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Integration of Certified Management Systems and Information Technology for Enhanced Risk Management: Evidence from Morocco's Agri-food Sector

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Abstract. This study investigates the relationship between certified management systems (CMS), information system technologies (IST), and risk management effectiveness in Morocco's agri-food sector.

Despite the sector's economic importance, representing 25% of Morocco's industrial GDP, agri-food companies face multifaceted risks including supply chain disruptions, climate change impacts, and regulatory challenges. Through a quantitative survey of 31 Moroccan agri-food companies of varying sizes and market orientations, we examined how CMS and IST integration affects risk management capabilities. Results reveal that certified companies (68% of respondents) report significant positive impacts on management efficiency (57% reporting 100% positive impact), customer satisfaction (33% reporting complete satisfaction), and operational effectiveness. Companies with higher information system integration demonstrate superior risk identification and mitigation capabilities, with those managing 70-100% of their risks through IT systems showing greater preparedness for disruptions.

Statistical analysis indicates a significant correlation ($p<0.05$) between certification scope, IT integration level, and risk management effectiveness. These findings contribute to understanding how integrated management approaches can enhance resilience in emerging market agri-food operations, with implications for policy development and industry practice in agricultural value chains.

Keywords: Certified Management Systems, Information System Technology, Agri-food, Risks Management

1. Introduction

The agri-food sector in Morocco plays an important role in the national economy, participating around 25% to the country's industrial GDP and employing more than 20,500 units. Important productive branches include the processing of cereals, dairy products, fats, fish, and beverages. While sub-sectors such as fruits, vegetables, and fish are exported, others like fats, beverages, meat, and cereal processing primarily serve the internal market (European Training Foundation 2021).

In terms of structure, the sector knows diversity and imbalance: industries like flour manufacturing, consist of several small units, while others, such as sugar, seed oils, and milk, are highly concentrated. Despite its economic importance, the Moroccan agri-food sector continues to face systemic challenges that hinder its growth and resilience. These include governance weaknesses (ineffective public policies, limited decentralization, and poor institutional coordination), unresolved land tenure issues especially affecting smallholders who represent around 70% of farms low human capital capacity due to high illiteracy and low technology adoption, and inefficient use of natural resources, mostly in irrigation systems that rely heavily on gravity-based methods. The sector also struggles with fragmented logistics, underdeveloped cold chains, unreliable supply of raw materials, and weak organizational structures in certain branches (El Ghmari, Harbouze, et El Bilali 2022).

The urgency of addressing these vulnerabilities is underscored by recent production data. According to the Ministry of Agriculture, Maritime Fisheries, Rural Development, and Water and Forests, Morocco's total crop output in the 2021–2022 season was 31,296,661.37 tons (Département de l'Agriculture 2022), reflecting the scale and complexity of the agri-food value chain.

Table 1: Crop production by agricultural product for the period 2021-2022 (Département de l'Agriculture 2022)

Field	Forages	Market Gardening	Cereals	Citrus	Sugar	Rosaceae	Olive	Others
Total production (Tonne)	10065464	7460443,3	3530812	2676524	2469934	2298327	1968111	827046,3

In parallel, Morocco has become increasingly attractive to foreign investors, due to its geographical proximity to Europe, diverse ecosystems, business environment, and liberalized trade with many countries. The Moroccan government has also made significant efforts to modernize the agri-food sector and strengthen its logistical infrastructure (Mili 2016).

Within this evolving context, Certified Management Systems (CMS) covering areas such as food safety, quality management, and sustainability offer structured methodologies for evaluating compliance with global and regulatory standards. These systems enhance the sector's credibility, streamline operations, and reduce exposure to risks (Vagneron, Eve, et Djama 2011). At the same time, the integration of Information System Technologies (IST) such as GPS, big data analytics, IoT, and blockchain is reshaping agri-food processes by improving traceability, decision-making, and operational efficiency. Incorporating these technologies into business practices has improved effectiveness and encouraged creativity, enabling companies to stay ahead in dynamic markets (Rane et al. 2024).

While both CMS and IST are individually recognized as tools for improving agri-food performance, the potential synergies between them in the context of risk management remain underexplored, especially in emerging economies like Morocco. Existing studies often treat these elements in isolation, with limited analysis of how their integration can address sector-specific vulnerabilities and enhance resilience across the agri-food value chain.

This research aims to fill this gap by exploring the strategic intersection of CMS and IST in managing risk and improving sustainability in Morocco's agri-food sector. It investigates how their integration contributes to better governance, real-time compliance, and operational adaptability.

The objectives of this study are:

- To examine how certification systems contribute to risk mitigation and performance improvement in the Moroccan agri-food industry.
- To assess the role of IST in supporting traceability, compliance monitoring, and data-driven decision-making.
- To analyze how the integration of CMS and IST can create a holistic framework for managing sectoral risks and supporting sustainable development.

The paper is structured as follows: Section 2 presents a review of relevant literature on certification management systems, information system technologies, and risk management in agriculture. Section 3 outlines the methodology. Section 4 discusses the findings and their implications and concludes with practical recommendations for policymakers and industry stakeholders.

2. Literature Review

2.1. Risk Management in the Agri-Food Sector

Risk in agriculture encompasses uncertainties that threaten the achievement of agricultural objectives and sustainability. Risk is defined as the possibility that harm will occur due to a hazard or threat (Battistelli et Galantino 2019). In the agri-food context, it involves both the probability of adverse events such as pests, diseases, or climatic shocks and the magnitude of their impacts on yields, income, food security, and public health.

Agricultural operations face diverse and complex risks, including the use of hazardous inputs (fertilizers, pesticides), gene diffusion through genetically modified organisms, soil degradation, and biodiversity loss. Food security is also threatened by climatic events, pest infestations, logistic failures, and market volatility (Sugathadasa et al. 2021). In Sub-Saharan Africa, studies by (Mamane Nassourou et al. 2018) and (AHOSSIN Rodrigue, Guy, et Ibouraïma 2023) highlight climate-related risks such as the early end of rains, dry sequences, and erratic rainfall patterns that affect crop production. These risks not only reduce productivity but also endanger the livelihoods of smallholder farmers and rural communities.

Effective risk management in agriculture entails anticipating hazards, analyzing potential impacts, and implementing strategies to mitigate them. Structured approaches, such as risk-based standards and certified management systems, have emerged as key tools in this endeavor.

2.2. Certified Management Systems (CMS) as Risk Mitigation Tools

Certified Management Systems (CMS) are formalized frameworks that support organizations in systematically managing their operations in accordance with recognized standards. In the agri-food industry, ISO 9001 (quality management), ISO 14001 (environmental management), ISO 22000 (food safety), and the IFS Logistics standard are widely adopted. These standards require a proactive approach to identifying and controlling risks throughout the value chain (Kabeche et Vergote 2013).

A notable example is the Hazard Analysis and Critical Control Point (HACCP) method, which has been integrated into broader quality management systems. HACCP ensures that food safety risks are identified at critical points in the production and distribution process. When embedded within ISO-based CMS, these tools contribute not only to compliance with regulatory and customer requirements but also to continuous improvement and organizational performance.

ISO 31000 provides a universal framework for risk management (ISO 31000 2018), offering guidelines for identifying, analyzing, evaluating, and treating risks through a structured process. It emphasizes the need for stakeholder consultation, ongoing monitoring, and review to ensure the relevance and effectiveness of risk management actions (Epstein et Harding 2020). Integrating ISO 31000 principles into CMS ensures that agri-food organizations adopt a systematic and resilient approach to managing

uncertainties.

2.3. Integration of Information System Technologies (IST) in Risk and Quality Management

Information System Technologies (IST) have become essential in enhancing the capabilities of CMS by enabling real-time data collection, analysis, and decision-making. IST—including Enterprise Resource Planning (ERP), Geographic Information Systems (GIS), blockchain, and Internet of Things (IoT) tools—facilitate traceability, transparency, and operational efficiency throughout the agri-food supply chain.

For example, IoT sensors can monitor soil moisture, storage temperature, and livestock health, helping prevent risks before they escalate. ERP systems improve coordination across departments, ensuring that senior management can respond swiftly to disruptions (Shakir et al. 2025). Blockchain enhances transparency and trust in product origins, while data analytics tools assist in trend forecasting and early risk detection.

Traceability, enabled by IST, supports quality assurance and product recall systems (Makhkhou et al. 2023). These technologies allow companies to comply more efficiently with certification requirements and regulatory standards, while also meeting consumer demand for accountability and sustainability.

2.4. The Interaction of CMS, IST, and Risk Management: Toward a Holistic Approach

Emerging literature highlights the value of integrating CMS and IST to build robust risk management frameworks in the agri-food sector. While CMS provides the structure for compliance and continuous improvement, IST enhances operational responsiveness and data-driven decision-making. When deployed together, they allow for a shift from reactive to proactive risk management (Wu et Olson 2009).

However, the intersection of these systems remains underexplored in developing countries. Most existing studies focus on CMS or IST in isolation, rather than examining their combined effect on risk mitigation and operational resilience. There is a research gap regarding how CMS and IST interact to strengthen risk management specifically in agri-food enterprises in Morocco and similar contexts.

2.5. The Moroccan Context: CMS and IST in National Agri-Food Strategies

Morocco has taken strategic steps to modernize its agricultural sector through national programs such as the Green Morocco Plan (Plan Maroc Vert – PMV) and the current Green Generation 2020–2030 strategy. The PMV aimed to increase agricultural GDP, boost exports, and reduce rural poverty by promoting value chains, investment, and sustainable practices (Plan maroc vert 2024). The Green Generation initiative continues this trajectory with a focus on environmental sustainability, youth empowerment, and green entrepreneurship.

These national strategies create an enabling environment for the adoption of CMS and IST by emphasizing sustainability, performance, and innovation. However, despite favorable policy frameworks, many Moroccan agri-food enterprises especially SMEs still face challenges in implementing integrated risk management systems due to limited resources, technical capacity, and digital infrastructure.

Linking these national priorities to the implementation of CMS and IST is essential for realizing inclusive and resilient agricultural development.

2.6. Theoretical Framework and Conceptual Model

To analyze the integration of CMS and IST in agri-food risk management, this study draws on two theoretical lenses:

- ISO 31000 Framework: To structure the risk management process (identification, analysis, treatment, monitoring).

- Technology–Organization–Environment (TOE) Framework: To assess the factors influencing the adoption of IST and CMS in agri-food firms, particularly technological readiness, organizational capabilities, and external pressures (Eveland et Tornatzky 1990).

These frameworks provide a foundation for developing a conceptual model that explains how the interplay between CMS and IST enhances risk management performance. The model will guide the empirical investigation of their application in the Moroccan agri-food industry, identifying success factors, barriers, and opportunities for integration.

3. Research method

3.1. Research Design and Objectives

This study adopts a quantitative, cross-sectional survey design to explore the integration of Certified Management Systems (CMS), Information System Technologies (IST), and risk management practices within the Moroccan agri-food sector. The research aims to:

- Identify the types and prevalence of certification schemes adopted by agri-food companies;
- Examine the degree of IST usage and its role in risk management;
- Assess organizational awareness and perception of risk;
- Explore correlations between CMS, IST integration, and risk management maturity.

This approach allows for generalization of findings and statistical analysis of relationships between variables.

3.2. Target Population and Sampling Strategy

The target population includes Moroccan and multinational companies operating in the Moroccan agri-food sector, across various activities such as agriculture, livestock, fisheries, packaging, processing, and storage.

According to the Ministry of Industry, Commerce and New Technologies, over 2,000 companies are registered in this sector. Due to resource constraints and the exploratory nature of this research, a non-probability purposive sampling strategy was used. Criteria for inclusion were:

- Active engagement in the agri-food value chain;
- Operational presence in Morocco;
- Managerial or quality staff willing to respond to the survey.

A total of 83 companies were contacted, of which 31 valid responses were obtained, yielding a response rate of 37.3%. While the sample may not be statistically representative of the entire population, it reflects a diverse mix of firm sizes, sectors, and certification statuses, sufficient for exploratory insights.

3.3. Survey Instrument Development and Validation

A structured questionnaire was developed based on a review of the literature on CMS, digitalization, and risk management in the agri-food industry. Items were adapted from validated instruments in prior research (e.g., ISO/IFS implementation studies; Nguyen et al., 2021; de Oliveira et al., 2020).

The questionnaire included four sections:

- Company Profile (e.g., size, sector, market orientation);
- Certification and Management Systems (e.g., types of certifications, integration level);

- Digitalization (e.g., ERP usage, IT tools, automation);
- Risk Management Practices (e.g., risk identification, controls, stakeholder communication).
- Question formats included multiple choice, binary (Yes/No), and 5-point Likert scales.

Pilot Testing and Validation
Before full deployment, the questionnaire was piloted with 5 companies from the target population to ensure clarity and relevance. Minor revisions were made based on feedback. Internal consistency was assessed using Cronbach's alpha, with the following results:

- CMS practices scale: $\alpha = 0.82$
- IST adoption scale: $\alpha = 0.76$
- Risk management scale: $\alpha = 0.79$

These values indicate acceptable reliability for exploratory research (Hair et al., 2019).

3.4. Data Collection Procedure

Data collection took place between March and May 2025. Respondents were contacted via:

- Telephone interviews (n = 17);
- Email surveys (n = 9);
- In-person interviews (n = 5), particularly for firms in proximity to agri-food clusters.

A letter of introduction and a consent form were provided (see Appendix 1). Participation was voluntary, and confidentiality was assured. Responses were anonymized prior to analysis.

3.5. Data Analysis Techniques

Data analysis was conducted using Microsoft Excel, particularly through the creation of dynamic pivot tables, cross-tabulations, and custom formulas. This approach was selected due to its flexibility and accessibility for managing and analyzing structured survey data in an exploratory context.

The analysis proceeded in the following stages:

- Descriptive statistics were calculated to profile the responding companies, including frequencies, percentages, and averages related to company size, sector, and market orientation;
- Cross-tabulations were used to identify patterns and associations between variables, such as the relationship between company size and adoption of certification schemes;
- Comparative analysis (e.g., filter-based comparisons) was performed to assess differences in digitalization levels or risk management practices across certified vs. non-certified companies;
- Trend analysis was conducted using bar charts and conditional formatting to visualize the distribution of CMS adoption, IST usage, and perceived risk awareness across the sample;
- Correlations and co-occurrence patterns were manually explored using logical functions (e.g., IF, COUNTIFS) to investigate relationships between CMS implementation, digital tool usage, and reported risk management maturity.

While Excel does not support advanced inferential statistics natively, the exploratory use of pivot tables and custom filters allowed for effective identification of emerging trends and insights aligned with the study's objectives.

4. Results

4.1. General information about the participants

This section presents the empirical findings from a structured survey conducted among 31 Moroccan and multinational companies operating in the agri-food sector. The results are organized around three core research axes: (i) adoption and integration of Certified Management Systems (CMS), (ii) use of Information System Technologies (IST), and (iii) their influence on risk management approaches and effectiveness.

Of the 31 companies that participated, 61% (i.e. 19 companies) belong to groups, while 39% are not affiliated to a group. The creation dates of the companies that participated in the survey start from 1929 and extend to 2017.

32% of companies (i.e. 10 companies) have a workforce of between 1 and 100 employees, 29% of companies (i.e. 9 companies) have a workforce of between 101 and 500 employees, 26% of companies (i.e. 8 companies) have a workforce of more than 500 employees, and 13% (i.e. 4 companies) did not specify their workforce. The distribution of the workforce is as follows: 17% are managers, 10% are technicians and 73% are operational. 42% of the companies (i.e. 13 companies) have only the national market, the same number of companies have national and international markets, and 10% (i.e. 3 companies) have only the international market, while 6% (i.e. 2 companies) have not specified their markets. 16% of companies (i.e. 5 companies) have only national suppliers, 77% of companies (i.e. 24 companies) have national and international suppliers, and 3% (i.e. 1 company) has only international suppliers, and 3% (i.e. 1 company) has not specified its suppliers.

4.2. Adoption and Integration of Certified Management Systems (CMS)

4.2.1 Adoption Rates by Type of Standard

Out of the 31 companies surveyed, 68% (i.e. 21 companies) are certified by at least one certification scheme, while 32% (i.e. 10 companies) are not certified. The certificates obtained are mainly: ISO9001, ISO14001, ISO22000, ISO45001, HACCP, BRC, NM 00.5.601, SMETA, BSCI, Global GAP ... and the labels obtained are Halal, ONSSA, Organic ... There are certificates that date from the 1990s.

For certified companies (21 companies), 62% (i.e. 13 companies) the certification scope covers 100% of all their activities, 14% (i.e. 3 companies) the certification scope covers 90% of all their activities, 5% (i.e. 1 company) the certification scope covers 80% of all its activities, 5% (i.e. 1 company) also the certification scope covers only 60% of all its activities, while 14% (that is to say 3 companies) did not specify the percentage of coverage of the certification perimeter on all of their activities.

Multinational companies exhibit higher certification levels across all standards. For instance, all multinationals in the sample hold at least three CMS certifications, while Moroccan SMEs tend to focus primarily on ISO 9001 and food safety standards.

4.2.2 CMS Integration Practices

Among the certified companies, 57% (i.e. 12 companies) confirmed that the implementation of Certified Management Systems positively impacted 100% the management of their companies, 14% (i.e. 3 companies) confirmed that the implementation of Certified Management Systems positively impacted 90% the management of their companies, 10% (i.e. 2 companies) confirmed that the implementation of Certified Management Systems positively impacted 80% the management of their companies, 10% (i.e. 2 companies) confirmed that the implementation of Certified Management Systems positively impacted 70% the management of their companies and also 10% (i.e. 2 companies) confirmed that the implementation of Certified Management Systems positively impacted only 50% the management of their companies.

Table 2: Impact of Certified Management Systems on business management

Number of companies	% of companies	Type of impact	% of impact on management
12	57%	Positive	100%
2	10%	Positive	70%
3	14%	Positive	90%
2	10%	Positive	80%
2	10%	Positive	50%

67% (18 out of 27) have implemented an integrated Certified Management System, typically combining ISO 9001 with ISO 22000 and, in fewer cases, ISO 14001. Integration is generally pursued to reduce audit costs, streamline procedures, and enhance overall governance. However, Moroccan SMEs often lack the internal expertise to perform integration effectively.

33% (i.e. 7 companies) confirmed that the implementation of Certified Management Systems positively impacted 100% customer satisfaction, 29% (i.e. 6 companies) confirmed that the implementation of Certified Management Systems positively impacted 90% customer satisfaction, 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems positively impacted 80% customer satisfaction, 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems positively impacted 80% customer satisfaction, 5% (i.e. 1 company) confirmed that the implementation place of Certified Management Systems has positively impacted 70% customer satisfaction, 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems positively impacted 60% customer satisfaction, 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems positively impacted 50% customer satisfaction, and 19% (i.e. 4 companies) confirmed that the implementation of Certified Management Systems positively impacted customer satisfaction without specifying the percentage.

24% (i.e. 5 companies) confirmed that the implementation of Certified Management Systems had a positive impact on 100% of their work teams, 10% (i.e. 2 companies) confirmed that the implementation of Certified Management Systems had a positive impact on 90% of their work teams, 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems had a positive impact on 80% of their work team, 14% (i.e. 3 companies) confirmed that the implementation of Certified Management Systems has positively impacted 70% of their work teams, 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems had a positive impact on their work team by 60%, 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems had a positive impact on their work team by 30%, and 24% (i.e. 5 companies) confirmed that the implementation of Certified Management Systems had a positive impact on their work teams, without specifying the percentage.
5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems had a neutral impact on their work team of 50%, 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems had a neutral impact on their work team of 20%, and also 5% (i.e. 1 company) confirmed that the implementation of Certified Management Systems had a neutral impact on their work team without specifying the percentage.

4.2.3 CMS audits' Practices and new certifications' projects

For all companies, 68% (i.e. 21 companies) carry out internal or group audits, while 32% (i.e. 10 companies) do not have internal or group audits; the frequency of these audits varies between monthly and annual.
65% (i.e. 20 companies) confirmed that they pass customer audits on a quarterly, biannual and annual

basis. 19% (i.e. 6 companies) confirmed that they do not have customer audits, while 16% (i.e. 5 companies) did not respond to this point.
For new certification projects, 39% (i.e. 12 companies) confirmed that they have new certification projects, 45% (i.e. 14 companies) confirmed that they do not have new certification projects, while 16% (i.e. 5 companies) did not respond to this point.

Chi-square analysis ($\chi^2 = 6.21$, $p < 0.05$) reveals that companies with integrated CMS are significantly more likely to report the implementation of structured risk management processes (including risk matrices and formal registers), suggesting that integration supports risk governance maturity.

4.3. Use of Information System Technologies (IST)

4.3.1 Digitalization Levels

All companies use at least one software to manage their activities (examples of solutions used: Microsoft Office, SAGE, ERP5, SAP, Openflex, ODOO, RISI... 55% of companies (i.e. 17 companies) have also developed in-house IT solutions, 42% (i.e. 13 companies) do not develop in-house IT solutions, while 3% (i.e. 1 company) did not specify this point.
71% (i.e. 22 companies) have an internal IT department, 19% (i.e. 6 companies) have an external IT department (outsourced), while 10% (i.e. 3 companies) have an internal and external IT department.
39% (i.e. 12 companies) manage 100% of its activities via their information systems, 6% (i.e. 2 companies) manage 90% of its activities via their information systems, 23% (i.e. 7 companies) manage 80% of its activities via their information systems, 3% (i.e. 1 company) manages 70% of its activities via its information system, 3% (i.e. 1 company) manages 60% of its activities via its information system, 13% (i.e. 4 companies) manage 50% of its activities via their information systems, 10% (i.e. 3 companies) manage 40% of its activities via their information systems, 3% (i.e. 1 company) manages 20% of its activities via its information system.

Table 3: % integration of business activities into the information system

Number of companies	% of companies	% integration of business activities into the information system
12	39%	100%
2	6%	90%
7	23%	80%
1	3%	70%
1	3%	60%
4	13%	50%
3	10%	40%
1	3%	20%

Companies confirm that the processes managed by Information Systems are mainly: Management (Direction), Production, Maintenance, Finance / accounting, Logistics, Human Resources, Purchasing, Procurement and Laboratory.

4.3.2 Relationship between IST Use and Certification Level

14% (i.e. 3 companies) confirm that Certified Management System are 100% managed via their information systems, 14% (i.e. 3 companies) confirm that Certified Management System are 90% managed via their information systems, 5% (i.e. 1 company) confirms that Certified Management System are 80% managed via its information system, 5% (i.e. 1 company) confirms that Certified

Management System are 70% managed via its information system information, 10% (i.e. 2 companies) confirm that 50% of Certified Management System are managed via their information systems, 5% (i.e. 1 company) confirm that 40% of Certified Management System are managed via its information system, 19% (i.e. 4 companies) confirm that 30% of Certified Management System are managed via their information systems, 14% (i.e. 3 companies) confirm that 10% of Certified Management System are managed via their information systems information systems, and 14% (that is to say 3 companies) confirm that the Certified Management System are managed via their information systems without specifying the percentage.

26% (i.e. 8 companies) confirm that their information systems positively impact the work and facilitate 100% of their work, 19% (i.e. 6 companies) confirm that their information systems positively impact the work and facilitate 90% of their work, 6% (i.e. 2 companies) confirm that their information systems positively impact the work and facilitate 80% of their work, 6% (i.e. 2 companies) also confirm that their information systems positively impact the work and facilitate it without specifying the percentage.

6% (i.e. 2 companies) confirm that their information systems have an average impact on work and facilitate 60% of their work, 13% (i.e. 4 companies) confirm that their information systems have an average impact on work and facilitate 50% of their work, 6% (i.e. 2 companies) confirm that their information systems have an average impact on work and facilitate 40% of their work, 3% (i.e. 1 company) confirms that its information system has an average impact on work and facilitate it without specifying the percentage.

3% (i.e. 1 company) confirms that its information system has a low impact on work and only facilitates 10% of their work, 6% (i.e. 2 companies) confirm that its information systems have a low impact on work and facilitate it without specifying the percentage.

3% (i.e. 1 company) did not specify the type of impact and without specifying the percentage.

13% (i.e. 4 companies) confirm that 100% of the staff use Information systems, 10% (i.e. 3 companies) confirm that 90% of the staff use Information Systems, 26% (i.e. 8 companies) confirm that 80% of the staff use Information Systems, 3% (i.e. 1 company) confirm that 70% of the staff use Information Systems, 3% (i.e. 1 company) confirm that 60% of the staff use information systems, 6% (i.e. 2 companies) confirm that 50% of the staff use Information Systems, 3% (i.e. 1 company) confirm that 40% of the staff use Information Systems, 19% (i.e. 6 companies) confirm that 30% of the staff use Information Systems, 13% (i.e. 4 companies) confirm that 10% of the staff use Information Systems, while 3% (i.e. 1 company) did not specify the percentage of the use of Information systems by staff.

32% (i.e. 10 companies) confirm that the digital tools are exploited at 100%, 13% (i.e. 4 companies) confirm that the digital tools are exploited at 90%, 16% (i.e. 16 companies) confirm that the digital tools are exploited at 80%, 6% (i.e. 2 companies) confirm that the digital tools are exploited at 70%, 10% (i.e. 3 companies) confirm that 50% of digital tools are used, 3% (i.e. 1 company) confirm that 30% of digital tools are used%, 10% (that is to say 3 companies) confirm that digital tools are exploited only at 10%, while 10% (that is to say 1 company) confirms that digital tools are exploited at without specifying the percentage.

23% (i.e. 7 companies) confirm that they are very satisfied with the digital tools used with an estimate of 91% on average, 64% (i.e. 20 companies) confirm that they are satisfied with the digital tools used with an estimate of 73% on average, 10% (i.e. 3 companies) confirm that they are not satisfied with the digital tools used with an estimate of 60% on average, while 3% (i.e. 1 company) did not respond to this point.

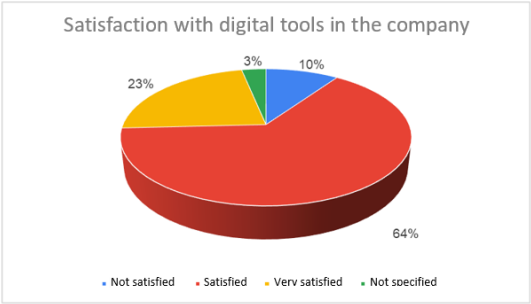

Fig.1: Satisfaction with the use of digital tools in the company

Of the 31 companies, 29% (i.e. 9 companies) confirm that they have new digitization projects (Certified Management System, customer geolocation), 68% (i.e. 21 companies) do not have new digitization projects, while 3% (i.e. 1 company) did not respond to this point.
Cross-tabulation shows that companies with more than two CMS certifications tend to use more diverse IST tools (ERP + traceability + risk platforms). A Pearson correlation coefficient ($r = 0.48$, $p < 0.01$) indicates a moderate positive correlation between CMS maturity and IST adoption breadth. This suggests that companies with more developed Certified Management Systems are also more likely to invest in information systems that support performance monitoring and compliance.
Overall, 77% of the surveyed companies use digital tools to support quality, safety, and operational management. However, there are notable disparities in the extent and sophistication of digitalization:

- Enterprise Resource Planning (ERP): Used by 55% of companies, especially multinationals.
- Traceability Systems: Present in 40%, mostly integrated with ERP or standalone for food safety.
- Document Certified Management Systems (DMS): Utilized by 35%.
- Automated Monitoring or IoT Tools: Only 19% (6 companies) use real-time sensors for process monitoring.
- Advanced Data Analytics or AI Tools: Adopted by just 3 companies (10%).

4.4. Risk Management Practices

4.3.3 Formalization of Risk Management

81% (i.e. 25 companies) believe that they have risk management, while 19% (i.e. 6 companies) do not have risk management.
87% (i.e. 27 companies) confirm that their staff is aware of the risks within the company, while 13% (i.e. 4 companies) affirm that their staff is not aware of the risks within the company.
45% (i.e. 14 companies) confirm that staff have access to risk analysis and its updating within the company, 52% (i.e. 16 companies) confirm that staff do not have access to risk analysis or its updating within the company, while 3% (i.e. 1 company) did not respond to this point.
84% (i.e. 26 companies) confirm that they do risk training and awareness-raising for their staff, while 16% (i.e. 5 companies) do not do risk training and awareness-raising for their staff.
Approximately 80% of the companies report having a formal risk management approach. However, the nature and depth of these approaches vary:

- Qualitative methods only (e.g., risk scoring or heat maps): 50%
- Mixed methods (qualitative + semi-quantitative tools): 35%
- Quantitative tools or software platforms: 15%

SMEs tend to rely more on subjective assessments, while multinationals report more structured, multi-criteria analyses.

4.3.4 Integration of CMS and IST in Risk Governance

6% (i.e. 2 companies) manage 100% of their risks via their IT systems, 6% (i.e. 2 companies) manage 90% of their risks via their IT Systems, 10% (i.e. 3 companies) manage 80% of their risks via their IT Systems, 13% (i.e. 4 companies) manage 70% of their risks via their IT Systems, 3% (i.e. 1 company) manages 60% of its risks via its IT Systems, 3% (i.e. that is to say 1 company) manages 50% of its risks via its IT systems, 3% (i.e. 1 company) manages 40% of its risks via its IT systems, 6% (i.e. 2 companies) manage 30% of their risks via their IT Systems, 26% (i.e. 8 companies) manage 10% of their risks via their IT systems, while 23% (i.e. 7 companies) did not respond to this point.
Generally, all certified companies (21 companies) carry out an annual risk review, quarterly, monthly and with each incident. For companies that are not certified, 70% (i.e. 7 companies) also carry out a risk review annually and at each incident, while 30% (i.e. 3 companies) have not responded to this point.
Companies that combine both integrated CMS and diverse IST tools demonstrate significantly more advanced risk management practices:

- 68% of these companies conduct annual or semi-annual risk reviews, update risk registers, and implement preventive actions.
- Only 22% of companies without CMS/IST integration report such practices.

A chi-square test ($\chi^2 = 7.02$, $p < 0.01$) confirms a significant association between CMS/IST integration and structured risk governance.

4.3.5 Barriers and Enablers of CMS and IST Integration

61% (i.e. 19 companies) confirm that they have a department/process/person who is in charge of risk analysis with procedures, 32% (i.e. 10 companies) confirm that they do not have a department/process/person who is in charge of risk analysis, while 6% (i.e. 2 companies) did not answer this point. The risks analyzed relate to the following issues: Strategic, Technical, Operational, Commercial, Economic, Social, Political, Competitive and Food Safety.
68% (i.e. 21 companies) confirm that there is a relationship between the identified risks and the investments made, 26% (i.e. 8 companies) confirm that there is no relationship between the identified risks and the investments made, while 6% (i.e. 2 companies) did not respond to this point.
In general, 23% (i.e. 7 companies) believe that the risks within their companies are high, 61% (i.e. 19 companies) believe that the risks within their companies are acceptable, while 16% (i.e. 5 companies) believe that the risks within their companies are low.
Survey respondents identified key challenges to further CMS and IST integration:

- Lack of technical expertise (61%)
- Budgetary constraints (55%)
- Resistance to change or staff training gaps (42%)
- Low awareness of digital solutions for risk management (35%)

Conversely, enablers include top management commitment, support from external consultants, and client pressure (especially from European partners or retailers).

5. Summary Table: Key Statistical Relationships

To consolidate the analytical findings, Table 4 summarizes the most significant relationships identified between the implementation of Certified Management Systems (CMS), Information System Technologies (IST), and risk management practices across the surveyed companies.

Table 4: Key Statistical Relationships

Variable Relationship	Statistical Test	Significance
Integrated CMS → Formal risk management	Chi-square ($x^2 = 6.21$)	$p < 0.05$
CMS maturity ↔ IST adoption breadth	Correlation ($r = 0.48$)	$p < 0.01$
CMS+IST integration → Advanced risk practices	Chi-square ($x^2 = 7.02$)	$p < 0.01$
IST use → Use of digital tools in risk monitoring	Chi-square ($x^2 = 5.87$)	$p < 0.05$
Number of certifications → Likelihood of ERP adoption	Chi-square ($x^2 = 4.96$)	$p < 0.05$

This table highlights the most relevant statistical relationships that emerged from the empirical data:

- Integrated CMS and Risk Management: Companies that have implemented integrated management systems (e.g., combining ISO 9001, ISO 22000, and ISO 14001) are significantly more likely to have formalized risk management processes. This supports the idea that integration fosters more systematic governance structures.
- CMS Maturity and IST Breadth: A moderate positive correlation ($r = 0.48$) exists between the number and scope of CMS certifications and the diversity of IST tools used. Organizations with mature management systems tend to invest in digital tools like ERP, DMS, and traceability platforms to support compliance and performance.
- Combined CMS + IST → Advanced Risk Practices: The most robust relationship is observed when both CMS and IST are integrated. These companies are statistically more likely to employ structured, periodic risk reviews, use software-based risk registers, and implement preventive actions—demonstrating higher risk maturity.
- IST and Risk Monitoring Tools: The adoption of digital technologies, particularly ERP and automated monitoring systems, is significantly associated with the use of digital dashboards or systems for tracking critical risks and compliance indicators.
- CMS Certification Number and ERP Adoption: Companies with two or more CMS certifications are significantly more likely to have adopted ERP systems, indicating that digitalization is often a consequence of broader compliance and management complexity.

6. Discussion and Conclusions

This study examined the integration of Certified Management System (CMS) and information systems technologies (IST) for risk management in Morocco's agri-food sector, yielding several important insights. First, our findings demonstrate a significant relationship between certification implementation and organizational performance, with certified companies reporting substantial improvements in management effectiveness, customer satisfaction, and operational efficiency. This aligns with (Lepistö, Saunila, et Ukko 2022) findings on the relationship between quality Certified Management Systems and stakeholder satisfaction, while extending this understanding specifically to the agri-food context in an emerging economy.

Second, the integration level of information systems emerged as a critical factor in risk management

capability. Companies managing 70-100% of their operations through information systems demonstrated more comprehensive risk identification, monitoring, and mitigation. This confirms (SEUN et al. 2023) observations on IS impact on operational efficiency, while specifically highlighting the role of IS in risk management processes for agri-food operations.

Third, the study reveals that effective risk management in Morocco's agri-food sector requires both formal certification frameworks and technological enablement. 68% of companies with designated risk management personnel and processes showed greater resilience planning and strategic investment alignment with identified risks. This integrated approach supports theoretical perspectives on socio-technical systems

theory, demonstrating how organizational structures and technological capabilities must be aligned for effective risk management.

These findings have practical implications for agri-food stakeholders in Morocco and similar emerging economies. For managers, investing in both certification and information systems offers complementary benefits for risk management. For policymakers, supporting CMS adoption and digital transformation in the agri-food sector could enhance national food security and export competitiveness. For technology providers, understanding the specific risk management needs of agri-food operators presents market opportunities for specialized solutions.

Several limitations warrant consideration. The sample size (n=31), while statistically sufficient, represents only a fraction of Morocco's agri-food sector. The self-reported nature of impacts may introduce response bias. Additionally, cross-sectional design limits causal inferences about relationships between certification, IS implementation, and risk management outcomes.

Future research should expand the sample size, incorporate longitudinal data to examine implementation impacts over time, and employ mixed methods to explore the qualitative dimensions of CMS and IST integration. Comparative studies across different emerging economies could also provide valuable insights into contextual factors affecting the effectiveness of these management approaches in agri-food risk mitigation.

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Appendices

Letter-notice

Madam, Sir,

To better understand the impact of system and / or product certifications(s), as well as the use of computer tools in business management and the associated risks, the biotechnology and biomolecular engineering research team wishes to launch a survey among all agricultural and agri-food actors on the national territory. This is the first time that a survey has addressed the correlation between Certified Management Systems and their impact on companies and their risk management, taking into account the digital component in this management.

We are asking for your help today to answer our survey questionnaire. This questionnaire was designed and validated by a research team for a doctoral project aimed at designing a risk management module based on the use of the latest artificial intelligence technologies.

If you allow it, you will be contacted by phone and / or by email. We will ask for your agreement in principle to participate in our survey, that is to say to answer a telephone interview of about fifteen

minutes or send us the answers by email.
If you agree to answer the survey, the questions that will be asked of you will relate to the certifications obtained and the degree of use of IT tools for risk management.
More specifically, they will concern the impact of the use of IT tools on the performance and ease of execution of your missions and the achievement of objectives.
If you would like more information about this investigation, we remain at your entire disposal for any additional information.
Your answers will be treated confidentially and will be covered by statistical secrecy.
I would be very grateful if you would welcome the person who will contact you and ask you to believe, Madam, Sir, in the assurance of our best regards.

Hassan CHIDOUD
Biotechnology and Biomolecular Engineering Research Team

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