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Development of an Organic Agriculture Ontology for Young Agripreneurs

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Abstract

This study develops an ontology of organic agriculture aimed at addressing the needs of young agripreneurs who seek to engage in organic farming as a comprehensive and sustainable agricultural business. The ontology is designed to support young agripreneurs in aligning their farming, management, and marketing practices with standardized organic agriculture systems. The purpose was to structure and represent domain-specific knowledge systematically, enabling its application in decision support and information systems. The ontology construction followed a three-stage framework: defining the purpose, developing the ontology, and conducting evaluations. A knowledge engineering approach with seven steps was applied, and the Hozo Ontology Editor served as the development tool. The resulting ontology comprises 127 classes, including nine core categories—Young Agripreneurs, Organic Farming, Products, Business, Markets, Agriculture Processes, Agencies, Services, and Document—supported by 118 subclasses. Furthermore, 31 properties and interrelationships were defined to represent the conceptual linkages within the domain. Evaluation by domain experts, based on five criteria—definition and scope, class identification, property specification, instance creation, and applicability—confirmed a high level of appropriateness. The final ontology, delivered in OWL format, provides a robust knowledge model for organic agriculture. Its significance lies in facilitating knowledge-based recommender systems that enhance decision-making and planning for young agripreneurs, ultimately contributing to sustainable agricultural entrepreneurship.

Keywords: agripreneurs; knowledge engineering; ontology development; organic agriculture; recommender systems

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1. Introduction

Organic agriculture is a form of sustainable farming that aims to utilize natural resources in a balanced manner, reduce dependence on synthetic chemicals, and promote a fair quality of life for farmers. It is also aligned with the United Nations Sustainable Development Goals (SDGs), adopted in 2015, which consist of 17 goals to be achieved by 2030 (National Institute of Development Administration, 2019). Among these, two goals are particularly relevant to organic agriculture: SDG 2: Zero Hunger, which focuses on ensuring food security through safe and diverse food supplies, and SDG 12: Responsible Consumption and Production, which emphasizes food production systems that minimize resource use and reduce waste.

Organic agriculture has emerged as a critical component of sustainable development, emphasizing ecological balance, soil restoration, biodiversity conservation, and the reduction of synthetic chemical use. This shift reflects a global movement toward responsible production and consumption, aligned with the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production). In Thailand, national policies underscore the ambition to strengthen organic agriculture and position the country as a regional leader. Strategic initiatives have prioritized standard development, certification systems, production efficiency, supply chain integration, digital technology adoption, and value-driven product development.

In Thailand, the government has envisioned becoming a regional leader in organic agriculture within ASEAN. The policy emphasizes developing standards and certification systems, promoting farmers' participation in organic agriculture, integrating production, processing, and marketing networks, as well as advancing research, technologies, and innovations that support the entire supply chain National Organic Agriculture Development Board. (2022). This

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direction reflects the national goal of advancing high-quality agriculture while fostering environmentally friendly and sustainable livelihoods.

The dynamics of social, economic, technological, and environmental changes significantly influence the development of organic agriculture in Thailand. Key drivers include the expansion of the digital society that attracts young farmers to agriculture, the growing consumption of healthy food, increasing environmental concerns, the impacts of climate change on agricultural productivity, and the integration of tourism with agriculture, which creates new market opportunities. Nevertheless, global market competition, economic volatility, and the lack of a centralized information system remain critical challenges. An environmental analysis reveals that Thailand possesses several strengths, including experienced farmers, high-quality and safe agricultural products, and the potential to develop high-value products. However, notable weaknesses remain, such as limited knowledge of organic agriculture, particularly among farmers, high initial investment costs, incomplete database systems, and the lack of international recognition of Thai organic standards. These factors highlight the necessity of fostering new knowledge and establishing robust support systems.

At present, organic farming has evolved from traditional practices into a model where farmers act as agricultural entrepreneurs, requiring competencies in production, management, technology utilization, and access to market information (Office of Small and Medium Enterprises Promotion, 2017). In particular, young agricultural entrepreneurs with digital capabilities can apply technology to enhance efficiency, reduce costs, and create value creation for organic agricultural products (Blake & Wijetilaka, 2015).

Nevertheless, a major challenge lies in the management of organic agriculture data, which currently lacks a centralized standardized system. Agricultural terminology varies across local contexts, making it difficult to efficiently integrate data across agencies (Joo et al., 2016). Therefore, the establishment of a standardized knowledge system is essential to support learning, information exchange, and strategic decision-making for young agricultural entrepreneurs. In this regard, ontology plays a crucial role in creating a controlled vocabulary, defining relationships among concepts, and enabling concept-based search. The development of an organic agriculture ontology thus represents a key approach to link semantic data, allowing entrepreneurs to effectively access, analyze, and utilize information. This, in turn, aids in production planning, selection of market-appropriate standards, and enhances the international competitiveness of Thai organic agriculture.

2. Literature Review

A comprehensive literature review was conducted to strengthen the theoretical foundation of this study and address reviewer concerns regarding insufficient engagement with ontology engineering frameworks and existing agricultural ontologies. This section is therefore expanded into four major components: (1) Organic agriculture (2) the foundations of ontology engineering, (3) agricultural ontologies and (4) research gaps motivating this study.

2.1. Organic agriculture

Organic agriculture has gained significant global attention as a production system that emphasizes sustainability, the conservation of natural resources, and a reduction in reliance on synthetic chemicals that negatively affect the environment, consumer health, and biodiversity (FAO, 2018; Reganold & Wachter, 2016). In this context, organic agriculture is recognized as a sustainable agricultural management system encompassing production, storage, processing, and transportation activities, all of which must comply with established organic standards (FAO & WHO, 2019). The system integrates multidisciplinary knowledge to maintain organic integrity and product quality throughout the entire supply chain (IFOAM, 2014). The core objective of organic agriculture is to preserve ecological balance while ensuring food safety and promoting environmental, social, and economic sustainability (IFOAM, 2008).

The International Federation of Organic Agriculture Movements (IFOAM) and the United Nations Conference on Trade and Development (UNCTAD) jointly established the Common Objectives and Requirements of Organic Standards (COROS), serving as a global framework for organic agriculture standards. COROS encompasses ten key principles: conserving biodiversity, restoring soil and water fertility, avoiding synthetic chemicals, preventing environmental pollution, prohibiting high-risk technologies (e.g., GMOs and irradiation), ensuring the ethical treatment of animals, maintaining organic integrity across the supply chain, ensuring traceability, and promoting fairness across all stakeholders (IFOAM & UNCTAD, 2012).

The United Nations adopted the Sustainable Development Goals (SDGs) for the period 2016–2030, which encompass the three pillars of sustainability: economic, social, and environmental dimensions (United Nations, 2015). Among the 17 SDGs, at least two goals are particularly relevant to the advancement of organic agriculture. The first is Goal 2, which aims to eradicate hunger, achieve food security, improve nutrition, and promote sustainable agriculture (United Nations, 2015; FAO, 2018). The second is Goal 12, which focuses on ensuring sustainable consumption and production patterns through the efficient use of natural resources, the reduction of chemical emissions, and the strengthening of technological and institutional capacities, particularly in developing countries (United Nations, 2015; UNEP, 2016). These goals collectively underscore the role of organic agriculture as a strategic approach to achieving sustainability across food systems.

Table 1. Summary of Key Objectives, Targets, and Core Elements

Key Objectives	Targets	Core Elements
1. Organic Agriculture Standards and Certification Systems	To achieve international recognition of organic agriculture standards and certification systems.	1. Organic agriculture standards 2. Organic certification systems
2. Production	To reduce production costs, enhance production efficiency, and strengthen production planning capabilities	1. Relevant production inputs 2. Management of organic agricultural land (crops, livestock, and aquaculture) 3. Production planning 4. Producers / Production sites
3. Processing	To enhance the value of organic agricultural products to meet consumer demands, including elderly consumers and health-conscious individuals.	1. Organic product standards 2. Types of organic products and processed goods 3. Processors 4. Product registration
4. Marketing	To promote marketing through online and offline channels at the community, national, and international levels.	1. Distribution channels / Sales outlets 2. Product and packaging design 3. Brand development 4. Logistics systems
5. Tourism	To promote value-driven and sustainable tourism.	1. Tourism identity development 2. Community-based tourism
6. Accounting	To provide farmers with knowledge of accounting and taxation.	1. Accounting management 2. Taxation

Table 1 summarizes the key objectives, targets, and core elements of Thailand's national action plan for organic agriculture. In Thailand, strategies aligned with global sustainability goals have been embedded in the 20-Year National Strategic Plan (2018–2037), which aims to strengthen national security, improve quality of life, foster a resilient and inclusive economy, promote social equity, and ensure the sustainable use of natural resources. Complementing this framework, a national action plan for organic agriculture has been implemented with the goal of positioning Thailand as a regional leader in value-driven organic agriculture within ASEAN by 2027. This initiative reflects the country's strong commitment to agricultural development grounded in economic, social, and environmental sustainability.

Young agripreneurs are individuals aged 18–45 who have launched agricultural businesses within the past 1–5 years. This group includes small-scale producers, cooperatives, farmer groups, companies, processors, distributors, as well as importers and exporters. Unlike traditional farmers, young organic entrepreneurs leverage information technology to support decision-making and enhance production efficiency (Smith et al., 2021). To achieve business success, young agripreneurs must develop competencies and assume key roles in four interconnected domains: (1) Organic production practices, which involve avoiding chemical inputs and restoring soil health; (2) Management and innovation, including business planning, cost management, and the integration of digital technologies; (3) Marketing and communication, leveraging online platforms to build brand identity and enhance product value; and (4) Transformational leadership, involving the dissemination of knowledge and serving as role models in guiding the transition to organic agriculture. Collectively, these roles enable young entrepreneurs to drive the sustainable growth of organic agriculture while remaining competitive in modern markets (Department of Agricultural Extension, 2016; Digital Economy Promotion Agency, 2022).

2.2. Foundations of Ontology Engineering

Ontology engineering involves the systematic development of formal knowledge structures comprising concepts, relationships, axioms, and constraints representing a domain. Seminal definitions such as Gruber's (1993) conception of ontology as a "formal, explicit specification of a shared conceptualization" and Studer et al.'s (1998) emphasis on shared understanding form the basis of contemporary ontology engineering. Within this context, ontologies enable consistent knowledge exchange, semantic interoperability, and reasoning across information systems.

Several methodologies guide ontology development. Noy and McGuinness (2001) propose a seven-step process involving scope definition, reuse analysis, term enumeration, class hierarchy construction, property specification, constraint definition, and instance creation. Uschold and King (1995) emphasize conceptualization, formalization, evaluation, and documentation. Gómez-Pérez (1995) extends these methods by proposing evaluation approaches, including accuracy, completeness, consistency, and computational performance. These methodologies collectively provide a structured and evidence-based foundation for ontology construction.

Knowledge-driven, data-driven, and vocabulary-driven approaches each offer distinct advantages. Knowledge-driven methods integrate expert insights and domain-specific documents. Data-driven methods derive entities from structured datasets, whereas vocabulary-driven approaches reuse existing taxonomies and controlled vocabularies. In practice, hybrid strategies often yield higher conceptual clarity.

2.3. Agricultural Ontologies

Agricultural knowledge systems have increasingly adopted ontologies to enhance data integration, information retrieval, and semantic interoperability across heterogeneous agricultural data sources (Gruber, 1995; Noy & McGuinness, 2001). Several prominent agricultural ontologies and digital systems have been developed to support different aspects of agricultural knowledge representation.

AGROVOC, a multilingual agricultural thesaurus maintained by the Food and Agriculture Organization of the United Nations (FAO), comprises over 40,000 concepts covering agriculture, forestry, fisheries, food security, and environmental domains (FAO, 2023). Despite its extensive coverage, AGROVOC provides limited granularity in representing organic certification workflows, documentation requirements, and entrepreneurial characteristics relevant to agribusiness decision-making (Caracciolo et al., 2013).

The Plant Ontology (PO) focuses primarily on plant anatomical structures and developmental stages, making it valuable for biological and genomic modeling but less suitable for certification processes or business-related knowledge (Cooper et al., 2013). Similarly, the Crop Ontology (CO) is designed to represent crop traits and phenotypic data to support plant breeding and genetic research; however, it does not address organic production standards or agribusiness workflows (Shrestha et al., 2012).

Other domain ontologies, such as the Agricultural Activity Ontology (AAO), describe agricultural activities and processes within farming systems but do not integrate certification-specific knowledge or market-oriented perspectives (Aubert et al., 2017). In Thailand, the Organic Agricultural Network (OAN) provides registries of certified farmers and related information; however, it lacks a formal semantic structure that would enable reasoning, interoperability, or cross-agency data integration (Department of Agriculture, 2020).

TraceThai, a blockchain-based traceability system, records product transactions and supply-chain events to enhance transparency, but it does not formalize conceptual relationships among production practices, certification standards, and compliance documentation (Pongsakornrungsilp et al., 2021). Collectively, these ontologies and systems offer foundational domain concepts, yet they do not provide an integrated semantic model capable of addressing the combined needs of young agripreneurs, organic certification workflows, and production–business–market linkages.

2.4. Research Gaps in Existing Knowledge Systems

The expanded literature review reveals several critical gaps motivating the present study:Ontology refers to the formal specification of concepts within a particular domain, including their properties, interrelationships, and logical rules that transform these relationships into shared understanding and knowledge (Gruber, 1993). The relevance of ontology development depends on its intended purpose, particularly in defining concepts and classes within a knowledge domain. Ontology development can be conducted using 3 primary approaches: (1) Data-driven ontology development, involving the analysis of entities and their interrelationships within databases to meet user information needs and identify unstructured attributes; (2) Vocabulary-driven ontology development, employing existing thesauri or controlled vocabularies to establish relationships and generate terminology for new concepts; and (3) Knowledge-driven ontology development, entailing the collection and analysis of information from documents, domain experts, and users to create knowledge that aligns with the contextual requirements of a specific domain (Noy & McGuinness, 2001).

Developing ontologies for organic agriculture can support young entrepreneurs in production planning, data management, and marketing of organic products. It also facilitates the implementation of organic practices in alignment with environmental, social, and economic sustainability principles (IFOAM, 2020). In Thailand, several agencies have established information systems to support organic production and product traceability. For example, the Organic Agricultural Network (OAN) under the Ministry of Agriculture and Cooperatives collects data on farmers, farms, and certification status to enhance network connectivity and member information verification. Trace Thai, managed by the Department of Internal Trade, employs blockchain technology and QR codes for product traceability, improving transparency and credibility. The Office of Agricultural Economics (OAE) maintains databases of economic and production statistics to inform policy and organic agriculture development plans.

Despite these efforts, no integrated information system currently consolidates data across organic production processes for Young agripreneurs, nor provides advanced analytics and personalized recommendations. Consequently, opportunities to leverage information technology for decision-making and business efficiency in organic agriculture remain largely untapped (Zhang et al., 2020). Developing an ontology-based knowledge framework for young organic agriculture entrepreneurs thus represents a critical foundation for creating information systems that enable holistic data management, advanced analytics, and strategic decision support in this complex and rapidly evolving sector.

The present study aims to develop an ontology for organic agriculture specifically designed to support young agricultural entrepreneurs. The research focuses on the domain of knowledge encompassing both organic agricultural practices and the roles, skills, and activities of young entrepreneurs. Thereby enabling represent the relationships among interrelated concepts, thereby providing a structured knowledge framework to support decision-making, information management, and strategic planning in the organic agriculture sector.

3. Methodology

This study aims to develop an ontology for organic agriculture tailored to the context of young agricultural entrepreneurs in Thailand, with the objective of defining a clear and structured scope of knowledge and understanding of organic agriculture that aligns with both national and international organic standards. The ontology developed in this research will serve as a foundation for the development of a semantic search system. The study is organized into three phases as shown on Fig. 1.

Phase I: Defining the Objectives of the Ontology focuses on articulating the research problem and clearly defining the scope and domain knowledge of organic agriculture relevant to young agripreneurs, thereby establishing a conceptual foundation for subsequent ontology development.

1) Research Problem Definition

Young agripreneurs in Thailand operate within a complex ecosystem of agricultural policies, certification bodies, production practices, and market opportunities. However, the information they rely on is fragmented across multiple agencies—such as IFOAM, the Organic Agriculture Certification Thailand (ACT), the Ministry of Agriculture, the Office of Agricultural Economics (OAE), the Organic Agriculture Network (OAN), and international certification bodies. These sources differ significantly in terminology, structure, depth, and accessibility, making it difficult for young agripreneurs to retrieve, compare, and apply relevant knowledge.

The fragmented nature of organic agriculture information gives rise to several practical challenges, including the limited availability of a standardized vocabulary across agencies, insufficient semantic integration among production processes, certification requirements, market information, and agribusiness knowledge, as well as complexities in navigating documentation and inspection workflows for organic certification. Additionally, opportunities for aligning specific products or production systems with suitable marketing strategies and business models remain constrained, particularly in the absence of digital tools that support semantic reasoning and personalized recommendations. While existing agricultural ontologies—such as AGROVOC, the Plant Ontology, and the Crop Ontology—provide valuable foundations for agricultural knowledge representation, they primarily focus on crops and biological concepts and therefore offer limited coverage of certification processes, entrepreneurial characteristics, business practices, and Thailand-specific regulatory contexts. Accordingly, there remains a need for an extended and integrative knowledge model that complements existing ontologies and more effectively supports strategic decision-making for young agripreneurs in organic agriculture.

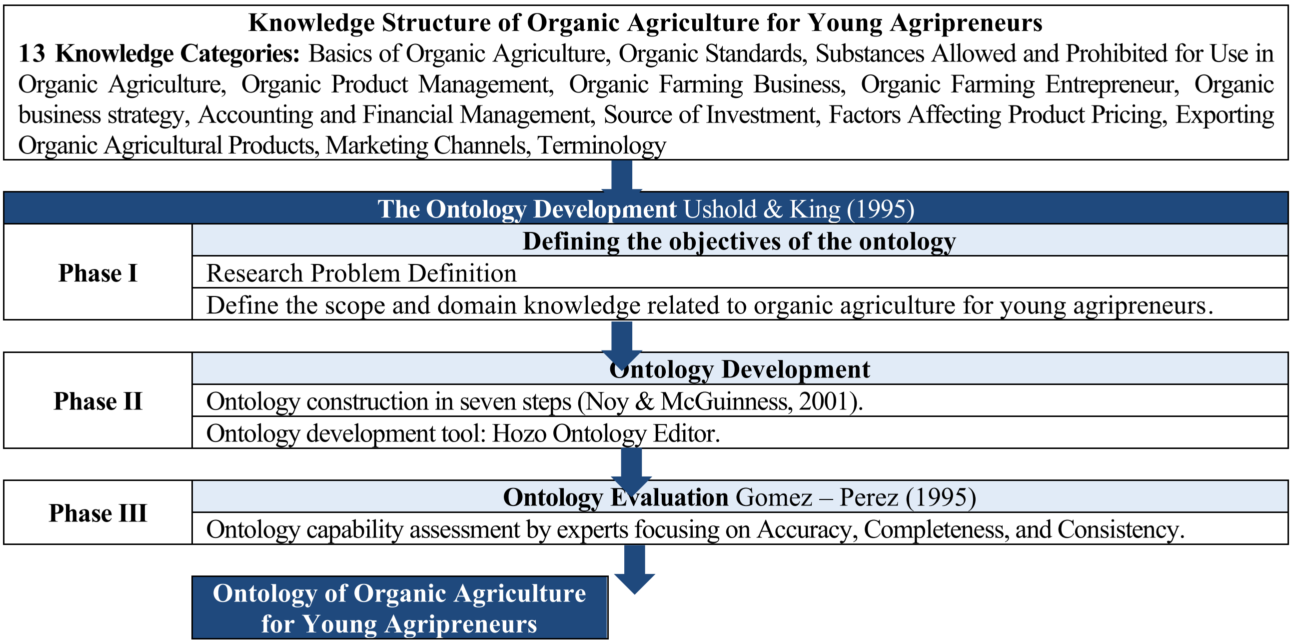

Fig. 1. Conceptual framework of the research phases

This study seeks to address these issues by developing a comprehensive ontology that formalizes the concepts, relationships, and processes relevant to organic agriculture for young agripreneurs, enabling semantic interoperability, knowledge integration, and intelligent decision support.

2) *Define the scope and domain knowledge related to organic agriculture for young agripreneurs.*

To ensure relevance and applicability, the ontology was designed around four primary use cases derived from expert consultations, document analysis, and stakeholder needs.

Scope 1: Certification Preparation and Compliance focuses on supporting young agripreneurs in identifying applicable organic standards for their farms, understanding required documentation and inspection procedures, and recognizing the relevant certification agencies responsible for certifying farms, production sites, or organic products.

Scope 2: Production Planning and Practice Selection **addresses** the need for young agripreneurs to understand permitted and prohibited substances, appropriate soil and nutrient management approaches, recommended crop or livestock practices, and the documentation required to demonstrate compliance with organic standards.

Scope 3: Business and Market Decision Support supports agripreneurs in identifying appropriate market channels (local, export, and online), as well as in understanding branding strategies, packaging requirements, pricing considerations, and business models aligned with their capabilities and specific product categories.

Scope 4: Information System Integration and Semantic Search enables government agencies, researchers, and platform developers to reuse the ontology as a standardized schema for linking and integrating data from existing systems (e.g., OAN, TraceThai, and OAE), thereby supporting interoperability, advanced analytics, and intelligent semantic knowledge retrieval.

Phase II: Ontology Development. In this phase, the researcher applied the knowledge engineering approach to ontology construction proposed by Noy and McGuinness (2001) as the framework for developing the ontology. The process consisted of seven steps:

1) Determine the Domain and Scope of the Ontology. The domain and scope of the ontology were defined based on its objectives to comprehensively cover standardized organic agriculture knowledge, together with related knowledge, in order to ensure compliance with the requirements and processes of organic farming standards.

2) Consider Reusing Existing Ontologies. Existing ontologies in Thailand and abroad were reviewed to identify relevant concepts associated with organic agriculture and young agricultural entrepreneurship.
3) Enumerate Important Terms in the Ontology. Key terms relevant to the domain were collected to ensure comprehensive knowledge coverage. Properties of the knowledge were specified using three approaches: top–down, bottom–up, and a combination of both.
4) Define the Classes and Class Hierarchy. Classes representing domain concepts were defined, including main classes and subclasses, and were structured into a hierarchical relationship to reflect the conceptual organization.
5) Define the Properties of Classes Slots. Relationships were specified and classified into three categories: (1) hierarchical relationships "is-a" representing subclass–class associations, (2) semantic relationships, including "attribute-of" describing entity characteristics and "part-of" representing component relationships", and (3) class properties, consisting of object properties and data properties.
6) Define the Facets of the Slots. Facets or constraints were specified to determine permissible values for properties, thereby enhancing the clarity of the ontology structure. These included: (1) String for textual or character data, (2) Number for numerical values, such as integers, and (3) Instance for individuals of other classes to establish relationships, with slot values constrained to instances of the designated classes.
7) Create Instances. Instances (individuals) were created for each class in the established hierarchy. This involved: (1) selecting the class, (2) creating example data for the class, and (3) specifying detailed class properties for each instance.

Phase III: Ontology Evaluation. This phase focused on examining the validity, coverage, and applicability of the ontology through expert assessment. The evaluation was conducted based on the principles of knowledge model validation, which encompass three main dimensions: 1) Accuracy – reflecting the extent to which the ontology represents the reality of the studied domain, 2) Completeness – indicating the extent to which the ontology covers all essential concepts and relationships within the domain, and 3) Consistency – assessing the logical coherence of the ontology to ensure that no internal contradictions exist. A five-point Likert scale (Likert, 1932) was employed to measure the appropriateness of the ontology in each dimension.

4. Results

4.1. The results of defining the objectives of the ontology

The knowledge categories in the organic agriculture ontology were derived through a systematic process of knowledge elicitation and classification. Topic analysis results from Scopus-indexed research journals were integrated with content and knowledge-structure analyses of relevant information resources, including organic agriculture standards and related documents. These sources were comparatively examined to identify overlapping, redundant, or semantically similar concepts, which were subsequently consolidated or eliminated. Knowledge classification theory was then applied to differentiate conceptual elements based on their functional roles, attributes, and contextual relevance, and to group semantically related elements into coherent and representative categories.

As a result of this process, the synthesized domain knowledge was formalized into 13 main categories, 55 subcategories, and 706 subgroups, each represented as a knowledge class within the organic agriculture ontology for young agripreneurs.

4.2. The results of ontology development

The organic agriculture ontology for young agripreneurs was developed the seven-step approach proposed as shown on Fig. 2.

1) Figure 2 illustrates the coherent knowledge structure of the ontology developed in this study. **The domain of** the ontology was defined as "Organic Farming," with a specific focus on Standard Organic Farming. Thirteen related conceptual categories were identified, including: (1) Young Agripreneurs, (2) Standard Organic Farming, (3) Organic Agricultural Products, (4) Agricultural Businesses, (5) Organic Markets, (6) Agricultural Processes, (7) Agencies related to organic standards, (8) Standards, (9) Certification, (10) Conditions for certification, (11) Certification Services, (12) Case Requests for certification, and (13) Supporting Documents for certification. These concepts were systematically interrelated to form an integrated and coherent knowledge structure.

2) The review of existing ontologies and information systems revealed gaps in coverage for organic agriculture and young agripreneurs in Thailand. While AGROVOC, a multilingual thesaurus/ontology with over 40,000 terms across food, agriculture, forestry, fisheries, and environment, provides a global standard for knowledge organization, it lacks concepts specific to organic agriculture and young agripreneurs. In Thailand, systems such

as the Organic Agricultural Network (OAN), the TraceThai blockchain-based traceability system, and the Office of Agricultural Economics (OAE) database collect information on farmers, production plots, certification, and economic statistics. However, these systems primarily link data within agencies and registered members, offering limited semantic integration. To address these limitations, a new ontology was developed, providing a structured and comprehensive framework that represents concepts, properties, and relationships relevant to organic agriculture for young agripreneurs.

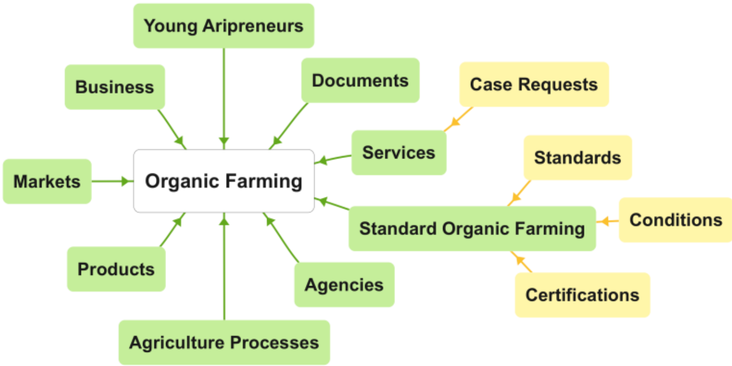

Fig. 2. Knowledge Scope of Standard Organic Farming and Related Concepts

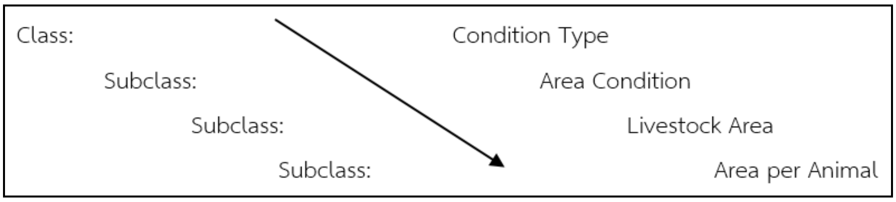

Fig. 3. Top–Down approach: Key terms from broad to specific levels.

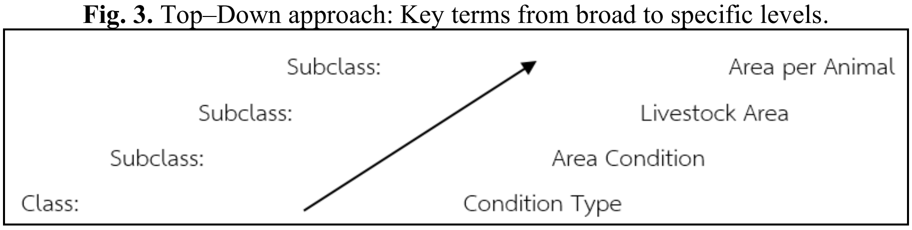

Fig. 4. Bottom–Up approach: Key terms from specific to general concepts.

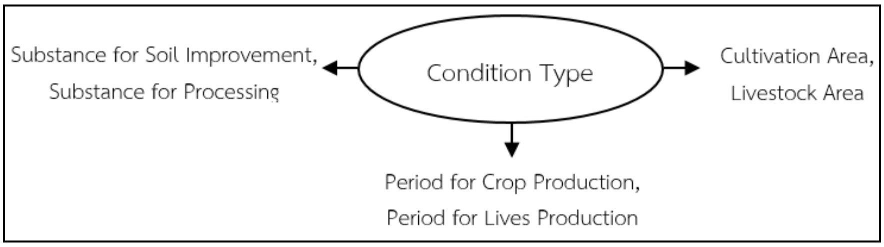

Fig. 5. Combination approach: Linking key terms with related concepts

3) Figures 3, 4, and 5 illustrate the approaches used to organize key terms for the development of the organic agriculture ontology for young agripreneurs. The key terms were systematically identified and categorized, and subsequently synthesized into three attributes: (1) terms, (2) properties, and (3) definitions. All terms were translated into English, the language used in system development. Three complementary approaches were applied to organize the terms. In the first approach, the top–down approach, broad, high-level terms were progressively refined into more specific concepts. In the second approach, the bottom–up approach, specific terms were aggregated into broader conceptual categories. In the third approach, the combination approach, the most critical terms were selected and linked to other relevant concepts to ensure semantic connectivity.

Table 2. Classes and definitions of classes and subclasses

No.	Class	Subclasses	Definition
1	Young Agripreneurs		Young agripreneurs can be categorized into various types of entrepreneurs, each with distinct properties.
		Entrepreneurs Type	Entrepreneurial types encompass small-scale producers, cooperatives, companies, farmer groups, organic product processors, distributors and retailers, as well as importers and exporters.
		Property Entrepreneurs	Entrepreneurial properties include age, educational background, business experience, specific needs, and unique attributes.
2	Organic Farming		Organic farming can be categorized into two forms: self-reliant organic farming and standard-based organic farming.
		Self-Reliant Organic Farming	The form of organic farming that has not yet been certified can be marketed in general markets; however, it does not carry a certification label.
		Standard Organic Farming	Certified organic farming has domestic and international markets, with authorized agencies providing standard-specific certification.
3	Products		Organic agricultural products traded in Thailand include rice, papaya, shrimp, pork, and chicken eggs.
		Product Type	The categories of organic agricultural products comprise organic vegetables, organic fruits, organic livestock products, organic compost, and organic processed foods.
4	Business		Organic agribusinesses include organic crop production, livestock production, fertilizer production, dietary supplements and vitamins, and ready-to-eat organic foods.
		Business Type	The types of organic agribusinesses include organic farming enterprises, organic processing and product management enterprises, and organic fertilizer and feed enterprises.
5	Markets		Organic markets include stores, supermarkets, organic restaurants, e-commerce platforms, EU markets.
		Market Type	The types of organic markets include local markets and export markets.
6	Agriculture Processes		The organic farming processes include Annual Crop Cultivation, Perennial Crop Cultivation,Ruminant Livestock Farming, Poultry Farming, Aquaculture
7	Agencies		Agencies related to organic farming and organic standards.
		Agency Type	The types of agencies are classified as government, private sector, state enterprises, and independent certification bodies.
		Agency Role Type	The roles of agencies are divided into certification and inspection bodies, and standard-setting bodies.
8	Service		Services provided by certification bodies for organic standard applications
		Service Type	Service types refer to the certification of farms, production sites, products, and farmer groups or communities that comply with organic standards.
		Case Request	Case requests include initial inspection, annual surveillance inspection, renewal inspection, inspection for new product types, inspection for expanded production areas, and inspection for additional members.
9	Document		List of documents submitted and types of documents for certification application and documents used to support inspections.
		Document Type	Document types refer to documents for application submission and inspection

4) As shown in Table 2, the organic agriculture ontology for young agripreneurs consists of 127 classes. Among these, nine main classes were identified: (1) Young Agripreneurs, (2) Organic Farming, (3) Products, (4) Business, (5) Markets, (6) Agricultural Processes, (7) Agencies, (8) Service, and (9) Document. A total of 118 subclasses were hierarchically organized under these superclasses using is-a relationships. Examples of classes and second-level subclasses, along with their descriptions, illustrating the hierarchical structure of the ontology and the relationships among concepts.

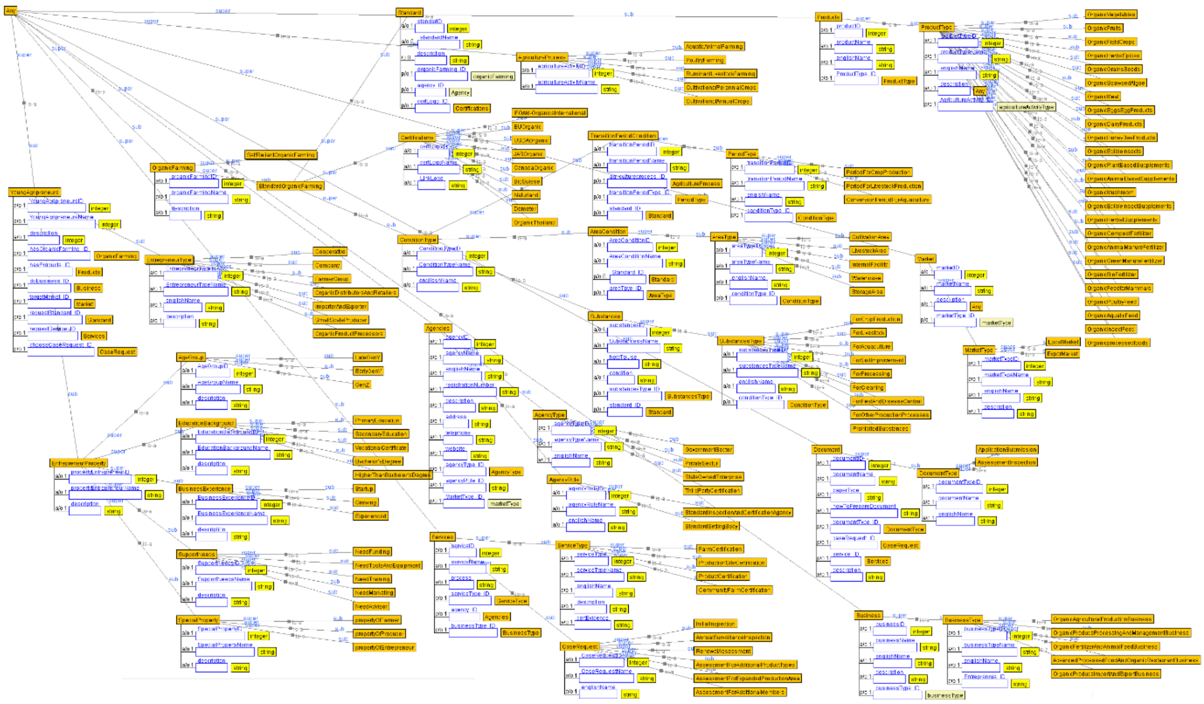

Fig. 6. Representation of the organic agriculture ontology for young agripreneurs.

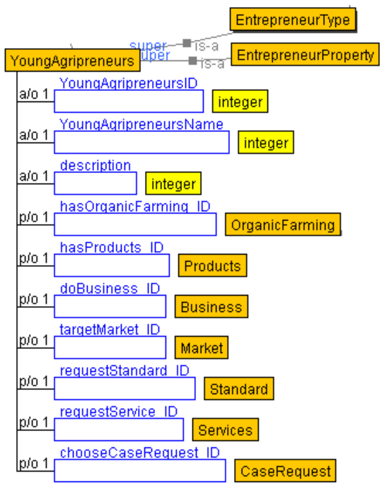

Fig. 7. Example of the Young Agripreneurs class

5) Figures 6 and 7 illustrate the properties (slots) of ontology classes and the relationships among concepts, including 118 *is-a* relationships, 107 *attribute-of* relationships, and 31 *part-of* relationships, which support semantic search and knowledge retrieval in organic agriculture for young agripreneurs.

6) The facets of the slots were defined to specify the permissible values for each property, thereby enhancing the clarity and precision of the ontology. The concepts within this ontology were found to include String, Integer, Instance, and Object Classes.

Table 4. Example of Slot Definitions and Corresponding Instances

Class Name	Property Name	Slot Type	Property Type	Class constraint	Instant
Young Agripreneurs	Young Agripreneurs ID	attribute-of	Data property	integer	1
	Young Agripreneurs Name	attribute-of	Data property	string	Smith T.
	Has Organic Framing	Part-of	Object property	Organic Framing	Standard Organic Framing
	Has Products	Part-of	Object property	Products	Rice
	Do Business	Part-of	Object property	Business	Organic Crop Production Business
	Target Market	Part-of	Object property	Market	EU Market
	Request Standard	Part-of	Object property	Standard	EU
	Request Service	Part-of	Object property	Service	Individual Farmer Farm Certification
	Choose Case Request	Part-of	Object property	Case Request	Initial Inspection
Standard	Standard ID	attribute-of	Data property	integer	1
	Standard Name	attribute-of	Data property	string	EU
	description	attribute-of	Data property	string	EU Regulation on Organic Production
	By agency	part-of	Object property	Agency	EU Commission
	Get Cert Logo	part-of	Object property	certification	EU Organic
Service	Service ID	attribute-of	Data property	integer	1
	Service Name	attribute-of	Data property	string	Individual Farmer Farm Certification
	Is Service Type	part-of	Object property	Service Type	Farm certification
	By agency	part-of	Object property	agencies	ACT
	Is Business Type	part-of	Object property	Business Type	Organic agricultural production business
Case Request	Case Request ID	attribute-of	Data property	integer	1
	Case Request Name	attribute-of	Data property	string	Initial Inspection
Document	Document ID	attribute-of	Data property	integer	2
	Document Name	attribute-of	Data property	string	National ID card
	Pape Type	attribute-of	Data property	string	Copy
	description	attribute-of	Data property	string	Used for identity verification
	Is Document Type	part-of	Object property	Document Type	Application submission
	Use for Case Request	part-of	Object property	Case Request	Initial Inspection
	Use for Service	part-of	Object property	Services	Individual Farmer Farm Certification
Substances	Substances ID	attribute-of	Data property	integer	14
	Substances Name	attribute-of	Data property	string	calcium oxide
	How To Use	attribute-of	Data property	string	Used for soil preparation

Class Name	Property Name	Slot Type	Property Type	Class constraint	Instant
	condition	attribute-of	Data property	string	Finely ground, used in appropriate amounts
	Substances Type	part-of	Object property	Substances Type	For soil amendment
Agencies	Agencies ID	attribute-of	Data property	integer	18
	Agencies Name	attribute-of	Data property	string	ACT Organic Company Limited
	Registration Number	attribute-of	Data property	string	EC No. 834/2007
	address	attribute-of	Data property	string	Nonthaburi, Thailand
	telephone	attribute-of	Data property	string	+66 2 580 0934
	website	attribute-of	Data property	string	actorganic-cert.or.th
	Agency Type	part-of	Object property	Agency Type	Private Sector
	Agency Type Role	part-of	Object property	Agency Role	Standard inspection and certification agency

7) Table 4 presents examples of slot definitions and their corresponding instances for each class in the ontology. These instances were created by selecting the target class, generating representative example data, and specifying detailed properties associated with each class. This process ensures that the ontology accurately represents domain knowledge and effectively supports semantic data retrieval in organic agriculture for young agripreneurs.

4.3. The result of ontology evaluation

Moreover, the ontology was evaluated by three experts with demonstrated expertise in information literacy, information technology, information systems management, Semantic Web technologies, ontology design and development, and knowledge engineering, in order to validate the accuracy and coherence of its structure and conceptual descriptions.

Table 5. Expert Evaluation Results of the Ontology (N = 3)

No.	Evaluation items	$\bar{x}$	Level
Defining the definition, scope, and objectives of ontology development			
1	The ontology matches the knowledge scope defined in this study.	4.00	High
2	The ontology adequately covers the knowledge scope in this study.	4.00	High
3	The ontology can be applied to develop an ontology for Organic for Young Agripreneurs.	4.00	High
	Total	4.00	High
Define Classes/Concepts			
4	The ontology defines concepts that appropriately describe knowledge.	4.00	High
5	The ontology appropriately classifies super classes.	3.00	Moderate
6	The ontology appropriately classifies subclasses.	3.00	Moderate
7	The ontology appropriately defines datatypes.	3.67	High
8	The ontology appropriately defines terms.	3.33	Moderate
9	The ontology appropriately defines class constraints.	3.67	High
	Total	3.44	High
Define Properties			
10	The ontology appropriately defines related properties to describe concepts.	3.67	High
11	The ontology appropriately defines relationships between related concepts.	3.67	High
12	The ontology appropriately defines the cardinality of related properties.	3.33	Moderate
13	The ontology appropriately defines the values of class properties.	3.67	High
14	The ontology has consistent relationships.	3.00	Moderate
	Total	3.47	High
Create Instances			
15	The ontology appropriately defines instances.	3.33	Moderate
16	The ontology defines data instances with correct terminology and grammar.	3.67	High

No.	Evaluation items	x̄	Level
	Total	3.50	High
Application to Ontology Development			
17	The ontology is accurate and reliable.	4.00	High
18	The ontology can be reused to develop other systems.	3.67	High
	Total	3.83	High

Table 5 summarizes the evaluation results, indicating that the definition of the ontology's scope, objectives, and conceptual definitions was rated as highly appropriate ($\bar{x}$ = 4.00), along with the identification of concepts and classes ($\bar{x}$ = 3.44), the definition of class properties ($\bar{x}$ = 3.47), the creation of classes and individual instances ($\bar{x}$ = 3.50), and the overall applicability of the ontology for development, practical use, and guidance for future enhancements ($\bar{x}$ = 3.83).

Overall, the ontology demonstrates readiness for integration into digital platforms supporting organic agriculture for young agripreneurs, including semantic search engines, recommender systems, and decision-assistance tools.

5. Discussion

This study integrated the ontology engineering approach of Uschold and King with the methodology of Noy and McGuinness to establish a systematic framework for ontology development. The ontology development process was implemented through the Hozo Ontology Editor, using OWL to formally represent the conceptual structure of organic agriculture standards. This structure was modeled through conceptual mapping using properties and classes in line with Semantic Web technologies. The results demonstrated that the developed ontology offers broad applicability, particularly in knowledge-based recommender systems, enabling accurate and systematic semantic linkages among diverse information sources. Furthermore, it can serve as a robust knowledge model for research in related fields such as agriculture, information technology, and knowledge management.

Moreover, the application of the Ontology Application Management Framework (OAM) played a critical role in controlling and managing the ontology development process. This framework enabled effective knowledge management through systematic categorization, management of class and data source changes, and the flexibility to extend the system in the future. Such capabilities provide practical benefits for young agripreneurs by facilitating access to relevant information, thereby supporting decision-making and production planning aligned with organic farming standards.

In comparison with related studies, several commonalities were observed. For instance, Fons et al. (2003) proposed an ontology-based framework to support knowledge sharing and decision-making in the agricultural domain, with a particular focus on modeling crop production processes and farm management activities. Their study emphasized a knowledge engineering–driven ontology development process, in which domain concepts, relationships, and constraints were primarily elicited through structured interviews and iterative workshops with agricultural experts. The ontology was implemented using WebODE, highlighting an early effort to formalize agricultural knowledge in a machine-interpretable form to enhance interoperability among agricultural information systems.

Similarly, Ramos et al. (2011) developed an agricultural ontology aimed at improving information integration and semantic consistency within agricultural knowledge management systems. Their work focused on defining core agricultural concepts, production activities, and resource relationships, relying heavily on expert consultation and consensus-building techniques to validate conceptual structures. The ontology was constructed using Protégé, reflecting the increasing adoption of standardized ontology development tools to facilitate reuse and extensibility. Both studies primarily framed agriculture from a production- and process-oriented perspective, with limited attention to certification systems, regulatory compliance, or socio-economic and entrepreneurial dimensions.

In contrast, the present study adopted a different approach by synthesizing knowledge from publicly available and authoritative information resources, including official organic farming standards issued by organizations such as IFOAM, EU Organic, USDA-NOP, ACT, and Thailand's Organic Agriculture Certification, as well as guidelines, manuals, and official websites. Rather than relying predominantly on expert elicitation, this strategy enabled the systematic integration of formal standards, theoretical frameworks, and practical guidelines into a comprehensive ontology structure.

As a result, the proposed ontology extends beyond production activities to incorporate certification workflows, compliance requirements, market structures, and agripreneurial characteristics, thereby addressing gaps identified in earlier ontology-based agricultural studies.The findings of this study further demonstrate that the developed organic agriculture ontology has the potential to evolve into a centralized knowledge base for the creation of digital applications and platforms in the organic agriculture domain. These may include online advisory systems, digital learning platforms, or internal knowledge management systems for agricultural organizations.

Moreover, the ontology can be integrated with governmental and institutional information systems to support the development of organic agriculture infrastructure in Thailand, such as certification systems, producer databases, and product traceability systems. Thus, the ontology not only serves as a valuable decision-support tool for young agripreneurs but also provides a foundational framework for the future development and integration of organic agriculture information systems. In addition, it offers a practical tool for learning and fostering a deeper understanding of organic farming systems across multiple dimensions.

Existing agricultural ontologies, such as AGROVOC, the Plant Ontology, and the Crop Ontology, primarily emphasize crops, traits, and biological classifications. Building upon these foundational resources, the proposed ontology extends the scope of knowledge representation to include certification processes, inspection workflows, documentation requirements, entrepreneurial competencies, and mechanisms for market selection. By incorporating these additional dimensions, the ontology addresses an underrepresented area in the literature, where regulatory and business aspects of agriculture have received comparatively limited formalization.

Furthermore, the ontology integrates certification-related knowledge by explicitly modeling major organic standards, including EU Organic, USDA-NOP, IFOAM, Organic Thailand, and ACT, together with associated certification request procedures and required public- and farm-level documentation. This integration provides structured support for certification-related decision-making and responds to a well-recognized need among farmers and agripreneurs for clearer navigation of organic certification processes, which are frequently characterized as complex and challenging in practice.

Although the concept of agripreneurship has gained increasing attention, its formal representation within semantic knowledge models remains limited. To address this gap, the proposed ontology explicitly models key characteristics of young agripreneurs, including age ranges, levels of experience, skills and competencies, as well as enterprise types and business strategies. This structured representation provides an evidence-based and context-specific conceptualization of young agripreneurs as a distinct user group, thereby responding directly to reviewer feedback and enhancing the ontology's relevance for personalized decision support and knowledge-based applications.

6. Conclusion

This study developed a comprehensive and semantically rich ontology for organic agriculture that is specifically aligned with the needs and contextual realities of young agripreneurs in Thailand. Responding to reviewer feedback and addressing key gaps in existing agricultural ontologies, the proposed framework integrates five core domains—organic production, certification standards, business and entrepreneurship, market structures, and agripreneur characteristics—into a unified and machine-interpretable knowledge model. Employing a rigorous ontology engineering methodology that encompassed domain scoping, knowledge elicitation, ontology reuse analysis, structured design strategies, and iterative expert validation, the study produced an ontology consisting of 127 classes, 31 object properties, and 18 data properties, supported by axioms and semantic reasoning capabilities. The resulting ontology demonstrates its effectiveness in systematically representing essential concepts and relationships, including product categories, organic standards, certification agencies, certification procedures, and required documentation, thereby providing a contextually accurate and integrated foundation for decision support, the results revealed several limitations and offered practical recommendations for future enhancement, as follows:

6.1. Domain Scope Limitations

This study primarily focused on the standards of organic agriculture and the knowledge relevant to new-generation agripreneurs within a defined context. Consequently, it may not fully encompass other critical aspects for the future development of organic agriculture, such as smart farming technologies, supply chain management systems, or organic agricultural marketing. Future research should consider expanding the scope to integrate digital technology and systemic management knowledge, thereby enhancing comprehensiveness and strengthening the applicability of research findings to meet the evolving needs of modern agribusiness.

6.2. Data Source Limitations

The ontology developed in this study relied on information extracted from books, manuals, documents, articles, and relevant research studies. However, these sources may not comprehensively cover all organizations or countries that establish organic agriculture standards, potentially resulting in certain data gaps. To improve completeness, future studies should expand and refine the database by incorporating information from international and regional standard-setting bodies or employing triangulation methods through cross-verification of multiple sources to minimize potential biases.

6.3. Application Constraints

The developed ontology can serve as a central knowledge base for developing applications or information systems related to organic agriculture. Nonetheless, its integration with governmental systems or other digital platforms may face constraints due to budget limitations and organizational policies, which could delay practical implementation. To facilitate effective application, it is recommended to establish standardized data formats for interoperability with various information systems and to conduct pilot testing of the ontology with relevant platforms to assess feasibility and address technical limitations prior to full-scale deployment.

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