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Melkeværet

A serious game to bridge climate service providers and agricultural users

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Photo by Jelmer Jeuring: Melkeværet game session in Vestland.

Norwegian Meteorological Institute

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Abstract

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Keywords

Seasonal and sub-seasonal forecasts, participatory methodology, serious gaming, farming

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1. Introduction

This report describes an activity carried out in the framework of the Climate Futures Centre for Research-based Innovation, which explored the use of a serious gaming approach for informing the development of (sub-)seasonal forecast services.

Climate services are a response to society's need for climate and weather information to support decision-making. They have been defined by the European Commission (2015) as "*the transformation of climate-related data – together with other relevant information – into customised products […] that may be of use for society at large"*. This definition points out the requirement for climate services to be tailored to the users to be relevant to their decision-making processes. This is particularly evident in the case of climate services for agricultural activities, where the growing availability of new forecasting information such as seasonal and sub-seasonal forecasts (S2S) needs to be transformed into meaningful and actionable products for farmers (Ceglar and Toreti, 2021). This transformation process is challenged, on one hand, by the forecast providers' scarce knowledge of farmers' decision processes and information needs and, on the other hand, by the difficulty of communicating effectively between individuals with different backgrounds and expertise. In addition to this, forecasts on the S2S timescale need to be communicated differently, with a larger emphasis on uncertainty and probabilities, compared to typical weather forecasts for the next couple of days. Communicating probabilities to lay audiences remains a challenge (Fundel et al., 2019; Stephens et al., 2019).

This work aims to address these challenges through a participatory research process based on serious game methodology. Serious games refer to all games used for a purpose other than entertainment. Past research in climate science has shown how games can be effective tools for communicating scientific content and create an arena for meaningful dialogue among stakeholders with different backgrounds and expertise (Flood et al., 2018). By simulating real dynamics, games offer a safe space for exploring complex issues, navigate decision-making contexts and testing strategies. We here leverage these characteristics of serious games to 1) collect information on how farmers use currently available forecast products in their everyday decision-making processes, 2) explore how the introduction of S2S forecast information changes these decision processes, and 3) facilitate a dialogue between providers and users on the potential and limitations of those forecasts as a climate service.

The development process of Melkeværet game started in May 2023 in collaboration with advisers from the Norwegian advisory organisation Norsk Landbruksrådgivning[1] (NLR). In the format of a board game coupled with computer-model support, it addresses farmers in the grass production sector in Norway and is conceived as a simulation of their activities during the summer season. The players are asked to play the role of managers of neighbouring farms and plan their activities in a context of limited resources, based on a range of information on weather and climate conditions for which they are willing to spend resources. The game experience is completed by the interface projection of a simplified grass growth model, which shows the players' performance along the simulation. The board game nature of Melkeværet allows it to be played by a group of people in the same room, around a table, while the video interface provides the players with feedback on their decisions, calculating and showing the results of their actions in terms of individual production of milk. Data on players' choices are collected during the gameplay and discussed collectively during the debriefing at the end of the game. Some questionnaires are also administered to the players during the game to collect information on their opinion of the forecast information and the role it plays in their decision-making process.

At the time of this report writing, three game sessions were carried out in Norway. Two game sessions involving mainly researchers and forecasters and one game session involving farmers, NLR advisers, forecasters and weather researchers were held between June and December 2024. Melkeværet was also played once in the context of an international school for early career researchers and practitioners on climate risk adaptation in Tanzania.

In this report we explain the developing process of the game and the game itself, describe the game sessions' structure and discuss the first findings with reference to the session held with farmers. We then conclude the report with the next steps of the work.

[1] Norsk Landbruksrådgiving is a cooperative linking research and agriculture. It aims at collecting and developing knowledge, which advisers pass on to business practitioners in agriculture.

2. The game

2.1 Developing process

The developing process of the game followed a 6-step approach (Figure 1):

1. The choice of the scenario for the game was inspired by previous work carried out by other researchers in Climate Futures on the interaction between weather events, forecast information and productivity in the Norwegian milk production sector (Oubrhou, 2023). The milk sector relies on the production of grass, which is highly impacted by weather conditions and is at the same time subjected to a relatively high timing flexibility of the production actions. This allows farmers to respond and adjust to weather conditions by anticipating or postponing fundamental activities, such as fertilizing the fields and harvesting the grass.
   The scenario was developed in close collaboration with NLR advisers, to recreate a realistic simulation of the activities and choices that must be made on a typical farm, integrating technical details relevant to the scope.
2. Once the game scenario had been defined, the game mechanics were developed by transforming real-life choices into game strategies and by introducing artifacts to support them, such as a board representing weekly steps to keep track of time, coins to represent money and time resources and cards containing the climate and weather forecast information.
3. A video interface was coded using the Python Pygame library. The interface consists of a model calculating the production of grass in terms of quantity and energy content for each player and transforming it into the quantity of milk produced. A series of buttons corresponding to the players' actions allows the game facilitator to influence the result by giving inputs to the model. At the same time, the interface provides the players with a visual representation of grass growth and milk production while playing.
4. Two pilot game sessions were conducted involving NLR advisers and researchers at MET to test the mechanics and the structure of the game, as well as the correct representation of the farming context.
5. Each of these sessions allowed for improvements in the game.
6. The structure of a typical game session was finalized by developing the additional supporting material, such as the presentation slides for the game introduction, instructions and storyline, and the questionnaires to collect data from the players during the gameplay. It is important to note that each game session also led to reflections on some limits and improvements to the game.

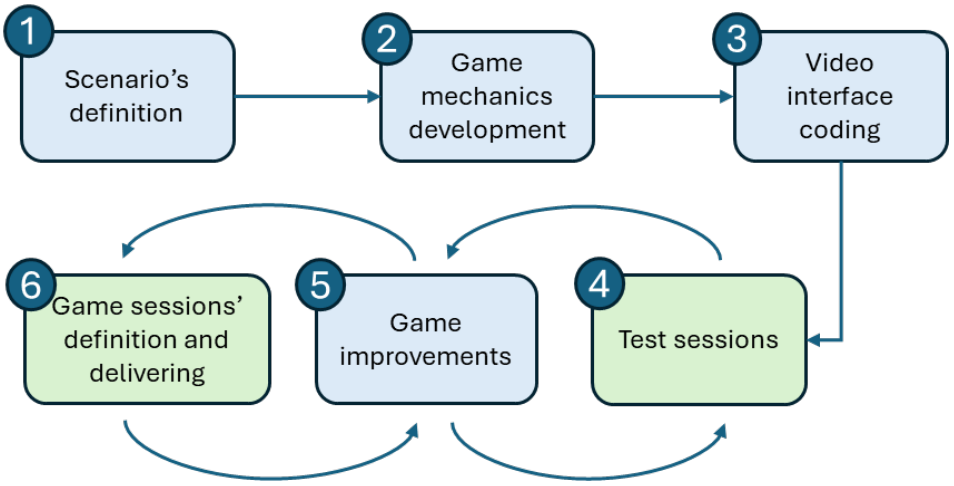

Figure 1 Game development procedure

2.2 Game description

2.2.1 Game context

Melkeværet is structured as a simplified simulation of the activities that need to be carried out on a cow milking farm in Western Norway, where two yearly grass harvests are generally carried out. Each player is the owner of a neighbouring farm with a 250 dekar pasture, whose exact location is not known to them. The player with the highest amount of resources at the end of the game, wins the game. The resources are generated by harvesting a high amount of grass with a high energy content to feed the cows and produce milk during one summer season, and can be spent for carrying out activities on the field.

2.2.2 Game structure and procedure

The players sit around a table, with a board representing the season calendar in the centre of the table (see Figure 2).

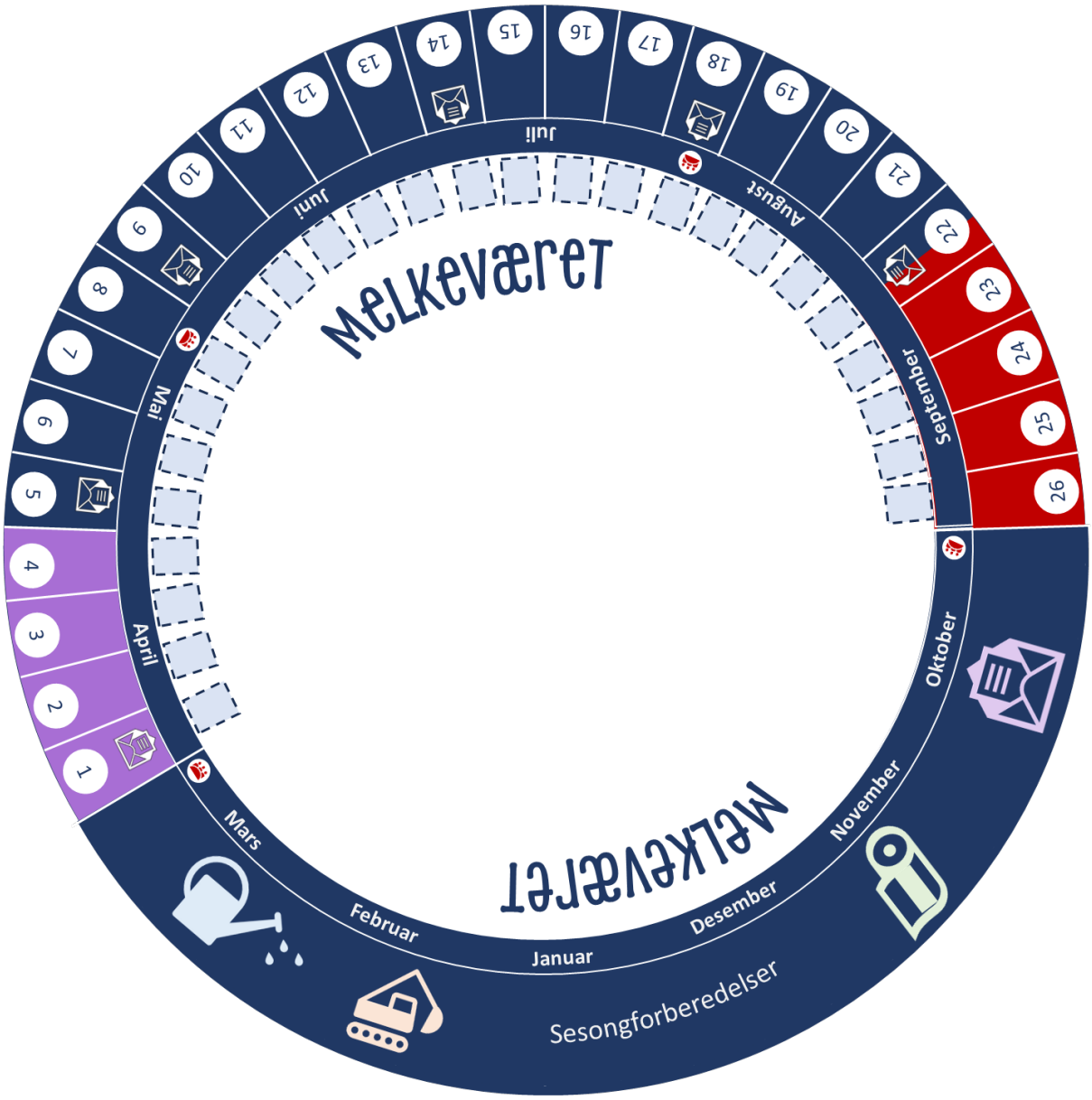

Figure 2 Board of Melkeværet, representing the productive season from April to September. The season is split into 26 weekly steps. A pawn moves from week to week during the gameplay.

At the beginning of the simulation, the players receive a random card with a description of their "character", which adds some playfulness to the activity. This expedient also helps the participants to enter a role play and detach themselves from reality so that they do not perceive a possible failure during the game as a personal failure (especially in case they are actual farmers).

The dimension of time is represented by a pawn moving from week to week on the board. Each week corresponds to a round, during which the players can make decisions.
Some decisions must be made before the start of the grass growth, such as building a drainage system on the field to avoid damage in case of high precipitation. Others must be made during the rest of the season, such as watering or fertilizing the field. See Table 1 for a complete list of the decision challenges faced by the players.

Table 1 List of the decision challenges faced by players during the game play that influence their final revenues.

When	Decision to make
Before the start of the growing season	Whether to dig a drainage system on a part or the whole field
Before or after the start of the growing season	The amount of plastic film to buy for covering the grass bales
	Whether to buy some watering equipment
During the growing season	Whether and when to water the field
	When to fertilize the field (compulsorily twice during the season)
	When to harvesting the grass (compulsorily twice during the season)

The players are provided with a limited amount of resources, represented by fictitious money, that they can use for performing the actions implied by their decisions. This forces the players to choose what to prioritize in their farm management, based on their interpretation of the climate information (see next subsection), on their attitude toward risk and on their pre-knowledge and experiences.
The game ends when all players have harvested their field for the second time.

2.2.3 Climate information

To make their decisions, the players have access to climate information:

- temperature and precipitation normals for the area (Figure 3);
- 10-day forecast issued once a week (Figure 4a);
- 21-day forecast issued once a week (Figure 4b);
- seasonal forecast issued once a month, showing the average conditions for the coming three months (Figure 5);
- an NLR monthly newsletter summarizing past conditions, presenting a descriptive overview of the seasonal forecasts and advising farmers based on this forecast;

The 10-day forecast and the 21-day forecast have been designed to mirror the actual forecasts available on MET's YR weather app, although extremely simplified. The seasonal forecast was designed to mirror a new product, not yet released by MET, so that the insights from the game sessions could contribute to its development process.

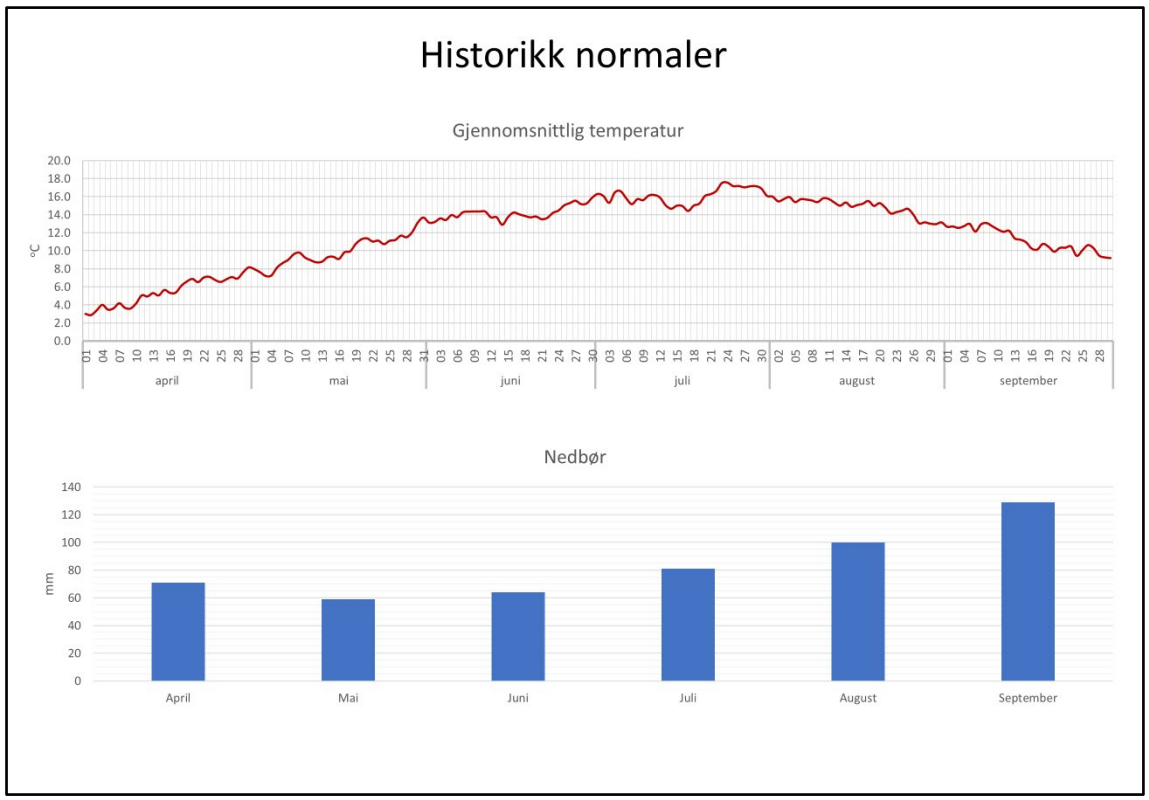

Figure 3 Normal precipitation and temperature of the area given to the players at the start of the game.

Uke	Nedbør mm	Temperatur høy/lav
14	36 (28-45)	22°/9°
15	16 (0-46)	18°/9°
16	0 (0-21)	26°/6°

(a)

	Temperatur høy/lav	Nedbør
Mandag	15°/-2°	
Tirsdag	12°/7°	0.4 mm
Onsdag	13°/4°	0.3 mm
Torsdag	11°/6°	1.6 mm
Fredag	9°/4°	1.2 mm
Lørdag	14°/6°	4.7 mm
Søndag	15°/9°	2.1 mm
Mandag	20°/6°	4.3 mm
Tirsdag	23°/7°	
Onsdag	22°/12°	

(b)

Figure 4 Examples of 21-day forecast (a) and 10-day forecast (b) issued weekly

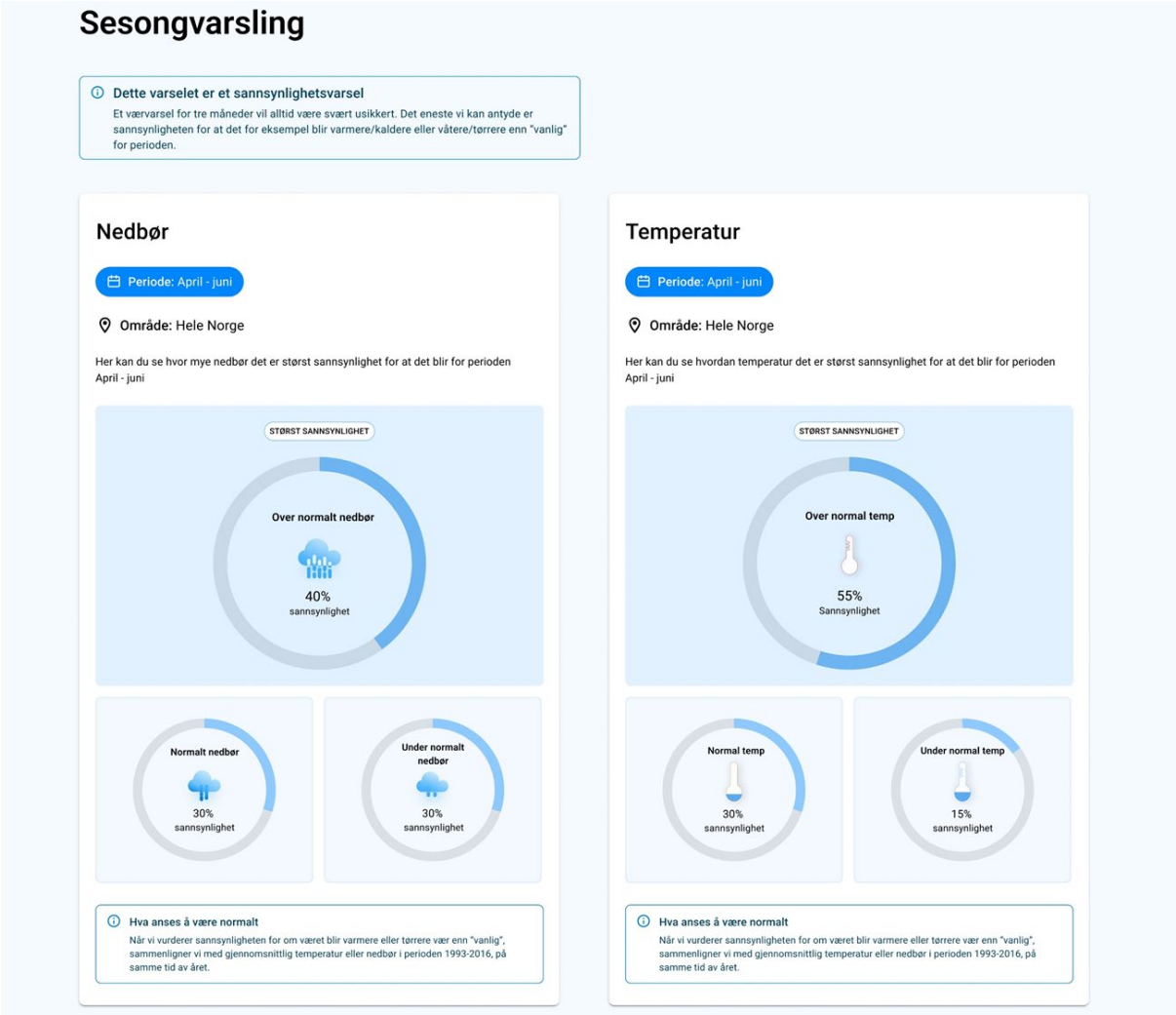

Figure 5 Example of seasonal forecast issued monthly.

At the start of each new week, the observed total precipitation and mean temperature of the previous week are revealed on the board (Figure 6).

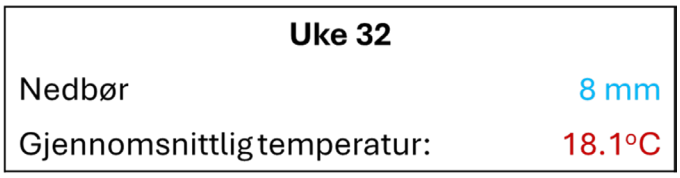

Figure 6 Example of a card showing the weekly observed total precipitation and mean temperature.

Different options regarding the free availability or paying requirement for the pieces of climate and weather information were also tested. In the game session described in the Results and Discussion section, each piece of information had the same cost. This forced the players to choose among the products and allowed us to observe their preferences depending on the game phase and situation.

2.2.4 Video interface

The decisions of the players are simultaneously registered in the video interface by the game facilitator (Figure 7). A graph of the grass biomass trend and one of the grass quality trend are shown and updated in real-time, to show to the players the outcome of their decisions and allow them to compare their performances. When a player decides to harvest the field, the interface shows the quantity of milk produced based on the amount and energy content of the grass.

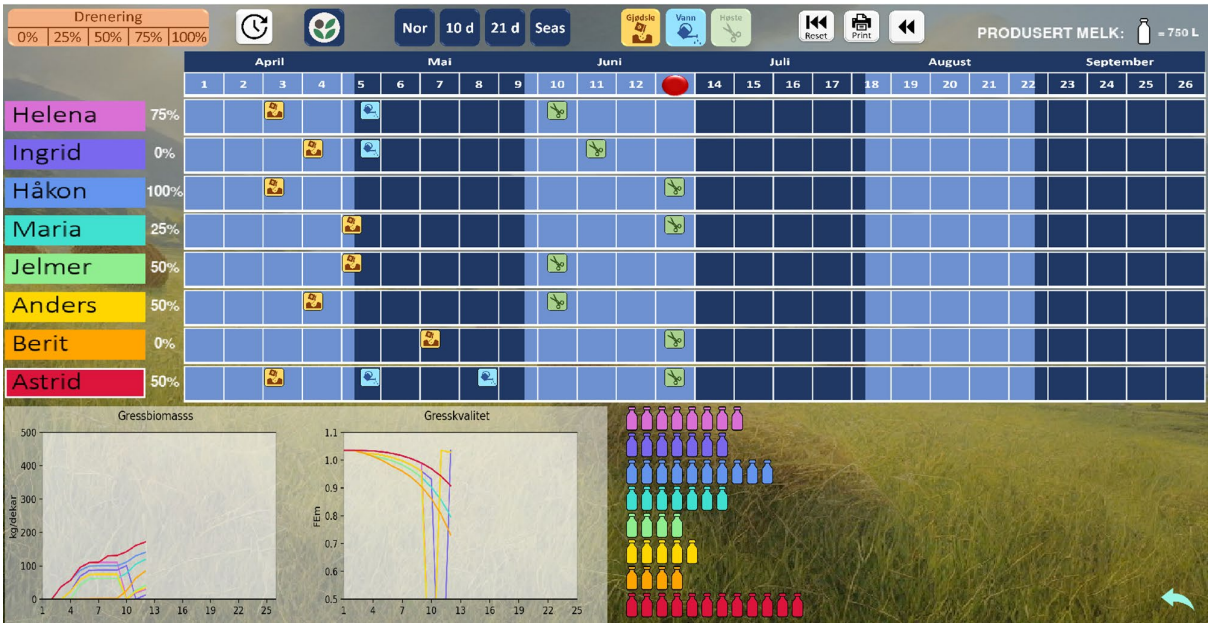

Figure 7 Screenshot of the video interface during a fictitious game. The screenshot was taken at week 13, when all the players had harvested once.

The model behind the interface was developed as a simplification of a system dynamic model developed by Oubrhou (2023). The grass energy content and biomass are functions of the temperature, water available, and fertilizers absorbed by the soil, smoothed in time to acknowledge a 6-week time lag in the effect of those factors. Watering the field increases the water available, and fertilizing introduces nutrients into the soil, with a

different outcome according to the meteorological conditions (for example, frozen soil reduces their absorption).
In case of high precipitation, no actions can be performed on the field, as driving a tractor on wet terrain would be dangerous and may damage the grass production. The players are subjected to different precipitation thresholds based on the surface of their field equipped with a drainage system. When harvesting, the model computes the quantity of milk produced as a function of the quantity – i.e. biomass – and quality – i.e. energy content – of the grass at that moment.

3. Game sessions

3.1 Structure

A Melkeværet game session is structured in three main phases (Figure 8).

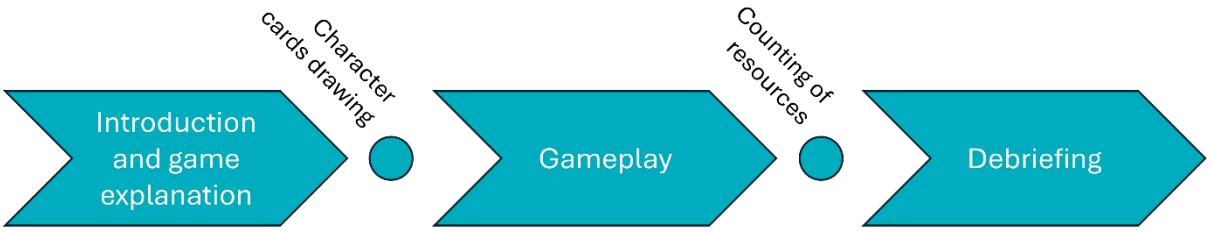

Figure 8 Timeline of a Melkeværet game session.

The three phases are separated by actions that facilitate the transition. As mentioned above, asking each participant to draw a character card and present themself to the others according to its description helps the transition of the focus from the real world to the game's fictitious one. Similarly, counting each player's resources to determine the winner facilitates closing the gameplay and allows shifting again the focus to the implications of the game experience for the real world.
The session is led by a facilitator. They are at the same time the person guiding the participants through the different phases, the master of the game, and the one responsible for assuring that each participant can contribute actively and have a positive experience.
One or more observers are necessary to take note of the participants' discussions and contributions.

3.2 Qualitative data collection

Through the game sessions, we collect qualitative insights on the values that farmers place on weather and climate information sources and on how those sources interact in their decision-making processes. The data collection is performed through:

1. The observation of participants' comments and references to their everyday activities during the gameplay;
2. The recording of players' choices through the video interface;

3. The administration of questionnaires during the gameplay, presented to the players as part of the game's fictitious world;
4. The conduction and observation of a collective discussion on the implications of the game experience for real-world decision-making practices during the debriefing phase.

4 Results and discussion

4.1 The game session in Vestland

A game session was organised in collaboration with NLR in a small municipality in Vestland. Four farmers, three men and one woman, participated as players in the game, together with a researcher from NORCE[2]. Moreover, two NLR advisers participated as observers and support for the farmers, by helping them follow the game dynamics when needed and providing technical insights into the interactions among weather factors and farming activities. A researcher from MET facilitated the session and mastered the game. Three observers from MET with different expertise (a social scientist, a forecaster and forecast model developer) took note of the dialogues and of the players' strategies. They also participated in the collective discussion during the debriefing by providing inputs linked to their expertise.

This session allowed us to assess the effectiveness of the developed tool (Melkeværet game) in engaging the farmers and to describe some first insights into farmers' decision-making processes and their opinions about different forecast products.

4.2 Participants' engagement

In general, despite the session having lasted approximately three hours, the participants were highly engaged during all its phases. Starting the simulation by taking the role of someone else contributed to create a positive atmosphere from the beginning. Moreover, being able to see the outcome of their decisions through the model interface made the players curious, willing to test their strategies and thus engage in the game. Since the video interface does not reveal early on who is winning, the atmosphere remains exciting and engaging until the very end. This allowed for a high level of information exchange between farmers and MET staff.

Despite Melkeværet presenting a simplified version of the complexity experienced in real life by farmers, the recreated decision-making context allowed them to recognize familiar situations and challenges.

The involvement of two NLR advisers was also beneficial for the activity. Contrary to MET staff, they sat at the game table among the players. They supported the farmers when some dynamics represented in the game was not clear, and they constantly asked relevant questions to them, making them reflect and comment on what they do and what they think about the forecasts.

[2] NORCE is an independent Norwegian research institute that conducts research for both public and private sectors, to facilitate informed and sustainable choices for the future in energy, health care, climate, the environment, society and technology.

4.3 Farmers' decision-making strategies

In general, we observed that farmers' strategy in the game were to base their decisions on the observations of the past weather more than on the forecasts, and to wait to see the development of the season before spending money on preparation actions. In the final questionnaire, one player even answered to "Do you think that you could have planned the season better from the start?" with the option "No, because it's never possible to plan precisely before the start of the season". They also implicitly used their personal experience, projecting the normal conditions in their own area on the game setting, which was from a different and (for them) unknown location. Through reference to their experience, they demonstrate to have a clear idea of what are the normal conditions in their area and showed an excellent memory of the past year's weather in relation to normal conditions. They were able to recall last year's weather conditions and its implications on farming from the real-world, and seemed to have the normal for their region very clear in their mind. This translates in local knowledge that can be leveraged in case of need, such as the rule of thumb shared by a farmer, according to which "when the first 2 months of the season are dry, you just have to wait a bit and the rain will come in June". However, how relevant this empirical knowledge still is in a changing climate context needs to be assessed.

Moreover, farmers do not make decisions alone but rather use the knowledge of the fellow farmers they trust. This is reflected in a general non-competitive attitude among the players, who were willing to share the information they had and to discuss it collectively. As they reported, the influence of each one's decisions on the decisions of the neighbouring farmers is also strong in real life contexts. We argue that the existence of such strong network connections can enhance the spread of information and good practices.

To this regard, it was interesting to note the trust relationship also between farmers and NLR advisers– and the NLR organisation in general. This was visible both in how the farmers engaged with the advisers during the game, and in the fact that they often preferred to read and use the NLR newsletters for their decisions instead of checking the seasonal forecast. This, together with the fact the NLR newsletters partially overlapped with the seasonal forecast information, eventually led to the decision of eliminating the NLR newsletters as a source of information in next game versions.

The participants' preference for the newsletter is also linked to a preference for descriptive pieces of information, that are able to convey more context to interpret the data compared to just numbers. This was explicitly reported by the farmers while discussing the possible formats of the seasonal forecast product during the debriefing, as described below.

4.4 The use of S2S products

As explicitly reported by some participants and in line with the fact that the 21-day forecast was seldom used during the game, there is a general lack of trust in the forecasted conditions for the third week displayed in that product. Farmers reported having been using the forecast in their daily life and having experienced a tendency for the days of the third forecasted week to reflect the local normal most of the time. For the area where the participants live, this means showing a close-to-50% chance of precipitation. This information was not seen as very useful for the farmers we talked to. The issue was largely discussed during the debriefing, when MET's forecast model developer also informed the participants on how to identify when the forecast is showing a strong signal for the third week by looking at the difference between the forecasted precipitation probabilities for consecutive days. The farmers followed the explanation closely and asked relevant questions, showing a high interest. This demonstrates how the game sessions can constitute also an opportunity for MET to train the farmers in getting a better understanding of and the most out of its products, such as the 21-day forecast.

Making use of the seasonal forecast was also reported as challenging by the participants. In the final questionnaire they generally answered the question *"What is the likelihood of you using the seasonal forecast during next season?"* with a low score. This could have been influenced by insufficient focus on initial decisions with long-term impacts in the game and which require long-term planification. This point will be addressed in the future development steps of the game. Another influencing factor could be that the initial seasonal forecast showed a higher probability for the season to be wetter than normal. However, it turned out extremely dry, before it became wet first in August, making the initial seasonal forecast looking misleading.

During the debriefing, the farmers also shared some reflections on the challenges to adopt such kinds of seasonal forecasts in their real life. They reported that they would benefit more from an overview of the conditions' development from one month to the next, instead of the average conditions of a 3-month period as shown in the seasonal forecast product.

Nevertheless, while not used as a direct support for making decisions, the seasonal forecast played an interesting role in the game as a trigger of a perceived need of more detailed weather forecast information. This suggests that, although there is uncertainty about long-term future weather, indications of long-term challenging conditions for essential tasks can raise the level of attention of farmers and trigger the use of weather forecast info.

4.5 Suggestions for improving the forecast products

During the debriefing, we were able to collect suggestions from the farmers about the improvement of the forecast products. They suggested the inclusion of wind data in the

21-day forecast, since they commonly use the wind prognoses for a personal qualitative assessment of the reliability of the precipitation forecast, based on empirical experience. They also suggested the introduction of the normal values in the forecast graphs, in order to allow for a comparison between the normal and expected values, which can be useful when assessing the strength of the model signal and therefore the reliability of the forecast. Finally, the discussion also brought to the hypothesis of adding a monthly description of the possible expected conditions in the seasonal forecasts. The hypothesis arose from the convergence of the farmers' need for information on a monthly scale, their preference for a textual description and the little skill that a monthly numerical value would have.

We summarize in Figure 9 the main findings discussed in this Section.

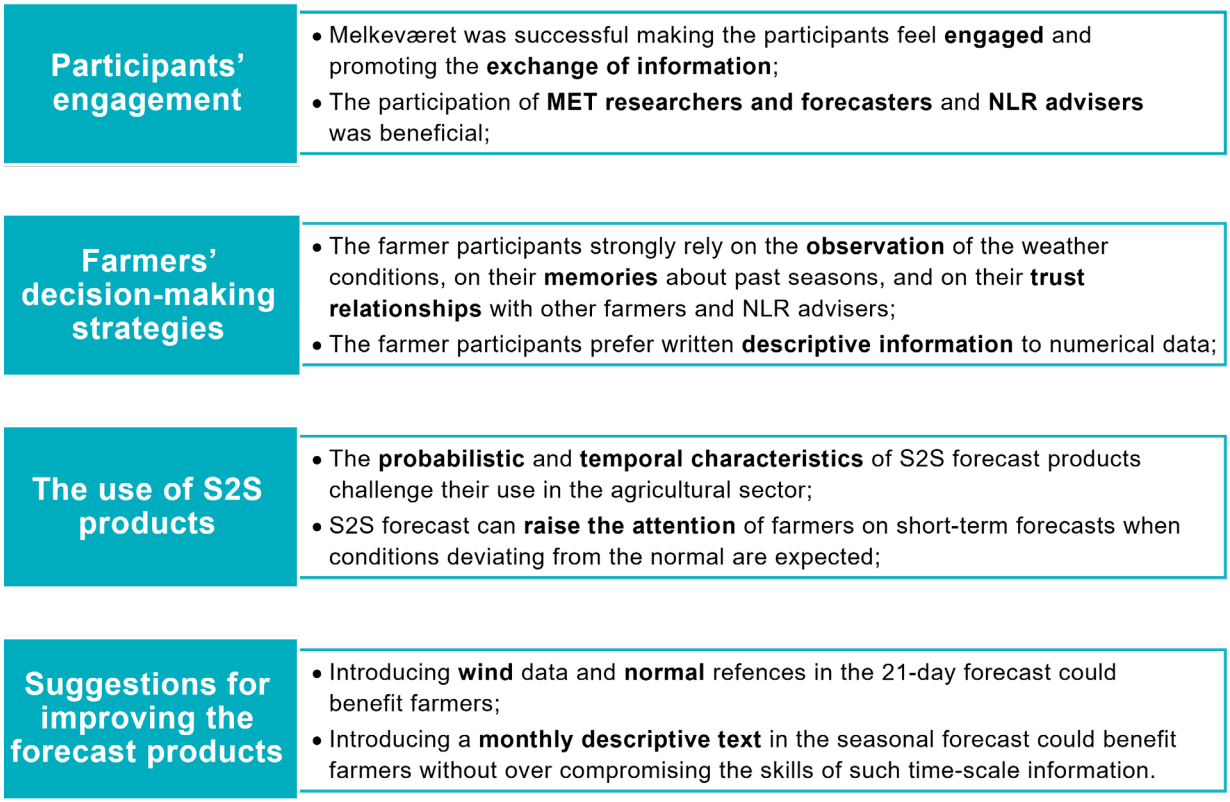

Figure 9 Summary of the key findings.

5. Conclusions

In this report we described the process of creating a serious game on farming decision-making in relation to weather forecasts and we discussed the preliminary findings derived from applying it with a group of farmers in Western Norway. The aim of the work was to allow the creation of a common understanding about forecasts' potential and limitations among service providers and farmers.

The methodology developed proved to be effective in engaging the participants, creating a positive environment for insightful discussions and encouraging the exchange of information between farmers, agricultural advisers, forecasters and forecast model developers. The findings derived from the game session concern farmers' decision-making strategies, their use and perspective of the S2S forecasts, as well as ideas for improving MET's forecast products. Those results will be critical for the future development of customized long-term forecast products by MET.

Both the development process and the implementation of the game session benefited from the collaboration between MET researchers and NLR advisers. The contribution of the NLR advisers was crucial in assuring the correct simulation of the Norwegian farming system in the game mechanics and the representation of the challenges that farmers in milk production encounter in reality. Moreover, they were a needed link between the researchers and the interested farmers, who were encouraged to participate in the research by the trust relationship between them and the advisers. NLR advisers' role will be fundamental in setting up future game sessions too.

From the advisers' point of view, Melkeværet is a training-supporting tool, to address and discuss with farmers crucial issues linked to agricultural professional activities. Similar opportunities concern also MET, for which the game sessions can be used to provide users with a better understanding of its forecast products.

Finally, this work has enabled the creation of a collaboration channel between MET and NLR, which will benefit future projects and activities for both institutions.

6. Future plans

Future plans concern the implementation of further game sessions with farmers to broaden the results, also in other areas of Norway. For this purpose, a version of the video interface is being developed in Unity software as a standalone app, in order to make the game easily implementable also by facilitators not familiar with Python programming language.

As mentioned above, the game mechanics are also under revision. The main changes aim at encouraging the use of S2S forecasts in the game, in order to enhance the discussions about them. Those changes concern eliminating the NLR newsletters and increasing the focus on decision challenges that implies a long-term perspective. To facilitate the implementation of the game, then, we are exploring some measures to shorten the duration of a game session.

Lastly, we want to stress the fact that the findings from this activity will contribute to draw recommendations for the implementation and improvement of S2S forecast products at MET, and that the successful implementation of Melkeværet led to the plan of including the serious game methodology also in other projects of the Institute.

Acknowledgements

First, we thank the farmers who participated in the Melkeværet session in Vestland. We are also grateful to NLR advisers Helena Elvatun and Håkon Øvstedal for their precious contributions during the development and implementation of the game. We thank our colleagues Camilla Garshol Albertsen and Lonneke Quirina van Bijsterveldt for their support during the game session and for their help in reviewing this report.

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