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BUILDING RESILIENT FOOD SYSTEMS: INTEGRATING ONTOLOGIES IN SEJAHTERA-SOUQ FOR IIUM'S SUSTAINABLE MARKETPLACE

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Abstract:

Sustainable food systems are integral to addressing global challenges such as food security, environmental degradation, and socio-economic resilience. As the demand for sustainable practices grows, ontologies provide a powerful means to organize, manage, and analyze the complexity of these systems. This paper examines the integration of ontologies into the Sejahtera-Souq, a marketplace initiative at the International Islamic University Malaysia (IIUM), to bolster food system resilience. Ontologies allow for a structured representation of data across the food supply chain, enabling automated sustainability assessments, greater transparency, and more efficient operations. Sejahtera-Souq, in line with IIUM's sustainability goals, stands to benefit significantly from ontology-based tools. By adopting such frameworks, the marketplace can track and manage food and optimize resource use. Moreover, ontologies can aid in mapping relationships between food products, their origins, processing methods, and their environmental impacts. This will facilitate informed decision-making for both producers and consumers, promoting a culture of sustainability on campus. This study not only reviews current applications of ontologies in food systems but also proposes a roadmap for integrating these technologies into Sejahtera-Souq. Through the use of ontology-driven intelligence, the marketplace can align itself with international standards for sustainability while fostering local socio-economic growth. The incorporation of these technologies into Sejahtera-Souq can serve as a model

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for other institutions seeking to implement sustainable marketplace frameworks, demonstrating how academic institutions can play a leading role in the global shift towards more resilient food systems.

Keywords:

Ontology-Driven, Sustainable Marketplace, Resilient Food Systems

Introduction

The global food system is increasingly challenged by factors such as a growing population, climate change, and diminishing resources, all of which threaten food security and sustainability (Godfray et al., 2010). Food systems must be resilient, meaning they can withstand and adapt to disruptions while continuing to function, to ensure the long-term availability of food and maintain environmental sustainability (Tendall et al., 2015). Ontologies structured systems that represent relationships among concepts in specific domains are becoming essential tools for implementing data-driven solutions to enhance sustainable agriculture and food systems.

Despite its alignment with International Islamic University Malaysia (IIUM) sustainability goals, Sejahtera-Souq currently lacks a systematic framework to assess, categorize, and communicate the sustainability attributes of its offerings. The absence of structured semantic infrastructure impedes the marketplace's ability to provide transparent, consistent, and data-driven insights into product sustainability. Consequently, both consumers and producers face challenges in making informed decisions aligned with ecological and ethical values. This problem highlights a critical gap in the platform's digital architecture, the need for an intelligent system capable of managing complex sustainability-related information across the food supply chain.

This paper focuses on the Sejahtera-Souq, a marketplace developed by IIUM to promote sustainable consumption and production based on the Sejahtera philosophy. This philosophy stresses the importance of balance across economic, social, and environmental aspects of life. Sejahtera-Souq provides a platform where local producers or IIUM community can offer eco-friendly goods, allowing consumers to make informed choices about sustainability.

The concept of Sejahtera (well-being) in IIUM encompasses both psychological and spiritual dimensions. A study on IIUM Malaysian postgraduate students found that they exhibited good psychological well-being, which supported their achievement of Sejahtera (Sarah Shamsul Azman et al., 2023). From an Islamic economic perspective, Sejahtera is viewed as a holistic concept that includes material, spiritual, and moral well-being (Suardi, 2020; Suardi, 2021). It aligns with the Maqashid Syari'ah, which emphasizes the preservation of religion, life, intellect, lineage, and wealth (Suardi, 2021). Islamic economics aims to ensure individual and societal welfare through the fulfillment of basic needs, optimal resource utilization, equitable distribution of wealth, and social justice (Suardi, 2021). This approach to Sejahtera is not merely about economic distribution but also involves continuous efforts to act righteously towards God and fellow humans based on Islamic teachings (Purwana, 2014).

Integrating ontologies into Sejahtera-Souq aims to strengthen food system resilience by improving supply chain management, increasing transparency, and encouraging

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environmentally conscious consumer behavior. This paper investigates how ontologies can be used to create resilient food systems in Sejahtera-Souq and addresses the technical and conceptual challenges associated with integrating ontologies into such a marketplace.

Research Objectives:

1. To explore how ontologies can be used to enhance food system resilience.
2. To develop a methodology for integrating ontologies into the Sejahtera-Souq platform.
3. To identify challenges and opportunities for ontology-driven sustainability in food systems.

Review Of Literature

Ontologies In Food Systems And Sustainable Marketplaces

Ontologies play a crucial role in enhancing sustainability and resilience in food systems by integrating knowledge across various disciplines (Musker et al., 2016). They facilitate the development of an "Internet of Food," which can improve resource efficiency, stimulate rural livelihoods, and promote responsible governance (Holden et al., 2018). Combining food ontologies with AI can foster sustainable food systems by enabling precision agriculture, sustainable food choices, and personalized diets (Adrian et al., 2023). The Ontologies Community of Practice (CoP) of the CGIAR Platform for Big Data in Agriculture aims to harness expertise in ontology development and identify innovative solutions for quality data annotation across agricultural research disciplines (Arnaud et al., 2020). These efforts contribute to the creation of comprehensive ontologies that encompass the environment-agriculture-food-diet-health knowledge spectrum, supporting decision-makers in addressing sustainability issues throughout the food system (Musker et al., 2016).

Ontologies serve as structured systems for defining relationships among concepts within a specific domain (Gruber, 1993). In food systems, ontologies allow the organization and integration of information related to agriculture, food production, supply chains, and sustainability metrics (Smirnov et al., 2021). They enhance data interoperability between systems and foster knowledge-sharing, both of which are critical for managing the complexities present in modern food systems. The ability to integrate data from various sources such as farms, processing plants, and retailers enables real-time decision-making (Antle et al., 2017).

One of the most notable examples of ontology use in food systems is FoodON, a detailed ontology that describes food products and their attributes (Dooley et al., 2018). This system helps classify food items based on factors such as their ingredients, processing techniques, and nutritional content, improving traceability and transparency across the food supply chain. FoodON has been used to track the full lifecycle of food products, supporting sustainable food practices (Dooley et al., 2018).

AgroPortal is another example that highlights how ontologies can foster data interoperability in agricultural settings. By providing a repository of vocabularies and ontologies specific to agriculture, AgroPortal enables users to share data related to soil conditions, crop management, and climate, helping improve agricultural sustainability (Jonquet et al., 2018).

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Sejahtera-Souq And IIUM's Sustainability Framework

The IIUM has implemented various sustainability initiatives on campus, including promoting waste recycling, efficient energy and water use, and environmental awareness among students and staff (Ninunroihan Jehtae et al., 2021). IIUM has also engaged in public-private partnerships to improve energy efficiency and reduce its carbon footprint, aligning with its Strategic Direction of Humanizing Education and the Sustainable Development Goals (R. Zahari et al., 2024). The concept of Sejahtera, a holistic and balanced approach, has been integrated into IIUM's curriculum, as exemplified by the 'Sejahtera Leadership' course in its MBA program (Arbaiah Abdul Razak et al., 2023). While not specific to IIUM, research on sustainable campus design in Malaysian universities suggests that a proactive approach from campus management is crucial for successful implementation of sustainability efforts, potentially through mechanisms like Integrated Project Delivery (F. A. Nifa et al., 2015).

The Sejahtera-Souq is rooted in IIUM's Sejahtera philosophy, which advocates for a holistic view of well-being, incorporating economic, social, and environmental sustainability. This marketplace, part of IIUM's sustainability agenda, connects local producers with consumers, offering eco-friendly products that encourage sustainable consumption. By promoting sustainably produced goods and ethical sourcing practices, the Sejahtera-Souq serves as a marketplace that contributes to social equity and environmental preservation, two vital components of sustainability.

Sejahtera-Souq aligns with IIUM's sustainability objectives and can serve as a model for resilient food systems. However, digital enhancements, such as real-time data integration, sustainability assessments, and transparent supply chain management, are necessary to fully realize its potential. Ontologies provide the required infrastructure by formalizing knowledge related to sustainability and resilience (FAO, 2019).

The Sejahtera philosophy emphasizes not only economic sustainability but also social fairness and environmental stewardship. Thus, any ontology integrated into Sejahtera-Souq must be aligned with these values, offering a structure that promotes ethical consumption, supports local economies, and encourages environmental protection (United Nations, 2015).

Ontology Integration In Sustainable Marketplaces

Sustainable marketplaces, which prioritize social and environmental responsibility, stand to benefit significantly from the application of ontologies. Ontologies enable systems to reason about data semantically and facilitate interoperability, thereby automating complex tasks such as sustainability assessments, carbon footprint analysis, and product lifecycle evaluations (Antle et al., 2017). These capabilities are particularly important for a marketplace like Sejahtera-Souq, where consumers and producers need accurate, up-to-date information about the sustainability of various products.

Research has shown that ontologies can improve the resilience of food systems. (Weber et al. 2023), for example, have proposed an ontology-based approach for managing agri-food systems by incorporating sustainability metrics, supply chain data, and environmental impacts. Such systems improve decision-making processes, increase transparency, and build trust in sustainable marketplaces. Similarly, (Smirnov et al. 2021) emphasized that knowledge-sharing frameworks based on ontologies facilitate collaboration between various stakeholders in the food system, from farmers to retailers.

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Research Methodology

Ontology Design For Sejahtera-Souq

The ontology designed for Sejahtera-Souq will be based on core principles of sustainability, resilience, and ethical consumption. Existing frameworks such as FoodON, AgroPortal, and the Sustainable Development Goals (SDG) Ontology will be adapted to meet the specific needs of Sejahtera-Souq (Dooley et al., 2018; Jonquet et al., 2018).

The main elements of the ontology will include:

- **Product Information**: Attributes of products such as origin, processing methods, environmental impact, and sustainability certifications.
- **Supply Chain Data**: Information about the various stages of the supply chain, from producers to distributors and retailers.
- **Sustainability Metrics**: Data on carbon emissions, water consumption, and waste management practices associated with each product (Godfray et al., 2010).
- **Consumer Preferences**: Insights into consumer behavior and preferences related to sustainability, ethical sourcing, and locally produced goods (Tendall et al., 2015).

Knowledge Acquisition And Formalization

The ontology will be developed by first acquiring knowledge from stakeholders in the Sejahtera-Souq ecosystem, including local producers, sustainability experts, and consumers. This knowledge will be formalized using the Web Ontology Language (OWL), which allows for semantic reasoning and data interoperability with other systems (Noy & McGuinness, 2001).

The ontology will then be validated through iterative testing using data from the Sejahtera-Souq platform. This process will ensure the ontology accurately captures the marketplace's complexity and can support decision-making related to sustainability and resilience (FAO, 2019).

Data Sources, System Architecture, And Validation Process

The ontology design process drew upon a combination of structured and unstructured data sources, including academic literature on food system sustainability, IIUM's internal guidelines on Sejahtera values, and qualitative inputs from marketplace stakeholders such as producers and administrators. Product metadata such as origin, production method, and packaging type will be collected from vendor submissions and mapped against established sustainability indicators (e.g. carbon footprint, local sourcing, halal compliance).

The proposed system architecture envisions integrating the ontology into a digital marketplace platform through a backend semantic reasoning framework. This framework would utilize the Web Ontology Language (OWL) and RDF triple stores to enable structured data representation and semantic interoperability. A RESTful API is conceptually planned to serve as the communication layer between the ontology database and the user interface, facilitating real-time queries and product filtering based on sustainability attributes. Additionally, SPARQL endpoints would support advanced semantic queries, enabling reasoning over the ontological structure to generate dynamic product recommendations and perform backend sustainability

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analytics. This conceptual design in **Figure 1** serves as a blueprint for future system development, aligning technical components with the goal of fostering an intelligent, sustainability-driven marketplace.

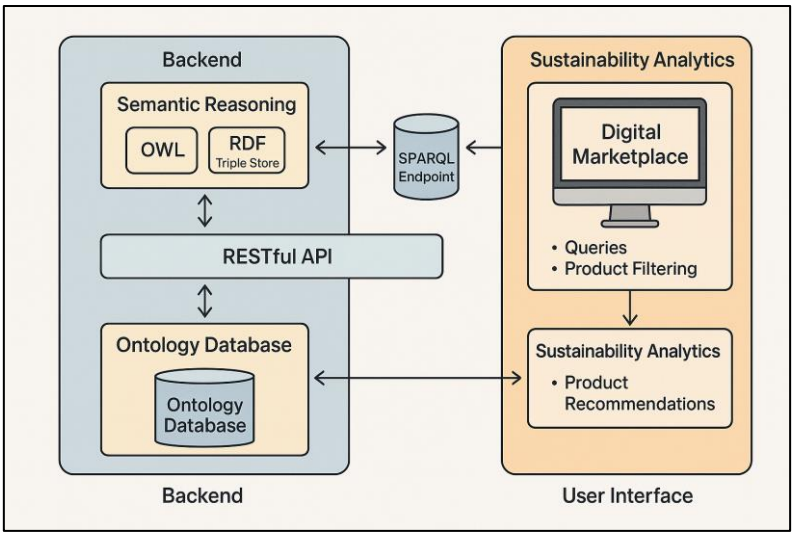

Figure 1: Proposed System Architecture.

To validate the ontology, a structured three-step process is proposed. First, conceptual validation will be pursued through expert reviews involving sustainability scholars and ICT system developers to assess the semantic soundness and domain alignment. Second, logical validation is intended to be conducted via SPARQL test queries, which will evaluate the internal consistency of class hierarchies and property constraints. Third, functional validation is planned through pilot integration into a prototype environment such as the Sejahtera-Souq platform where simulated user interactions and feedback mechanisms will be employed to examine usability, the practical relevance of sustainability classifications, and system responsiveness. Collectively, these steps are designed to ensure that the ontology is both theoretically rigorous and pragmatically viable.

Embedding The Ontology Into Sejahtera-Souq's Digital Infrastructure

The ontology will be embedded into Sejahtera-Souq's digital platform using a reasoning engine that can process semantic queries. For instance, a user might search for products with the lowest price or locally produced goods that meet specific sustainability criteria (Jonquet et al., 2018).

This reasoning engine will evaluate product attributes and provide recommendations based on predefined sustainability criteria, empowering both producers and consumers to make decisions that align with the Sejahtera philosophy of balanced living.

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Ontology Diagram For Sejahtera-Souq Integration

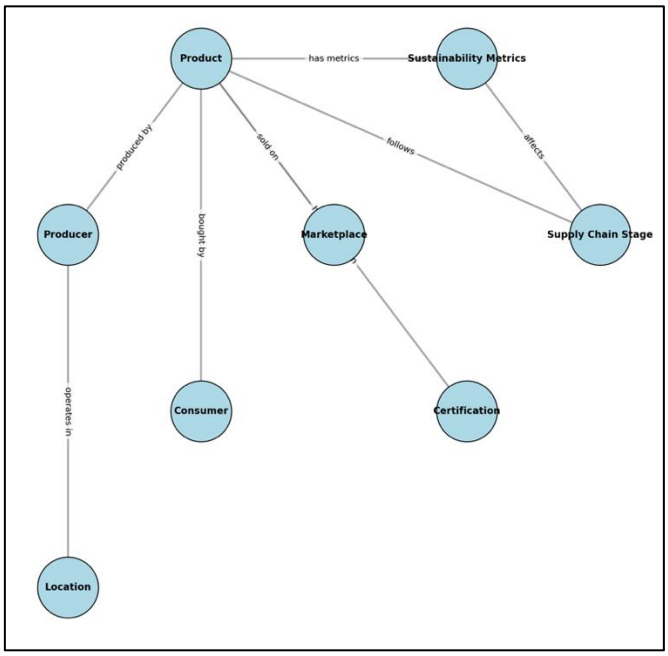

Figure 2: Ontology Diagram for Integrating Ontologies into Sejahtera-Souq.

The ontology designed for Sejahtera-Souq provides a structured framework to represent the relationships between key entities such as products, producers, consumers, and sustainability metrics. This diagram **(Figure 2)** illustrates how these entities are interconnected, showing how sustainability attributes are embedded into the marketplace's operations.

Pilot Implementation And Initial Observations

To ground the theoretical ontology framework in practical application, a functional prototype of Sejahtera-Souq has been developed and made accessible online at https://sejahtera-souq.iium.edu.my/. The platform serves as a digital marketplace that integrates sustainability-oriented product information in alignment with IIUM's Sejahtera philosophy. A pilot deployment was conducted within the IIUM community, involving local producers, student users, and campus administrators. Initial observations reveal that the ontology-enhanced marketplace enables structured classification of products based on attributes such as locality, ethical sourcing, and environmental impact. Users reported that the visibility of these attributes influenced their purchasing decisions, with many expressing appreciation for the system's ability to recommend products that align with sustainability values. Producers also provided positive feedback, noting the platform's potential to increase consumer trust and promote responsible marketing. While the system demonstrates strong potential in promoting ethical consumption, ongoing refinement is necessary, particularly in automating metadata input and improving real-time sustainability scoring. Overall, the prototype illustrates how theoretical constructs of ontology can be successfully translated into a working digital infrastructure for sustainable campus marketplaces.

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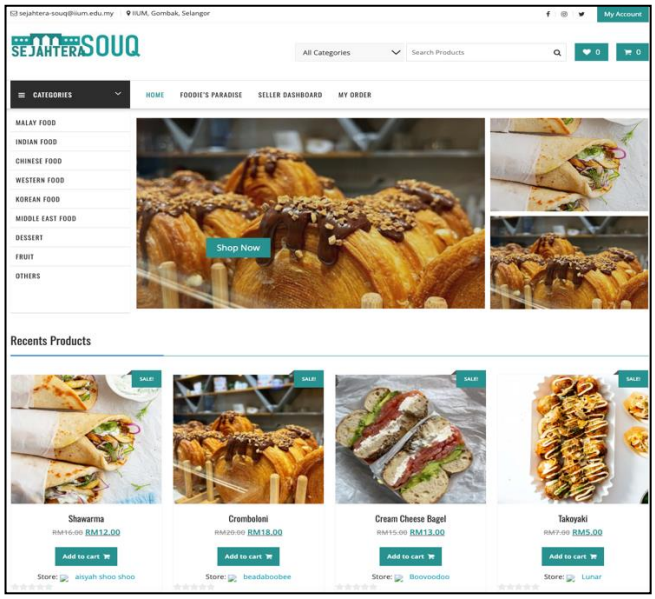

Figure 3: IIUM Sejahtera-Souq Marketplace

Data Analysis And Discussion

Enhancing Resilience In Food Supply Chains

An ontology-driven framework will greatly enhance the resilience of food supply chains in Sejahtera-Souq. The system will provide real-time insights into the supply chain, such as product availability, environmental impacts, and ethical sourcing practices. In cases where a supplier cannot meet demand due to environmental issues, the system could suggest alternative suppliers that meet similar sustainability standards (Godfray et al., 2010).

Additionally, ontological reasoning allows for automated risk assessments, helping the system identify supply chain vulnerabilities and propose preventive measures. This capability will bolster the overall resilience of the marketplace, ensuring continued functionality even in the face of external challenges (Tendall et al., 2015).

Ontological Reasoning And Sustainability

Ontological reasoning is essential for advancing sustainability in Sejahtera-Souq. By organizing knowledge about product attributes and environmental impacts, the ontology will automatically evaluate the sustainability of each product listed in the marketplace. Consumers will receive personalized recommendations based on product sustainability profiles, enabling more environmentally conscious purchasing decisions (Chukwube, 2023).

Producers will also benefit from the system's ability to offer insights into how their practices affect sustainability. For instance, a producer might receive data on their water usage and be encouraged to adopt more sustainable methods (FAO, 2019). This feedback loop will foster continuous improvement within the marketplace and support Sejahtera-Souq's long-term sustainability goals.

Challenges And Opportunities

Although ontology integration offers clear benefits, several challenges need to be addressed. One significant issue is the difficulty in developing interoperable ontologies that work across

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different systems (Noy & McGuinness, 2001). Many existing ontologies were created independently, making it challenging to achieve seamless integration.

Another challenge is the ongoing need to update the ontology to reflect changes in sustainability standards and consumer behavior. As new sustainability metrics are developed and consumer preferences evolve, the ontology must be regularly updated to remain effective (United Nations, 2015).

Despite these challenges, the opportunities provided by ontology integration are substantial. By using semantic reasoning, Sejahtera-Souq can set a global standard for sustainable marketplaces, fostering transparency, accountability, and resilience in food systems (FAO, 2019).

Conclusion

This research highlights the potential of ontologies to improve the resilience and sustainability of food systems, particularly within the context of IIUM's Sejahtera-Souq. By structuring knowledge about product attributes, sustainability metrics, and supply chain data, the proposed ontology-driven system can help both producers and consumers make more informed decisions. Integrating ontologies into Sejahtera-Souq will enhance supply chain resilience, promote transparency, and encourage ethical consumption, in alignment with the Sejahtera philosophy.

Future research should explore expanding the ontology to include other domains, such as waste management, renewable energy, and water conservation. Additionally, integrating machine learning techniques could improve the ontology's adaptability and decision-making capabilities in response to evolving conditions (Arp et al., 2020).

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