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Research article

Design of a Knowledge-Based System for Economic Plants: A Case Study of Thailand

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Abstract: (1) Background: Knowledge management is essential for sustainable business practices in agriculture, particularly for high-value economic plants with commercial potential. This research presents the design and development of a knowledge-based system for economic plants in Thailand, integrating traditional ecological knowledge with modern information management principles. Traditional ecological knowledge is essential for sustainable agroforestry practices, yet this knowledge is eroding with socio-economic changes, creating critical gaps in agricultural information systems; (2) Methods: The study employed a system development life cycle approach with stakeholder engagement principles, resulting in: a) a conceptual framework for economic plant knowledge classification based on ontology-based agricultural knowledge management; b) a comprehensive database design using Entity Relationship Model principles integrating botanical, economic, regulatory, and cultural dimensions; and c) a prototype web-based application enabling effective knowledge acquisition, storage, sharing, and application through dual-interface accessibility; (3) Results: The system facilitates access to critical information about plant characteristics, propagation methods, utilization opportunities, value addition processes, and relevant regulations. Together, these features create an information ecosystem that supports sustainable agribusiness development. This knowledge management solution addresses the fragmentation of valuable traditional and scientific knowledge while providing a centralized platform accessible to farmers, entrepreneurs, researchers, and policymakers. The system preserves intellectual capital by converting tacit traditional knowledge into explicit, shareable resources; (4) Conclusions: The findings indicate that the developed knowledge-based system contributes to preserving traditional ecological knowledge, enhancing information accessibility, and supporting economic development through improved decision-making in agricultural business contexts. The system offers significant business value through enhanced value chain coordination, innovation facilitation, and sustainability integration.

Keywords: Knowledge management; database nanagement; sustainable agriculture; agribusiness information systems; value chain management

1. Introduction

The management of natural resources is a critical domain for sustainable business development, particularly in countries like Thailand, where the agricultural sector contributes significantly to economic growth. The Royal

Forest Department of Thailand, as the primary government agency responsible for forest and wildlife sustainability, has actively promoted the cultivation of economic plants - perennial trees with commercial value that can be grown outside conservation areas [1]. These plants offer substantial business opportunities through direct cultivation, processing, and value-added activities, creating both immediate and long-term economic benefits for stakeholders across the value chain. Economic plants represent a valuable business asset. The Thai government has encouraged their use as collateral for financial transactions, including loans and credit applications. This novel approach to natural resource valuation requires standardized evaluation criteria and comprehensive information about the plants' characteristics, cultivation requirements, processing methods, and market potential. For plant growers and processors to maximize economic returns, they require access to accurate, relevant, and timely knowledge about these high-value species. Traditional agroforestry systems, which combine woody perennials with crops and animals, have historically provided multiple non-wood products and ecological benefits while meeting diverse socio-economic needs sustainably across various agroecological conditions [2]. However, these traditional systems are breaking down for various reasons, and farmers' traditional ecological knowledge is eroding due to socio-economic changes [3].

Knowledge represents an unlimited and appreciating asset - the more it is utilized, the greater its value becomes. Integrating existing knowledge with new insights generates innovative applications and creates additional economic opportunities. Knowledge and information are essential for farmers to tackle contemporary agricultural challenges, where knowledge is increasingly vital for development, surpassing traditional capital factors [4]. However, information about economic plants in Thailand remains fragmented across multiple stakeholders, including government departments, research institutions, and local experts. This fragmentation creates significant barriers to knowledge access, sharing, and application, ultimately limiting the potential business value of these resources. It is important to note that the term "knowledge-based system," as used in this study, refers to a structured knowledge repository designed to capture, organize, and disseminate domain-specific knowledge rather than an expert system with automated inference or reasoning capabilities. This usage aligns with the knowledge management perspective, in which a knowledge-based system denotes any information system that facilitates the systematic management of organizational or domain knowledge, encompassing knowledge acquisition, storage, retrieval, and sharing [5]. This distinction is significant because the primary challenge addressed in this research is knowledge fragmentation and inaccessibility rather than the automation of decision-making processes.

The absence of a centralized knowledge management system creates several challenges. These include limited access to critical information, restricted dissemination of knowledge, disconnection between related knowledge domains, barriers to knowledge enhancement and innovation, and difficulties in preserving valuable traditional knowledge. Traditional ecological knowledge is essential for sustainable agroforestry practices, yet gaps in knowledge about multi-purpose trees hinder their sustainable management [2]. The economic and environmental roles of associated trees are often underassessed, and gaps in knowledge of multi-purpose trees must be addressed for sustainable management [6]. Knowledge management systems have been applied effectively in agricultural contexts across various countries. Information technology enhances public accessibility and interaction via web platforms, and citizen science can enhance knowledge on invasive alien species through web-based interfaces that boost citizen participation in training and data generation [7]. The importance of data aggregation for medicinal plant research is emphasized, highlighting challenges in developing medicinal plant databases and the need to establish minimum standards [8]. Ontology is crucial for knowledge management in agriculture, helping classify agricultural information and build knowledge databases [9]. Agricultural knowledge management systems frameworks that include modules for knowledge acquisition and representation emphasize improving intelligence and efficiency in knowledge sharing [10].

The development of comprehensive databases has proven essential across various plant-related domains. Plant-based extracts can replace synthetic pesticides and antimicrobials, and knowledge bases that compile data on plant uses for crop protection support applications under the One Health approach [11]. Ethnobotanical databases enhance understanding of human-plant relationships and ethnopharmacology, facilitating hypothesis generation and testing while preserving traditional knowledge amidst cultural change

[12]. A global database of plant services for humankind aids in understanding plant-human interactions for future well-being, with research highlighting the importance of conserving biodiversity for human benefit [13]. Repository databases of indigenous herbal medicinal plants, including names in local languages and links between plant pictures and their medicinal uses, demonstrate the vital role of traditional medicine in healthcare systems [14]. In the broader international context, web-based knowledge management systems with dynamic interfaces are proposed to enhance communication among farmers, facilitate collaboration between farmers and agricultural experts, and address knowledge transfer issues arising from employee transitions in agriculture [15]. Internet technologies can enhance knowledge sharing among rural communities, with government and donor support essential for progress, as failure to address the digital divide leads to ongoing poverty [16]. Information and communication technologies are improving access to information for farmers and can revolutionize knowledge sharing in agriculture, with new information services being vital for farmers in rural areas [17].

This research addresses the critical need for improved knowledge management in the agricultural sector, with a specific focus on economic plants in Thailand. The primary objectives are to (1) design a conceptual framework for organizing and classifying economic plant knowledge and evaluate its appropriateness through expert assessment of the knowledge organization structure, (2) develop a comprehensive database model integrating various knowledge dimensions and assess its content correctness and completeness, and (3) create a prototype web-based platform for knowledge access, sharing, and application and evaluate its usability and usefulness for stakeholder decision-making. These objectives align with design science research principles, in which artifact evaluation serves as the primary mechanism for demonstrating research contributions [18].

2. Research Methodology

This study adopts a design-oriented research approach, focusing on the systematic design and development of an information system artifact rather than empirical hypothesis testing. The research is classified as a design science study, in which the primary contributions are the design artifacts themselves — namely, a conceptual knowledge classification framework, a database model, and a prototype web-based platform [19]. The scope of the study encompasses the full system development process from requirements analysis through prototype implementation, to produce a functional knowledge-based system for economic plants in Thailand. Unlike empirical research that tests theoretical propositions through data collection and statistical analysis, design science research contributes to knowledge through the creation and evaluation of artifacts intended to solve identified organizational or domain-specific problems [20]. Accordingly, the validity of this research is assessed through the utility and applicability of the resulting system design rather than through hypothesis testing or inferential statistics. This study employed the System Development Life Cycle (SDLC) approach to design and develop the knowledge-based system for economic plants. The SDLC methodology provides a structured framework for information system development, ensuring alignment with user requirements and business objectives. New-generation agricultural system models for sustainability require user-driven approaches to model development that emphasize collaboration in model development and knowledge product creation [21]. Stakeholder engagement is crucial for addressing major agricultural challenges, and linking model development with user-driven knowledge products enhances food security innovation [22]. The research process consisted of the following key phases that integrate both technical development and stakeholder needs assessment.

2.1 Need study and data collection

The initial phase involved assessing the knowledge management requirements for economic plants through comprehensive data collection. The design aimed to develop a system capable of managing knowledge sharing, linking related knowledge domains, and providing comprehensive coverage of the botanical, economic, regulatory, and cultural dimensions of economic plants. This approach aligns with research emphasizing that relevant information is crucial for agricultural development, and that unambiguous interpretations are needed for farmers to make informed decisions [23]. The scope of economic plants addressed in this study is based on the classification established by the Royal Forest Department of Thailand,

which designates two categories of trees permitted for cultivation outside conservation areas: non-timber economic plants (20 species) and economically valuable timber species (58 species). The current prototype focuses on 20 species selected from the economically valuable timber category. The selection criteria for inclusion were based on the following considerations: (1) the species must be designated as economically valuable timber by the Royal Forest Department, (2) the species must be suitable for cultivation in the study area (Nakhon Ratchasima Province), and (3) sufficient knowledge from both documented sources and local practitioners must be available to populate the knowledge base across the three primary categories (Profilers, Knowledge Profiles, and Expert Directory). The prototype screenshots presented in Figures 5 and 6 display Siamese Rosewood (*Dalbergia cochinchinensis*) and Teak (*Tectona grandis*) as representative examples; however, the system contains knowledge entries for all 20 selected species. Future development aims to expand coverage to include the remaining economically valuable timber species as well as the 20 non-timber economic plant species, subject to the availability of comprehensive knowledge from relevant stakeholders.

The stakeholder engagement process involved three principal groups: (1) government officials from the Royal Forest Department and related agricultural agencies who provided regulatory and policy-level information regarding economic plant designation and utilization guidelines; (2) local farmers and community practitioners in Nakhon Ratchasima Province who contributed experiential knowledge on cultivation practices, traditional uses, and cultural beliefs associated with economic plants; and (3) academic researchers and subject matter experts in botany, agroforestry, and agricultural economics who provided scientific and technical knowledge. Data collection was conducted through semi-structured interviews and document analysis. Interviews with government officials focused on regulatory frameworks and plant designation criteria, while interviews with local practitioners captured tacit knowledge regarding traditional cultivation and utilization methods. Document analysis encompassed official publications, research reports, and community-level records of economic plants. The insights gathered from these stakeholder groups directly informed the design of the three-category knowledge classification structure (Profilers, Knowledge Profiles, and Expert Directory), ensuring that the system architecture reflected the information needs and knowledge domains identified across stakeholder groups. This stakeholder-informed approach aligns with research emphasizing that participatory methods in agricultural system development enhance the relevance and adoption potential of resulting knowledge products [24].

The data collection process incorporated both electronic and paper-based documentary sources from relevant agencies, communities, and subject matter experts. This included harvesting explicit knowledge from documented sources and tacit knowledge from experience-based insights and lessons learned from practitioners. Traditional ecological knowledge is essential for sustainable agroforestry practices, yet it is eroding due to socio-economic changes, making its preservation and documentation critical [2]. The methodology recognized that herbarium data complements published literature in ethnobotanical studies, and that traditional knowledge conservation is crucial amidst cultural change [12]. The comprehensive approach to data collection addressed the challenge that knowledge of agroforestry systems' functioning and dynamics is limited and that trends vary across agro-ecological conditions and market access [25]. By integrating diverse knowledge sources, the study aimed to bridge the gap between traditional ecological knowledge and modern agricultural information systems. This multi-source approach supports the development of minimum standards for plant databases while addressing under-documentation of traditional plant knowledge [8, 13]. The data collection framework also considered that a unified approach in ethnobotany is necessary for effective research, supporting comparative analysis and knowledge archiving [26].

2.2 Design of Knowledge Flow Relations

This phase focused on creating linkages between knowledge categories to establish a coherent knowledge structure. The knowledge base was organized into three primary categories: Profilers (basic information about economic plants), Knowledge Profiles (specialized knowledge related to economic value), and Expert Directory (information about knowledge providers and their expertise). This structured approach aligns with research that emphasizes that ontology aids in classifying agricultural information and in building knowledge databases. Key technologies for knowledge acquisition and representation are essential for improving intelligence and efficiency in knowledge sharing [9]. **Figure 1** illustrates the high-level relationship

design between these knowledge categories, establishing the foundation for knowledge integration and accessibility. The design addresses the challenge that data structuring and mining enhance integration processes, and that effective management systems reduce project delays and costs through timely information that significantly impacts project execution [27]. The knowledge categories were further analyzed to identify relationships among subcategories, resulting in a comprehensive knowledge network, as shown in **Figure 2**. This network approach supports the principle that integrated approaches reduce costs and improve processes in project implementation, while methodology provides structured solutions for complex industry problems.

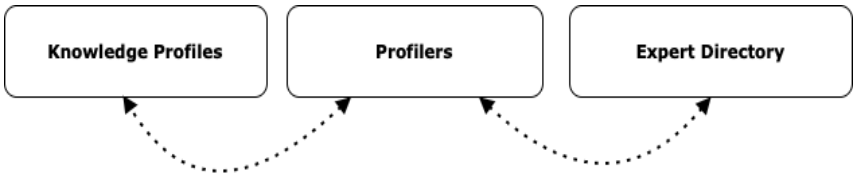


Figure 1. The design of links in the category of economic plants

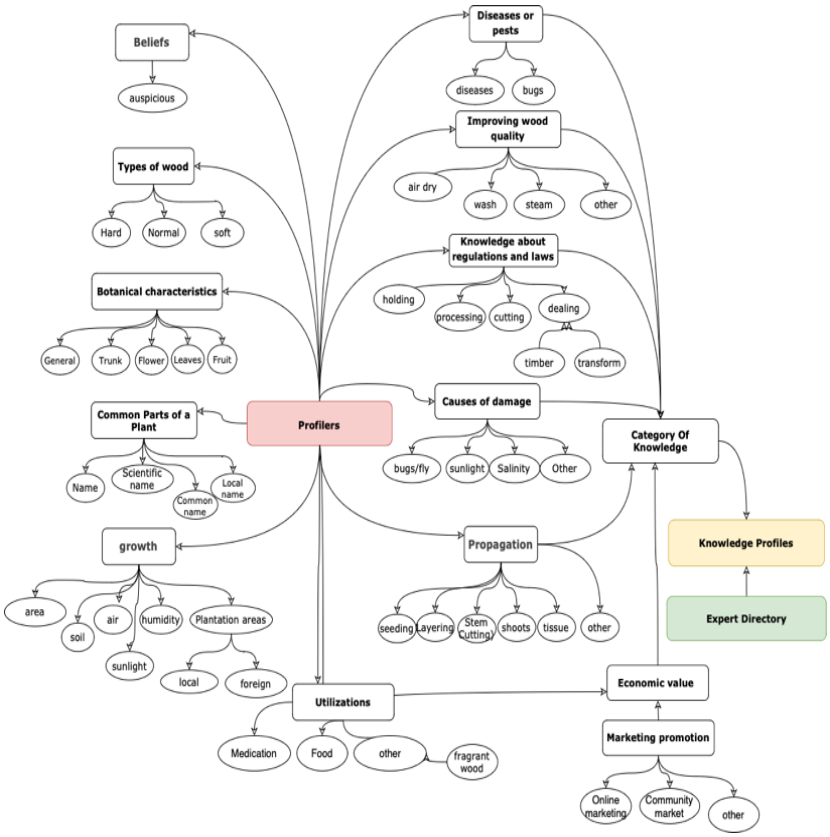


Figure 2. The design of the related links between the subcategories of economic plants

The knowledge classification framework used principles from the Dewey Decimal Classification System to organize knowledge obtained during data collection systematically. This systematic approach addresses the need for standardized environments for data submission and retrieval, supporting the integration of diverse scientific knowledge into dynamic databases. Each primary category was divided into specific subcategories that facilitate comparative research and knowledge archiving through community contributions. The framework incorporates the principle that tools for browsing and editing databases are essential for effective knowledge management, and that international standards committees play an important role in facilitating global collaboration [26]. The three-category structure was designed to address specific knowledge domains: Profilers store general information about economic plants, including botanical characteristics, propagation methods, plantation areas, diseases and pests, and cultural beliefs and practices.

Knowledge Profiles store specialized knowledge in three domains: general knowledge of economic value (including prevention of plant diseases and pests, propagation techniques, maintenance requirements, and fundamental utilization methods), knowledge about economic benefit utilization (including processing methods, quality improvement techniques, texture maintenance, storage requirements, damage prevention, value addition opportunities, marketing strategies, and supporting agencies), and knowledge about regulations and laws (including business-related regulations and compliance requirements). The Expert Directory stores information about knowledge providers, including individual experts and institutional knowledge holders, along with their contact information and expertise domains.

$$\text{Popularity score Rating} = \frac{\sum_{i=1}^{n}(x_i)}{\sum_{i=1}^{n}(N_i)} \quad (1)$$

where

$\sum_{i=1}^{n}(x_i)$ is the total of scores

$\sum_{i=1}^{n}(N_i)$ is the total number of experts

The system incorporates a popularity score rating mechanism for each knowledge component, calculated using Equation 1, to provide a community-based quality indicator. The scoring uses a five-point Likert scale (1 = least useful, 5 = most useful), where each qualified expert registered in the Expert Directory may assign a single rating per knowledge entry. The variable x_i represents the score assigned by expert i, and N_i represents the count of each contributing expert (equal to 1 per expert), such that the equation computes the arithmetic mean of all expert ratings for a given knowledge entry. While the computation is mathematically equivalent to a simple average, its formal specification serves two purposes within the system design: first, it provides an unambiguous definition for database implementation, and second, it establishes the foundation for potential future extensions such as weighted scoring based on expert domain relevance or experience level.

It is important to clarify the functional scope of the knowledge-based system in relation to knowledge processing. The system is designed primarily as a knowledge repository and retrieval platform rather than an inference-based expert system. The principal functions include knowledge acquisition from diverse sources, structured storage using a relational database architecture, organized retrieval via a three-category classification framework, and knowledge sharing via a web-based interface. The system does not, in its current form, incorporate automated reasoning engines, production rules, or algorithmic recommendation mechanisms. Instead, knowledge rules within the system operate at the organizational level — governing how knowledge is classified into Profilers, Knowledge Profiles, and Expert Directory categories, how relationships between knowledge subcategories are structured (as illustrated in Figure 2), and how content quality is indicated through the popularity score rating mechanism (Equation 1). This community-based scoring approach serves as a soft validation rule, enabling users to prioritize knowledge endorsed by multiple experts rather than relying on system-generated inferences. This design decision reflects the study's primary objective of addressing knowledge fragmentation and accessibility challenges rather than automating decision-making processes. The distinction is consistent with knowledge management system typologies that differentiate between repository-oriented systems focused on knowledge codification and capture, and reasoning-oriented systems focused on automated inference and decision support [28]. Future development may extend the system toward recommendation capabilities, such as suggesting suitable plant species based on geographic and climatic conditions or recommending value-addition pathways based on plant characteristics, which would require integrating rule-based or machine-learning components [29].

2.3 Knowledge Quality Assurance and Validation

Ensuring the quality, accuracy, and trustworthiness of knowledge content is a fundamental concern for the system, particularly given the integration of traditional ecological knowledge with scientific information. The knowledge quality assurance process operates through three complementary mechanisms: expert-mediated content validation, administrative review, and community-based scoring. First, all knowledge entries submitted to the system undergo review by authorized administrators before publication

on the public-facing interface. The administrative section restricts content management functions to authorized users, ensuring that only vetted information is made accessible. This gatekeeping function serves as the primary quality control mechanism, preventing unverified or inaccurate content from entering the knowledge base. Second, the selection of contributing experts follows domain-relevant criteria. Experts registered in the Expert Directory are identified based on documented expertise in relevant fields, including academic qualifications, institutional affiliations, professional experience in economic plant cultivation or processing, and recognized standing within local farming communities for traditional knowledge holders. The Expert Directory stores these credentials, enabling system administrators to assess contributor qualifications when evaluating submitted knowledge.

Third, the popularity score rating mechanism (Equation 1) provides a post-publication quality indicator based on aggregated expert evaluations. A minimum threshold of three expert ratings is required before a popularity score is displayed for any knowledge entry, ensuring that scores reflect a baseline level of consensus rather than individual opinion. It is acknowledged that this threshold represents a practical minimum for the prototype stage, and future development may increase this requirement as the expert user base expands. Regarding resolving conflicts between traditional and scientific sources, the system adopts a complementary rather than hierarchical approach. Both traditional ecological knowledge and scientific information are stored as distinct knowledge entries with clear source attribution, allowing users to access and compare perspectives from different knowledge traditions. When direct contradictions arise, the administrative review process flags such entries, facilitating resolution through consultation with relevant domain experts. The system does not automatically prioritize one knowledge type over another, consistent with research advocating for the respectful integration of indigenous and scientific knowledge systems in agricultural contexts. To address knowledge currency, the database includes a timestamp field (Knowledge_timestamp) that records the most recent update for each entry. System administrators are responsible for periodic content reviews to identify entries requiring updates based on new research findings, regulatory changes, or evolving cultivation practices. Future development will incorporate automated notification mechanisms to alert administrators when entries exceed a predefined age threshold without review, supporting systematic content maintenance [30].

3. Designing the Knowledge Base

While Section 2 established the conceptual knowledge classification framework and the relationships between knowledge categories, this section presents the translation of that conceptual design into a physical database architecture. The database design phase constitutes a distinct design artifact within the design science research approach, representing the operational specification that enables system implementation. The database design phase translated the conceptual knowledge framework into an operational data structure using the Entity-Relationship Model (ERM). This model established relationships among various knowledge categories, creating a comprehensive, integrated data architecture, as shown in **Figure 3**. The ERM approach aligns with research demonstrating that integrated methodological frameworks improve connectivity in management systems, where data structuring and mining enhance integration processes [27]. Comprehensive databases have proven essential across various plant-related domains, with integrated data curation supporting genome sequences, literature, and diverse genomic data for better analysis and application [31]. The Entity Relationship Model facilitated the detailed specification of data elements through comprehensive data dictionaries for each knowledge category. These dictionaries defined column names, descriptions, data types, and relationships with other tables, following principles established in successful plant database development. Research shows that databases supporting comparative studies and molecular biology research require visualization tools and systematic data organization to enhance user experience [31]. The systematic approach to database design addresses the challenge that big data dimensions enhance global connectivity and project management, while ecosystem frameworks generate economic value in industries [32].

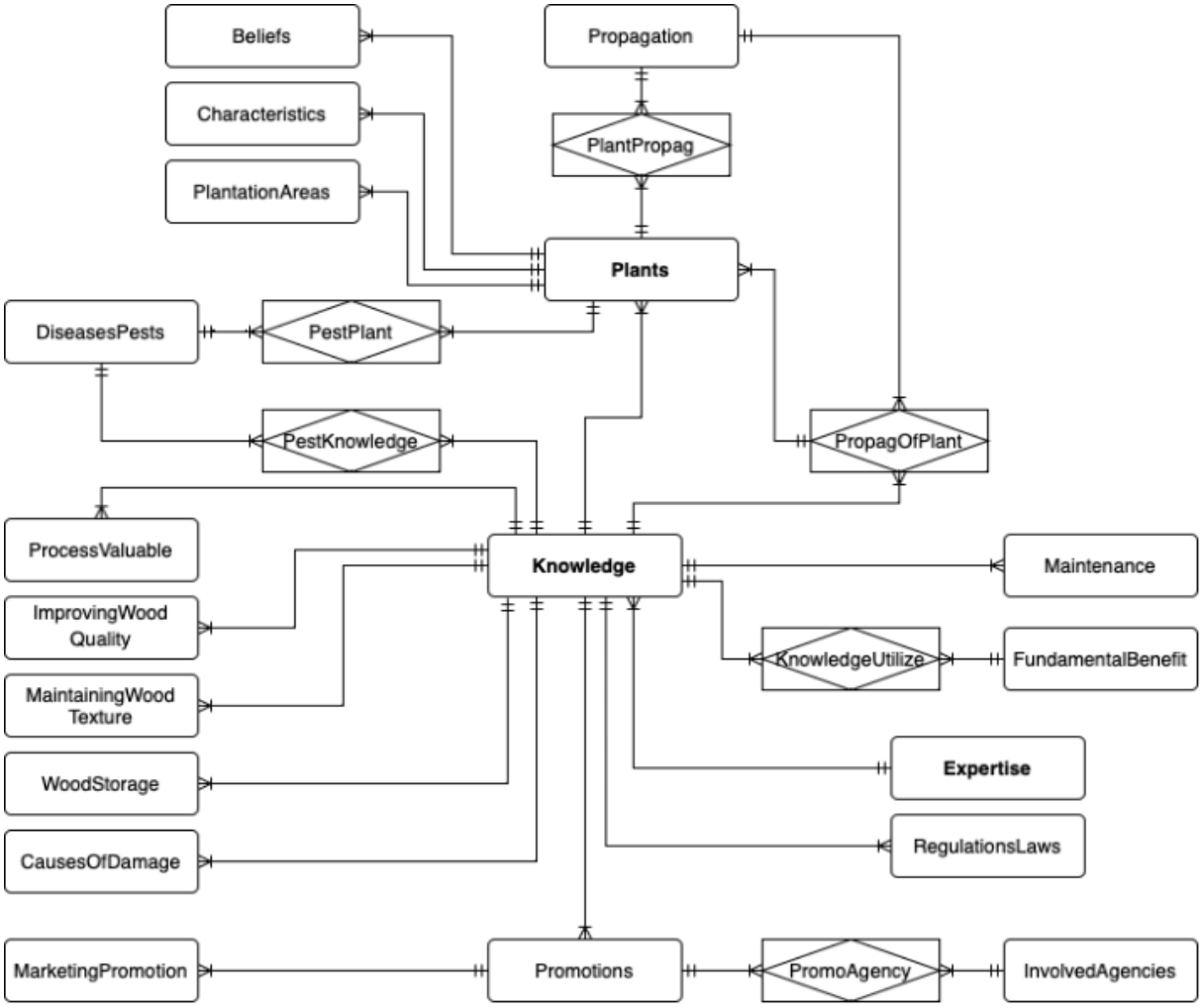


Figure 3. The entity relationship model of economic plants

Table 1 presents the data dictionary for the Utilization table, which stores the classification of different utilization types associated with economic plants (e.g., medicine, food, fragrant wood). This table uses a simple two-field structure with an auto-generated primary key (UtilizeID) and a descriptive label (UtilizeTitle), serving as a reference table linked to other knowledge components within the database. **Table 2** presents the data dictionary for the Knowledge table, which serves as the central repository for storing individual knowledge records within the system. Each record is identified by a composite code (KnowledgeID) incorporating the recording year and a sequential number. The table captures essential metadata, including the knowledge title, search keywords, creation date, and a timestamp for tracking updates. The popularity score field (RatingScore) stores the community-based validation score calculated using Equation 1. Foreign key relationships link each knowledge record to the relevant plant species (PlantID) and contributing expert (ExpertID), establishing the relational connections illustrated in the entity relationship model (Figure 3). This detailed specification approach supports the principle that database development requires careful attention to data heterogeneity and multidimensionality in complex systems [33]. The comprehensive data dictionary approach ensures the database effectively manages diverse knowledge types, maintains data integrity, and supports various user needs. Database design must accommodate user-friendly interfaces for researchers and users, while providing access to genetic resources for comparative analysis [34]. The structure facilitates comparative and functional analysis of plant information, supporting both research applications and practical implementation [35].

The database architecture incorporates multiple knowledge dimensions to support comprehensive plant information management. This multidimensional approach aligns with research findings that databases

should integrate various types of data, including transcriptomic data, genetic variations, and phenotype links, to support agricultural benefits [36]. The design recognizes that databases aid researchers in related plant studies by including functional annotations and multi-data integration [34]. Knowledge bases that compile data from multiple sources support applications across various domains, with comprehensive databases enhancing understanding and research capabilities [11]. The comprehensive data dictionary (see **Appendix**) provides detailed specifications for all database tables, establishes clear data governance protocols, and ensures data integrity throughout the system. This systematic documentation approach supports the principle that databases require continuous updates with new data and methods while maintaining high-quality data management standards [37]. The detailed specification ensures that the database can support diverse applications while maintaining consistency and reliability in knowledge management. The architecture supports the integration of traditional ecological knowledge with modern information management principles, addressing the critical need to preserve and make accessible valuable agricultural knowledge [38].

Table 1. Example of a detailed dictionary of a utilization table

No	Columns	Descriptions	Data Type	Constraints	References/ Remarks
1	UtilizeID	Code for Utilization: The format is a unique three-digit number, such as 001 or 002.	Varchar	PK	Auto generate
2	UtilizeTitle	Names of utilization, such as medicine and food	Varchar		

Table 2. Example of a detailed dictionary of an economic plant table

No.	Columns	Descriptions	Data Type	Constraints	References /Remarks
1	KnowledgeID	Code for stored knowledge in the format of YY9999. Details are as follows: YY is the year the knowledge information was recorded. 9999 is the sequence in which knowledge information was recorded in that year. Example data: 640001, automatically generated from the system	Varchar	PK	Auto generate
2	KnowledgeDate	Date of knowledge creation	Date		
3	KnowledgeName	Knowledge names specified by the knowledge creator.	Varchar		
4	Keywords	Identification of knowledge keywords used for categorizing and searching	Varchar		
5	RatingScore	The popularity score of knowledge identified by those who take it, and calculated according to Equation 1	Integer		
6	ExpertID	Code of Knowledge expertise	Varchar	FK	Expertise
7	PlantID	Code of valuable plants	Varchar	FK	Plants
8	Knowledge_timestamp	Date and time of updating the latest information Automatically generated from the system	DateTime		*(auto generate)*

4. Website Development for Economic Plants

The prototype system was developed using a three-tier architecture comprising a presentation layer, application logic layer, and data storage layer. The presentation layer was implemented using HTML5, CSS3, and JavaScript to ensure cross-browser compatibility and responsive design across desktop and mobile devices. The application logic layer was developed using ASP.NET with C# as the server-side programming language, handling request processing, business logic execution, and communication between the user interface and database. The data storage layer utilized Microsoft SQL Server 2019 Community Edition as the relational database management system, implementing the entity relationship model described in Section 3. User authentication was implemented using a role-based access control mechanism that distinguishes between two user types: public users, who access the display interface without authentication, and authorized administrators, who must authenticate with a username and password before accessing the content management functions described in Section 4.2. Session management and input validation were implemented to mitigate common web security vulnerabilities. The prototype was deployed on a Windows Server environment within the university network infrastructure during the development and evaluation phases.

Table 5. Technology stack of the prototype system

Component	Technology
Front-end	HTML5, CSS3, JavaScript
Back-end framework	ASP.NET (C#)
Database management system	Microsoft SQL Server 2019 Community Edition
Web server	Internet Information Services (IIS)
Operating system	Windows Server
Authentication	Role-based access control with session management
Deployment environment	University network infrastructure

The final phase involved developing a prototype website based on the knowledge base design. The database was implemented using SQL Server 2019 Community Edition, creating an integrated repository for economic plant knowledge, as illustrated in Figure 4. The web-based approach aligns with research demonstrating that information technology enhances public accessibility and interaction via web platforms, with web-based interfaces boosting citizen participation in training and data generation [39]. Dynamic web-based knowledge management systems can improve networks and facilitate collaboration between stakeholders and experts [40]. The website development focused on creating both public-facing information display components and administrative knowledge management functions. The system was designed for multi-platform accessibility via standard web browsers across desktop and mobile devices. This approach addresses research findings that web-based knowledge management systems are essential for enhancing communication, and it builds on frameworks aimed at improving connectivity among users [40]. The dual-interface design supports the principle that knowledge management systems should provide standardized environments for data submission and retrieval while supporting multimedia storage, including images, sound, and video [26].

4.1 Results Display Section

The display section provides public access to economic plant information through an intuitive user interface. The main page (**Figure 5**) displays plant names and images with navigation options to access detailed information. This user-friendly approach follows successful database design principles, enabling users to access information through intuitive interfaces that enhance the user experience [34]. The interface design aligns with research findings that databases should facilitate data visualization and exploration, enabling users to browse and analyze information effectively [41].

Users can select specific plants to access comprehensive information including botanical characteristics, cultivation requirements, utilization methods, and related knowledge (**Figure 6**). This comprehensive information structure addresses the need for databases that link diverse types of information for agricultural benefits, supporting both research applications and practical decision-making [31]. The

information presentation follows principles established in successful plant databases that provide access to genetic resources for comparative analysis while maintaining user-friendly navigation [35]. The display system supports integrating various knowledge domains, aligning with research findings that databases should facilitate hypothesis generation through data visualization tools [42].

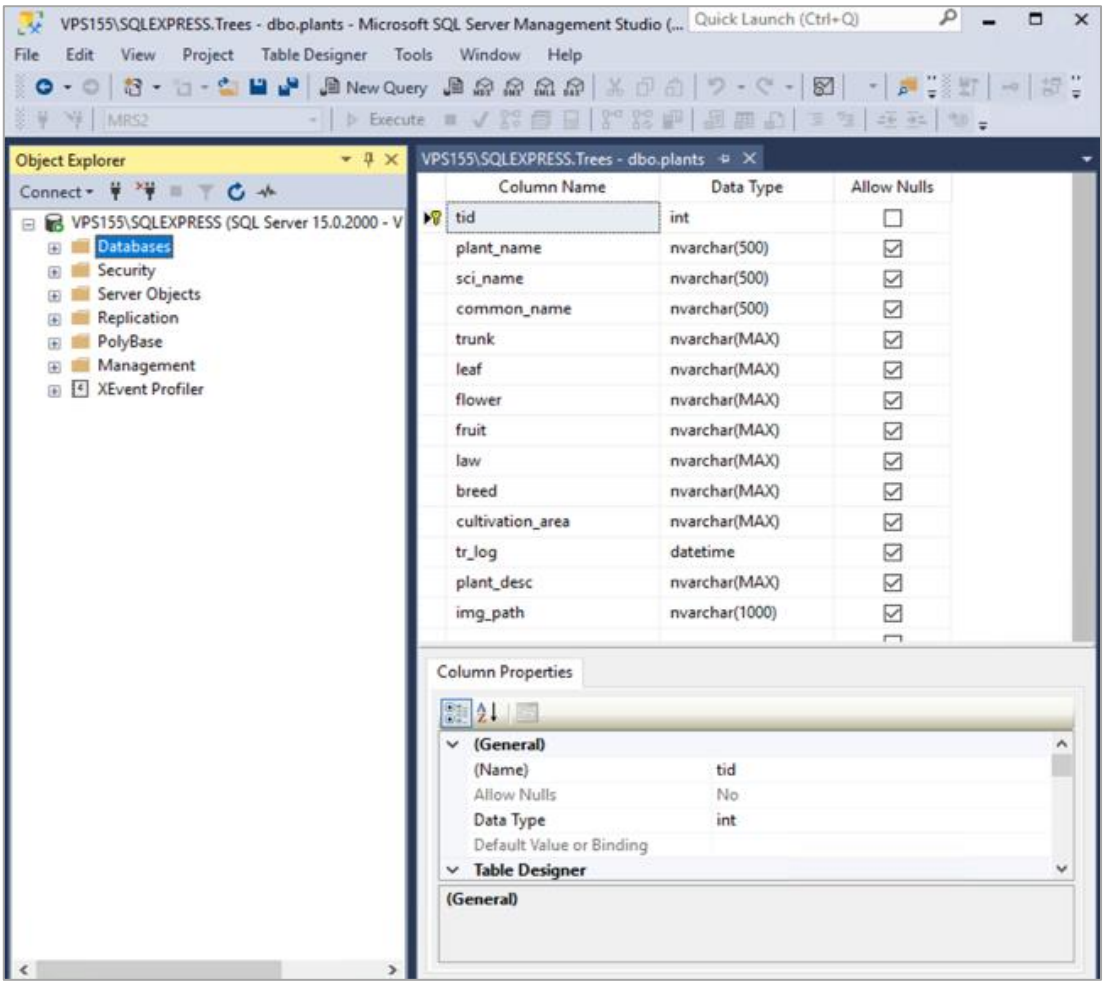


Figure 4. An example of creating a knowledge data table with the entity relationship database management program

4.2 Information Management Section

The administrative section (**Figure 7**) provides authorized users with tools to manage knowledge content, including adding new information, updating existing content, and maintaining data accuracy and relevance. This administrative approach aligns with research emphasizing that databases require tools for browsing and editing to maintain data quality and support collaborative analysis among researchers [43]. The management interface addresses the principle that effective management systems reduce project delays and costs through structured information management [44]. This dual-interface approach ensures both public accessibility to validated knowledge and controlled administrative functions for knowledge governance and quality assurance. The design supports research findings that contribution mechanisms enhance collaborative and comparative analysis among researchers, while standardized environments facilitate effective data management. The system architecture addresses the need for databases that can be continuously updated with new data and methods while maintaining high-quality standards for knowledge management. The administrative functions support the principle that knowledge management systems should encourage comparative research through community contributions while maintaining data integrity and reliability [45].

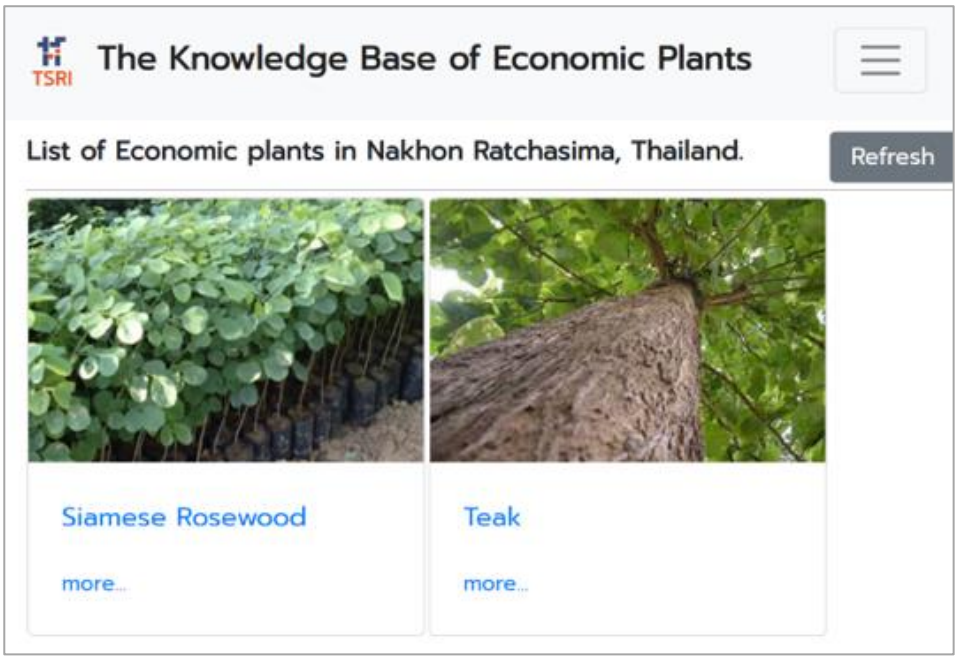


Figure 5. Section on Result Display on the Website Main Page of Economic Plants

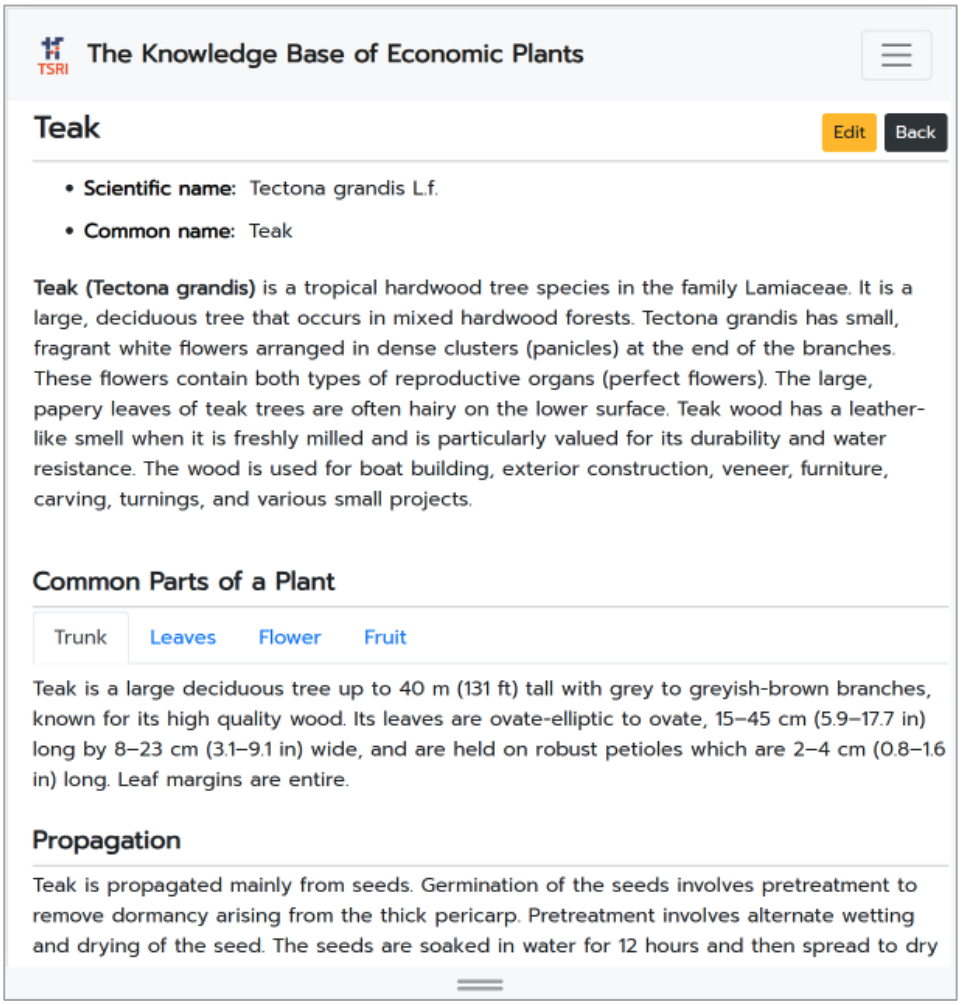


Figure 6. Section on the information structure of economic plants

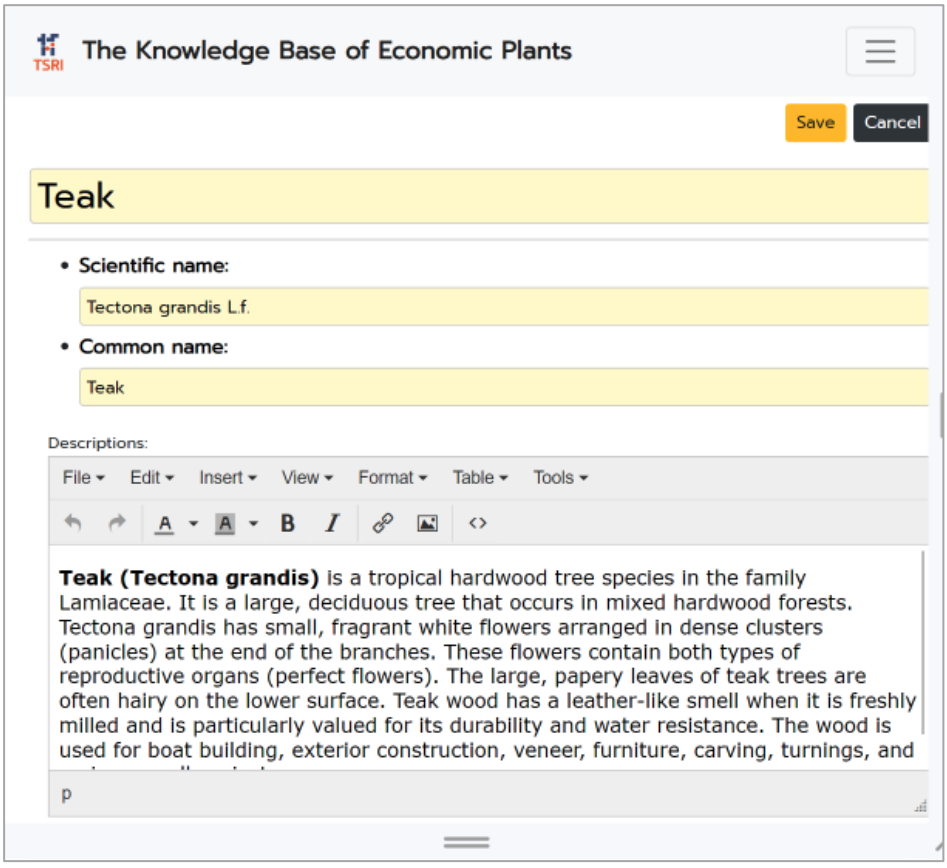


Figure 7. Section on Information Management of Economic Plants

4.3 System Evaluation through Expert Validation

To assess the usefulness, correctness, and overall quality of the knowledge-based system, an expert validation approach was employed. A panel of five subject matter experts was invited to evaluate the system. The panel comprised specialists in agricultural knowledge management, information system development, and economic plant cultivation, ensuring coverage of both the technical and domain-specific aspects of the system. The evaluation was conducted using a structured questionnaire based on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The assessment criteria were organized into four dimensions: (1) content correctness and completeness, evaluating whether the knowledge base accurately represents botanical, economic, regulatory, and cultural information about economic plants; (2) system usability, assessing the ease of navigation, information retrieval, and overall user experience across both the public display and administrative interfaces; (3) usefulness for decision-making, measuring the perceived value of the system for supporting stakeholders in cultivation planning, value addition identification, and regulatory compliance; and (4) knowledge organization and structure, evaluating the appropriateness of the three-category classification framework (Profilers, Knowledge Profiles, and Expert Directory) for representing economic plant knowledge. The expert panel also participated in a case demonstration using Teak (*Tectona grandis*) as a representative economic plant. Each expert was asked to perform a series of tasks, including retrieving botanical characteristics, accessing propagation methods, reviewing utilization information, and navigating the knowledge profile and expert directory sections. Following the task-based demonstration, experts provided qualitative feedback on system strengths and areas for improvement. Table 3 presents the summary results of the expert validation. The overall mean score across all evaluation dimensions was 4.25 (S.D. = 0.43), indicating high satisfaction with the system. Content correctness received a mean score of 4.05, confirming that the knowledge base accurately captures essential information about economic plants. System usability scored 4.21, with experts noting that the dual-interface design facilitated both public access and administrative management. Usefulness for decision-making received a mean score of 4.57, suggesting that the system

provides practical value for diverse stakeholders. Knowledge organization scored 4.18, supporting the appropriateness of the adopted classification framework.

Table 3. Summary of Expert Validation Results by Evaluation Dimension

No.	Evaluation Dimension	$\overline{x}$	S.D.	Level
1	Content correctness and completeness	4.05	0.45	High
2	System usability	4.21	0.65	Very High
3	Usefulness for decision-making	4.57	0.46	Very High
4	Knowledge organization and structure	4.18	0.14	High
	Overall	**4.25**	**0.43**	**Very High**

Qualitative feedback from the expert panel highlighted several strengths, including the comprehensive integration of multiple knowledge dimensions, the accessibility of the web-based platform across devices, and the practical relevance of linking botanical information with economic utilization and regulatory knowledge. Suggestions for improvement included expanding the number of plant species covered, incorporating multimedia content such as instructional videos for propagation techniques, and adding a search function with advanced filtering capabilities.

5. Discussion and Business Implications

The knowledge-based system for economic plants constitutes a structured contribution to agricultural information management, with several implications for agribusiness practice. By centralizing and organizing knowledge about economic plants, the system addresses critical information gaps that have previously limited sustainable agribusiness development. The system's comprehensive approach aligns with research demonstrating that the benefits of agricultural systems generally outweigh their costs, with major knowledge gaps existing in understanding plant benefits and their economic value [46]. Economic valuation is crucial for investment decisions, and standardizing research protocols can improve comparability across studies. To contextualize the contribution of the proposed system, **Table 4** presents a structured comparison with existing plant-related databases and knowledge management platforms relevant to economic plants, both internationally and within Thailand.

As shown in **Table 4**, existing platforms primarily serve botanical, taxonomic, or biodiversity documentation purposes and target research-oriented users. While these platforms make significant contributions within their respective domains, several gaps remain that the proposed system addresses. First, none of the existing platforms integrate economic value chain information — including processing methods, value addition opportunities, marketing strategies, and supporting agencies — as a structured knowledge component. Second, regulatory and legal information on business-related compliance requirements for economic plants is absent from all the compared platforms. Third, traditional ecological knowledge, while recognized as essential for sustainable agroforestry practices [2], is either absent or only peripherally captured in existing systems. The proposed system explicitly structures this knowledge dimension and converts tacit traditional knowledge into a retrievable form. Fourth, the Expert Directory with credential-based attribution and the community-based popularity scoring mechanism provide quality assurance features not found in the compared platforms. Fifth, the proposed system is specifically designed to serve a broader stakeholder base, including farmers and entrepreneurs, whereas existing platforms predominantly target researchers and scientific practitioners. It should be noted that the proposed system is not intended to replace these existing platforms but rather to complement them by addressing the specific needs of economic plant knowledge management in the Thai agricultural context. The system occupies a distinct niche at the intersection of knowledge management, agricultural business information, and traditional knowledge preservation, a space not fully covered by existing resources [47].

Table 4. Comparison of the proposed knowledge-based system with existing platforms

Feature / Criterion	PROSEA (Plant Resources of South-East Asia)	Flora of Thailand (Forest Herbarium)	Thai Biodiversity Information Facility (TH-BIF)	Agroforestry Species Switchboard (World Agroforestry)	Proposed System
Primary focus	Botanical and utilization documentation of SE Asian plant resources	Taxonomic classification and botanical description	Biodiversity occurrence records and species distribution	Agroforestry species linking across databases	Economic plant knowledge management integrating botanical, economic, regulatory, and cultural dimensions
Knowledge dimensions	Botanical, utilization	Botanical, taxonomic	Biodiversity, ecological	Agroforestry, ecological	Botanical, economic, regulatory, cultural, and traditional ecological
Traditional ecological knowledge	Limited	Not included	Not included	Limited	Explicitly captured and structured
Economic value chain information	Partial (utilization only)	Not included	Not included	Partial	Comprehensive (cultivation, processing, value addition, marketing, regulations)
Regulatory and legal information	Not included	Not included	Not included	Not included	Included as a dedicated knowledge category
Expert directory and attribution	Not included	Not included	Not included	Not included	Included with credential-based expert profiles
Community-based quality scoring	Not included	Not included	Not included	Not included	Included (popularity score rating)
Administrative content management	Limited	Limited	Limited	Not applicable (aggregator)	Dual-interface with public display and administrative management
Target users	Researchers, botanists	Taxonomists, researchers	Researchers, conservation practitioners	Researchers, agroforestry practitioners	Farmers, entrepreneurs, researchers, policymakers
Geographic scope	South-East Asia	Thailand	Thailand	Global	Thailand (economic plants designated by the Royal Forest Department)

Value Chain Enhancement is supported by the expert panel's assessment of the system's usefulness for decision-making, which indicated that the integrated knowledge structure provides practical value across multiple stages of the agricultural value chain. The comprehensive knowledge base links information across propagation and cultivation, processing, marketing, and regulatory compliance, enabling stakeholders to identify value-addition opportunities. The extent to which this translates into measurable business process improvements requires longitudinal field assessment with diverse stakeholder groups. Economic incentives for cultivation include income, land quality, and market access, and financial analysis shows that some plantations yield higher net present values than alternatives [48]. Intellectual Capital Management represents another crucial advantage, as traditional ecological knowledge constitutes a valuable form of intellectual capital that has historically been underutilized due to fragmentation and accessibility challenges. The system preserves this intellectual capital while making it actionable for business applications, effectively converting tacit knowledge into explicit, shareable resources. The erosion of traditional ecological knowledge documented in the literature [2] underscores the practical relevance of this preservation function. The dataset aids understanding of human-plant interactions for future well-being, promoting research on plant-human relationships while supporting biodiversity conservation and policy-making [13].

Risk Mitigation capabilities emerge as agricultural businesses face numerous risks, including plant diseases, market fluctuations, and regulatory compliance. The knowledge base provides critical information for risk assessment and mitigation, enabling proactive management strategies rather than reactive responses to challenges. et al. [1] indicate that optimal cultivation strategies vary significantly across different future scenarios, and portfolio approaches can reduce exposure to cost risks in agricultural strategies. Tree cultivation remains cost-effective compared to alternative options, and forest ecosystem services enhance social value. However, socio-economic drivers significantly affect cultivation outcomes, underscoring the importance of local community participation and benefit-sharing [3]. The system also serves as a potential catalyst for innovation. By integrating diverse knowledge domains and facilitating knowledge sharing, the platform creates an environment conducive to innovation in agricultural practices, processing methods, and product development. This innovation potential represents a significant competitive advantage for businesses in the agricultural sector. Antle et al. [21] demonstrate that new-generation agricultural system models require user-driven approaches that emphasize collaboration in model development and knowledge product creation. Stakeholder engagement is crucial for addressing major agricultural challenges, with advances in data and technology being essential for achieving sustainable development.

Sustainability Integration occurs as the system promotes sustainable business practices by preserving traditional knowledge about environmentally appropriate cultivation methods while linking economic and ecological considerations. This integrated approach aligns with growing market demands for sustainable products and practices. Large-scale cultivation activities predominantly have negative socio-economic impacts, particularly on land and livelihoods, with positive impacts rare and often accompanied by challenges [49]. Local community participation is crucial for successful initiatives, and bottom-up approaches enhance success rates [3]. The system addresses these challenges by providing comprehensive information to support sustainable decision-making. The findings align with research demonstrating the effectiveness of agricultural knowledge bases for storing diverse media formats and facilitating online knowledge sharing. The application of systematic classification systems echoes approaches utilized in various knowledge management contexts. The knowledge management approach implemented in this study addresses several critical challenges identified in the literature, including the need for accessible knowledge-sharing platforms to bridge gaps in agricultural knowledge [7]. The system provides this accessibility through web-based interfaces available across devices, supporting research findings that ontology-based agricultural knowledge management frameworks improve intelligence and efficiency in knowledge sharing [9]. The system addresses the need for farmers to access comprehensive information by providing dedicated knowledge categories for economic utilization and decision-making support [23]. While the expert validation provides encouraging initial evidence for the system's practical relevance, the business implications discussed above should be interpreted

as informed projections rather than empirically demonstrated outcomes. Full realization and measurement of these benefits will require broader deployment, user adoption studies, and longitudinal impact assessment across diverse stakeholder groups and geographic contexts.

6. Conclusion

This research presents the design and prototype implementation of a knowledge-based system for economic plants in Thailand, providing a structured management solution for agricultural knowledge. The conclusions drawn in this study are based on two sources: (a) demonstrated system functionality through the prototype implementation and expert validation (Section 4.3), and (b) conceptual analysis of the system's potential business implications grounded in existing literature. The system provides a structured approach to addressing the fragmentation of economic plant information, as demonstrated through the prototype implementation and supported by the expert panel's positive assessment of content correctness and knowledge organization (Table 3), through three key components: a conceptual framework for knowledge classification based on systematic organizational principles, a comprehensive entity relationship database model integrating diverse knowledge domains, and a functional web-based platform for knowledge access, sharing, and management. It should be noted that the business implications discussed in Section 5 represent anticipated benefits informed by literature and system design logic rather than outcomes measured from large-scale deployment or longitudinal usage data.

From a business management perspective, the system has the potential to deliver value through improved decision-making, enhanced value chain coordination, preservation of intellectual capital, risk mitigation, facilitation of innovation, and integration with sustainability—benefits supported by expert validation results and analogous findings in the agricultural knowledge management literature. However, full realization of these benefits requires broader deployment and empirical assessment. Accordingly, the conclusions presented here should be understood as grounded in the study's design science contributions — namely, the successful development and initial expert validation of the system artifacts — rather than as claims of demonstrated real-world impact, which remains subject to future empirical investigation. The system addresses critical challenges identified in agricultural knowledge management, where traditional ecological knowledge continues to face erosion pressures as previously discussed [2]. By making critical knowledge accessible to diverse stakeholders, the system supports sustainable agribusiness development while preserving valuable traditional ecological knowledge. Research demonstrates that datasets aid in understanding plant-human interactions for future well-being, promoting biodiversity conservation and supporting policy-making through comprehensive information access [13].

Several limitations of this study should be acknowledged. First, the system evaluation was conducted through expert validation with a small panel rather than large-scale user testing with diverse stakeholder groups, such as farmers, entrepreneurs, and policymakers. Consequently, the generalizability of the usability and usefulness findings remains constrained. Second, the current prototype covers a limited number of economic plants, and the knowledge base has not yet achieved comprehensive coverage of all species designated by the Royal Forest Department of Thailand. Third, as discussed in Section 2.2, the system functions as a knowledge repository and retrieval platform without automated reasoning or recommendation capabilities, which limits its capacity to provide personalized decision support. Fourth, the system has not been evaluated under real-world field conditions where factors such as internet connectivity in rural areas, digital literacy among target users, and long-term data maintenance may affect adoption and sustained usage. Fifth, the popularity score rating mechanism (Equation 1) depends on a sufficient number of expert evaluations to produce meaningful quality indicators, and this critical mass has not yet been established during the prototype stage. These limitations are important considerations for interpreting the findings and provide direction for future research and system enhancement.

While the system incorporates quality assurance mechanisms, including administrative review and community-based scoring (Section 2.3), the risk of misinformation in a user-contributed knowledge system cannot be eliminated. The accuracy of traditional ecological knowledge entries is particularly challenging to

verify through conventional scientific validation, and the system relies on expert credential verification and administrative gatekeeping rather than automated fact-checking processes. Future development should explore additional validation mechanisms, such as cross-referencing with established scientific databases and peer verification workflows among registered experts. Seventh, the current prototype focuses on economic plants in Nakhon Ratchasima Province, which may limit the representativeness of the knowledge content for other regions of Thailand where ecological conditions, cultivation practices, and traditional knowledge differ. Expansion to additional provinces would require region-specific stakeholder engagement and data collection to ensure contextual relevance. Eighth, the digital divide remains a significant concern for system adoption among rural farming communities, who constitute a primary target user group. Factors such as limited internet infrastructure, low digital literacy, and lack of access to computing devices in rural areas may constrain the system's reach and practical impact. Addressing these barriers will require complementary strategies such as offline access capabilities, mobile-optimized interfaces, and capacity-building programs for target users.

The knowledge management solution aligns with research emphasizing that ontology-based agricultural knowledge management systems enhance intelligence and improve the efficiency of knowledge sharing, with frameworks that include modules for knowledge acquisition and representation [50]. The system adheres to the principle that web-based knowledge management systems enhance communication among stakeholders, facilitating collaboration among experts while addressing knowledge transfer issues in agricultural contexts [51]. The comprehensive database approach supports the finding that integrated data curation enhances analysis and application capabilities, with databases serving as essential tools for comparative studies and advancing research [31]. The system's multidimensional approach to knowledge organization aligns with research findings that comprehensive databases should integrate various types of information to support both research applications and practical decision-making [31, 34, 35]. The preservation of traditional knowledge components aligns with research that highlights the crucial role of traditional knowledge conservation amidst cultural change, with unified approaches necessary for effective knowledge management and research [12, 26]. The web-based accessibility ensures that information technology enhances public interaction and participation, supporting the principle that dynamic systems can improve stakeholder networks and collaboration [7].

Future research should focus on expanding the expert validation to larger-scale user evaluation involving farmers, entrepreneurs, and policymakers to assess field-level effectiveness, expanding the knowledge base to include additional economic plants for broader applicability, enhancing user interface design based on usability testing and user experience research, implementing advanced analytics for knowledge pattern identification and trend analysis, and exploring integration with mobile applications for field-based knowledge access and real-time information sharing. These future directions align with research emphasizing that databases require continuous updates with new data and methods while maintaining high-quality standards for knowledge management [52]. The development should also consider research findings that stakeholder engagement is crucial for addressing major agricultural challenges, with advances in data and technology being essential for achieving sustainable development goals [53].

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