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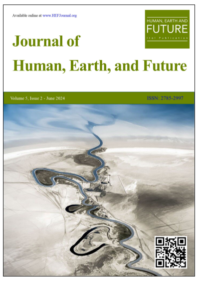

Requirements Engineering of Knowledge Management System for Smallholder Dairy Farmers

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Abstract

This research aims to investigate aspects of knowledge management in smallholder dairy farming, focusing on four primary objectives: understanding the existing knowledge management processes, identifying the necessary knowledge for management, exploring the dominant knowledge management processes and the factors influencing them, and assessing the use of technology in supporting the knowledge management system. Through a qualitative and quantitative approach, this study successfully identified various needs that will aid in developing a knowledge management system. The research results show that the knowledge management process in small-scale dairy farming involves farmers, cooperatives, extension services, and industry. Farmers in livestock management undertake a holistic knowledge management process. Cooperatives augment this by creating guidebooks from best practices, holding training meetings, distributing informational materials, overseeing milk quality standards, and enhancing skills. Extension workers bridge theoretical knowledge with practical application. The industry plays a crucial role by offering comprehensive training, monitoring standards, and supporting farmers' professional development. The findings indicate that knowledge sharing is the dominant process, involving knowledge related to livestock care, reproduction, milk transactions, animal health, and farmer finance. The key factors influencing this process are People, Technology, and Organization. The results provide a solid foundation for further developing a more technical knowledge management system for smallholder dairy farmers, offering new insights into effective processes and technologies for knowledge management in this field.

Keywords: Knowledge Management System; Dairy Farm Management; Knowledge in Dairy Farm; Farm Management System.

1. Introduction

Technology improves existing business processes in various fields. Technological developments affect how agricultural actors provide the best results with innovation and efficiency. One sector that continues to develop with the use of technology is dairy farming. Technology in dairy farms is implemented in medium-scale dairy farms and large milk-producing companies. This is different from smallholder dairy farms that lack the use of technology. The smallholder dairy farming population has a downward trend because the community sees being a small farmer as not

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providing an excellent income to improve the family's economy. Smallholder dairy farmers are dominated by old farmers who are no longer young. Regeneration of small farmers continue to decline because the next generation is not interested in becoming farmers. They prefer other professions to improve the family's economy.

The knowledge management system (KMS) in agriculture already has a framework proposed by previous researchers. One of the ways knowledge managements in the agricultural context was put forward by Gardeazabal et al. [1] was through a framework, namely Agricultural Knowledge Management for Innovation (AKM4I). AKM4I focuses on the flow and management of information and knowledge between various stakeholders in the agri-food system. In addition, research by Fote et al. [2] proposed a Knowledge-Based Management System (KBMS) that simplifies Precision Farms' decision-making process. A chat system for knowledge sharing was proposed by Ong et al. [3] in the context of a Dynamic Web-Based Knowledge Management System (DW-KMS) for small-scale agriculture. The KMS proposed by Ong et al. [3] focuses on optimizing communication between small farmers and agricultural experts using a chatbot application. Although AKM4I and KBMS provide a general framework for knowledge management in agriculture, there are specific aspects or unique challenges faced by smallholder dairy farmers that still need to be addressed. DW-KMS introduces the use of chatbots for communication. However, this research explores how this technology is integrated with the local socio-cultural and economic factors of smallholder dairy farmers. More in-depth research is needed on how knowledge management can be adapted to support specific dairy farming activities, such as reproductive management, herd health, and milk transactions.

The discrepancy regarding the use of technology by medium- to large-scale farmers and smallholder dairy farmers shows a difference in the knowledge they have. The problem is the need for knowledge possessed by smallholder dairy farmers. Most of the farmers in rural areas have a low level of education. Other problems encountered are a need for more ability to adopt new mechanisms and negative perceptions of farmers towards the use of technology [4, 5]. For farmers to take advantage of technology, intensive educational activities are needed involving educational institutions, agricultural extension workers, and farmers who are experienced in agricultural technology to play a role in sharing knowledge. Thus, knowledge becomes essential to be taught and managed adequately. A reliable system is needed to manage knowledge related to technology implementation, especially in smallholder dairy farms. Knowledge-based systems can support the sustainability of a business process [6, 7]. As a problem-processing system, it derives information from a knowledge system and uses it to obtain valuable results and for decision-making [7]. Initial studies are needed to identify needs that are a basis for developing a knowledge management system for small-holder dairy farmers. Thus, this research will answer research questions (RQ) to identify the initial needs for developing a knowledge management system in this field, as follows:

- ***RQ1:*** How is the knowledge management process of smallholder dairy farmers?
- ***RQ2:*** What knowledge is needed in managing smallholder dairy farmers?
- ***RQ3:*** What knowledge management processes dominate smallholder dairy farmers? What factors influence it?
- ***RQ4:*** What technologies have been used to support implementing knowledge management systems at smallholder dairy farmers?

2. Literature Review

Agricultural knowledge management systems aim to make it easier for farmers and stakeholders to share and use information and experiences. These platforms for managing agricultural knowledge are well-structured thanks to technological advancements like information and communication technology [8]. One strategy is using e-agriculture, which uses ICT tools to help with knowledge management in the agricultural sector [9]. One more arrangement is the advancement of agro-promoting stages that give ranchers admittance to showcase data, learning assets, and government plans, subsequently engaging them to sell their items and further develop their occupations [9]. Additionally, visualization methods can make agricultural data, such as crop selection, soil composition, and yield, more easily understood and utilized [10]. This information board framework expects this information to overcome any issues among conventional and present-day cultivating rehearsals, increment efficiency, and mitigate neediness in the agricultural area [11].

Knowledge management in agriculture involves capturing, organizing, and sharing knowledge to improve agricultural practices and address challenges in the sector. Creating a multi-professional, multidisciplinary knowledge economy requires collaboration among stakeholders, including farmers, policymakers, and scientists [12]. Implementing knowledge management approaches can help make knowledge interoperable and accessible, creating a "group memory" that can be used globally in real time [13]. Knowledge management processes can trigger continuous innovations in agriculture and improve the livelihood of rural communities in developing countries [14]. However, there is a disconnect in the studies conducted by different groups of scholars, leading to a lack of coherent development in agriculture knowledge management literature [8]. Information and Communication Technology (ICT) can be used for knowledge management in agriculture, known as e-agriculture, to enhance a well-structured Agricultural Knowledge Management

System [15]. Knowledge management practices vary among farmers, with those who supply firms adopting them more intensively and having a larger production scale.

Knowledge is experience, expert insight, and a combination of various information evaluated for effective action to achieve excellence. Knowledge consists of tacit and explicit. Tacit knowledge is very attached to individuals and difficult to express, so it is difficult to share with others, for example, insight, intuition, and experience. Tacit knowledge exists in actions, experiences, values, and individual emotions [16]. Acit, complex knowledge, developed and internalized by the knower over a long period, is almost impossible to reproduce in a document or a database. Such knowledge incorporates so much accrued and embedded learning that its rules may be impossible to separate from how an individual acts [17, 18].

There are explicit and tacit types of knowledge. Explicit knowledge is knowledge that we can see and learn. Explicit knowledge has been expressed and described in words and numbers. It can be communicated to others and can be processed. One of the most important ideas about both forms of knowledge is that tacit knowledge must be communicated and shared within organizations. Therefore, tacit knowledge must be converted into words or numbers so everyone can understand it [16]. According to the Nonaka and Takeuchi Model of Knowledge Conversion [19], the knowledge conversion process consists of Socialization, Externalization, Internalization, and Combination (Figure 1). Socialization is changing tacit knowledge into tacit knowledge. Externalization is changing tacit knowledge into explicit knowledge. The combination turns explicit knowledge into explicit knowledge. Internalization turns explicit knowledge into tacit knowledge. Knowledge management is how to manage the knowledge conversion process to run effectively. Knowledge management in an organization is carried out to achieve a competitive advantage. The knowledge management process consists of knowledge discovery, knowledge capture, knowledge sharing, and knowledge application [19] (Figure 2).

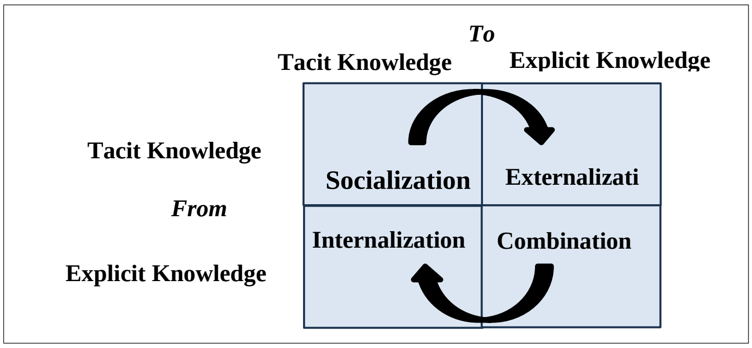

Figure 1. Nonaka and Takeuchi Model of Knowledge Conversion

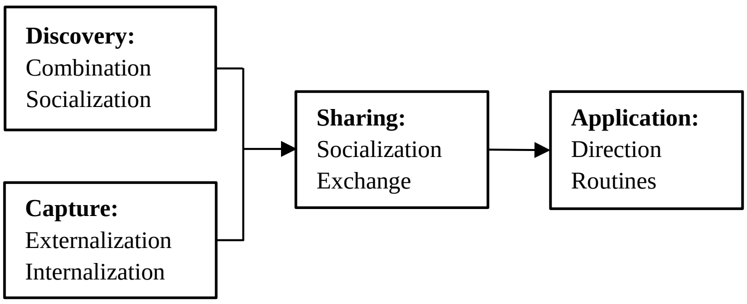

Figure 2. The process of knowledge management in an organization

Taxonomies are most helpful in organizing declarative knowledge, such as that embodied by diagnostic systems. The construction of a taxonomy involves identifying, defining, comparing, and grouping elements. Organizational knowledge taxonomies, however, are driven not by basic first principles or "real" attributes but by consensus. All the organizational stakeholders need to agree on the classification scheme to derive the taxonomy-it cannot be theoretical but empirical. The decision tree is a knowledge-taxonomy method. A decision tree describes a hierarchical or flowchart representation of a decision process. This method is very well suited to procedural knowledge and is easy to produce and understand [18].

The knowledge taxonomy of dairy farming encompasses various aspects such as breeding tools, traits, feed and fodder management practices, and clean milk production practices. Farmers' knowledge of breeding tools and traits influences their attitudes toward their use in dairy production [20]. Similarly, the knowledge level of dairy farmers regarding improved feed and fodder management practices can be measured through knowledge tests [21]. Furthermore, dairy farmers' knowledge and adoption of clean milk production practices can also be assessed [22]. The knowledge taxonomy of dairy farms involves classifying and organizing knowledge related to dairy farming practices. Two classes of knowledge can be distinguished: declarative knowledge, concerned with facts in a domain, and procedural knowledge, which is knowledge of how to use declarative knowledge. Declarative knowledge includes maintaining animal health, providing green pasture, animal selection, and using crossbreed cows to improve milk production [23]. Different knowledge representation schemes can be used to represent these types of knowledge, depending on their characteristics, such as completeness, certainty, generality, and level. The existing dairy farm management applications mainly use production rules as the knowledge representation scheme. However, efforts should be made to promote and strengthen the existing good practices in knowledge management processes to enhance dairy production.

3. Methods

This research is an initial stage in developing a knowledge management system, which is carried out by identifying and analyzing needs. This research was conducted with a qualitative and quantitative approach. The research stages are explained as follows (see Figure 3):

- ***Step 1:*** Literature study and building research instruments. The literature study was carried out to study the concepts of knowledge management system processes based on the theoretical framework. Interview questions are built based on the theoretical concepts that have been studied. Interview questions were used to explore the business processes carried out in smallholder dairy farm management related to the knowledge management process.
- ***Step 2:*** Data collection. Data was collected by interviewing relevant stakeholders, namely experienced farmers from large or medium farms and small farms, extension workers, cooperatives, and industry.
- ***Step 3:*** Analysis of interview data. The analysis was carried out by mapping the business processes from the interviews to theoretical concepts related to the knowledge management process. Apart from that, identify the knowledge contained in the knowledge management process. The results of knowledge identification are processed to form a draft knowledge taxonomy.
- ***Step 4:*** Evaluate the results of data analysis using Focus Group Discussion (FGD). FGD was conducted with the farmers group, dairy industries, and cooperatives to discuss the knowledge identified during the interview. FGDs are carried out to agree on the identified knowledge by agreeing, correcting, or completing it. So, at this stage, the agreed taxonomy knowledge is obtained. In this research, data collection was carried out in the dairy farming area on the island of Java - Indonesia. This area is used as a sample for collecting research data, considering that smallholder dairy farms in Indonesia are most widely spread on the island of Java.
- ***Step 5:*** Systematic Literature Review (SLR). SLR has three steps for literature review, referring to [9]: planning, conducting, and reporting the review. Planning is done by identifying the objectives and needs of the review, providing research questions, and creating a review protocol as rules that must be considered. The review is carried out by selecting literature according to needs, assessing the quality of the literature that has been collected, and performing extraction. The report consists of explaining the data synthesis process and interpreting the results. The interpretation of the results is directed at identifying the dominant knowledge management processes in the technology-based agricultural sector. In addition, this SLR was carried out to identify technological trends used to support the knowledge management process in fields related to this research.
- ***Step 6:*** Critical Success Factors Identification. The findings in the previous stage (step 5) will be used as the basis for carrying out this step. At this step, we will conduct a more specific literature review on which areas of this knowledge system will be developed as a reference for system development. The literature review identifies the success factors that influence the knowledge process. The results of identifying success factors from the literature review serve as the basis for the next steps. The next stage is to conduct interviews. Interviews were conducted to evaluate the success factors resulting from the literature review. In addition, interviews were also conducted to explore other success factors that had not been found in the literature review process. The success factors obtained from the interview were then used as the basis for building an initial model. This initial model was built by determining the priority of the factors received. This priority determination stage is carried out quantitatively using an analytical hierarchy processing (AHP) approach.

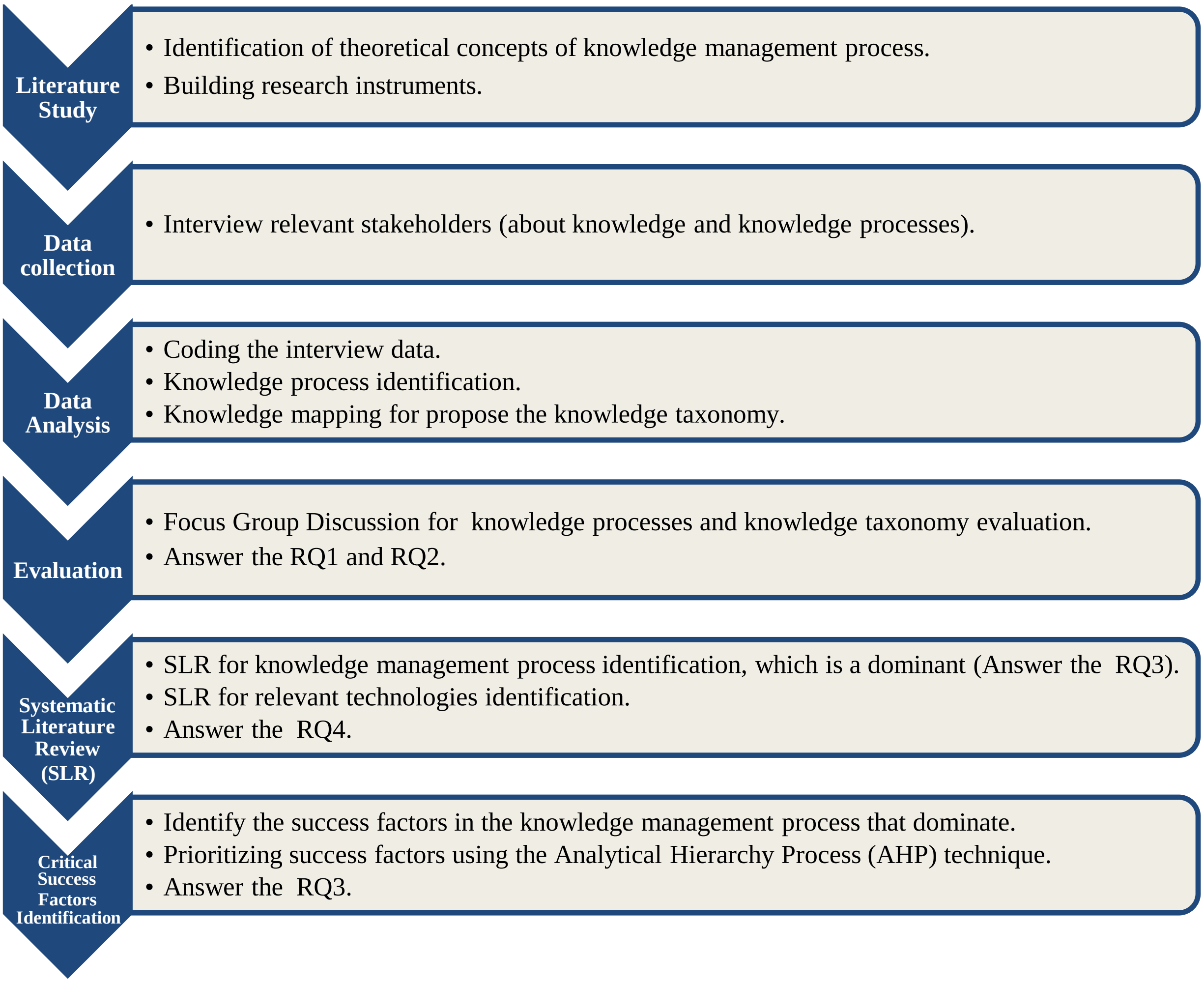

Figure 3. Research Methodology

4. Results and Discussion

4.1. Data Collection

The research instrument was compiled based on the results of a literature study, which was used as a reference in data collection. Interviews were conducted by asking questions related to the workflow that is carried out every day. Factors that influence job success, obstacles in the job, and digging deeper regarding the knowledge used in work, how they learn, and how they communicate with their co-workers. Observations of work processes also corroborated the results of interviews related to flow.

Data collection was carried out by conducting interviews with stakeholders related to the management of dairy farms. Stakeholders relevant to this research are experienced farmers from large or medium farms and small farms, extension workers, cooperatives, and industry. The stakeholder work area is in the Java Island area. 14 stakeholders were interviewed, namely:

- 2 experienced farmers for large or medium farms;
- 4 experienced farmers for small scale farms;
- 4 representatives of dairy cooperative board;
- 4 extension workers who are extension workers from the government, cooperative extension officers, and livestock health officers;
- 2 experts from industries.

Data collection was also carried out by observing farms and cooperatives. This observation was carried out on the island of Java. Observation focuses on observing the work processes carried out by farmers, cooperatives, and extension workers. Besides that, several documents were also observed to see what records and reports were made to support business processes. The documents that have been observed are farmer records, milk collector records, cooperative records, cooperative reports, livestock health records, report forms, and data recapitulation of cooperative members and cow population.

4.2. Mapping of Knowledge Management Process

The analysis was carried out by mapping the business process flow from the interview results to theoretical concepts related to the knowledge management process. The knowledge management process consists of knowledge discovery, knowledge capture, knowledge sharing, and knowledge application [16]. Each process has sub-processes, as in the discovery process, there is a combination and socialization process; in the capture process, there is externalization and internalization; in the sharing process, there is socialization and exchange; and in the application process, there is direction and routine. Apart from that, each process is differentiated between stakeholders. There are four stakeholders: smallholder farmers, cooperatives, extensions, and industries. Mapping results can be seen in Table 1.

Table 1. Business Process Mapping into Knowledge Management Process

KM Processes		Farmers	Cooperatives	Extensions	Industries
Discovery	Combination	Recording livestock care learned from the internet	Create a guidebook for farmers based on learning results in books or the internet regarding best practices in livestock management	Recording new knowledge and information obtained from the internet, books and training modules	
	Socialization	Follow the instructor's instructions regarding treatment of diseases in cattle	-	Participate in training related to livestock extension including livestock health	
Capture	Externalization	Recording of how to monitor the reproductive cycle	Recording how to monitor reproductive cycles. Following training from various regions on livestock management through special programs	Recording of livestock medical records, related to the treatment performed on livestock and the results	
	Internalization	Practicing the learning outcomes that have been read from the internet. Usually suggestions from community groups (Facebook, WA Group).	Practice monitoring regarding the quality of the milk delivered	Providing care and medicine to livestock in accordance with what is learned from the book	
Sharing	Socialization	Regular meetings between farmers	Cooperative meetings with their members for training as well as cooperative and livestock management meetings	Provide direct counselling to farmers	Provide training to farmers regarding livestock management to produce quality milk
	Exchange	-	Providing information circulars to farmers	Create livestock medical records for extension workers and farmers	-
Application	Direction	Teach the farmer's helpers for care and milking	Follow directions from extension workers to improve the welfare of farmer members	Provide direct direction to farmers regarding the care of sick cows including the reproductive process	
	Routine	Method of milking Feed composition Cage care Calculation of the reproductive cycle	Recording of milk deposits based on quality	Examination of sick cows according to the farmer's request	Monitor farmers and cooperatives, including the quality of milk purchased

The knowledge management process undertaken by farmers involves a variety of practices and methods in livestock care. This process includes acquiring and applying knowledge from online sources, including community groups on social media, and adhering to instructions from instructors about managing livestock diseases. An essential component of these practices is the documentation and monitoring of reproductive cycles. Moreover, farmers regularly convene to exchange knowledge and best practices. Another essential aspect is training farmers' assistants in grooming and milking and other technical elements like feed composition, stall upkeep, and monitoring reproductive cycles. In livestock management, cooperatives enhance farmers' practices and knowledge. They spearhead the creation of guidebooks that compile best practices in livestock management, drawing from a wealth of information available in books and online. These cooperatives also facilitate the recording and monitoring reproductive cycles, integrating learnings from various regional training programs. A significant part of their initiative involves conducting regular meetings for training purposes, focusing on cooperative management and effective livestock care. These meetings serve as platforms for sharing insights and discussing management strategies. Moreover, cooperatives actively distribute informational circulars to farmers, ensuring a constant flow of updated knowledge and guidelines. They also endorse the directives from extension workers aimed at improving the welfare of farmer members. Another crucial function is overseeing the recording of milk deposits, emphasizing maintaining quality standards. Through these diverse activities, cooperatives stand at the forefront of advancing livestock management practices among farmers.

Extension workers play a critical role in livestock management, bridging advanced knowledge and practical implementation. Their responsibilities include gathering new knowledge and information from various sources such as the internet, books, and specialized training modules. They actively participate in training programs related to livestock health and extension, which enhances their capacity to provide expert advice and assistance. Their role is crucial to maintaining detailed livestock medical records and documenting treatments and their outcomes. They apply their learned knowledge in providing appropriate care and medicine to livestock, adhering closely to established guidelines. Extension workers also engage directly with farmers, offering personalized counselling and guidance. They are instrumental in creating comprehensive livestock medical records, which are invaluable resources for both themselves and the farmers. Additionally, they provide specific instructions to farmers on managing the health of sick cows, including aspects of the reproductive process, and conduct examinations of sick cows upon the farmers' requests. Through these varied activities, extension workers significantly contribute to improving livestock health and management practices in farming communities.

In dairy farming, the industry plays a vital role in elevating livestock management standards and milk production. A primary function of the industry is to provide comprehensive training to farmers. This training focuses on various aspects of livestock management with the end goal of producing high-quality milk. Such educational initiatives are crucial for farmers to develop and refine their skills in effective livestock care, leading to enhanced milk production. Furthermore, the industry assumes a monitoring role, overseeing both farmers and cooperatives. This oversight extends to the quality of milk being produced and purchased, ensuring that it meets the standards of excellence. Through these efforts, the industry helps maintain quality control and actively contributes to the professional development of farmers, thereby improving the overall efficiency and productivity of the dairy farming sector.

4.3. Proposed a Knowledge Taxonomy

Identification of knowledge is carried out by classifying several words found in interviews so that words that have the potential to become knowledge are arranged hierarchically to form a knowledge taxonomy. The knowledge taxonomy formed from identifying essential words in interviews was evaluated and agreed upon again by relevant stakeholders through several FGD sessions. The results explain that in dairy farm management, five crucial pieces of knowledge are required, namely how to care for livestock, how to handle livestock reproduction, how to transact milk, how to pay attention to livestock health, and how to carry out financial records from the farmer's aspect. Each knowledge consists of several more detailed sub-knowledge. The results of knowledge taxonomy can be seen in Figure 4.

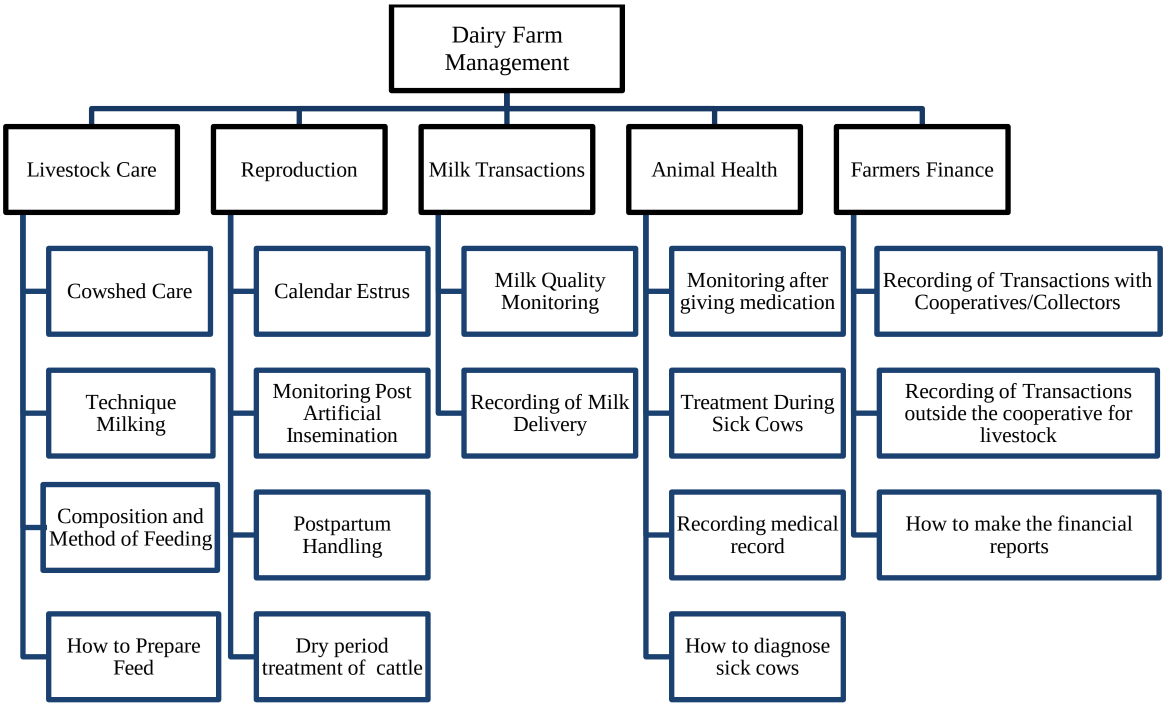

Figure 4. Knowledge Taxonomy of Smallholder Dairy Farm

4.4. Systematic Literature Review for Identification Dominant of Knowledge Management Process

This section describes the implementation results at each stage of the systematic literature review and discusses the outcomes.

Planning

A. Identification of the need for the review:

This SLR aims to discover state-of-the-art KMS research, especially about the mechanisms or processes used in KMS implementation and technologies that have supported KMS in agriculture in the last five years. In addition, this SLR also aims to identify the technology used for smart farming, which will be used as reference material in preparing KMS for smart farming in future research. With the results of this SLR, researchers can conduct further studies to find a suitable knowledge management system model for implementing smart farming.

B. Provide Research Questions for SLR:

Research questions were designed based on the needs of the review. The research questions are listed in the list below.

- Research Question for SLR (RQ-SLR1): How is the knowledge management process in agriculture?
- Research Question for SLR (RQ-SLR2): What kind of technology is applied in smart farming system?

C. Development of Review Protocol:

The scope and stages of selection are determined in this step. The scope used for collecting literature is selecting a database of reputable publication sources, type of literature, year of publication, and keywords. In addition, the specified scope also looks at the population or field of research, intervenes in parameters as needed, makes comparisons, and looks at the outcomes and the context. The protocol related to the scope can be seen in Table 2. Next is to determine the steps for sorting the literature. These steps start with initiation, title, and abstract, and full-text selection. Inclusion and exclusion criteria were determined for each stage as selection rules (see Table 3).

Table 2. The Review Protocol (Scope)

Parameters	Scope
Database	Scopus, Science Direct, ACM Digital Library, ProQuest, IEEE Explore
Type of Sources	Journal, Proceeding, Book, Book Section/Chapter
Year	2018 - 2022
Keyword	Knowledge Management Agriculture, Knowledge Management Smart Farming, Smart Farming, Agriculture Technology
Population	Knowledge Management System, Smart Farming, Agriculture
Intervention	Contribution, Methodology, KM Process, and Technologies
Comparison	Contribution, Methodology, KM Process, and Technologies
Outcome	Various types of KM Process, and Technologies
Context	Knowledge Management System in Smart farming

Table 3. The Review Protocol (Stages)

	Stages	Inclusion Criteria	Exclusion Criteria
1	Initiation	• According to search keywords • English • Publication year 2018-2022	Languages other than English Publication year outside 2018-2022
2	Tittle and Abstract Selection	• Knowledge management system • Agriculture • Smart farming • Technology	Not Knowledge Management Not agriculture Not smart farming
3	Full Text Selection	• KMS model • KM Mechanism • Smart Farming Technologies • Agriculture Technologies • Open access paper	Does not have a discussion about KMS in the field of Agriculture/Smart Farming or does not discuss smart farming technology. Full text cannot be accessed

Conducting the Review

A. Primary Studies Selection:

This section identifies literature using keywords in the electronic journal database that have been determined at the beginning. The tool used to facilitate reference management is the Mendeley desktop. The scope and stages of the literature selection are based on the review protocol determined in the previous section. Table 4 summarizes the literature collected and then selected according to the criteria.

Table 4. Literature Selection Results

Sources	Stage 1	Stage 2	Stage 3
Scopus	34	10	4
Science Direct	104	8	6
ACM Digital Library	533	16	2
IEEE Xplore	24	16	2
ProQuest	168	40	11
Total	**863**	**90**	**25**

B. Quality Assessment:

A literature quality assessment is carried out at this stage. The quality of the literature is a material consideration for whether the literature is used or not. Literature quality was assessed using the quality test checklist in Table 5. Each selected literature was examined and then assessed according to the checklist provided. The results of the assessment of the quality of the literature can be seen in Table 6. The successfully selected literature has a score of more than equal to seven so that all literature can be used for the next stage.

Table 5. Quality Test Checklist

Checklist	Checklist Question
C1	Does the article clearly describe the research objectives?
C2	Does the article write a literature review, background and context of the research?
C3	Does the article display related work from previous research to show the main contribution of the research?
C4	Does the article describe the proposed architecture or methodology used?
C5	Does the article clearly describe the parameters related to smart farming and/or knowledge management?
C6	Does the article have research results?
C7	Does the article present conclusions that are relevant to the research objective/problem?
C8	Does the article recommend future work or improvements for the future?

Table 6. Literature Quality Test Results

#	References	C1	C2	C3	C4	C5	C6	C7	C8	Total
1	Moysiadis et al. (2021) [24]	1	1	0.7	0.7	1	1	0.8	1	7.2
2	Fielke et al. (2020) [25]	1	1	1	1	1	1	0.8	1	7.8
3	Eastwood et al. (2019) [26]	1	1	0.7	0.7	1	1	1	0.8	7.2
4	Ayre et al. (2019) [27]	1	0.8	1	1	1	1	0.8	0.7	7.3
5	Rijswijk et al. (2019) [28]	1	1	0.7	0.7	1	1	1	1	7.4
6	van der Burg et al. (2019) [29]	0.8	1	0.8	0.7	0.8	1	1	1	7.1
7	Fakhar Manesh et al. (2021) [30]	0.7	1	0.8	1	1	1	1	0.8	7.3
8	Alemu et al. (2018) [31]	1	1	1	1	1	1	1	1	8
9	Fote et al. (2020) [2]	1	1	1	0.5	1	1	1	0.6	7.1
10	Skobelev et al. (2019) [32]	0.8	0.7	0.7	1	0.8	1	1	1	7
11	Iaksch et al. (2020) [33]	1	0.8	0.7	1	1	1	0.5	1	7
12	Ingram et al. (2022) [34]	1	0.8	1	1	0.8	0.8	0.8	0.8	7
13	Vukadinovic et al. (2022) [35]	0.8	1	0.8	1	1	0.8	0.8	0.8	7
14	Contreras-Medina et al. (2019) [36]	1	1	1	1	1	1	0.8	1	7.8
15	Mazzetto et al. (2019) [37]	1	0.8	0.8	0.7	1	1	1	0.7	7
16	Ciruela-Lorenzo et al. (2020) [38]	1	1	1	0.7	0.7	1	1	0.7	7.1
17	Symeonaki et al. (2020) [39]	1	1	1	0.7	1	1	1	0.8	7.5
18	Kulikov et al. (2020) [40]	1	1	1	0.7	1	1	0.8	0.7	7.2
19	Pölönen et al. (2021) [41]	1	1	1	0.7	1	1	1	0.7	7.4
20	Ong et al. (2021) [3]	1	1	1	0.7	1	0.7	0.8	0.8	7
21	Marinchenko (2021) [42]	0.8	1	1	0.8	0.8	1	0.8	0.8	7
22	Mushi et al. (2022) [43]	1	0.8	0.8	1	1	1	1	0.8	7.4
23	Sayed et al. (2022) [44]	1	1	1	0.8	1	1	0.8	0.8	7.4
24	Gardeazabal et al. (2021) [1]	1	1	1	0.7	1	1	1	0.7	7.4
25	Lytos et al. (2020) [45]	1	1	1	0.7	1	1	1	0.7	7.4

C. Data Extraction:

Data extraction will be carried out by adjusting RQ-SLR1 and RQ-SLR-2. The data extraction format is to create a table consisting of information containing references (authors, year, title), contribution, methodology, performance, characteristics related to KM, and technology used both for smart farming and KM. The characteristics that indicate the application of the KM process are extracted by following the KM concepts described by Becerra-Fernandez & Sabherwal [46].

Reporting The Review

A. Data Synthesis

The outcomes of the literature's selection and extraction are used for synthesis to produce the findings that address the research questions. The reporting stage is to synthesize data and interpret it. Data synthesis will be done by making a resume in the form of 2 points of view to answer RQ1 and RQ2. The processing of the data extraction findings to address RQ1 is shown in the first resume as tables or graphs. The classification and mapping of KMS types and the most popularly recognized KM mechanisms are done in the first summary. The next stage is to make a resume in the form of tables and or graphs to display information about the various types of technology used in implementing smart farming.

Literature was collected using the keywords described in the previous section, and several selection criteria were applied. Figure 5 shows the year distribution for the 25 studies that comprised the chosen literature's results. Additionally, the outcomes of the chosen literature were divided into three categories based on studies that discussed smart farming, knowledge management, or both (Figure 5). There are 14 papers discussing smart farming (SF), two articles discussing knowledge management (KM), and nine papers discussing smart farming and knowledge management (SF&KM) out of the 25 types of literature that have been chosen.

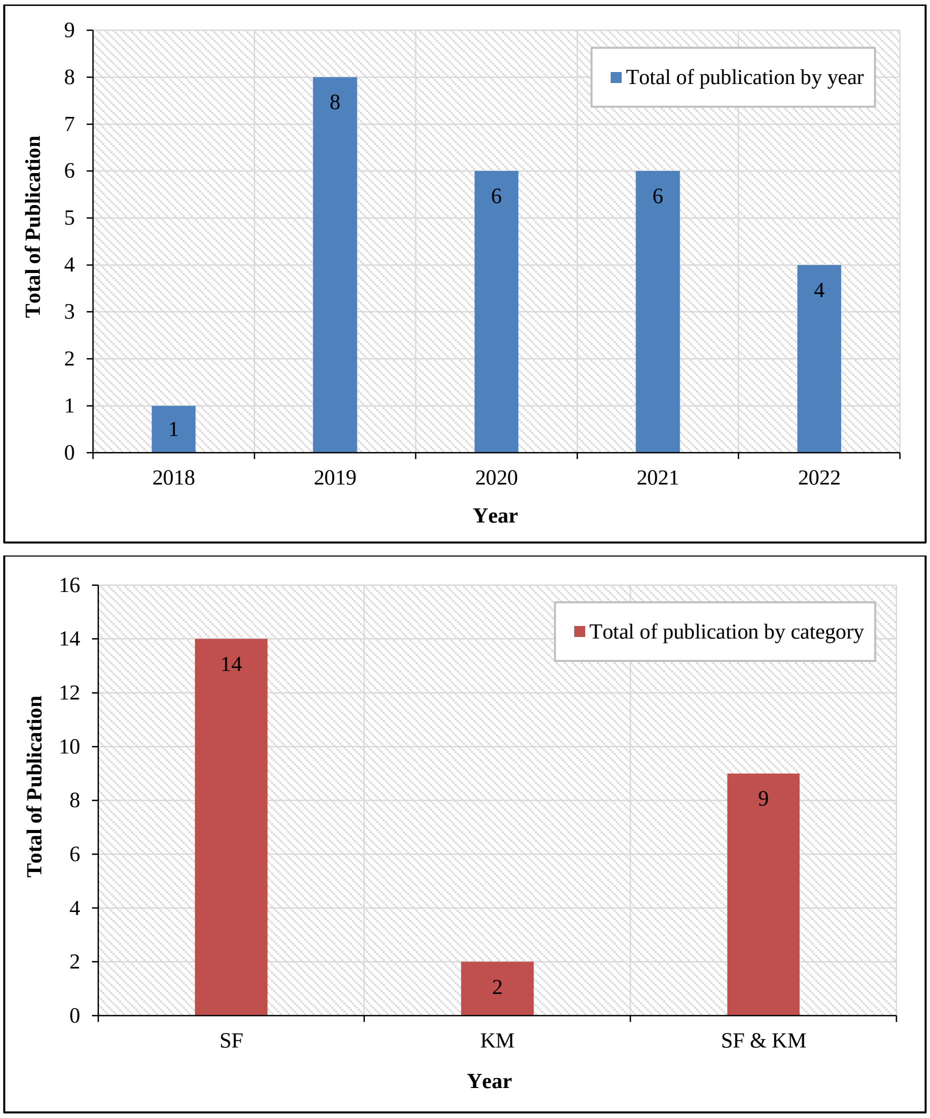

Figure 5. Number of Publications by Year and Per Category

B. SLR Result Interpretation:

Data synthesis to answer RQ1 refers to the theoretical concept of knowledge management presented by Becerra-Fernandez & Sabherwal [46]. The concept explains that KMS is a system used to find, capture, share, and apply knowledge within an organization to achieve competitive advantage. In the agricultural context, Gardeazabal et al. [1] have proposed a framework, namely Agricultural Knowledge Management for Innovation (AKM4I). AKM4I focuses on the flow and management of information and knowledge between various stakeholders in agri-food systems. This framework enhanced earlier agricultural knowledge management, which did not explicitly consider issues of power, politics, ownership, and trust when combining scientific and local knowledge among various stakeholders, used linear, reductionist innovation paths, and did not pragmatically integrate innovation. In addition, some researchers [2, 47] propose a new Knowledge-Based Management System (KBMS) that simplifies decision-making processes in Precision Farms. Ong et al. [3] proposed a Dynamic Web-Based Knowledge Management System (DW-KMS) for small-scale agriculture. This KMS focuses on optimizing communication between small farmers and agricultural experts using the Chatbot application. Finally, research by Symeonaki et al. [39] introduces a competitive architectural framework in context-aware middleware to integrate agricultural WSAN into IoT via cloud infrastructure and resources to efficiently support remote monitoring and control of facility systems in real-time in precision farming. Thus, if it is mapped on the concept of KMS [46] in the agricultural context, we can refer to KBMS [2] for the knowledge discovery process, DW-KMS [3] for the process of sharing/transferring knowledge, AKM4I [1] for the process of capturing and sharing knowledge, and a framework [39] as a form of knowledge application in the field. Other literature is also reviewed one by one by looking at the characteristics of the implementation of the knowledge management mechanism used and then mapped against the concept of the knowledge management process put forward by Becerra-Fernandez & Sabherwal [46]. The results of the study mapping can be seen in Table 7.

Table 7. The Results of Literature Mapping to KM Processes

KM Processes	KM Sub Processes	Authors	Sources	Total
Discovery	Combination	Ayre et al. (2019); Rijswijk et al. (2019); van der Burg et al. (2019); Fote et al. (2020); Iaksch et al. (2020); Mazzetto et al. (2019); Ciruela-Lorenzo et al. (2020); Sayed et al. (2022)	[2, 27-29, 38, 37, 38, 44]	8
	Socialization	Fielke et al. (2020)	[25]	1
Capture	Externalization	Fakhar Manesh et al. (2021); Contreras-Medina et al. (2020); Mazzetto et al. (2019); Ciruela-Lorenzo et al. (2020); Kulikov et al. (2020); Sayed et al. (2022)	[30, 37, 38, 40, 44, 48]	6
	Internalization	Fakhar Manesh et al. (2021)	[30]	1
Sharing	Socialization	Fielke et al. (2020); Eastwood et al. (2019); Ayre et al. (2019); Rijswijk et al. (2019); van der Burg et al. 2019); Fakhar Manesh et al. (2021); Alemu et al. (2018); Iaksch et al. (2020); Fote et al. (2020)	[2, 25-31, 33]	9
	Exchange	Eastwood et al. (2019); Ayre et al. (2019); Alemu et al. (2018); Iaksch et al. (2020); Ong et al. (2021)	[3, 26, 27, 31, 33]	5
Application	Direction	Eastwood et al. (2019)	[26]	1
	Routine	Kulikov et al. (2020); Pölönen et al. (2021); Marinchenko (2021); Mushi et al. (2022)	[40-43]	4

Literature mapping to the knowledge management process sequentially for three processes from the highest in socialization (sharing), combination, and externalization. Several studies explain the application of knowledge and technology-based agriculture, which makes agricultural extension the main element. Knowledge of agriculture and its extension communication network is an essential component of an agricultural innovation system with the potential for digital disruption [25]. Extension agents can act as data analysts and expert users of the software. They also combine their knowledge of the agricultural context with data collected through innovative technology in agricultural knowledge [26]. Additionally, research by Eastwood et al. [26] shows that design processes support agricultural extension agents in enhancing their digital agency by enabling them to recognize and act on the systemic nature of digital innovation. The role of extension agents in the smart farming sector illustrates how the knowledge management process is carried out. Based on the literature review results, the process of discovery and sharing sequentially occupies the most popular position for previous research. The need to create and disseminate knowledge is relatively high when applying technology and knowledge-based agricultural systems. The process of seeking knowledge to implement smart farming is integral to starting its implementation. According to Rijswijk et al. [28], understanding digital agriculture is at an early stage. With limited understanding, the digital future is being explored and interpreted. In addition, it is essential to make smart farming knowledge explicit so it is easy to spread, primarily through the extension network for implementing smart farming.

Identifying the technology used for smart farming will be a source of reference information to prepare KMS smart farming for future study. To answer RQ2, identify and categorize the technologies addressed in the literature. Table 8 and Figure 6 show the results of the identification and classification of the technology. Database Management Systems and Big Data technologies are the most widely discussed technologies. Smart farming uses many connected technologies to generate large amounts of data [49]. The data generated from the smart farming process, if it has yet to be processed further, has low value, and most of it is not useful or essential for business [2]. Several frameworks of knowledge systems in agriculture have been proposed, and their discussion has been explained to answer RQ1.

Table 8. Technologies in Smart Farming

Type of Technology	Authors	Sources	Total
Mechanical Technology	Moysiadis et al. (2021); Ayre et al. (2019); Symeonaki et al. (2020)	[24, 27, 39]	3
Cyber Physical System	Fakhar Manesh et al. (2021) Symeonaki et al. (2020)	[30, 39]	2
Big Data	Moysiadis et al. (2021); Fakhar Manesh et al. (2021); Iaksch et al. 2020); Ciruela-Lorenzo et al. (2020); Symeonaki et al. (2020); Sayed et al. (2022); Lytos et al. (2020)	[24, 30, 33, 38, 39, 44, 45]	7
Artificial Intelligence	Moysiadis et al. (2021); Fielke et al. (2020); Symeonaki et al. (2020); Ciruela-Lorenzo et al. (2020)	[24, 25, 38, 39]	4
Drone	Ayre et al. (2019); Lytos et al. (2020)	[27, 45]	2
Cloud Computing	Moysiadis et al. (2021); Ciruela-Lorenzo et al. (2020); Symeonaki et al. (2020); Pölönen et al. (2021); Eastwood et al. (2019)	[24, 26, 38, 39, 41]	5
IoT	Fakhar Manesh et al. (2021); Iaksch et al. (2020); Vukadinovic et al. (2022); Ciruela-Lorenzo et al. (2020); Symeonaki et al. (2020); Lytos et al. (2020)	[30, 33, 35, 38, 39, 45]	6
Sensor	Moysiadis et al. (2021); Ayre et al. (2019); Contreras-Medina et al. (2019); Lytos et al. (2020)	[24, 27, 36, 45]	4
Decision Support System	Fielke et al. (2020) Fote et al. (2020) Gardeazabal et al. (2021)	[1, 2, 25]	3
Database Management System	Eastwood et al. (2019); Ayre et al. 2019); Rijswijk et al. (2019); van der Burg et al. (2019); Fote et al. (2020); Skobelev et al. (2019); Ingram et al. (2022); Kulikov et al. (2020)	[2, 26-29, 32, 34, 40]	8
Interaction Technology	Fielke et al. (2020); Eastwood et al. (2019); Ciruela-Lorenzo et al. (2020)	[25, 26, 38]	3
Web	Alemu et al. (2018); Ciruela-Lorenzo et al. (2020); Ong et al. (2021); Mushi et al. (2022)	[3, 31, 38, 43]	5
Management Information System	Rijswijk et al. (2019); Vukadinovic et al. (2022); Mazzetto et al. (2019); Kulikov et al. (2020)	[28, 35, 37, 40]	4
Knowledge Management System	Fote et al. (2020); Ong et al. (2021); Fielke et al. (2020); Rijswijk et al. (2019); Contreras-Medina et al. (2020); Gardeazabal et al. (2021) Alemu et al. (2018); Skobelev et al. (2019)	[1-3, 25, 28, 31, 32, 48]	7
Expert System	Fote et al. (2020)	[2]	1
Geographic Information System	Vukadinović et al. (2022)	[35]	1
Educational System	Vukadinović et al. (2022)	[35]	1
OLTP & OLAP	Mazzetto et al. (2019)	[37]	1
eCommerce	Ciruela-Lorenzo et al. (2020)	[38]	1
Block Chain	Ciruela-Lorenzo et al. (2020); Marinchenko (2021)	[38, 42]	2
Enterprise Resource Planning	Kulikov et al. (2020)	[40]	1
Data Mining	Gardeazabal et al. (2021)	[1]	1

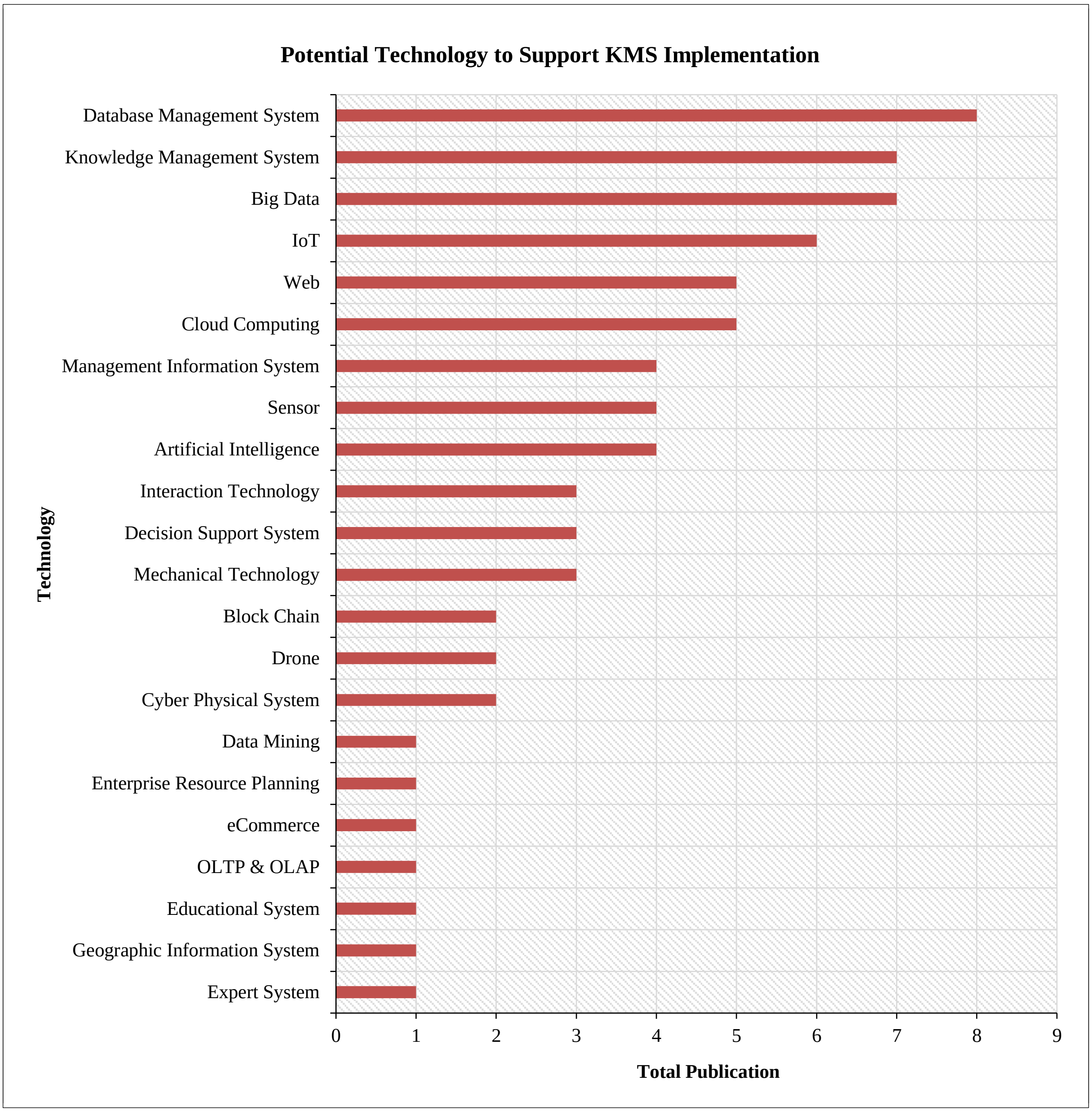

Figure 6. Technology Trends in Smart Farming

4.5. Success Factors

Based on the stages of the systematic literature review, knowledge sharing is the most dominant area for the knowledge management process in smart farming. Therefore, the focus of the initial development of knowledge-based systems can be prioritized on the knowledge-sharing process. Knowledge sharing is communicating knowledge among a group of people. The group may consist of members involved in formal institutions, for example, between colleagues in the workplace and informal. The interaction may occur between at least two people or more. The fundamental purpose of knowledge sharing is to utilize available knowledge to improve the group's performance. Generally, knowledge sharing is one of the most challenging processes to implement in knowledge management. Organizations should seek an effective method to disseminate and share knowledge between different levels of human resources. Therefore, knowing what success factors affect knowledge sharing on dairy farms is essential. Moreover, how do we rank the factors that influence the success of knowledge sharing on dairy farms based on their priorities?

This research will use a case study on a dairy farm in West Java Province, Indonesia. Dairy farming is still widely practiced, especially in Bogor, West Java Province, Indonesia. Dairy farming in the Bogor area is quite diverse, ranging from small farmers with 2–10 cows, medium farmers with more than ten cows, to large-scale farmers. Farmers usually sell their milk to the cooperative. A cooperative is an institution that collects milk and then sells it to the milk processing industry in large quantities with a contract system. Milk production produced by dairy farms is undoubtedly essential to meet the demands of the milk processing industry, which is quite large for both small and large farmers. Another important thing is the handling of milk, which is done correctly. The quality of milk can determine its feasibility for consumption. Milk handling at the farmer level is carried out by paying attention to milking procedures. Milk handling at the cooperative level is a sanitizing process before milk collection. Collected milk samples are taken to test the content and quality of the milk. These processes are part of the process that must be well understood by each party to maintain the quality of milk and increase the selling price.

Knowledge related to dairy farming includes cow rearing, feeding, reproductive handling, milking, sanitation, milk handling, and many other processes. This knowledge is undoubtedly precious. If all parties can carry out their duties based on the proper knowledge, the production chain to produce the best quality milk will be achieved. Dissemination of knowledge on small farms is usually obtained from generation to generation from parents or senior and experienced people in their environment. Knowledge of large-scale farming should have been documented in SOPs and ready to be carried out by employees. Problems of access to appropriate technology and deep problems in the organization and management of research, education, and extension systems often constrain farm development in the area. The Indonesian government seeks to facilitate dairy farmers by assigning dairy extension workers to their fields. Livestock extension workers are educated people assigned to educate farmers to increase their productivity. In addition, extension agents also play a role in promoting and studying farmers, innovation, and changes in farmers behavior [50, 51]. Literature studies were conducted to identify the factors that influence the success of knowledge sharing gained from previous studies. The results are categorized as organization, people, and technology (see Table 9).

Table 9. Success Factors of Knowledge Sharing in Dairy Farm

Category	Factors	Authors	Sources
Organization	Organizational Structure	Mohd. Judi et al. (2018)	[52]
	Leadership	Abdullah & Sulaiman (2016)	[53]
	Formalization	Adamsone-Fiskovica et al. (2021)	[51]
	Incentive	Abdullah & Sulaiman (2016)	[53]
	Community	Elmquist & Krysztoforski (2016)	[54]
	Place for Discussion	Adamsone-Fiskovica et al. (2021)	[51]
People (Individual/Group)	Attitude	Abdullah & Sulaiman (2016)	[53]
	Trust	Shehab et al. (2018)	[55]
	Commitment	Shehab et al. (2018)	[55]
	Teamwork	Mohd. Judi et al. (2018); Elmquist & Krysztoforski (2016); Shehab et al. (2018)	[52, 53, 55]
	Reciprocity	Shehab et al. (2018)	[55]
	Self-Efficacy	Shehab et al. (2018)	[55]
	Altruisme	Shehab et al. (2018)	[55]
	Reputation	Shehab et al. (2018); Abdullah & Sulaiman (2016)	[53, 55]
Technology	IT application	Adamsone-Fiskovica et al. (2021); Mohd. Judi et al. (2018); Abdullah & Sulaiman (2016); Elmquist & Krysztoforski (2016)	[51-54]

Factors that influence the success of knowledge sharing are grouped into three categories, as shown in Table 1: organization, individual, and technology. Research by Adamsone-Fiskovica et al. [51] mentions that factors related to the organization are formalization, organizational structure, and leadership. Formalization is the level of formality in an interaction within the organization. Based on this study, the lower the formalization of the organizational structure, the more it will help to share knowledge between units. They also stated that the higher the complexity of the organizational structure (bureaucracy), the more knowledge is shared between units. Furthermore, the more centralized the decision-making power of an organization, the less help to share knowledge between units. The relevant individual factors that influence knowledge sharing include attitude [54], commitment [52], trust, reciprocity, self-efficacy, altruism, and reputation [55, 56]. A factor represents a technical approach, i.e., technology that contributes to knowledge sharing [53].

A knowledge-sharing culture must be seen as a positive force for creating an innovative organization, notably through reciprocal elements. This situation requires the organization to identify and create a caring community among employees with shared interests to achieve the goal. The problem is maximizing employee potential and ability to create new knowledge and building a conducive environment for them to share knowledge. The availability of a place for discussion significantly affects the running of knowledge sharing. A survey conducted by Adamsone-Fiskovica et al. [51] found indications that the dissemination strategy needs to be supported by a good workspace. The closeness between a discussion room and the lecturer's room dramatically affects the degree of success in sharing knowledge. It is recommended that an existing or newly developing organization implement the best workspace strategic planning by integrating people, place, process, art, and design in encouraging and stimulating knowledge-sharing behavior among their employees, which can significantly impact organizational performance.

This research was conducted qualitatively and quantitatively. The case study was conducted on a dairy farm in the Bogor area, West Java Province, Indonesia. A qualitative approach is carried out by conducting interviews to determine the success factors that influence knowledge sharing on dairy farms in the region. Interviews were conducted with six respondents consisting of two seniors farmers, two experts from dairy cooperative managers, extension workers from the Agricultural Education Center, Ministry of Agriculture Indonesia, and a senior lecturer in the field of dairy farming in Bogor. Based on the literature review, it was found that fifteen success factors influenced knowledge sharing in this field (Table 10). Furthermore, the results of the interviews showed that four factors were eliminated: Organizational Structure, Reciprocity, Self-Efficacy, and Altruism. Two new factors were added, namely IT infrastructures and cultures. Thus, there are thirteen acceptable success factors (see Table 10).

Table 10. Factors Accepted by interview

Category	Factors
Organization	Organizational Culture
	Leadership
	Formalization
	Incentive
	Community
	Place for Discussion
People (Individual/Group)	Attitude
	Trust
	Commitment
	Teamwork
	Reputation
Technology	IT Infrastructure
	IT Application

Factors received in the interview process will be further processed for the quantitative stage. The AHP approach is applied to compile the identified factors. The following stages discuss the results of the analysis process:

1. *Constructing and Defining Success Factors*

The previously identified factors are used as the basis for this stage. These factors are then allocated to a variable to facilitate data processing. The letter F denotes the word factor and is followed by the serial number of the factor starting from number 1 so that the variables formed are F1, F2, and so forth. Table 11 shows the factors allocated to the variables.

Table 11. Factors and Variables

Categories	Factors	Variables
Organization	Organizational Culture	F1
	Leadership	F2
	Formalization	F3
	Incentive	F4
	Community	F5
	Place for Discussion	F6
People	Attitude	F7
	Trust	F8
	Commitment	F9
	Teamwork	F10
	Reputation	F11
Technology	IT Infrastructure	F12
	IT Application	F13

2. *Compare Each factor with Pair wise Comparison Matrices*

Each success factor (F) is compared to give priority to other factors. This is done by making a priority comparison table of each factor to facilitate the comparison process with the Pairwise Comparison Matrices (see Table 12). Fill it in by analyzing the priorities between the F row and the F column. In practice, we only need to analyze the priorities in F below or above the diagonal line. Diagonal lines are shown in grey. This is consistent with the mathematical equation that says if A: B = X, then B: A = 1 / X. Example: if the priority F1 (line): F2 (column) = 5, then the priority of F1 (column): F2 (line) = 1/5.

Table 12. Comparison of Priority Success Factors in Knowledge Sharing

Factors	Fl	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	1.00	0.14	0.14	0.11	0.20	0.14	0.11	0.11	0.33	0.33	0.33	0.11	0.20
F2	7.00	1.00	3.00	0.14	3.00	1.00	0.14	0.14	0.20	3.00	0.14	0.14	3.00
F3	7.00	0.33	1.00	0.14	3.00	3.00	3.00	0.33	3.00	0.33	0.33	1.00	3.00
F4	9.00	7.00	7.00	1.00	5.00	7.00	5.00	3.00	3.00	3.00	5.00	5.00	5.00
FS	5.00	0.33	0.33	0.20	1.00	0.33	0.20	0.20	3.00	0.33	0.20	0.14	0.33
F6	7.00	1.00	0.33	0.14	3.00	1.00	0.20	0.20	3.00	0.20	0.20	0.14	0.33
F7	9.00	7.00	0.33	0.20	5.00	5.00	1.00	0.14	5.00	0.33	3.00	0.33	3.00
F8	9.00	7.00	3.00	0.33	5.00	5.00	7.00	1.00	5.00	3.00	1.00	1.00	7.00
F9	3.00	5.00	0.33	0.33	0.33	0.33	0.20	0.20	1.00	0.33	0.33	0.14	0.20
F10	3.00	0.33	3.00	0.33	3.00	5.00	3.00	0.33	3.00	1.00	1.00	0.33	5.00
F11	3.00	7.00	3.00	0.20	5.00	5.00	0.33	1.00	3.00	1.00	1.00	3.00	5.00
F12	9.00	7.00	1.00	0.20	7.00	7.00	3.00	1.00	7.00	3.00	0.33	1.00	5.00
F13	5.00	0.33	0.33	0.20	3.00	3.00	0.33	0.14	5.00	0.20	0.20	0.20	1.00
Total	**77.00**	**43.48**	**22.81**	**3.54**	**43.53**	**42.81**	**23.52**	**7.81**	**41.53**	**16.07**	**13.08**	**12.55**	**38.07**

3. *Determination of Weight Factor*

This stage determines the weights of each factor of success (F), the weight value between 0-1. Initially, we have normalized first, that is, to determine the weights for each pair of factors (F1…13, F1…13). The weight of the pair is calculated by dividing the value of each cell by the sum of all values in the same column (based on Table 4). Examples of weighting factors (F1, F1) = 1 / ((1 +7 +7 +7 +5 +9 +9 +9 +9 +3 +3 +3 +5)) =0.01299, then for the weight of (F2, F1) = 7 / ((1 +7 +7 +7 +5 +9 +9 +9 +9 +3 +3 +3 +5)) = 0.09091. The weight results can be seen in Table 5 for all pairs with the same calculation. The total weight for each column is 1. Next is to look for value weights for each factor F. This is done by summing each priority weight value on each row of the table (based on Table 5) divided by the number of factors F, in order to obtain the weight of each factor F. Example weighting factor F1 = (0.01299 + 0.00329 + 0.00626 + 0.03139 + 0.00459 + 0.00334 + 0.00472 + 0.01423 + 0.00803 + 0.02075 + 0.02549 + 0.00885 + 0.00525) / 13 = 0.01148. With the same calculation, all weighting factor F results can be seen in Table 13.

4. *Setting Priorities*

The calculation results in the previous stage are then arranged based on the most significant weight value so that it is obtained, as shown in Table 13.

Table 13. Factors Order by Weight

#	Variables	Factors	Weights	Percentages
1	F4	Incentive	0.24901	24.90%
2	F8	Trust	0.15149	15.15%
3	F12	IT Infrastructure	0.12083	12.08%
4	F11	Reputation	0.10337	10.34%
5	F7	Attitude	0.07784	7.78%
6	F10	Teamwork	0.07698	7.70%
7	F3	Formalization	0.0633	6.33%
8	F2	Leadership	0.04631	4.63%
9	F13	IT Application	0.03271	3.27%
10	F5	Community	0.02356	2.36%
11	F6	Place for Discussion	0.02327	2.33%
12	F9	Commitment	0.01897	1.90%
13	F1	Organizational Culture	0.01235	1.24%

The analysis results using AHP were validated by looking at the consistency ratio. To get the consistency ratio, we first calculate the consistency index obtained with the equation, which can be seen in Figure 7. Lambda Max represents the average of the total weight of the criteria and the total weight, while n is the number of factors. The consistency ratio is calculated by dividing the consistency index by the random index (see Equation 1 and Table 14). The Random Index is the value that has been determined in this approach. The random index for a factor of thirteen is 1.56. The consistency ratio can be calculated using Equation 2 and Table 15. Acceptable models are those with a CR <0.10. The CR results obtained in this study were 0.05. Thus, this model is acceptable.

$$Consistency\ Index\ (CI) = \frac{{\lambda_{max}}^{-n}}{n-1} \quad (1)$$

$$Consistency\ Ratio = \frac{Consistency\ Index\ (CI)}{Random\ Index\ (RI)} \quad (2)$$

Table 14. Consistency Calculation Matrix

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	Total Weight
FI	0.0002	0.0000	0.0001	0.0004	0.0001	0.0000	0.0001	0.0002	0.0001	0.0002	0.0003	0.0001	0.0001	0.0017
F2	0.0049	0.0012	0.0070	0.0022	0.0037	0.0013	0.0003	0.0010	0.0003	0.0100	0.0006	0.0006	0.0042	0.0372
F3	0.0054	0.0005	0.0026	0.0024	0.0041	0.0042	0.0075	0.0025	0.0043	0.0012	0.0015	0.0047	0.0047	0.0455
F4	0.0262	0.0361	0.0688	0.0633	0.0257	0.0367	0.0476	0.0861	0.0162	0.0419	0.0857	0.0893	0.0294	0.6530
F5	0.0017	0.0002	0.0004	0.0015	0.0006	0.0002	0.0002	0.0007	0.0019	0.0005	0.0004	0.0003	0.0002	0.0087
F6	0.0029	0.0007	0.0005	0.0013	0.0022	0.0008	0.0003	0.0008	0.0023	0.0004	0.0005	0.0004	0.0003	0.0133
F7	0.0101	0.0138	0.0013	0.0049	0.0099	0.0100	0.0037	0.0016	0.0104	0.0018	0.0197	0.0023	0.0068	0.0961
F8	0.0163	0.0224	0.0183	0.0131	0.0160	0.0162	0.0414	0.0178	0.0167	0.0260	0.0106	0.0111	0.0256	0.2515
F9	0.0012	0.0035	0.0005	0.0029	0.0002	0.0002	0.0003	0.0008	0.0007	0.0006	0.0008	0.0004	0.0002	0.0123
F10	0.0030	0.0006	0.0101	0.0072	0.0053	0.0090	0.0098	0.0033	0.0055	0.0048	0.0059	0.0020	0.0101	0.0765
F11	0.0040	0.0166	0.0136	0.0058	0.0119	0.0121	0.0015	0.0132	0.0075	0.0064	0.0079	0.0247	0.0136	0.1388
F12	0.0139	0.0192	0.0052	0.0067	0.0192	0.0195	0.0152	0.0153	0.0201	0.0223	0.0030	0.0095	0.0157	0.1848
F13	0.0025	0.0003	0.0006	0.0022	0.0027	0.0027	0.0006	0.0007	0.0047	0.0005	0.0006	0.0006	0.0010	0.0197

Table 15. Consistency Ratio Calculation

Factors	Total Weight	Criteria Weight	Ratio
F1	0.0017	0.0115	0.15
F2	0.0372	0.0535	0.70
F3	0.0455	0.0592	0.77
F4	0.6530	0.2241	2.91
FS	0.0087	0.0259	0.34
F6	0.0133	0.0320	0.42
F7	0.0961	0.0860	1.12
F8	0.2515	0.1391	1.81
F9	0.0123	0.0307	0.40
F10	0.0765	0.0767	1.00
F11	0.1388	0.1033	1.34
F12	0.1848	0.1192	1.55
F13	0.0197	0.0389	0.51
Consistency Ratio Calculation		Lambda Max	1.00
		CI	0.08
		CR (<0.1)	0.05

The success factors that influence the knowledge sharing obtained up to this stage are arranged by considering the weight per criterion and the weight per factor. The results of weighting per criterion and factor can be seen in Figure 7. These results indicate that people are the primary determinant in the knowledge-sharing process at the dairy farm. The main factors in sequential people are trust, reputation, attitude, and teamwork. The second criterion that influences is the availability of technology, especially information technology infrastructure in the regions, to support the running of applications. The final criterion determining the organization consists of incentives, formalization, leadership, community, place for discussion, commitment, and cultural factors.

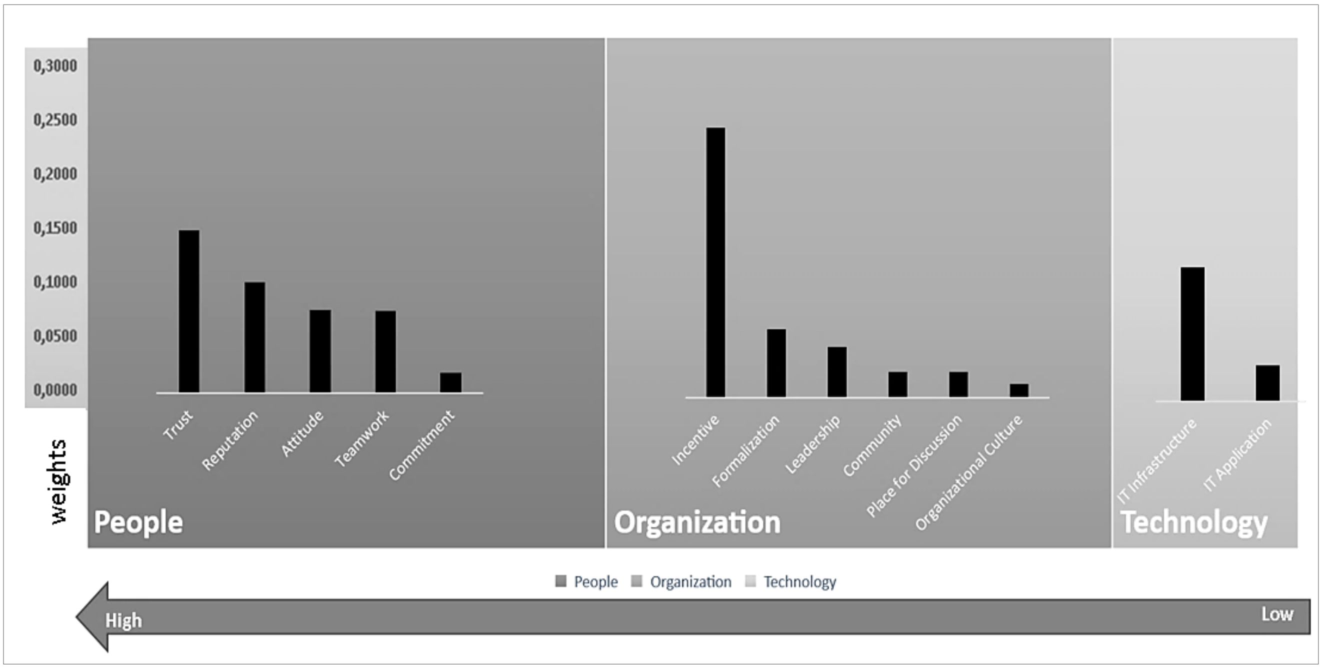

Figure 7. Model Factors Knowledge Sharing Based on Prioritization

5. Conclusion

This research identifies aspects that can be used to develop a knowledge management system on small-scale dairy farms. The research results show that the knowledge management process in small-scale dairy farming involves farmers, cooperatives, extension services, and industry. Farmers in livestock management undertake a holistic knowledge management process, incorporating learning from online resources and social media groups, adhering to expert advice for disease management, and focusing on critical practices such as documenting and monitoring reproductive cycles and training assistants in technical aspects of care. Cooperatives augment this by creating guidebooks from best practices, holding training meetings, distributing informational materials, and overseeing milk quality standards, thus fostering knowledge sharing and skill enhancement. Extension workers bridge theoretical knowledge with practical application, gather diverse information, conduct health training, maintain medical records, provide personalized counseling, and guide livestock care and disease management.

The industry plays a crucial role by offering comprehensive training for quality milk production, monitoring standards, supporting farmers' professional development, ensuring quality control, and enhancing overall efficiency in the dairy farming sector. Besides that, this research found that the knowledge taxonomy in dairy farms explains that in dairy farm management, five crucial pieces of knowledge are required, namely, how to care for livestock, how to handle livestock reproduction, how to transact milk, how to pay attention to livestock health, and how to carry out financial records from the farmer's aspect. Each knowledge consists of several more detailed sub-knowledges. The knowledge management process that has been dominantly carried out in this field is knowledge sharing. Factors that influence knowledge sharing sequentially based on priority are People, Technology, and Organization. Based on the findings in this research, parts of the need for a knowledge management system have been identified, such as the knowledge management process, the need for the knowledge used, and the success factors in taking an approach to strengthening the dominant knowledge management process in this field. This research can be continued to develop a knowledge management system at a more technical level. The results provide a solid foundation for further developing a more technical knowledge management system for smallholder dairy farmers, offering new insights into effective processes and technologies for knowledge management in this field.

The contribution of this research is to explicitly state the knowledge management process that occurs on small-scale dairy farms. The identified knowledge management processes are mapped into theoretical concepts to make it easier for scientists and system developers to understand the knowledge management process in this field. Apart from that, this research contributes to presenting knowledge taxonomies. Knowledge taxonomy provides a theoretical framework related to the knowledge involved in managing small-scale dairy farms. Finally, this research presents information that knowledge sharing is the dominant knowledge management process and presents a model of critical success factors that must be considered in successful knowledge sharing.

6. Declarations

6.1. Author Contributions

Conceptualization, S.I. and D.S.; methodology, D.S. and S.I.; software, B.W.; validation, D.S. and Y.R.; formal analysis, S.I. and D.S; investigation, S.I. and Y.R.; resources, S.I., D.S., and Y.R.; data curation, D.H. and Y.R.; writing—original draft preparation, S.I.; writing—review and editing, D.H., Y.R., and M.W.; visualization, D.H. and B.W; supervision, D.S. and M.W.; project administration, S.I. and B.W.; funding acquisition, S.I. and D.S. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

Data sharing is not applicable to this article.

6.3. Funding

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6.4. Institutional Review Board Statement

Not applicable.

6.5. Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

6.6. Declaration of Competing Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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