\* |
| 9. | Sorghum | 13.31 | 17.28 | 21.59 | 15.10 | 12.01 | 16.15 | 17.97 | 21.11 | 20.45 | 18.81 | 3.08 |
| 10. | Sugarcane | 15.93 | 14.71 | 28.06 | 10.58 | 11.89 | 6.54 | 8.13 | 8.13 | 8.66 | 22.93 | -8.25\* |
| 11. | Sunflower | 26.06 | 27.45 | 21.86 | 14.97 | 15.48 | 27.81 | 25.64 | 19.82 | 36.14 | 23.58 | 1.67 |
| 12. | Wheat | **-** | **-** | **-** | 25.65 | 24.87 | 30.65 | 19.68 | 19.68 | 24.56 | 31.57 | **-** |

Note: \*\*\*, \*\* & \* indicates significance at one, five and ten per cent level of probability

**Table 3: Crop-wise mechanization in Karnataka in 2020-21**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sl.****No.** | **Crop** | **Cost of cultivation (Rs./ha)** | **Components of Cost of Cultivation (Rs./ha)** | **MI (%)** |
| **Human Labour** | **Animal Labour** | **Machine Labour** |
| 1. 1.
 | Paddy | 111761.20 | 25229.03(22.57) | 3808.53(3.41) | 20862.53(18.67) | 41.81 |
| 1. 2.
 | Greengram | 55117.65 | 13583.38(24.64) | 2842.38(5.16) | 9115.05(16.54) | 35.69 |
| 1. 3.
 | Wheat | 80099.75 | 12742.28(15.91) | 4183.90(5.22) | 7808.05(9.75) | 31.57 |
| 1. 4.
 | Redgram | 77366.03 | 22124.25(28.60) | 5729.03(7.41) | 12230.75(15.81) | 30.51 |
| 1. 5.
 | Blackgram | 33937.67 | 11911.41 (35.10) | 1299.77(3.83) | 5476.56(16.14) | 29.31 |
| 1. 6.
 | Maize | 71439.45 | 15153.93(21.21) | 7020.675(9.83) | 8426.10(11.79) | 27.54 |
| 1. 7.
 | Sunflower | 52497.48 | 17992.03(34.27) | 1934.65(3.69) | 6148.15(11.71) | 23.58 |
| 1. 8.
 | Bengalgram | 46887.70 | 12286.05(26.20) | 5346.63(11.40) | 5311.98(11.33) | 23.15 |
| 1. 9.
 | Sugarcane | 121072.20 | 40686.05(33.60) | 4042.45(3.34) | 13310.35(10.99) | 22.93 |
| 1. 10.
 | Pearl millet | 40239.60 | 11932.14(29.65) | 3223.55(8.01) | 4324.78(10.75) | 22.20 |
| 1. 11.
 | Groundnut | 77048.20 | 23722.85(30.79) | 5117.80(6.64) | 7671.83(9.96) | 21.01 |
| 12. | Sorghum | 51634.40 | 17429.85(33.76) | 4489.80(8.70) | 5078.23(9.83) | 18.81 |
| 1. 13.
 | Finger millet | 48660.08 | 13637.23(28.03) | 4510.83(9.27) | 4034.5(8.29) | 18.18 |
| 1. 14.
 | Soyabean | 45118.70 | 13851.06 (30.70) | 2804.64(6.22) | 3469.89(7.69) | 17.24 |
| 1. 15.
 | Cotton | 81022.28 | 30298.20(37.39) | 5639.3(6.96) | 6968.75(8.60) | 16.24 |
| 1. 16.
 | Onion | 85806.75 | 28185.69(32.85) | 866.56(1.01) | 5400.79(6.29) | 15.68 |
| 1. 17.
 | Chilli | 45670.65 | 24121.21 (52.82) | 2016.30(4.41) | 4600.8(10.07) | 14.97 |

Note: Figures in parentheses indicate per cent to the cost of cultivation

The extent of mechanization varied from 14.97 to 41.81 per cent among the crops in the study area. It was highest for paddy (41.81 %). It was followed by green gram (35.69 %) and wheat (31.57 %). Mechanization was lowest for onion (15.68 %) and chilli (14.97 %). It was interesting to note that pulses also have the highest mechanization compared to other crops because handpicking in pulses is labour intensive and also requires skilled labour for harvesting, thus subjecting farmers to undertake mechanization. The percentage of machine cost in the total cost of cultivation is not uniform, it varies among different crops. The cost of machine labour to the total cost of cultivation was highest for paddy, which accounts for around 18 per cent of the total cost of cultivation, whereas it is around 6 per cent for onion. All the crops had less than 20 per cent of machine labour cost in the total cost of cultivation. So, there is scope to increase mechanization in different operations in the cultivation of these crops.

The operation-wise extent of mechanization in major crops of Karnataka during the year 2020-21 is presented in Table 4. The average mechanization index has been estimated for all the operations in which preparatory tillage, irrigation and harvesting or picking have the highest use of machine power as compared to other operations, i.e., 49.68, 42.82 and 41.32 per cent, respectively. The preparatory tillage has the highest extent of mechanization in the majority of the crops, as majorly equipment and machinery are used in land preparation. The results are also in line with the study conducted by Reddy *et al.* (2017), Gamlath *et al.* (2018) and Bhandari *et al.* (2023), where it was noticed that mechanization was highest for land preparation or ploughing or tillage operation. For irrigation, electric motors and pump sets have been used, whereas for harvesting use of combine harvesters can be seen in the study area. It was found that manuring and weeding were the least mechanized operations. Among the crops, the use of machine power was highest in paddy as compared to other crops. For instance, operations such as preparatory tillage, sowing, irrigation and threshing were highly mechanized. Also, harvesting operation was highly mechanized in wheat, paddy, red gram and green gram crops.

**Table 4: Operation-wise mechanization for major crops in Karnataka (2020-21)**

**(Per cent)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Operations/ Crops** | **Bengalgram** | **Blackgram** | **Chilli** | **Cotton** | **Finger millet** | **Greengram** | **Groundnut** | **Maize** | **Onion** |
| 1. | Preparatory tillage | 42.72 | 58.45 | 46.56 | 23.20 | 20.00 | 69.99 | 43.30 | 43.63 | 46.34 |
| 2. | Sowing/ planting / transplanting | 30.08 | 25.20 | 24.54 | 0 | 0 | 62.91 | 17.01 | 7.76 | 37.88 |
| 3. | Irrigation | 45.17 | 44.00 | 21.67 | 48.43 | 1.21 | 56.25 | 51.63 | 33.59 | 34.13 |
| 4. | Manuring | 0 | 0 | 3.34 | 0 | 0.02 | 0 | 1.53 | 0.63 | 2.14 |
| 5. | Plant protection | 6.39 | 7.67 | 6.00 | 1.55 | 8.72 | 11.08 | 27.56 | 33.9 | 4.66 |
| 6. | Interculture/ Weeding | 0 | 0.67 | 0 | 0 | 0 | 0.85 | 0.20 | 0 | 0 |
| 7. | Harvesting/ picking | 41.21 | 34.88 | 0 | 0 | 2.68 | 64.69 | 0.86 | 55.6 | 0 |
| 8. | Threshing/ winnowing | 40.61 | 35.45 | NA | NA  | 5.19 | 30.14 | 2.49 | 22.61 | NA |

Note: NA-Not Applicable

**Contd…**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Operations/ Crops** | **Paddy** | **Pearl millet** | **Redgram** | **Sorghum** | **Soyabean** | **Sugarcane** | **Sunflower** | **Wheat** | **Average** |
| 1. | Preparatory tillage | 80.21 | 55.12 | 67.61 | 58.88 | 46.77 | 56.00 | 41.03 | 44.76 | 49.68 |
| 2. | Sowing/ planting/ transplanting | 25.50 | 27.00 | 36.24 | 21.49 | 22.89 | 3.49 | 29.73 | 30.29 | 23.65 |
| 3. | Irrigation | 83.71 | 17.78 | 60.61 | 37.87 | 45.88 | 71.20 | 21.02 | 53.71 | 42.82 |
| 4. | Manuring | 4.03 | 1.34 | 0 | 0 | 4.00 | 1.14 | 0 | 0 | 2.02 |
| 5. | Plant protection | 74.10 | 6.77 | 40.41 | 7.83 | 8.00 | 75.47 | 22.46 | 24.45 | 21.59 |
| 6. | Interculture/ Weeding | 0 | 1.00 | 1.15 | 0 | 0.66 | 11.10 | 0 | 0 | 2.23 |
| 7. | Harvesting/ picking | 86.75 | 24.00 | 71.78 | 25.45 | 28.00 | 60.34 | 2.53 | 79.68 | 41.32 |
| 8. | Threshing/ winnowing | 30.33 | 22.00 | 17.46 | 22.63 | 30.00 | NA | 17.34 | 27.54 | 23.37 |

Note: NA-Not Applicable

**4. CONCLUSION:**

The study has examined the Growth rate analysis and revealed there was significant growth in mechanization in many of the zones, while the highest and significant growth was observed in the NETZ (6.73 %) and HZ (6.03 %) zones. Mechanization was highest for NEDZ (41.76 %) followed by NDZ (36.65 %) and STZ (28.80 %), and was lowest in CZ (16.18 %), NTZ (17.77 %) and SDZ (23.19 %) for the year 2020-21. There is an increasing trend in farm mechanization in Karnataka, with a 2.51 per cent¬ positive and significant growth rate and the extent of farm mechanization for the year 2020-21 stood at 26.87 per cent. The crops such as paddy, redgram and greengram have the highest growth in mechanization with 7.70, 6.88 and 6.76 per cent significant growth rates, respectively. The extent of mechanization varied from 14.97 to 41.81 per cent among the crops in the study area. It was highest for paddy (41.81 %) and green gram (35.69 %), whereas it was lowest for chilli (14.97 %). The cost of machine labour to the total cost of cultivation was highest for paddy, which accounts for around 18.67 per cent of the total cost of cultivation, whereas it is around 6.29 per cent for onion. The operation-wise extent of mechanization in major field crops was estimated, and it was found that more machine power was utilized in preparatory tillage (49 %), irrigation (41 %) and harvesting/picking (41 %) operations. Inter-zonal and inter-crop disparity in the adoption of farm mechanization is reported in this study, and this can be overcome by improving the availability of farm power and farm machinery and or equipment through expanding new custom hiring centres and developing suitable and affordable farm machinery and or equipment engineered to specific crop and regional characteristics.

**Disclaimer (Artificial intelligence)**

**Option 1:**

**Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.**

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**Details of the AI usage are given below:**

**1.**

**2.**

**3.**

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