AgriLink

AgriLink. Agricultural Knowledge: Linking farmers, advisors and researchers to boost innovation

Deliverable 2.2: Synthesis Country Report (Version 1.0)
Partner: RURALIS – Institute for Rural and Regional Research

The role of advisory services in farmers' decision making for innovation uptake. Insights from case studies in *Norway*

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September, 2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727577

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List of acronyms

AgriLink	Agricultural Knowledge: Linking farmers, advisors and researchers to boost innovation
AMS	Automatic milking system
AOS	Advisory Organization Supplier
AKIS	Agricultural Knowledge and Innovation System
DoA	Description of the Action
E-bells	Electronic bells
EU	European Union
FK	Felleskjøpet Agri
Micro-AKIS	Micro-level Agricultural Knowledge and Innovation System
NAES	Norwegian Agricultural Extension Service
NGO	Non-Governmental Organizations
NSG	Norwegian sheep and goat
NUTS	Nomenclature of Territorial Units for Statistics
R-FAS	Regional Farming Advisory System
SMN	Sparebanken I Midt-Norge
TCM	Trigger-Cycle Model
WP	Work package

Executive Summary

The Norwegian team has studied two cases where both belong to the Technological Innovation Cluster. In case one, we have studied the implementation of milking robots in the region of Trøndelag. A milking robot is a device associated with increased efficiency and productivity, and consequently profitability in dairy farming and a more flexible work situation for dairy farmers and their households. Trøndelag is a region where dairy farming is the major agricultural production. The implementation of milking robots started early, and the density of the technology is greater here than in other parts of the country. We made in total 29 interviews in Trøndelag, of which 20 were adopters and nine were non-adopters.

In case study two, the focus was on the use of electronic bells on sheep in the region of Sogn og Fjordane. This technology makes it possible to trace sheep during the pasture season. Some sheep farmers experienced big losses of sheep in 2009, and therefore the county administration started as part of a project to offer sheep farmers' electronic bells on sheep at a subsidized price. They wanted farmers to test if bells could contribute in reducing the loss of animals. This case is about the implementation of a new technology but also about the management of common resources. Sheep farmers use large outfield pastures that they own or have the right to use together with other farmers. Sheep farmers were organized in pasture groups many years ago, where they cooperate in collecting the sheep in the autumn. When the county started to offer e-bells, it was required that only formalized pasture groups could apply for support. Thus, this case also belongs to the Natural Resource Common Management Cluster. We carried out 21 interviews with sheep farmers in Sogn og Fjordane, 19 of which were adopters and two were non-adopters.

From case study one, we recognize a change in advisory services from when the pioneers first started to implement the robots as early as 2000 until the later adopters implemented in the last years. In the beginning, there were usually only the suppliers that gave advice, and the traditional advisory organization was not part of this. Still, the suppliers are very important in both the assessment stage, in the implementation and for regular maintenance of the equipment. In particular, the milk cooperative Tine is very active in advising farmers about farm management using data from the robot. Besides the suppliers of robots, the adopters and the non-adopters have much the same micro-AKIS; they use the same advisors where the traditional advisory organizations in agriculture are important partners, in particular Tine for milk production and NAES for plant production.

In this case, we see that banks and accounting companies have a crucial role because they decide whether the investment and innovation will be realized or not. Farmers that have implemented a milking robot seem to have gained needed services from the traditional advisors in combination with advice from the supplier of the robot and suppliers from other connected technologies.

The nine non-adopters in the study consisted mainly of three groups. The first group consisted of farmers that are part of a joint farm, where they (together with several other farmers) are managing the farm, and therefore do not need the extra workforce that the milking robot represents. As many farmers' motivation to invest in the robot is to get more flexibility, these farmers lack this incentive, as they already have flexibility by sharing the farm work. They are generally more critical of the structural changes towards bigger farms in Norwegian agriculture, placing this change on the milking robot, as those investing utilize the robots' capacity by expanding.

The second group is younger people that do not have resources to invest in a robot. They have either no access or cannot afford arable land and/or milk quotas. Additionally, several lack arable land and find it difficult to get predictable land lease agreements. Making a big investment in land, milk quotas and a milking robot (which means a considerable debt), and the unpredictability of renting and not owning land and quotas, can be a big worry and a barrier for the farmers to implement a robot. The third group consists of farmers that are going to invest in a robot in the next 1-2 years mainly because of generational change on the farm and a need for upgrading. Regarding advisors and AKIS-actors, these nine farmers do not differ from the rest of the sample, and the non-adoption of the robot cannot be placed as explanations of lacking support or a different microAKIS. As described above, the non-adoption is more due to lack of resources or incentive. The non-adopters' descriptions of their AKIS are not less detailed or active than the farmers that are adopters.

The agricultural policy in Norway has encouraged and stimulated farmers to increase production and growth. When a farmer has decided to invest in a new farm building, the financial support has been connected to growth and in many cases investment in a milking robot. For many farmers, a consequence has been a need for investment in new milk quotas and buying or renting arable land and grassland in addition to investing in a farm building. The results for many farmers has been large loans and increased production. From our study, we can see that many farmers that have implemented a robot is quite small, i.e. they are dependent on buying or renting large quotas of milk and buying or renting large areas of land to increase milk production and become profitable. Such farmers are in a situation where small changes in framework conditions may reduce profitability dramatically. In addition, farmers are vulnerable according to changes in the health situation and in general wellbeing. In the end, we are not sure if all farms with milking robots are sustainable.

In case study 2 about sheep farmers and e-bells, farmers wanted to test bells because they wanted to reduce loss of animals and many mention that they were curious about the new technology as well. The small technology companies are the formal advisors beside that farmers advice each other mainly through the organization Norwegian goat and sheep (NSG) and the local pasture groups. NSG and Nortura, the meat cooperative, were initially very active in sheep farmers meeting to tell about the e-bells and sometimes they invited the technology companies to join meeting to present their technology.

Some farmers got information and advice in the different phases (awareness and implementation) only from other farmers in their pasture group. Often there is one person in the group, usually the leader, who supports others in preparing the bells for the season and giving advice. This person usually has regular contact with the technology company on behalf of himself and others. Other farmers do everything on their own without much contact with advisors or other farmers. In addition, some adopters have contact with the technology companies in connection with the use of e-bells; adopters of e-bells use the same advisors as non-adopters. Their micro-AKIS represents the traditional advisory organizations, but some claim that there is little advice in general on sheep production. The main reason why some farmers do not use the technology seems to be the price and that the outfield areas are less challenging. Age and interest for data seems to influence the decision to implement bells as well.

Some sheep farmers complained about the availability among the high-tech companies on giving advice. The high-tech companies are small and resources for advisory are limited. Additionally, they are located far away from the region, and there may be a challenge for the means of giving advice. When sheep farmers vary in interest for data, and farming is in many cases more like a hobby, it is sometimes a challenge to reach farmers. As the technology develops, utilization of data will require more contact between farmers and the suppliers. To secure utilization then may demand another method for advice than today. The main challenge for full implementation of e-bells in sheep herds today is the price in relation to the price for sheep meat. It is not economically sustainable to in invest in e-bells on all sheep.

No farmers use bells on the entire herd because they perceive them to be too expensive. On the other hand, they find the bells useful because of the save time, and they learned a lot about where sheep move during a pasture season. For some sheep farmers, the implementation of e-bells has increased the contact with participants in the pasture group; they have a new activity for cooperation and discussion.

These two case studies explore and deepen the role of advisors in innovation processes. Because the two cases are very different in many dimensions, they also show some different results. Nevertheless, our analysis indicates that the traditional advisors may have a limited role as a trigger and stimulation of innovation among farmers. In technological innovation, the suppliers are crucial. Further, our study shows that various groups of advisors have important but specific roles in the process of assessing and implementation of innovations.

1. Introduction

The general goal of WP2 (Innovation case studies in Focus Regions: micro to meso analysis) is twofold. Firstly, WP2 aims at understanding why, how and from whom European farmers and farm managers gather and exchange information to underpin their decision-making on development and /or implementation of different types of innovation. A second aim of WP2 is to analyse the role played by advisors in these processes accounting for the range of advisory services available in a series of focus regions across Europe. The Focus Region is a key concept adopted by AgriLink, and was defined as a farm census region supplying the socio-demographical and farm structural context that might help to explain the farmers' micro-AKIS diversity and its implications to innovation up-take and the role played by advisors.

The conceptual framework (Deliverable D1.1) underlying the implementation of these goals relied on three major assumptions. The first was that the diversity of farmers and farms leads to different decision-making processes and influences the type of advisors and the roles they play on them. Second assumption consisted in assuming that innovation might not be in convergence with the sustainable development purposes, meaning that innovation can negatively affect or be indifferent to the sustainability dimension. Hence our willingness to investigate both adoption and non-adoption situations. Finally, a third assumption establishes that the diversity and the transformation in the advisory landscape in European countries and regions is a relevant variable explaining the role advisors play (or not) in the farmers' decision-making processes related with the innovation uptake.

AgriLink developed an integrated research framework (Deliverable D2.1) aimed at gathering empirical data for the micro-scale concept of AKIS (Agricultural Knowledge and Information System), the farmer micro-AKIS, and for the mesoscale concept of R-FAS (Regional Farming Advisory System), in relation with the up-take processes of diverse types of innovation by farmers across the EU. This deliverable (D2.2) prepared by the 13 partners involved in WP2 offers a synthesis of the qualitative insights on the farmers' micro-AKIS and the role played by advisors in the selected case studies. These were delimitated at the census region level and focused on a group of farmers representative of a specific innovation (e.g. biologic pest control), comprising both adopters and non-adopters.

1.1 The case studies

The Norwegian team at Ruralis carried out two case studies. The first one belongs to the Technological Innovation cluster, and the technology studied is automatic milking systems (AMS), or "milking robots", in dairy farming. The focus region is the county of Trøndelag (Figure 1), where dairy farming is the major agricultural production. The groups of farmers selected for this case are dairy farmers that have adopted milking robots and non-adopters. One of the main reasons the milking robot was chosen as a case is because it has become a well-established technology. Additionally, it represents a relatively new transformation in Norwegian agriculture, where almost half of Norwegian dairy farmers have implemented the technology during the last ten to twenty years. By the end of 2018, 47 percent of Norwegian milk production came through an AMS (TINE, 2019) and the percentage increase. The innovation creates challenges for the established advisory system in Norwegian agriculture. New actors establish in the system and there is an increasing need for advisory services to keep up with the technological development. Hence, it is important to study advisors' role, if they have one, and their function in innovation processes as we have seen in the Norwegian milk production over the past 20 years. It is also important to study who is important for farmers, and if traditional advisory service is less important. How does the advisory service system look like from the farmers' perspective (micro-AKIS)?

Figure 1: The focus region: Trøndelag

The second case belongs to both the Natural Resource Common Management cluster and the Technology Innovation cluster. The technology studied is electronic bells on sheep to better control livestock's movements in tracking their locations. The sheep farmers belong to different pasture groups. The groups cooperate in collecting the animals in the autumn and in buying and operating the e-bells, thus this case was defined to belong to the Natural Resource Common Management cluster as well. The group of farmers are sheep farmers and the focus region is the county of Sogn og Fjordane (*Figure 2*). This case was chosen because it combines cooperation of management between farmers and introduction of new technology. Electronic bells are involves rather new technology that has been used only for some years, and it is still not fully developed. The technology has the potential to contribute to increasing the sustainable use of outfield resources in sheep production, which is an important industry in many rural areas of Norway. The introduction of new technology involves a reorganization of the cooperation. In start of the study, we did not know how the relation between cooperation and new technology was.

Figure 2: The focus region of Sogn og Fjordane

1.2 Advisory trends and challenges

At the national level, there has been a transformation toward privatization and paid services in Norway (Klerkx et al. 2017). This has resulted in less advice for some groups of farmers who do not want to pay for services. Another consequence is little cooperation between advisory organizations because of more competition. A study carried out by Ruralis shows that many advisors lack relational competence, a competence that is important to secure learning and implementation of advice (Kvam and Stræte, 2018). Another important point is that advisory organizations have had little focus on innovation and learning from their own experience that is important for the fit between demands for advice and offer of advice. A challenge in Norway is long distances, thus making it costly and time consuming to visit farmers. This, among others, has increased the focus on using digital technology in advisory services, but still, there is a huge potential in improving the use of distant advice and digital technology (Kvam and Stræte, 2018). The fact that farmers are more diverse and with increasingly specialized production, demand both specialist and generalist competence among advisors. It is a challenge for advisory organizations to follow up changes in farmers' different needs, and private companies selling technology equipment has improved their role as advisors in agriculture.

The challenges are much the same at the regional level as at the national level; for example, milking robots. The number of farmers implementing milking robots has increased resulting in larger farms with more debt. Additionally, the dairy farmers experience competition over milk quotas and land area, and the situation has become tougher and riskier in general, which influences advisors. For example, in some cases, the farmers are more knowledgeable regarding technology than their advisors. The "traditional" advisory services Norwegian Agricultural Extension Service (NAES) and Tine are struggling to keep up with the technological development compared to the suppliers of the technology, Felleskjøpet Agri (FK) and Lely, who become important advisors for the farmers parallel to being sellers.

Many of the farmers in the county Sogn og Fjordane are part-time farmers managing small sheep farms. In many cases, the farm is more like a hobby resulting in the farmer not necessarily being as focused on the production because they are busy with their main job. This has proved to be a challenge for advisors. Economic challenges for the main advisory organization on sheep holding and thus less focus on advice, is reported as a challenge for sheep farmers in the region. According to the two producing companies of electronic bells, the main challenge is to reach sheep farmers in the region. Another challenge is to further develop the technology and the bells, and secure that farmers utilize the potential of the technology.

1.3 Innovation areas and sustainable development

1.3.1 Robot milking in the region of Trøndelag

The relation between Automatic Milking Systems (AMS) in the region of Trøndelag and sustainability is complex and ambiguous, and there are several side effects and indirect effects. For environmental sustainability, the increase in productivity per cow, i.e. fewer CO_2 emissions, is a positive effect. Regarding effects on animal welfare, this can be seen as both positive and negative. It is positive because the cow has more freedom in not being in a tie stall and has the ability to choose when to eat and when to be milked. The milking robot can also be seen as negative because the cows are usually part of a bigger herd, where it can be more difficult to have a good overview of each cow. In addition, due to the high demand for productivity and the accessible measure of productivity at the individual level, the low productive cows may be phased out of production at an early age. This issue is complex, and there are several issues that could be addressed here, but most often animal welfare effects of the milking robot are related to increased herds, i.e. concentration of production that may give negative environmental effects.

Regarding economic sustainability, the milking robot is seen as positive through increased productivity and because it is most often combined with more than double production. However, the access to land, the need for transport of fodder, the degree of depth is important to the final economic result and how economic sustainable the innovation is. It may be net negative economically. Regarding social sustainability, the milking robot is seen as positive by increased flexibility for the farmer and household because it makes it possible for them to live a life more like the rest of modern society. Farms with milking robots often have fewer problems with succession than farms without robots.

There is an increasing distinction between adopters and non-adopters of milking robots. The non-adopters experience less recruitment, less attention from advisors, etc. It seems like investing in a new barn means investing in a milking robot. This demands a certain land area and quota, and not all farmers in Norway have resources for such an investment. This situation may have a negative effect on some goals in Norwegian agriculture policy; such as living in rural regions, utilizing outfield land and domestic food production and self-sufficiency.

1.3.2 Electronic bells in the region of Sogn og Fjordane

When it comes to the electronic bells, there are three main challenges connected to sustainable development. The first is the price of the e-bells. Today, they cost too much, and farmers use e-bells only on a part of the herd despite that they find it useful. Thus, the technology is not economic sustainable. The second challenge is farmers' ability to use the data produced from the bells. This is a worry among the producers of the bells because farmers need advice for utilizing the data. The third point is that the technology is still not fully developed, and there are still problems with the bells. Nevertheless, the technology is diffused to many sheep farmers in the region. This is mainly because farmers perceive the bells to be useful; they gain a better overview of the herd and save time looking after the sheep. Reduced loss of animals and more time can be devoted to other areas of income generation and increase efficiency in farm management. If the e-bell technology develops further, and the companies manage to reduce the price, the e-bells may contribute to a more sustainable development of sheep production in the county. The bells may contribute to improved animal welfare; i.e. if it hinders predators from killing sheep, if it makes farmers more aware of sickness among the sheep on pasture and if the technology helps find the sheep in the autumn. Using e-bells may contribute to increased utilization of outfield resources, which is a goal in Norwegian agricultural policy. Utilizing outfield resources are free and can contribute to reducing the use of imported feed. These effects may together increase productivity and profitability. There may also be effects on social sustainability because buying bells is a common activity in the pasture groups. The common activity may lead to farmers meeting more often, establishing new common projects and increasing social activities.

1.4 Report outline

The report outline is as follows. First, we describe AgriLink' key concepts and research questions in chapter 2. Then, we present an overview of the case studies and methodological approaches in chapter 3. In chapter 4 the country case studies is presented and farmers group and advisory suppliers. The next part, chapter 5, comprises the result from the two case studies. In chapter 6, we discuss results according to the research questions and in chapter 7, we present the case study narratives. The report ends with chapter 8, where we summarize some insights and highlights.

2. AgriLink key concepts and research questions

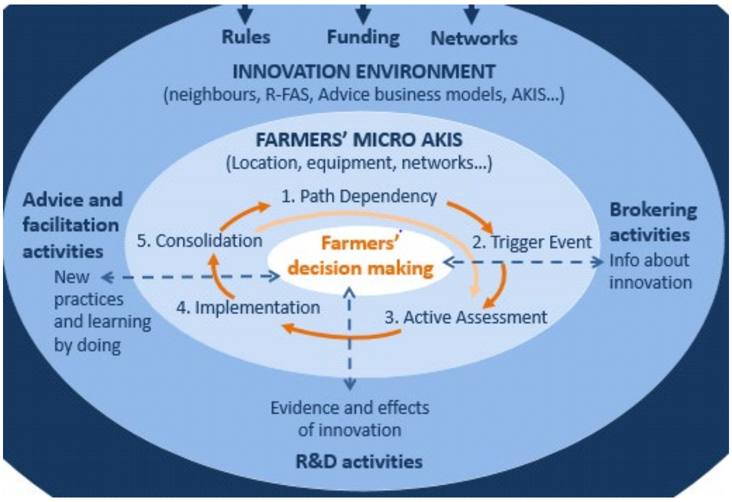
AgriLink key concepts, which are relevant for data collection in WP2 comprised of the focus region, the farmers' micro-level Agricultural Knowledge and Information System (micro-AKIS), the mesoscale concept of R-FAS (Regional Farming Advisory System) and the trigger-cycle model (TCM). These concepts were established in the AgriLink DoA and elaborated by the project conceptual framework (see Deliverable D1.1).

The Focus Region is as a farm census region that establishes the boundaries of the case study for data collection on micro-AKIS and R-FAS. Preferential geographical region is defined at NUTS 3, which is in certain cases is replaced by NUTS 2 to achieve a better case study delimitation.

The micro-AKIS describes the micro scale knowledge system that farmers personally assemble, including the range of individuals and organizations from which they seek service and exchange knowledge with, the processes involved and how they translate this into innovative activities (or not). Empirical uptake of this concept entails answering two questions: a) who influences farmers (and farm households) in decision-making on adopting or choosing not to adopt innovations; and, b) how, i.e., what are the processes describing the knowledge assemblage by the farmers and the role played by the different sources involved (see D2.1)

AgriLink defines the R-FAS as the set of organizations that enable farmers to develop farm-level solutions, enhance skills and coproduce knowledge with advisors. These are envisaged by AgriLink in a pluralist view, including traditional advice providers (chambers of agriculture, public bodies, etc.), farmer-based organizations (unions, associations, cooperatives, etc.), independent consultants, NGOs, upstream or downstream industries and high-tech sectors. Hence, R-FAS covers the full range of these organizations in a given region and their connection to wider AKIS organizations, as well as a range of services, including research, advice and brokering - meaning they can be active at different steps of the farmers' decision-making processes and use different methods at these different steps.

The trigger-cycle model established that farmers' decision-making regarding the innovation uptake is driven by a triggering event that initiates a path-dependency break cycle composed by three main phases that can be described to account for the advisors role: a) farmers' awareness of the innovation, encompassing brokering activities developed by advisors to disseminate the innovation and to (co-)create trigger events influencing farmers' decision-making processes; b) active assessing innovation entailing advisors assemblage of information on the innovation costs, benefits and side-effects by developing and involvement in R&D activities; c) supporting farmers in innovation implementation by delivering advice and carrying out facilitation activities. The *Figure 3* offers an integrated view of the TCM and the key concepts that were implemented in WP2 through the case studies delimitation and the data collection at farm micro-level and at the R-FAS meso-level.



Source: AgriLink

Figure 3: Integrated view of the TCM and AgriLink key concepts

The research questions to be answered with the empirical approach of WP2 are synthesized in *Box 1*. The research questions aim at responding to the WP2 goals through the empirical approach delineated in D2.1 built on the AgriLink conceptual framework (presented by the deliverable D1.1).

Box 1: AgriLink empirical research questions for WP2

• ***What roles do advisory services play in the cycles of farmers' decision-making?***   • The cycles comprising the trigger-cycle model developed by the AgriLink conceptual framework to understand farmers' decision-making processes regarding innovation uptake and to describe respective micro-AKIS. The advisor's role is investigated in three phases of this model: 1) the farmers' awareness of the innovation, encompassing brokering activities developed by advisors to disseminate the innovation and to (co-)create trigger events influencing farmers' decision-making processes; 2) active assessing of innovation entailing advisors assemblage of information on the innovation costs, benefits and side-effects by developing and involvement in R&D activities; 3) supporting farmers in innovation implementation by delivering advice and carrying out facilitation activities.
• ***What is the relationship between different types of farmer and advisory suppliers in the decision-making process?***   • Comprising heterogeneity in farmers profile, farm structural features and farm business models; the nature of the innovation; regional context; R-FAS landscape and business models (including models associated with the digitization of agriculture); the role of advisement in different stages of the farmers' decision-making cycles and if these are creating new advisory supply opportunities and/or new functions, and as well as new forms of path dependency
• ***How does the transformation of the advisory suppliers' landscape influence farmers' decision-making and uptake of innovation?***   • Accounting for R-FAS history and on how new configurations of R-FAS (generally depicted as more fragmented and pluralistic) play on the relation between farmers and advice, regarding: a) allowing for more creativity, triggers and a diversity of knowledge and information channels for farmers; b) influencing farmers' access to information and knowledge and equity on farmer information access.

Source: AgriLink

3. Case studies overview and methodological approach

3.1 Case studies selection

The case study delimitation in AgriLink was built through two dimensions. One of the dimensions was the spatial delimitation of the R-FAS boundaries at the focus region level, and the second dimension was the farmer selection in relation to the innovation type. *Table 1* presents the selected innovation according respective innovation type and the sustainability challenge addressed by innovation.

Table 1: Selected innovations and sustainability challenges

Type of innovation	Innovation cluster	Selection focus	Sustainability challenge addressed
Technological	Autonomous vehicles, robots, drones, intelligent sensors/Precision Farming	IT (Information technologies)	Climate change, Eco-efficiency, Pests & diseases
			Growth and jobs – Digitalization
			Food security – Biodiversity, Food provision
Process (farming practices)	Biological Pest Control	Integrated ecological farming	Climate change, Eco-efficiency, Pests & diseases
	Soil Improving cropping systems		Food security – Biodiversity, Food provision
Marketing and financing	Retro-innovation	Diversification	Growth and jobs – Business diversification, Social cohesion
	Introducing new crops		
	Direct marketing		Eco-efficiency
	Developing new activities		
Social and organizational	Natural resources common management	Collaborative organizations	Growth and jobs – Social cohesion, Digitalization
			Food security – Biodiversity
	Labour Innovative arrangements		Eco-efficiency, Pests & diseases

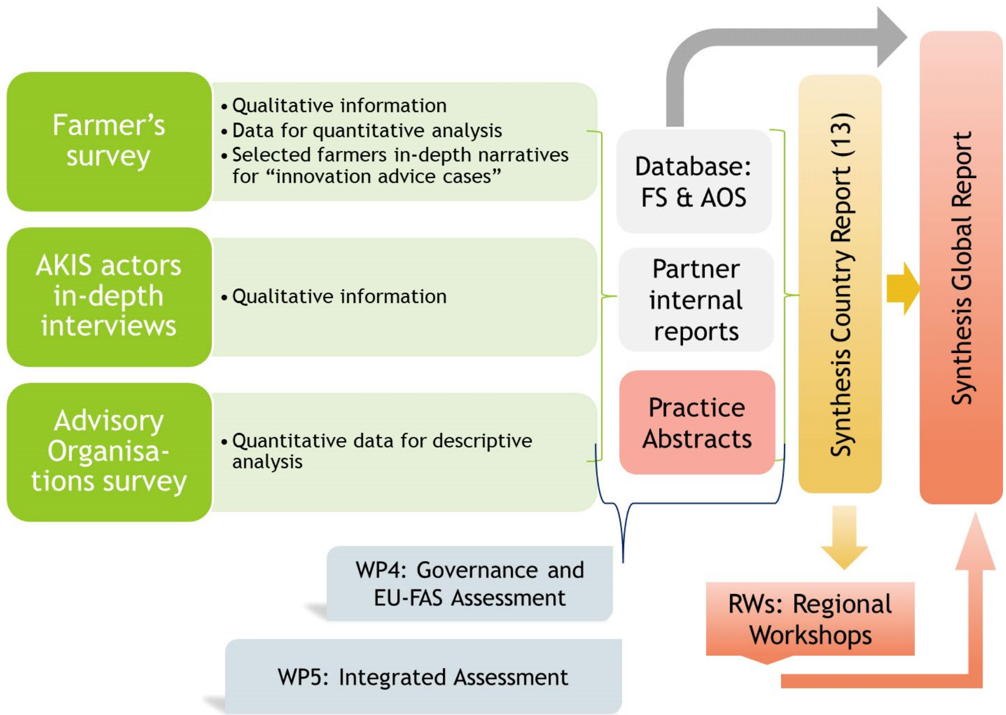
Source: AgriLink

The farmers' selection in each case study is built on targeting groups of farmers amongst whom the innovation is already widespread so that it would be possible to characterize the micro-AKIS supporting innovation up-take of adopters, as well as the micro-AKIS of non-adopters.

3.2 Methodological framework

The methodological framework implemented in WP2 consists of a mixed-method strategy (for a detailed description see WP2 research protocol in D2.1), combining a case study approach with quantitative survey-type data collection. It is implemented in three steps. The first step was the case studies' selection, which is already described. The second step consisted of delineating and implementing two major surveys: 1) to farmers to collect the data for describing the micro-AKIS and the role the advisory providers play in it; and, 2) to advisory providers to enable describing R-FAS in relation with the innovation addressed by each case study.

Figure 4 depicts an overview of the WP2 data collection strategy, highlighting the intermediate outputs and the outcomes generated from the data analysis, including the inputs to subsequent WPs.



Source: AgriLink

Figure 4: Overview of WP2 data collection and reporting

The farmers' survey was conducted through a question-guide comprising both open-ended and closed-ended questions intended to gather quantitative data on whom and how type of questions (who are the advisory services providers and how these are provided), along with qualitative data on the why and how type of questions allowing for in-depth understanding of farmers' micro-AKIS. Quantitative data from the farmers' survey (FS) were entered on a database, while qualitative information and narratives descriptions were recorded and analysed in order to provide the descriptive and analytical insights. This deliverable, the synthesis country report, presents the outputs of both, the data analysis and description and the qualitative insights for each case study.

The farmers' survey was mainly implemented through face-to-face interviews, conducted by members of research teams or duly trained students, following a question-guide including open, mixed and closed questions to collect data on the trigger events, the farmers' innovation evaluation, knowledge and information sources, flows and social networks, farmer profile and demographics, business model and farm structure. FS comprised a set of matrixes to gather data to describe farmer micro-AKIS for the three main stages of the TCM (awareness, active assessment and implementation of the innovation) and on the micro-AKIS used by the respondent for farm management in general, as well as an optional on the household micro-AKIS for the family farms when family members were shown to be influential actors for information and knowledge flows assembled by farm decision-maker(s). Detailed information on the farmer survey and respective question-guide is available at the Deliverable D2.1.

The advisory organization supplier's (AOS) question-guide builds mainly on closed-ended questions and addressed formal providers of advice (see *Box 2*), excluding informal providers. Formal advisory suppliers comprise organizations providing advisory services as a secondary activity and /or providing them for free (e.g. associated with the supply of inputs or software). In-depth information on the R-FAS is gathered through complementary in-depth semi-structured interviews delivered to a small number of regional AKIS actors.

Box 2: Definitions on advisory for R-FAS survey

Advisory services
- A service activity that enables farmers to develop farm-level solutions, enhance skills and coproduce knowledge with advisors.

Advisory suppliers
- Any organization that delivers advisory services to farmers.

Advisory organizations
- Traditional suppliers specialized in the supply of advisory services to farmers. This corresponds to former 'extension suppliers'

Source: AgriLink

The question-guide for advisory organizations comprised mostly closed questions and addressed data collection to: a) describe the organization, including its ownership status, action level, advisory services supplied, funding resources and in-house R&D facilities; b) characterize its human resources, their distribution according to front-office and back-office activities, qualifications, certification and training, and on the methods they use for supplying advisory services; c) describe the type of advisory services clients and the main topics of these services; d) identify the national and regional public support to the advisory organization, including funding and other type of support to back-office activities (training, R&D and networking activities); e) assess organization benefit from current EU level policy instruments, such as EU-FAS, EIP-AGRI, and rural development programs; f) describe the organization advisory services supplied in relation with the innovation at stake in the case study, and the back-office activities undertaken by the organization to support the supply of these services; and, g) collect the organization's vision regarding the major challenges to be faced in the next years by the advisory suppliers, in the focus region, regarding the innovation development.

The in-depth interviews to AKIS key actors collected their knowledge on the innovation path in the region, on major innovation triggers, on their evaluation on the farmers' knowledge and information needs and demands along the various stages of the innovation TCM and to what extent R-FAS is responding to these demands. The target number of interviews to key actors was established as five, whereas they can be fewer depending on the number of relevant actors is each case study.

The data analysis and qualitative insights obtained in each case study are also part of this deliverable, the synthesis country report. Detailed information on the advisory organization supplier survey and respective question-guide is available in the Deliverable D2.1.

In addition, this deliverable if comprise of the description and the insights gathered from detailed narratives of farmers' decision-making processes regarding the uptake of the innovation built on the TCM and addressing the advisory supplier's role. Three narratives per case study were included in the data collection conducted by the WP2 to generate information for the integrated assessment in WP5.

3.3 Sampling strategy

The target population for sampling purposes was a group of farmers with relative similar technical-economic orientation amongst whom the innovation is already widespread, enabling the identification of adopters and non-adopters that choose not to adopt the innovation. Hence, the target population sampled is defined by two criteria: 1) innovation adopters and (informed) non-adopters; with, 2) a similar technical-economic orientation, whilst addressing farm structural heterogeneity among the targeted group of farmers, which might lead to the inclusion of farmers with different farm styles and/or business models. In addition, specific categories of non-adopters, such as droppers, or of adopters, such as partial adopters, were accounted for in sampling purposes when found to be relevant in the targeted population.

A sample of 40 to 50 farmers was planned for each case study. A snowball-type sampling procedure was adopted relying on the support of key-informants ('gatekeepers') familiar with the targeted group of farmers, which might include farmer associations, researchers and other AKIS actors and experts. To avoid selection bias, different information sources needed to be used and crosschecked (See Deliverable D2.1 for a detailed description of farmers sampling strategy).

The advisory organizations were sampled through a snowball process relying on diverse sources to ensure that the complete spectrum of advisory organizations supplying (or that could supply) advisory or related services is included in the sample. A minimum of 20 organizations was planned for the cases where sampling was needed to cover the advisory diversity. In other cases, with little formal suppliers on the ground the strategy was to interview the maximum of existing organizations.

4. Country case-studies, farmers group and advisory suppliers

In this section, we are going to present the two case studies carried out by the Norwegian researchers. The first one belongs to the Technological Innovation cluster and the second one to the Technological Innovation cluster and the Natural Resource Common Management cluster.

4.1 Case study 1 - Technological Innovation cluster, milking robots

Dairy farming has experienced major technological developments with several associated innovations. One of the most important is the introduction of milking robots or automatic milking systems (AMSs). Implementing a milking robot on a farm often requires more than just the robot itself, but also rebuilding or building of a new barn, which enables loose housing for the cows, where they are able to move freely in order to eat, sleep and for milking. Investment in a new barn often includes installing AMS. The cows decide for themselves when to go to the robot for milking, but are motivated by getting feed (concentrate) in the robot. Compared with cows in a tie-stall barn, the cows in a loose-housing barn with a milking robot are milked more frequently, often three-four times a day. The milking robots are often combined with other devices in the barn like a robot for feeding, activity measuring, robot for cleaning, etc. A milking robot is a device associated with increased efficiency and productivity, and consequently profitability in dairy farming and a more flexible work situation for dairy farmers and their households. Management of dairy farming is partly based on data and tools related to the Norwegian Dairy Herd Recording System (NDHRS). When installing AMS, the potential of data input increases, and new options of decision tools follow the AMS. Dairy farmers in various degrees make use of these options. There are different kinds of milking robots, but the basic principle is about the same. Robots from Lely and DeLaval are the brands with the greatest share of the market in Norway; in addition, there are the brands SAC and GEA. The implementation of the robots has gone relatively fast from 170 robots nationwide in 2006, and by end of 2016, there were 1,726 robots (Tine, 2016). Nationwide approximately 200–250 AMSs are installed every year. Today, more than half of all milk in Norway has gone through a milking robot, and almost half of the dairy farms in Norway have milking robots. This development is accompanied by substantial structural changes that are described more in detail in chapter 4, where we present results from the study.

With the aim to study the implementation of milking robots in Norway, choosing Trøndelag as focus region is a natural choice because of the density of dairy farming in this area. It is located in the middle of Norway, and dairy farming is the major agricultural production in the region. Due to this, the implementation of the milking robot started early, and the density of the technology is greater here than in other parts of the country. The first AMS was installed in Norway in 2000, and in Trøndelag around 2001-2002. There are about 1500 dairy farms in the region of Trøndelag (SSB, 2018), and the number of farms with milking robots is estimated to approximately 500. However, this is increasing, with about 40-50 robots sold each year at regional level. The rate of robots per farm may vary in statistics because it depends on how joint farms are counted. A joint farm is a farm where two or several farmers cooperate in a common production, here dairy. Their herds and milk quotas are merged into the same production with for example one milking robot. In dairy farming, joint farming is rather common but there are regional variations. The share of joint farming in Trøndelag is rather high. In 2019 there were 180 joint farms in Trøndelag (counting from two to six member farms) (Landbruksdirektoratet, 25.06.2019 https://www.landbruksdirektoratet.no/no/produksjon-og-marked/melk/melkekvoter/statistikk).

The county of Trøndelag has 41,265 km2 land, and the population was 448,744 in January 2018. Population density is 11,1/km2 (Trøndelag Fylkeskommune, 2018). Trøndelag is a rich region of natural resources. There are large iron-rich marsh areas in the inner parts of the region, and wide valleys are particularly characteristic. In the areas around the Trondheim Fjord lies some of the country's most fertile agricultural areas. There are also large forest areas and watercourses. In the eastern part towards the Swedish border lies the mountainous areas and areas in the south have upland terrain and mountain plateaus. In addition, the region has large coastal areas with several islands.

Trøndelag is the largest agricultural county in the country and has about 16% of Norway's agricultural area. Nevertheless, only 4,2% of the area is cultivated land, and most of the agricultural land lies in populous municipalities around the Trondheim fjord where there is large pressure from housing and infrastructure construction (Trøndelag Fylkeskommune, 2018). This has led to Trøndelag being the county where most agricultural area has been transferred to non-agricultural uses the recent years.

Agriculture and forestry does not represent a large-scale employment at the county level, with only 2,7% of the employment in the county. However, this number is affected by Trondheim, the fourth largest city in Norway. There are 13 municipalities in which more than 10% of the employed jobs are in agriculture and forestry. In addition, there are many indirect jobs in the food industry. Trøndelag is one of the largest agricultural producers in Norway. In 2017, 70,000 tons of meat were produced in Trøndelag. Only the county Rogaland has higher meat production. Trøndelag is the largest producer of cattle, with a production of 17,087 tons in 2017. The county is also the second largest producer in the country of poultry and pork, and the third largest producer of sheep meat. Trøndelag also has a considerable milk production, 326 million litres in 2016. This corresponds to 21% of the total milk production in Norway (Trøndelag Fylkeskommune, 2018).

Main actors of the regional AKIS, related to the innovation, are farmer-based organizations and farmer cooperatives. The main dairy cooperative, TINE SA is Norway's largest processor, distributor and supplier of dairy products with 11,400 members (owners) and 9,000 cooperative farms (Tine, 2018). Tine has exported cheese for many years, but this export will be terminated due to restrictions on subsided export. The domestic market is the overall most important. The cooperative offers advisory services and support to farmers, and they develop digital tools and create systems for management of data. Today, Tine has their own advisors specialized in AMS, also in the specific brands. The supplier cooperative Felleskjøpet Agri (FK) is also a main actor in the regional AKIS, as the supplier of the most sold milking robot brand, DeLaval. In addition, FK is a provider of building, installation, concentrate, tools and machinery for most farm productions in Norway, as well as acting as advisors regarding their range of products. Their associative supplier, Fjøssystemer, is a private company and supplier of the second most sold robot brand, Lely. They also provide AMS services and advisory services, in addition to building and installation of husbandry productions in Norway. Both suppliers contribute to planning the building, type of AMS, support service in the implementation stage of the innovation and beyond. Another AKIS actor is Norwegian Agricultural Extension Service Trøndelag (NAES), which is a farmer-owned cooperative offering advisory service for farmers. In the region of Trøndelag, there are about 50-60 advisors. Together with nine other similar cooperatives, they own the national umbrella organization for this advisory service. There are also other advisors in the farmers' cooperatives, such as the meat cooperative Nortura. However, they leave advisory service for dairy farming to Tine but in some cases when the issue is beef production or cattle, Nortura can also be involved. In addition to these actors, the regional bank, Sparebank 1 Midt-Norge (SMN), and the regional department of Innovation Norway are important actors in the local AKIS. SMN is a regional branch of a national financial services group, with advisors specialized in insurance, investments and accounting related to

agriculture. Innovation Norway is an instrument for the Norwegian government to support innovation and development of Norwegian enterprises and industry, including farmers. Further, several accountancy firms and consultants offer farmers advisory service in specific topics.
Some challenges in the regional AKIS are the general trend of privatization of services, and paid services, together with higher requirements for specialist expertise. The farmers' need for specialist expertise in a range of fields of their farming business requires a certain level of cooperation between the AKIS actors. However, this can be a challenge for the advisory organizations as they are in increasing competition with each other. It is also an expressed challenge among the advisors to be able to keep up with the technological development and even the farmers' expertise in their own farming. In addition to this, the region is experiencing larger farms, with larger productions where decisions create complicated consequences for management choices. At the same time, a large number of farmers do not expand. This group may be difficult for the advisers to keep a focus on when those who are larger demand more expertise.

4.2 Case study 2 – Technological Innovation cluster, electronic bells

Sheep farming in Norway is in a very high degree based on grazing in outlying fields, i.e. forests, mountains, moors etc. Often farmers cooperate using this common land. They are organized in pasture groups and cooperate mainly for gathering the sheep in the end of the season. They also sometimes cooperate in maintaining for example bridges and small cottages that are useful when looking after and collecting the sheep in autumn. Cooperation in pasture groups has long traditions but we recognize that the implementing of a new technology, the electronic bells, has changed and enhanced the cooperation. The case was selected to explore how a new technology is implemented in organizations that operate management of common pasture resources.

Norwegian high-tech companies have developed electronic bells for use on sheep or other animals, making it easier to control and localize them on mountain pastures during the summer pasture season. Some selected pasture groups in the county of Sogn og Fjordane were testing electronic bells in 2010 on request from the county agriculture administration. The county agriculture administration wanted experience in the use of e-bells and examine if the use can contribute in reducing loss of animals on pasture and help finding causes for loss. In this instance, bells from the company "Telespor" were used. Today, farmers use two different electronic bells; the bell developed by Telespor, which relies on a cell phone reception, and a bell developed by a company called "FindMy," which relies on satellite coverage (GPS).

The bell developed by Telespor receives GPS-positions from satellites and sends the information via the mobile network to the supplier company's server, which sends the information to the farmers who accesses the information through their computers, smartphones or tablets. The farmer is then able to monitor the movement of the sheep. It is also possible to notify if individual sheep equipped with a bell has been staying in the same place for long periods. How frequent the bells report the sheep's position is chosen by the farmer and is usually one-two times per day. The bells have limited battery time and frequent reporting depletes the battery faster. However, the farmer is able to change the programming of the bells from his/her computer, smartphone or tablet and can, for example, increase the report frequency when it is time to collect the sheep or when there are signs of something being wrong. The price for the bell, battery and the subscription needed to support it was in 2018, 1506 NOK per bell per year. Additionally the farmers have to pay a fixed price for yearly services.

The bell developed by FindMy utilizes satellites and does not rely on a mobile network. The information sent from the bells goes via satellite directly to the farmers' computer, phone or tablet. This is advantageous in areas with poor mobile network reception. Large parts of Sogn og Fjordane and especially the mountainous pasture areas suffer from poor or no mobile network coverage, making FindMy's bells the only alternative for many sheep farmers. A main drawback with these bells is that they only allow for one-way communication. The farmer cannot re-program the bells once the sheep are out to pasture. Except the one-way communication, the bells are similar and report so far the same types of information as Telespor. The price for a bell, battery and subscription in 2018 was 2100 NOK per bell. Additionally, farmers have to pay a fixed yearly price for services.

Both companies have on-going development connected to the technology aiming to make it more sustainable for farmers. Most farmers interviewed used the FindMy bells because the mountain pastures were located in an area with low mobile coverage. Below, figure 5 shows a sheep with an electronic bell on its neck. Figure 6 shows, based on data from the e-bell, how the sheep herd moved during the pasture season. They start pasturing where they drop off in the spring (the red points) and move and spread during the season. The different colours show where the sheep move from one month to the other. The dark green colour point shows where the herd is located at the end of the season.

Figure 5: Sheep with electronic bell

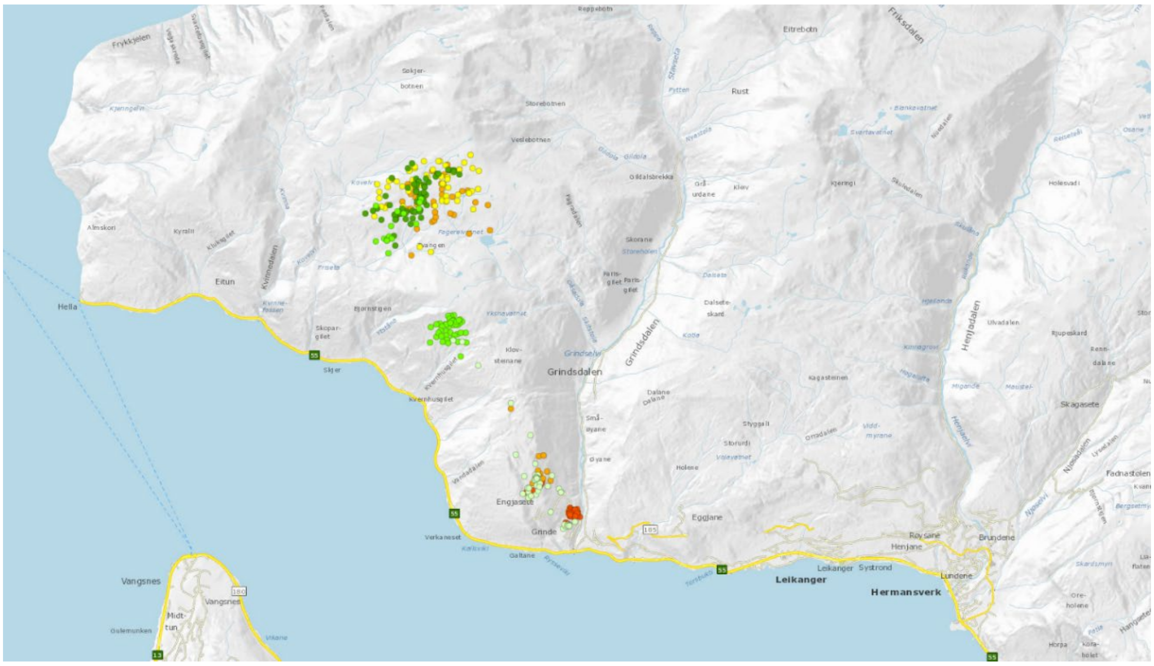


Figure 6: Map showing movement of the sheep during a season

The reason why this case also belongs to the Natural Resource Common Management cluster is that groups of sheep farmers cooperate in using a common resource, mountain pastures. About 35% of the land in the county has organized cooperation of pasture, where farmers own or have the right to use the land as pasture. Farmers using the same outfields have cooperated for decades in collecting sheep in the autumn. When the county administration offered sheep farmers to buy electronic bells for a reduced price, initially as a vehicle to reduce predators killing sheep, only formal pasture groups were allowed to apply for support. Thus, farmers had to formalize their pasture groups, and they got a new task for common management in searching for support and implementing the e-bells that require collaboration between the farmers in several dimensions.

The pasture groups have lasted for many decades, so they do not represent any innovation. What is new is that support for buying e-bells required a formalization of the pasture group. Thus, only formalized groups were obliged to apply for and gain support. Applying for support and implementing a new technology represented a new common activity for the pasture groups, and in our case, we looked for possible effects of cooperation in implementing and using the new technology.

The county of Sogn og Fjordane is the fourth largest county for sheep meat production. Compared to other counties, it is steep, has rough terrain, smaller holdings and huge grazing areas. The geography is challenging for sheep farmers, and the new e-bell technology may in particular be very useful for farmers in this region.

Another reason for selecting this county is that Sogn og Fjordane is very different from Trøndelag. Compared to Trøndelag, Sogn og Fjordane has different conditions for farming (more hilly and scattered fields), different farm structure (smaller farms) and different production. From this follows an assumption that the regional AKIS are different. To make a more robust study, we preferred a variation of the two case regions.

The county of Sogn og Fjordane has 18,623 km2 land, and the population was 110,230 in January 2018 (www.sfj.no). Population density is sparse, only 6/km2. The county has huge outlying fields with big mountain areas. The county has the third largest share of employment in agriculture in Norway. In agriculture, livestock, in particular cattle, sheep, and in some places goats are the main production. In some part of the county, the production of fruit and berries is important.

Half of the land is suited for the pasture of livestock farming, where sheep is the most important. The county is the fourth largest county for sheep meat production and represents 8,7 % of the national production of sheep and lamb meat. Sheep production is distributed evenly among the 26 municipalities of the county.

There are several challenges related to sheep and pasture, for example utilization of a common good that a common pasture represents; loss of lambs on pasture; conflict with societal objectives to increase the population of predators; a need for physical fences to keep the sheep on pastures; and collecting sheep after the season on pasture is a labour-intensive activity. Today, sheep farmers are searching for technological tools that can help to meet some of these challenges. Relevant technologies are electronic bells, but drones, thermo-searching cameras and non-visible electric fences are technologies under development that are not yet in the market for sheep.

In 2016, the number of sheep (mother sheep) in the county was 76,583 compared to 82,215 in 2006. There were 1562 farm holdings with sheep, and the average holding was 59 sheep (compared with the country average of 75). Most sheep farmers have jobs besides farming or they combine sheep production with other agriculture production, such as dairy production or fruit/berry production. Tourism is an important income for farmers in some areas.

The main advisory organizations in agriculture are located in offices in all counties. These organizations are Tine - the dominating dairy cooperative offering a range of services to its members- and, Felleskjøpet Agri (FK), also a cooperative that is the dominant actor in the input supply industry offering farmers concentrate, fertilizer, machines, equipment and seed. FK has employees responsible for sales that also give advice to farmers. Nortura is the dominating meat cooperative that also offers advice to livestock farmers. Norsk Landbruksrådgivning (NAES) is a cooperative and an independent advisory organization offering services originally on plant production but has developed and broadened its offer in the last years. All these advisory organizations are located in Sogn og Fjordane, but none offer advice on e-bells. Nortura has one advisor in the region that covers sheep and goat. He invites the two companies offering e-bells to join meetings with sheep farmers so they can inform about the products and innovations. This advisor knows the two e-bells very well, but does not look at himself as having a role in advising farmers about the technologies. He mentions that he want to be neutral according to the farmers' choice of bells.

The two companies offering the e-bells are the formal advisors. As both companies mentioned, the interest organization, Norwegian sheep and goat (NSG) and the meat cooperative Nortura, have an important role in informing sheep farmers about the new technology. The organizations invite the companies to join member meetings where they sometimes inform the farmers about the technology and sometimes give courses and teach the farmers how to use the technology.

The two bell companies use, according to themselves, many resources on advising. A challenge is to communicate the possibilities and thus potential with using the technologies to farmers. Farmers need to understand and use the available information. The companies assumed transfer of knowledge to farmers and development of the technology to be the main challenges for the future.

The *price* of the bells is high compared to the price farmers are paid for the meat and that is why the farmers have not bought e-bells for all animals despite that they sometimes feel a need. The producers of bells believe that farmers may save a lot of time if they use the bells, and if they account for reduction in use of time, they may gain earnings using the bells. There are also possibilities for long time effects of use, for example if farmers breed animals that pasture on the best available pastures according to nutrition. According to one of the producers, a negative effect may be that farmers trust the technology and stop the regular following up in the outfields. Both technology companies work to develop the bells to withstand tough environments and increase the usefulness of the bells in different ways.

4.3 Group of farmers targeted and sampling strategy

4.3.1 Case study 1 - Technological Innovation cluster, milking robots

The target group of farmers were farmers belonging to dairy farmer groups in the region (county) of Trøndelag that had or had not implemented milking robots in their production. Due to information from AKIS actors, there were no droppers in the region (besides maybe 1 –2 farmers that had retired without having successors). No droppers were interviewed. Droppers are almost non-existing as it is very rare that dairy farmers remove an AMS when it is installed.

There was an attempt to find clusters of adopters and non-adopters inside the region to get the best comparable conditions (access to advisors, culture and key persons in the microAKIS), together with other criteria such as production size and age - there can be some obvious reasons for why someone has not implemented the milking robot like small scale dairy farms, age of farmer, no successors, etc. Despite the high adoption rate of milking robots in the region, some farmers are more advanced than others in how they use their technology. It was attempted to capture the diversity among the farmers alongside the other criteria. Because dairy farmers with milking robots often have to increase their production to utilize the milking robot to pay the investment, the AMS-farms are often larger than dairy farms without AMS. Due to this, attempts were made to find non-adopters that met the prerequisites based on farm size (milk quota and number of cows) to be able to implement AMS on their farm. The idea was that it would be interesting to compare these farmers' microAKIS with the AMS-farmers' microAKIS in order to identify reasons why some implement and others do not. Another criterion was to ensure that farmers with the different kinds of robot brands (Lely, DeLaval and others) were included in the sample because of their relation to different suppliers and AMS service advisors.

The procedure for sampling was first to pick 3-4 municipalities where we assumed there was a cluster for dairy farmers. We asked extension service in the municipality (public service) and other advisory service actors to give us a list of a number of farmers in the municipality that were above medium size (above 25 cows), some with AMS and some without. That was all the information we received, and then we started to call farmers from the list to make interview appointment.

We interviewed 29 farmers in total. Of these, 20 farmers were adopters of milking robots and 9 were non-adopters (Table 2). In the lack of droppers in the region, which are rare also on national level, or almost non-existing, no droppers were interviewed.

Table 2: Farmers surveyed

Innovation case study	Adopters	Non-adopters	Droppers	Total
Technology Innovation	20	9	0	29

Source: AgriLink – Country

Figure 7 below shows in which municipalities farmers interviewed are located.

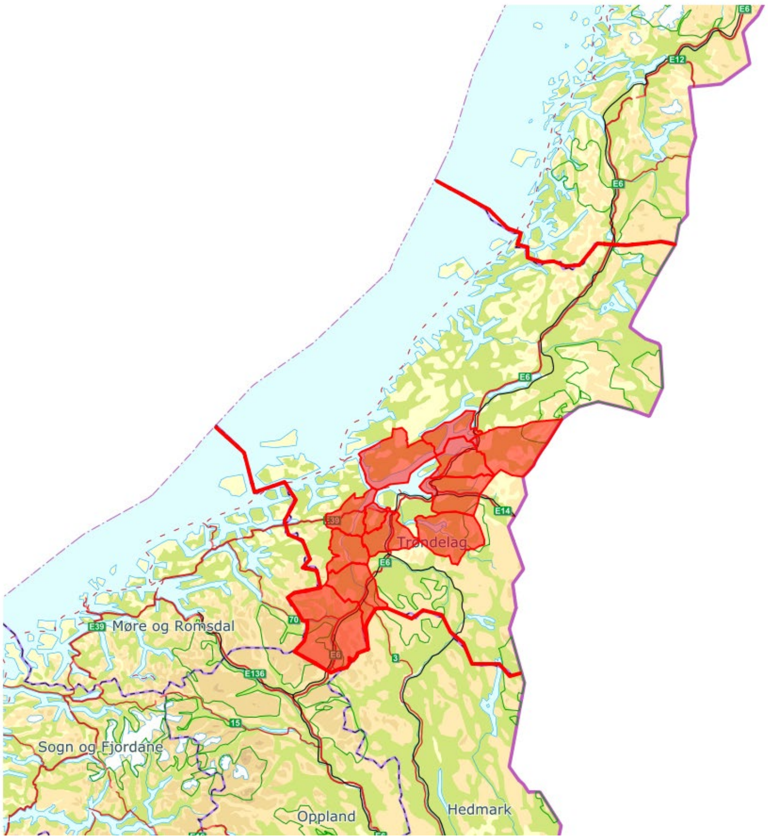


Figure 7: Map of Trøndelag showing municipalities from where the farmers were located.

4.3.2 Case study 2 – Technological Innovation cluster, electronic bells on sheep

The target group of farmers were farmers belonging to sheep farmer groups in the region (county) of Sogn og Fjordane, which had or had not implemented electronic bells on sheep or that had dropped the use of bells.

Because one main point was to look at group effects of cooperation on implementing and using new technology, it was important to interview sheep farmers from different pasture groups. Many sheep farmers have jobs beside agriculture, thus, it was also important to interview both full time and part time farmers to see if there were any differences between the two groups according to adoption and micro-AKIS. It was also a criterion to interview farmers using e-bells from the two different producers, Telespor and FindMy.

We contacted two key informants from the region to get an overview of the situation and information and advice about farmers to contact and interview. One informant was a sheep farmer. Her pasture group was early testing the implementing of e-bells on request from the county administration. The other contacted key informant was a person from the county administration. After starting the interviewing, we usually asked farmers about input on whom to contact for more interviews (snowball). It turned out that it was not so easy to find farmers for interviews, in particular the group of droppers or non-adopters. On the other hand, most sheep farmers used e-bells where the terrain made it useful, but some use only a very few bells. Table 3 shows the results from the interviews. In total, 21 farmers were interviewed. Of these, 19 were adopters, and two were non-adopters.

Table 3: Farmers surveyed

Innovation case study	Adopters	Non-adopters	Droppers	Total
Technology Innovation and Natural Resource Common Management	19	2	0	21

Source: AgriLink – Country

The map below in Figure 8 shows in which municipality the sheep farmers are located.

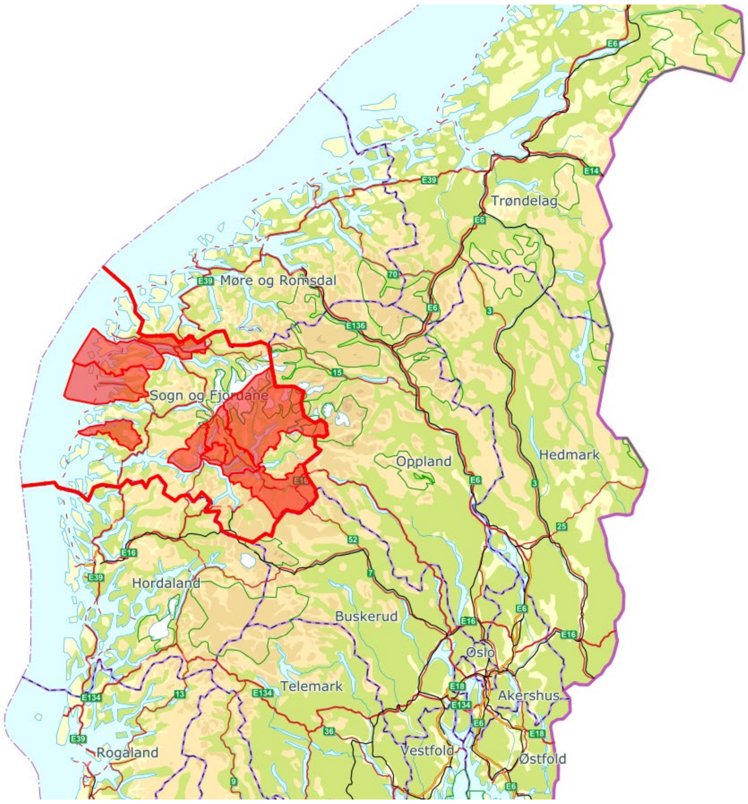


Figure 8: Map of the county of Sogn og Fjordane with its municipalities, showing location of farmers interviewed.

4.4 AKIS experts and advisory organizations

4.4.1 Case study 1 - Technological Innovation cluster, milking robots

In the Technology Innovation cluster, we identified eight AKIS experts in total. Two of the AKIS experts represent the suppliers FK Agri and Fjøssystemer, who are providers of the most sold AMSs, DeLaval and Lely. In addition, two AKIS experts are from the dairy cooperative TINE, covering the north and south part of the Trøndelag region. These organizations represent the main advisors who provide advice directly related to the robot to dairy farmers. The four other experts interviewed are advisors, where the milking robot more indirectly created demand of different advisory services, like investments and accounting (two experts from SMN bank and one from Innovation Norway). In addition, there was one advisor from NAES, which provides advice on agronomy but has developed and broadened the offer in the last years. Sampling of actors was based on the interviews with farmers, where it became clear that especially Fjøssystemer/Lely, FK Agri/DeLaval and TINE had the roles as main advisors related to the robot. In identifying which persons to interview in the different organizations, we mostly consulted with the organizations, explaining the project and which actors we were looking for, and we were further guided to people they thought would meet our criteria. As researchers, we also ourselves have a rather good overview of the farmers in the region.

4.4.2 Case study 2 – Technological innovation cluster and Natural Resource Common Management cluster, electronic bells on sheep

In the Technology Innovation and Natural Resource Common Management cluster, we identified five AKIS experts in total. These experts occurred through the initial search for information and informant interviews, and we regard them as the most important and relevant ones for the distribution and implementation of this new technology in pasture groups. The two first once, were contacted initially before we started the interviews with farmers to gain more information about use of e-bells and to get advice on where and how to start data collection of sheep farmers.

The first AKIS expert interviewed was the sheep farmer we contacted initially (she is also an advisor in the advisory organization, NAES) who was part of a pasture group that initially in 2010 tested out the e-bells on a request from the county agriculture administration. She has written reports about experiences from the use of e-bells, and she was very active in joining meetings in the sheep farmers' interest organization, NSG, for informing other sheep farmers in the region about the results from testing. She was the leader of NSG in her municipality, and thus, we refer to her as a representative for NSG. We had an interview with her early in the data collection to gain an overview of the use of the technology in the county, how farmers implemented the technology and their main advisors.

The second AKIS expert interviewed was a person from the county agriculture administration. The administration initiated and operates the project to support pasture groups in buying e-bells. The informant is responsible for supporting pasture groups with grants, and she has a good overview of the situation among sheep farmers in the county.

The third and fourth AKIS experts were both from the two technology companies that developed the electronic bells, FindMy and Telespor. These companies represent the main/formal advisors to sheep farmers using e-bells. The fifth one interviewed was the regional advisor on sheep from the meat cooperative, Nortura. He regularly arranges meetings for sheep farmers in the region where he sometimes invites the two companies to present and inform about their bells and development activities. Sometimes he also presents the two bells for sheep farmers himself based on slides he has received from the two companies. This advisor has a lot of knowledge about sheep farmers in the county, and he is an important person for the two companies to reach sheep farmers.

It was through interviews with farmers that we got information about advisors in implementing and using the technology. In addition to the two companies, they mentioned other sheep farmers as the most important advisors. Some farmers did not have direct contact with the technology companies at all; they only got advice and support from sheep farmers.

From the description of the advisory supplier landscape in the region, the only organization of interest for the innovation is Nortura, the meat cooperative. Compared to the other three main advisory organizations, Nortura has fewer resources to use on the advisory services because of economic challenges in their business. Thus, only one person is responsible for sheep and goat advice in the region, which means that he is an advisor for about 3000 sheep and goat farmers. Tine, which gives advice to dairy farmers, has more resources and gives advice regularly to dairy farmers in the region. NAES, which is active in advice in plant and berry production, has a considerable group of advisors in the region. FK focuses more on bigger farms, but has a group of advisors or sellers in the region focusing on the sale of e.g. machinery and equipment, seeds, fertilizer and pesticide.

It was quite clear from the first interviews that the main advisors for implementing e-bells were the two companies that have developed the bells. These were the only actors giving advice besides the farmers advising each other.

4.5 Farmers selected for in-depth narrative interviews

4.5.1 Case study 1 - Technological Innovation cluster, milking robots

In the selection of narratives, we selected one early adopter and one late adopter to show differences in advisory support from the early beginning of implementation and until today. The two farmers were selected because they seem to be typical for the farmers belonging to the two groups. The non-adopter selected is typical for the group of farmers that have invested in a new farm building but lack resources to invest in a robot. This farmer is young and has newly built a new barn, but because of a lack of resources, he was not able to invest in a robot. The narrative shows that the available land or access to rent land, quotas and economy are conditions decisive for investment in a robot. The second group of non-adopters are typically older farmers that have nobody to take over the farm. Then it is more obvious that they are not going to invest in a milking robot. This latter group of non-adopters are not represented among the narratives.

4.5.2 Case study 2 – Technological Innovation clusters, electronic bells on sheep

For the Technology Innovation and Natural Resource Common Management cluster, two adopters and one non-adopter were interviewed for narratives. The non-adopters were a full-time farmer where the main productions were milk and cherry production. He gave an interesting explanation for not adopting the e-bell, and thus he was selected for the narrative. The other non-adopter in the sample was a retiree and he had a few sheep for hobby production. The two adopters selected have many years' experience in using e-bells. One was the leader of a pasture group, and he was a full-time farmer. He has a lot of experience in supporting other sheep farmers in using bells. The other adopter was a retired veterinarian and former leader of a pasture group of farmers. He got most of his information and advice on e-bells from a farmer belonging to the same pasture group. Both interviews explain well the adaptation process of the new technology and reflections around the use of the technology and sustainability.

5. Results

5.1 Case 1: The role of farm advice in the innovation case study, technological innovation – milking robot

5.1.1 Findings related to the Farmers' survey

Farmers' profile and farm structure

The majority of the farmers in the sample have a combination of dairy and meat production. The main crop production is grass for feed, but some of the farmers also produce grain (Figure 9). The majority have permanent grasslands and infield pasture for grazing. Of those who have grain production, barley is the most common grain produced. The sample includes one organic farm.

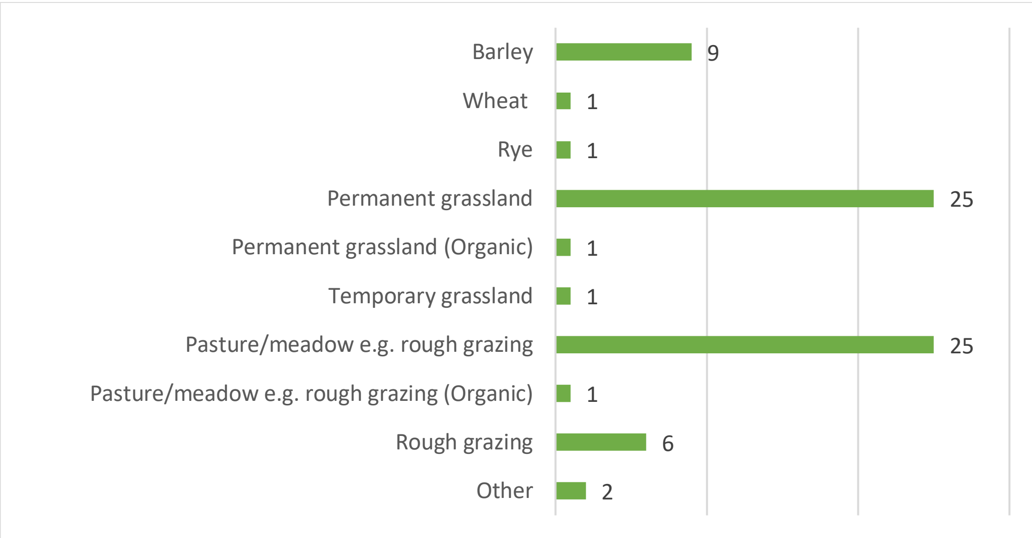


Figure 9: Crops produced by farmers in the sample

When it comes to farm size in the number of cows, most of the farmers have between 20 and 60 dairy cows (Figure 10). The non-adopters are only represented in the two lowest categories with 60 cows as a maximum, while adopters have up to 100 cows. The farm size according to the number of cows in this sample coincides with the structural limitations of the milking robot. A robot has the capacity to milk a certain number of cows a day, and for most robots, this number is about 60-70 milking cows. Other limitations that affect size are the milk quota system in Norway. As of 2019, the highest allowed milk quota is 900,000 litres per farm (Norwegian Agriculture Agency, 2019). This is equivalent to approximately 100-120 dairy cows, based on a yield of 7500 litres a year per cow. In order to utilize the capacity of the robot, there is no point for Norwegian farmers to have more than two milking robots with the present regulation of milk quota. In addition to other conditions, such as a geography that gives little access to large continuous areas of farmland for most of Norwegian farmers, the majority of adopters have only one milking robot.

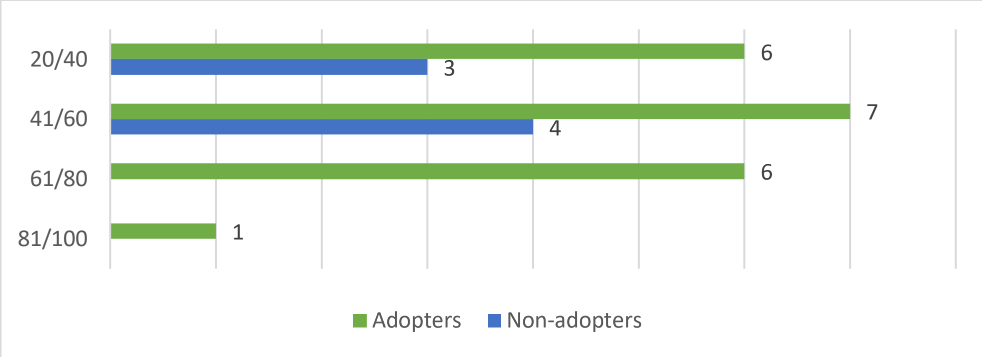


Figure 10: Number of dairy cows per farm among adopters and non-adopters

Regarding farm size in area, the majority in the sample have 41-80 hectares of arable land (Figure 11). As noted above, there are often some structural differences between adopters and non-adopters. This difference also applies to the size of arable land as shown in the sample. We have no non-adopters in the categories over 120 hectares. Despite our attempt to find farmers of comparable sizes, it was not possible to find examples of non-adopters among the biggest farms, neither regarding arable land nor in the number of cows.

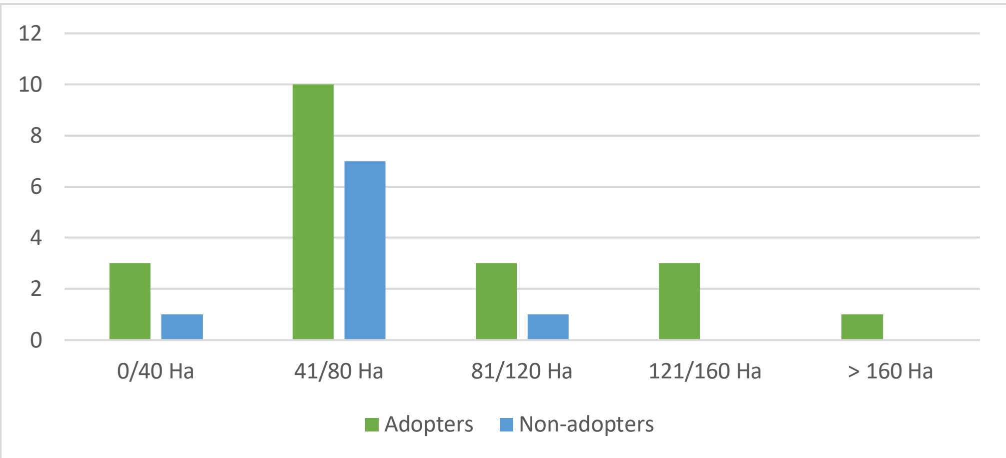


Figure 11: Total area of arable land (ha) including infield-grazing areas among adopters and non-adopters.

As for the farmers' business models, approximately half of the farmers in the sample had some type of supplementary income related to the farm. For most of the farmers, this included forestry, agro-tourism (hunting and fishing) and leasing of machinery with/without labour.

The majority of the farmers in the sample work full time as farmers (Figure 12). Few of the farms are family driven, in the sense that others in the family other than the farm holder himself/herself work full time as farmers. Though, most of the farmers have several family members working part time on the farm. In addition, it is common among the farmers to have employees, both full time and part time. For most, these employees are related to the scheme of farm relief workers in Norwegian agriculture.

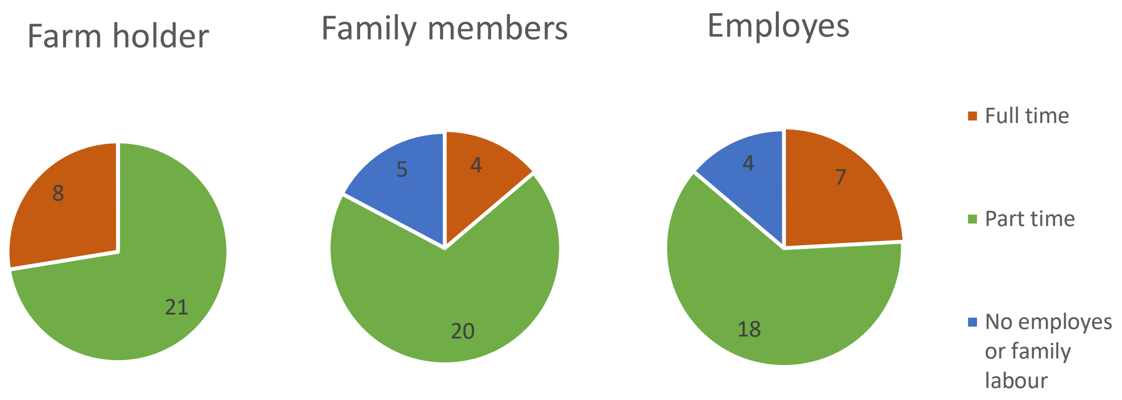


Figure 12: Farm labour strategy in the sample

The farmers in the sample have an age range between 21 and 70 years, where the majority is between 40 and 60 years old (Figure 13). Most of the farmers have a high school diploma in agriculture, and most of the rest have a university degree, where six are in agriculture and five are not in agriculture (Figure 14). Educational level does not seem to have much impact on how farmers themselves experience mastering implementing the robot. Further, many of them do not express a need for particularly good digital skills in order to manage the robot. Despite the fact that this is not seen as a necessary skill among those who have a robot, it is rather obvious that they have a skill they do not even consider a skill, which is the interest in new technology. They are curious and searching for ways to improve their farming. However, some of the non-adopters have this interest too, but they are mainly non-adopters due to lack of resources to buy a milking robot. Nevertheless, many of the farmers told us they were concerned about not having enough digital skill before they implemented the robot, but in retrospect, they consider this a groundless concern.

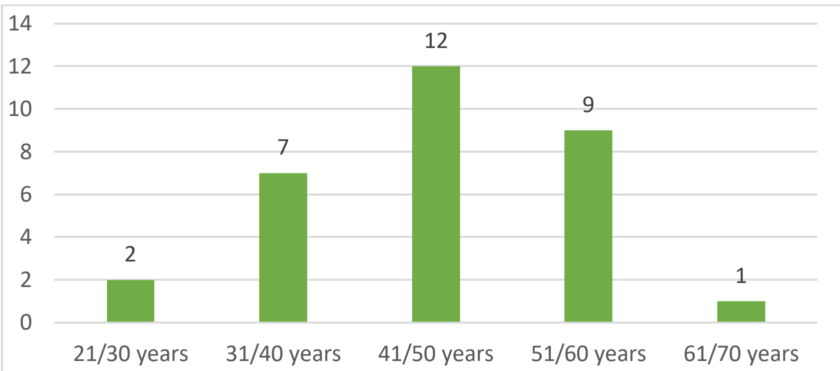


Figure 13: Age of farmers in the sample

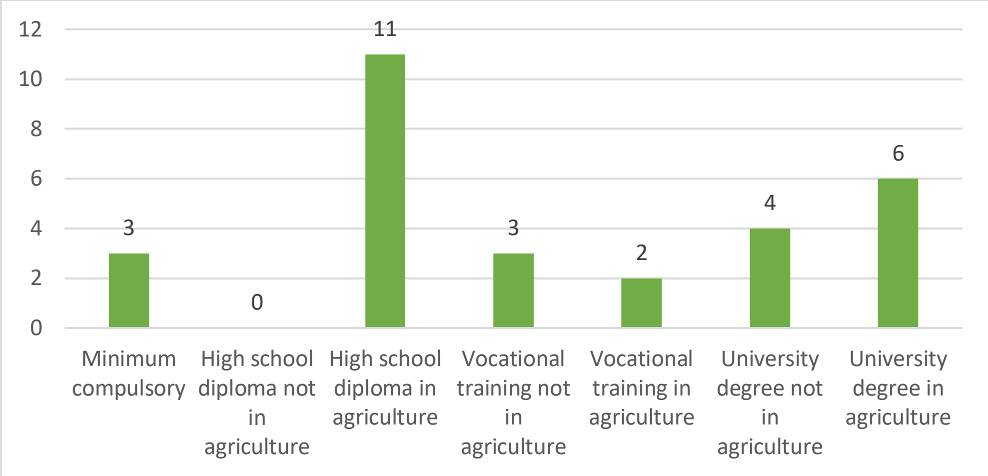


Figure 14: Education level of farmers in the sample

Related to the age range, most of the farmers have a long experience being farmers. More than half of the farmers have more than 15 years of experience (Figure 15). For many of the farmers with milking robots, this means that they already had considerable experience in farming without a robot before implementing the robot. Several of the farmers with a robot mention that part of their motivation for implementing robot was to make farming more attractive to the next generation, making succession more likely. Many of them also include not only their partner, but also their children in the decision. Four of the farmers report that they are certain of having successors, while the rest of the farmers do not know. No one reported not having any successor. Despite having succession as a motivation to upgrade the farm, it does not seem to worry the farmers much, and several mentioned other possible successors other than their own children in either neighbourhood or in the family. Besides, many still have some years left before retirement, and some of their children are too young to decide on these matters. In addition, several are concerned about not putting pressure on their children to take over the farm.

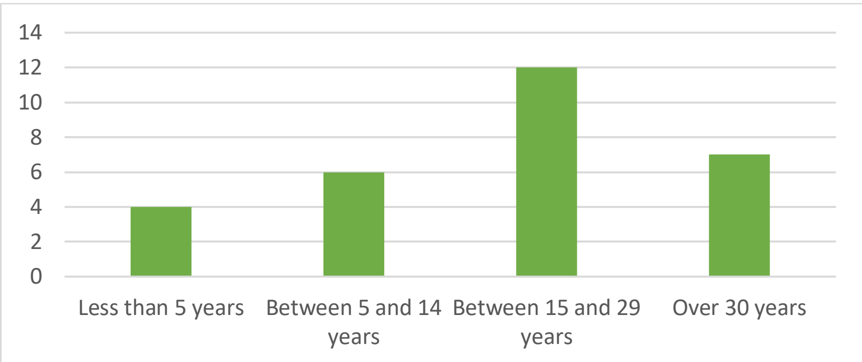


Figure 15: Years of experience being a farmer among farmers in the sample

To summarize, the average farm in the sample produces milk and meat, with mainly grassland crops and grazing areas. The farm has approximately 50 cows and between 40 to 80 hectares of arable land. The average farmer in the sample is a man between 40 to 60 years old, working full time as a farmer. He has a high school diploma in agriculture and has between 15 and 30 years of experience. Beside these farmers, the sample includes farms and farmers that differ from this picture; for instance, there are three female farm holders, one organic farm, and a couple of farmers who in addition to milk production are running agro-businesses based on tourism or "Green Care."

Farmers' attitudes towards innovation and change

The cooperative farmer-based organizations are the main provider of advisory services to the farmers in the sample (Figure 16). In this case, these are mainly Tine, Felleskjøpet and NAES. The second most common provider of advice and support are the input companies in the private sector, which in this case is mostly Fjøssystemer. A third main source of advice is neighbours and other farmers. Some of the farmers live in an area with a very active social environment among the farmers, and in these areas, the neighbours are some of the most important sources for advice and support, especially among co-adopters.

Overall, the nature of interaction between farmers and advisors are one to one, phone, email or SMS. The farmers are very diverse in what type of support they seek. The adopters mainly use the input provider specialized to their type of robot in questions regarding the robot (e.g. Felleskjøpet and Fjøssystemer). Some of them also use Tine for this, but this regards only a few of the farmers, as most of them use Tine on a more general basis as the main management advisor in dairy production. Although, in dairy production with AMS, most of the management is somehow related to the robot (performance/yield, feeding, breeding, etc.). Felleskjøpet and NAES are also often mentioned as providers of advice on farm management and development, but NAES is more often used specifically for agronomic issues. Felleskjøpet, in addition to their DeLaval expertise, is often used for advice in feeding.

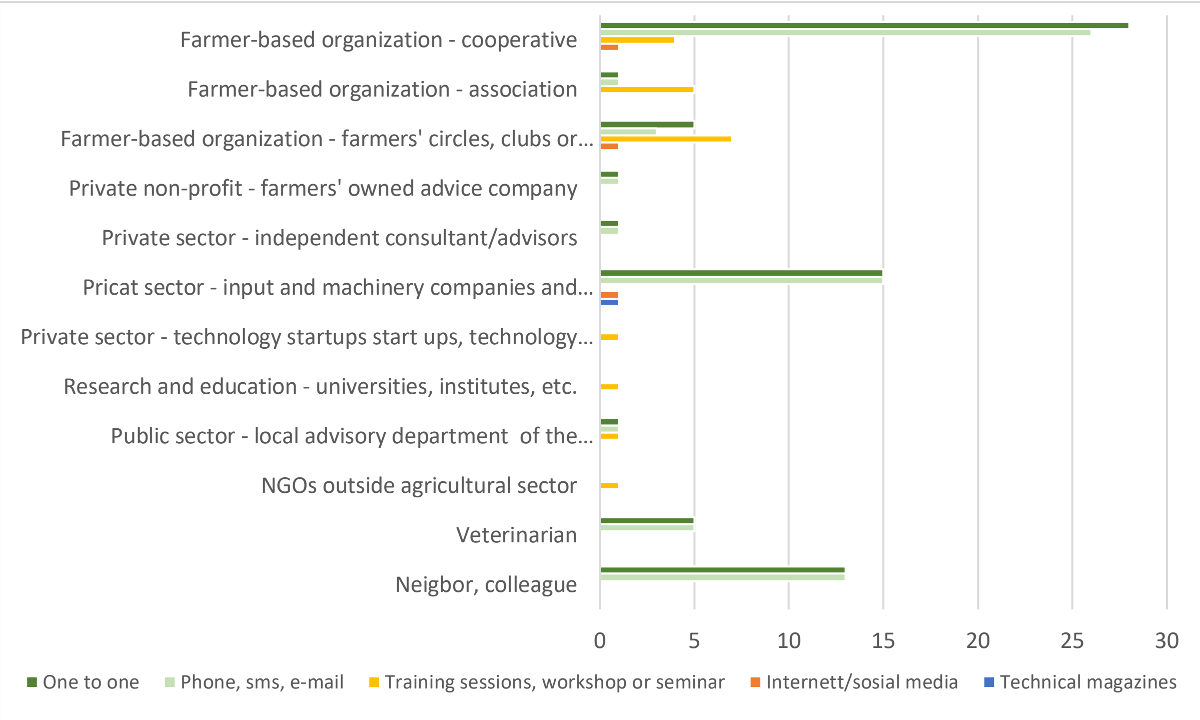


Figure 16: Who advises you about the current management and planning of your farm? And how is the advice provided?

The interviews did not give a general impression of dissatisfaction among the farmers with their access to support on a daily basis, although some mentioned areas where they were dissatisfied. In general, the dissatisfaction revolved around individual issues, such as poor chemistry on a personal level with an advisor, or the feeling of insufficient knowledge of an advisor, along with poor follow-up. Most farmers did not seem to experience this, and those who did expressed that if they were dissatisfied they just replaced the advisors.

A majority of the farmers expresses that knowledge about feeding and livestock management is the most important knowledge for them in their current management. For the adopters, the robot is important regarding livestock management, where their challenge is to interpret information from the robot, which makes it possible to be at the forefront when it comes to animal health, while also observing the animals' behaviour physically. Further, many mention agronomy (plant production) and economy (farm management) as important. The farmers generally acquire this knowledge through experience from work on their own farm, while also seeking knowledge from others (neighbours, advisors, etc.) (Figure 17). In addition, magazines (technical, agronomy, livestock, etc.) are a central source of knowledge about farm management for many of the farmers.

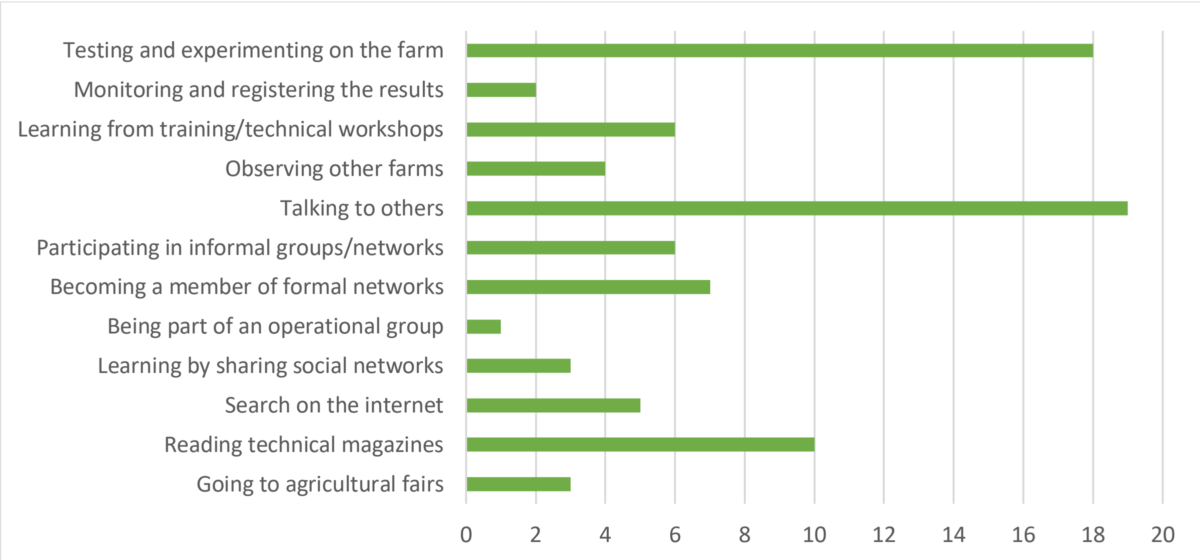


Figure 17: Learning process and activities undertaken in gaining knowledge and skills the farmers need for current management and planning in their farm

From interviews, it is possible to distinguish pioneers/early adopters, i.e. the ones that implemented the robot early. When it comes to late adopters, this can be the group of farmers implementing the robot later than 2015. However, it is perhaps not fair to categorize new and young farmers implementing robot in 2015 as late adopters. It can be that the farmers that have run a farm for many years and implement a robot in 2015 that are the late adopters.

Farmer innovation paths and trigger cycle change model

As presented in the case study descriptions, of the 29 dairy farmers interviewed, 20 farmers were adopters and 9 were non-adopters of the milking robot. The farmers interviewed describe the dissemination of the innovation in the focus region in a very similar manner. Many farmers have frequently quit farming in the region, and those who want to proceed expand, both in area and in production (milk quota). Overall, there are fewer farmers, but they perceive those who continue farming as very motivated, and in some areas in the region, there is a strong social environment among the farmers who are left. Several of the farmers told us they experienced almost a "contagious" effect in the areas where the robot first was implemented. Maybe because of factors such as competition, but also resource availability and/or that the farmers experienced in their own neighbourhood that the AMS-technology worked, several farmers in the same areas implemented the robot. As a result, it was created a strong environment for knowledge exchange in these areas. The farmers also have matching perceptions about why some do not adopt. It is often related to the need to upgrade the farm, along with prospects of succession. A farmer approaching retirement age, with a farm that needs upgrading and without someone to take over the farm, will not have any incentive to invest in a robot. Because implementing a robot is often about changing the whole farm system on the farm, e.g. from tie stalls to loose housing, there are often more costs related to the implementation than only buying the robot. The size of the changeover in restructuring both buildings, production size and management system is often too big for the farmers who are not certain of a continuous future in farming.

In addition to this group of non-adopters, there are non-adopters who are in a mixed situation eager to adopt the technology but lack the resources (capital, land, milk quotas, etc.). This can be one of the disadvantages of being a late adopter of the milking robot in Norway. The access to land can be scarce, especially if all the other farmers in the area have expanded and already acquired the land from the farmers deciding to quit in your area. Thus, farmers have no guarantee of access to land close to the farm, i.e. to rent or to buy. This scenario is exemplified by one of the three narratives (see 7.1.3), where a non-adopter tries to buy land areas nearby his farm during the interview. He needs more arable land in order to expand the farms' production, considering a future robot purchase. Due to the debt the farmer is going to incur when implementing a robot, he is dependent on having the resource base to increase his production. In an extreme consequence, the lack of resources may rather end up with closure of the farm, although, this is not a general tendency. Most farmers express that the milking robot is one of the reasons why so many in fact continue farming, and that the robot is helping to make it more attractive for the next generation.

The farmers, both adopters and non-adopters, mostly evaluate the milking robot as beneficial for Norwegian agriculture. They particularly emphasize positive effects on productivity, business competitiveness, worker health and well-being, as well as positive effects on the local community and societal issues related to rural development and local/national food production (Figure 18). The farmers interviewed do not evaluate the robot of being directly detrimental to many of the issues, but several point out the environment as an aspect where the robot can have a detrimental effect. The farmers' explanation of this is because of the loose housing concept. Larger livestock and more frequent milking can make it more difficult to utilize pasture areas, which may have an effect on the cultural landscape due to less grazing. Moreover, several of the farmers are critical to the structural changes of increasingly larger farms, which by many is assumed to be prompted by the entry of milking robots in Norwegian agriculture.

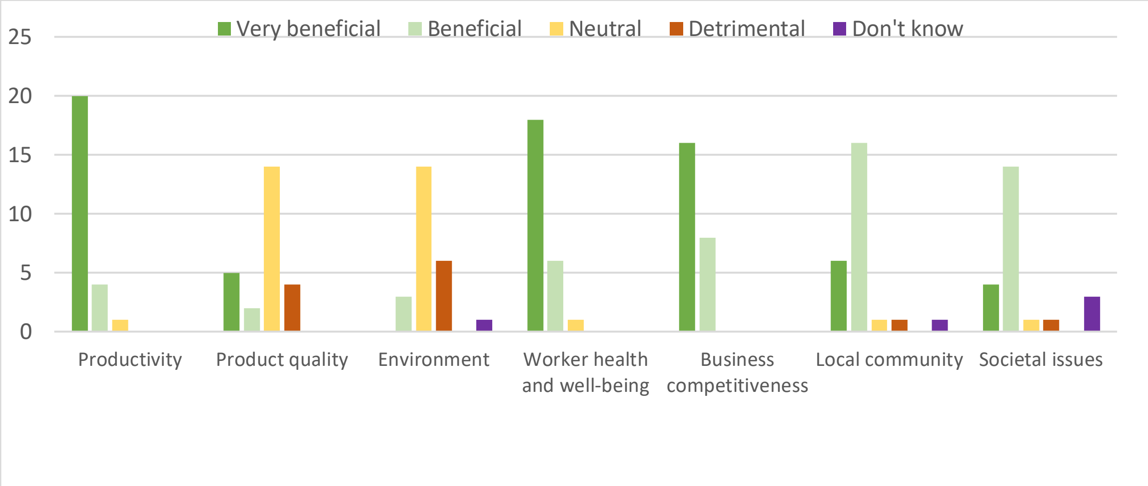


Figure 18: The farmers' evaluations on the effects of the innovation on their farm

The milking robot first came to Norway in 2000, and the timing of the farmers' awareness of the innovation corresponds to this event (Figure 19).

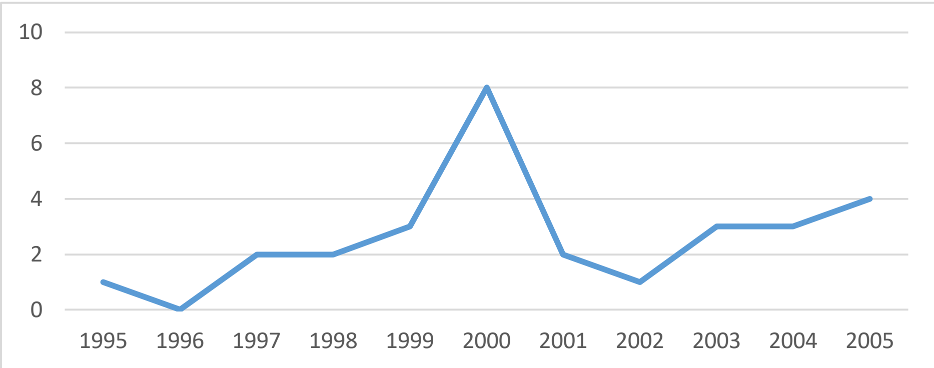


Figure 19: The year that the farmers became aware of the innovation

Most of the farmers became aware of the milking robot through the input companies Lely (Fjøssystemer) and DeLaval (Felleskjøpet), who they already had contact with in buying other kinds of equipment and machinery (Table 4). In the early 2000s, input companies, sometimes together with Tine and other farmers, organized visits to early adopters and held demonstrations of the robot. Several study trips abroad were also arranged to Denmark, Sweden, the Netherlands and Germany. It seems as word spread through arranging such demonstrations. The farmers that heard about the robot before year 2000 mainly read about it in technical magazines or saw it in ads from the input companies.

Table 4: Persons or entities that made the farmers aware of the innovation

Persons or entities that made the farmers aware of the innovation	Number of farmers
Farmer-based organization - cooperative	2
Private sector - input and machinery companies and industries	15
Technology start-ups, Technology companies	2
Research and education - universities, institutes, etc.	4
Business partner or farm contractor	1
Neighbour farmer or peer	5
Agricultural technician (informal, acting as an individual)	1
Other	2

The farmers are very diverse in whether they went directly from awareness of the milking robot technology to active assessment (Figure 20). For this fact, there are several explanations. For those who became aware of the innovation at an early stage, especially before 2000, it is natural that active assessment first started after some years, as the robot was not in use in Norway before the year 2000. A high degree of uncertainty also describes the first years of the milking robot in Norway. Because one had not yet seen whether the technology worked in the end, advisors and the dairy cooperative were very reluctant to recommend investing in the technology. Due to this, some of the farmers waited until the benefits became clearer.

Additionally, the timing of the awareness and the farmers' situation at the time is also highly relevant regarding how long it took between awareness and assessment. As mentioned earlier, investing in a milking robot often involves changes in the whole management system on the farm, including new buildings and expansion of production. Due to this, the farmers who thought of upgrading the farm anyway at the time of the awareness often went directly to the active assessment of the technology. While for others, thinking about upgrading was not as relevant, as it was not necessary to upgrade the farm at the time being.

In general, the adopters used varied time from awareness of the innovation until actually assessing it on their own farm, with a time span from 1 month to 21 years. Added to the aspects already mentioned, it must be noted that there are personal factors involved here too, as some of the farmers express clearly that they need considerable time before they decide on something, while others like to be in the forefront and not linger.

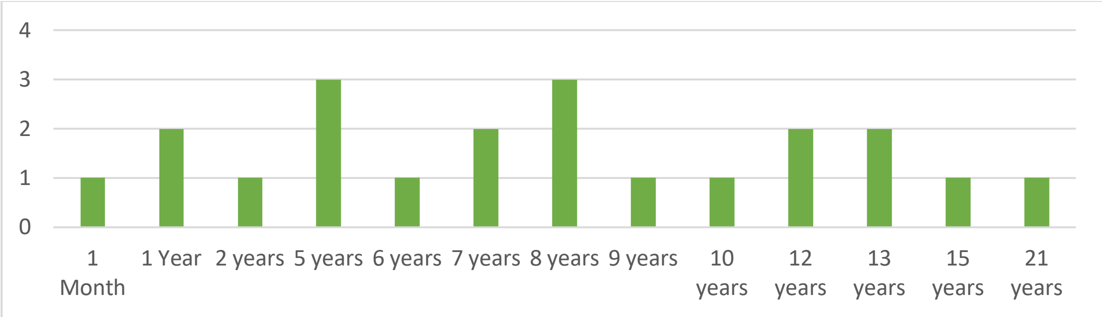


Figure 20: Years between farmers' awareness of the milking robot and active assessment

Many of the farmers describe comparable contexts and triggering events for why they started an active assessment of a milking robot on their farm. For a majority of farmers, it had to do with a situation where the farm in one way or another needed upgrading or expansion in order to be viable. Further, several farmers also describe a situation with either health issues, or family-related issues, that could not be compatible with the way the farm was managed. Due to this, the wish for more flexible working hours and the need for expansion or upgrading the farm are the main trigger events for the farmers to start assessing the milking robot on their farm (Figure 21).

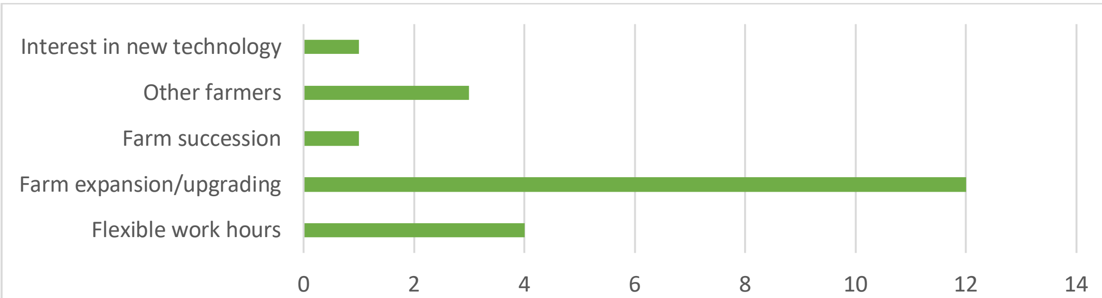


Figure 21: What made farmers think seriously about assessing the innovation on their farm (trigger event)

The active assessment stage is in this case the timeline from when the farmer actively decided to assess the milking robot on their farm, to the point where the robot is in operation on the farm (Figure 22). Most of the adopters used between 1 and 3 years from when they started active assessment of the technology until they actually started to use it on their own farm.

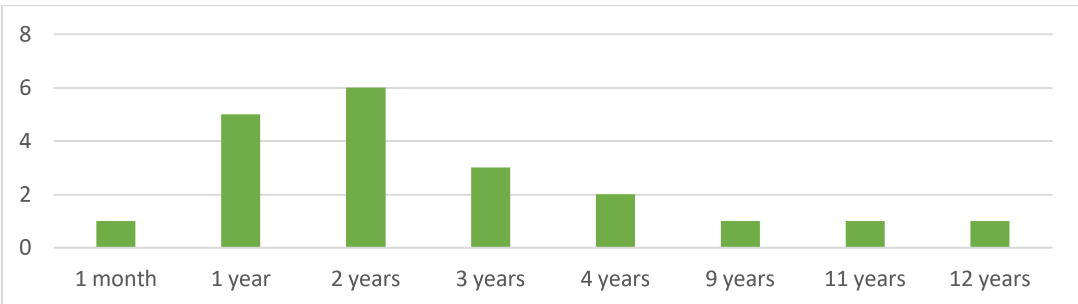


Figure 22: Years between farmers' active assessment and implementation

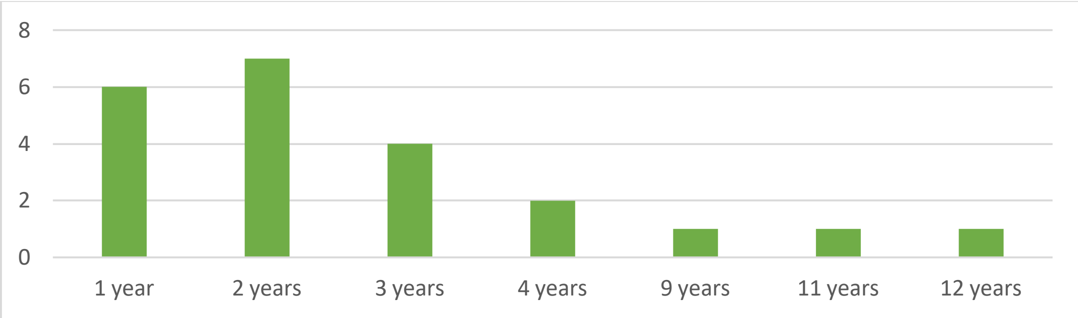


Figure 23: Years between farmers' active assessment and implementation

Farm accounting and management is the knowledge that clearly stands out as very important in the farmers' assessment stage. All the farmers highlight this area of knowledge. They point out that many pieces had to fall into place in the management plan to make it profitable to invest in robot technology. This included the costs of the robot itself, but also building costs and preparing the farm resource base with enough milk quota, number of cows and arable land. Other knowledge and skills mentioned by the farmers were the technology and digital skills. Several point out this area of knowledge, but most of them do not emphasize the need for knowledge, but rather underline that it is not necessary to know a lot about technology and data. The emphasis was rather on having the ability to attain knowledge about the robot from the advisors who are going to teach you how to use it. According to the farmers, the need is not to already have a lot of digital knowledge and competence, but the interest in technology and the skill to be open-minded in learning new things.

During the active assessment period, three main activities were involved in the process for most of the farmers, observing on other farms, talking to others (other farmers, advisors, suppliers) and reading technical magazines (Figure 23). All of the farmers paid visits to other farmers who already had implemented the robot to observe and attain knowledge of different ways to implement the robot. Visits were often arranged by the robot providers; Lely/Fjøssystemer, DeLaval/Felleskjøpet and SAC/GEA/AK-machines. Additionally, some of the farmers went on visits by themselves, often explained by not trusting in getting the whole picture of up- and downsides by the farmers picked out by the input providers. Several also emphasize that they wanted to talk to other farmers without the advisors and robot providers being present, to get a more honest version from the other farmers. Likewise, as mentioned earlier, often the neighbouring farmers' choice of robot helped to decide which solution the farmers chose. Due to this, the farmers also tell about many phone calls and informal meetings with other farmers in their local community about different ways of implementing robot technology. In addition to paying visits to other farmers and talking to advisors, suppliers and other farmers, several report that they took time to read a great deal about the robot technology and issues related to managing a farm with this technology in farm magazines.

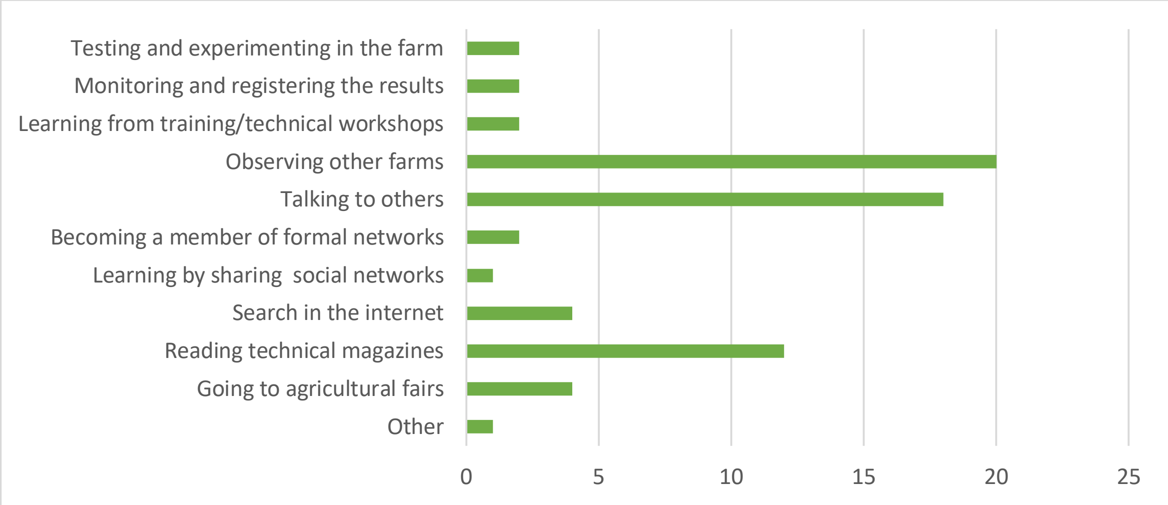


Figure 24: Learning process and activities undertaken in gaining knowledge and skills the farmers needed to assess the innovation

In view of the activities undertaken and knowledge needs in the assessment period, it corresponds to who the farmers had the closest contact with during this time. We see that farmer-based cooperatives (Tine), the input suppliers (Lely, DeLaval, SAC and GEA) and other farmers were most important with relatively frequent contact (Figure 25). The nature of the contact was one-to-one or by phone in all the cases. The farmers often started out with having contact with several of the input suppliers, and after a while, choosing one of them. The farmers often explained their choice based on the feeling of how trustworthy the suppliers appeared, based on both competence and knowledge, but not least personal chemistry. A few of the farmers only had contact with one of the suppliers from the beginning, often because they had from before connections to the supplier by having close family members, friends or neighbours working within these input companies.

Tine was the main supplier of covering the need of knowledge on farm management and economy, taking into account a comprehensive picture of the farm's resource base and further development in making the investment profitable. Here, of course, banks were also important, as all the farmers needed to take up a loan, but not many of the farmers used these advisors in the same extent as the other advisors. A couple of farmers used NAES instead of Tine in farm and building management, but two of the farmers who were using them as building managers ended up replacing them with other advisors due to lack of competence and personal chemistry. For others, NAES was important for advice about estimating the farms resource base in relation to the robot.

The farmers seem very satisfied with the support and advice they got at the assessment stage, especially from Tine and the suppliers. Although the farmers seem to be aware of the double role of the suppliers as both advisors and salespersons, as several reflected upon this in the interviews, emphasizing that they did not take on trust everything the suppliers presented to them.

Given the data from the interviews, there is a tendency where early adopters seemed to be very active in seeking advice and support from others, both advisors and other sources by themselves in the assessment period. This is presumably because of less developed services in the traditional advisory organizations in the first years the milking robot was in use in Norway. This does not necessarily mean these pioneers are using more advisors on a daily basis than the other farmers. On the contrary, some of them even use fewer advisors, both because they search for so much information themselves and because they have earned so much expertise using the robot that paying for advice related to the robot is seen as waste of money.

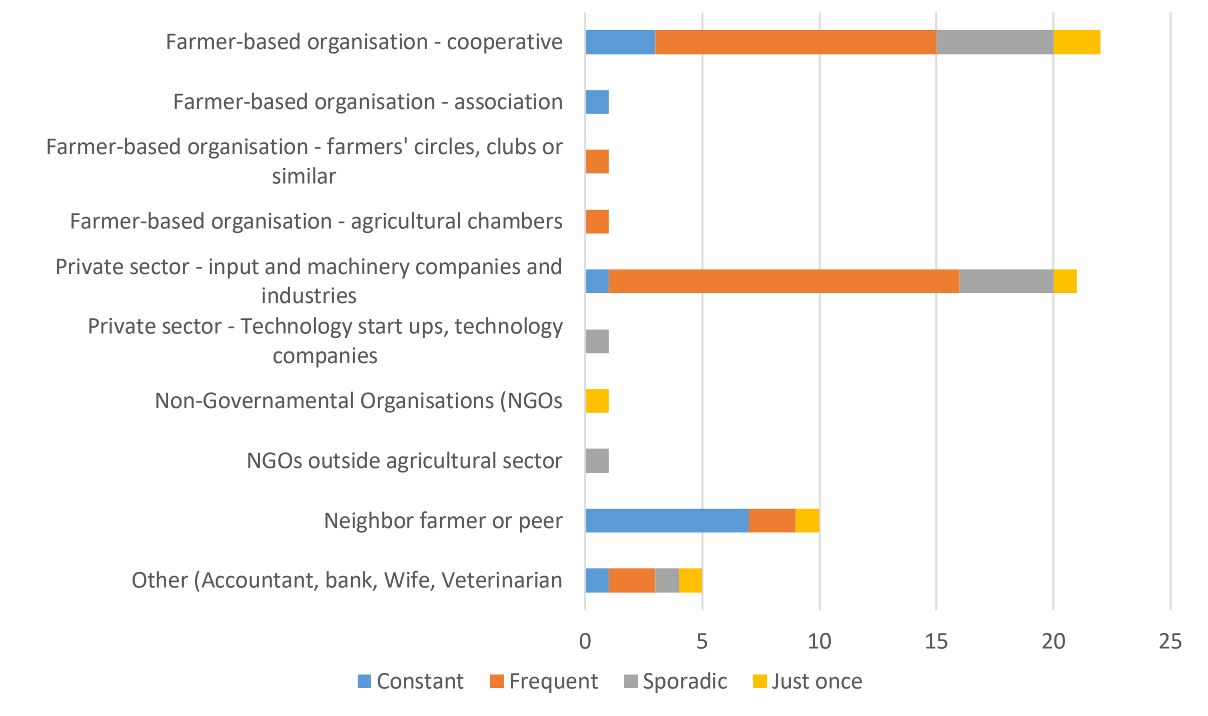


Figure 25: From whom the farmers received support to assess the innovation and the frequency of contact

Table 5 presents the factors, including costs, benefits, risks, and uncertainties, that the farmers considered in their assessment of implementing a milking robot. Most of the farmers mentioned that flexible working hours were the most important beneficial factor as part of their assessment. Concerning risks, costs and uncertainty factors, the high cost of the milking robot was the most important factor in their assessment. Investing in a milking robot, along with considerable rebuilding on the farm, often ended with the farmers left with a rather large debt. Therefore, much of the assessment was about reducing costs so that the debt would be as small as possible. This involved everything from construction costs, the barn design, the type of robot and service agreements, to the necessary size of production (number of cows and arable land). Considering all these costs, many of the early adopters were prepared by their advisors not to expect any income during the first five years with the milking robot.

Table 5: The factors (costs, benefits, risks and uncertainties) the farmers considered in their assessment of the innovation

Factors	Freq
High costs/Strategies to reduce costs	15
Increased quality of life	1
Flexible working hours	20
Future recruitment	2
Improved animal health	2
Increased production	3
Interesting technology	1
Loss of rented farmland/rented milking quotas	2
Getting sick or injured	2
Power outages	2

In general, some of the farmers found it difficult to distinguish between this stage and the active assessment stage. This was often related to the scope of the implementation that could involve buying land, more cows and build a new barn. For this reason, the farmers were asked how long the stage lasted from when the milking robot was put into operation and to the point they felt the start-up phase was over. Despite preparing the farm buildings and production for the robot is a part of the implementation, it became easier for the farmers to answer when putting the question in this way. As a result, the assessment stage and implementation stage merge in this case.

When asking the farmers about their main motivation for implementing the robot their answers correspond a great deal with both the aspects involved in the trigger event and the factors that were important in the assessment period, which are flexible working hours and upgrading the farm (Figure 26). Some also mention easier workload and succession as the main motivation.

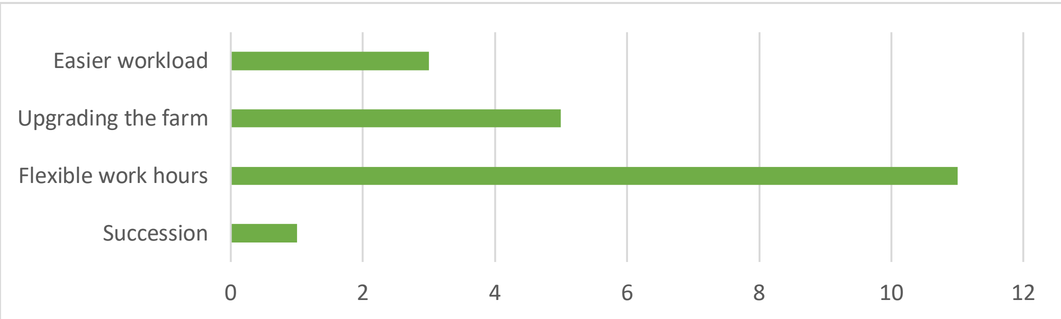


Figure 26: Main motivation for implementing the innovation

The farmers' stories of the implementation stage are not very diverse, and two main areas of skills and knowledge were identified as needed in this phase: technical/digital skills regarding the robot, and knowledge about the animals (especially related to feeding and milking). For many of the farmers, the implementation involved moving the animals into a new environment, maybe a different barn and from tie stalls to loose housing. Because of this, knowledge about animal behaviour in introducing them to both a new environment and milking in a box with machinery was important. Feeding, both when, where and which mix, was a central component in guiding the cow traffic through the milking robot and in making new routines in this early phase. Having the animals in a loose housing system was also new to a majority of the farmers, and they needed to learn how to manage the livestock in this way and spotting problems before they became too big.

The technical part of learning to use the robot is described as a bit overwhelming for many of the farmers, and they characterize the first days as chaotic and that they felt a bit alone, despite good support from advisors. In questions about how the farmers gained the knowledge and skills they needed, most of them combined testing and experimenting on their farm, with support from others, both farmers, advisors and more formal networks (Table 6).

Table 6: Learning process and activities undertaken in gaining knowledge and skills the farmers needed for implementing the innovation on their farm

Activity	Freq
Testing and experiment on the farm	11
Monitor and registering the results	1
Learning from training/technical workshops	5
Observing other farms	4
Talking to others	13
Participating in formal networks	12
Search on the internet	2
Reading technical magazines	4

There is general agreement on which advisors and support were most important in the implementation stage. Primarily, advisors and service personnel from the milking robot providers DeLaval (Felleskjøpet), Lely (Fjøssystemer) and others (e.g. SAC and GEA) were essential for the farmers in the implementation stage (Figure 27). These advisors, which are also salespersons of the robot technology, provide technical support and instruction for how to use the robot. Starting to use the robot is often an intense period of time that lasts a couple of days, where these technicians are present. Overall, the farmers are very pleased with the advice they got from these actors and found a lot of support in having someone to ask about anything related to the robot. Just a couple of the farmers mention that they experienced a varying degree of competence among these advisors. Several were particularly satisfied with the follow-up they got from the input providers 1-2 months after the start-up, where the technicians came to see how it was going and to repeat the instructions they went through during the first couple of days the robot was set in operation. Because of the chaotic feelings in the first days, many of the farmers benefited from this repetition.

The other key AKIS-actor in this period are advisors from the dairy cooperative Tine. Tine provides advisors, which are specialized in the start-up of milking robots, both DeLaval and Lely. According to the farmers, Tine and the input provider often operated in teams, where the input provider was responsible for the technical part, and Tine was responsible for livestock management, feeding and milking - all related to the specific robot. Regarding Tine, the farmers are more diverse in how pleased they are. The majority are very satisfied with the start-up "advisory package" provided by Tine, but some expressed a lack of competence on robot-related issues and that they lagged behind the input providers. This is especially applicable for the early adopters, which is natural because it took some time before the traditional advisory services managed to build up expertise in the technology compared with the input providers who sold the technology. However, there are also later adopters mentioning a difference in competence between the traditional advisory services and the input providers. Altogether, the farmers are mostly very pleased with the support provided by Tine in the implementation stage.

Tine and the input providers also have another role, often as organizer of putting farmers together in small networks of farmers with robots of the same brand ("robot rings"). The knowledge and support from local farmers are by many farmers put forward as very important. In choosing which robot to buy, many of the farmers said it was crucial which robot the neighbouring farmers had so that everyone could benefit from each other's experiences.

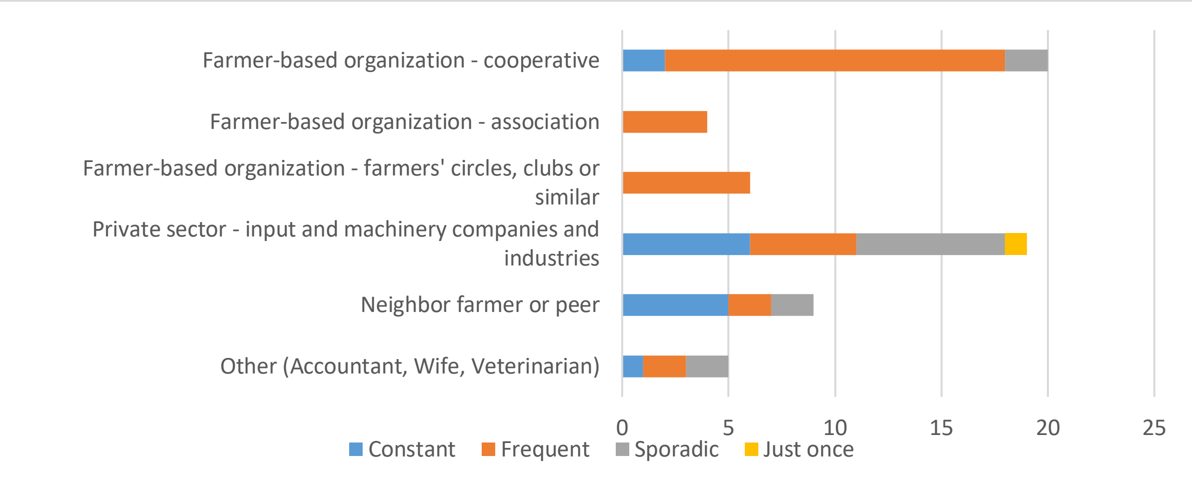


Figure 27: From whom the farmers received support to implement the innovation and the frequency of contact

As mentioned earlier, the milking robot set some structural conditions for the size of the farm. Therefore, it pays for the farmers to optimize the farm size and structure according to the robot's capacity. Several farmers mention that they have plans to expand slowly, regarding the number of cows and milk quotas, so the robot technology production potential is utilized. Of course, this only applies to those who have enough barn space and the opportunity to buy more milk quota. Others do not talk about expanding, but maybe replacing the robot they have and buying a newer model, in order to prevent many repairs due to an aging robot. There were also some farmers among the sample who had the opposite attitude because that they had upgraded the farm to this extent, they would not do further development on the farm for a while. One of them argued that he had invested in a robot to get more leisure time and flexibility, and if he was to start optimizing and increasing the production, it would just cause more work and it would be all for nothing.

Nine of the farmers interviewed were non-adopters of the milking robot technology, and three different main stories emerge from these 9 farmers. The three stories, or group of farmers, differ in their farm structure situation and attitudes towards the robot technology. Hence, they give a valid supplement to understanding the innovation process of milking robots in Norway. The first group are three farmers who are going to implement a milking robot within the next 1-2 years. Three of them because of generational change on the farm, because the younger generation is a pusher for upgrading the farm and applying new technology. In these cases, the former generation has not been very interested in the technology, but are now seeing it as beneficial for making it more attractive for the next generation. Thus, especially regarding more flexible working hours, making farming more comprehensible with family life, but also because of easier access to support schemes and loans than experienced earlier.

The second group includes four other non-adopters who want to implement the milking robot on their farm but lack the resources to do so. They have either no access or cannot afford arable land and/or milk quotas. One of the farmers in this group was going to implement a robot in 2017, but right before buying more milk quota, the market changed, and the milk quota prices went up -resulting in the farmer not being able to afford the quota and therefore not able to justify financially investing in a robot. Additionally, several lack arable land and find it difficult to get predictable land lease agreements. Making a big investment in land, milk quotas and a milking robot (which means a considerable debt), and the unpredictability of renting and not owning land and quotas, can be a big worry and a barrier for the farmers to implement a robot.

The third group, consisting of two of the ten non-adopters, are the only ones expressing that they definitely are not going to adopt the technology. They explain this by being a part of a joint farm, where they together with several other farmers are managing the farm, and therefore do not need the extra workforce that the milking robot represents. As many farmers' motivation to invest in the robot is to get more flexibility, these farmers lack this incentive, as they already experience that they have flexibility by sharing the farm work. One of them expressed that because of the lost workload due to implementing a robot, one of them would have had to quit farming, which none of them wishes to do. They also state that they like the milking operation and do not want to lose this connection with the cows. They are generally more critical of the structural changes towards bigger farms in Norwegian agriculture, placing this change on the milking robot, as those investing utilize the robots' capacity by expanding.

Regarding advisors and AKIS-actors, these ten farmers do not differ from the rest of the sample, and the non-adoption of the robot cannot be placed as explanations of lacking support or a different microAKIS. As described above, the non-adoption is more due to lack of resources or incentive. The non-adopters' descriptions of their AKIS are not less detailed or active than the farmers that are adopters.

5.1.2 Findings from the AKIS expert interviews and advisory organizations survey

Advisory landscape in the focus region

Based on the interviews we have identified that the advisory landscape in the region of Trøndelag contains advisory service from farmer-based organizations, farmer cooperatives, banks and public support, including private input suppliers that are perceived by the farmers as both salespersons and advisors (Table 7). As described initially, the main actors are: the dairy cooperative, TINE SA, with 9,000 dairy farms as members (at National level – in the region there are about 1500 dairy farms) that produce, distribute and export dairy products. The supplier cooperative Felleskjøpet Agri (FK) is the supplier of the most sold milking robot brand, DeLaval. In addition, Felleskjøpet is a provider of building, installation, feed concentrate, tools and machinery, as well as acting as advisors. Fjøssystemer is a private company and supplier of the second most sold robot brand, Lely. They also provide AMS

services and advisory services, in addition to building and installation for husbandry productions in Norway. Another AKIS actor is the Norwegian Agricultural Extension Service Trøndelag (NAES), which is a farmer-owned cooperative offering advisory service for farmers. In addition to these actors, the bank Sparebank I Midt-Norge (SMN) and the regional department of Innovation Norway are important actors for financing investments for farmers. Further, there are Nortura (the biggest meat cooperative), the local county administration, veterinarians and the farmer based organizations: Bondelaget and Bonde- og Småbrukarlaget (Farmers Association). At local level, the municipalities, there are often public administrations for agriculture. Historically this administration offered a free extension service for farmers. However, the last decades there has been a turn for this administration from extension service to emphasize on regulation and control of farming. The organization of the public administration is delegated to the municipality, and from that follows a variation in how this is organized and which tasks that are given most priority. In some situations there are inter-municipality cooperation, which may open for specialization among the employees, for extension service included. Added to these formal advisors, informal advisory suppliers are farmers' circles or groups, which are initiated by the more formal advisory services. However, the farmers themselves in local communities initiate some, where the farmers get advice from colleagues with similar productions and farms.
A trend that is not unique for Trøndelag is that advisory services have gone from being a free service, often based on the farmers' membership in different organizations, to costing the individual farmer. The former public extension service was free. There are various forms of costs, e.g. the input suppliers do not take payment for the advices they give because it is included as a part of the sale of products in the end. Although, all the big cooperatives Tine, Nortura, Felleskjøpet experience economic pressure, and now offer fewer free advisory services than before.

Table 7: Type of actors giving farmer advice

Type of actors	Actors
Farmers-based cooperatives	Tine, Felleskjøpet (DeLaval supplier), Nortura
Private farmers owned advice company	NAES
Farmer-based organizations	Bondelaget og Bonde-og småbrukarlaget (Farmers Association)
Private sector – input machinery companies	Fjøssystemer (Lely supplier), AK maskiner (SAC and GEA supplier)
Neighbours/colleagues	Farmers, partner, farmers circles
Banks and finance	Sparebank I SMN, SMN Regnskap
Public support	Innovation Norway, County administration, and local administration in municipalities
Others	Veterinarians

The main actors in advisory service in this case is the suppliers of robots and the dairy cooperative TINE. Further, the NAES and economy actors are also if high importance. These actors in this region constitute four different groups of advisory service. They are different organized and have different functions for farmers. Suppliers like Felleskjøpet are localized with 17 local sales points in the region with various degrees of salespersons for AMS.

Further, Tine, has organized their advisory service in a specific department at national level with regional representation. The advisory service from Tine must be characterized as embedded as the milk supply chain is the main activity for the dairy cooperative, even though there is a specific department.

Economy actors like accounting and bank. The accounting company is a kind of cooperative with local offices. In the region they are about 400 employees of which 70 is working with farmers. The bank has 15 farm advisors in the region and four insurance consultants.

NAES has about 60 employees in the region. They are dedicated to specific themes like grass, grain, economy, vegetables, machinery, constructions etc. A high degree of the employees has education at Master level.

These four groups of advisory services have different business models.

The suppliers are partly private stock companies and partly farmer owned cooperative. Their business model is based on sale of machinery and equipment. However, the investment farmers do often imply a kind of service agreement with the supplier, for example a service for the milking robot related to regular service and emergent service for a fixed annual price. In this case, the advisory service is a part of selling a product. However, there may be gliding switch to embedded service where the specific service is paid by hour/package.

Tine is a farmer owned cooperative for dairy farms. The main task for Tine is to give their dairy farm members a good service and a good price for the milk. The business model for the advisory service is based on a combination of covering costs from the milk price to farmers (i.e. lowering price to farmer), and paid services per hour/package. This balance is an issue for discussion in Tine and among the farmers. The development seems to be more demand driven advisory service and increased share of income from price per hour/package. For AMS can Tine offer a service package related to feeding and robot specific to what type of robot that is installed on the farm.

The bank has an important role to finance the investment at farms. Often the bank finances the major part of the investment. From that follows they are an important actor to discuss with the farmer and they can decide if the investment (in AMS) will be realized or not. They can also raise conditions that the farmer must fulfil, like ambitions of expansion to make the investment economic sustainable. The bank does not charge their advisory service but finance their staff through the margins for the transactions and loans to their customers. The bank must balance their ambition on supporting investment (margins) with the risk of failure (loosing money).

The business model for the accounting company and the bank is to be of benefit for their members. However, this financial sector is regulated and it is defined by law how to operate in the market. All their income is based on economic transactions with their customers or sale of service. Advisory service in economy questions is related to especially when the farmer consider investment in the farm, like AMS, and in analyses if economic results of the farm production. The role of an accountant is often to control the plan of investment. Is the plan sustainable?

NAES is an independent advisory service organized as a farmer owned cooperative. Their primary activity is to offer and sell advisory service to farmers. As a cooperative, the goal is not profit maximization but to increase benefit to the farmer. Sources for their income are member fees, sale of advisory service, income from external funded projects, support from member organizations and a few municipalities, and governmental support.

The actors' back-office activity varies. The suppliers and the economy actors most often have back-office activates related to competence development of their employees, that often are similar to other product sectors in their business activity. Further, they have tools and methods to manage and analyse data and information in the specific case for farmers.

The dairy cooperative Tine has a comprehensive system for data management and analysis at farm level to support farmer and his/her advisor to improve the farm management. Further, Tine also has a systematic education of new advisors employed. They also have an ambition to maintain and develop advisors' competence. This ambition may be more challenging to fulfil.

NAES have a national umbrella organization that coordinate some issues across the regional organizations. This also includes competence development for advisors, and networks that can support the single advisor.

Key players of advice for the innovation area in the focus region

The picture painted by the advisory landscape and key players for the innovation uptake of milking robots by the farmers in chapter 5.1 corresponds very well with the interviews with AKIS actors and advice providers in Trøndelag. Related to the awareness stage (the early 2000s for most of the farmers and advisors), the advisors tell about farmers who on their own, without the push from either advisors or suppliers, went abroad to explore the possibilities the milking robot could give them. Because of the uncertainty about the technology between both suppliers, farmers and advisors in Norway, the robot became known through these "forward-leaning" farmers' independent exploratory search for new technologies they could bring in to make their farming easier. These farmers talked to foreign suppliers and farmers about their experiences with the technology, read technical magazines about the new technology, and decided to bring it to Norway. After these first "movers", the input providers, Lely, DeLaval, SAC and GEA, through their national suppliers (Felleskjøpet, Fjøssystemer and AK-maskiner), were the first ones to unroll the technology for a broader market in Norway. Because of this, the farmers themselves, technical magazines and the robot suppliers were the most important actors in the awareness stage for both farmers and advisors, rather than the traditional advisory services, such as NAES, and the cooperatives Tine or Nortura.

The assessment stage is where most of the advisors and AKIS actors are more active. At this stage, the farmer needs several kinds of information and knowledge in order to make decisions for his/her future farm. Regarding the size and scope of investment the milking robot is it puts many different advisors in action. Tine, NAES, Felleskjøpet/DeLaval, Fjøssystemer/Lely, AK-maskiner/SAC/GEA, Innovation Norway, the banks and accountants are important in providing financial support and planning of the investment and future farm management as a whole. As described earlier, some of the actors (Tine, Fjøssystemer/Lely and Felleskjøpet/DeLaval) have bigger roles than other advisors in this period. Further, they are also central in the implementation stage, as they have developed customized start-up advisory services directly related to the different milking robots and have specialized advisors trained in the technology. Tine has advisors specialized on the most common robots, DeLaval and Lely, in addition to specialized advisory service on feeding, milk production and breeding related to dairy production with milking robots.

Overall, the advisors and AKIS actors perceive the milking robot as positive for the farmers. In the early 2000s when the milking robots first came to Norway, there was still a lot of scepticism about the uncertain effects of the milking robot. There was focus on the potential for a poorer overview of the animal herd, greater health challenges that would lead to poor animal welfare, less contact between the cows and the farmer and the vulnerability of relying on technology- whether it would be stable enough and work over a long period. Today, the AKIS-actors and advisors tell a different story, where no one within the dairy cooperative, or among the suppliers, are no longer sceptical of these aspects. According to advisor/salesperson from Fjøssystemer and Felleskjøpet, they have not sold a milking parlour since 2009-2010, only robots. The farmers who are upgrading their farm today do not ask whether to get a robot or not, they only need advice on which brand. According to the advisor/salesperson from Felleskjøpet, they sold 15-20 milking robots a year in Trøndelag before 2017, and today (2019), 30-35 robots are sold a year. The advisors express that they almost see nothing but positive effects on the farmer level due to more flexible working hours, a more effective production, less workload and increased income. Albeit, on the structural level of Norwegian agriculture as a whole, they see that the milking robot decreases the need for employment and thereby the number of people employed in agriculture, which they see as negative for the future sustainability of Norwegian agriculture. In addition, several see that the milking robot has led to an increase in large-scale production and that this is not possible in all regions of Norway. Another consequence mentioned by the AKIS actors is that the farmers are forced to expand and invest if they are going to survive, and not all farmers have the resources to do so, which results in them quitting farming. A recently follow up of public policy on this development is that Innovation Norway is going to prioritize financing smaller farm (15-30 cows) investments in milking robots, rather than the larger farms.

Transformation of advisory landscape

Due to the scope of innovation up-take of the milking robot in Trøndelag, some changes in the dynamics in the advisory landscape have emerged (this also applies to other regions in Norway with dairy production). Input suppliers are primarily salespersons and not advisors, but are used by farmers as advisors. The salespersons from both Felleskjøpet and Fjøssystemer tell that their personnel are perceived as advisors, but they emphasize that they are salespersons first. Although, they have a double role, and act as advisors because they have the first-hand knowledge about the technology. Additionally, they think the farmers appreciate the advice they get from them because they are practical and relevant for the farmers in their daily use of the robot. They do not find this double role as troublesome, first because the traditional advisory services now increasingly are paid services too, and second because the advice they give the farmers is trustworthy and cannot be bad advice since then they would lose all their customers. Despite this, the suppliers emphasize that they have to balance their role of both advisor and salesperson, and not be too eager to increase their sales because the most important is that the farmers' needs are met and see the expected results of the advice they get.

There are several challenges for the advisory services related to the rapid increase of farmers adopting milking robots in the region. One main challenge according to the advisors and AKIS actors is to keep up with the farmers needs for specialized advice. The farmers are more specialized now than before, in that they may have more knowledge than the advisors on certain areas while lacking some knowledge in other areas. For the traditional advisory service, they acknowledge that they have challenges in keeping up with the technological development. They see the need for the different actors to collaborate more across organizations, despite being competitors, in order to meet the farmers' needs for specialized advice in a range of different fields of farming connected to the robot. This may be a bigger challenge for the traditional advisory services (NAES and Tine) than for the input suppliers of the milking robots, who often are the ones with updated knowledge about new technology. However, the suppliers also see the need for more collaboration between the different actors in order to coordinate their advice to the farmers in providing them the "whole package" and not only bits and pieces.

Both the suppliers and the advisors point out that the traditional advisors may be more used by the farmers implementing robots today than the farmers who were early adopters. One of the advisors explain that the farmers who are implementing now are not among the most forward-leaning farmers and are more uncertain and have less interest in technology than the farmers that already have adopted the technology. Due to this, they require more support, not only from the suppliers, but also from the more traditional advisory services. This trend is also due to the traditional advisory services adaption to the new situation of increasing adoption of milking robots and meeting the farmers' needs for knowledge and support on this. However, the suppliers are not sure the traditional advisory services will manage to keep up with the future technological development, as they are the most updated on the technology and the farmers increasing requirements for expertise in the field.

5.2 The role of farm advice in the innovation case study, technological innovation cluster- electronic bells on sheep

5.2.1 Findings related to the farmer survey

During data collection, it was clear that the pasture group for farmers was not a new way of organizing sheep farmers in the region of Sogn og Fjordane. These groups have existed for decades mainly for farmers supporting each other in collecting sheep in the autumn and bringing them home. When the county administration decided to support sheep farmers in buying e-bells, they demanded that formalized pasture groups sent an application. The groups did not represent any innovation in itself, and there was not given any external support for the extension of the cooperation in the groups. The innovation was the new technology where farmers needed advice for implementation. The pasture groups had to cooperate in applying for money for buying the technology and results show that many of the members of the pasture groups have cooperated closely in implementing the new technology.

Farmer profile and farm structure

In the case from the region of Sogn og Fjordane, only three of the farmers in the sample are full-time farmers and only one of them is a full-time sheep farmer (Figure 28). The two full-time farmers have both sheep in combination with dairy production, and one produces cherry as well. Two of the farmers in the sample are retired, and the remaining farmers (16) combine farming with part-time or full-time work outside agriculture. They have various occupations such as teachers, nurses, engineers, carpenters, advisors, etc. Three of the farmers interviewed were women, and two of the farmers did not use e-bells (non-adopters). However, both of the non-adopters had participated in testing the bells but decided not to invest in the technology because the bells proved to be ineffective due to the lack of mobile network.

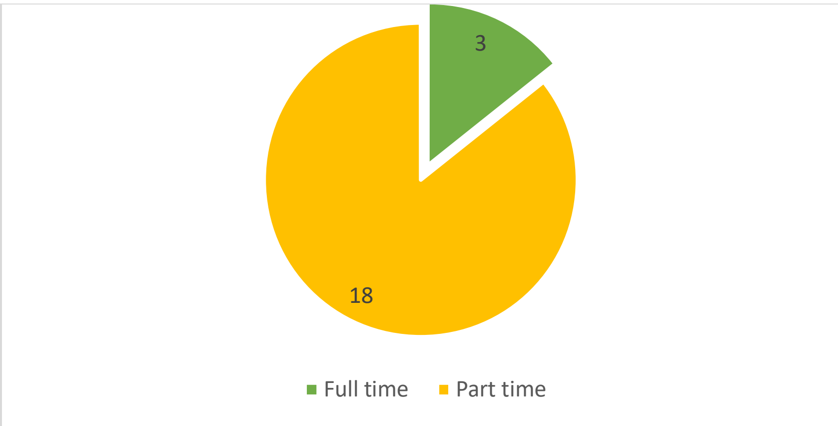


Figure 28: Farm labour strategy in the sample

As shown in Figure 29, grass for feed is the main production of all farms in our sample. Only one farmer grew other crops, and he was a full-time farmer with dairy and cherries as the farms main productions.

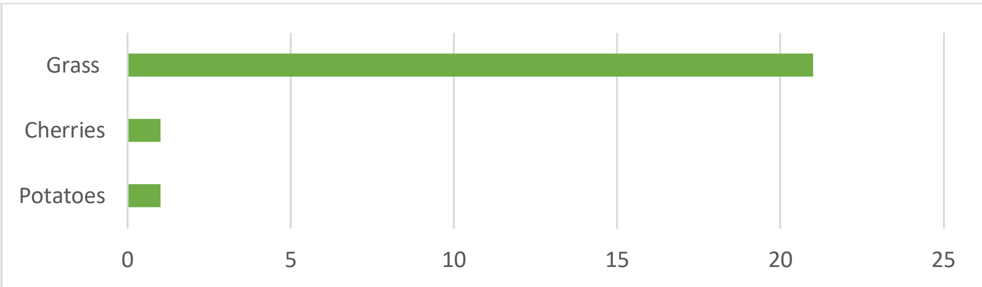


Figure 29: Crops produced by farmers in the sample

The number of sheep varies among the farmers. Figure 30 shows that the majority of the farmers in the sample have less than 50 sheep, and thus a very small herd, which is typical for hobby farmers or farmers with other main productions. The full-time sheep farmer had 140 winter-fed sheep. However, he had recently reduced his herd because of low prices due to overproduction of lamb and mutton. Three of the farmers had more than 150 winter-fed sheep, and the largest sheep farmer in the sample had 350 winter-fed sheep. The non-adopter and dropper had 40 and 30 sheep respectively.

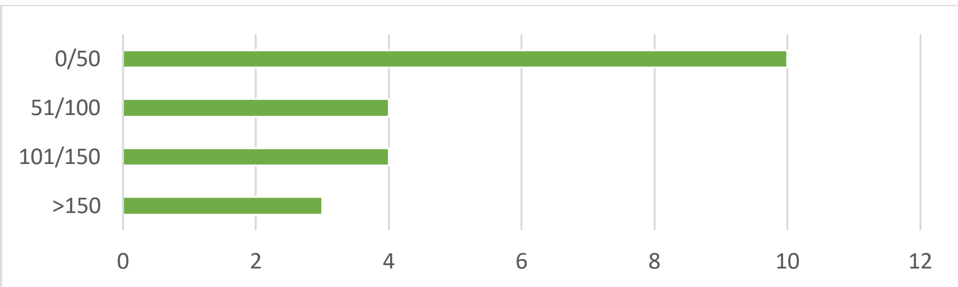


Figure 30: Number of sheep among farmers in the sample

As shown in Figure 31, the farms in the sample are small and similar regarding the total area of arable land associated with each farm. Sixteen of the farms have less than 20 ha of arable land including infield-grazing areas, and seven farms have less than 10 ha. The availability of grassland is the main limiting factor for the sheep farmers and determines how many sheep the farm can feed during the winter. When spring comes and the sheep have borne lambs, they are transported to the summer pasture. The pasture spans in some cases waste mountainous areas in relative proximity to the farm. Access and exploitation of these areas and their resources is the cornerstone of sheep production in Sogn og Fjordane and in Norway in general.

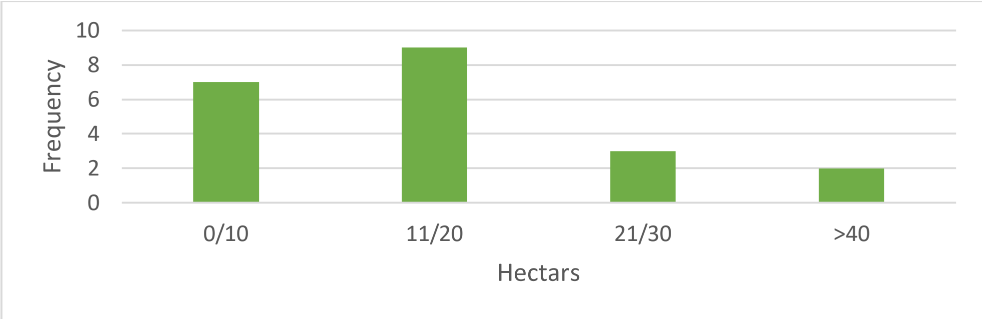


Figure 31: Total area of arable land (Ha) including infield grazing area

Figure 32 shows that only three of the farmers in the sample work full time in agriculture. The rest of the farmers have work outside agriculture, and two farmers are retired. Additionally, 12 of the farmers in the sample have income outside agriculture that is associated with the farm. Forestry and agro-tourism were the most common. The majority of farmers claimed that these activities accounted for less than 25 % of the farms' total income.

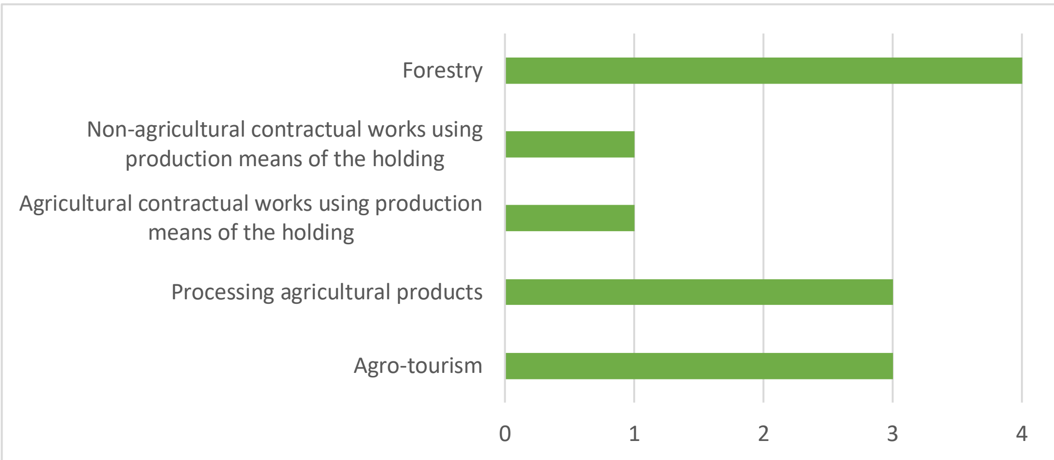


Figure 32: Alternate sources of income associated with the farm

The majority of sheep farmers in our sample (18) are more than 40 years old, and only three farmers are below 40 (Figure 33). This reflects the national average age among farmers in Norway, which was 53 years of age in 2018. Some of the farmers had managed to secure a successor, but many had not or were unsure whether their sons or daughters were interested in continuing the farm. A few farmers remarked that it was difficult for their children to settle down in the area because they were not always able to find suitable work for their spouses, especially if the spouse was not from the region.

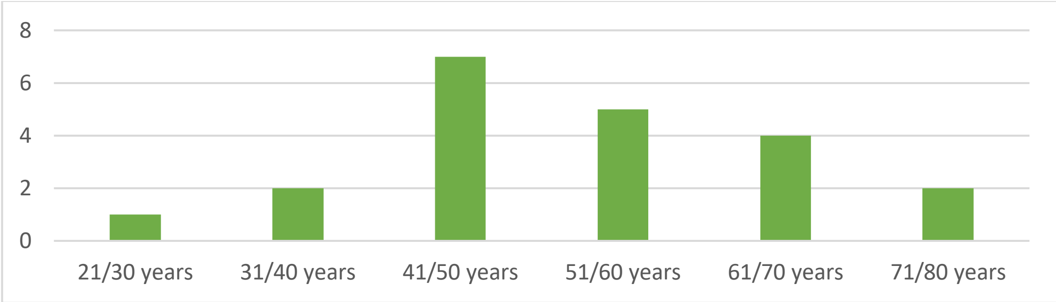


Figure 33: Age of farmers in the sample

All of the farmers in the sample had access to some kind of computer and the Internet. When asking about their computer skills, none of the farmers claimed to be especially computer savvy but expressed that they were able to handle computers to a fair extent, at least to meet their own needs. However, it was clear that some of the farmers were more proficient than others. The younger farmers and the farmers who claimed to be interested in new technology used computers and other digital devices more frequently and in a more advanced fashion compared to the farmers who were older or did not care for digital tools at all.

In Figure 34, we can see that farmers in the sample have a varied educational background. Seven farmers have a university degree, but not in agriculture, and represent the largest group. Altogether, 85 % of the farmers have a university degree or a high school diploma in agriculture or not in agriculture.

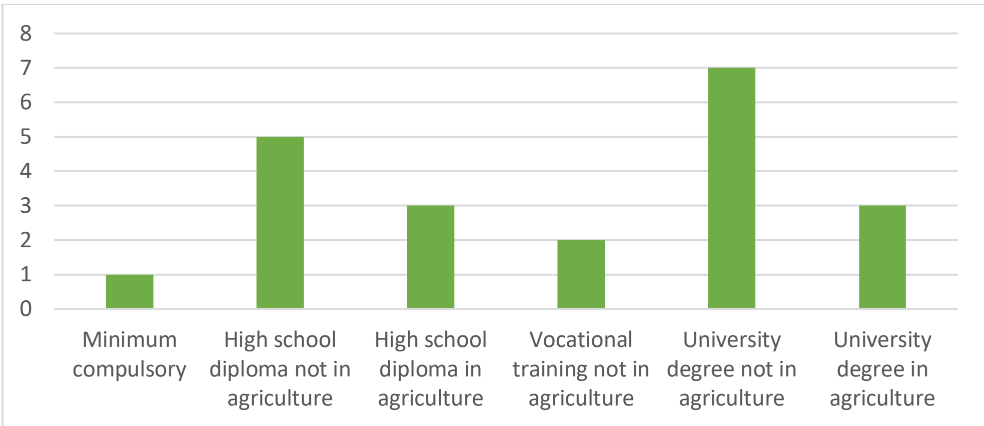


Figure 34: Education level of farmers in the sample

The majority of the farmers in the sample are experienced farmers. Eleven of the farmers have more than 30 years of experience; six farmers have between 15 and 29; and four farmers have between 5 and 14 years of experience (Figure 35). Thus, it is an experienced group of farmers in the sample. It is worth noting that the farmers who grew up on a farm or contributed to farm work when they were younger sometimes counted this work as parts of their farming careers. Therefore, the amount of experience does not necessarily mirror the time the farmers have run the farm.

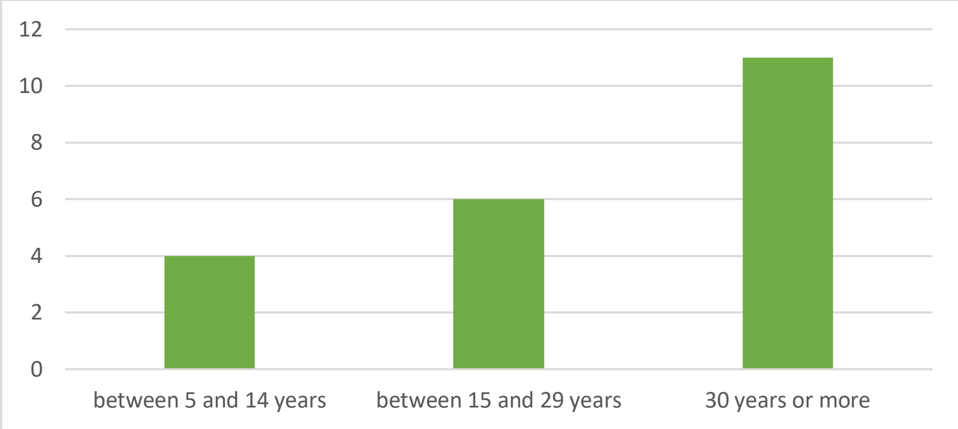


Figure 35: Years of experience being a farmer among farmers in the sample

To sum up, three of the farmers in the sample are full time farmers, and only of them is a full time sheep farmer. The remaining farmers have work besides farming or are retired. The farmers in the sample are quite old with long experience from farming. The education level is high but not necessarily from agriculture. Sheep farming is currently not profitable because of overproduction of lamb and mutton in Norway. However, most of the farms in the sample have small herds and practice farming as a hobby or as a part of a lifestyle or activity, which has always been present in the area. These farmers are not so dependent or focused on profit.

Farmer advisors and their attitudes towards innovation and change

Figure 36, shows who advise the farmers about the current management and planning of the farm. The most common advisors are the farm-based cooperatives in agriculture. These are Nortura for meat production, Tine for dairy farmers and mainly NAES for plant production. Only a few farmers mention Felleskjøpet, the input supplier. Neighbours and colleagues are the second most used advisors. It seems like farmers discuss all kinds of farm-related topics with neighbours and other farmers. One of the farmers jokingly remarked that the main impact of the e-bells was as a new conversation piece. Farmer associations and technology companies are the third most important source of advice. The majority of farmers mentioned the farmer organization "Sheep and Goat" (NSG), which is the national interest organization for sheep and goat farmers. NSG is in some cases closely connected to the local pasture groups. The members' organization arranges meetings for members on topics related to sheep and goats, and e-bells are regularly a topic on meetings. The technology companies are the two providers of e-bells. They advise the farmers on the use and maintenance of the equipment, as well as dealing with equipment that has malfunctioned. A few farmers also mention other advisors.

Figure 36 also shows provision of advice. One-to-one advice is the most common form of advice by nearly all of the providers. Phone, SMS and/or e-mail are also common, particularly with the technology providers. Their offices are located far away from the county making it time-consuming and costly to visit farmers and advice face-to-face. The farmer-based cooperatives and the farmer association arranges training sessions, workshops and seminars on topics relevant for the farmers, which are frequently used by most of the farmers in the sample. Sometimes Nortura and NSG invite the technology companies to join meetings to promote the e-bells and inform the farmers about new functionalities and other updates on the equipment.

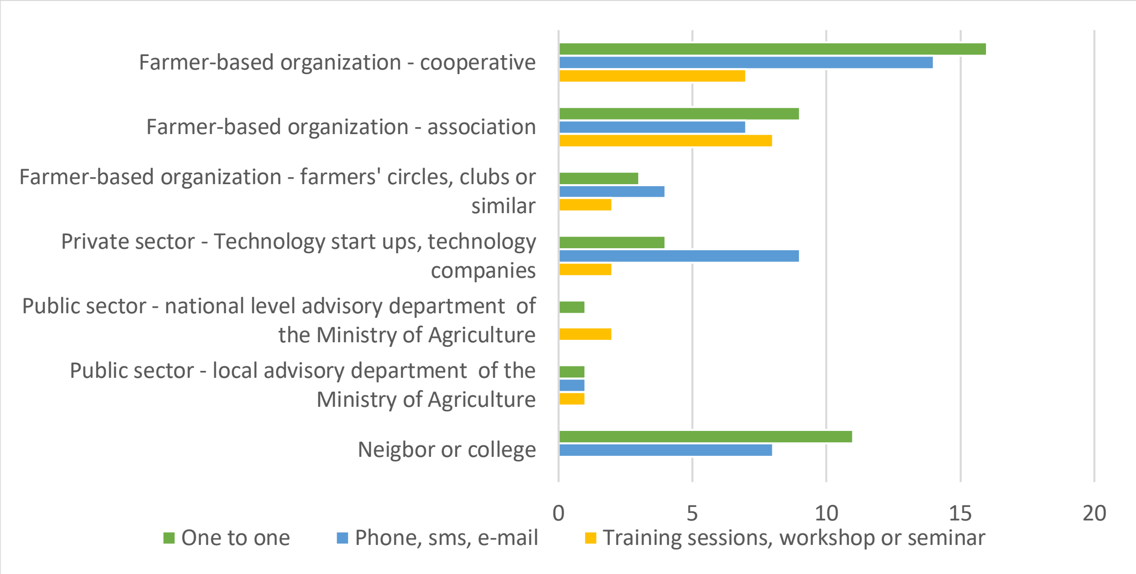


Figure 36: Who advises you about the current management and planning of your farm, and how is the advice provided?

How satisfied farmers are with advisors differs. The dairy farmers are quite satisfied with Tine, and the only cherry producer is very satisfied with NAES. However, the farmers in the sample are not satisfied with Nortura that is the only advisor on sheep production in the region. One female farmer stated "Advice on sheep is nearly non-existent (…)."Some of the farmers expressed that they did not feel the need for advice, and therefore they did not bother seeking it. Sheep farming was more of a hobby, and their herd was too small to gain any meaningful advantages from advisors. The sheep farmers were satisfied with the activities and meetings in the local farmers' associations and in particular in "Sheep and Goat". Most of the farmers attended these meetings. When it comes to the technology companies providing the e-bells, the responses were mixed. Some of the farmers were very satisfied, and others the opposite. One of the farmers stated "I am very satisfied with 'FindMy,' and their service-mindedness and support". Another stated that the company "provides bad service because they were not available on the phone". However, from the interviews, we learned that only a few farmers actually had direct contact with the technology companies. Most farmers got advice regarding the e-bells through other farmers or figured out the use themselves.

Charging the e-bells requires a separate piece of equipment and a common practice among the farmers is to share one or two charging devices within the pasture group. Some of the more tech-savvy members or the group leaders typically ended up being in "charge" of the charging devices. These farmers would often also be the persons who ordered the e-bells for the entire pasture group and who had the most direct contact with the supplier. As a result, these farmers accumulated the most knowledge regarding programming and practical use of the equipment. The other farmers in the pasture group would therefore use these farmers as their main advisors and contacted them if they needed help with the equipment instead of approaching the suppliers directly.

By far the most common activities for gaining new skills and knowledge is talking to other farmers and neighbours, as well as testing and experimenting on the farm (Figure 37). Nearly all of the farmers in the sample mention these activities as most important. Nearly half of the farmers mention becoming a member of a formal network as an important source of skills and knowledge and six farmers mentioned searching on the Internet. Only one farmer mentioned digital social networks as a source for learning.

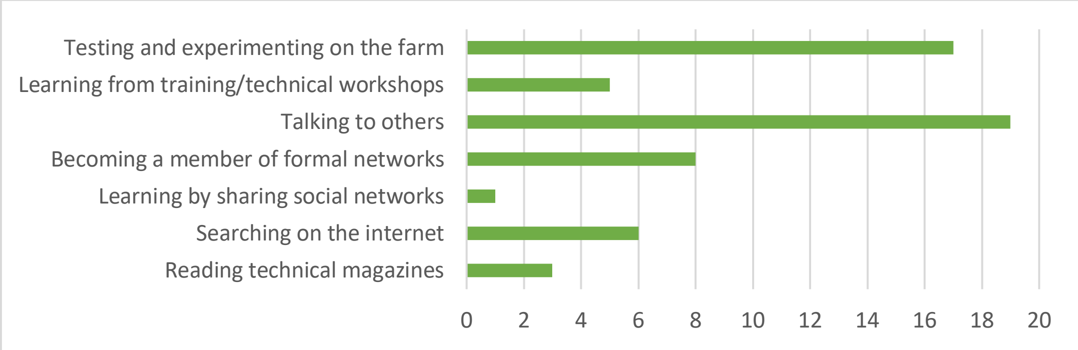


Figure 37: Learning process and activities undertaken for gaining knowledge and skills to address the farmers' need for current management and planning on their farm

Farmer innovation paths and trigger cycle change model

It was a common perception among the farmers we interviewed that older farmers were more reluctant to adopt new technology, such as e-bells. However, over half of the farmers interviewed were over 50 years old, and almost all of them had adopted e-bells. The farmers also pointed out that the farmers who did not partake in any of the activities in the pasture groups typically did not use e-bells. This is partly explained by the fact that e-bells have to be purchased through a pasture group to be eligible for subsidies, but also by the common dynamic of key pasture group members helping and advising the members in both preparing and using the equipment. When we ask the farmers why some farmers did not partake in the pasture groups, common answers were that they were not interested, not very social or more individualistic. Another point made by some farmers was that some pasture groups had a more challenging terrain. Where the terrain was easily available and straightforward, there was less of a need for e-bells. The pastures also differ according to loss of animals because of predators, and thus the need for e-bells.

The sheep farmers differ in how many e-bells they have within their herds. Most of the farmers fitted around 1/3 of the herd with e-bells; one of the farmers had e-bells fitted to half of the herd, while some only had between two and four e-bells. Ideally, farmers would have had e-bells on the entire herd, but because of the high costs, this was not an option. Some even considered having bells on 1/3 of the herd to be uneconomical. Whether this is true or not comes down to the nature of each farm's pasture, and the behaviour of the sheep. For example, farmers with herds that typically walk long distances and spread out found the e-bells more useful than the farmers whose herds went more together and shorter distances. One of the non-adopters described his herd in the last category and a terrain that was easily available and straightforward, and he did not feel the need for implementing e-bells.

As mentioned earlier some farmers were more familiar with technical equipment and found the equipment easier to implement. In many cases, these farmers had leading roles in ordering, charging and programming the bells for the other members of the pasture group. They were also the ones who typically had direct contact with the supplier on behalf of themselves or neighbours. This dynamic was present in all the pasture groups we interviewed and stood out as one of the most important factors for allowing farmers to adopt and implement the technology.

In Figure 38, we can see how farmers evaluate the possible effects of the innovation. Today, the farmers mention that the technology is still not fully developed, and the price is too high. Nevertheless, more than half of the farmers emphasize increased productivity through use. This they explain by the use of fewer resources to look after the sheep and that they avoid loss of animals. Many farmers also judge worker health and well-being as beneficial. It is easier to find the sheep, and you know where to look for them. It is not so much stress connected to collecting the sheep in the autumn. More than half think the use of the technology is beneficial according to business competiveness. This is connected to increased profitability, spending less time looking for the sheep and a higher survival rate. Some mention benefits for the local community because farmers get more motivated to use outfield pastures. It was also mentioned that it might be more interesting for the younger generation to take over the farms with the use of new technology. About half of the farmers mention a positive social effect when some pasture groups increase contact and cooperation between members.

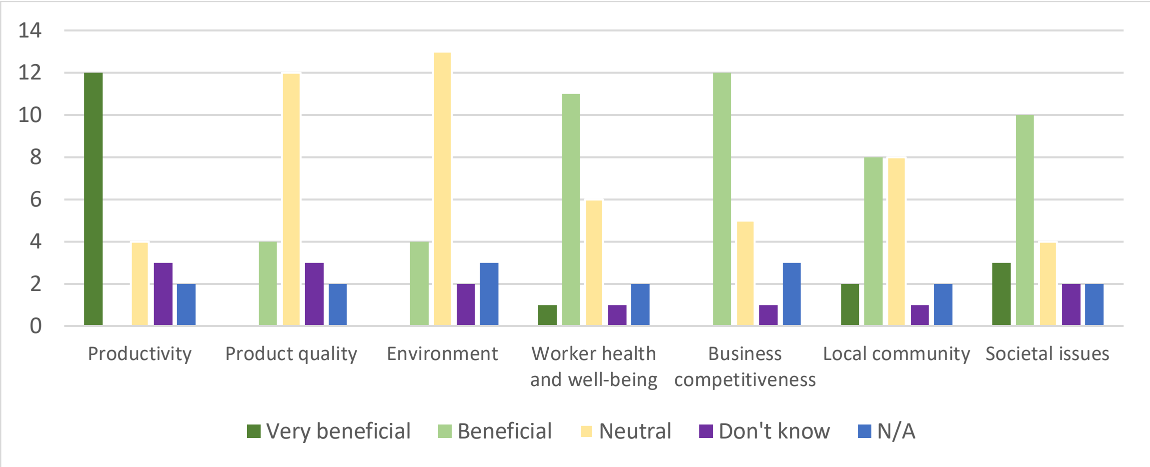


Figure 38: The farmers' evaluations on the effects of the innovation on their farm

Most farmers in the sample heard about the technology around 2010 when the county administration started the project to encourage farmers to use e-bells (Figure 38). Then, many meetings were arranged to inform about the possibility to test e-bells in municipalities where farmers had experienced loss by predators in the last year. Usually, the organization NSG and Nortura arranged meetings. One farmer, a pioneer, was aware of the technology already in 2006, and started to test very early. The rest of the farmers got information around 2012-2013.

The project to encourage farmers to test e-bells was established by the county because of a high loss of animals in some municipalities in 2009. For some farmers, this was the trigger event. Others emphasize the possibility for the new technology to control the animals' location and to more easily find them in the autumn, and thus decrease loss in that way. Some also mention that the use of new technology is a trigger in itself. In 2010, only farmers located in areas with a high loss of animals were offered to buy e-bells at a reduced price. Later, around 2012, most pasture groups in the county got the same offer. This is the reason why there are two peaks in the curve in Figure 39.

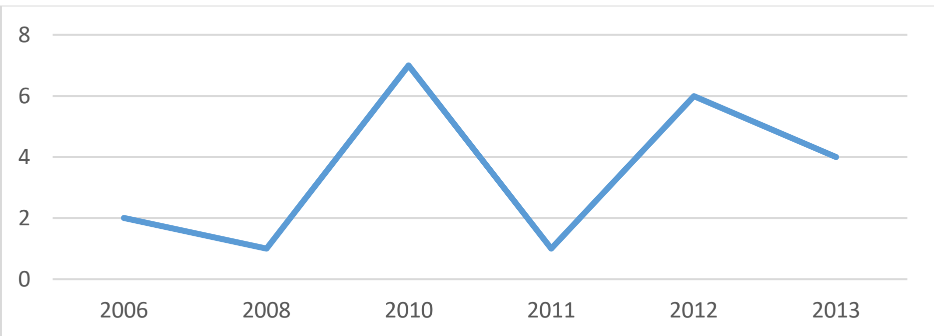


Figure 39: The year that the farmers became aware of the innovation

The awareness stage

Farmers became aware of the innovation for the first time by talking to other farmers in the pasture group, in farmers meetings arranged by NSG and Nortura, where the two technology companies presented the innovation when they joined such arrangements (Table 8). Four farmers mentioned the county administration as a source. When the county administration offered e-bells at a subsidized price, it was interesting for farmers to test the e-bells.

Table 8: Persons or entities that made the farmers aware of the innovation

Persons or entities that made the farmers aware of the innovation	Freq
Farmer-based organization - cooperative	3
Farmer-based organization – association (NSG)	10
Private sector - input and machinery companies and industries	2
Private sector - technology start-ups/ companies	6
Public sector - national level advisory department of the Ministry of Agriculture	4
Neighbour farmer or peer	6

Figure 40 shows the time between when the farmers heard about the e-bells and actively started to assess the use of the e-bells. Eight farmers started to assess use a very short time after they heard about the e-bells. The reason for this short time is that the county administration started the project to encourage farmers to test e-bells in 2010, and informed the farmers about possibilities to test e-bells for the same season. Other farmers spent 1-4 years assessing use. One reason why some spent more time might be that they did not receive an offer to buy at a subsidized price the first year and thus had to wait for that possibility. Another reason may be that some farmers were not so motivated when they first heard about the e-bells, but they experienced a contagion effect from farmers that already used the e-bells.

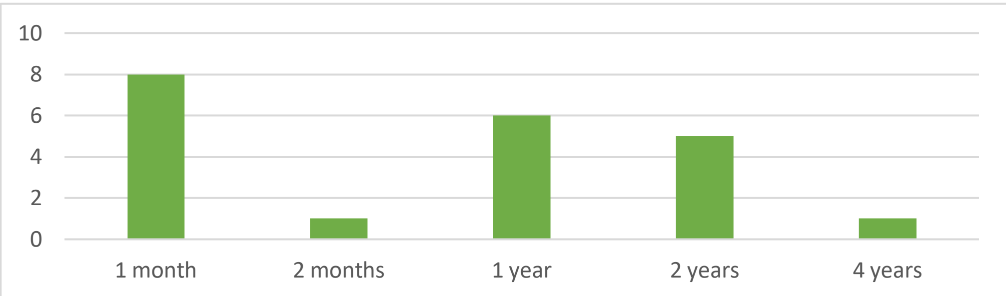


Figure 40: Length of the awareness stage

The assessment stage

Many farmers saw the potential of using the new technology to save time looking after the sheep and to have better control of the sheep (better management of livestock on rangeland) (Figure 41). As mentioned, some farmers were also interested in the new technology, and this was an important part of the assessment. Farmers also mentioned the fact that the innovation was subsidized as an important part of assessment and the possibility to join the pasture group in this activity. In this case, the assessment mentioned above can be the first phase of assessment of the technology. The other phase of assessment may be when the farmers bought a few e-bells for testing them. For testing them, they had to implement the bells, thus assessing and implementation happened at the same time. Despite the high price, farmers could afford to buy a few e-bells for testing. If they received some financial support for buying some e-bells, it was not a major issue.

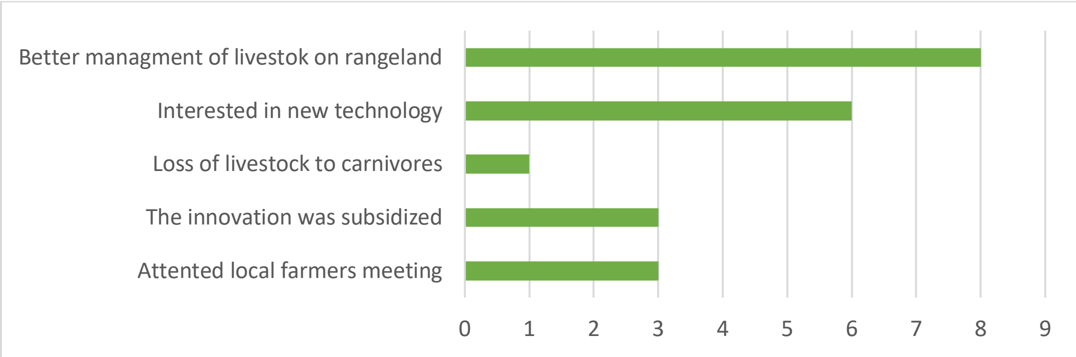


Figure 41: What made farmers think seriously about assessing the innovation on their farm (trigger event)

It might not be easy for farmers to answer the question of years between active assessment and implementation for the reasons mentioned above. When farmers started testing some e-bells, they (at the same time) had to implement the e-bells. This may be the reason why we have a range between one month and four years in the answers (Figure 42). According to answers from farmer interviews, we see that farmers usually buy e-bells for one year for testing and then decide if they want to continue buying more e-bells the next year or not. The two non-adopters tested the Telespor e-bell one year and decided not to invest in or use e-bells. The rest decided to buy some more e-bells the next year. It is possible to say that most farmers use one year of testing/assessing the bells and then implement the next year. It varies a lot how many bells the adopters have implemented.

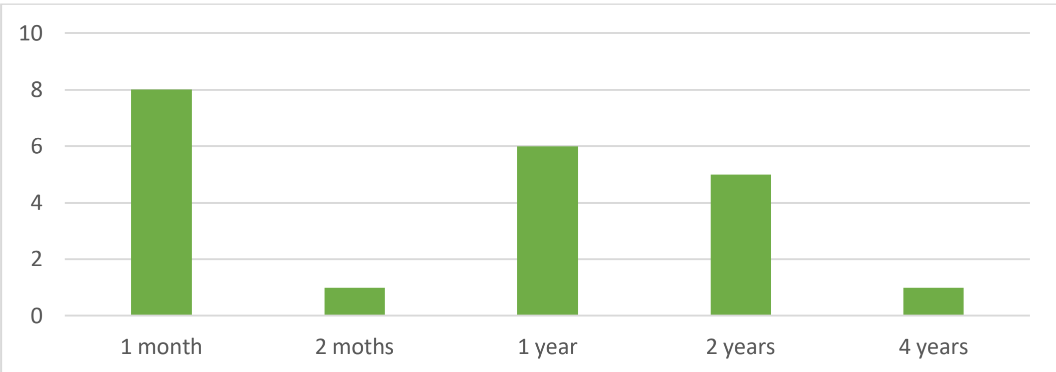


Figure 42: Length of assessment stage

Figure 43 shows learning processes undertaken in gaining knowledge and skills for assessing the innovation. Some of these activities may have been undertaken before the farmer started testing the technology, but it also includes testing of the e-bells. Sixteen farmers learned about the innovation by talking to other farmers and by testing the e-bells on their own animals. This was the farmers' most common way to gain knowledge about the technology in the assessment phase. Other farmers with similar pastures have gained very relevant experience. However, to be sure about the effects, the farmer has to test on their own pasture. Additionally, seven farmers mention searching on the Internet and reading technical magazines to gain knowledge and skills.

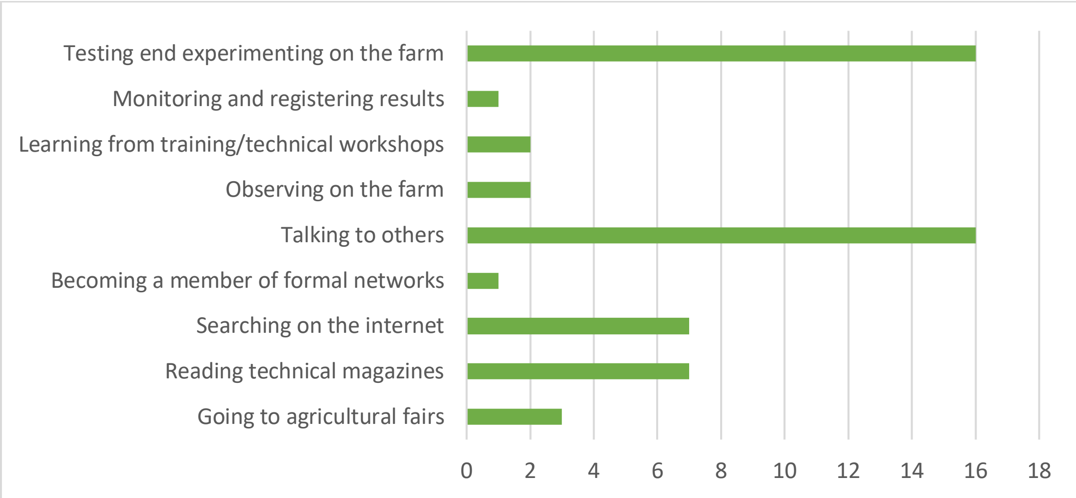


Figure 43: Learning processes undertaken in gaining knowledge and skills the farmers needed to assess the innovation

Farmers received support to assess the innovation from different sources, both the assessment phase before testing the innovation and during the test phase. We think the answers in Figure 44 below covers both these assessment phases. Fifteen farmers received support from NSG, eight of them frequently. Twelve mention the two technology companies as support actors to assess the innovation. Only four farmers have had frequent or constant support from those, most have had sporadic contact. Six farmers mention neighbour farmers as important support for assessing the innovation. Four of these farmers have had constant support from neighbours. Four farmers mention Nortura that represent the farmers' meat cooperative.

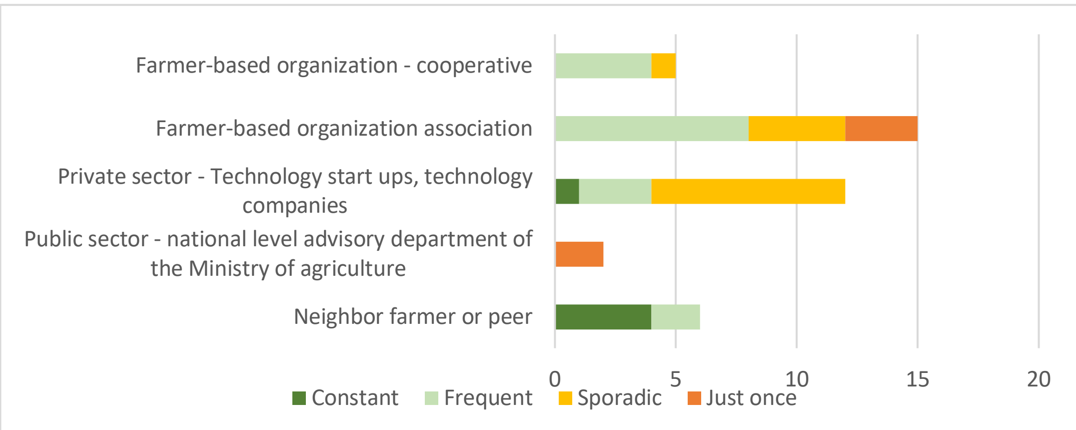


Figure 44: From whom the farmers received support to assess the innovation and the frequency of contact

Farmers considered different aspects when assessing the innovation. From Table 9, we can see that better livestock management was mentioned by 20 farmers as an important condition when assessing the e-bells. Twelve farmers mentioned that subsidizing the e-bells was important. On the negative side, 11 farmers mentioned malfunctioning equipment.

Table 9: Which factors (costs, benefits, risks, and uncertainties) the farmers considered in their assessment of the innovation

Factors	Freq
Viable due to subsidies	12
High costs	4
Interested in new technology	3
Better livestock management on rangeland	20
Malfunctioning equipment	11
Poor cell phone reception in the area	2
Equipment durability	3

Implementation stage

As mentioned, the farmers have to implement the technology to test if it is functioning, i.e. they have to test and implement at the same time. Some spend 1-2 years of testing before they decided to implement more bells or not. The main motivation for implementing the innovation was better management of livestock on rangeland (Figure 45). In addition, interest in new technology was an important motivation for five farmers. One farmer mentioned that he expected the technology to improve and that using the technology was important to secure improvement.

As mentioned earlier, some farmers have only a very few e-bells, so the technology is implemented on a very small part of the herd. A small rate of implementation is justified by costs and lack of need. Many farmers would like to use more e-bells, but the high cost prevents them from investing. One farmer hopes the producers find new ways of using the technology. A broader market will reduce price and make it economically sustainable to buy more e-bells.

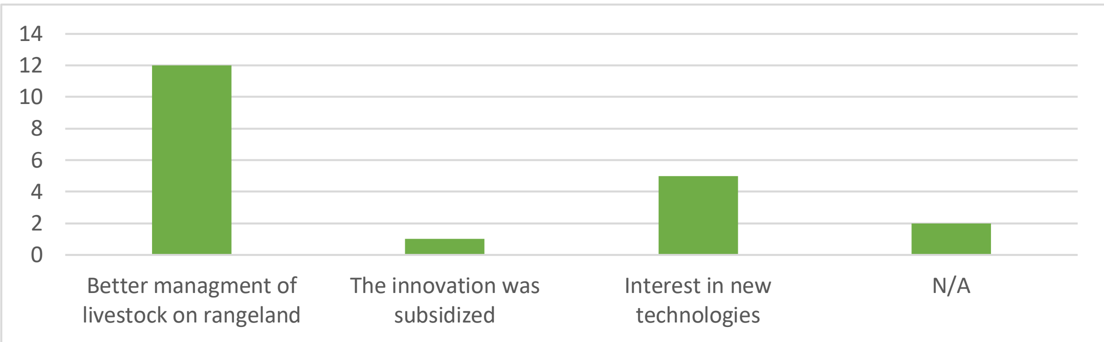


Figure 45: Main motivation for implementing the innovation

Table 10 shows activities undertaken in gaining knowledge and skills for implementation. Naturally, the same activities are undertaken as in the assessment phase. The majority of the farmers talk to other farmers, and they test and experiment on the farm to gain knowledge and skills to implement the innovation.

Table 10: Learning processes and activities undertaken in gaining knowledge and skills the farmer needed for implementing the innovation on their farm

Activity	Freq
Test and experiment on the farm	18
Learning in training/technical workshops	1
Observing on the farm	2
Talking to others	19
Becoming a member of formal networks	4
Searching the internet	6
Reading technical magazines	2

Three actors stand out when it comes to support implementing the technology. It is the farmer-based association, NSG, the technology companies and neighbouring farmers (Figure 46). Traditional advisory services support neither assessment nor implementation of the technology.

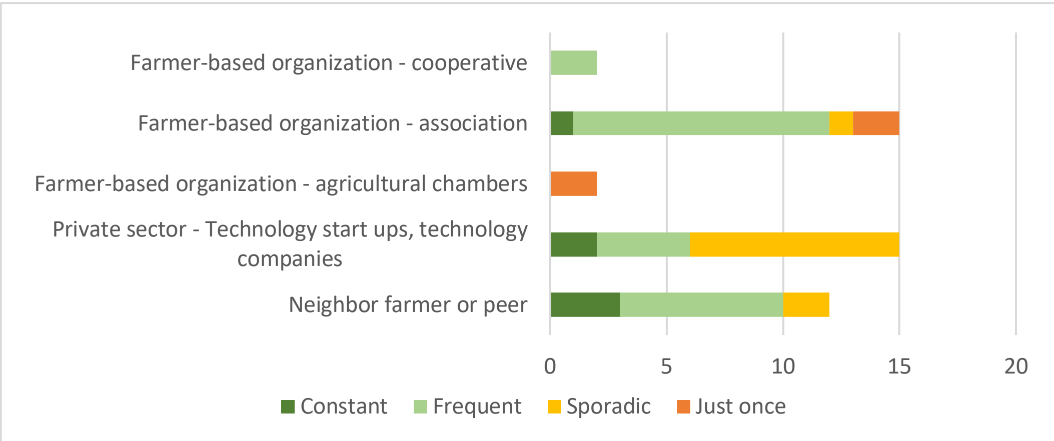


Figure 46: From whom the farmers received support to implement the innovation and the frequency of contact

Farmers that find the technology useful hope and think that the technology will develop and the price will be reduced so the benefit and use can increase. If this happens, they will increase the use of e-bells.

One group of non-adopters are old farmers that do not want to invest in e-bells because of price and/or they are not interested in new technology. This group of farmers are not potential adopters. The second group of non-adopters consists of farmers that may see potential in using the bells if the technology and the equipment improve and the price is reduced. The non-adopter also consists of a third group of farmers that do not see the potential in use because the pasture is straightforward and the risk for loss is small. We do not see that lack of support is a reason why some farmers do not adopt the technology. The potential adopter in narrative 7.2.3 expresses that if the situation changes and he starts to lose lambs, he will assess the implementation of e-bells. Many adopters point to the price of the e-bells and express that they would buy more bells if the price reduces.

Farmer innovation micro-AKIS

What we can see in this case is that the new technology triggers some farmers because it can reduce some challenges in sheep management. Some farmers tested or assessed first one technology (Telespor). This e-bell did not function in all areas because of lack of mobile network coverage. When

a new technology was introduced (FindMy), based on satellite, this represented a new trigger for farmers that did not have mobile coverage. They assessed the new technology, and some decided to test (and implement) the technology on a few animals. After assessing for one or two seasons, many farmers implemented some more bells on the herd. Among farmers that had implemented the technology, on average 10 % of the herd used e-bells. If the technology develops and/or price is reduced, we believe that farmers will be triggered and start to assess to buy even more e-bells.
One of the non-adopters decided not to test the FindMy-technology when the bell was introduced. An important reason for the non-adopter was that he did not experience any problems in finding or collecting the sheep. Another reason for not buying e-bells was the cost of the technology. The farmer believed that if you first start buying e-bells for a few sheep, you usually buy more because you feel a need to have e-bells on the whole herd. "You never know if you will lose a sheep with a bell. Thus, you will be dependent on the bells. Then it will be too expensive. The economy in sheep holding is already very bad and will be even worse if we implement all new technology offered". The other non-adopter is retired. He too tested e-bells from Telespor for two seasons, but decided to drop use afterwards. He thought the bells were too expensive.

In general, micro-AKIS farmers have contact with Nortura, Tine (if they have dairy production) and NAES for plant production. Some of the farmers that have implemented the new technology have in additional contact with the technology companies. Other farmers use farmers from the pasture group as advisors and discussion partners about the new technology.

5.2.2 Findings from the AKIS expert interviews and advisory organizations survey

Advisory landscape in the focus region

The advisory landscape in the region of Sogn og Fjordane (S&F) is much the same as in other regions in Norway. The advisory organizations are: *Tine*, the dominating dairy cooperative offering a range of services to its members; and *Felleskjøpet Agri* (FK), a cooperative that is the dominant actor in the input supply industry offering farmers concentrate, fertilizer, machines, equipment and seed. FK has employees responsible for sales who also give advice to farmers. *Nortura* is the dominating meat cooperative that offers advice to livestock farmers. *Norsk Landbruksrådgivning* (NAES) is a cooperative and an independent advisory organization offering services originally for plant production but has developed and broaden their offer the last years. These advisory organizations have offices in all counties in Norway. In addition, there are a number of advisory suppliers in S&F, such as technology companies, farmer-based interest organizations, input and machinery suppliers, private economic advisors, veterinarians, etc. (Table 11). All actors mentioned, beside the two technology companies that are located outside the region, have been located in the region for many years.

A trend in S&F, as in other regions, is paid advisory services. Earlier services were public and free, while today there are no longer public services. Nevertheless, this may vary in the different regions. In case study 1 in Trøndelag, and also in case study 2 there may be municipalities that offer some extension services. In case study 2, we can observe that the county administration for agriculture have a role in encourage farmers to use the new technology by offering them the technology to a reduced price, but they are not part of the extension service. The cooperatives in agriculture experience economic pressure, and NAES (an independent organization) has to take payment for all services. In addition, Tine, the milk cooperative offers only one free meeting each year for members. FK and Nortura still offer free services, but they have reduced their offer. One result is for example that they organize more group advice, and they prioritize larger farms before smaller farms.

Table 11: Agricultural advisory suppliers in the region

Type of actors	Actors
Farmers-based cooperatives	Tine, FK, Nortura
Private farmers owned advice company	NAES
Farmer –based associations	Norwegian Sheep and Goat (NSG)
Private sector – input machinery companies	e.g. on technology and devices, machinery and equipment, fodder, etc.
Private sector-technology start-ups/companies	Telespor, FindMy
Banking and finance	Local banks
Public support	Innovation Norway, county administration
Neighbours/colleagues, farmers in pasture group	Farmers
Others	Veterinarian

Key players of advice for the innovation area in the focus region

The two technology companies offering the e-bells are the formal advisors on the innovation. As both companies mention, the farmers' interest organization, Norwegian Sheep and Goat (NSG) has had and has an important role in informing sheep farmers about the new technology, and they invite the technology companies to join member meetings where they inform farmers about possibilities and instruct them in how to use the technology. The meat cooperative, Nortura, has the same role. The one advisor from Nortura in the region that covers sheep production invited the two technology companies offering e-bells to join meetings with sheep farmers so they can inform them about their products and innovations. This advisor knows the two e-bells very well, but does not look at himself as having a role in advising farmers about the technology. Both Nortura and the organization NSG, have been important at the trigger stage in informing farmers about the technology. In the active assessment and implementing stage, the two technology companies advise farmers besides farmers advising each other.

The trigger event for a broad introduction of the e-bells to sheep farmers in the county was what happened in 2009 when predators killed a large amount of sheep in some municipalities in the county. The county administration then established a pilot project to test the use of e-bells from Telespor in some municipalities in the county that experienced large losses of lambs. After testing, the county administration offered sheep pasture groups to apply for e-bells at a reduced price to test the use. Initially, predators were the trigger event.

In this case, we have defined *the active assessment* stage to be when farmers start to assess the e-bells and when they buy the first few e-bells for testing a season. The price for a few e-bells is not very expensive, and all farmers can afford to buy some bells for testing. According to the technology

companies, they are important advisors at this stage, but also other farmers are important advisors for many farmers.
In most cases, the assessment stage has resulted in *implementation* of more e-bells. The need for advice is the same for a few and many e-bells. According to the two companies, farmers gain advice from the technology companies and other farmers. The group of "other farmers" are usually farmers with a high interest for data, and they think it is useful to follow the movement of the sheep. In many cases, one farmer in the pasture group, often the leader, is the main supporter/advisor of the other farmers, and s/he is the one that has the contact with the e-bell company on behalf of the rest of the group. In other cases, individual farmers have direct contact with the company.

For the two technology companies offering e-bells, a challenge is to reach sheep farmers to give appropriate advice, secure that they utilize the functions and thus utilize the potential of the e-bell. The bells have many additional functions that only a few farmers utilize. It demands personal advice to use the functions that may increase efficiency of the production. FindMy emphasize that farmers with whom they have direct contact are more satisfied with the technology than other farmers are. As mentioned, many farmers only discuss and gain advice from colleagues and have no contact with the companies.

Another challenge mentioned by the companies is the price of the e-bells. Today farmers perceive that they cost too much, and because of that, they use e-bells only on part of the herd. A challenge is also that the technology is still not fully developed, and the equipment is still not robust enough to handle rough weather and environments. Nevertheless, many sheep farmers in the county use the technologies.

The advisor from Nortura mentioned a new actor that may offer a cheaper solution than the two e-bell companies. If this actor is able to develop a useful product for farmers at a cheaper price, it may represent a threat to the two established companies in the future.

The county administration started to support farmers in buying e-bells because of large losses of sheep by predators in some municipalities. This trigger initiated a pilot to test the use of e-bells in some municipality in 2010. Additionally, there are other reasons why the county administration wanted to support sheep farmers. It is a vulnerable group of farmers, often farmers are old, the sheep herd is small and profitability in production is low. Despite this, there is a wish and a goal at the regional level to keep the small sheep farmers utilizing the rich outfield resources. Outfield resources are free and may reduce the need to import fodder and concentrate and thus reduce the carbon footprint. To keep farmers in sheep farming, the social environment is important. Thus, the county administration demanded farmers to formalize the established pasture groups and to apply for subsidized bells through the group. In that, the group got another common activity that could increase cooperation, support of each other, social events and continuing engagement around the groups and sheep farming. In this way, the project was also about social sustainability.

Today, predators are not a big problem in the region. The reason why farmers decided to buy and use e-bells is according to the technology companies that it made it easier to look after the sheep during their summer pasture, and it is easier to collect the sheep in the autumn. The e-bells are useful because farmers gain a better overview of the herd, save time looking after the sheep and reduce loss of animals because of this.

Farmers do not involve the traditional advisory organizations in the implementation of new technology. The function for the only advisory organization involved, Nortura, is to secure that farmers gain information about the technology. As the Nortura advisor expressed, they want to be neutral according to the two technologies. This may be because Nortura has ownership interest in Telespors' e-bell.

The AKIS experts evaluate the innovation as not yet fully developed. However, they think the technology will be further developed, and thus contribute to increase the sustainable development of sheep farming.

The public role has been important for diffusion of the innovation in the county by the county agriculture division subsidizing the e-bells for pasturing groups. The technology companies have not received any support in advising farmers, but they have gained support from Innovation Norway in establishing their companies and in developing new products. Additionally, the technology companies have joined research projects connected to the use and development of the e-bell technology.

Transformation of advisory landscape

The two technology companies, Telespor and FindMy are producing the e-bells used by sheep farmers in S&F, and they offer advisory services for implementing and using the e-bells. The main differences between the companies are that one companies utilizes mobile networks while the other relies on satellites.

Telespor was established in 2004. The company is located in Tromsø, a city in northern Norway. This company developed and sells e-bells and gives advice on how to use them. Farmers have to pay for the e-bells and a yearly fee. After this, advice is free, as well as repairing broken e-bells. Telespor has established a web-based platform, where farmers can follow the animals. Another company mounts the e-bells. Telespor has 4-5 employees, where one person is responsible for R&D activities and training of the advisors. In season, three employees give farmers advice. The number of employees has been stable in the last years. The contact between the company and farmers happens mainly by phone or e-mail. They sometimes visit groups of farmers, both small groups and larger groups, often in connection with meetings arranged by Nortura or NSG. The company does not know how many e-bells they have in S&F. In the season, they gain about 60-70 inquiries every day by phone or e-mail. The enquiries are about how to prepare the bells before the season, programming them and how to interpret error messages.

Telespor has received some support from Innovation Norway when establishing the company and for development activities. They have also joined some R&D projects to develop the use of the technology. Their closest partners for cooperation are farmers, research institutes and universities. The company has 60,000 bells in use in Norway and some in Sweden, Finland and Iceland.

A challenge for the company is that the mobile network changes. This means they have to change technology, and farmers have to change to the new technology. A challenge for farmers is to understand what messages from the bell mean. Most farmers need advice on understanding this.

Sheep farmers experienced a need to develop e-bells for better control of their own herd and established the company FindMy in 2013. The company is located at Kvikne, a small town in the middle of rural Norway. It was not possible to use the mobile net in their outfield location so they had to base the e-bell on satellite signals. The company is very active in product development, first in how to utilize data from the e-bells better. This activity is in-house. They are in close cooperation with farmers for product development.

FindMy has seven employees with four employees in 100 % employment. The company has grown since it was established. One person is responsible for training and R&D activities inside the organization. In total, three people provide advice to farmers in the season. The advisors have higher education. To be an advisor, employees have to join a training course. Training is provided from their own employees. It takes only one week to understand the system and to start advising. In the season, advisors provide advice daily. They have registered 609 phone calls in one day. In the high season, they have on average about 120 phone calls every day and six in the low season.

The type of advice provided is mainly technical about the equipment and about animal keeping, and usually advice is given by phone and e-mail. When they go to S&F, they advise groups of farmers, small and large groups. They also give advice via an Internet portal. In the last years, they have developed added functionality to the e-bells that only a few customers use. According to the company, face-to-face contact is required to learn about how to use the new functionalities. This means the advisors need to meet the farmers more often than currently. It is a challenge for the company to know how to best get in contact with farmers for advising them. Another challenge is the construction of the e-bells. They have to be very robust to meet tough conditions. The company has a lot of cooperation with the advisory organization NAES and a private consultancy company on electronics. The company has received some support from Innovation Norway when establishing and developing the company. They also joined some research projects for developing the technology.

FindMy focused initially on e-bells for sheep. Now reindeer and cattle use the e-bells. They sell in Norway, and some in Sweden and Finland. They also have a few customers in Brazil and Africa. FindMy's e-bell is popular in S&F because many farmers lack mobile coverage on outfield pasture.

The two e-bell companies are new actors in the advisory landscape in the county of Sogn and Fjordane. The traditional advisors are not part of giving advice on e-bells for sheep, where the two start-up companies and neighbour farmers are the main advisors for farmers. Sheep farmers experience that the traditional advisor on sheep, Nortura, have less resources than earlier for giving advice and NAES, that give advice on plant production, now demand payment for services.

6. Discussion: Answering research questions

In this section, we discuss our findings across cases to provide empirical elements to answer our three research questions.

6.1 Role of advisory suppliers in the farmers' TCM and innovation paths

6.1.2 What roles do advisory services play in the cycles of farmers' decision-making?

Which role does advisory services play in "triggering" events?

In case one, milking robot: Related to the awareness stage (the early 2000s for most of the farmers and advisors), the advisors tell about farmers who on their own, without the push from either advisors or suppliers, went abroad to explore the possibilities the milking robot could give them. Because of the uncertainty about the technology between both suppliers, farmers and advisors in Norway, the robot became known through these "forward-leaning" farmers' independent exploratory search for new technologies they could bring in to make their farming easier. These farmers talked to foreign suppliers and farmers about their experiences with the technology, read technical magazines about the new technology, and decided to bring it to Norway. After these first "movers", the input providers, Lely, DeLaval, SAC and GEA, through their national suppliers (Felleskjøpet, Fjøssystemer and AK-maskiner), were the first ones to unroll the technology for a broader market in Norway. Because of this, the farmers themselves, technical magazines and the robot suppliers were the most important actors in the awareness stage for both farmers and advisors, rather than the traditional advisory services, such as NAES, and the cooperatives Tine or Nortura.

Many of the farmers describe comparable contexts and triggering events for why they started an active assessment of a milking robot on their farm. For a majority of farmers, it had to do with a situation where the farm in one way or another needed upgrading or expansion in order to be viable. Further, several farmers also describe a situation with either health issues, or family-related issues, that could not be compatible with the way the farm was managed. Due to this, the wish for more flexible working hours and the need for expansion or upgrading the farm are the main trigger events for the farmers to start assessing the milking robot on their farm).

For case two, the e-bells: The regional department of the Ministry of Agriculture initiated in 2010 a project to encourage farmers to test e-bells on sheep. The reason was high losses by predators in some municipalities in the focus region in 2009. The county administration offered sheep farmers in some municipalities that had experienced high loss of lamb to buy electronic bells for a subsidized price for testing. For most farmers these two factors, better management of livestock on mountain pasture and interest for new technology, were the main trigger events. For early adopter's, the loss of animals was a trigger too.

The county administration, Nortura and NSG were arranging a meeting where they informed farmers about the project and possibilities to test e-bells. Additionally Nortura and NSG informed members about the new technology at farmer meetings, and sometimes they invited the technology companies to join meetings to present the e-bells. Some farmers also read about the new technology in newspapers and magazines. Additionally, other farmers were an important source of information for many farmers to become aware of the new technology. According to the farmer survey, NSG, the technology companies and other farmers were the main actors that made farmers aware of the innovation.

Which role did advisors have in supporting farmers in assessing the innovation?

Case 1: The assessment stage is where most of the advisors and AKIS actors are more active. At this stage, the farmer needs several kinds of information and knowledge in order to make decisions for his/her future farm. Regarding the size and scope of investment the milking robot is, it puts many different advisors in action. Tine, NAES, Felleskjøpet/DeLaval, Fjøssystemer/Lely, AK-maskiner/SAC/GEA, Innovation Norway, the banks and accountants are important in providing financial support and planning of the investment and future farm management as a whole. As described earlier, some of the actors (Tine, Fjøssystemer/Lely and Felleskjøpet/DeLaval) have bigger roles than other advisors in this period.

Case 2: To assess the innovation, the farmers received support from NSG that had experience from the use of the bells from its members. Twelve farmers mentioned support from the technology companies, where most farmers had sporadic contact. In addition, a few farmers mentioned Nortura. Data shows that some farmers had a lot of communication with the technology companies in the testing phase while others had no contact with the producers of the e-bells. Instead, these farmers discussed regularly with other farmers in the pasture group.

Which role did advisors play in implementing the innovation?

Case 1: The advisors played at crucial role in implementation of AMS. For most farmers this kind of technology was very new, implying new routines and need for new knowledge. If the farmers are not familiar with computer technology, this innovation also implies another new challenge for the farmer. In this period, the suppliers and Tine are most important for farmers. The suppliers have developed customized start-up advisory services directly related to the different milking robots and have specialized advisors trained in the technology. Tine has advisors specialized on the most common robots, DeLaval and Lely, in addition to specialized advisory service on feeding, milk production and breeding related to dairy production with milking robots.

Case 2: Learning activities undertaken for gaining knowledge for implementation was mainly talking to other farmers and testing and experimenting on their own farm. Six farmers mentioned searching on the Internet. According to the implementing phase, three actors stand out when it comes to supporting the implementation of the technology. It is the farmer-based association, NSG, the technology companies and other farmers. It varies among farmers who are supporting them. When some farmers use the e-bell company regularly, other farmers use members of the pasture group for support. Others again, implement the technology on their own without much direct support. The farmers that get support from the technology companies communicate via phone or e-mail. When supported from farmers, they usually meet face-to-face or phone each other. What we can see from the interviews is that the traditional advisory services are not part of the group of actors giving advice to farmers in implementation of this innovation.

6.2 Farmers diversity and role of advisory in innovation uptake processes

6.2.1 What is the relationship between different types of farmer and advisory providers in the decision-making process?

How do farm characteristics relate to the role of advice in decision-making for different innovation areas?

Case 1: From the interviews, we can see that the pioneers adopting AMS had nearly no advisory support and had to find out themselves how to implement the robot. These farmers were interested in new technology and developed competence to handle the robot more or less on their own. The later adopters do not necessarily have the same interest for the technology and many of them are much more dependent on the suppliers and the traditional advisors to handle the data and the technology.

The difference between adopters and non-adopters of the technology is often related to the need to upgrade the farm, along with prospects of succession. A farmer approaching retirement age, with a farm that needs upgrading and without someone to take over the farm, will not have any incentive to invest in a robot. Because implementing a robot is often about changing the whole farm system on the farm, e.g. from tie stalls to loose housing, there are often more costs related to the implementation than only buying the robot. The size of the changeover in restructuring both buildings, production size and management system is often too big for the farmers who are not certain of a continuous future in farming. In addition to this group of non-adopters, there are non-adopters who are in a mixed situation eager to adopt the technology but lack the resources (capital, land, milk quotas, etc.). This can be one of the disadvantages of being a late adopter of the milking robot in Norway. The access to land can be scarce, especially if all the other farmers in the area has expanded and already acquired the land from the farmers deciding to quit in your area. Thus, farmers have no guarantee of access to land close to the farm, i.e. to rent or to buy.

The decision to implement a robot or not is a very big decision for farmers and it is not so easy to see the consequences of such an investment for the farmers and its family. Thus, for some farmers there may be a need for a whole approach before they take the decision to implement a robot to be sure it is the right decision. Some advisory organizations offer such strategic tools today, where the farmer has to formulate goals and strategies for the activity, but not many farmers join such strategic processes.

Case 2: Some characteristics by the farm and farmers may influence the decision to implement e-bells. Older farmers are not always so interested in new technology and for some of them the contact with advisors decrease with age. Interest for data and new technology is typical for some adopters. Often these farmers support other members of the pasture group with less interest and competence with knowledge and other support. It is I many cases the farmers with interest for the new technology and data that contact the e-bell producers and gain direct support on the use of the bell.

A reflection is that some pasture groups are more active and use more bells than others do. Some farmers talk about a “contagion” effect. When some buy, others follow. If the farmers’ environment in the pasture groups is good, such an effect may increase. Less data-interested farmers say that they are dependent on other farmers in the pasture group to support them in preparing bells before the season. It may increase implementation if farmers know they have supporting farmers in the pasture group. Some farmers use less challenging outfield areas and they have not experienced loss of animals. In such a situation, there are fewer needs for investing in e-bells.

The small technology companies do not have many resources to give advice, and they do not reach all farmers, so the other actors’ support has been decisive to implement the technology among sheep farmers in the region. Support from other actors has also been decisive for the technology companies in developing and improving their products. According to the e-bell companies, they are dependent on direct contact with farmers to secure that farmers utilize the potential of the technology. This may be a challenge for the less technology and data interested sheep farmers in the region that are dependent on colleagues to implement new developments of the technology.

6.3 Transformation of advisory suppliers and farmers’ innovation uptake processes

6.3.1 How does the transformation of advisory provider’s influence decision-making and uptake of innovation among farmers?

How does the new configuration of R-FAS affect the relationship between farmers and advice?

As Norway is not member of the EU, there is no regulation of R-FAS in Norway. There is of course a regionalized advisory service for farmer as described in 5.1.2 and 5.2.2.

How does a new governance model of farm advice influence access to shared knowledge, the accumulation and distribution of knowledge about effects of the innovation?

For AMS the advisory service is almost complete private (suppliers, dairy cooperative and economic actors). The suppliers of course try to strengthen their own positions and brand in the market. An important issue here is data generated through the milking robot. Tine want to be neutral to the various types of AMS and have specialists on the main types of robots. Tine has a data analysis system that can be applied with all types of robots, while the suppliers have to some degree overlapping systems. All together this creates a situation where issues of ownership of data is important to secure a flow of data (and from that follows knowledge) across the AKIS to benefit for all actors. However, this situation do not seem to be present today, even though there are efforts to secure the farmer his or hers ownership to data.

For e-bells, the new technology-based companies are new actors within AKIS and have an advisory role in our case. This role has been developed with support from the more traditional AKIS-actors (Nortura, NSG, the county administration) where we can see a cooperation between many actors to secure informing, testing and implementation of the new technology that is supposed to influence sheep farmers in a sustainable way. NSG and partly Nortura have spread information to farmers via member meetings and their member magazine. The member organization NSG has been a node of the different steps in the diffusion of the new technology. The technology companies have platforms where they share knowledge about the technology and how to utilize it, which is accessible for users. Not all farmers utilize this possibility, only the more technology and data-interested farmers do. In this case, the network of actors and close contact between farmers in pasture groups and in NSG has been decisive for the sharing and distribution of knowledge among actors.

7. Case study narratives

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8. Conclusions: Insights & Highlights

The Norwegian team has studied two cases where both belong to the Technological Innovation Cluster. In case one, we have studied the implementation of milking robots in the region of Trøndelag. A milking robot is a device associated with increased efficiency and productivity, and consequently profitability in dairy farming and a more flexible work situation for dairy farmers and their households. Trøndelag is a region where dairy farming is the major agricultural production. The implementation of milking robots started early, and the density of the technology is greater here than in other parts of the country. We made in total 29 interviews in Trøndelag, of which 20 were adopters and nine were non-adopters.

In case study two, the focus was on the use of electronic bells on sheep in the region of Sogn og Fjordane. This technology makes it possible to trace sheep during the pasture season. Some sheep farmers experienced big losses of sheep in 2009, and therefore the county administration started as part of a project to offer sheep farmers' electronic bells on sheep at a subsidized price. They wanted farmers to test if bells could contribute in reducing the loss of animals. This case is about the implementation of a new technology but also about the management of common resources. Sheep farmers use large outfield pastures that they own or have the right to use together with other farmers. Sheep farmers were organized in pasture groups many years ago, where they cooperate in collecting the sheep in the autumn. When the county started to offer e-bells, it was required that only formalized pasture groups could apply for support. Thus, this case also belongs to the Natural Resource Common Management Cluster. We carried out 21 interviews with sheep farmers in Sogn og Fjordane, 19 of which were adopters and two were non-adopters.

8.1 Case Study One – Milking Robots

From case study one, we recognize a change in advisory services from when the pioneers first started to implement the robots as early as 2000 until the later adopters implemented in the last years. In the beginning, there were usually only the suppliers that gave advice, and the traditional advisory organization was not part of this. Still, the suppliers are very important in both the assessment stage, in the implementation and for regular maintenance of the equipment. In particular, the milk cooperative Tine is very active in advising farmers about farm management using data from the robot. Besides the suppliers of robots, the adopters and the non-adopters have much the same micro-AKIS; they use the same advisors where the traditional advisory organizations in agriculture are important partners, in particular Tine for milk production and NAES for plant production.

In this case, we see that banks and accounting companies have a crucial role. First, they decide whether the investment and innovation will be realized or not. If there is doubt, often these actors force farmers to negotiate with suppliers or the farmer has to adjust the plan to what especially the bank regards as sustainable in the economic sense. Other advisory services can support farmers with knowledge and analyses. The bank has the power to make the final decision when they say yes or no to fund the plan of investment. The account takes the role as controller of the economic analysis; is the investment plan solid and reasonable? Their role, both the bank and the account, is based on their staff, or advisors, being competent in farming at least above a minimum competency. They all interact with other advisory services to gain complementary and alternative knowledge to be able to consider the farmers' investment plan. Farmers that have implemented a milking robot seem to have gained needed services from the traditional advisors in combination with advice from the supplier of the robot and suppliers from other connected technologies.

The nine non-adopters in the study consisted mainly of three groups. The first group consisted of farmers that are part of a joint farm, where they (together with several other farmers) are managing the farm, and therefore do not need the extra workforce that the milking robot represents. As many farmers' motivation to invest in the robot is to get more flexibility, these farmers lack this incentive, as they already have flexibility by sharing the farm work. One of them expressed that because of the lost workload due to implementing a robot, one of them would have had to quit farming, which none of them wishes to do. They also state that they like the milking operation and do not want to lose this connection with the cows. They are generally more critical of the structural changes towards bigger farms in Norwegian agriculture, placing this change on the milking robot, as those investing utilize the robots' capacity by expanding.

The second group is younger people that do not have resources to invest in a robot. They have either no access or cannot afford arable land and/or milk quotas. One of the farmers in this group was going to implement a robot in 2017; but right before buying more milk quota, the market changed, and the milk quota prices went up - resulting in the farmer not being able to afford the quota and therefore not able to justify financially investing in a robot. Additionally, several lack arable land and find it difficult to get predictable land lease agreements. Making a big investment in land, milk quotas and a milking robot (which means a considerable debt), and the unpredictability of renting and not owning land and quotas, can be a big worry and a barrier for the farmers to implement a robot. The third group consists of farmers that are going to invest in a robot in the next 1-2 years mainly because of generational change on the farm and a need for upgrading.

Regarding advisors and AKIS-actors, these nine farmers do not differ from the rest of the sample, and the non-adoption of the robot cannot be used as explanations of lacking support or a different microAKIS. As described above, the non-adoption is more from the lack of resources or incentives. The non-adopters' descriptions of their AKIS are neither less detailed nor active than the farmers that are adopters.

The agricultural policy in Norway has encouraged and stimulated farmers to increase production and growth. When a farmer has decided to invest in a new farm building, the financial support has been connected to growth and in many cases investment in a milking robot. For many farmers, a consequence has been a need for investment in new milk quotas and buying or renting arable land and grassland in addition to investing in a farm building. The results for many farmers has been large loans and increased production. From our study, we can see that many farmers that have implemented a robot is quite small, i.e. they are dependent on buying or renting large quotas of milk and buying or renting large areas of land to increase milk production and become profitable. Such farmers are in a situation where small changes in framework conditions may reduce profitability dramatically. In addition, farmers are vulnerable according to changes in the health situation and in general wellbeing. In the end, we are not sure if all farms with milking robots are sustainable.

Another issue raised is the development of and the consequences for the dairy sector when many farmers implement milking robots. The Norwegian government wants to increase the size and production of farms, and Innovation Norway is supporting such a development with loans and financial support. In many cases, we see very small farms investing in robot milking. This mean they sometimes have to buy and rent large areas of agricultural land to increase the number of cows and raise milk production to be profitable. The results of this are that some farmers rent farmland far away from their own farm and need to drive long distances to fetch fodder for the animals. This activity is time-consuming and not environmental friendly. Another consequence is that farmers have to invest more money when a robot is included, usually they have to buy or rent milk quotas, rent land and altogether this means they have to invest many million Norwegian kroner. These farmers are in a very tough and vulnerable situation. They are dependent on renting land that everything is going well in the barn, that the farmers are healthy and that they are able to work a lot for many years. As one farmer said, "to survive economically, I have to work in addition to farming. First, I do the milking in the morning, then I go to work outside the farm and afterwards I go to the barn to milk the cows and do the other farm work". Another farmer talked about the mental pressure of a large debt.

In this case, the new advisors were the suppliers of the robot and additional technology innovations. Otherwise, there was not a large difference between the adopters and the non-adopters according to the types of advisors. On the other hand, there are differences in how much farmers use the advisors. It seems like adopters use, for example, the Tine advisors more frequently than the non-adopters do.

It was surprising that so many adopters represented small farms with few resources initially, and it was interesting to see that adopting had a contagion effect. In some areas, nearly all farmers had invested in a robot, when in other areas only a few farmers had invested. Triangulation of data has been valuable and contributed to a better understanding of the changes and challenges of the advisory system in connection with the technology.

8.2 Case study two - electronic bells

In case study 2 about sheep farmers and e-bells, farmers wanted to test bells because they wanted to reduce loss of animals, and many mention that they were curious about the new technology too. The small technology companies are the formal advisors besides the farmers advising each other through the organization Norwegian goat and sheep (NSG) and the local pasture groups. NSG and Nortura, the meat cooperative, were initially very active in sheep farmers meeting to talk about the e-bells, and sometimes they invited the technology companies to join meetings to present their technology.

Some farmers got information and advice in the different phases (awareness and implementation) only from other farmers in their pasture group. Often there is one person in the group, usually the leader, who supports others in preparing the bells for the season and giving advice. This person usually has regular contact with the technology company on behalf of himself and others. Other farmers do everything on their own without much contact with advisors or other farmers. In addition, some adopters have contact with the technology companies in connection with the use of e-bells; adopters of e-bells use the same advisors as non-adopters. Their micro-AKIS represents the traditional advisory organizations, but some claim that there is little advice in general on sheep production. The main reason why some farmers do not use the technology seems to be the price and that their outfield areas are less challenging. Age and interest for data seems to influence the decision to implement bells as well.

No farmers use bells on the entire herd because they perceive them to be too expensive. On the other hand, they find the bells useful because of the save time, and they learned a lot about where sheep move during a pasture season. For some sheep farmers, the implementation of e-bells has increased the contact with participants in the pasture group; they have a new activity for cooperation and discussion.

In this case, narrative five is a good example of successful advice. A good network among sheep farmers in the region (through both the organization NSG and pasture groups) has been important for the successful diffusion of e-bells to sheep farmers. What was surprising in this case was the absence of the advisory organizations in advising farmers. Despite this, a network of actors with different roles managed to make diffusion possible. It seems like farmers with an interest in data are more eager to utilize the potential of bells and establish contact with the suppliers for advice. Other farmers rely on colleagues in their pasture group for advice.

Narrative six, where one of the two non-adopting sheep farmers is interviewed, he experienced that the e-bells he tested as part of the assessment stage did not function because the lack of mobile network coverage. He tested the e-bells because he lost many lambs to predators the previous year. When a new technology was introduced the year after with satellite coverage, he did not feel the need to test because predators were not a threat anymore, and he did not experience any problems in localizing the sheep during pasture or in collecting the sheep in the autumn. Therefore, he chose not to invest in new and expensive e-bells. In this case, the trigger event before testing the first type of e-bell did not exist when a new e-bell was introduced.

Some sheep farmers complained about the availability among the high-tech companies on giving advice. The high-tech companies are small and resources for advisory are limited. Additionally, they are located far away from the region, and there may be a challenge for the means of giving advice. When sheep farmers vary in interest for data, and farming is in many cases more like a hobby, it is sometimes a challenge to reach farmers. As the technology develops, utilization of data will require more contact between farmers and the suppliers. To secure utilization then may demand another method for advice than today. The main challenge for full implementation of e-bells in sheep herds today is the price in relation to the price for sheep meat. It is not economically sustainable to in invest in e-bells on all sheep.

It was surprising that the traditional advisory system was not much involved in giving advice, but farmer organizations and farmers themselves were very central in the Trigger Cycle Model (TCM). The important role of the county administration for diffusion was also surprising. Triangulation of data has given a supplement of data and important aspects of advice and challenges in utilization of the technology.

These case studies explore and deepen the role of advisors in innovation processes. Because the two cases are very different among many dimensions, they also show some different results. Nevertheless, our analysis indicates that the traditional advisors may have a limited role as a trigger and stimulation of innovation among farmers. In technological innovation, the suppliers are crucial. Further, our study shows that various groups of advisors have important but specific roles in the process of assessing and in the implementation of innovation.

References

Klerkx, Laurens, Egil Petter Stræte, Gunn-Turid Kvam, Eystein Ystad & Renate Marie Butli Hårstad (2017): Achieving best-fit configurations through advisory subsystems in AKIS: case studies of advisory service provisioning for diverse types of farmers in Norway, The Journal of Agricultural Education and Extension, DOI: 10.1080/1389224X.2017.1320640

Kvam, G.T og Stræte, E.P. (2018). Rådgivning I landbruket – en casestudie. Rapport nr. 1/2018, Ruralis – Institutt for rural og regional forskning, Trondheim.

Norwegian Agriculture Agency (2019). Mjølkekvotar. Retrieved 28.03.19, from https://www.landbruksdirektoratet.no/no/produksjon-og-marked/melk/melkekvoter#dette-er-kvoteordninga-for-mjoelk

Mur, R. and S. Nederlof (eds), (2013). Innovation for fashion or action? Building Innovation Capacity. Amsterdam: KIT Publishers.

Renting, H., Marsden, T.K. and Banks, J. (2003). Understanding Alternative Food Networks: Exploring the Role of Short Food Supply Chains in Rural Development. Environment and Planning A, 35(3), 393-412.

Rotmans, J. and Loorbach, D. (2010). Towards a Better Understanding of Transitions and their governance: A systemic and Reflexive approach. In: J. Grin, J. Rotmans and J. Schot, Transitions to Sustainable Development: New Directions in the Study of Long-term Transformative Change. London: Routledge, pp. 105-220.

Nasjonalt Beiteprosjekt 2009-2012. Statens Landbruksforvaltning. Rapport-nr.:14/2013.

Sogn og Fjordane Fylkeskommune. https://www.sfj.no/landbruk.334884.nn.html (23.05.2019).

Tine (2016). Melkeroboter i Norden. Retrieved 25.03.19, from https://medlem.tine.no/aktuelt/nyheter/fagnytt/melkeroboter-i-norden-2016

Tine, (2018). About TINE. Retrieved 27.03.19, from https://www.tine.no/english

Trøndelag Fylkeskommune (2018). Trøndelag i tall 2018. Retrieved 25.03.19, from https://www.trondelagfylke.no/vare-tjenester/plan-og-areal/kart-statistikk-og-analyse/statistikk-og-analyse/

SSB (2018). Strukturen i landbruket. Retrieved 25.03.19, from https://www.ssb.no/statbank/table/11583/tableViewLayout1/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727577