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Development of IoT-Based Breeding and Feed Management Application with Design Thinking Approach in Sheep Farming Industry (Case Study of PT. Agro Surya Perkasa)

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A B S T R A C T

This study explores the development of an IoT-based application for breeding and feed management in sheep farming using the Design Thinking approach, with a case study at PT Agro Surya Perkasa. A qualitative-descriptive method was used, applying five stages of Design Thinking: Empathize, Define, Ideate, Prototype, and Test. Data were obtained through interviews, field observations, and literature review involving experienced farmers, livestock managers, and IoT experts. The results show that the application addresses key challenges in breeding and feed efficiency through practical features such as breeding reminders, feed tracking, and health monitoring. The study demonstrates the potential of IoT to enhance livestock productivity and sustainability, offering valuable insights and a reference for similar innovations in other livestock sectors.

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INTRODUCTION

The food sector is an important pillar in the Indonesian economy, making a major contribution to economic growth, labor absorption, and food security. According to Aprillyana Rosita (2024), food is a basic human need, and everyone has the right to the same rights to meet their needs, including the right to food. Food includes foods that come from a variety of sources, including animal, plant, and water products as well as various processed products that have been processed for consumption and drinking that also require resilience. Food security has become a concern in the modern era characterized by increasingly complex challenges such as climate change, population growth, and rapid socio-economic transformation. Efforts to ensure an adequate, quality, and sustainable food supply are becoming increasingly urgent (Aprillyana Rosita, 2024).

As a country rich in natural resources with the characteristics and potential of each region, Indonesia has the opportunity to achieve self-sustaining food security if local governments are able to cooperate well with the central government, and with the role of food technology to develop food diversity. In an era where technological innovation and changing consumption patterns are shaping the landscape of agriculture and food, building food security is no longer just about increased production, but also about adapting to rapid and complex changes. One type of food in Indonesia is animal protein derived from beef, lamb/goat or chicken.

There are several proposed solutions to address these challenges, including more selective selection of broodstocks, the use of the latest technologies in feed management, as well as education and training for farmers to increase knowledge of better management, such as through online courses and training programs (Lioutas et al., 2010) and with the application of better technology and management, the potential for improved efficiency and quality in sheep farming can be achieved, both in Indonesia and in other countries. Internet of Things (IoT) technology has changed the way animal feed is managed in various parts of the world, providing operational efficiency and increasing production yields. In Europe, for example, an IoT-based feed monitoring system using RGB-D sensors has been implemented to monitor feed height in silos in real-time. This technology allows farmers to track feed consumption with high accuracy, predict feed needs based on historical data, and reduce waste. With the integration of cloud-based software, farmers can make smarter decisions for logistics management and other operational needs, thereby lowering overall costs (Raba et al., 2020).

The application of Internet of Things (IoT) technology in sheep farming, both in Indonesia and internationally, has had a significant impact on the efficiency and effectiveness of livestock management. In Indonesia, the use of IoT in the agriculture and livestock sectors is growing to address challenges related to feed management, livestock health monitoring, and environmental management more effectively. For example, IoT sensors to monitor feed quality and livestock health allow farmers to make data-driven decisions in real-time, which helps reduce waste and increase livestock productivity (Chakim et al., 2023)).

In overcoming the various challenges faced by the sheep farming industry, the design thinking approach that focuses on a deep understanding of user needs, can be applied in the development of technological solutions that are more in line with the specific needs of sheep farmers. Through the integration of digital technology with a design thinking approach, it is hoped that sheep farms in Indonesia have the opportunity to be more sustainable and productive, answering local challenges while improving the economic welfare of farmers. This shows the great potential of technology-based innovations to create a real impact on the livestock industry.

LITERATURE REVIEW

Theory Review

This research is based on the basic concept of design thinking, which is an important approach in creating innovative solutions that are centered on the needs of users, in this case sheep farmers. The approach consists of five main stages of Empathize, Define, Ideate, Prototype, and Test designed to deeply understand user challenges and develop targeted solutions. In addition, this research is also based on the theory of sustainability in livestock, which includes three main pillars: economic, social, and environmental. These pillars ensure that livestock practices are not only ecologically responsible, but also support the economic and social well-being of farmers.

Strategy Management

In the book Strategic Management and Business Policy: Globalization, Innovation and Sustainability, the stages of strategic management are comprehensively explained with a systematic approach. The stages of strategic management in this book follow a classic framework but are enriched with modern issues, such as globalization, innovation, and sustainability. This approach helps organizations to not only compete locally but also relevant in a global context. Strategy management can help organizations to set clear and measurable goals, identify and understand competitors so that they can develop strategies to compete effectively, help organizations understand trends and changes in the environment so that they can adapt to these changes, and can also help organizations to improve performance by using resources effectively and efficiently.

Digital Transformation

Digital transformation, according to Kumar (2022) in his article entitled Digital Transformation-Key Dimensions, is the process of using technology to better engage customers, improve processes, and utilize people for better results. According to Vial (2019), defining digital transformation is a process that aims to improve an entity by triggering significant changes to its properties through a combination of information technology, computing, communication, and connectivity.

According to Osmundsen et al. (2018), there are factors that can cause a company/organization to carry out digital transformation, including the following:

1. Regulatory changes
2. Changing competitive landscape
3. Shift/change to digital form of industry
4. Changing consumer behavior and expectations.

Design Thinking

According to Soni Ansori et al, (2023), design thinking is an approach that involves collaborating with users to find solutions to a problem. The main goal is to create services that are innovative, in accordance with user needs, and can solve existing problems.

Design thinking in the context of sheep farming is an innovative approach that focuses on creating solutions that suit the specific needs and challenges faced by farmers. With this approach, solution development begins with a deep understanding of the problems experienced by sheep farmers, including livestock health issues, feed management, market access, and operational efficiency. This approach involves the participation of farmers at every stage of the process, so that the resulting solutions are more relevant and practical to implement in their daily lives.

METHODOLOGY

Types of Research

Indrawati (2018) defines research as the process of finding a solution to a problem by thoroughly searching and analyzing all factors that may cause the problem. This research was conducted to formulate solutions for the development of IoT-based livestock and feed management applications using a design thought approach, based on the problem formulation that has been described in the previous chapter. In this study, the researcher conducted qualitative interviews based on strategies to observe and understand the problems faced by producers in livestock management and feed management by conducting in-depth interviews about phenomena and events in certain contexts to solve problems.

Research Stages

This research began with the collection of initial data to determine the objectives of the study. Then a literature review was carried out on theories relevant to research and research before determining the research position. After that, a framework of thought was made to describe the logic of the research in the form of diagrams. Then the Design Thinking approach was chosen as the research methodology.

Data Collection

By combining primary and secondary data, researchers can produce comprehensive and in-depth analysis, as it combines direct insights from primary sources with broader contextual information. This combination allows

for validation of findings, identification of information gaps, and more accurate and strategic decision-making. In addition, the combination of these two data improves research efficiency, strengthens the credibility of the results, and creates more holistic insights to solve problems effectively.

RESEARCH RESULT

Research Results

This research uses a Design Thinking approach consisting of five stages, namely Emphatize, Define, Ideate, Prototype and Test. In the early stages of this study, the researcher tries to understand the needs, feelings, and challenges of the users or stakeholders who are the target of the research. The methods used in this stage include in-depth interviews, observations, and literature studies. From this initial stage, data collection will be carried out from the results of in-depth interviews from users, then continued by making a summary of the reduction data that is useful for researchers in concluding the right solution with a complete understanding of the collected data.

Interview Transcript

In the interview transcript, the information was obtained by the researcher from several sources through questions and answers directly or indirectly. This aims to get in-depth perspectives, experiences, or specific knowledge from the speakers.

The researcher prepared 17 interview questions that were asked to 3 internal Agro Surya people who were involved in various important aspects and had complementary roles to ensure that innovation in the field of livestock was needed by all stakeholders in sheep/goat farming. The questions were compiled to explore the information needed by sheep/goat farmers in Indonesia. The conclusion from the results of the internal interview of Agro Surya was obtained information that Farm Agro Surya needs a tool to detect sick sheep so that they can be treated early and reduce mortality.

Documen Transcript

In document transcripts, researchers gather information from various archives, reports, policies, official records, or other documents relevant to the research topic. It aims to provide a historical context that supports research arguments based on written facts.

Currently, Agro Surya raises sheep and always experiences mortality. In 2025, mortality at Agro Surya will be worth IDR 29,585,000.

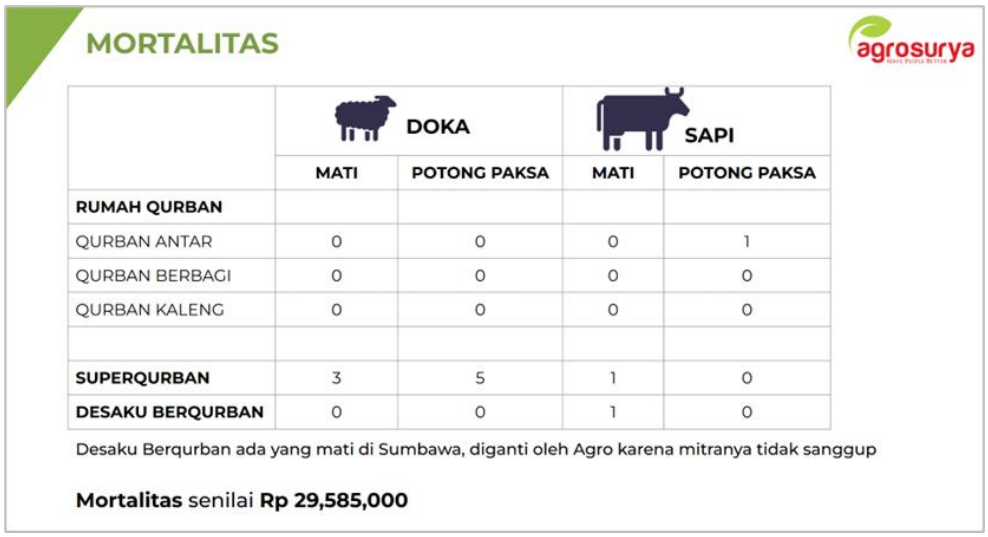


Figure 1. Mortalitas at Agro Surya

DISCUSSION

Emphatize

At this stage, the researcher tries to "put themselves in the user's shoes" through observation, interviews, and direct interaction methods to see the problem from the user's point of view. The main goal is to build empathy and explore authentic insights as a basis for formulating appropriate and relevant problems. With this approach, the resulting solution is not only based on assumptions, but is actually needed based on the real experience and needs of the user.

Emphaty Map

Emphaty Map is a visual tool used to help product development teams understand and gain in-depth insights into breeding and feed management applications. Resource persons can effectively leverage map empathy tools to ensure that the design process is user-focused and relevant to their needs.

The results of the Emphaty Map can be concluded several things, namely:

1) Livestock activities still rely heavily on manual labor, which takes time and energy. Most farmers do all daily activities manually, from feeding, cleaning the barn, checking the sheep, to shearing and bathing the sheep. The absence of aids makes this work very time-consuming, labor-intensive, and causes physical exhaustion. This condition causes work efficiency to be low, while the workload continues to increase as the livestock population increases. Farmers urgently need simple tools or technology to ease basic tasks so that they can focus on improving the quality of livestock and managing them more strategically.
2) Farmers have a high awareness of the importance of seed, feed, and reproductive system management. Although operations are still traditional, farmers have a good knowledge of the technical aspects that are important for the success of their business. They emphasized that superior seed quality, precision in feeding, and an orderly and measured breeding system are the main foundations for increasing sheep population, growth, and productivity.

They also understand the importance of recording and monitoring the reproductive cycle, although not all of them are able to do so consistently due to limited tools and systems.

3) Technology is seen as a key solution for efficiency, control, and growth. All farmers agree that the use of technology will bring significant changes in the farming process. They want tools such as feed shredding machines, bile detection devices, production recording software, and livestock identification chips (RFID). This technology will not only alleviate the daily workload, but also allow for better control over livestock health, feed efficiency, and reproductive success. Technology is seen as a bridge to a more modern, precise, and competitive farming system.
4) There is great hope for running a professional, efficient and sustainable farm. The farmers not only focus on daily technical work, but also have a vision to develop their business in the long term. They want a more scalable, data-driven work system that supports sustainable growth. Professionalism in managing livestock, efficiency in the use of resources, and sustainability in the production chain are the goals they want to achieve. Despite the many obstacles, the spirit to grow remains strong and shows that they are ready to transform if given the right support.
5) Limited human resources and capital are the main obstacles to business development. Almost all farmers face challenges in terms of the number and capacity of the workforce. A lot of work has to be done alone or with a small team, thus hindering efficiency and productivity. In addition, limited capital makes it difficult for them to invest in technology, cage repair, purchase quality feed, or procurement of superior seeds. Without adequate financial support and manpower, they find it difficult to innovate or expand their business, even to maintain the stability of daily operations.
6) Opening up market access and ecosystem support are the determining factors for success. In addition to internal improvements, farmers also really hope for support from external parties such as the government, distribution institutions, or the private sector. They need wider and more stable market access so that livestock products do not only depend on seasonal moments such as aqiqah or qurban. A more structured market will provide certainty of sales and encourage continuous improvement of livestock quality. This support also includes technical assistance, business management education, and access to adequate capital.

SAYS:	**THINK:**
• Jobs such as feeding, cattle checks, and sheep slaughter are very time-consuming and labor-intensive. • All daily activities are still done manually. • Farmers really need tools to ease their work.	• Superior seeds, good feed, and breeding systems are the keys to the success of the farm. • Efficiency is needed, especially in the management of time, labor, and capital. • The importance of building a structured system from upstream to downstream for business sustainability.

FEEL	DOES
• Feeling tired and overwhelmed due to the heavy daily workload and lack of tools. • Frustrated with limited human resources, time, and market access. • There is a strong push to run farms more professionally and efficiently.	• The main activities include feeding, cleaning the cage, monitoring the passion and health of livestock. • Some also make feed, slaughter, and record livestock data. • Most of it is still done traditionally and has not been technologically integrated.
PAIN: • The physical workload is very high because the work is still manual and there are few auxiliary tools. • Limited human resources and capital make it difficult to develop and efficient business. • There is no adequate system to support effective control, reproduction, and marketing. **GAIN:** • Want to make work lighter and more efficient with the help of technology (digital tools and systems). • Expect productivity to increase—both in terms of weight, population, and livestock quality. • They want a farm that is professional, sustainable, and has wide and stable market access.	

Figure 2. Empathy Maps

Source : Processed Researcher (2024)

User Journey Map

The results of Customer Journey Mapping show that farmers are still working manually, so they get tired quickly and need a more efficient way of working. They begin to understand the importance of the quality of seeds, feed, and livestock health, but still learn on their own without much guidance. Some have tried improvements such as recording and arranging marriages, but limited tools and capital. They feel that the work is very hard and they need help. Even so, they have high hopes to make the farm more modern and thriving with the support of technology and a clear market.

Define

After carrying out the User Journey Map and Emphaty Map processes in the Emphaty stage, the researcher then analyzes the problems that exist in the Define stage. At this stage, the researcher first determines the priority of the problem. Then it is then included in the Jobs To Be Done (JBTD) process. After the process mentioned above, it is continued with the POV (Point of View) and HMW (How Might We) process. The following is the Define process in this study.

Table 1. Problem Statement

Aspects	*Feedback* (Interview from Breeders)	Problem
Thinking	Farmers think about the importance of the quality of seeds, feed, and livestock health management.	Lack of access to information and technical guidance for effective livestock management.
Doing	Daily activities such as feeding, cleaning the cage,	Lack of use of tools and technology in daily activities of farming.

Aspects	*Feedback* (Interview from Breeders)	Problem
	and checking the birah are still done manually.	
Feeling	. Farmers feel tired, overwhelmed, and their work is inefficient.	High workload causes fatigue and decreases the motivation of farmers.
Pain Point	The absence of tools and systems makes work stack and physically burdensome.	Reliance on manual labor decreases productivity and work efficiency.
Opportunities	Farmers hope that there will be systems and tools so that work is lighter and livestock yields increase.	There is no concrete solution to meet the needs of the modern work system of farmers.

From the table above, it can be seen that sheep farmers face serious challenges in carrying out their daily operations. Most still carry out manual work such as feeding, checking the health of livestock, and cleaning the cages, which take significant time and effort. Although they are starting to consider using technology to improve efficiency, there are still doubts about their ability to adopt the technology. Emotionally, they show enthusiasm and optimism, but are accompanied by concerns about adaptability and low levels of digital literacy.

After conducting interviews and analyzing and determining the priority of the problem, the next step for researchers is to carry out the Jobs To Be Done (JTBD) stage which functions as a tool to understand the deepest needs of users, not only what they do, but why they do it. JTBD helps to dig into the deep reason, situation, and goals of users when they use a product or service to accomplish a specific task. By understanding these aspects, the development team can craft a more precise statement of the problem, design relevant solutions, and avoid decisions based on mere assumptions.

Table 2. Point Of View (POV) dan How Might We (HMW)

Insight	***Needs***	***Point Of View***	***How Might We***
Sheep farmers still carry out all activities manually, such as feeding and regulating reproduction, which exhausts them. They are beginning to realize the importance of efficiency, seed quality, and livestock health, but do not yet have access to tools or	They need a lighter and more efficient work system, simple tools that can be used immediately, and technical education that is appropriate to field conditions and easy to understand.	An independent farmer who wants to increase productivity and grow his business in a more modern way, but is still limited by resources, market access, and technological support.	How can we help farmers manage their businesses more efficiently and sustainably, through simple tools and systems that can be implemented immediately and support their productivity?

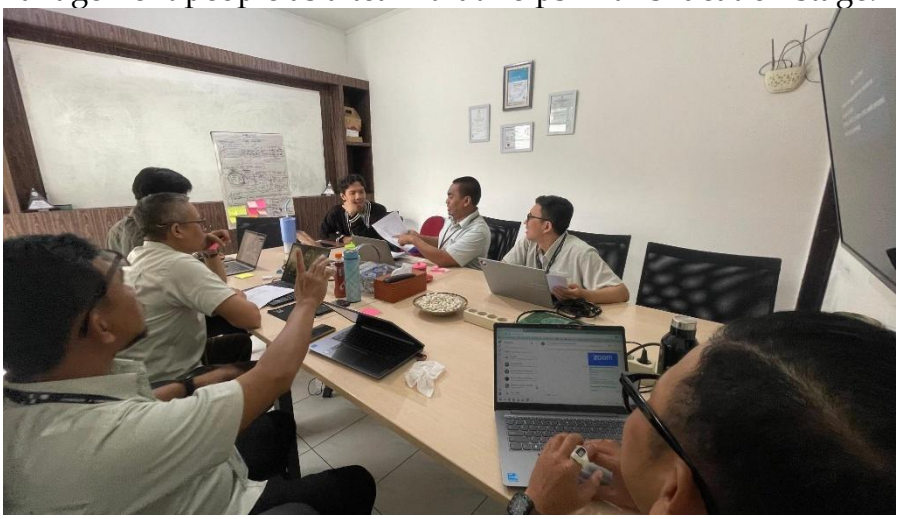
supporting information.			

Ideate

The ideation stage is the process of brainstorming and developing various ideas based on the understanding that has been obtained from the empathy stage and problem definition. The goal is to get as many ideas as possible so that the expected solution will also have many chances of success and potential.

Brainstorming

In this Ideation stage, the researcher brainstormed with 5 people from Agro Surya's internal party on May 8, 2025. These five people consist of 2 top management people who from the beginning became resource persons and three middle management people as a team that helps in this ideation stage.



Source: Researcher-Processed Data (2025)

Categorizing

At the brainstorming stage, 20 (twenty) ideas are produced which we then categorize and group those that have similarities in ideas so that there is no redundancy.

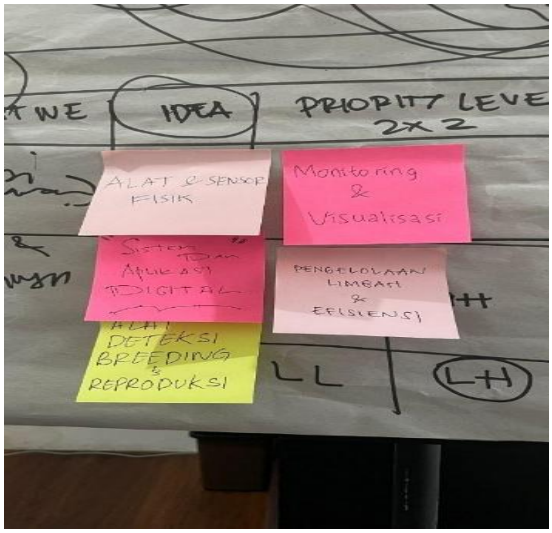


Figure 3. Similarities in ideas

Source: Researcher-Processed Data (2025)

Dot Voting

Figure 4. Dot Voting
Source: Researcher-Processed Data (2025)

From the grouping of 20 ideas into 5 categories of ideas, the rating of each idea based on Value and Effort was discussed, with the following criteria:

1. Quadrant 1 (High Value, Low Effort), which is ideas that are easy to do and provide high value. Also called High Value, Low Effort (Do Now)
2. Quadrant 2 (High Value, High Effort), i.e. ideas that are difficult to implement but provide high value. It is also called High Value, High Effort (Do Next).
3. Quadrant 3 (Low Grade, Low Effort), which are ideas that are easy to implement but give low grades. It is also called Low Value, Low Effort (Do Next).
4. Quadrant 4 (Low Grade, High Effort), which are ideas that are difficult to implement and give low grades. It is also called Low Value, High Effort (Don't Do).

Based on the discussion of rating mapping for unique ideas in the form of a 2x2 Matrix.

Summary Proses Ideate

The following is a summary of the results of Dot Voting which summarizes the stages of Ideate that have been carried out by the researcher, and presented in the form of Table 5. below.

Table 5. Summary Proses Ideate

Yes	Category	Idea	Description
1	System & Interface	Lightweight application for Livestock Management & Production Efficiency	This application was created to make it easier for farmers to manage feed, monitor health, and record the reproductive cycle of their livestock, all simply through a cellphone, without the hassle of logging in or needing a constant internet connection. Farmers only need to enter the age and weight of the sheep, then the application automatically gives feed recommendations. Each sheep also has its own profile that can be accessed quickly using a QR-Code. In essence, this application helps work lighter, but the results are maximized.
2	Feature	Feed management	Farmers only need to enter data on the age and weight of the sheep, then the system provides daily feed

			recommendations (amount and composition). This feature saves time and reduces feed calculation errors.
		Reproductive Cycles & Reminders of Birahi	Breeders can record the date of birth and the mating cycle of sheep, and get notified when the mating period or the ideal time for mating arrives. Increase breeding effectiveness.
		Health monitoring	Farmers can detect the health of animals early by recording body temperature and daily diet rhythms so that they can anticipate early and adjust the amount of feed
		Simple Livestock Data Management	Each sheep can have a profile: name/code, age, last weight, health status, mating cycle. Equipped with QR Code for quick access while in the cage

Source: Researcher-Processed Data (2025rhythm)

Confirm Ideas to Users

The solution that has been formulated is then translated into the functionality of the system, which is then developed in the form of a site map to provide an initial overview of the prototyping. The preparation of this site map helps clarify the user flow (user flow) that will be the basis for designing the application prototype. An illustration of the sitemap is shown in the following image:

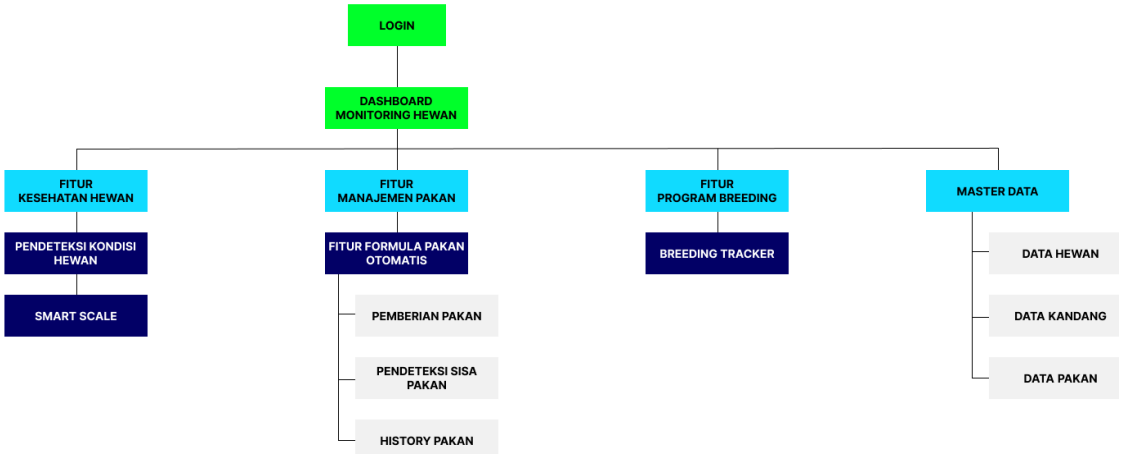


Figure 5. Sitemap for Application Prototype

Source: Researcher-Processed Data (2025)

Prototype

The purpose of this prototype is not just to build an application, but to create tools that are truly relevant to the activities and work rhythms of farmers. It is hoped that this prototype can be the first step towards the digitalization of livestock that is affordable, sustainable, and can be widely adopted by local farmers. With more accurate and easily accessible data, cage owners can make feed, breeding, and health care decisions based on factual records, not estimates. Time efficiency increases, the risk of forgetting is reduced, and livestock productivity is pushed up, making this application a practical foundation for the digitization of small- to medium-scale farms.

Objectives

Reducing Physical and Administrative Workload of Farmers

The application is designed to simplify daily activities such as recording feed, feeding periods, and livestock health. With lightweight and easy-to-use features (no login, you can go offline), this app helps ease workloads and increase efficiency, especially for farmers who are not yet familiar with technology.

Help Data-Driven Decision-Making

Farmers have been relying on intuition. This application provides feed recommendations, livestock history recording, and visual guidance for disease detection, including a QR code feature for livestock identification, so that decisions can be made appropriately and with minimal risk.

Supporting Gradual Digital Transformation in the Livestock Sector

This application is the first step towards inclusive and realistic livestock digitalization. The design is adjusted to field conditions (practical, fast, not dependent on signals), and encourages the formation of a digital ecosystem that is integrated with cooperatives, e-commerce, financial services, and official reporting.

Key Features

The app has three main features designed to be simple and easy to use, even for farmers with limited digital literacy: feed management, breeding programs, and livestock health monitoring. Data input can be done quickly via icon or voice, with automatic recaps and scheduled reminders.

1. Feed Management
   Record the time, type, and amount of feed per cage or livestock practically. Equipped with daily checklists and monthly recaps of feed consumption and stock estimates, so that feed management becomes more efficient and structured.
2. Program Breeding
   Record the entire reproductive cycle, from mating to birth, with automatic reminders. The app also provides ideal time recommendations for rebreeding and stores offspring data and livestock status, aiding data-driven population planning.
3. Health Check
   Record symptoms, vaccination schedules, and livestock treatment with easy input via icons or manuals. Vaccine reminders, action suggestions, and quarantine alert features are available for infectious disease cases. All documented medical history for long-term evaluation.

Test

The results of the prototype test to 4 breeders, obtained the following results:

Advantages (what works well)

1. Design, Application structure design has led to field needs. The use of functional elements such as icons, input columns, and parameter displays supports farm activities technically.
2. UI/UX, In general, the user flow has followed the work process of the farmer. The application allows users to monitor and record in a sequence that suits their daily life in the cage.
3. Animal Health Feature, This feature is considered very important by all resource persons because it allows early detection of sheep conditions. This helps prevent potential losses due to illness or decreased performance.
4. Feed Management features, feed consumption recording and daily requirement estimation support cost efficiency and reduce waste. This feature helps farmers in setting the amount and schedule of feeding appropriately.
5. The Breeding Program feature, the app provides records of mating periods, and births. This helps farmers manage the genetic quality of sheep in a planned and measured manner.

Disadvantages (what needs improvement)

1. Appearance, some breeders mentioned that the application display is still rigid and less attractive, icon visualization is looking for other alternatives.
2. Color, color choice is considered uncomfortable to see for a long time, and does not provide clarity in distinguishing categories or data status (e.g.: healthy/sick, active/off).
3. Flow for farmers, "Even though the steps in this application have been massaged, for farmers who are not used to using the application, there is still a need for simple guidance.
4. Manual data, with economic considerations, the data input process is still carried out manually without automatic integration (for example, sensors or RFID), so it has the potential to increase the workload and increase the risk of input errors.

At this stage, testing refers to three main aspects, namely desirability, viability, and feasibility.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of interviews and analysis, sheep farmers face various pains such as high manual workload, lack of tools, limited human resources and capital, and limited market access. However, they also have gains in the form of expectations for efficiency through simple technology, improved production quality, and more professional and data-driven management. The main problem identified is the reliance on manual work without the support of adequate tools and technology. With a Jobs To Be Done and Point of View approach, the formulation of How Might We is geared towards solutions that help farmers manage livestock efficiently through simple tools and systems that are easy to implement.

Through the ideation process, a solution was developed in the form of a simple livestock management application with features such as feed recording, breeding period reminders, health monitoring, and QR codes for livestock

identification. The prototype was designed using Figma with a focus on user-friendly interface and offline operation. Trials were conducted through FGDs and System Usability Scale (SUS) by four farmers. The results show that the application is quite helpful but still needs improvement in the aspects of appearance, input flow, and usage guidance. These findings confirm that the Design Thinking approach is effective in designing digital solutions that fit the needs and real conditions of farms in the field.

Recommendation

1. Phased Development – Focus on refining core features such as breeding reminders, feed tracking, and livestock history before further IoT integration.
2. Digital Literacy Training – Provide regular training and visual guides (videos, infographics, print modules) to make it easier for all farmers to use the application.
3. Offline Mode Reinforcement – Strengthen offline features and auto-sync to stay optimal in locations with limited networks.
4. Use Design Thinking Sustainably – Make this approach the company's digital innovation standard to keep solutions relevant to user needs.
5. Cross-Team Collaboration – Build an active feedback system between IT teams, management, and breeders to ensure application development according to field needs.

ADVANCED RESEARCH

1. Long-Term Evaluation of Application Impact on Farm Performance
   Further research can focus on quantitative and qualitative evaluation of the impact of applications on increasing productivity, cost efficiency, and livestock health in the longer term.
2. Real-Time Integration of IoT Technology
   Follow-up studies are suggested to explore more deeply about the real-time use of IoT devices (e.g. temperature sensors, RFID, or automated feed monitoring tools) and their impact on data-driven decision-making.
3. User Experience (UX) and User Behavior Analysis
   Future research can delve deeper into how user behavior changes after using the app and how UX design can be adapted to local customs in the traditional livestock sector.
4. Expansion of Studies to Different Scales and Types of Farms
   It is recommended to test this application or similar developments in other types of livestock (cattle, goats, chickens) and at various scales (micro, small, to industrial), to see adaptability and cross-sector challenges.

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