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Improving Management Methodology of Vegetable Oil Enterprises: an Integrated Process, Quality, and Digital Framework

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Abstract: The vegetable oil and fats industry is strategically important for food security and agro-industrial development, yet its enterprises are often managed through fragmented, technically oriented practices that lag behind the sector's growing technological, regulatory, and market complexity. This study aims to develop an integrated methodological framework for improving the management of vegetable oil (oil-fat) industry enterprises. A qualitative, design-oriented methodology was applied, combining a narrative synthesis of international literature published mainly between 2019 and 2026 with conceptual framework construction and an illustrative case application to Uzbekistan. The results show that technological, quality, lean, digital, and strategic management tools generate managerial value only when they are embedded in a coordinated management mechanism. On this basis, a four-pillar Integrated Management Improvement Framework is proposed, covering technological-operational modernization, integrated quality-safety-environmental management, digital process management, and strategic performance management, and operationalized through an Enterprise Management Maturity Index. Applied to Uzbekistan's more than 240 oil-fat enterprises, the framework reveals a gap between policy-driven growth targets and actual managerial maturity, especially in digital process integration and strategic performance measurement. The study contributes a sector-specific, multi-pillar diagnostic instrument that links previously separate management literatures and provides a basis for future empirical validation.

Keywords: Digital transformation; Enterprise management methodology; Maturity index; Quality management; Vegetable oil industry

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1. Introduction

The vegetable oil and fat oil-fat industry is one of the most strategically significant branches of the global agro-industrial complex. Its output, including edible oils, margarine, specialty fats, and protein-rich oilseed meals, underpins food security, animal-feed supply chains, and a growing range of oleochemical and industrial applications. As the global population is projected to approach nine billion by 2050, pressure on the sector to expand output while reducing waste and greenhouse-gas emissions is intensifying. Meeting this pressure requires not only agronomic and technological progress in oilseed cultivation and processing, but also a fundamental modernization of how enterprises in this sector are managed.

Structurally, oil-fat enterprises differ from many other branches of food manufacturing in ways that make management especially demanding. Raw-material supply is strongly seasonal and agronomically dependent, exposing enterprises to

volatility that must be absorbed through inventory, procurement, and production planning. Extraction and refining technologies are capital-intensive and increasingly complex, ranging from conventional mechanical pressing and hexane-based solvent extraction to emerging green alternatives such as ethanol, supercritical CO₂, and enzymatic aqueous extraction. Each technology involves distinct safety, environmental, economic, and quality implications. Refining stages, including degumming, neutralization, decolorization, and deodorization, must simultaneously satisfy food-safety regulations, product-quality specifications, and cost-efficiency requirements, while by-product streams such as oilseed meal, cake, and other residues must be valorized rather than discarded. This combination of technical complexity, regulatory stringency, and market volatility means that the quality of enterprise management, including planning, process control, quality assurance, digital integration, and strategic decision-making, is at least as decisive for competitiveness as the underlying processing technology itself.[1]

Despite notable technological progress in the sector, including smart sensing, artificial-intelligence-based process optimization, and big-data platforms now being piloted in edible-oil manufacturing, the management methodology of many enterprises in this branch, particularly in transition and developing economies, has not kept pace with technological development. In practice, this is visible in fragmented and reactive quality control rather than integrated management systems, limited or siloed use of digital enterprise tools, weak linkage between shop-floor operational indicators and strategic objectives, and organizational-economic mechanisms that have not been sufficiently adapted to modern digital and quality-management practices. The result is a widening gap between the technological potential now available to the industry and the actual managerial capacity of individual enterprises to exploit these opportunities effectively.[2]

Uzbekistan's oil-fat industry illustrates this gap clearly. The sector has expanded from only 19 enterprises with approximately 3.6 million tonnes of cottonseed-processing capacity in the early 1990s to more than 240 enterprises today, employing over 15,000 people and processing an estimated 4.39 million tonnes of oilseeds annually. This expansion is expected to continue under the Strategy of New Uzbekistan for 2022–2026, which targets a substantial increase in agro-industrial enterprise output and an additional one billion US dollars in agricultural export potential, alongside broader commitments to intensify agricultural growth and modernize agro-industrial infrastructure. Realizing these ambitious policy-driven targets will depend not only on continued investment in processing technology but, equally importantly, on whether individual enterprises adopt management methodologies capable of coordinating operational, quality, digital, and strategic dimensions in an integrated manner.

Addressing this problem requires a balance between the theoretical and applied aspects of the subject. On the theoretical side, management science offers well-established constructs for describing how enterprises coordinate resources, goals, methods, and performance criteria. These include organizational-economic management mechanisms, the Balanced Scorecard as a strategic-management system, and maturity models that describe the staged development of organizational capability. On the applied side, enterprise managers, industry associations, and policymakers need practical diagnostic instruments that indicate where improvement efforts should be concentrated first and in what sequence. Previous research demonstrates that formal quality-management certification, Lean Six Sigma, and manufacturing execution systems can improve selected dimensions of enterprise performance. However, these approaches do not sufficiently explain how such instruments should be combined within a single enterprise and adapted to the specific characteristics of the oil-fat industry. Developing these separate findings into an integrated, sector-specific methodology therefore represents a central research task.[3]

A review of the recent literature reveals three related gaps that this article addresses. First, the literature on oil-fat processing technology is rich and rapidly advancing, but it is predominantly technical in focus and rarely connects processing innovation with enterprise-management methodology. Second, the broader food-industry management literature has developed increasingly sophisticated tools, including integrated quality-safety-environmental management systems, Industry 4.0-driven quality frameworks, lean and Six Sigma methods, digital process management, process mining, strategic performance-management systems such as the Balanced Scorecard, and organizational-economic management mechanisms. However, these tools are typically studied in isolation from one another and are rarely tailored to the structural specifics of the oil-fat subsector. Third, empirical and methodological attention to Central Asian and specifically Uzbekistani oil-fat enterprises remains limited, despite the sector's scale and strategic importance within the region.

Therefore, the present study focuses on developing a comprehensive methodology for organizing enterprise management in the oil-fat industry. The proposed approach seeks to integrate operational planning, quality management, digital transformation, resource efficiency, strategic performance assessment, and organizational-economic coordination into a unified management framework. Such integration can provide enterprises with a systematic basis for diagnosing current capabilities, identifying critical management gaps, prioritizing improvement measures, and monitoring the results of implemented interventions. The methodology is particularly relevant for enterprises operating under conditions of seasonal raw-material availability, changing market demand, increasing environmental requirements, technological modernization, and growing expectations regarding product safety and quality.[4]

The practical significance of the proposed methodology lies in its potential to strengthen the connection between technological modernization and managerial development. Digital technologies, advanced analytical tools, quality-management systems, and production-control mechanisms can generate substantial benefits only when they are supported by appropriate organizational structures, clearly defined responsibilities, measurable performance indicators, and coordinated strategic objectives. Consequently, improving the management methodology of oil-fat enterprises should be viewed not as an isolated administrative task but as an integral component of industrial modernization and sustainable competitiveness. For Uzbekistan, such an approach may contribute to more efficient utilization of agricultural raw materials, improved production productivity, enhanced product quality, greater utilization of by-products, reduced resource losses, and stronger integration of domestic enterprises into regional and international food and industrial markets.

Accordingly, the purpose of this research is to develop an integrated methodological framework for improving the management of vegetable oil industry enterprises, synthesizing recent international literature across the domains identified above and illustrating the framework's practical relevance through the case of Uzbekistan's oil-fat sector. The specific objectives are: (1) to synthesize recent, predominantly 2019–2026, literature on technological modernization, quality-safety-environmental management, lean and digital process management, and strategic performance management as they apply to food and oil-fat processing enterprises; (2) to identify the structural and managerial challenges that distinguish oil-fat enterprises from other branches of food manufacturing; (3) to design an integrated, multi-pillar management-improvement framework, operationalized through a conceptual maturity index; and (4) to apply the framework descriptively to Uzbekistan's oil-fat industry in order to assess its current managerial positioning relative to national development targets.[5]

2. Materials and Methods

This study adopts a qualitative, design-oriented research methodology that combines literature synthesis with conceptual framework construction, followed by an illustrative case application. This approach is appropriate because the article's central contribution is methodological, namely the design of an integrated management-improvement framework, rather than the statistical testing of a predefined hypothesis against firm-level data. The research design follows a logic comparable to that used in the development of widely adopted management methodologies such as the Balanced Scorecard and technology-specific maturity grids, in which recurring themes identified through literature analysis are synthesized into a structured and practically applicable management instrument. The study represents a narrative and expert-guided synthesis rather than a systematic review conducted under a registered protocol such as PRISMA. Accordingly, formal screening counts concerning records identified, screened, and excluded are not reported. The methodological procedures are described in sufficient detail to provide conceptual transparency and facilitate replication.

Instrument

Because the study is conceptual and design-oriented, no laboratory materials or specialized technical equipment were required. The research materials consisted primarily of peer-reviewed journal articles, a peer-reviewed conference contribution, and publicly available industry, governmental, and international statistical documents. The research employed two principal instruments.[6]

The first instrument was a structured literature-search and coding protocol. This protocol specified the principal source platforms, search terminology, publication period, inclusion criteria, and thematic coding categories used during the literature analysis. The protocol provided a consistent basis for identifying relevant evidence and organizing the literature according to its contribution to enterprise management, operational efficiency, quality assurance, digital transformation, and strategic performance management.

The second instrument, which also constitutes the principal methodological output of the study, was a diagnostic maturity grid. The grid evaluates four major management pillars using a five-level ordinal scale ranging from Level 0, representing an absent or ad hoc management condition, to Level 4, representing an advanced and optimized management condition. Each maturity level is characterized by qualitative descriptors that allow the evaluator to identify the prevailing organizational capability on the basis of observable evidence.

The maturity descriptors were developed to support practical enterprise assessment. Observable evidence may include the existence and degree of implementation of certified management systems, the level of enterprise software integration, the use of digital production and analytical technologies, the degree of process standardization, the availability of performance indicators, and the existence of a strategic measurement system incorporating multiple organizational perspectives. The pillar-level results are subsequently normalized to a common scale ranging from zero to one and aggregated into a conceptual Enterprise Management Maturity Index. The calculation procedure and weighting principle are presented in the subsequent analytical section.[7]

Data Collection

The literature search targeted peer-reviewed journal articles published through recognized international academic publishers and research platforms, including MDPI, Frontiers, Taylor and Francis, Elsevier through ScienceDirect, Emerald, and Springer. Additional sector-specific, governmental, institutional, and Uzbekistan-related sources were considered where they provided relevant contextual or empirical information concerning the oil-fat industry and its management environment.

The search strategy combined terminology describing the core industrial field with terminology associated with enterprise management and organizational development. The principal subject terms included vegetable oil, edible oil, oilseed processing, and oil-fat industry. These terms were combined with management-oriented concepts such as enterprise management, management methodology, quality management system, digital transformation, digital maturity, process mining, lean management, Six Sigma, Balanced Scorecard, and organizational-economic management mechanism.

The literature search primarily emphasized publications issued between 2019 and 2026. Particular attention was given to recent studies published between 2023 and 2026 in order to ensure that the proposed methodology reflects contemporary technological developments, digital transformation practices, and modern approaches to industrial management. A limited number of earlier foundational publications were retained when their conceptual or methodological contribution remained directly relevant to the development of the proposed framework.

Sources were included when they addressed at least one of four thematic domains relevant to the management of oil-fat enterprises. The first domain concerned processing and extraction technologies that have direct implications for operational management, production efficiency, resource utilization, and process control. The second domain concerned quality, food safety, environmental management, and their relationship with organizational and enterprise performance. The third domain incorporated lean management, digital transformation, enterprise resource planning, manufacturing execution systems, process management, and process mining. The fourth domain covered strategic and organizational-economic approaches to performance management, including multidimensional performance measurement and organizational coordination mechanisms.

A regional source focusing on the digitalization context of Uzbekistan was included as supplementary evidence because of its direct contextual relevance. Since this source represents a peer-reviewed conference contribution rather than a journal article, it was not treated as equivalent to the core journal evidence base. Instead, it was used primarily to illustrate the relevance of digital management approaches within the national economic environment.[8]

Data used for the illustrative case application were collected separately from the academic literature. Sector-level information concerning the number of operating enterprises, processing capacity, production volumes, employment, and export activity was obtained primarily from industry-association materials and international trade statistics. National development targets and policy priorities were derived from official strategic documents concerning the development of New Uzbekistan. These sources were used to establish the economic and institutional context in which oil-fat enterprises operate.

Because industry-association materials do not represent independently audited academic datasets, selected information concerning cottonseed-processing capacity and raw-material availability was cross-referenced with international agricultural production statistics. In particular, national raw-cottonseed production data were compared with information contained in the Production, Supply and Distribution database of the United States Department of Agriculture Foreign Agricultural Service. This cross-checking procedure was intended to reduce the risk of relying on a single institutional source and to strengthen the contextual reliability of the sector-level assessment.

The case illustration does not constitute a primary firm-level survey, experimental investigation, or statistical analysis of individual company financial statements. Instead, the collected information serves to demonstrate how the proposed management methodology can be interpreted and applied within the structural conditions of the Uzbekistan oil-fat industry.

Data Analysis

The selected sources were examined in detail and thematically coded according to the four principal domains established during the research design. Within each domain, recurring managerial mechanisms, organizational success factors, technological requirements, performance drivers, and implementation limitations were identified and compared. Particular attention was given to relationships between technological modernization and managerial capability, as well as to the organizational conditions required for successful implementation of digital and quality-management instruments.

The thematic findings were subsequently synthesized through an inductive analytical procedure. Rather than treating individual management technologies as independent solutions, the study identified areas of managerial capability that repeatedly appeared across the literature. These recurring areas were consolidated into four interdependent management pillars. Each pillar represents a broader organizational capability and therefore encompasses multiple management practices and technologies rather than a single managerial technique.

The maturity model was then developed to operationalize these conceptual findings for diagnostic purposes. A five-level maturity structure was established for each management pillar. The levels reflect a gradual transition from fragmented and reactive management practices toward standardized, integrated, data-driven, and continuously optimized organizational processes. The descriptors for each level were formulated using qualitative evidence concerning process-management maturity, digital transformation, quality-system development, strategic performance measurement, and organizational coordination.[9]

The maturity assessment is based on observable organizational characteristics rather than subjective judgments alone. Evidence considered in the assessment may include the formalization of business processes, integration of information systems, availability of real-time operational data, implementation of quality and environmental management systems, use of analytical technologies, alignment of operational indicators with strategic objectives, and the presence of mechanisms for continuous improvement.

The pillar-level scores are normalized to a common zero-to-one scale to enable comparison between different dimensions of enterprise management. The normalized values are subsequently combined into the conceptual Enterprise Management Maturity Index. The index is designed primarily as a diagnostic and planning instrument rather than as a statistically calibrated measurement scale. Its purpose at the present stage is to provide a structured method for identifying management weaknesses, establishing improvement priorities, and monitoring organizational progress over time.

The analytical procedure therefore consists of three interconnected stages. The first stage identifies relevant management practices and organizational mechanisms through literature synthesis. The second stage translates these practices into measurable maturity characteristics and organizes them into four management pillars. The third stage aggregates the pillar-level assessments into an integrated maturity index that can support enterprise-level diagnosis and improvement planning.

This methodological structure allows the study to connect theoretical management concepts with practical requirements of oil-fat enterprises. It also provides a basis for comparing enterprises with different levels of technological and organizational development without assuming that technological investment alone represents managerial maturity. In this way, the proposed methodology emphasizes the interaction between operational efficiency, quality management, digital capability, strategic coordination, and continuous organizational improvement.

Finally, the case data were analyzed descriptively. Indicators from different sources were tabulated, checked against one another where overlapping measures existed, and

discrepancies were recorded rather than adjusted. The sector's position was then assessed qualitatively against the level descriptors of each pillar, so that the resulting case assessment is illustrative rather than statistically estimated. As a literature-synthesis-based study, the analysis does not include primary data collection from individual enterprises, nor does it statistically estimate the weights or thresholds of the maturity index; these limitations are discussed in Section 3.13.[10]

3. Result and Discussion

Structural and managerial characteristics of oil-fat industry enterprises

The literature synthesis confirms that oil-fat enterprises face a distinctive combination of structural pressures that shape their management requirements. Raw-material supply is seasonal, agronomically variable, and increasingly linked to broader sustainability and food-supply pressures, requiring management systems capable of absorbing volatility in procurement, storage, inventory management, and production scheduling. Processing technology spans a wide spectrum of maturity, from conventional mechanical and hexane-based solvent extraction to emerging green alternatives such as ethanol, supercritical carbon dioxide, and enzymatic aqueous extraction, as well as pre-treatment innovations involving microwave, ultrasound, and pulsed-electric-field technologies. Each of these technological choices carries distinct implications for occupational safety, environmental compliance, product quality, energy efficiency, resource utilization, and capital expenditure, meaning that technology and process-management decisions cannot be considered independently.

Refining operations must simultaneously satisfy stringent food-safety requirements and cost-efficiency targets, while by-product streams must be effectively valorized to maintain competitiveness and improve resource efficiency. Oilseed meal, cake, and other residual materials can provide additional economic value when appropriate recovery, processing, and utilization systems are established. Taken together, these characteristics mean that management in the oil-fat industry must integrate operational, technical, regulatory, environmental, and strategic considerations more closely than is typical in less technically complex and less seasonally constrained branches of food manufacturing. This structural profile provides the analytical starting point for the management domains reviewed in the subsequent sections, each of which contributes a distinct but complementary managerial capability.[11]

Technological Modernization as a Management Lever

Recent literature demonstrates that technological modernization is increasingly becoming a management concern rather than merely an engineering issue. Contemporary Industry 4.0 approaches to edible-oil manufacturing encompass smart sensing technologies, artificial-intelligence applications, Internet-of-Things communication networks, and big-data analytical platforms. These technologies create opportunities for enterprises to collect, integrate, and interpret operational information across multiple stages of production.

Artificial intelligence is increasingly being applied to process-parameter optimization during refining, decolorization, and deodorization, while also supporting predictive maintenance and quality-control decision-making. The integration of blockchain and Internet-of-Things technologies can strengthen supply-chain traceability, improve information transparency, and facilitate the monitoring of material flows from raw-material procurement through processing and distribution. These developments demonstrate that digital technologies are transforming not only production processes but also the information architecture through which managerial decisions are made.

At the product-quality level, gas-sensor arrays combined with deep-learning classification demonstrate the potential to automate the assessment of edible-oil quality. Advanced sensor systems can capture chemical and physical characteristics of oil samples,

while machine-learning models can process these signals and classify product conditions. Such developments illustrate the gradual transition of artificial-intelligence-based sensing from laboratory research toward practical quality-control applications in food-processing enterprises.

From a management perspective, this body of research indicates that technological modernization functions as an important enabler of managerial capability. Real-time sensing and big-data platforms can transform previously reactive and inspection-based operational management into proactive and data-informed decision-making. Continuous monitoring allows managers to identify deviations at an earlier stage, evaluate process performance, anticipate equipment failures, and respond to quality risks before they develop into significant production or financial losses.[12]

However, these benefits depend on the organizational capacity of enterprises to exploit advanced technologies effectively. Employees must possess appropriate technical and analytical skills, production processes must be sufficiently documented and standardized, digital infrastructure must be reliable, and management structures must support the integration of technological information into decision-making. Enterprises that introduce digital technologies without corresponding organizational and management-system development may experience fragmented information flows, underutilized technological resources, and limited returns on digital investment.

Technological adoption should therefore be understood as one component of a broader enterprise-management transformation. The maturity of technological modernization should not be measured exclusively by the number or sophistication of technologies installed. It should also reflect the extent to which digital technologies are integrated with production planning, process control, quality management, maintenance, supply-chain coordination, strategic planning, and continuous improvement. This perspective supports the inclusion of technological and digital capability as a central pillar of an integrated management methodology for oil-fat enterprises.

Integrated Quality, Safety, and Environmental Management Systems

A second major theme concerns the performance effects of formal quality, occupational-health-and-safety, and environmental management systems. In the food-processing sector, management systems based on internationally recognized standards provide structured mechanisms for controlling production processes, identifying operational risks, monitoring environmental impacts, improving workplace safety, and maintaining consistent product quality. Their importance is particularly pronounced in oil-fat enterprises because these organizations must simultaneously satisfy food-safety requirements, environmental obligations, occupational-safety standards, customer expectations, and economic performance objectives.

Research involving food-processing companies over an extended period demonstrates that implementation of environmental, occupational-health-and-safety, and food-safety management standards can contribute positively to environmental performance and organizational outcomes. The financial effects of certification, however, may differ across industrial subsectors and individual enterprises. Some segments may experience stronger financial benefits, whereas others may demonstrate more complex or mixed relationships between formal certification and profitability. This indicates that certification itself should not be considered an automatic source of financial improvement.

The practical effectiveness of management-system certification depends substantially on the extent to which certified procedures are integrated into everyday operational management. A certificate can confirm the existence of a formal management framework, but it does not by itself demonstrate that employees consistently apply the associated procedures, that managers use system-generated information in decision-making, or that corrective and preventive actions are effectively connected to production performance.

An integrated quality, safety, and environmental management system can provide stronger organizational coordination when quality indicators, occupational-safety indicators, environmental indicators, and production-performance measures are incorporated into a common managerial structure. Such integration can reduce duplication of procedures, improve communication between organizational units, strengthen accountability, and support coordinated responses to operational risks.

For oil-fat enterprises, this integration is particularly important because individual production activities can simultaneously affect product quality, consumer safety, worker safety, energy consumption, water utilization, waste generation, and environmental performance. A management decision designed to improve one dimension may therefore influence several other dimensions. An integrated system enables these interactions to be considered simultaneously rather than through isolated departmental decisions.[13]

Recent research on Food Quality Management 4.0 further demonstrates that Industry 4.0 technologies can be connected with several fundamental quality-management functions, including quality design, quality control, continuous improvement, quality assurance, and quality policy and strategy. Sensor technologies, blockchain systems, and artificial intelligence represent important technological instruments in this transformation. Nevertheless, their application remains more concentrated in operational quality control and assurance than in higher-level strategic quality management.

This imbalance highlights an important management challenge. Digital technologies can substantially improve monitoring and control while leaving strategic quality planning relatively underdeveloped. For oil-fat enterprises, the effective integration of technological tools with strategic quality objectives is therefore necessary to ensure that digitalization contributes not only to the detection of defects but also to the prevention of quality problems, process improvement, risk reduction, and long-term organizational development.

Evidence from agro-processing small and medium-sized enterprises additionally indicates that formal quality-management-system implementation can improve operational efficiency. These findings reinforce the relationship between quality management and enterprise performance while demonstrating that standardized management practices can support more efficient use of organizational resources.

Together, the reviewed studies indicate that quality, occupational safety, and environmental management should be treated as an integrated pillar of enterprise management rather than as separate compliance functions. At the same time, the strategic dimension of this pillar requires deliberate managerial attention. The effectiveness of quality and environmental systems depends not only on formal certification but also on their integration with production processes, employee responsibilities, digital information systems, performance measurement, risk management, and continuous improvement.

Lean and Process-Efficiency Methodologies

Lean and Six Sigma methodologies constitute a third important domain in the management of oil-fat enterprises. These approaches focus on systematic identification and elimination of waste, reduction of process variation, improvement of workflow, optimization of resource utilization, and enhancement of product quality. Their relevance to oil-fat processing is particularly significant because the industry operates with substantial raw-material, energy, water, labor, equipment, and logistics requirements.

Research on Lean Six Sigma applications in the food industry demonstrates that these methodologies can contribute to improvements in efficiency, quality, and safety across different food-production operations. Process improvement, waste reduction, supply-chain optimization, productivity enhancement, and food-safety improvement represent important areas in which lean-based approaches can generate organizational benefits.

Within oil-fat enterprises, lean principles can be applied to multiple stages of the production and supply process. Procurement activities can be analyzed to reduce unnecessary delays and inventory losses. Storage operations can be optimized to minimize deterioration and improve material turnover. Processing lines can be examined to identify bottlenecks, unnecessary movements, equipment downtime, excessive energy consumption, and variations in production performance. Refining operations can similarly be evaluated in terms of process stability, resource consumption, yield, and product-quality consistency.

The application of Green Lean Six Sigma extends these principles by connecting operational efficiency with environmental sustainability. Environmental improvements are more likely to become sustainable when waste reduction, resource efficiency, energy management, pollution prevention, and quality improvement are incorporated into a unified improvement strategy. Isolated efficiency projects may produce short-term operational gains without necessarily creating a durable organizational system for environmental performance.

This perspective is particularly relevant to oil-fat enterprises because the sector generates several material and energy flows that have both economic and environmental implications. Efficient utilization of oilseed raw materials, reduction of processing losses, recovery and valorization of by-products, optimization of energy consumption, and reduction of unnecessary waste can simultaneously support economic efficiency and environmental performance.[14]

Research focusing on the pre-implementation phase of Lean Six Sigma in food-sector small and medium-sized enterprises further demonstrates that organizational readiness is a critical factor. Leadership commitment, workforce training, employee participation, management support, and a favorable quality culture influence whether improvement initiatives can be successfully introduced. These factors demonstrate that the selection of an appropriate management tool is not sufficient by itself to ensure successful implementation.

For oil-fat enterprises, Lean and Six Sigma should therefore be integrated into the broader management system rather than implemented as isolated productivity programs. Their effectiveness depends on the existence of reliable performance data, clearly documented processes, trained personnel, management commitment, and mechanisms for monitoring improvement results. When these conditions are present, lean methodologies can contribute to the identification of operational inefficiencies and provide a structured basis for continuous improvement.

The literature consequently supports the inclusion of process efficiency and continuous improvement as an important component of the proposed enterprise-management methodology. This component complements technological modernization and integrated quality management by translating organizational and technological capabilities into measurable improvements in productivity, resource efficiency, process stability, and waste reduction.

For oil-fat enterprises specifically, Lean Six Sigma principles are directly applicable to reducing extraction and refining losses, standardizing changeover and maintenance procedures across seasonal production cycles, and minimizing by-product waste, objectives that align closely with the sector's cost and sustainability pressures discussed in Section 3.1.

Digital process management: ERP, MES, and process mining

The fourth domain concerns the digitalization of enterprise management itself, as distinct from the digitalization of production technology. Recent research on process-mining maturity in manufacturing and logistics enterprises provides a structured means of assessing how systematically an organization captures, analyzes, and acts upon digital

traces of its own operational processes. This capability is increasingly important for identifying inefficiencies that may remain invisible within conventional management reporting systems. Process mining can connect operational event data with actual business workflows, allowing managers to identify process deviations, bottlenecks, unnecessary activities, delays, and opportunities for improvement.[15]

Recent evidence from the manufacturing sector reinforces the view that the managerial benefits of digitalization depend on organizational readiness as well as technological capacity. Research on manufacturing-execution-system adoption in small and medium-sized manufacturing enterprises demonstrates that transforming MES-generated information into useful key performance indicators requires parallel investment in process documentation, clearly defined responsibility structures, employee training, and management procedures. The availability of software does not automatically ensure that the information generated by the system will become useful managerial knowledge.

Digital maturity research similarly demonstrates that the maturity level of an enterprise is more important than the simple presence of digital technologies. Organizations may possess enterprise resource planning systems, manufacturing execution systems, cloud platforms, Internet-of-Things devices, or analytical tools while continuing to operate with fragmented information flows and weak coordination between departments. Higher levels of digital maturity are characterized by greater integration of information systems, standardized processes, reliable data structures, analytical capabilities, and faster translation of information into managerial decisions.

Evidence from transition-economy environments reflects a comparable pattern. Successful digitalization of management processes requires not only the implementation of enterprise resource planning systems, manufacturing execution systems, Internet-of-Things technologies, cloud platforms, and data analytics, but also organizational redesign, clearly defined responsibility structures, workforce training, investment-appraisal methodologies, and performance-monitoring systems. When these elements are integrated into a coordinated organizational-economic mechanism, digitalization can contribute to reduced transaction costs, improved operational visibility, faster decision-making, and more efficient resource utilization.[16]

Taken together, these findings reinforce a pattern identified in the preceding domains. Digital and technological tools generate management value only when they are embedded within a deliberately designed organizational-economic mechanism. Digital transformation should therefore be understood as an organizational transformation process rather than simply an information-technology implementation project. For oil-fat enterprises, this distinction is particularly important because production, procurement, quality, maintenance, logistics, and financial information are closely interconnected. Effective digital management requires these information flows to be coordinated rather than maintained as isolated departmental systems.

Strategic Performance Management

The final domain concerns the strategic layer of enterprise management, namely the process through which operational, quality, environmental, financial, and digital information is transformed into strategic decisions. Strategic performance management provides organizations with mechanisms for translating long-term objectives into measurable indicators and connecting operational activities with broader organizational priorities.

The Balanced Scorecard represents one of the most established approaches in this field. Its original structure incorporated four major perspectives covering financial performance, customer-related outcomes, internal processes, and learning and growth. Over time, the approach developed beyond a simple performance-measurement instrument into a broader strategic-management system. Strategy maps, for example, provide a means of visualizing relationships between strategic objectives and illustrating

how improvements in organizational capabilities and internal processes can contribute to customer and financial outcomes.[17]

Despite its widespread adoption, the implementation of the Balanced Scorecard involves several methodological challenges. Organizations may interpret performance perspectives differently, select inconsistent indicators, or experience difficulties in establishing empirically supported causal relationships between individual performance dimensions. Contemporary developments increasingly emphasize the integration of advanced analytical technologies, artificial intelligence, sustainability indicators, and environmental, social, and governance considerations into strategic performance-management systems.

Empirical research involving manufacturing enterprises indicates that formal strategic planning is positively associated with organizational performance. Structured multi-perspective performance-management systems can therefore provide production enterprises with a framework for connecting operational activities to strategic objectives. For oil-fat enterprises, such integration is particularly relevant because financial outcomes are affected by multiple operational factors, including raw-material utilization, production yield, energy consumption, product quality, equipment availability, waste generation, environmental compliance, and market performance.

At the organizational-mechanism level, management research emphasizes the importance of integrating resources, influencing factors, goals, principles, functions, management methods, instruments, information technologies, and performance criteria into a coherent system. Treating these elements independently can create organizational fragmentation and reduce the effectiveness of managerial decisions. A coordinated management mechanism, by contrast, enables the enterprise to align available resources with strategic priorities and performance requirements.

These findings suggest that strategic performance management in oil-fat enterprises requires more than the introduction of a multi-perspective measurement tool. Strategic measurement must be explicitly connected with operational management, quality and safety systems, digital infrastructure, process-improvement activities, and organizational-economic mechanisms. The strategic layer therefore functions as a coordinating mechanism through which information generated by the other management domains can be translated into priorities, targets, resource-allocation decisions, and continuous-improvement initiatives.

Proposed Integrated Management Improvement Framework

Synthesizing the thematic domains identified in the literature, this study proposes an Integrated Management Improvement Framework for oil-fat industry enterprises. The framework is structured around four interdependent management pillars that collectively represent the principal dimensions of enterprise-management maturity.[18]

Pillar I: Technological and Operational Modernization.

The first pillar encompasses process instrumentation, smart sensing, predictive maintenance, artificial-intelligence-supported process optimization, production monitoring, and technological improvement across extraction, refining, and by-product-recovery operations. Its primary objective is to strengthen the technological and operational capability of the enterprise while improving production stability, resource utilization, product quality, and equipment reliability.

Technological modernization is considered within the broader context of operational management. The framework therefore emphasizes not only the acquisition of modern equipment but also the integration of technological information into production planning, process control, maintenance management, quality assurance, and managerial decision-making. The maturity of this pillar increases as enterprises move from predominantly

manual and reactive control toward automated monitoring, predictive analysis, integrated process management, and continuous technological optimization.

Pillar II: Integrated Quality, Safety, and Environmental Management.

The second pillar encompasses integrated quality-management, food-safety, occupational-health-and-safety, and environmental-management systems. It extends formal management standards toward real-time monitoring, digital quality control, traceability, risk management, environmental performance measurement, and continuous improvement.

The purpose of this pillar is to ensure that quality and compliance are not treated as isolated administrative functions but are incorporated into everyday production and management activities. A mature system integrates quality indicators, food-safety requirements, occupational-safety measures, environmental objectives, and operational performance into a unified management structure. This approach allows enterprises to identify interactions between production efficiency, resource consumption, worker safety, product quality, and environmental performance.

Pillar III: Digital Process Management.

The third pillar encompasses enterprise-wide digital infrastructure, including enterprise resource planning systems, manufacturing execution systems, Internet-of-Things technologies, cloud-based platforms, data analytics, and process-mining capabilities. It also incorporates the organizational changes required to make digitalization effective, including responsibility structures, employee training, process documentation, data governance, and managerial procedures.

The central principle of this pillar is that digital transformation should improve the visibility and controllability of enterprise processes. A mature digital-management environment enables managers to access reliable operational information, identify process deviations, analyze performance trends, monitor workflows, and support timely decision-making. Process mining and advanced analytics can additionally provide continuous insight into actual business processes and reveal inefficiencies that may not be visible through conventional reporting.

Pillar IV: Strategic Performance Management.

The fourth pillar encompasses multi-perspective strategic performance measurement and its integration with the organizational-economic management mechanism. It incorporates financial, customer, internal-process, learning and development, environmental, quality, and digital-performance indicators where appropriate to the enterprise's strategic objectives.

The purpose of this pillar is to establish a direct connection between long-term strategic objectives and day-to-day operational activities. Strategic performance indicators should therefore be derived from organizational priorities and linked to measurable operational processes. This enables management to evaluate whether technological investments, quality initiatives, digitalization projects, and process-improvement programs are contributing to broader enterprise objectives.

The four pillars are interdependent rather than independent. Technological modernization generates operational data and creates opportunities for improved process control. Integrated quality, safety, and environmental management establishes requirements and standards for the responsible operation of these processes. Digital process management connects information generated across organizational functions and converts operational data into actionable managerial knowledge. Strategic performance management then integrates these results into a coherent system of objectives, indicators, resource-allocation decisions, and improvement priorities.

Lean and process-efficiency methodologies function as cross-cutting mechanisms connecting the first three pillars. Waste reduction, process standardization, continuous

improvement, and efficiency enhancement depend simultaneously on appropriate process instrumentation, effective quality control, reliable information systems, and organizational participation. Consequently, lean management should not be viewed as a separate isolated program but as an improvement methodology that operates across technological, quality, and digital-management dimensions.

The proposed framework therefore establishes an integrated management architecture in which technological capability, quality and safety performance, digital maturity, operational efficiency, and strategic coordination reinforce one another. Its central methodological principle is that enterprise performance improvement cannot be achieved sustainably through isolated interventions. Instead, improvement should proceed through coordinated development of the enterprise's technological, organizational, digital, quality, and strategic capabilities.

To operationalize the framework diagnostically, each pillar is assessed on the five-level maturity scale presented in Table 1. An enterprise's overall management maturity can then be expressed through the conceptual Enterprise Management Maturity Index (EMMI):

$$EMMI = w1 \cdot POI + w2 \cdot QSEI + w3 \cdot DPI + w4 \cdot SPI$$

where POI, QSEI, DPI, and SPI denote the normalized (0–1) maturity scores of Pillars I–IV respectively (the Level 0–4 assessment in Table 1 divided by 4), and $w1$ – $w4$ are pillar weights summing to unity. As a starting point in the absence of enterprise-specific expert data, equal weighting ($w1 = w2 = w3 = w4 = 0.25$) is proposed; consistent with established practice in multi-criteria strategic-management design and with recent quantitative digital-maturity measurement approaches for manufacturing enterprises these weights may subsequently be refined for a given enterprise or subsector through structured expert-elicitation methods such as the Analytic Hierarchy Process. The value of the EMMI lies less in its absolute score than in its ability to identify which pillar constitutes the binding constraint on an enterprise's overall management maturity; its empirical calibration is identified in Section 3.13 as a priority for future research.[19]

Table 1. Maturity levels of the four management pillars for oil-fat industry enterprises

Pillar	Level 0: Absent/ad hoc	Level 1: Initial	Level 2: Developing	Level 3: Established	Level 4: Advanced
I. Technological-Operational	Manual, undocumented operations; no predictive maintenance	Basic mechanization; purely reactive maintenance	Partial process instrumentation; isolated sensor monitoring	Integrated smart sensing/IoT monitoring across key stages	AI-driven optimization, predictive maintenance, big-data decision support
II. Quality-Safety-Environmental	No formal quality system; end-of-line inspection only	Basic HACCP/intermal checks	Certified QMS (e.g., ISO 9001) partially implemented	Integrated ISO 9001/22000/14001/45001 system, regular audits	Industry-4.0-enabled real-time quality management and traceability
III. Digital Process Management	Paper-based records; no enterprise software	Isolated spreadsheets/local databases	Departmental software without integration	Enterprise-wide ERP/MES with documented processes	Process-mining-enabled, continuously benchmarked digital management
IV. Strategic Performance	No formal strategic planning	Annual financial planning only	Departmental KPIs without strategic linkage	Balanced-Scorecard-type multi-perspective system	Dynamic, data-integrated strategic mechanism linking BSC to real-time operations

Illustrative application to Uzbekistan's vegetable oil (oil-fat) industry

Applying the framework descriptively to Uzbekistan's oil-fat sector illustrates both the scale of opportunity and the managerial gap that the framework is designed to address. The key sector indicators are summarized in Table 2.

Table 2. Key indicators of Uzbekistan's vegetable oil and fat (oil-fat) industry

Indicator	Value	Source
Operating oil-fat enterprises	240+	Zufarov (n.d.)
Enterprises, early 1990s (baseline)	19	Zufarov (n.d.)
Sector employment	15,000+	Zufarov (n.d.)
Total annual oilseed processing (industry-association estimate)	4.39 million tonnes	Zufarov (n.d.)
of which cottonseed (industry-association estimate)	3.59 million tonnes	Zufarov (n.d.)
of which soybean and sunflower (combined)	0.8+ million tonnes	Zufarov (n.d.)
National raw-cottonseed production, independent cross-check (2023/24–2024/25)	1.14–1.18 million tonnes	USDA FAS (n.d.)
Vegetable oil production (baseline year, 2019)	~280 thousand tonnes	Zufarov (n.d.)
Oilseed meal production (baseline year, 2019)	650+ thousand tonnes	Zufarov (n.d.)
Minimum per-capita consumption norm	14 kg/year	Zufarov (n.d.)
Estimated domestic industrial demand	~250,000 tonnes/year	Zufarov (n.d.)
Exports of fats, oils, and cleavage products (2024)	US\$47.47 million	Trading Economics
National target: agro-industrial output growth (by 2026)	1.5× baseline	President of the Republic of Uzbekistan
National target: additional agricultural export potential	+US\$1 billion	President of the Republic of Uzbekistan

Note: the industry-association processing estimate (Zufarov, n.d.) and the independent USDA FAS raw-cottonseed production estimate are not directly comparable, as they measure different quantities (total processed seed intake vs. a single season's domestic harvest); both are reported for transparency. Vegetable oil and meal output refer to 2019, the most recent year for which a full sectoral breakdown is publicly available.

Two features of these data are particularly important for interpretation. First, the sector's rapid expansion from a small base means that it now combines newer, foreign-investment-backed processing facilities with many smaller, long-established enterprises, so managerial maturity is likely to vary widely within the industry. Second, the industry-association processing estimate and the independent USDA FAS raw-cottonseed figure differ markedly. The most plausible explanation is that the two statistics measure different quantities, namely total seed intake processed by fat-and-oil enterprises (including seed drawn from stocks, other regions, or prior harvests) versus a single season's domestic harvest. Publicly available sources do not fully reconcile this discrepancy, so it is reported as a genuine data-quality limitation of the sector-level evidence base (see Section 3.13) rather than resolved artificially. This finding is itself managerially meaningful: without reliable, enterprise-level operational data, neither policymakers nor managers can accurately benchmark capacity utilization, which underlines the importance of digital process management. Moreover, when the modest current export value is set against the national export-expansion and output-growth targets, it becomes clear that substantial managerial, and not only technological, upgrading will be required.

Assessed qualitatively against the four framework pillars, Uzbekistan's oil-fat sector displays an uneven maturity profile. Its capacity growth and the entry of investment-

backed processing facilities suggest advancing maturity in Pillar I (Technological-Operational Modernization), particularly among larger and newer enterprises, though this is likely to remain unevenly distributed across the sector. Pillar II (Quality-Safety-Environmental Management) is increasingly relevant given the sector's export orientation and the international certification expectations documented in the broader literature but sector-wide certification coverage is not reported in the available industry data, consistent with the broader international pattern of quality-management effort concentrating on operational control rather than integrated, strategically positioned systems. Pillars III and IV (Digital Process Management and Strategic Performance Management) appear, on the basis of the qualitative evidence and the organizational-economic development literature to represent the most significant constraints on overall management maturity. The scale of enterprise-wide ERP/MES adoption and Balanced-Scorecard-type strategic measurement in Uzbekistan's oil-fat enterprises is not documented in available sector reporting, suggesting that these are the pillars most likely to require the deliberate, framework-guided investment discussed in Section 3.11 if the sector is to meet the output-growth and export-expansion targets set out in national strategy.

Practical implementation roadmap

To translate the framework from a diagnostic instrument into an actionable management tool, Table 3 outlines an indicative phased implementation roadmap across the four pillars. An enterprise whose Pillar III and IV scores are the binding constraint, as appears typical in the Uzbekistan case discussed above, would prioritize the corresponding short-term actions before advancing to medium- and long-term measures, while continuing incremental improvement in pillars where it is already more mature.

Table 3. Indicative phased implementation roadmap by management pillar

Pillar	Short term (0–12 months)	Medium term (1–3 years)	Long term (3+ years)
I. Technological-Operational	Audit existing extraction/refining equipment; install baseline process sensors at critical control points	Deploy IoT monitoring and predictive-maintenance scheduling across production lines	Integrate AI-based process optimization and big-data decision-support platforms)
II. Quality-Safety-Environmental	Formalize HACCP procedures; gap-assess against ISO 9001/22000	Achieve integrated ISO 9001/22000/14001/45001 certification with regular audit cycles	Move toward real-time, Industry-4.0-enabled quality traceability
III. Digital Process Management	Consolidate departmental records into a shared digital system; define data-ownership rules	Implement enterprise-wide ERP/MES with documented process maps (Bianchini et al., 2024; Ochilov, 2026)	Adopt process mining for continuous workflow benchmarking
IV. Strategic Performance	Define core financial and operational KPIs linked to enterprise objectives	Design and roll out a Balanced-Scorecard-type multi-perspective measurement system	Integrate strategic indicators with real-time operational and digital data within a unified organizational-economic mechanism

The roadmap also highlights the cross-cutting role of lean and process-efficiency methods: staged, well-trained implementation recurs as a success factor across every pillar in the reviewed literature, from quality-system certification to digitalization and strategic measurement. This suggests that pacing and change-management capacity, not only technical or financial resources, determine an enterprise's ability to progress through the maturity levels in Table 1.

Why integration matters: interpreting the findings

Why do the reviewed management tools deliver value primarily when they are implemented in combination? The literature synthesized across Sections 3.1–3.9 provides a consistent explanation. Across technological modernization, quality and safety management, lean methods, digital process management, and strategic performance management, individual tools depend on complementary organizational conditions. Sensors and artificial intelligence require documented processes, appropriate organizational structures, and qualified personnel capable of interpreting and acting upon the information generated by these technologies. Certified quality systems can contribute to improved financial and operational outcomes only when their principles are incorporated into routine organizational practices. Manufacturing Execution System data become practically useful when clear responsibility structures, relevant performance indicators, and established procedures for data interpretation are present. Similarly, strategic scorecards require reliable operational information in order to provide meaningful and credible assessments of organizational performance.

Each management pillar therefore creates important preconditions for the effective functioning of the other pillars. Technological modernization generates operational data, quality systems provide standards and control requirements, digital process management transforms operational information into actionable knowledge, lean methods support process efficiency, and strategic performance management converts these inputs into organizational priorities and long-term objectives. The interaction among these elements explains why integrated adoption can generate results that isolated interventions may fail to achieve. This mechanism provides a strong conceptual basis for an integrated multi-pillar framework rather than a collection of independent technical recommendations.

The same reasoning explains why the oil-fat industry requires a sector-specific adaptation of an integrated management framework. The seasonality of raw-material supply, the technological complexity of extraction and refining, the safety requirements associated with processing operations, and the economic importance of by-product valorization increase the potential costs of poor coordination among operational, quality, digital, and strategic decisions. Management decisions in one area can directly influence outcomes in another. For example, technological modernization without appropriate quality controls may increase operational risks, while digitalization without organizational restructuring may generate data without corresponding managerial value. Consequently, generic management recommendations developed for the broader food-processing sector should be adapted to the technological, organizational, and economic characteristics of oil-fat enterprises rather than applied without modification.

Implications for Uzbekistan and Other Applications

The Uzbekistan case illustrates a tension that may also be relevant to other transition and developing economies with expanding oil-fat sectors. Ambitious policy-driven growth targets are being pursued alongside a sector whose managerial maturity, according to the qualitative assessment presented in Section 3.8, appears comparatively stronger in operational and technological capabilities while remaining less developed in digital process management and strategic performance measurement.

This asymmetry is important because digital and strategic-management capabilities enable enterprises to transform existing processing capacity and export opportunities into sustained organizational performance. Technological capacity alone does not guarantee

effective utilization of resources, rapid managerial response, or long-term competitiveness. For oil-fat enterprises in Uzbekistan, particularly smaller and medium-sized firms, industry associations and policymakers could therefore consider measures that strengthen digital process management and strategic performance capabilities alongside continued investment in processing technologies.

Potential measures include sector-wide digital-adoption programs, shared ERP and Manufacturing Execution System infrastructure designed for smaller enterprises, professional development programs for digital management and data analysis, and the broader introduction of Balanced-Scorecard-type strategic planning practices. Such measures could complement existing investments in extraction, refining, storage, quality control, and by-product processing. The investment-incentive framework applicable to fat-and-oil processing could also be considered as a potential mechanism for encouraging investment in digital infrastructure, management systems, workforce development, and organizational modernization.

The framework can also be extended to other agro-processing sectors that exhibit comparable structural characteristics. Because the four-pillar structure is derived from general management mechanisms rather than from oil-specific technologies alone, the framework could be adapted to seasonal and capital-intensive industries such as sugar production, flour milling, and cotton processing. In such applications, the descriptors of the technological-operational pillar would need to be modified according to sector-specific technologies, while the principles of quality management, digital process management, operational efficiency, and strategic performance management could remain broadly applicable.

Theoretical Contribution

From a theoretical perspective, the proposed framework extends the organizational-economic mechanism literature into a sector-specific management instrument for the oil-fat industry. Previous research has examined organizational-economic mechanisms in areas such as logistics management and the broader digitalization of manufacturing management. The proposed framework expands this perspective by connecting organizational-economic mechanism design with quality management, food safety, environmental management, technological modernization, digital process management, lean methods, and strategic performance management.

A central theoretical contribution is the integration of management domains that have frequently been examined independently. Quality-management research primarily focuses on standards, certification, process control, and organizational quality performance. Strategic-management research emphasizes performance measurement, strategic alignment, organizational objectives, and long-term value creation. Digitalization research concentrates on process visibility, data integration, automation, and digital maturity. The proposed framework brings these perspectives together within a common organizational-economic structure designed specifically for oil-fat enterprises.

The conceptual Enterprise Management Maturity Index provides a structured and extensible approach for representing this integration. Rather than evaluating digitalization, quality management, technological modernization, or strategic management separately, the index conceptualizes managerial maturity as a multidimensional capability. Its four-pillar structure makes it possible to identify both strengths and development gaps within an enterprise and to examine the relationships among technological, organizational, digital, and strategic capabilities.

The framework is conceptually comparable to maturity-based approaches used in process management and digital transformation research, but it extends their scope beyond digital process management alone. The proposed approach therefore contributes a broader conceptualization of enterprise maturity that reflects the specific managerial requirements of oil-fat enterprises, including production technology, quality and safety,

resource efficiency, digital coordination, organizational-economic mechanisms, and strategic performance management.

Limitations and Directions for Future Research

This study has several limitations that also establish important priorities for future research. First, the research is based on a narrative and design-oriented literature synthesis and does not include primary survey, interview, or financial data collected directly from individual oil-fat enterprises. Consequently, the Uzbekistan case presented in Section 3.8 should be interpreted as an illustrative qualitative assessment rather than as a statistically validated empirical model. The equal weighting of the four management pillars within the proposed Enterprise Management Maturity Index also remains a conceptual assumption and has not yet been empirically calibrated.

A logical next stage of research would involve collecting firm-level survey and panel data from a representative sample of oil-fat enterprises. Such data could be used to examine differences in managerial maturity across enterprises, identify relationships between individual management pillars, and empirically determine appropriate pillar weights. Fixed-effects panel models, structural equation modeling, expert-elicitation methods, or other appropriate quantitative techniques could be applied depending on the structure and availability of the data. Empirical validation would also make it possible to refine the maturity levels and establish measurable indicators for each pillar.

Second, the sector-level statistics used in the Uzbekistan illustration rely substantially on an industry-association source rather than on a fully independently audited academic dataset. A comparison with independent international agricultural and trade data identified a substantial discrepancy concerning cottonseed volumes, while the publicly available documentation does not provide sufficient evidence to resolve the difference conclusively. Future research should therefore strengthen the statistical foundation of the framework by systematically cross-referencing industry information with Uzbekistan's official state statistics, relevant ministries, customs data, international agricultural databases, and other independently verifiable sources.

Third, the framework has been illustrated through a single national case. Although Uzbekistan provides a relevant context for examining management transformation in a developing and transition economy, application to additional oil-fat-producing countries would provide stronger evidence concerning the generalizability of the proposed model. Comparative studies could examine enterprises operating under different regulatory, technological, institutional, and market conditions and determine which components of the framework remain stable and which require contextual adaptation.

Finally, the Enterprise Management Maturity Index is currently designed as a diagnostic and planning instrument rather than as a predictive model. Future empirical research should investigate whether higher maturity levels are systematically associated with measurable improvements in operational efficiency, product quality, resource productivity, innovation, profitability, export performance, or other organizational outcomes. Such research would extend existing studies that examine the effects of individual quality-management certifications by evaluating the potential performance implications of an integrated multidimensional management index.

Despite these limitations, the proposed framework provides managers, industry associations, and policymakers with a structured and literature-grounded basis for identifying managerial capability gaps and prioritizing improvement initiatives. Its principal value lies in treating technological modernization, quality and safety management, lean efficiency, digital process management, and strategic performance management as interconnected components of a single organizational-economic system. This integrated perspective provides a foundation for subsequent empirical testing, sectoral adaptation, and practical implementation in oil-fat enterprises and other agro-processing industries.[20]

4. Conclusion

This study developed an integrated methodological framework for improving the management of vegetable oil (oil-fat) industry enterprises, motivated by the observation that technological and quality-management innovation in the sector has outpaced the modernization of the management methodologies needed to exploit it. The synthesis of recent international literature showed that technological, quality, lean, digital, and strategic management tools create lasting value only when they are embedded in a deliberately coordinated management mechanism rather than adopted in isolation. On this basis, the study proposed an Integrated Management Improvement Framework built on interdependent pillars of technological-operational modernization, integrated quality-safety-environmental management, digital process management, and strategic performance management, supported by a conceptual Enterprise Management Maturity Index, a staged maturity scale, and a phased implementation roadmap. Its illustrative application to Uzbekistan indicated that the managerial capability of oil-fat enterprises is comparatively stronger in operational and technological terms than in digital process integration and strategic performance measurement, and that closing this gap is likely to be decisive for turning national growth targets into sustained enterprise performance. The research contributes to science by bringing together technological, quality-related, digital, and strategic strands of management literature, which are usually studied separately, into a single sector-adapted diagnostic and planning instrument, and by extending organizational-economic mechanism theory to the oil-fat industry, while future research should validate the framework with firm-level data and test it in other expanding oil-producing economies.

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