

INTEGRATING ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE DEVELOPMENT OF SUGARCANE MARKETING SYSTEMS IN KARNATAKA

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ABSTRACT

The sugarcane sector plays a vital role in Karnataka's agrarian economy, yet its marketing systems face persistent challenges such as price volatility, supply-chain inefficiencies, delayed payments, market information asymmetry, and sustainability concerns. This study examines the potential of integrating Artificial Intelligence (AI) to enhance the sustainable development of sugarcane marketing systems in Karnataka. The research explores how AI-based tools-such as predictive analytics, demand forecasting, smart logistics, digital market platforms, and real-time price intelligence-can improve market efficiency, transparency, and farmer income stability. Using field-level observations, stakeholder analysis, and secondary data evaluation, the study assesses current marketing constraints and evaluates AI-driven solutions for optimizing procurement, transportation, storage, and mill operations. The findings suggest that AI integration can reduce market uncertainties, improve decision-making, enhance value-chain coordination, and support environmentally and economically sustainable marketing practices. However, successful adoption depends on digital infrastructure development, farmer awareness, policy support, and institutional coordination. The study concludes that AI-enabled marketing reforms can significantly strengthen sugarcane value chains and contribute to inclusive and sustainable agricultural development in Karnataka.

KEYWORDS: Artificial Intelligence (AI), Sugarcane Marketing, Sustainable Development, Smart Supply Chain, Karnataka.

Introduction

Sugarcane is one of the most significant commercial crops in Karnataka, contributing substantially to rural employment, agro-industrial growth, and regional economic development. The crop supports a wide network of stakeholders, including farmers, sugar mills, transporters, traders, cooperatives, and allied industries producing sugar, ethanol, jaggery, and other by-products.

Despite its economic importance, sugarcane marketing systems continue to face persistent challenges such as price fluctuations, delayed payments to farmers, inefficiencies in procurement and transportation, limited market transparency, and weak coordination across the value chain. These issues often reduce farmer profitability and hinder sustainable sectoral growth. In recent years, the agricultural sector has begun transitioning toward digital and technology-driven systems aimed at improving productivity, transparency,

and sustainability.

Among emerging technologies, Artificial Intelligence (AI) offers significant potential to transform agricultural marketing systems through data-driven decision-making, demand forecasting, supply-chain optimization, and digital market integration. AI-enabled platforms can provide real-time market information, optimize logistics, predict price trends, and improve procurement planning, thereby enhancing market efficiency and reducing uncertainties for farmers and processors.

The concept of sustainable development in agricultural marketing extends beyond economic gains to include environmental responsibility and social equity. Sustainable sugarcane marketing systems must ensure fair price realization for farmers, efficient resource use, reduced post-harvest losses, and stable market linkages while also addressing climate and environmental concerns. Integrating AI technologies into marketing operations can support these goals by

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enabling smarter planning, reducing waste, and strengthening coordination among stakeholders.

In Karnataka, where sugarcane cultivation is concentrated in both irrigated and semi-arid regions, marketing inefficiencies and sustainability concerns remain critical policy and research issues. The adoption of AI-driven solutions in procurement, price intelligence, logistics management, and digital market platforms presents opportunities to modernize existing systems and improve farmer welfare. However, successful integration requires supportive infrastructure, institutional reforms, farmer awareness, and policy support.

This study aims to examine how Artificial Intelligence can be integrated into sugarcane marketing systems to promote sustainable development in Karnataka. It explores current marketing challenges, evaluates AI-based solutions, and assesses their potential to improve transparency, efficiency, and long-term sustainability within the sugarcane value chain. The research ultimately seeks to contribute to policy discussions and practical strategies for creating a more resilient and farmer-centric marketing system.

Objectives

- To analyse the existing structure and challenges of sugarcane marketing systems in Karnataka.
- To assess the potential role of AI technologies in improving market information, pricing, and supply-chain coordination.
- To examine the role of digital platforms in reducing intermediaries and improving direct market access.
- To propose a sustainable and technology-driven model for sugarcane marketing reforms.

The Karnataka Scenario in Sugarcane Production

Karnataka is one of the leading sugarcane-producing regions of India, with cultivation spread across nearly 5 to 8 lakh hectares. The crop plays a crucial role in supporting the country's sugar industry, with 76 sugar factories operating in the state as of 2023 and providing employment to thousands of people. Sugarcane cultivation is widespread due to favourable agro-climatic conditions and well-developed irrigation facilities, making the state a significant contributor to sugar production and exports of sugar-based products. Sugarcane farming serves as a major livelihood source for millions of farmers.

Nationally, the state ranks third in sugarcane production after Uttar Pradesh and Maharashtra, and it stands second in sugar recovery efficiency

after Maharashtra. Sugarcane cultivation is spread across 16 districts, with major producing areas including Belagavi, Bagalkot, Vijayapura, Mandya, Mysuru, Chamarajanagar, and Bidar, which together form the core sugarcane belt of the state.

Below Table shows Sugarcane production districts and district-wise working sugar industry, (2023-24):

SL NO	DISTRICTS	WORKING SUGAR INDUSTRY
1	Belagavi	28
2	Bagalkot	13
3	Vijaypur	09
4	Gadag	01
5	Haveri	02
6	Uttar Kannada	01
7	Dhavanagere	01
8	Ballari	01
9	Vijaynagar	02
10	Bidhar	05
11	Kalburgi	04
12	Yadagiri	01
13	Chamarajnagar	01
14	Hasan	01
15	Mandy	05
16	Mysore	01
	Total	76

Source: S. Nijalingappa Sugar Institute, Belagavi

The district-wise distribution of working sugar industries clearly indicates that sugar factories are the most important and reliable markets for sugarcane farmers in Karnataka. With a total of 76 operational sugar industries during 2023-24, these factories form the backbone of the sugarcane marketing system in the state by directly procuring cane from farmers through regulated supply arrangements. Districts such as Belagavi, Bagalkot, and Vijayapura emerge as the primary sugarcane markets, as they host the highest concentration of sugar industries. Belagavi alone accounts for 28 sugar factories, making it the most significant sugarcane procurement hub in the state.

The high density of mills in these districts reduces transportation costs, ensures timely cane crushing, and provides assured markets, which stabilizes farm income and minimizes post-harvest losses. The sugar factory-centered marketing system is central to sugarcane farmers' livelihoods in Karnataka. The concentration of mills determines market accessibility, price realization, and income security for farmers,

highlighting the critical role of sugar industries as the major institutional markets within the state's sugarcane value chain.

Sugarcane Area, Production and Productivity in Karnataka during 2019-20 to 2023-24

Year	Area (in lakh ha)	Sugarcane Production (in MT)	Productivity (Yield in Tonnes)
2019-20	4.29	38.18	89.00
2020-21	4.43	42.53	96.00
2021-22	6.37	61.15	96.00
2022-23	6.59	59.35	90.06
2023-24	5.43	41.81	77.00
Average Area (2019 to 2024)	5.42	48.60	89.61
% to Total (India)	10.33	11.26	108.94

Source: Economics and Statistics Department of Agriculture & Farmers Welfare, Final Est. 2023-24

The data reveal important trends that directly relate to the need for AI integration in sugarcane marketing systems:

Fluctuation in Area under Cultivation:

The sugarcane cultivation area increased from 4.29 lakh hectares in 2019–20 to 6.59 lakh hectares in 2022–23, before declining to 5.43 lakh hectares in 2023–24. Such fluctuations indicate farmers respond to market prices, water availability, and policy changes. Lack of stable market signals often causes inconsistent planting decisions.

Variation in Production Levels: Production rose sharply to 61.15 MT in 2021–22, but declined in the following years. This shows that even when cultivation area expands, production does not always remain stable due to climate stress, input costs, or delayed payments from sugar mills.

Declining Productivity Trend: Productivity peaked at 96 tonnes per hectare during 2020–21 and 2021–22 but declined to 77 tonnes per hectare in 2023–24. This fall suggests issues such as water stress, soil degradation, and inefficient crop management practices.

Comparison with National Productivity:

The table also shows that average productivity in Karnataka's recent performance highlights the need for technological and management improvements in the state.

Relevance to AI-Based Marketing Systems

The observed fluctuations reveal marketing and supply chain inefficiencies, which AI systems can address by:

- Predicting production and demand patterns.

- Guiding farmers on optimal planting and harvesting time.
- Supporting mill-wise cane allocation and transport logistics.
- Reducing payment delays through digital monitoring.
- Forecasting prices and market demand.
- Optimizing supply chains to reduce wastage.

Sustainability Perspective

AI-driven systems can help ensure:

- Stable farmer income.
- Efficient resource utilization.
- Reduced market risk.
- Improved productivity.
- Better coordination between farmers and sugar mills.

Sugarcane Marketing Problems and Consequences in Karnataka



This structure highlights that marketing inefficiencies are systemic rather than isolated, directly supporting the research focus on integrating Artificial Intelligence (AI) for sustainable development of sugarcane marketing systems.

- Price instability reflects fluctuations in cane prices caused by volatile sugar markets, policy changes, and uneven demand–supply dynamics, which create income uncertainty for farmers.
- Delayed payments by sugar mills emerge as a critical issue, leading to liquidity problems, indebtedness, and reduced capacity of farmers to invest in sustainable farming practices.
- Market structure constraints, characterized by limited competition, mill monopolies, and

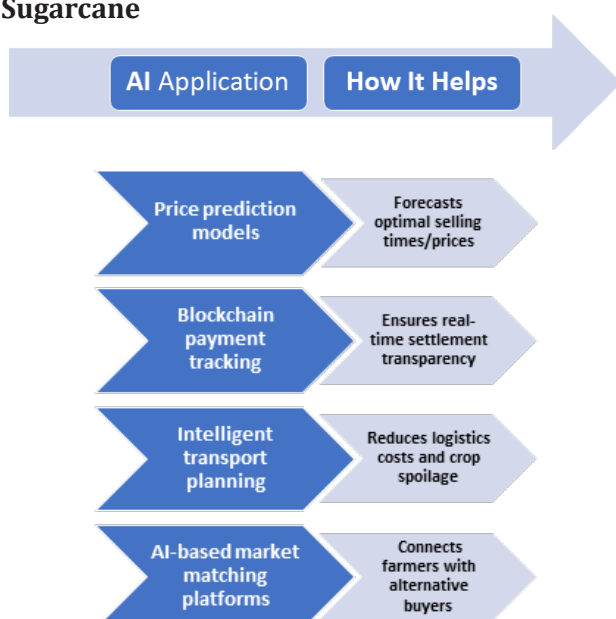
lack of alternative buyers, weaken farmers' bargaining power and restrict transparent price discovery.

- Transport and logistics issues, including inadequate infrastructure, poor scheduling, and delays in cane movement, reduce cane quality and recovery rates, increasing economic losses.
- Policy constraints further complicate marketing through rigid pricing mechanisms, regulatory delays, and inconsistencies between state and central policies.

Artificial intelligence can address these interconnected problems by enabling price forecasting, improving payment transparency through digital tracking systems, optimizing logistics via intelligent scheduling, enhancing market intelligence platforms, and supporting evidence-based policy formulation. Overall, the study underscores that sustainable development of sugarcane marketing in Karnataka is crucial.

Problem Category	Description	Consequences
Price instability	FRP not compensating costs	Low profit, protests
Delayed payments	Mills owe delayed bills	Financial stress, reliance on credit
Market structure	Few buyers (mills), poor alternatives	Limited bargaining power
Transport & logistics	Poor rural transport	Higher costs, quality loss
Policy constraints	Central policy levers not aligned	Unaddressed pricing reforms

Bridging to AI for Sustainable Marketing of Sugarcane



The integration of specific AI tools provides functional benefits, demonstrating a transition from traditional marketing practices toward a more transparent, efficient, and sustainable system.

Firstly, price prediction models are highlighted as a major AI application. In Karnataka, sugarcane farmers often face price uncertainty due to fluctuating market demand, FRP policies, and delayed payments from sugar mills. AI-driven predictive analytics can analyse historical price data, production trends, climatic factors, and demand-supply patterns to forecast optimal selling times and prices. This helps farmers make informed marketing decisions, reduce exploitation, and enhance income stability.

Blockchain-based payment tracking ensures real-time settlement transparency. One of the critical issues in Karnataka's sugarcane marketing system is delayed payment by mills. Blockchain technology creates a tamper-proof digital ledger system where transactions between farmers, mills, and intermediaries are recorded transparently. This reduces corruption, improves accountability, and builds trust among stakeholders, contributing to financial sustainability.

Intelligent transport planning focuses on logistics optimization. Sugarcane is a perishable crop that must be crushed within a short time after harvest. AI-based route optimization and supply chain management systems can minimize transportation delays, reduce fuel costs, and prevent crop spoilage. This improves operational efficiency and lowers environmental impact through reduced carbon emissions.

AI-based market matching platforms connect farmers directly with alternative buyers such as jaggery units, ethanol plants, and cooperative sugar factories. By using machine learning algorithms, these platforms can match supply with demand efficiently, eliminate unnecessary intermediaries, and improve price realization for farmers.

Overall, the AI-integrated marketing ecosystem is where predictive analytics, blockchain transparency, smart logistics, and digital market platforms work together. In the context of Karnataka, where sugarcane plays a major role in rural livelihoods and agro-industrial development, integrating AI into marketing systems can promote economic sustainability, reduce inefficiencies, enhance farmer income, and strengthen institutional governance.

Conclusion

The study on "Integrating Artificial

Intelligence for Sustainable Development of Sugarcane Marketing Systems in Karnataka” highlights the transformative potential of AI-driven technologies in addressing long-standing inefficiencies within the sugarcane marketing ecosystem. Sugarcane remains a critical component of Karnataka’s agrarian economy; however, persistent challenges such as price volatility, delayed payments, supply-chain bottlenecks, limited market transparency, and sustainability pressures continue to affect farmer incomes and market stability.

The study demonstrates that the integration of Artificial Intelligence tools-such as predictive analytics, demand forecasting, smart logistics management, digital marketing platforms, and real-time price intelligence-can significantly enhance operational efficiency and transparency across the sugarcane value chain. AI-enabled systems can improve procurement planning, optimize transportation and storage, reduce post-harvest losses, and strengthen coordination between farmers, mills, traders, and policymakers. As a result, farmers can benefit from better price realization, timely payments, and informed decision-making.

The study affirms that AI-enabled reforms in sugarcane marketing systems can create a more resilient, transparent, and sustainable agricultural marketing framework in Karnataka. By aligning technological innovation with farmer-centric policies and institutional support, Karnataka can move toward inclusive growth, enhanced value-chain efficiency, and long-term agricultural sustainability.

References:

1. Economics and Statistics Department of Agriculture & Farmers Welfare, Final Est. 2023-24.
2. S. Nijalingappa Sugar Institute, Belagavi.
3. www.industryarc.com
4. <https://evolution.earthathome.org/grasses/andropogoneae/sugarcane-history/>
5. sugarcane.dac.gov.in
6. www.StatisticsAPY.com
7. Chalawadi I. Chanabasappa (2008). “Problems and Prospects of Production and Marketing of Sugarcane with Reference to Belagavi District of Karnataka State”. Post-Graduate Department of Studies and Research in Commerce, Karnataka University, Dharwad-580003.
8. Nandisha, Dhananjaya K. B. (2024). “Production and Marketing of Sugarcane in Karnataka: Issues and Challenges”. ISSN Online: 2349-4182.
9. Government of Karnataka (2020-2021). “Sugarcane”. Visvesvaraya Trade Promotion Centre, Bangalore.
10. Nazish Aijaz et al. (2025). “Artificial Intelligence in Agriculture: Advancing Crop Productivity and Sustainability”.