



Operational Efficiency and Capacity Utilisation in The Haryana Cooperative Sugar Mills Ltd: A Comparative Analysis

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Abstract— *This study examines the operational efficiency of The Haryana Cooperative Sugar Mills Ltd. by analysing installed capacity, capacity utilisation, crop days, cane crushed, sugar production, sugar recovery, and workforce trends. The findings indicate structural expansion accompanied by fluctuating but gradually stabilising utilisation levels. Production performance shows a strong linkage between cane crushed and sugar output, while recovery rates influence technical efficiency. A steady decline in workforce size, despite the use of old machinery, reflects improved labour productivity and administrative rationalisation. The study highlights the importance of balancing workforce optimisation with technological modernisation to ensure sustained efficiency and long-term agro-industrial competitiveness.*



Keywords— *Operational Efficiency, Capacity Utilisation, Cooperative Sugar Mills, Economic Stability.*

I. INTRODUCTION

important agro-based industrial sectors, contributing significantly to rural employment, agricultural development and regional economic integration. India is among the largest producers and consumers of sugar, with over 700 installed sugar factories and a crushing capacity of approximately 340 lakh metric tons annually, supporting nearly 5 crore farmers and their families, and about 5 lakh direct workers engaged with these mills. Thus, the performance of sugar mills is not merely an industrial concern but a critical component of rural economic stability and agro-industrial sustainability.

Within this broader national framework, cooperative sugar mills, in particular, have historically provided a platform for farmer participation in processing, price stabilisation, and forward linkages between agriculture and industry. In the cooperative model, sugarcane growers often hold stakes in the mill's governance and profit-sharing mechanisms, which, in theory, should align peasant interests with industrial performance. However, despite

The sugar industry remains one of India's most this participatory structure and institutional advantage, many cooperative mills face persistent operational inefficiencies in capacity utilisation, seasonal variations, workforce productivity, and technical recovery rates (Arun & Sharma, 2025). Consequently, the long-term viability of cooperative mills depends not only on their social objectives but also on their operational performance.

In this context, operational efficiency in sugar mills is fundamentally assessed through a set of production and workforce indicators. Installed capacity, expressed as tonnes of cane that can be processed per day (TCD), establishes the theoretical maximum throughput of a mill. Yet, structural capacity alone does not guarantee performance, because actual utilisation of this installed capacity, termed capacity utilisation, reflects how effectively a mill converts its designed processing potential into real output during the crushing season. Earlier studies on the Indian sugar industry highlight persistent underutilisation of capacity across regions, often

resulting from inadequate cane supply, operational delays, and climatic disruptions (Kumar & Arora, 2009). Therefore, the relationship between installed capacity and capacity utilisation forms the first analytical linkage in evaluating operational efficiency.

Building upon this structural–operational linkage, crop days, or the number of effective crushing days during a season, emerge as another important determinant of mill efficiency. Sugar production is inherently seasonal, and the duration of the crushing season directly impacts the volume of cane processed. A longer operational season, with fewer interruptions, is commonly associated with higher throughput and better utilisation of installed capacity. Conversely, when crop days are limited due to delayed harvesting, low cane availability, or early season closures, total output declines and per-unit costs increase (V.K. Mishra, 2018). Thus, crop days are closely interconnected with both capacity utilisation and overall production performance.

Extending this temporal dimension into measurable input performance, cane crushed — the total volume of sugarcane processed within a season, constitutes the primary input indicator determining the scale of operations. In turn, sugar production reflects the total processed output and depends not only on cane volume but also on the sugar recovery rate — a technical indicator that measures the quantity of sugar extracted per unit of cane crushed. Higher recovery rates indicate efficient milling technology, better-quality cane, and effective processing conditions, and even small improvements in recovery percentage can substantially boost sugar output without increasing raw material input. Therefore, cane crushed and sugar recovery together form the technical bridge between input processing and final production performance. Studies confirm that recovery rates and crushing volumes are key determinants of efficiency in both cooperative and private sugar sectors.

Beyond these structural and technical dimensions, workforce structure significantly influences operational efficiency. The number of employees and associated labour productivity affect costs, maintenance capacities, and processing continuity. While overstaffing can inflate operational costs, understaffing may impair maintenance and technical operations, ultimately affecting production performance. Hence, workforce efficiency is intrinsically linked with production indicators such as cane crushed and sugar output. Empirical assessments suggest that workforce efficiency varies significantly among mills, particularly between cooperative and private sugar factories, where managerial practices and workforce optimisation differ.

Taken together, installed capacity determines structural potential; capacity utilisation reflects operational realisation; crop days shape seasonal duration; cane crushed measures input scale; sugar recovery determines extraction efficiency; sugar production represents output achievement; and workforce size influences productivity and cost dynamics. These variables do not operate independently but interact within a systematic framework of industrial performance.

Despite the centrality of these indicators, most existing research on sugar industry performance has been comparative across regions or sectors (private vs cooperative), with limited emphasis on intra-institutional, longitudinal performance analysis of individual mills. This creates a significant research gap, particularly in states like Haryana, where cooperative sugar mills play a vital role in agro-industrial development. The state's emerging agro-industrial profile and cooperative sector involvement provide a fertile context for focused assessment of operational efficiency patterns. An in-depth study of The Haryana Cooperative Sugar Mills — examining installed capacity, capacity utilisation, crop days, cane crushed, sugar production, sugar recovery, and number of employees — can reveal performance trends over time and pinpoint operational strengths and inefficiencies.

Accordingly, the present research aims to address this gap through a comprehensive analysis of these key variables. By employing descriptive statistical methods and performance indicators, the study seeks to identify trends, variability and interrelationships among production and workforce measures. Ultimately, such an integrated assessment is essential for enhancing managerial strategies, informing policy interventions, and ensuring the sustainable contribution of cooperative sugar mills to rural economic development and agro-industrial growth.

II. SIGNIFICANCE OF THE STUDY

The present study is significant as it provides a micro-level assessment of operational efficiency in the Haryana Cooperative Sugar Mills, integrating structural, technical, and workforce indicators within a unified analytical framework. By examining installed capacity, capacity utilisation, crop days, cane crushed, sugar production, sugar recovery, and number of employees, the research offers a comprehensive understanding of performance dynamics over time. The findings are expected to support evidence-based managerial decisions, optimise resources, and enhance productivity. Moreover, the study contributes to policy discourse on strengthening cooperative agro-industries and promoting sustainable rural industrial development in Haryana.

III. PROFILE OF THE HARYANA COOPERATIVE SUGAR MILLS

The Haryana Cooperative Sugar Mills Ltd., Rohtak, is a cooperative agro-based industrial unit operating under the Government of Haryana's cooperative framework. It was established with the objective of promoting farmer participation in sugar processing and strengthening rural industrial development. The mill operates through a member-based structure in which sugarcane growers are associated with procurement and governance mechanisms.

3.1 Historical Development and Establishment

The Haryana Cooperative Sugar Mills Ltd., Rohtak, emerged from the post-Independence cooperative movement that aimed to integrate sugarcane growers with industrial processing through farmer-led institutional frameworks. Official government records indicate that the mill was incorporated on 24 May 1954 under the Cooperative Societies Act, with its registered office located at Rohtak (Bhali Anandpur), thereby securing formal legal recognition as a cooperative industrial enterprise. Subsequently, the unit commenced operations in the mid-1950s as a functional sugar manufacturing plant. Scholarly documentation on the development of Haryana's sugar sector further notes that the mill was formally established in 1956 with an initial installed crushing capacity of 1750 tonnes of cane per day (TCD), making it one of the earliest cooperative sugar units in the state's agro-industrial landscape (Official Website of The Haryana Cooperative Sugar Mills Ltd., 2025). Over the decades, reflecting technological upgradation and expansion in processing infrastructure, the mill has enhanced its crushing capacity, which presently stands at 3500 TCD in 2025, indicating significant institutional growth and operational modernisation.

IV. OBJECTIVES

- i. To examine the trends in installed capacity and capacity utilisation of the Haryana Cooperative Sugar Mills.
- ii. To analyse the relationship between crop days, cane crushed, and sugar production.

V. RESEARCH METHODOLOGY

The study is based on secondary data collected from official records of The Haryana Cooperative Sugar Mills Ltd., annual reports, and relevant government publications. The selected variables include installed capacity, capacity

utilisation, crop days, cane crushed, sugar production, sugar recovery, and number of employees. The analysis covers a defined time period from 2004-05 to 2022-23 to examine trends and performance variations. Descriptive statistical techniques, such as the mean, standard deviation, and coefficient of variation, are used to assess variability and efficiency. Various types of graphs have been created using Microsoft Excel. The results are interpreted within an operational efficiency framework to identify performance patterns and potential constraints affecting the mill's productivity.

VI. RESULTS AND DISCUSSIONS

This section presents the empirical findings derived from the analysis of selected operational and workforce variables of The Haryana Cooperative Sugar Mills Ltd. The results are interpreted in relation to capacity utilisation, production performance, and labour efficiency. The discussion critically examines observed trends, interrelationships among variables, and their implications for overall operational efficiency.

6.1 Capacity Utilisation and Production Performance:

Capacity utilisation and production performance constitute the core dimensions of operational efficiency in sugar mills. Installed capacity represents the mill's structural potential, while actual utilisation reflects the extent to which this potential is realised during the crushing season. Production performance, measured by crop days, cane crushed, sugar output, and recovery rate, provides insight into the unit's technical and operational performance. These variables are interrelated, as variations in operational duration and input processing directly influence production outcomes. Therefore, analysing capacity utilisation alongside production indicators offers a comprehensive understanding of the mill's efficiency dynamics.

Table. No. 1: Installed Capacity and Capacity Utilisation (2004-05 to 2022-23)

Seasons	Installed Capacity (TCD)	Capacity Utilisation (%)
2004-05	1750	104.36
2010-11	3500	58.77
2016-17	3500	81.68
2022-23	3500	84.64

Source: Sugarfed Haryana, 2025

The data indicate a significant structural expansion and subsequent variation in operational efficiency over the study period. In 2004–05, the installed capacity of The Haryana Cooperative Sugar Mills Ltd. was 1750 TCD, with a capacity utilisation of 104.36 %. The utilisation exceeding 100 % suggests intensive operational performance, possibly due to extended crop days or higher-than-rated crushing efficiency.

By 2010–11, the installed capacity was expanded to 3500 TCD, reflecting infrastructural modernisation and scaling

up of operations. However, capacity utilisation sharply declined to 58.77 % during this period, indicating underutilisation of the expanded capacity, which may be attributed to cane supply constraints or operational disruptions. In subsequent years, utilisation improved to 81.68 % in 2016–17 and further to 84.64 % in 2022–23, suggesting gradual stabilisation and better operational management, though still below optimal full-capacity performance levels.

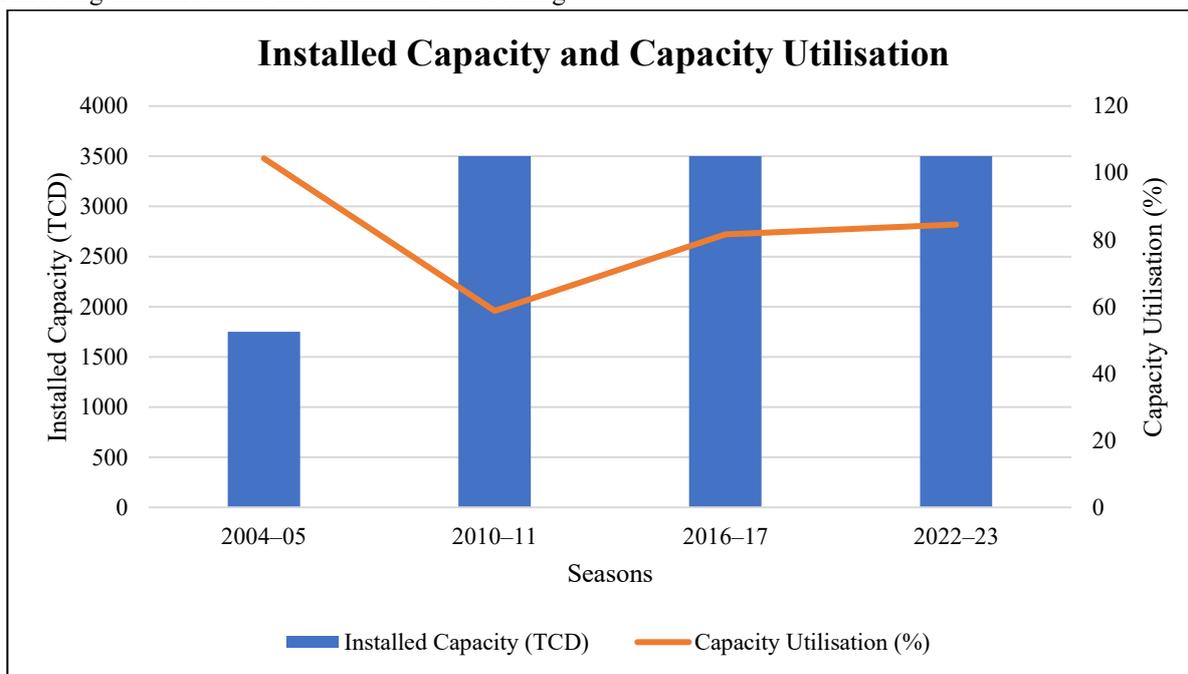


Fig. No. 1: Installed Capacity and Capacity Utilisation (2004-05 to 2022-23)

Source: Based on Table No. 1

6.2 Analysis of Crop Days and Operational Duration

Crop days represent the effective number of crushing days during a sugar season and serve as a direct indicator of operational duration. Since sugar production is seasonal, the length of the crushing period significantly influences overall mill performance. A higher number of crop days generally enables better utilisation of installed capacity, provided there is adequate cane supply and smooth technical functioning. Conversely, shorter operational duration may indicate delayed commencement, early closure, or interruptions due to cane shortages or mechanical breakdowns.

Operational duration is closely interlinked with cane crushed and overall production output, as extended crushing periods allow higher throughput and improved recovery of fixed costs. Therefore, analysing crop days over time helps in understanding fluctuations in the mill's operational stability and efficiency.

Table No. 2: Crop Days (2004-05 to 2022-23)

Year	Crop Days
2004-05	73
2010-11	107
2016-17	168
2022-23	196

Source: Sugarfed Haryana, 2025

The data reveal a substantial increase in operational duration over the study period. In 2004–05, the mill operated for only 73 crop days, indicating a relatively short crushing season. This duration increased to 107 days in 2010–11, reflecting some improvement in operational continuity. A significant expansion is observed in 2016–17, with 168 crop days, suggesting enhanced cane availability and improved operational management. By

2022–23, crop days further increased to 196, indicating greater stability and extended seasonal functioning. The overall upward trend demonstrates progressive

improvement in operational duration, which likely contributed to better capacity utilisation and higher production performance over time.

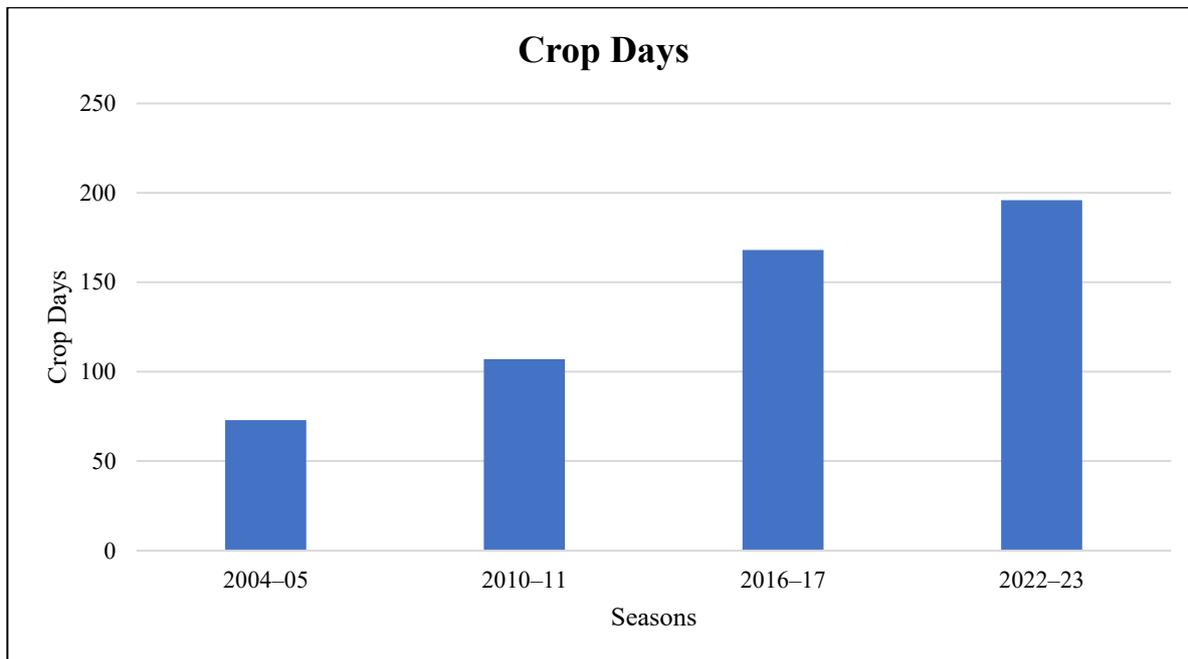


Fig. No. 2: Crop Days (2004-05 to 2022-23)

Source: Based on Table No. 2

6.3 Cane Crushed and Sugar Production Trends

Cane crushed and sugar production are key indicators of operational performance in a sugar mill. The volume of cane processed determines the scale of production, while sugar output reflects the efficiency of conversion and processing. These two variables are closely interrelated, as fluctuations in cane supply, operational duration, and technical efficiency directly influence production levels across different crushing seasons.

Table No. 3: Cane Crushed and Sugar Production (2004-05 to 2022-23)

Year	Cane Crushed	Sugar Production
2004-05	7.31	7.32
2010-11	9.65	7.90
2016-17	13.27	12.48
2022-23	12.61	11.87

Figures are in % to Total

Source: Sugarfed Haryana, 2025

The data indicate a progressive rise in both cane crushed and sugar production over time, reflecting a close functional relationship between input processing and output generation.

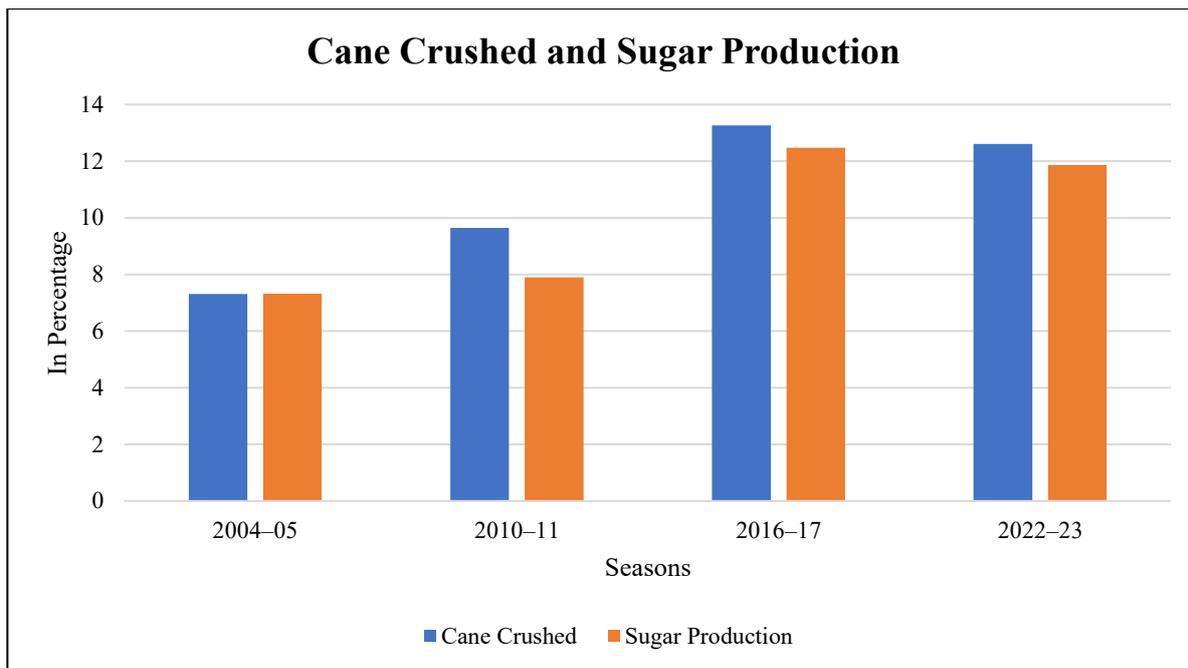


Fig. No. 3: Cane Crushed and Sugar Production (2004-05 to 2022-23)

Source: Based on Table No. 3

In 2004–05, lower cane crushing corresponded with comparatively lower sugar production, suggesting limited operational throughput. By 2010–11, although cane crushed increased noticeably, sugar production did not rise proportionately, indicating variations in recovery efficiency or operational factors. A significant improvement is observed in 2016–17, where higher cane crushed is closely matched by increased sugar output, demonstrating improved conversion efficiency. In 2022–23, despite a slight decline in cane crushed, sugar production remained relatively high, indicating stable recovery and operational performance.

6.4 Sugar Recovery Efficiency

Sugar recovery efficiency refers to the percentage of sugar extracted from the total cane crushed during the production process. It serves as a key technical indicator of milling performance and reflects the quality of cane, processing technology, and operational management. Variations in recovery efficiency influence overall sugar output and determine the effectiveness of resource utilisation within the mill.

Table No. 4: Sugar Recovery (2004-05 to 2022-23)

Year	Sugar Recovery (%)
2004-05	9.86
2010-11	6.90
2016-17	9.27
2022-23	9.03

Source: Sugarfed Haryana, 2025

The data reveal noticeable fluctuations in sugar recovery efficiency over the study period. In 2004–05, the recovery rate was 9.86%, indicating relatively efficient extraction. However, a sharp decline is observed in 2010–11, where recovery dropped to 6.90 %, suggesting possible issues related to cane quality, operational disruptions, or technical inefficiencies. Subsequently, recovery improved significantly to 9.27 % in 2016–17, reflecting the restoration of technical efficiency and better processing conditions. In 2022–23, the recovery rate declined slightly to 9.03%, but remained comparatively stable. Overall, the trend highlights periods of fluctuation followed by recovery and stabilisation in extraction efficiency.

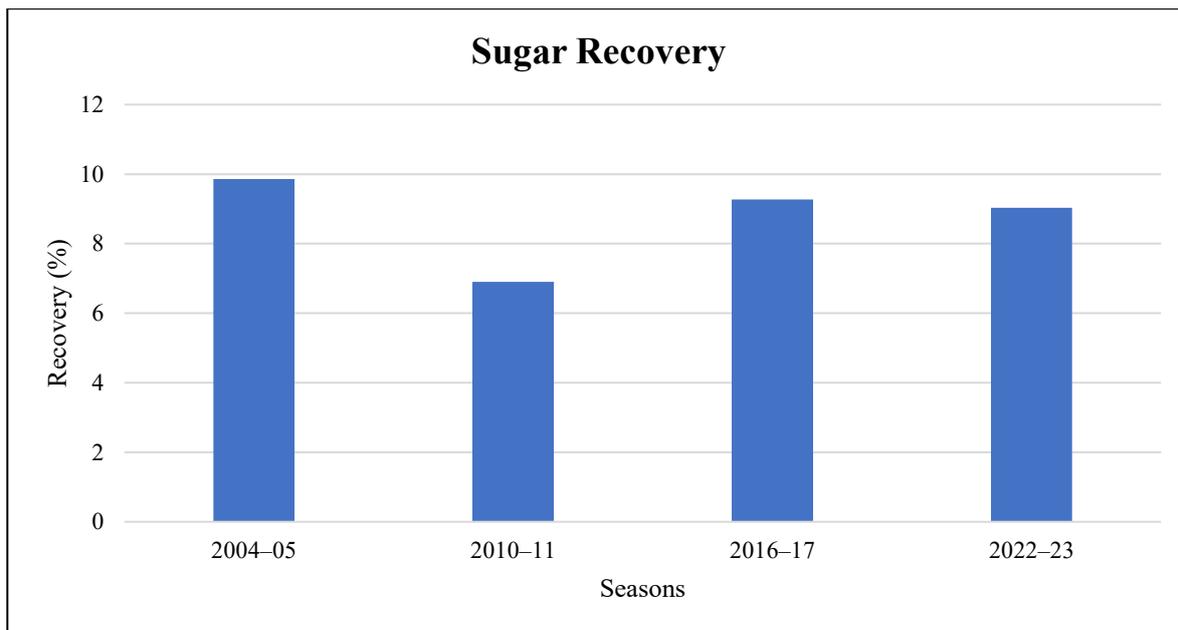


Fig. No. 4: Sugar Recovery Efficiency (2004-05 to 2022-23)

Source: Based on Table No. 4

6.5 Workforce in the Mill

The workforce is a vital component of a sugar mill's operational framework. Employees are engaged in technical processing, maintenance, administration, and seasonal operations. The structure and size of the workforce influence productivity, cost efficiency, and continuity of production activities. Effective workforce management ensures smooth operations, timely crushing, and overall industrial performance within the mill.

Table No. 5: No. of Employees (2004-05 to 2022-23)

Year	No. of Employees
2004-05	859
2010-11	725
2016-17	509
2022-23	399

Source: The Haryana Coop. Sugar Mills Ltd., 2025

The continuous decline in the number of employees, despite the mill operating with largely old machinery from its initial establishment, presents an important dimension of operational efficiency. In 2004-05, the mill employed 859 workers, which gradually reduced to 399 by 2022-23. Since major technological modernisation has not taken place and the core machinery remains traditional, the reduction in workforce cannot be fully attributed to automation or advanced mechanisation. Instead, it reflects administrative rationalisation, contractual staffing patterns, and improved labour management practices.

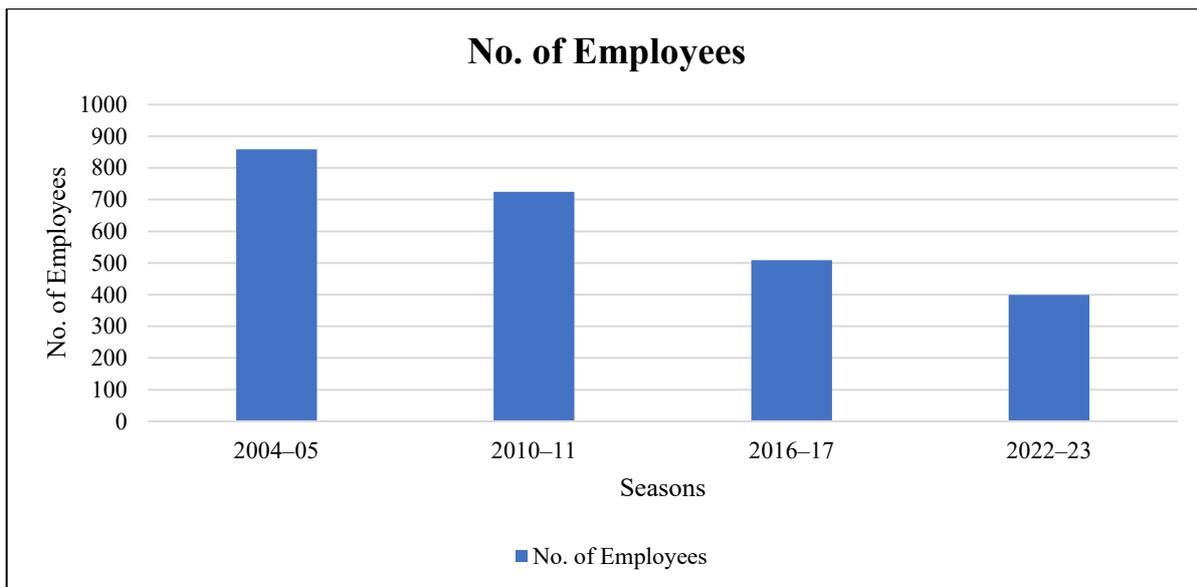


Fig. No. 5: No. of Employees (2004-05 to 2022-23)

Source: Based on Table No. 5

Operating old machinery typically requires greater maintenance effort and skilled manpower to ensure production continuity. Therefore, sustaining or improving production performance with a reduced workforce under such conditions suggests enhanced managerial coordination and better utilisation of human resources. However, dependence on ageing equipment may also limit potential gains in productivity and recovery efficiency. Thus, while workforce rationalisation indicates cost optimisation and improved labour productivity, the presence of outdated machinery underscores the need for technological upgradation to achieve sustained, long-term efficiency and competitiveness.

6.5.1 Labour–Output Relationship

The analysis of workforce trends in relation to production performance reveals a significant transformation in the labour–output relationship within the mill. Over the study period, the number of employees declined steadily, while indicators such as cane crushed, sugar production, and operational duration showed overall improvement or stabilisation. This inverse movement suggests an increase in labour productivity, with higher or sustained output achieved with a comparatively smaller workforce.

Despite operating with largely old machinery, the mill maintained production performance, indicating improved labour efficiency and better coordination in operational management. The extended crop days and relatively stable recovery rates further imply that output was not adversely affected by workforce reduction. Therefore, the labour–output relationship demonstrates a shift toward greater productivity per employee. However, reliance on ageing

machinery may limit further gains, highlighting the importance of balancing workforce optimisation with technological modernisation for sustained efficiency improvements.

VII. FINDINGS OF THE STUDY

The analysis reveals a consistent improvement in operational duration, as reflected in the steady increase in crop days over the study period. The extension of crushing days indicates enhanced operational continuity and better management of cane procurement. This extended operational duration directly contributed to higher cane-crushing volumes, demonstrating a strong positive relationship between crop days and input processing levels.

The trend in cane crushed shows substantial growth over time, particularly during periods of extended crop duration. This increase in input processing is closely associated with corresponding growth in sugar production, confirming a direct functional linkage between cane crushed and output generation. However, variations in sugar production relative to cane crushed also reflect the influence of recovery efficiency and technical factors.

Overall, the findings suggest that improved crop duration played a crucial role in strengthening production performance. The interrelationship among crop days, cane crushed, and sugar production highlights that operational stability and extended crushing seasons are central determinants of higher industrial output and greater mill efficiency.

VIII. CONCLUSION

The overall analysis of operational performance in The Haryana Cooperative Sugar Mills Ltd. reveals a dynamic pattern of structural expansion, fluctuating efficiency, and gradual stabilisation over the study period. The increase in installed capacity and extended crop days reflects institutional growth and improved operational continuity. Although capacity utilisation initially declined after expansion, subsequent years have shown a progressive recovery and better management of production processes. Trends in cane crushed and sugar production demonstrate a strong functional relationship, while fluctuations in sugar recovery highlight the influence of technical and raw material factors on output efficiency.

The consistent reduction in workforce, despite the continued use of old machinery, suggests improved labour productivity and administrative rationalisation. However, dependence on ageing equipment may constrain future efficiency gains. Overall, the findings underscore the need for technological upgradation alongside workforce optimisation to ensure sustainable operational performance and long-term competitiveness of the cooperative sugar mill.

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