Intelligent Knowledge Management for Enhancing Sustainable Food Systems: The Case of Sweden

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Abstract: Intelligent Knowledge Management (IKM) aims to establish intelligent integration of the food system to capture, organize, analyze, and utilize information and knowledge that promotes sustainable food production. With the growing importance of sustainable food systems, understanding consumer behavior, customer needs, food preferences, producer demands, and local regulations is necessary. However, integration challenges within the Swedish food system create significant obstacles. Inappropriate Knowledge Management systems, system complexity, dynamic environments, inability to learn from and reuse data, information overload, and insufficient data collection and analysis contribute to these challenges. This study uses a case study approach and literature review to collect and analyze data. The proposed solution is an IKM conceptual model based on the knowledge-based theory of the firm, leveraging AI-powered techniques to manage and analyze large datasets from various stakeholders in the food supply chain. This model enhances forecasting and planning capabilities, improving decision-making processes. Future research should further develop the IKM system to achieve the potential results outlined in this paper.

1 INTRODUCTION

The modern food supply chain is complex and poses significant challenges, particularly regarding sustainability. It is essential to integrate and manage knowledge within these systems to support sustainable food production and consumption (Touboulic & Walker, 2015; Mensah et al., 2024).

With the global population increasing and environmental concerns becoming more prominent, there is an urgent need for efficient and sustainable food systems. This urgency is particularly evident in Sweden, where sustainability is a top national priority, and the food sector is essential to the economy and society.

Intelligent Knowledge Management (IKM) seeks to tackle these challenges by establishing a comprehensive system that captures, organizes, analyzes, and utilizes information and knowledge throughout the food supply chain. By making use of advanced technologies like Artificial Intelligence (AI) and Machine Learning (ML), IKM systems can offer actionable insights that improve decision-making, streamline processes, and encourage innovation (Mena et al., 2014; Jarrahi et al., 2023).

In Sweden, incorporating sustainable practices into the food supply chain is met with significant barriers, including the system's complexity, constantly changing environments, information overload, and inadequate data management (Garnett, 2013). These challenges underscore the need for a robust IKM system to address these issues and promote a more sustainable food system.

This paper suggests an IKM conceptual model based on the Knowledge-Based Theory (KBT) tailored to Sweden's sustainable food supply chain. The model utilizes AI-powered techniques to manage and analyze extensive datasets from various stakeholders, thereby enhancing forecasting and planning capabilities and improving decision-making processes. Through a combination of a case study and literature reviews, this research aims to demonstrate the potential benefits of implementing such a system and provide a roadmap for future sustainable food system management developments.

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The paper is structured as follows: Firstly, it describes KBT and knowledge management for sustainable food based on a thorough literature review as the theoretical foundation. It then investigates the description and analysis of sustainable food systems in Sweden. Subsequently, it presents a goal and conceptual models based on KBT and AI. Lastly, the paper outlines future research and presents the conclusion.

2 KNOWLEDGE-BASED THEORY (KBT) OF THE FIRM

KBT posits that knowledge is the most strategically significant resource of a firm. Unlike traditional resources that can be easily replicated, knowledge's unique, tacit, and complex nature provides a sustainable competitive advantage (Grant, 1996). This theory emphasizes the role of a firm's ability to create, transfer, and utilize knowledge to achieve superior performance.

According to KBT, firms exist because they are better at integrating and coordinating knowledge than markets (Kogut & Zander, 1992). Knowledge within a firm is embedded in individuals and organizational routines, processes, and cultures, making it difficult for competitors to imitate (Nonaka & Takeuchi, 1995). This inimitability is a key source of competitive advantage, as it allows firms to differentiate themselves and protect their core competencies.

The knowledge-based view also highlights the importance of dynamic capabilities, which are the firm's abilities to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments (Teece et al., 1997). Firms that continually innovate and adapt their knowledge base are more likely to succeed in the long run.

Moreover, the theory suggests that firms should invest in mechanisms to facilitate knowledge sharing and creation. This includes fostering a collaborative culture, implementing knowledge management systems, and encouraging continuous learning and development (Alavi & Leidner, 2001). Effective knowledge management can improve decision-making, innovation, and operational efficiency (Heisig, 2024).

Critics of KBT argue that it may overemphasize the role of knowledge and underappreciate other critical resources, such as physical assets and financial capital (Spender, 1996). Therefore, KBT has been selected in this research, which has significantly influenced strategic management literature and practice, particularly in industries where knowledge and innovation are paramount.

3 KNOWLEDGE MANAGEMENT FOR SUSTAINABLE FOOD SYSTEMS

Knowledge management is a strategic method that systematically gathers, organizes, shares, and analyzes knowledge within an organization (Heisig, 2024). It utilizes this knowledge to improve performance, stimulate innovation, and accomplish strategic objectives. Knowledge management can be fundamental in sustainable food systems in tackling the intricate challenges associated with sustainability, efficiency, and resilience.

Knowledge management involves various procedures and technologies crafted to tap into an organization's expertise and information. These procedures encompass knowledge generation, storage, retrieval, and distribution. Efficient knowledge management guarantees that valuable information is accessible to the appropriate individuals at the right time, facilitating informed decision-making and continual improvement (Nonaka & Takeuchi, 1995).

Knowledge management is essential for integrating diverse data sources and stakeholder viewpoints in sustainable food systems. This integration is vital for comprehending and overseeing food production, distribution, and consumption dynamics. For example, knowledge management systems can combine information from farmers, suppliers, distributors, consumers, and regulators to comprehensively view the food supply chain (Garnett, 2013). Such a comprehensive perspective is critical for pinpointing inefficiencies, minimizing waste, and promoting sustainable practices.

Despite its potential benefits, implementing knowledge management in sustainable food systems presents several challenges. These include data silos, resistance to change, absence of standardized processes, and the necessity for cultural shifts towards knowledge sharing (Davenport & Prusak, 1998). Overcoming these challenges necessitates a strategic approach that involves strong leadership, a clear knowledge management strategy, and ongoing stakeholder training and support.

Incorporating advanced technologies like AI and ML has significantly bolstered knowledge management capabilities. These technologies enable

the analysis of large datasets, the identification of patterns, and the generation of predictive insights. AI and ML can automate the extraction of knowledge from vast amounts of unstructured data, making it easier to derive actionable insights (Becerra-Fernandez & Sabherwal, 2014). For instance, AI-powered knowledge management systems in the food supply chain can forecast demand.

Knowledge management is a pivotal component of sustainable food systems, offering tools and frameworks to manage the complexity and dynamics of the food supply chain. By leveraging advanced technologies and fostering a culture of knowledge sharing, knowledge management can substantially contribute to sustainability goals. Future research and practical applications should address implementation challenges and further enhance knowledge management capabilities to support the evolving needs of sustainable food systems.

4 SUSTAINABLE FOOD SYSTEMS IN SWEDEN

Sustainability is a top priority in Sweden's efforts to promote environmental responsibility, economic viability, and social well-being. In collaboration with various stakeholders, the Swedish government has introduced several initiatives to encourage sustainability in the food industry. This part looks at the main components, obstacles, and advancements in sustainable food systems in Sweden.

Sweden has consistently prioritized sustainability, as demonstrated by its national policies and regulatory frameworks. The Swedish Food Strategy, introduced in 2017, outlines the government's vision for a sustainable food system that considers ecological, economic, and social aspects. The strategy emphasizes the importance of local food production, reduced environmental impact, and improved food security (Swedish Government, 2017).

In addition, Sweden's Environmental Objectives system establishes specific targets for reducing greenhouse gas emissions, enhancing biodiversity, and minimizing the use of harmful chemicals in agriculture. These goals are crucial for establishing a sustainable food system that aligns with the overarching objectives of the European Green Deal (Naturvårdsverket, 2020).

Collaboration among various stakeholders, including government agencies, farmers, food producers, retailers, and consumers, is essential for advancing sustainable food systems in Sweden. Organizations such as the Swedish Board of Agriculture (Jordbruksverket) and the Swedish Environmental Protection Agency (Naturvårdsverket) play pivotal roles in coordinating efforts and supporting sustainable practices.

Furthermore, initiatives such as the "From Farm to Fork" strategy underscore the significance of a comprehensive approach involving all players in the food supply chain. This strategy aims to establish a more sustainable and resilient food system by promoting sustainable farming practices, minimizing food waste, and encouraging healthy and sustainable diets (European Commission, 2020).

Technological innovation and research drive sustainability in Sweden's food systems. Advances in precision agriculture, biotechnology, and digitalization have enabled more efficient and sustainable farming practices. For example, using drones and sensors for precision farming helps optimize resource utilization, reduce environmental impact, and enhance crop yields (Swedish University of Agricultural Sciences, 2021).

Research institutions and universities in Sweden, such as the Swedish University of Agricultural Sciences (SLU), are actively involved in studying and advocating for sustainable food production methods. Their research contributes to developing new technologies and practices that support sustainable agriculture and food systems.

Despite significant progress, Sweden still faces several challenges in establishing a sustainable food system. These challenges include dealing with the impact of climate change, finding the right balance between productivity and sustainability, and ensuring that everyone has fair access to sustainable food. The integration challenges within Sweden's sustainable food system have proven to be a significant obstacle. One contributing factor to this challenge might be the inappropriate Knowledge Management systems. Other factors include the system's complexity and large scale, dynamic environment, the inability to learn from and reuse data, information overload, and inadequate data collection and analysis. As a result, a problem model (refer to Figure 1) has been developed to illustrate the causes and effects of the identified problems in Sweden's sustainable food system. These identified problems also present opportunities for innovation and enhancement. By continuing to invest in research and development, fostering collaboration among stakeholders, and implementing robust policies, Sweden can further enhance the sustainability of its food systems and serve as a model for other countries.

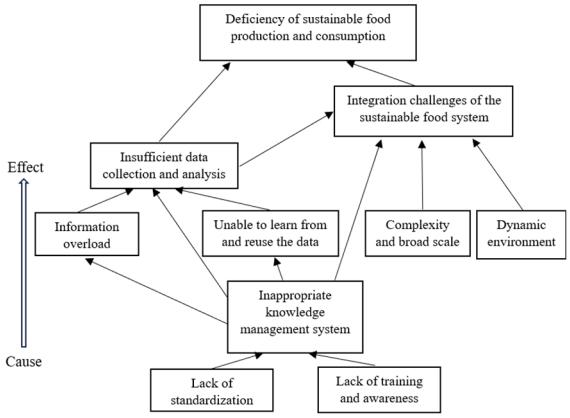

Figure 1: Problem model.

5 INTELLIGENT KNOWLEDGE MANAGEMENT (IKM)

IKM represents a transformative approach to managing the complex and dynamic information flows within organizations and systems, particularly in the context of sustainable food systems. IKM integrates advanced technologies, such as AI, ML, and big data analytics, to enhance the capabilities of traditional knowledge management systems (Jarrahi et al., 2023). This integration aims to improve decision-making processes' efficiency, accuracy, and effectiveness by leveraging vast amounts of data and converting it into actionable insights. IKM builds on the foundational principles of KM but significantly extends its scope and capabilities through intelligent technologies. The core components of IKM are defined in Table 1.

Table 1: Key components of IKM.

KeyComponents	Define
Data Collection and Integration	IKM systems are designed to collect data from various sources, including databases, social media, sensors, and transactional records. Integrating these diverse data sources allows for a comprehensive view of the system being managed (Bhimani & Willcocks, 2014).
Data Analysis and Interpretation	Advanced analytics and AI algorithms are employed to analyze the collected data. Machine learning techniques can identify patterns, predict trends, and provide insights that would be difficult or impossible to detect using traditional methods (Chen et al., 2012).

Table 1: Key components of IKM (cont.).

Knowledge Creation and Storage	The insights generated through data analysis are transformed into knowledge and then stored in a centralized knowledge repository. This repository ensures that knowledge is accessible to all relevant stakeholders and can be reused and updated as new data becomes available (Nonaka & Takeuchi, 1995).
Knowledge Sharing and Utilization	IKM emphasizes the importance of sharing knowledge across organizational boundaries. Collaboration tools, digital platforms, and communication channels facilitate the dissemination of knowledge, enabling stakeholders to make informed decisions quickly and effectively (Alavi & Leidner, 2001).
Continuous Learning and Adaptation	One of the key features of IKM is its ability to learn from new data and adapt to changing conditions continuously. Feedback loops ensure that the system evolves and improves over time, enhancing its resilience and responsiveness (Teece, 2007).

In the context of sustainable food systems, IKM plays a crucial role in addressing the challenges associated with food production, distribution, and consumption. Applying IKM can lead to more sustainable practices by optimizing resource use, reducing waste, and improving supply chain efficiency (refer to Table 2).

Table 2: Applications of IKM in Sustainable Food Systems.

Applications	Define
Enhanced Decision-Making	By providing real-time insights and predictive analytics, IKM helps stakeholders make better decisions regarding crop selection, irrigation scheduling, pest management, and supply chain logistics (Kamilaris, Kartakoullis, & Prenafeta-Boldú, 2017).
Sustainable Practices	IKM supports adopting sustainable practices by identifying areas where resource use can be minimized and environmental impacts can be reduced. For example, AI-driven models can optimize fertilizer application to reduce runoff and improve soil health (Wolfert et al., 2017).

Table 2: Applications of IKM in Sustainable Food Systems (cont.).

Improved Collaboration	The knowledge-sharing capabilities of IKM foster collaboration among farmers, processors, distributors, and consumers. This collaboration leads to more integrated and efficient food systems that respond better to market demands and regulatory requirements (Verdouw, Beulens, & Trienekens, 2013).
Consumer Engagement	IKM enables better consumer engagement by providing transparency and traceability throughout the food supply chain. Consumers can access information about their food's origin, quality, and sustainability, which can influence their purchasing decisions and promote sustainable consumption (Kshetri, 2018).

IKM represents a significant advancement in how organizations and systems manage information and knowledge. By integrating advanced technologies such as AI and ML, IKM enhances decision-making, promotes sustainable practices, and fosters collaboration across the food system. As sustainability and resource management challenges continue to grow, adopting IKM will be crucial in creating resilient and efficient systems capable of meeting the needs of a rapidly changing world.

6 IKM FOR SUSTAINABLE FOOD SYSTEMS

According to the problem model of the previous section, a goal model has been created to illustrate a comprehensive framework aimed at achieving improved sustainable food production and consumption (refer to Figure 2). The model integrates various components and processes, highlighting the interplay between data collection, ML, AI, and knowledge management. Below is a detailed description of each component and its role within the model.

- Improved Sustainable Food Production and Consumption: This is the main goal of the model, aiming to enhance the sustainability of food production and consumption practices.
- Intelligent Integration of a Sustainable Food System: This component focuses on creating a cohesive and intelligent system that integrates various sustainable practices across the food production and consumption chain.
- Accurate Data Collection and Analysis: Accurate and comprehensive data collection and analysis are critical for informed decision-making. This component ensures that all relevant data is gathered and analyzed effectively to support sustainable practices.
- Utilized Scenario Analysis and Knowledge Management Using Adaptive AI-based Decision-Making: This process involves using scenario analysis and adaptive AI-based decision-making tools to manage knowledge effectively. It ensures that decision-making processes are adaptive and informed by the latest data and scenarios.
- Utilized ML and Predictive Modeling: ML and predictive modeling are employed to analyze historical data and predict future trends and outcomes. This helps in making proactive decisions to enhance sustainability.
- Historical Data: Historical data provides a foundation for analysis and modeling. It is utilized to understand past trends and inform future strategies.
- Integration of AI: AI integration is critical for automating processes and making intelligent decisions. It supports various aspects of the model, including data analysis, scenario planning, and predictive modeling.
- Standardization: Standardization ensures that processes and data are uniform across the system, facilitating better integration and comparison.
- Training and Awareness: Continuous training and awareness programs are necessary to ensure that all stakeholders are informed about sustainable practices and how to implement them effectively.

Furthermore, interconnections in the goal model can be explained as follows:

- Data Collection and Analysis: Accurate data collection and analysis feed into scenario analysis and ML/predictive modeling.
- Scenario Analysis and ML: These processes use historical data to create models and scenarios that inform decision-making.
- Knowledge Management and AI Integration: AI-based decision-making tools utilize scenario analysis and ML insights to manage knowledge dynamically.
- Standardization and Training: These support systems ensure the framework operates smoothly

by maintaining consistency and enhancing stakeholder capabilities.

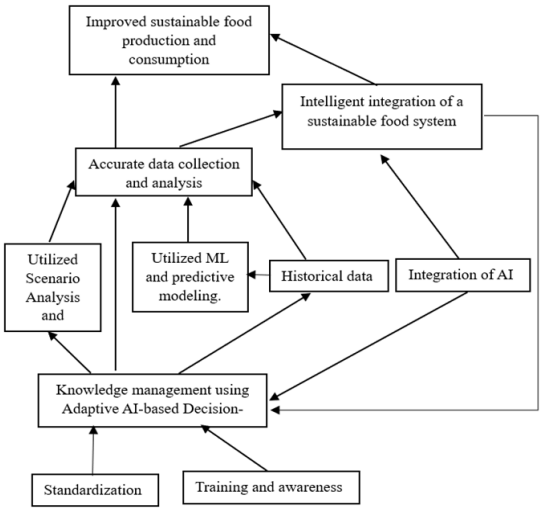

Figure 2: Goal model.

Therefore, according to the problem and goal model and KBT, a conceptual model has been proposed (refer to Figure 3) to illustrate the conceptual model of IKM for a sustainable food system.

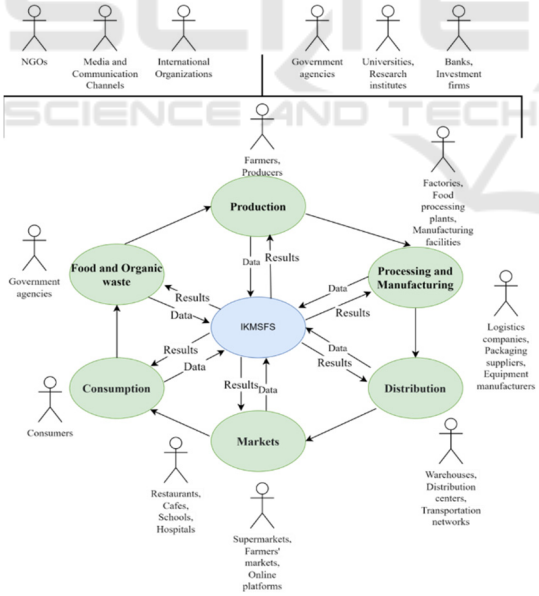

Figure 3: Conceptual model of IKM for the sustainable food system.

The model demonstrates how IKM integrates various sectors within the food system to enhance sustainability. Below is a detailed description of the key components and their interactions, as depicted in Figure 3.

- IKM: It is the core of the model, which serves as the central hub for the collection, analysis, and dissemination of data, information, and knowledge (DIK). IKM enables effective decision-making and coordination across the entire food system.
- Production: This component includes farmers and producers responsible for growing and supplying raw agricultural products. IKM facilitates the flow of DIK to and from the production sector, providing insights and feedback (Results) that can improve farming practices and sustainability.
- Processing and Manufacturing: This sector involves factories, food processing plants, and manufacturing facilities that transform raw agricultural products into consumable goods. IKM supports this sector by providing DIK that enhances processing efficiency and product quality while ensuring sustainability.
- Distribution: Distribution encompasses logistics companies, packaging suppliers, and equipment manufacturers responsible for moving goods from production and processing facilities to markets. Through IKM, distribution processes are optimized, ensuring timely and efficient delivery of goods with minimal environmental impact.
- Markets: This component includes supermarkets, farmers' markets, and online platforms where consumers can purchase food products. IKM helps markets by providing DIK that informs supply chain decisions, market trends, and consumer preferences.
- Consumption: This sector comprises consumers who purchase and consume food products. It also includes institutions such as restaurants, cafes, schools, and hospitals. IKM enables a better understanding of consumption patterns and promotes sustainable consumption practices by disseminating relevant information and feedback.
- Food and Organic Waste: This component addresses the management of food waste and organic materials, involving recycling and waste reduction efforts. IKM plays a crucial role in managing waste by providing DIK with waste reduction strategies, recycling processes, and the circular economy.

Surrounding the central and primary components are various external entities that interact with and influence the sustainable food system:

- NGOs, Media, and Communication Channels: They play a role in disseminating information, raising awareness, and advocating for sustainable practices.

- International Organizations: These organizations provide guidelines, support, and collaboration opportunities for global sustainability efforts.
- Government Agencies: They regulate, support, and implement policies that promote sustainability in the food system.
- Universities and Research Institutes: These entities contribute to the knowledge base by conducting research and providing innovations.
- Banks and Investment Firms: Financial institutions support sustainable practices through funding and investments.

The bidirectional flow of DIK and Results marks the interaction between IKM and each component. This continuous exchange ensures that each sector receives the necessary knowledge and feedback to improve sustainability practices. The model illustrates a holistic approach where all sectors and external entities are interconnected, emphasizing the importance of collaboration and knowledge sharing in achieving a sustainable food system.

7 FURTHER RESEARCH

This research can present numerous avenues for future research, particularly in Sweden. While this study has laid the groundwork, several areas warrant further investigation to deepen our understanding and improve the implementation of IKM in sustainable food systems, as described below.

Before designing the IKM system, conducting a needs analysis based on the proposed models in this paper is important. This should include examining the problem, goal, and conceptual models. By doing so, we can ensure that the system meets the requirements of all stakeholders and explores various options. To achieve better results, it may be beneficial to focus on one or two counties in Sweden, such as Dalarna and Halland, and then generalize the findings to the entire country.

Future research should focus on longitudinal studies that track the implementation of IKM in Sweden's food system over extended periods. These studies can provide valuable insights into the long-term impacts of IKM on sustainability outcomes, allowing researchers to identify trends, challenges, and best practices that evolve. Longitudinal data will critically assess the effectiveness and adaptability of various IKM strategies to changing environmental and economic conditions.

Comparative studies between Sweden and other countries with similar or different food system structures can yield significant findings. By comparing the effectiveness of IKM in diverse contexts, researchers can identify universal principles and context-specific factors that influence the success of IKM initiatives. This comparative approach can help develop tailored strategies for cultural, economic, and regulatory differences.

The rapid advancement of technologies such as blockchain, the Internet of Things (IoT), and advanced analytics offers new opportunities for enhancing IKM. Future research should investigate how these emerging technologies can be integrated into IKM frameworks to improve data accuracy, traceability, and decision-making processes. Pilot projects and case studies exploring these technologies can provide practical insights into their potential benefits and limitations. Understanding the dynamics of stakeholder engagement is necessary for implementing IKM successfully.

Future studies should examine the roles and perspectives of various stakeholders, including farmers, processors, distributors, consumers, and policymakers, in the IKM process. Research should also explore effective collaboration models that foster active participation and knowledge sharing among stakeholders, leading to more inclusive and resilient food systems. While environmental sustainability is a primary focus, the economic and social impacts of IKM on the food system should not be overlooked. Future research should assess how IKM influences the economic viability of food enterprises, job creation, and social equity within the food system. Understanding these impacts can help design policies and interventions that promote holistic sustainability, balancing ecological, economic, and social goals.

Research should focus on how policies affect the adoption of IKM in food systems and identify ways to improve them. Additionally, it should explore the impact of knowledge dissemination on consumer behavior and effective strategies to enhance awareness of sustainable consumption.

8 CONCLUSIONS

IKM aims to integrate the food system intelligently to promote sustainable food production. The Swedish food system challenges include inappropriate knowledge management systems, system complexity, dynamic environments, and information overload.

The proposed IKM conceptual model, based on KBT and leveraging AI-powered techniques, aims to manage and analyze large datasets from various stakeholders in the food supply chain. This model

enhances forecasting, planning capabilities, and decision-making processes, ultimately promoting sustainable food production and consumption. The model's holistic approach integrates intelligent systems, AI, accurate data analysis, and continuous learning to facilitate proactive decisions that enhance sustainability. The model underscores the pivotal role of IKM in integrating and optimizing various sectors within the food system. Future research aims to advance the understanding and application of Intelligent Knowledge Management in enhancing sustainable food systems. By addressing these areas, researchers can contribute to developing adaptive and inclusive food systems to meet the sustainability challenges.

In conclusion, integrating IKM into the Swedish food system has great potential for promoting sustainability. With advanced technologies, the proposed IKM model can facilitate informed decision-making and efficient management across the food supply chain.

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