Supporting Dutch Dairy Farmers in Transitioning to Ecological Farming with an Online Platform

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Despite being a major agricultural exporter, the Netherlands relies heavily on conventional farming methods. These methods are not sustainable, and ecological farming offers a solution. However, its adoption remains limited due to barriers such as knowledge gaps. These barriers could potentially add more stress to farmers and cause mental health problems, thereby hampering the transition to ecological farming. Therefore, this research project investigates how online platforms can support dairy farmers in transitioning to ecological farming, particularly in facilitating knowledge acquisition.

This research involved literature reviews, followed by interviews with Dutch dairy farmers and the evaluation of prototypes. Through literature reviews, the study identified four types of support dairy farmers could potentially benefit from through online platforms: 1) a subsidy information board, 2) a training programs and courses information board, 3) technical guides with videos, and 4) online social support. These online supports were prototyped and evaluated during the interviews.

The evaluation with dairy farmers revealed that online social support resonates the most with them, while other online supports also show some degree of usefulness in facilitating knowledge acquisition and moving toward more ecological farming. Additionally, a new type of online support was suggested and its potential to synergize with other online supports was considered an interesting topic worth exploring in future research. Overall, the outcomes of this study can guide future researchers in developing comprehensive online platforms that can effectively aid dairy farmers in their journey toward ecological farming.

Additional Key Words and Phrases: Dutch Dairy Farmer, Ecological Farming, Precision Dairy Farming, Online Platform, Mental Health

1. INTRODUCTION

Although the Netherlands has a small land area, it ranks as the second-largest agricultural export country globally [16]. However, the main approaches utilized by farmers are conventional and these are not sustainable and environmentally friendly. Conventional agriculture causes risks such as soil erosion, water pollution, biodiversity loss, reduced animal welfare, and adverse effects on general population's health due to, for example, the increasing use of fertilizers and pesticides [4, 29, 33]. Therefore, there has been a growing call in recent years for an alternative practicable approach to substitute conventional farming methods and address the problems associated with the widespread use of pesticides and fertilizers, and this approach is the ecological farming.

Ecological farming is an evolving approach that prioritizes sustainability while trying to maintain the same yield as conventional farming [19, 37, 38]. Examples of such ecological approaches are organic farming, regenerative farming, and precision farming. In the Netherlands, however, according to Eurostat [13], the use of ecological farming is not that widespread at the moment. In fact, the share of total organic agricultural land in the Netherlands was 4.22% in 2021 [13]. It is relatively lower than other European countries like Austria or Estonia, and thus there is an urgent need to support Dutch farmers to move towards a more ecological way of farming. However, adoption of this new farming practice faces barriers. One of the barriers is "the lack of integral knowledge that can be applied by farmers" and "the limited knowledge dissemination" [9, 26]. These barriers could put more pressure on farmer already stressful occupations if they adopt ecological farming, thereby affecting their mental health and potentially leading to some disastrous outcomes such as suicide [2, 6, 8, 24]. This risk of exacerbating mental health problems would then deter farmers from transitioning to the new farming approaches. One way to alleviate farmers' concerns about evolving to the new generation of ecology-based sustainable production systems and prevent them from suffering from mental health problems caused by the difficulty of acquiring new farming knowledge is the use of online platforms [36].

Traditionally, farmers have sought knowledge and assistance from technical agricultural advisory services, neighbors, agricultural schools and programs, government agencies, or through experiments on their farming land [30]. As the internet becomes more widespread, online systems have become a new way for them to access information [36]. While previous studies have developed online applications for general agricultural knowledge management [15] or knowledge exchange in organic arable farming [19], there is limited research specifically targeting dairy farmers transitioning to precision dairy farming, a form of ecological farming[1] that uses technology and data to monitor animals and improve farm performance [5, 10, 17]. Therefore, the problem statement leads to the following research question:

How could an online platform support dairy farmers in their transition to ecological farming, especially in acquiring new farming knowledge?

This can be answered with the following sub-questions:

1. What kind of support through online platform could be beneficial to dairy farmers for acquiring new knowledge?
2. What are farmers' perceptions of an initial prototype or design to provide support in acquiring new farming knowledge?

It is important to note that not all technologies in precision dairy farming are primarily focused on sustainability. In this research, we focus on the segment of precision dairy farming where technologies are utilized for ecological purposes.

2. METHODS

In this section, we will discuss the approach we used to answer the main research question. To address the main question, we first answered two sub-questions. Initially, we identified the types of support through online platform that could be beneficial for dairy farmers. Based on these findings, we then developed and presented prototypes to dairy farmers. Finally, we analyzed farmers' perceptions and suggestions regarding the prototypes to answer the main research question and conclude the research project.

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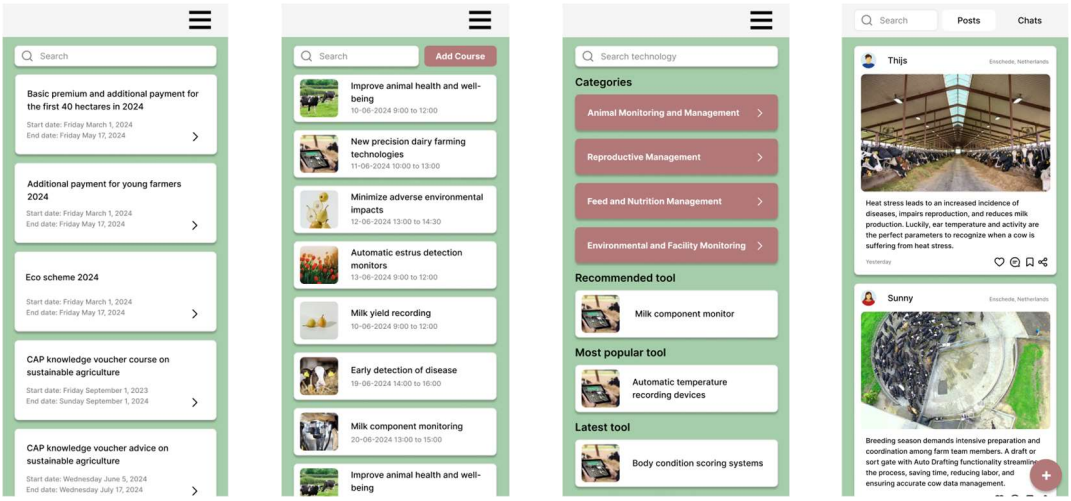

Figure 1: Main page of the 4 prototypes (from left to right: the subsidy information board, the training programs and courses information board, the technical guides with videos, and the social support)

2.1 On Answering SRQ1

To determine what type of support can benefit dairy farmer on the online platform, literature reviews were conducted. Relevant literature was collected from Google Scholar and Scopus using search terms such as "ecological farming", "knowledge acquisition", "mental health", and "online platform". These search terms serve as categories useful for addressing the first sub-question.

During the reviews, we studied literature that explore farmers' mental health problems and potential methods to alleviate their stress. Additionally, existing digital and non-digital approaches or tools through which dairy farmers acquire innovative knowledge and information were examined. Their advantages were identified and analyzed for potential inclusion in the prototypes. Furthermore, literature exploring the application of online platforms in other domains provide inspiration for the design of the prototypes as well. Through this literature review, we identified the potential types of online support that can assist dairy farmers in acquiring new knowledge, which were then prototyped, and collected a list of design guidelines that were incorporated into the development of the prototypes.

2.2 On Answering SRQ2

According to the information gathered in the literature review, we created prototypes and presented them to Dutch dairy farmers during semi-structured interviews. In this section, we will discuss the recruitment process of the evaluation, the material used during the evaluation, the procedure and questions we went through with the participants, and the method of interview data analysis.

2.2.1 Recruitment

To recruit Dutch dairy farmers, we searched for contact information of dairy farmers online and sent them the interview invitation email. In the first email, we checked if dairy farmers were willing to participate in our 20–30-minute interviews that would be conducted in English. Only if they accepted the invitation did we send out the second email. In the second email, details of the meeting were discussed, including the schedule and the method (in person or online) of the interview, the information letter, and the consent form.

In cases where dairy farmers could only speak Dutch but were willing to participate, instead of conducting the interview face-to-face, we shared the interview questions and clear instructions, both in Dutch, via email. The instructions included a brief introduction to the research, a guide on how to answer the questions, and any important information from the information letter. Along with the questions and instructions, the consent form, modified to remove the audio-recorded section, was sent to the participants. They were asked to sign it before starting to answer the questions. Finally, we planned to recruit at least 3 participants due to the limited time frame of this research.

2.2.2 Evaluation Material

In total, we created 4 prototypes (see Figure 1) along with 6 key interactions (see Table 1 and Appendix A). They were based on the findings of the literature review (see Section 3.1). These prototypes were created with Figma [14] and are low-fidelity. We opted for low-fidelity prototypes rather than high-fidelity ones because the focus of the research is the general exploration of design or functionalities that can support Dutch dairy farmers in the transition, rather than focusing on specific functionalities. Moreover, the prototypes were created in the form of mobile applications as smartphones have been shown to be the prevailing tool to obtain agricultural information [27].

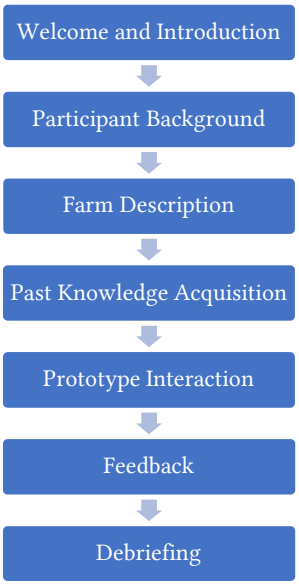

Figure 2: Evaluation procedure

Table 1: Prototypes and key interactions

Prototypes	Key Interactions
Subsidy Information Board	Click on the subsidy you are interested in to get more detailed information.
Training Programs and Courses Information Board	Find a training course that you are interested in and enroll in it.
	Create a course that you would like to offer and submit it for review.
Technical Guides with Videos	Check out a technology that you don't know. Watch the tutorial video and read the technical guide to understand how it works.
Social Support	Create a new post to ask farming questions.
	Send your questions to your friends, advisors, or groups in private chats.

2.2.3 Evaluation Procedure

To successfully conduct an interview, the evaluation procedure (see Figure 2) and questions (see Appendix B) were planned and formulated after the literature review and the development of the prototypes. The general structure of the interview questions about the participants' background included basic demographic questions (age, length of time in the industry), general questions about their farm (whether it is conventional or more ecological), and current methods of gathering new knowledge. This was followed by questions about the interviewees' perceptions and suggestions regarding the prototypes. After participants had performed key interactions with each prototype, they were asked to score each prototype on a scale of 1 to 10, where 10 means very useful in acquiring knowledge and moving toward more ecological farming, and were asked to provide reasons for their scores. Additionally, their willingness to transition toward ecological farming if the prototypes become a reality was explored.

2.2.4 Data Analysis

During the data analysis process, we examined the scores participants gave to each prototype and identified themes from their responses by reading through all answers and noting down the similarities and differences. We ranked the four prototypes by their average scores to determine how helpful each one is to dairy farmers in facilitating knowledge acquisition and transitioning toward more ecological farming. The findings from this analysis were used to answer the main research question.

2.2.5 Ethics

The interview was reviewed and approved by the Ethics Committee Computer & Information Science of the University of Twente under application number 240391.

2.3 On Answering MRQ

After conducting the literature review and the interviews, we gathered all the data needed to answer the main research question. We then identified what was expected and what was surprising by comparing the results from the first and second sub-questions. Finally, we drew conclusions based on all the findings.

3. RESULTS

3.1 Literature Review

To answer the first sub-question, literature reviews were conducted. During the reviews, papers focusing on farmers' mental health were studied to understand how dairy farmers can gain new knowledge without causing too much stress [2, 3, 23]. Additionally, some studies have explored how online resources can help farmers acquire knowledge faster and easier [36] and application design for general knowledge exchange in farming [1, 15, 19, 20]. These papers, along with those investigating existing methods through which farmers acquire new knowledge [18, 39], help understand the kind of support that could be beneficial for dairy farmers. Apart from these literature sources, studies discussing the current condition of the dairy farming industry in the Netherlands were considered to understand the needs and habits of current dairy farmers [12, 22, 25, 28, 35].

To select the online supports potentially beneficial to dairy farmers in acquiring knowledge, we used existing knowledge acquisition methods as the basis and considered how moving them online would fit without being too stressful for farmers to use. Finally, four types of online support have been identified: the subsidy information board, the training programs and courses information board, the technical guides with videos, and the online social support.

3.1.1 Subsidy Information Board

An information board that displays all subsidy information related to precision dairy farming could help dairy farmers find subsidies more easily, rather than having to navigate multiple websites in search of financial resources. Dairy farmers in the precision dairy farming industry need to invest in new technologies and modernize their farm operations to stay competitive in the long run [28]. Although these new inputs increase efficiency and improve animal health and well-being, they are costly and require ongoing maintenance [24]. These expenses pose a significant financial burden, particularly for Dutch dairy farmers already struggling with high land prices [35].

In the Netherlands, bank loans are the primary source of finance for farmers to cover these costs. However, according to a study by the European Commission and European Investment Bank, 15% of farms faced challenges in accessing loans for investment in 2017, a percentage higher than the European Union average [12]. This is due to a high proportion of Dutch dairy farms earning less than the low-income threshold, causing finance providers to doubt their ability to repay loans [28]. This situation highlights the financial struggles faced by many Dutch dairy farmers and emphasizes the need for subsidies to alleviate Dutch dairy farmers' financial strain and support their transition to precision dairy farming [35]. In fact, studies have shown the positive impact of agricultural subsidies on farmers' income [11, 34]. This positive impact results from increased milk production, as farmers can purchase technologies and improved breed dairy cattle, and from the increased production of dairy products such as butter and cheese. Without subsidy support, farmers struggling with financial burdens would encounter great difficulty in transforming their livelihood, let alone transitioning to more ecological farming [11]. Nevertheless, while several agencies have provided online financial support for dairy farmers

seeking to adopt more sustainable farming practices, this information is often fragmented and time-consuming to find [21]. Thus, farmers may benefit from an online platform that gathers all relevant subsidy information from various sources, enabling them to find the necessary subsidy information more efficiently [36].

3.1.2 Training Programs and Courses Information Board

An information board that displays all training programs and courses related to precision dairy farming, and provides details on them, could facilitate farmers in acquiring knowledge by saving their time spent searching for relevant courses across multiple websites. The main purpose of these training courses is to transfer knowledge from researchers to farmers and educate farmers to make better decisions [18]. To transition to precision dairy farming, apart from financial support, dairy farmers need to put effort into learning new knowledge and skills, such as how to make the right decisions based on data obtained from precision dairy farming technology like a milk component monitor [17, 31]. Thus, training courses are an important medium for dairy farmers to successfully evolve their farming practices.

Furthermore, training courses are not limited to researcher-to-farmer interactions but can extend to farmer-to-farmer exchanges. Trained farmers can disseminate agricultural knowledge and technologies to their non-trained peers, which has been proven to be a cost-effective and practical alternative to conventional training programs where researchers directly teach farmers [39]. Indeed, directly training all dairy farmers, especially in the rapidly developing field of precision dairy farming, would be prohibitively expensive. However, similar to the information about financial support, information about various training courses is often spread across different online platforms, requiring farmers to spend a lot of time searching for the courses they need [21]. Therefore, an information board that pulls all training programs and courses related to precision dairy farming together could help them find their target courses more easily, thereby facilitating knowledge acquisition [36].

3.1.3 Technical Guides with Videos

Technical guides with videos could keep farmers informed about new technologies and farming knowledge related to precision dairy farming. According to a study exploring the preferences for different online knowledge exchange tools among organic farmers who grow arable crops, advisors, and researchers, videos received the highest score for ease of use, while technical guides received the highest score for practicality [19]. Videos are praised for being direct and easy to understand because they show the machines in action. In fact, existing online platforms targeting organic farmers, such as Access Agriculture [1], also utilize videos as the main tool to disseminate knowledge. In the study, some feedback suggested that videos should be short (2 to 8 minutes). However, some participants also criticized that some videos were too general and lacked enough practical details. Nevertheless, this issue can be addressed. It is suggested that videos could be used in conjunction with technical guides due to the detailed information the guides can include [19]. In this context, videos and technical guides are then complementary, providing dairy farmers with both ease of use and practicality.

Additionally, platforms like Access Agriculture [1] and Organic Farm Knowledge [20], developed to present different knowledge exchange tool types [19], use various themes to categorize all kinds of knowledge. This could be a useful design suggestion for prototypes, as users would find what they need more quickly. In addition to different themes, featured tools, including recommended tools, most popular tools, and latest tools, are highlighted to help users select the technologies they could employ on their farms [1, 20]. These features, combined with the technical guides and videos for each technology, could effectively facilitate the knowledge acquisition of Dutch dairy farmers and should be incorporated into the prototypes to test whether they would be helpful for Dutch dairy farmers in their transition to precision dairy farming.

3.1.4 Social Support

Social support could allow farmers to learn new knowledge from peers and positively impact their mental health. In a study exploring how social media may support farmers transitioning to more sustainable agriculture, self-training and transmission were identified as the common uses of social media among farmers [25]. Farmers learn from other's experiences and provide opinions and advice on each other's decisions through social media. Indeed, many farmers have already started using social media such as Facebook and Instagram as a new medium to obtain various kinds of knowledge, ranging from technical to commercial [22, 25]. This is seen by policymakers and researchers as key to moving toward more ecological farming [7] because knowledge can be exchanged without spatial or temporal boundaries [32]. Moreover, a paper that studied a WhatsApp group set up to support groups of French farmers participating in a plan aimed at reducing pesticide use and explored how indeterminacy is fostered to induce agro-ecological transition found that several features of social media can induce indeterminacy and thereby facilitate the transition [7]. These features include the openness of the social environment, the instantaneous sharing of visual content, the sharing of innovative agricultural practices, and the evolution of known practices with new meanings. The openness of the social environment enables farmers to build connections with other farmers and potentially develop interest in new themes shared by other members. The instantaneous sharing of visual content allows farmers to compare different realities and identify feasible farming practices. The sharing of innovative agricultural practices enhances farmers' innovativeness and motivates them to transition to new practices. The evolution of understanding on known agricultural practices helps farmers challenge conventional approaches, thereby sparking their interest in trying new practices [7]. Overall, these features highlight social media's ability to facilitate knowledge acquisition.

Furthermore, it has been found that social support protects against adverse mental health problems resulting from stress [2, 3, 23]. The openness of social media allows farmers to share their feelings and challenges with others, and this gives them a sense of community [7]. Therefore, since social support can help farmers manage stressors like difficulties in acquiring and understanding new technology and knowledge, while also protecting against the negative effects of stress on well-being, it is considered a good feature to incorporate into prototypes and test the potential effectiveness for Dutch dairy farmers in their transition to precision dairy farming.

Following these four kinds of support, four prototypes were created to be used in the evaluation, as described in Section 2.2.2.

3.2 Evaluation

To answer the second sub-question, more than forty Dutch dairy farmers were invited to participate in the interviews. In

the end, three participants accepted the invitation and were contacted successfully. One interview was done face-to-face, and the other two were completed via email as the participants indicated they only spoke Dutch. In the sections below, the participants' background, experience, and feedback on the prototypes will be discussed.

3.2.1 Participants' Background and Experience

Among the participants, one dairy farmer is over 40 years old, one is over 50 years old, and one is over 65 years old. All of them have an average of 30 years of experience in the dairy industry and currently have a more ecological farming approach on their farms. According to one of the participants, "*in order to supply to the 'better for milk stream of AH', having a more ecological farm is also necessary.*" (Farmer 2). This shows that more and more clients of milk products are requesting and hoping to buy products coming from more sustainable farms. This explains why dairy farmers, like our participants, would gradually shift from conventional farming to more ecological farming. For example, one participant mentioned, "*At the time, I could not sell the milk as organic because there was not enough demand. Therefore, I started farming traditionally and slowly moved towards the organic standard. So, in 1995, I got the organic license.*" (Farmer 1).

Back in the day, the growth and use of online platforms were very limited. The major ways for these participants to learn new farming knowledge were visiting colleagues who were already doing ecological farming, consulting advisors, participating in research projects, or through trade journals and courses in agricultural schools like Wageningen University & Research. However, they do not reject using online platforms in the modern day, as more than one participant uses social media as one of their mediums to acquire knowledge, which is actually one of the prototypes we made. So, in the next section, we will discuss the participants' feedback on the four prototypes.

3.2.2 Participants' Feedback on the Prototypes

On a scale of 1 to 10, where 10 means very useful in acquiring knowledge and moving toward more ecological farming, particularly precision dairy farming, each prototype has been given a score. The average scores will indicate the potential of different kinds of online support in helping dairy farmers transition to ecological farming, especially in acquiring new farming knowledge. In cases where a participant gave more than one score to a prototype, we used the average of those scores as its final score.

3.2.2.1 Subsidy Information Board

The subsidy information board prototype received an average score of 4. The main reason for the low score is that one participant thinks it does not directly help in making the initial decision to transition to ecological farming. The decision to transition is driven more by the farmers themselves and their understanding of sustainable practices. He explained, "*When you are a farmer, especially a traditional farmer, there is no reason to look at or open the phone to go through the subsidy information board because you first have to decide that you want to change. And when you make that decision, then you will look for how you can do it. At that time, it can be helpful.*" (Farmer 1). On the other hand, other participants think it is helpful while also emphasizing the importance of keeping the subsidy information recent and complete, as they explained that these things change rapidly from year to year.

3.2.2.2 Training Programs and Courses Information Board

The training programs and courses information board prototype received an average score of 7. This prototype received positive feedback in general. Participants liked that all kinds of courses related to precision dairy farming are put in one place, and one participant especially liked the capability to create a course because he hopes more people will engage in ecological farming.

3.2.2.3 Technical Guides with Videos

The technical guides with videos prototype received an average score of 6. Two out of three participants think it would be handy to have this application. One participant mentioned, "*I like that tutorial videos are included because we are busy at work and there isn't always time to read the user manual or technical guide.*" (Farmer 3). However, two participants also pointed out that it would be very difficult to keep the information up-to-date, which is an important factor in keeping this online support useful. If that does not work, it would reduce its usefulness for acquiring new knowledge about new technologies.

3.2.2.4 Social Support

The social support prototype received an average score of 8. All participants are familiar with this type of online support and think that "*this kind of knowledge sharing can be very effective.*" (Farmer 2). Two of them have already used similar existing support online, such as WhatsApp and Facebook, while one has not, but all of them gave it a very high score which indicates its high potential in supporting dairy farmers transitioning to ecological farming. Nevertheless, the participant who does not use any social media concerns about privacy issues and the filter bubble, which are the reasons he does not want to use social media: "*They feed people with information, and information gets accumulated. So, people only get one kind of information.*" (Farmer 1). Additionally, two participants mentioned, "*People have all kinds of social apps on their phones, which they use for this kind of purpose. If a new app were created, there wouldn't be enough people using the app.*" (Farmer 1). These concerns are worth discussing. However, they are not the focus of our research and will be left for future research.

3.2.2.5 Other Support

One of the participants has suggested an additional kind of online support that he thinks would help dairy farmers significantly in transitioning to more ecological farming. Let's call it the "farm aid application" for simplicity. He explained, "*Suppose I was a traditional farmer looking at a cow or some plants, and the cow was showing some symptoms. It would be very handy if I could get my phone, type in 'cow shows this and this,' and find out how to treat it.*" (Farmer 1). Moreover, the farm aid application would provide more than one solution to a question: "*It could provide different treatments, including more sustainable options, with alternatives rated for their sustainability.*" (Farmer 1).

He continued to explain why the farm aid application should offer multiple answers: "*Because I strongly believe that people should eventually make their own choices based on all the available information, or at least almost all of it. There are traditional farmers who have a mindset that they also want to transition to more sustainable farming. However, they may face financial or other obstacles. With the right information, they can make more sustainable choices, even if not the most sustainable ones, so the farm becomes a little bit better.*" (Farmer 1). Lastly, he gave the farm aid application a score of 8.

4. DISCUSSION

According to the scores participants have given to each prototype, the social support on an online platform is considered the most effective and helpful in supporting dairy farmers' transition to ecological farming, especially in acquiring new farming knowledge. Following it are the training programs and courses information board, the technical guides with videos, and lastly the subsidy information board.

In fact, it is not surprising to see that online social support received the highest score among the four prototypes. It has been proven to allow farmers to learn new knowledge from peers [7, 25] and positively impact their mental health [2, 3, 23], as supported by the literature. Additionally, farmers' familiarity with it and positive feedback from their real experiences contribute to its high score. As for the training programs and courses information board, it has also received positive feedback in supporting dairy farmers. The participants in the interviews appreciate the collection of courses and the farmer-to-farmer knowledge exchange. This appreciation likely results from the convenience of being able to find all training programs and courses in one place [36] and from the cost-effectiveness of the farmer-to-farmer knowledge exchange [39], as demonstrated in literature.

Regarding the technical guides with videos, although participants feel that it is slightly less useful compared to the social support and the training programs and courses information board, their feedback indicates that they appreciated the inclusion of tutorial videos due to their direct and easy-to-understand nature. This appreciation is understandable, as videos also received the highest score for ease of use among tools [19]. Indeed, many technologies are published, and it is impossible for dairy farmers to read all the technical manuals to find what they need during their busy work lives. The technical guide becomes more helpful once they know which technologies to explore further, as it was praised for its practicality [19]. Apart from that, having continuous updates and maintenance is crucial for this kind of online support, as new technologies are always being published. Only if this is handled and achieved can the technical guides with videos demonstrate their best usefulness. The same idea applies to the subsidy information board because subsidy information also changes rapidly.

Among the four prototypes, the subsidy information board received the lowest score because we overlooked that there are two phases in the adoption of precision dairy farming: first, farmers have to make the initial decision, and then they will start to look up how to evolve successfully. The subsidy information board only becomes supportive after farmers have decided to transition to more ecological farming, as it facilitates the finding of relevant financial resources [36]. However, it is rather useless in the first phase because it does not improve dairy farmers' understanding of sustainable practices, thereby having only a limited effect on making the initial decision. This issue is less significant for the other three online supports, as they all contribute to a deeper understanding of sustainable practices to some degree, which can inspire farmers to transition.

All in all, based on the past literature and feedback from the interview participants, all four types of online support have their advantages and challenges if implemented. While each type is helpful to some degree in supporting dairy farmers' transition to precision dairy farming, especially in knowledge acquisition, online social support by other farmers stands out. This form of online support resonates the most with dairy farmers and has the highest potential to help them evolve successfully.

4.1 Farm Aid Application and Future Work

In addition to the four online supports that were included in the prototypes, the interviews led to an additional suggestion for technology. The farm aid application, suggested by one participant, provides an interesting direction for future research. In fact, there is potential for the farm aid application to synergize with other online supports. For example, the farm aid application could record and analyze the questions a user has asked. It could then link to the training programs and courses information board and recommend relevant courses if it detects that several questions on the same topic have been asked. Additionally, it could link to the technical guides with videos when the answers involve the use of technologies aimed at sustainability. This integration would allow users to access information about the technology easily, as they can find everything in one application. Furthermore, if a user finds that a solution provided by the farm aid application works well, the application could allow the user to share their experience with other users by, for example, leaving comments on that specific solution. All of these are possibilities for how the farm aid application can work with other online supports to provide more features and help to dairy farmers. Potentially, it could be more effective than using a single online support in facilitating knowledge acquisition and transitioning toward more ecological farming. Therefore, the farm aid application and its potential to support dairy farmers' transition to ecological farming, especially in acquiring knowledge, would be an interesting topic worth exploring in future research.

4.2 Strengths and Limitations

Due to the short timeframe in which this research has been conducted, two limitations can be mentioned. The first is the number of participants. It is difficult for merely three Dutch dairy farmers to represent the average thinking of all dairy farmers in the Netherlands. The second is the limited responses from the email interviews. This method of interviewing was not planned initially, but to overcome the language barrier we added the email interviews. As a result, the answers from participants who did these interviews were not as elaborate as those from the participant with whom I interviewed face-to-face.

Nevertheless, our research has its strengths. The major strength is the use of prototypes based on outcomes of the literature review in the interview. With the prototypes, participants can better assess whether these online supports are truly helpful to them without having to imagine how each would look based on descriptions alone. As a result, the feedback provided by the participants is more valuable for evaluating the online supports.

5. CONCLUSION

This research contributes to a deeper understanding of the supports an online platform could provide to help Dutch dairy farmers transition to precision dairy farming and acquire relevant knowledge. It also offers an analysis of the usefulness of these online supports by studying past literature and gathering opinions from real dairy farmers. Providing a basis for this topic, the results can guide future researchers to develop comprehensive online platforms that can effectively aid dairy farmers in their journey toward precision farming.

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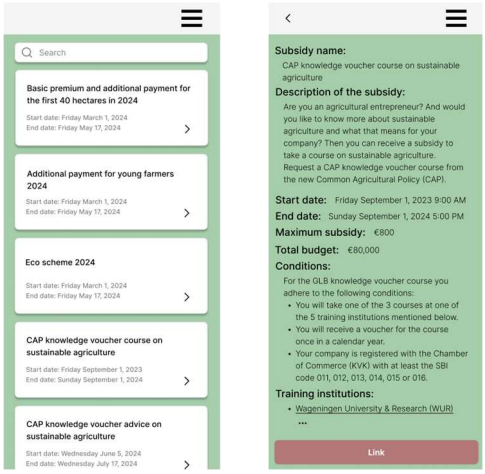
A. PROTOTYPES

This appendix displays each key interaction with images of the prototypes and cites the sources of images and information used in the prototypes.

A.1 Subsidy Information Board

Key interaction: Click on the subsidy you are interested in to get more detailed information.

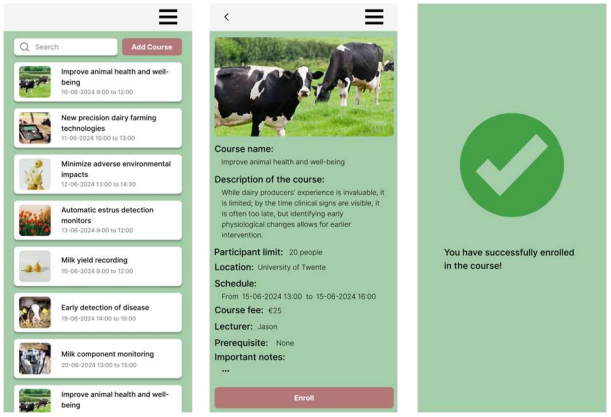


Sources:

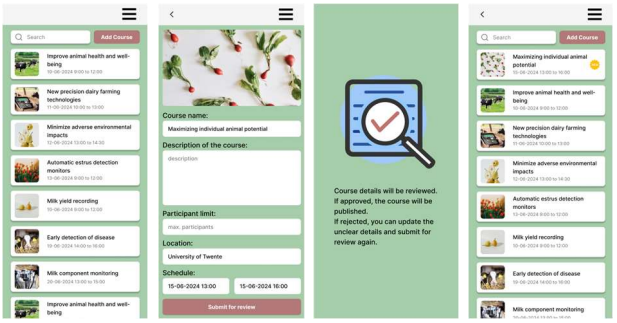
- https://www.rvo.nl/subsidies-financiering/glb-2024

A.2 Training Programs and Courses Information Board

Key interaction: Find a training course that you are interested in and enroll in it.



Key interaction: Create a course that you would like to offer and submit it for review.

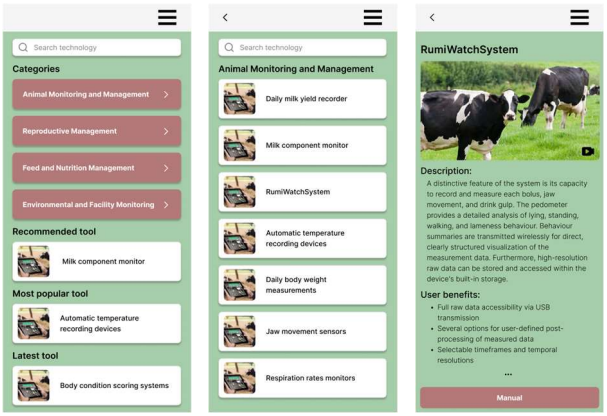


Sources:

- https://foodsystems.tech/innovation/precision-feeding-technologies-20230909103436
- https://www.dpi.nsw.gov.au/animals-and-livestock/dairy/dairy-technologies
- https://www.thecattlesite.com/articles/4328/what-does-the-future-hold-for-precision-dairy-farming
- https://www.dairyreporter.com/Article/2023/07/18/low-cost-precision-technology-can-detect-bovine-respiratory-disease-days-before-symptoms-appear

A.3 Technical Guides with Videos

Key interaction: Check out a technology that you don't know. Watch the tutorial video and read the technical guide to understand how it works.

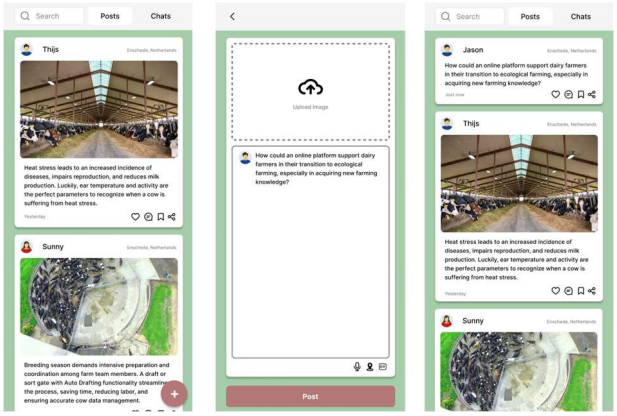


Sources:

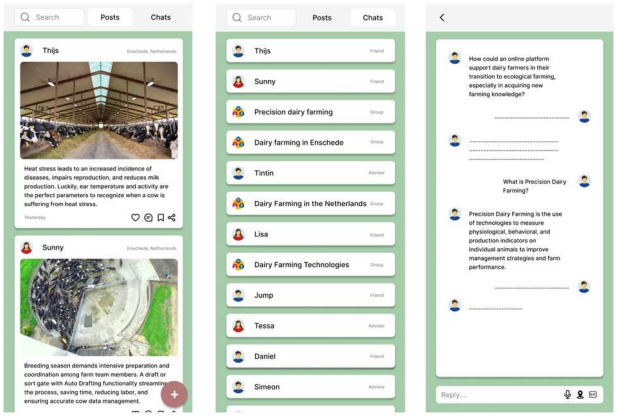
- https://www.rumiwatch.com/

A.4 Social Support

Key interaction: Create a new post to ask farming questions.



Key interaction: Send your questions to your friends, advisors, or groups in private chats.



Sources:

- https://www.cowmanager.com/news/cowmanager-autodrafting/

- https://www.cowmanager.com/cow-management/modules/nutrition/

B. INTERVIEW QUESTIONS

1 What is your age?

2 How long have you worked in this industry?

3 Can you briefly describe your farm?

4 Is your farm conventional or more ecological? (If conventional, go to question 5; if more ecological, go to question 6)

5 Have you ever considered moving toward more ecological farming, like precision dairy farming? If yes, what stops you from evolving your farm? (Go to question 7)

6 Were your farms conventional, or did you employ a more ecological approach from the start of your career? (Go to question 7)

7 Have you ever encountered difficulty acquiring new farming knowledge? (If yes, go to question 8; if no, go to question 9)

8 How do you address this problem? (Go to question 9)

9 How do you acquire new knowledge?

10 Why (or why not) do you use online platforms to obtain new knowledge?

11 I have prepared 4 prototypes, and I have 1 or 2 interactions that I hope you can perform on each prototype.

12 On a scale from 1 to 10 (10 means very helpful, 1 means no help), how helpful do you find each of these four types of support in acquiring knowledge and moving toward more ecological farming, particularly precision dairy farming? Why? (one score for each prototype)

13 What are some other online supports that you think would help you acquire knowledge and move toward more ecological farming, particularly precision dairy farming? Why?

14 If these online supports (including prototypes) become a reality, will they affect your willingness to move toward (more) ecological farming, particularly precision dairy farming? Why?