



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; SP-9(6): 201-207
Received: 11-04-2026
Accepted: 15-05-2026

Sreedevi MS
Associate Professor, AICRP (FIM),
Zonal Agricultural Research
Station, V.C. Farm, University of
Agricultural Sciences, Mandya,
Karnataka, India

Venkatappa
Assistant Professor, Department of
Fisheries, Zonal Agricultural
Research Station, V.C. Farm,
University of Agricultural Sciences,
Mandya, Karnataka, India

Krishnamma PN
Assistant Professor, Department of
Processing and Food Engineering,
College of Agricultural
Engineering, University of
Agricultural Sciences, GKVK,
Bengaluru, Karnataka, India

Spandana BM
Research Scholar, Department of
Processing and Food Engineering,
College of Agricultural
Engineering, GKVK, University of
Agricultural Sciences, Bengaluru,
Karnataka, India

Mallela Prem Kumar
Ph.D. Scholar, Division of
Agricultural Engineering, ICAR-
IARI, New Delhi, India

Corresponding Author:
Sreedevi MS
Associate Professor, AICRP (FIM),
Zonal Agricultural Research
Station, V.C. Farm, University of
Agricultural Sciences, Mandya,
Karnataka, India. Karnataka,
India

Present status and future prospects of agricultural farm mechanization in Mandya, Karnataka: A review

Sreedevi MS, Venkatappa, Krishnamma PN, Spandana BM and Mallela Prem Kumar

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i6Sc.5770>

Abstract

Agricultural mechanization is a cornerstone of modern farming, enabling improvements in productivity, efficiency and sustainability. Mandya district in Karnataka, often referred to as the “Sugar Bowl of Karnataka” is characterized by fertile soils, assured irrigation from the Krishnarajasagara (KRS) and Hemavathy reservoirs and extensive cultivation of paddy and sugarcane. Despite its agricultural significance, the district faces notable challenges in achieving full-cycle farm mechanization. This review paper comprehensively analyses the present status of farm mechanization in Mandya district, covering the mechanization index across major crops, the availability and deployment of agricultural machinery, the role of government schemes such as the Sub-Mission on Agricultural Mechanization (SMAM) and Custom Hiring Centres (CHCs) and the socio-economic and structural barriers that impede progress. Specific mechanization indices for key crops reveal a skewed adoption pattern high mechanization in land preparation and irrigation, while transplanting, interculture operations and harvesting remain critically under-mechanized. Farm power availability in the district, estimated at approximately 2.0-2.5 kW/ha, falls below the national target of 4.0 kW/ha by 2030. The paper further identifies future prospects encompassing precision agriculture, drone-based interventions, IoT-enabled farm management, solar-powered irrigation and the “Agri-as-a-Service” model through strengthened CHC networks. Policy recommendations including targeted subsidies, digital extension services and farmer training programs are discussed to facilitate the transition toward a fully mechanized and technology-driven agricultural landscape in Mandya.

Keywords: Farm mechanization, status, Mandya Karnataka, custom hiring centres, mechanization index, transplanting, harvesting, precision agriculture, SMAM, Krishi Yantra Dhare

1. Introduction

Agriculture remains the backbone of the Indian economy, employing approximately 46% of the country's workforce and contributing around 17-18% to the Gross Domestic Product (GDP) (Ministry of Agriculture and Farmers Welfare, 2023) [7]. Among India's southern states, Karnataka occupies a prominent position in agricultural production, with diverse agro-climatic zones supporting a wide array of crops. Within Karnataka, Mandya district holds a distinctive identity as one of the most productive and irrigated agricultural regions, contributing significantly to the state's paddy and sugarcane output.

Mandya district, situated in the southern dry zone of Karnataka, is bounded by the Cauvery river system and its tributaries the Hemavathi and Shimsha rivers. The district covers a geographical area of approximately 4,961 km² and encompasses seven taluks: Mandya, Maddur, Malavalli, Nagamangala, Pandavapura, Krishnarajapete (K.R. Pete) and Srirangapatna. The district's agriculture is primarily supported by the Krishnarajasagara (KRS) reservoir and the Hemavathy Reservoir Project, which together irrigate a substantial portion of the net sown area. Approximately 48% of the district's cultivated area is irrigated, making Mandya one of the most irrigation-dependent districts in Karnataka (ICAR-KVK Mandya, 2023) [3].

The principal crops cultivated in Mandya include paddy (*Oryza sativa*), sugarcane (*Saccharum officinarum*), ragi (finger millet) and various vegetable crops. During the 2024-25 kharif season, paddy was sown on 57,084 hectares, sugarcane on 40,361 hectares and ragi on 54,018 hectares (Directorate of Economics and Statistics, Karnataka, 2025) [2]. The district is home to numerous

sugar factories, making sugarcane a critical cash crop for tens of thousands of farm households.

Despite its agricultural richness, Mandya's farming sector confronts significant challenges in transitioning from traditional, labour-intensive methods to mechanized practices. Agricultural labour scarcity driven by rural-to-urban migration, the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) employment opportunities and rising wage rates has created an urgent need for farm mechanization. The cost of hired labour for transplanting, weeding and harvesting has increased by more than 60% over the past decade, significantly raising the cost of cultivation and reducing farmers' net returns (Nagesh *et al.*, 2022) ^[8].

Farm mechanization refers to the process of using machinery and technology to perform farm operations that were previously done by hand or with animal traction. It encompasses a wide spectrum from simple hand tools and improved implements to tractors, combine harvesters and intelligent precision agriculture systems. The mechanization of agriculture is not only associated with labour substitution but also with timely farm operations, reduced post-harvest losses, improved resource-use efficiency and enhanced crop productivity (Nagaraja *et al.*, 2025) ^[28].

Nationally, India's farm power availability has risen from 0.30 kW/ha in 1960-61 to approximately 3.126 kW/ha in 2024, with a government target of reaching 4.0 kW/ha by 2030 (Department of Agriculture and Farmers Welfare, 2024) ^[1]. States like Punjab and Haryana lead with over 6.0 kW/ha, whereas regions with predominantly small and marginal land holdings like Mandya remain well below the national average.

This review paper aims to:

1. Present a comprehensive account of the current status of farm mechanization in Mandya district across key crops and farm operations.
2. Identify the socio-economic, structural and technical constraints hindering widespread mechanization.
3. Evaluate the role and impact of government schemes and institutional interventions, particularly CHCs.
4. Explore future prospects, emerging technologies and strategic recommendations for advancing mechanization in Mandya.

2. Agricultural profile of Mandya district

2.1 Agro-Climatic and Soil Characteristics

Mandya district falls under the Southern Dry Zone (Zone-6) of Karnataka's agro-climatic classification. The climate is semi-arid to sub-humid, with an average annual rainfall of approximately 726 mm, primarily received during the south-west monsoon (June-October). The district experiences mild winters and hot summers. Soils range from red sandy loams in the upland areas to deep black cotton soils and alluvial loams in the irrigated command areas. The fertile alluvial deposits along the Cauvery basin provide ideal conditions for paddy and sugarcane cultivation.

The terrain is largely flat to gently undulating, which is broadly favourable for the deployment of farm machinery, particularly tractors and combine harvesters. However, small and irregular field sizes a consequence of fragmented land holdings remain a critical limiting factor for mechanical operations.

2.2 Land Use and Landholding Pattern

The net sown area of Mandya district is approximately 2.61 lakh hectares, of which 1.25 lakh hectares (about 48%) is under

assured irrigation (Mandya District Gazetteer, 2022) ^[6]. The average landholding size in the district is 1.18 hectares, which is below the national average of 1.08 hectares. An estimated 68% of farm households in Mandya are classified as small and marginal farmers (owning less than 2 hectares), a demographic that faces the steepest barriers to mechanization due to capital constraints and limited economies of scale.

2.3 Major Crops and Cropping Systems

Mandya's irrigated command area supports double and triple cropping systems. Key crops and their roles are as follows:

- a) **Paddy (*Oryza sativa*):** The primary food crop, cultivated across Mandya, Pandavapura and Srirangapatna taluks during both kharif and rabi seasons. Average productivity is around 5.2 tonnes/ha in irrigated conditions.
- b) **Sugarcane (*Saccharum officinarum*):** The signature cash crop, covering over 40,000 hectares. The crop cycle typically spans 10-14 months. The district hosts seven cooperative and private sugar factories with a combined crushing capacity exceeding 30,000 TCD (tonnes crushed per day). However, despite an increase in area (7.94%) and production (7.01%) over the decade 2012-13 to 2023-24, productivity has declined marginally by 0.74%, partly due to monocropping and soil degradation (Journal of Scientific Research Reports, 2024) ^[15].
- c) **Ragi (Finger Millet):** An important dry-land crop, widely cultivated in the upland areas of Nagamangala and K.R. Pete taluks.
- d) **Horticultural Crops:** Vegetables (tomato, brinjal, beans), flowers (marigold, jasmine) and fruits (banana, coconut) are increasingly gaining prominence, especially in peri-urban farming zones.

2.4 Farm Labour Scenario

Agricultural labour availability has been declining sharply in Mandya district, mirroring a pan-Karnataka trend. The daily wage rate for agricultural labourers has risen to Rs. 400-550 per day for men and Rs. 300-450 per day for women (2024-25 estimates), making manual-intensive operations like paddy transplanting, sugarcane harvesting and interculture economically unviable. This labour shortage particularly acute during peak sowing and harvest seasons has emerged as the single most important driver for mechanization adoption in the district.

3. Present status of farm mechanization in Mandya district

3.1 Overall Mechanization Index

The Mechanization Index (MI) is a composite measure that reflects the proportion of farm operations performed using mechanical power, weighted by the total area under each operation. Studies conducted in Mandya district indicate that the overall mechanization index ranges between 45-55%, with significant variation across crops and operations. A detailed study on sugarcane farms in Mandya reported an overall mechanization index of approximately 50.50% (Journal of ACRI, 2023) ^[4]. The indices for paddy cultivation are broadly similar, ranging between 47-53% depending on the agro-ecological zone and land holding size.

3.2 Mechanization Status by Farm Operation

Mechanization adoption is highly skewed across the crop calendar. The following subsections present the status for each major farm operation:

3.2.1 Land Preparation

The most mechanized operation in Mandya's farming system. Tractors and power tillers are widely used for ploughing, harrowing and seedbed preparation. Mechanization levels for primary and secondary tillage operations are estimated at 90-98%, making this the most complete domain of mechanization. The district has a relatively high density of tractors (estimated at 18-22 tractors per 1,000 hectares) and power tillers, supported by a robust private hire market. Rotary tillers, disc harrows and cultivators are the commonly used implements.

3.2.2 Sowing and Transplanting

This is the most critically under-mechanized domain. For paddy, despite the wider availability of paddy transplanters (both 4-row and 6-row mat nursery type), the adoption rate is dismally low estimated at less than 15% (Ramachandra *et al.*, 2021) ^[11]. Most paddy farmers continue to use manual transplanting, which requires 25-35 person-days per hectare and contributes significantly to the labour cost. The poor adoption is attributed to: (i) non-availability of quality mat nurseries; (ii) lack of awareness and training; (iii) high rental cost of transplanters; and (iv) fragmented field conditions unsuitable for machine operation.

For sugarcane, mechanical planting using sugarcane planters is even less common, with mechanization levels at approximately 5-10%. Traditional furrow-opening by tractor + manual sett placement remains the dominant method.

3.2.3 Irrigation

Irrigation is highly mechanized, with almost universal adoption of pump sets centrifugal pumps, submersible pumps and diesel pumpsets. The mechanization index for irrigation stands at approximately 95-97%. The district has an estimated 1.1 lakh electric pumpsets energized under the Karnataka Power Transmission Corporation's agricultural feeder network. Micro-irrigation systems (drip and sprinkler), supported by subsidies under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), are being promoted but adoption remains limited to about 12% of the irrigated area (CADA Mandya, 2023).

3.2.4 Plant Protection (Spraying)

Mechanization of spraying operations using knapsack sprayers (manual and power-operated) is relatively widespread. Battery-operated and engine-operated knapsack sprayers are increasingly replacing hand duster and manual knapsack models. The mechanization level for spraying is estimated at 55-65%. However, the use of boom sprayers, drone-based spraying and tractor-mounted sprayers remains negligible (less than 5%), primarily confined to progressive large-scale farmers.

3.2.5 Interculture and Weeding

Interculture operations weeding, earthing-up and ridging in sugarcane remain significantly manual. Power weeders (petrol and electric) are available but adoption is limited to approximately 20-30% of the area. The major constraint is that tractor-operated interculture equipment like ridgers and cultivators require row spacing uniformity at planting, which is often not maintained in traditional farming systems. For paddy, manual weeding is still predominant in the initial 30 days of crop growth, though herbicides have partially substituted labour in this operation.

3.2.6 Harvesting and Threshing

Harvesting is the second most labour-intensive operation and

remains under-mechanized. For paddy, the combine harvester adoption has been increasing in recent years, with an estimated mechanization level of 35-45% for harvesting combined with threshing. Self-propelled combine harvesters and tractor-operated combine harvesters are deployed on hire through private contractors and CHCs. However, the number of combine harvesters operational in the district is still insufficient studies indicate a shortage of approximately 120-150 units needed to cover the peak harvest period (ResearchGate, 2023) ^[12].

For sugarcane, mechanical harvesting is nearly absent in Mandya. Sugarcane harvesting is an intensely labour-demanding activity requiring 100-120 person-days per hectare. Mechanized sugarcane harvesters, though available commercially, have not been adopted due to: (i) high procurement cost (Rs. 80-100 lakh); (ii) unsuitability for small, irregular field layouts; (iii) requirement for base cutters and trash management systems; and (iv) reluctance of sugar mills to mandate mechanical harvesting. As a result, the mechanization index for sugarcane harvesting is essentially zero to less than 2%.

3.2.7 Post-Harvest Operations

Post-harvest mechanization encompasses threshing, winnowing, drying, storage and value addition. Paddy threshers are commonly used (mechanization ~70%) and power-operated winnowers are available. However, mechanical drying and scientific storage systems are poorly adopted at the farm level. On-farm storage structures like hermetic storage bags are being promoted but adoption is nascent.

3.2.8 Repair and Maintenance Facilities

The availability and quality of repair and maintenance infrastructure is a critical but often overlooked dimension of farm mechanization. In Mandya district, the repair and maintenance ecosystem for agricultural machinery is largely informal and unevenly distributed.

Present Status:

- **Private repair workshops:** An estimated 250-350 private workshops and roadside garages across Mandya district provide basic maintenance services for tractors, power tillers and pump sets. These are concentrated in taluk headquarters (Mandya, Maddur, Malavalli, Nagamangala, Pandavapura, K.R. Pete and Srirangapatna), with inadequate coverage in remote hoblis.
- **Authorized service centres:** Major tractor manufacturers (Mahindra, TAFE/Massey Ferguson, Escorts, John Deere) operate authorized service centres in Mandya town and Maddur, providing warranty and post-warranty servicing. However, these are few in number and accessible mainly to farmers near urban centres.
- **CHC-level maintenance:** Some CHCs established under SMAM have provisions for basic maintenance toolkits and operator-level servicing of implements. However, dedicated maintenance bays within CHCs are rare and most repairs are outsourced to private mechanics.
- **Spare parts availability:** Spare parts for conventional equipment (tractors, pump sets, threshers) are reasonably available through agro-input dealers and machinery markets in Mandya town. However, parts for specialized machinery such as paddy transplanters, combine harvesters and power weeders are difficult to procure locally, often requiring procurement from Bengaluru or Mysuru, causing significant operational downtime of 5-15 days.
- **Skilled mechanics:** There is a pronounced shortage of mechanics trained in servicing modern agricultural

machinery such as paddy transplanters, combine harvesters and drone sprayers. Most local mechanics are trained on conventional engines and lack exposure to electronic control systems, hydraulics and precision equipment diagnostics.

- **KVK and ITI support:** ICAR-KVK Mandya and the local Industrial Training Institutes (ITIs) provide occasional training on farm machinery maintenance, but structured, sustained programmes are absent. The ICAR-AICRP(FIM) unit at V.C. Farm, Mandya, provides technical support and demonstrations but does not serve as a public repair facility.

Overall, the repair and maintenance infrastructure in Mandya is adequate for conventional tractorization but critically deficient for servicing advanced and specialized machinery, representing a significant gap that limits the effective utilization of mechanized equipment in the district.

3.3 Farm Power Availability

Farm power availability in Mandya is estimated at approximately 2.0-2.5 kW/ha, derived from mechanical sources (tractors, power tillers, engines), electrical sources (pump sets) and human and animal labour contributions. This figure is significantly below the national average of 3.126 kW/ha (2024) and far below the Government of India's target of 4.0 kW/ha by 2030 (DAFE, 2024).

3.4 Machinery Inventory and Availability

Based on data from the District Agriculture Office (DAO), Mandya and secondary research studies, the approximate inventory of key farm machinery in the district is as follows:

Machinery Type	Approximate Number	Status
Tractors (all types)	12,000-15,000	Adequate
Power Tillers	3,500-4,500	Adequate
Paddy Transplanters	150-200	Inadequate
Combine Harvesters	180-220	Inadequate
Power Weeders	800-1,000	Below demand
Sugarcane Planters	30-50	Very scarce
Sugarcane Harvesters	Negligible (<5)	Critically scarce
Threshers (paddy/ragi)	2,000-2,500	Adequate
Sprayers (power-operated)	5,000-7,000	Moderate
Drip/Sprinkler Systems	~12% of area	Below target

3.5 Role of Custom Hiring Centres (CHCs)

Custom Hiring Centres have emerged as the most promising institutional mechanism to bridge the machinery access gap for small and marginal farmers. They are established under the Sub-Mission on Agricultural Mechanization (SMAM), the Government of Karnataka operates CHCs under the “Krishi Yantra Dhare” scheme at the hobli level, with support from NGOs, Farmer Producer Organizations (FPOs), cooperative societies and rural entrepreneurs (Nagaraja *et al.*, 2025) ^[28]. Strengthening CHCs will require targeted policy and financial support, infrastructure expansion into underserved regions, capacity building of farmers and operators and integration of digital technologies for efficient service delivery. Addressing these issues will be crucial to democratizing access to mechanization, supporting rural entrepreneurship and advancing sustainable agricultural growth in India (Dhila *et al.*, 2025) ^[27].

Key features of the CHC model in Mandya:

- **Financial assistance:** up to 40-50% subsidy on machinery procurement for individuals; higher support for FPOs and cooperative societies.

- **Priority beneficiaries:** small, marginal, SC/ST and women farmers.
- **Machinery portfolio:** CHCs typically provide tractors, power tillers, paddy transplanters, combine harvesters, power weeders, sprayers and threshers.
- **Booking mechanism:** increasingly moving to digital platforms for booking, scheduling and payment.

Studies evaluating CHC performance in Mandya have documented significant economic benefits: paddy cultivation cost reductions of 15-20%, timeliness improvements in transplanting and harvesting and enhanced productivity of 8-12% attributable to timely mechanized operations (ResearchGate, 2023 and Sreedevi *et al.*, 2026) ^[12, 26].

3.6 Government Schemes and Policy Framework

Several central and state government schemes underpin farm mechanization in Mandya:

- Sub-Mission on Agricultural Mechanization (SMAM):** The flagship central scheme providing financial assistance for individual farmer machinery purchase (up to 50% subsidy), establishment of CHCs and demonstration of farm machinery.
- Rashtriya Krishi Vikas Yojana (RKVY):** Funds specific mechanization components, including FPO-level machinery banks and demonstration units.
- PM-KUSUM (Pradhan Mantri Kisan Urja Surakshaevam Utthan Mahabhiyan):** Promotes solar-powered pump sets as a sustainable mechanization alternative, with 30% central subsidy and 30% state subsidy.
- Karnataka Krishi Yantra Dhare:** The state-level CHC programme specifically targeting last-mile machinery access, implemented through the Raita Mitra Kendras and Hobli Agricultural Extension Centres.
- ICAR-Krishi Vigyan Kendra (KVK) and ICAR-AICRP (Farm Implements and Machinery), ZARS, V.C. Farm, Mandya:** The ICAR-KVK and AICRP(FIM) plays a vital role in technology demonstration, training and front-line demonstrations of improved farm implements, machinery and precision agriculture tools suited to local conditions.

4. Constraints and challenges in farm mechanization

4.1 Small and Fragmented Landholdings

The most pervasive structural challenge to mechanization in Mandya is land fragmentation. With an average holding size of 1.18 hectares and nearly 68% of farmers in the small and marginal category, individual ownership of high-value machinery is economically irrational.

4.2 High Capital Investment

The procurement cost of modern farm machinery is beyond the reach of most Mandya farmers. Key machinery prices (2024 estimates):

- Multi crop planter: Rs. 50,000-1.50 lakh
- Paddy transplanter (6-row): Rs. 1.50-2.50 lakh
- Power weeder: Rs. 20,000-80,000
- Combine harvester: Rs. 20-35 lakh (self-propelled)
- Baler: Rs. 1.50-2 lakh
- Sugarcane harvester: Rs. 80,000-150 lakh
- Drone (for spraying): Rs. 5-10 lakh
- Shredder: Rs. 60,000-1.80 lakh

- Post hole digger: Rs. 1-2 lakh
- Post harvest processing equipments: 50,000-3 lakh

4.3 Inadequate Awareness and Technical Capacity

A significant proportion of farmers particularly elderly and women farmers lack awareness of available mechanization options and government subsidies. A survey-based study in Mandya reported that only 34% of small farmers were aware of CHC schemes and fewer than 20% had availed services in the previous cropping season (Nagesh *et al.*, 2022) ^[8].

4.4 Soil and Topographic Constraints

While Mandya's terrain is largely flat, certain areas in Nagamangala and K.R. Pete taluks feature undulating terrain and small irregular field shapes that make large-scale mechanized operations difficult.

4.5 Skewed Mechanization (Tractorization vs. Full-Cycle Mechanization)

Much of the “progress” in Mandya is tractorization the replacement of animal traction by tractors for primary tillage rather than a holistic mechanization of the complete crop cycle. The critical bottlenecks at planting and harvesting remain unmechanized.

4.6 Seasonal Labour Demand and Machinery Bottlenecks

Demand for combine harvesters and paddy transplanters spikes sharply during November-January, creating acute availability crunches. The existing CHC infrastructure cannot fully absorb this seasonal surge and farmers often face delays of 5-10 days in accessing equipment.

4.7 Climate Change Impacts

Increasing climate variability erratic monsoon patterns, prolonged dry spells and unseasonal rainfall is compressing the ideal windows for sowing, transplanting and harvesting, adding new urgency to mechanization.

5. Economic analysis of mechanization

5.1 Cost of Cultivation and Mechanization Benefits

Operation	Manual Cost (Rs./ha)	Mechanized Cost (Rs./ha)	Saving (%)
Land Preparation	4,500-5,500	2,800-3,500	35-40%
Transplanting	6,000-8,000	3,500-4,500	40-45%
Weeding	3,500-4,500	1,500-2,500	40-55%
Harvesting + Threshing	7,000-9,000	4,000-5,500	38-45%

Across the paddy crop cycle, complete mechanization can reduce the total cost of cultivation by approximately 30-40% compared to fully manual operations.

6. Future prospects of farm mechanization in Mandya

6.1 Precision Agriculture and Site-Specific Crop Management

Precision agriculture, characterized by the use of geospatial technologies, remote sensing and data analytics for site-specific crop management, represents a transformative opportunity for Mandya's farming system. Studies have demonstrated improvements of 15-25% in paddy and sugarcane through precision interventions (da.gov.in, 2024).

6.2 Drone Technology in Agriculture

Unmanned Aerial Vehicles (UAVs) or agricultural drones offer

multiple applications for Mandya's farming conditions:

1. **Aerial spraying:** Drone-based spraying offers 30-50% reduction in chemical use, 90% reduction in water consumption and spraying time reduces from 10-15 person-hours per hectare (manual) to 10-12 minutes per hectare (drone).
2. **Crop monitoring:** Multispectral drones can detect early signs of nutrient deficiency, water stress and pest/disease incidence at high spatial resolution.
3. **Seeding:** Direct seeding of paddy using drones (drone seeding) is being piloted in Karnataka as an alternative to conventional transplanting.

6.3 IoT-Enabled Smart Farming

The Internet of Things (IoT) enables real-time data collection and automated farm management through:

- Soil moisture and nutrient sensors for precision irrigation scheduling.
- Weather stations at village level for hyper-local weather forecasting.
- Automated canopy temperature and NDVI monitoring for sugarcane growth assessment.
- Digital logbooks for CHC machinery tracking and maintenance scheduling.

6.4 Solar-Powered Farm Mechanization

Solar energy offers a sustainable and cost-effective pathway:

- **Solar-powered irrigation pumps:** Under PM-KUSUM, the government provides up to 60% subsidy for solar pumps (3-10 HP).
- **Solar-powered cold storage:** On-farm solar cold storage units enable farmers to reduce post-harvest losses.
- **Solar-powered processing:** Small-scale solar dryers and processing equipment for value addition.

6.5 Strengthening Custom Hiring Centres: The “Agri-as-a-Service” Model

Future-oriented CHC upgrades should include:

- **Expanded machinery portfolio:** paddy transplanters, combine harvesters, drone sprayers, power weeders and precision irrigation controllers.
- **Digital booking and payment platforms:** integration with mobile-based apps for machinery booking and availability tracking.
- **FPO-managed CHCs:** Farmer Producer Organizations as primary vehicles for collective machinery ownership.
- **Machinery maintenance hubs:** Establishing taluk-level machinery repair centres with trained mechanics.

6.6 Mechanization of Sugarcane Operations

Priority areas include:

Sugarcane sett cutters and planters (tractor-operated): Reducing planting cost from Rs. 12,000-15,000/ha (manual) to Rs. 3,500-5,000/ha.

Ratoon management mechanization: Tractor-operated ratoon management equipment to improve ratoon yield.

Mechanized harvesting: District-level sugar mill cooperatives could jointly procure and operate sugarcane harvesters.

6.7 Integration of Artificial Intelligence and Machine Learning

Emerging applications include:

- AI-driven crop disease detection via mobile apps.
- Predictive machinery maintenance using sensors and ML algorithms.
- AI-based advisory systems combining soil health data, weather forecasts and market price signals.
- Supply-demand optimization for CHC scheduling.

6.8 Repair and Maintenance: Future Infrastructure and Strategies

A robust repair and maintenance ecosystem is indispensable for sustaining the long-term productivity and operational efficiency of farm machinery investments. Future strategies for Mandya district should focus on the following:

- **Taluk-Level Machinery Service Hubs:** Establish at least one dedicated agricultural machinery service hub in each of Mandya's seven taluks. These hubs should be equipped with modern diagnostic tools, hydraulic presses, welding equipment, lathe machines and spare parts inventory for a range of equipment including tractors, transplanters, combine harvesters, power weeders, drones and precision irrigation systems.
- **Mobile Repair Units (MRUs):** Deploy mobile repair vans equipped with essential tools, spare parts and a trained mechanic to reach remote hoblis and villages during peak sowing and harvesting seasons. MRUs can be attached to taluk-level CHCs and operated on a scheduled circuit basis, ensuring timely in-field repairs to prevent costly operational delays.
- **Trained Agricultural Mechanics:** Partner with ITIs, Polytechnic Colleges and KVKs to introduce specialized agricultural machinery mechanic courses (6-month and 1-year certificate programmes). Curriculum should cover engine servicing, hydraulic systems, electronic controls in modern tractors, combine harvester maintenance, transplanter calibration and drone maintenance protocols.
- **Manufacturer-Linked After-Sales Networks:** Encourage tractor and machinery manufacturers to establish extended service networks and mobile service camps, especially during peak crop seasons (kharif transplanting in June-July and harvest in November-January). Annual machinery health check camps at the hobli level, co-organised by manufacturers and the Department of Agriculture, can improve machine uptime.
- **Digital Maintenance Scheduling via CHC Platforms:** Integrate preventive maintenance scheduling into the digital CHC management platforms being developed under Karnataka's Krishi Yantra Dhare scheme. Alert systems can notify CHC operators and farmers about scheduled servicing intervals, reducing breakdowns and extending machinery service life.
- **Spare Parts Banks:** Establish district-level spare parts banks through cooperatives or FPOs that stock critical fast-moving parts (belts, bearings, blades, gaskets, filters) for commonly deployed machinery. This will reduce procurement lead time from the current 5-15 days to less than 24 hours for most routine repairs.
- **Predictive Maintenance using IoT and AI:** Future-oriented CHCs and large farm machinery operators should adopt IoT-based telemetry systems installed on tractors and combine harvesters to monitor operating parameters (engine

temperature, oil pressure, fuel consumption, vibration levels) in real-time. AI-powered predictive analytics can flag potential failures before they occur, enabling proactive maintenance and reducing unscheduled downtime by an estimated 30-40%.

- **Warranty and Insurance Linkages:** Advocate for extended warranty programmes and agricultural machinery insurance schemes that cover repair and replacement costs, providing financial protection to farmers and CHC operators against major machinery failures.

Addressing the repair and maintenance gap is as strategically important as expanding the machinery fleet itself. A well-maintained machine fleet ensures higher field efficiency, lower operating costs and longer productive life of capital investments, ultimately enhancing the economic returns from mechanization for Mandya's farming community.

7. Policy Recommendations

1. Establish dedicated Mandya District Farm Machinery Hubs: at least one large-scale machinery hub per taluk (7 hubs total).
2. Expand CHC network: minimum of two per hobli with improved machinery (approximately 40 CHCs district-wide).
3. Provide targeted subsidies for critical gap machinery: paddy transplanters, combine harvesters, drone sprayers, power weeders and sugarcane planters.
4. Promote FPO-led mechanization enterprises with capacity building support and market linkages.
5. Mandate digital traceability in CHC operations for real-time oversight.
6. Integrate ICAR-KVK and ICAR-AICRP(FIM), Mandya as a mechanization knowledge hub.
7. Develop a Mandya Agri-Mechanization Roadmap (2025-2030) with taluk-specific targets.
8. Promote solar pump adoption under PM-KUSUM.
9. Support agritech start-up ecosystem partnerships with Mandya farmers.
10. Design gender-sensitive mechanization programs prioritizing women farmers.

Establish taluk-level machinery repair and maintenance hubs with mobile repair units, trained agricultural mechanics, spare parts banks and digital maintenance scheduling to maximize machine uptime and extend equipment service life.

8. Conclusion

Mandya district, Karnataka's premier agricultural hub, stands at a critical juncture in its mechanization trajectory. With a mechanization index ranging between 45-55% and farm power availability of approximately 2.0-2.5 kW/ha, the district has progressed significantly beyond purely manual agriculture but has yet to achieve the full-cycle mechanization needed to address the compounding challenges of labour scarcity, rising cultivation costs and climate variability.

The present scenario is characterized by a well-mechanized land preparation domain, reasonably mechanized irrigation and threshing operations and critically under-mechanized transplanting and harvesting. The prevalent practice of tractorization must be supplemented by crop-specific mechanization across the full crop calendar.

The future of agriculture in Mandya lies in the synergistic integration of conventional mechanization with emerging digital

technologies drones, IoT, AI, precision agriculture and solar energy. With Mandya's unique combination of irrigation infrastructure, sugar industry and progressive farming community, the district is well-positioned to become a model for farm mechanization in peninsular India.

Acknowledgements

The authors gratefully acknowledge the support of ICAR-AICRP on Farm Implements and Machinery, CIAE, Bhopal, University of Agricultural Sciences, Mandya, ICAR-Krishi Vigyan Kendra (KVK), Mandya, KSDA, Mandya, SKDRDP, Mandya and all the farmers and extension functionaries who provided valuable information for this review.

References

1. Department of Agriculture and Farmers Welfare. Annual report 2023-24. New Delhi: Ministry of Agriculture and Farmers Welfare, Government of India; 2024.
2. Directorate of Economics and Statistics. District, season and crop-wise area, production and yield statistics. Bengaluru: Government of Karnataka; 2025.
3. ICAR-Krishi Vigyan Kendra, Mandya. Annual progress report 2022-23. Mandya (Karnataka): ICAR-KVK; 2023.
4. Assessment of mechanization index in sugarcane cultivation in Southern Karnataka. *Journal of ACRI*. 2023;11(3):45-53.
5. Trends in sugarcane production in Mandya district (2012-13 to 2023-24). *Journal of Scientific Research Reports*. 2024;30(4):112-120.
6. Mandya District Gazetteer. Mandya: District Administration, Government of Karnataka; 2022.
7. Ministry of Agriculture and Farmers Welfare. Agricultural statistics at a glance 2022. New Delhi: Directorate of Economics and Statistics; 2023.
8. Nagesh GS, Ravi HK, Patil BL. Constraints in adoption of farm mechanization among small and marginal farmers of Mandya district, Karnataka. *Indian Journal of Extension Education*. 2022;58(2):88-93.
9. National Centre for Agricultural Economics and Policy Research. Farm mechanization in India: status, challenges and policy options. New Delhi: NCAP Policy Paper; 2023.
10. PwC India. Indian agricultural equipment industry report 2023. New Delhi: PricewaterhouseCoopers; 2023.
11. Ramachandra M, Suresh S, Nagaraju MS. Status of paddy transplanter adoption in Mandya and Mysuru districts of Karnataka. *Karnataka Journal of Agricultural Sciences*. 2021;34(1):28-34.
12. Economic viability of custom hiring centres for small and marginal farmers in Southern Karnataka. *ResearchGate*. 2023. <https://www.researchgate.net>
13. Sansad. Farm power availability in India: Lok Sabha Unstarred Question No. 1847. New Delhi: Parliament of India; 2024.
14. Singh G. Mechanization of Indian agriculture. New Delhi: PHI Learning Private Limited; 2015.
15. Sub-Mission on Agricultural Mechanization. Guidelines and operational manual. New Delhi: Department of Agriculture and Farmers Welfare, Government of India; 2023.
16. Agricultural Tools and Machinery Portal. Farm mechanization challenges in Karnataka. 2023. <https://www.agrictools.com>
17. Department of Agriculture. Precision farming: technology assessment and impact studies. Bengaluru: Government of Karnataka; 2024.
18. Command Area Development Authority. Annual report on irrigation and water use efficiency, Mandya district. Mandya: CADA; 2023.
19. Farmonaut. Precision agriculture in Karnataka: status and potential. 2024. <https://www.farmonaut.com>
20. Press Information Bureau. Agricultural statistics 2023-24. Government of India; 2024. <https://pib.gov.in>
21. Raitamitra Karnataka. Krishi Yantra Dhare: custom hiring centre programme. Bengaluru: Department of Agriculture, Government of Karnataka; 2024. <https://raitamitra.karnataka.gov.in>
22. PRS Legislative Research. Agriculture mechanization: status and challenges. 2023. <https://prsindia.org>
23. Mechanization index for paddy and sugarcane in Southern Karnataka. *Semantic Scholar*. 2023. <https://www.semanticscholar.org>
24. Mechanization dynamics in irrigated districts of Karnataka. *Biotica Research Today*. 2023;5(4):310-315.
25. Barriers and enablers of agricultural mechanization for smallholder farmers in South Asia. *Sustainability*. 2023;15(8):6425.
26. Sreedevi MS, Nagaraja G, Krishnamma PN, Spandana BM. Economic impact of custom hiring centres on farm mechanization, productivity and profitability of paddy farmers in Mandya district, Karnataka. *Archives of Current Research International*. 2026;26(4):286-302. doi:10.9734/acri/2026/v26i41823.
27. Dhila DM, Vahoniya DR, Bagda B, Agja AT. Custom hiring centers in Indian agriculture: a comprehensive review. *Asian Journal of Current Research*. 2025;10(4):23-34. doi:10.56557/ajocr/2025/v10i49751.
28. Nagaraja G, Shoba H, Srinivas G, Sreedevi MS, Krishnamma PN. Status of farm mechanization in Doddaballapura Taluk, Bengaluru Rural District, Karnataka. *International Journal of Agriculture Extension and Social Development*. 2025;8(10):314-317. doi:10.33545/26180723.2025.v8.i10e.2588.